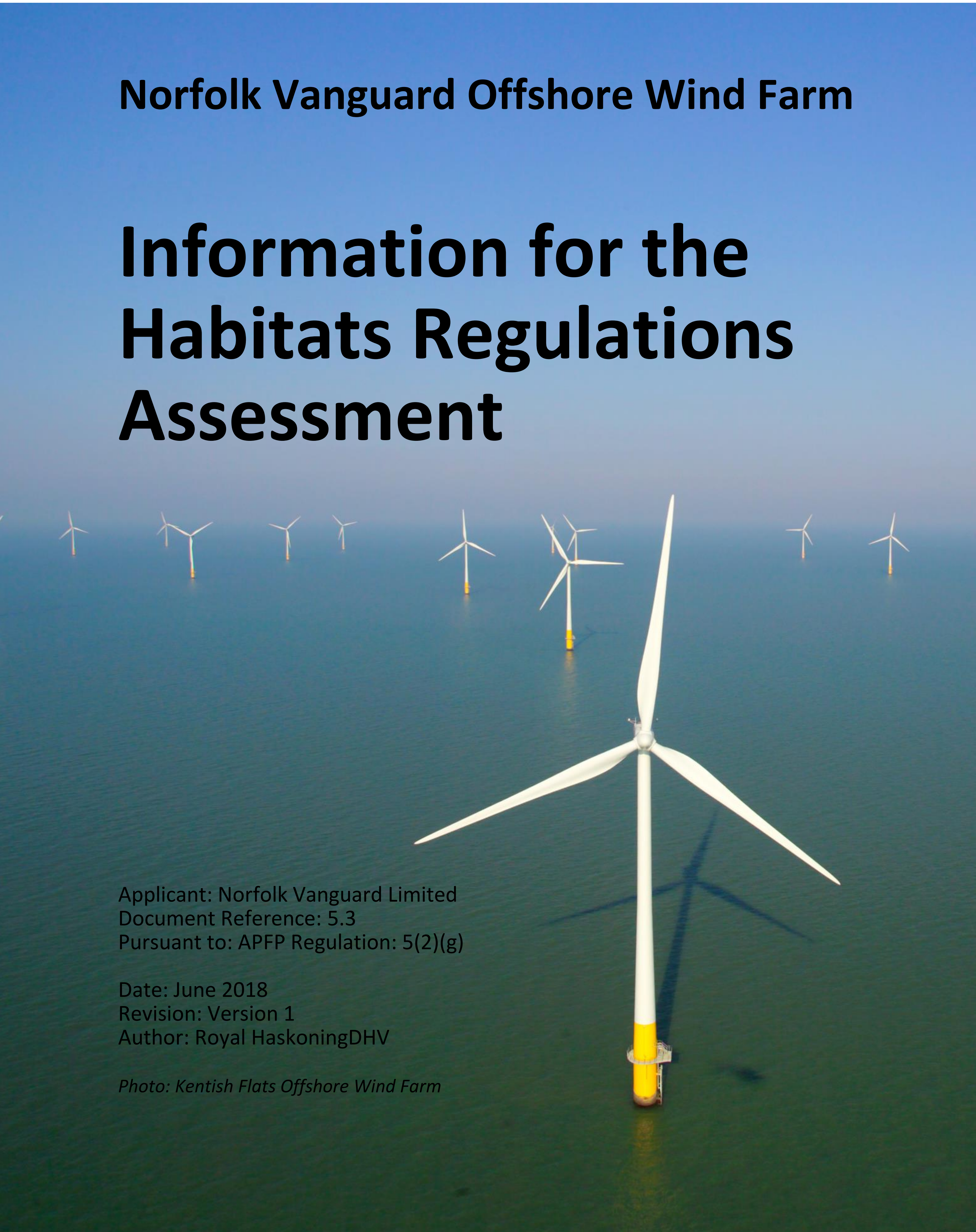
Norfolk Vanguard Offshore Wind Farm

Information for the Habitats Regulations Assessment



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For and on behalf of Norfolk Vanguard Limited

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Date: 8th June 2018

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20/02/18	02D	Second draft for Norfolk Vanguard Limited review	GK, MacArthur Green	JL	AD
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13/06/18	01F	Final for DCO submission	MT, DT, JL, GC	GK, AD	AD

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Glossary

ADD	Acoustic deterrent devices
AfL	Agreement for Lease
AU	Assessment Unit
AWAC	Acoustic Wave and Current
BDMPS	Biologically Defined Minimum Population Scales
BEIS	Business Energy and Industrial Strategy
BTO	British Trust for Ornithology
CI	Confidence Interval
CIS	Celtic and Irish Sea
cSAC	candidate Special Area of Conservation
CV	Coefficient of Variation
DECC	Department of Energy and Climate Change
DEPONS	Disturbance Effects on the Harbour Porpoise Population in the North Sea
DOW	Dudgeon Offshore Wind Farm
DML	Deemed Marine Licence
DWR	Deep water routes
EA4	East Anglia Four
EIA	Environmental Impact Assessment
EIFCA	Eastern Inshore Fisheries and Conservation Agency
EcIA	Ecological Impact Assessment
EMF	Electromagnetic fields
EN-1	NPS for Energy
EN-3	NPS for Renewable Energy Infrastructure
EN-5	NPS for Electricity Networks Infrastructure
EOD	Explosive Ordnance Disposal
EPP	Evidence Plan Process
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Group
FAME	Future of the Atlantic Marine Environment
FCS	Favourable Conservation Status
GBS	Gravity base structure
GNS	Greater North Sea
GSD	Ground Sampling Distance
HDD	Horizontal Directional Drilling
HRA	Habitats Regulations Assessment
HRGN	Habitats Regulations Guidance Note
IAMMWG	Inter-Agency Marine Mammal Working Group
IROPI	Imperative Reasons of Overriding Public Interest
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
KDE	Kernal Density Estimates
LAT	Lowest Astronomical Tide
LiDAR	Light Detection and Ranging
LSE	Likely Significant Effects
MU	Management Units

MMO	Marine Management Organisation
NBSG	Norfolk Barbastelle Study Group
NEQ	Net explosive quantities
NNR	National Nature Reserve
NPS	National Policy Statement
NVC	National Vegetation Classification
NV East	Norfolk Vanguard East
NV West	Norfolk Vanguard West
NWT	Norfolk Wildlife Trust
O&M	Operation and Maintenance
OLEMS	Outline Landscape and Environmental Management Strategy
OWF	Offshore Wind Farm
PAM	Passive acoustic monitoring
PBR	Potential Biological Removal
PCoD	Population Consequences of Disturbance
PEI	Preliminary Environmental Information
PEIR	Preliminary Environmental Information Report
PPG	Pollution Prevention Guidance
PSA	Particle size distribution
pSAC	possible Special Area of Conservation
pSPA	potential Special Protection Area
PTS	Permanent Threshold Shift
QA	Quality assurance
REC	Regional Environmental Characterisation
RSPB	The Royal Society for The Protection of Birds
SAC	Special Area of Conservation
SCI	Sites of Community Importance
SIP	Site Integrity Plan
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Bodies
SNS	Southern North Sea
SPA	Special Protection Area
SSC	Suspended Sediment Concentrations
SSSI	Site of Special Scientific Interest
SST	Sea Surface Temperature
STAR	Seabird Tracking and Research
TSEG	Trilateral Seal Expert Group
TWT	The Wildlife Trusts
UXO	Unexploded Ordnance
VWPL	Vattenfall Wind Power Ltd
WDC	Whale and Dolphin Conservation
WS	West Scotland
ZOI	Zone of Influence

Terminology

Attenuation pond zone	Zone within which the attenuation pond at the onshore project substation or Necton National Grid substation will be located.
Array cables	Cables which link the wind turbines and the offshore electrical platform.
Facies	A body of rock with specified characteristics (including chemical, physical and biological features) that distinguishes it from adjacent rock.
Indicative mitigation planting	Areas identified for mitigation planting at the onshore project substation and Necton National Grid substation.
Interconnector cables	Buried offshore cables which link the offshore electrical platforms
Jointing pit	Underground structures constructed at regular intervals along the cable route to join sections of cable and facilitate installation of the cables into the buried ducts
Landfall	Where the offshore cables come ashore at Happisburgh South
Landfall compound	Compound at landfall within which HDD drilling would take place
Link boxes	Underground chambers or above ground cabinets next to the cable trench housing low voltage electrical earthing links.
Mobilisation area	Areas approx. 100 x 100m used as access points to the running track for duct installation. Required to store equipment and provide welfare facilities. Located adjacent to the onshore cable route, accessible from local highways network suitable for the delivery of heavy and oversized materials and equipment.
Mobilisation zone	Area within which the mobilisation area will be located.
National Grid new / replacement overhead line tower	New overhead line towers to be installed at the National Grid substation.
National Grid overhead line modifications	The works to be undertaken to complete the necessary modification to the existing 400kV overhead lines
National Grid substation extension	The permanent footprint of the National Grid substation extension
National Grid temporary works area	Land adjacent to the Necton National Grid substation which would be temporarily required during construction of the National Grid substation extension.
Necton National Grid substation	The existing 400kV substation at Necton, which will be the grid connection location for Norfolk Vanguard
Offshore accommodation platform	A fixed structure (if required) providing accommodation for offshore personnel. An accommodation vessel may be used instead
Offshore cable corridor	The corridor of seabed from the Norfolk Vanguard OWF sites to the landfall site within which the offshore export cables would be located.
Offshore electrical platform	A fixed structure located within the wind farm area, containing electrical equipment to aggregate the power from the wind turbines and convert it into a more suitable form for export to shore.
Offshore export cables	The cables which bring electricity from the offshore electrical platform to the landfall.
Offshore project area	The overall area of Norfolk Vanguard East, Norfolk Vanguard West and the offshore cable corridor
Onshore 400kV cable route	Buried high-voltage cables linking the onshore project substation to the Necton National Grid substation
Onshore cable corridor	200m wide onshore corridor within which the onshore cable route would be located as submitted for PEIR.
Onshore cable route	The 45m easement which will contain the buried export cables as well as the

	temporary running track, topsoil storage and excavated material during construction.
Onshore cables	The cables which take the electricity from landfall to the onshore project substation
Onshore project area	All onshore electrical infrastructure (landfall; onshore cable route, accesses, trenchless crossing technique (e.g. Horizontal Directional Drilling (HDD)) zones and mobilisation areas; onshore project substation and extension to the Necton National Grid substation and overhead line modification)
Onshore project substation	A compound containing electrical equipment to enable connection to the National Grid. The substation will convert the exported power from HVDC to HVAC, to 400kV (grid voltage). This also contains equipment to help maintain stable grid voltage.
Onshore project substation temporary construction compound	Land adjacent to the onshore project substation which would be temporarily required during construction of the onshore project substation.
Running track	The track along the onshore cable route which the construction traffic would use to access workfronts
Safety zones	A marine zone outlined for the purposes of safety around a possibly hazardous installation or works / construction area under the Energy Act 2004.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.
The Applicant	Norfolk Vanguard Limited
The OWF sites	The two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West
The project	Norfolk Vanguard Offshore Wind Farm, including the onshore and offshore infrastructure
Transition pit	Underground structures that house the joints between the offshore export cables and the onshore cables within the landfall
Trenchless crossing zone (e.g. HDD)	Temporary areas required for trenchless crossing works.
Workfront	The 150m length of onshore cable route within which duct installation would occur

1. INTRODUCTION

1.1. Purpose of Habitats Regulations Assessment Report

1. The purpose of this Information to Support Habitats Regulations Assessment (HRA) report is to provide information to the Planning Inspectorate on the potential for adverse effect on the integrity of European and Ramsar sites as a result of the proposed Norfolk Vanguard Offshore Wind Farm (herein 'Norfolk Vanguard' or 'the project'). The report is intended to inform the process of undertaking an Appropriate Assessment as required under the Habitats Regulations.

2. The HRA process derives from the requirements of specific European Directives and the UK Regulations that implement their requirements in national law which are outlined in section 2 of this report.

3. In addition to fully designated Special Areas of Conservation (SAC)s and fully classified Special Protection Areas (SPA)s, the HRA process also has to be applied as a matter of law or policy to the following sites (also referred to as 'Natura 2000' sites):

- Sites of Community Importance (SCI);
- Potential SPAs (pSPAs);
- Possible SACs (pSACs);
- Candidate SACs (cSACs); and
- Listed and proposed Ramsar sites (internationally important wetlands designated under the Ramsar Convention 1971).

4. This report therefore covers potential effects upon the following:

- Offshore ornithology – features of SPAs, pSPAs and Ramsar sites, including rare and vulnerable birds (as listed on Annex I of the Birds Directive), and regularly occurring migratory species;
- Benthic habitats (Habitats Directive Annex 1) - SACs, SCI and cSACs where appropriate;
- Marine mammals (Habitats Directive Annex II Species) – SACs, SCIs and cSACs as appropriate; and
- Onshore ecology, including ornithology – features of Natura 2000 sites (SPAs, SCIs, cSACs and SACs as appropriate).

5. The structure of this HRA Report is as follows:

- Section 1 (this section): Introduction to the document and the structure of the assessment;
- Section 2: Legislation, Policy and Guidance: This section puts the HRA document into a legislative context and details the policy and guidance given by a number of Governmental, statutory and industry bodies in relation to the HRA process.

- Section 3 - Project Overview: An outline of Norfolk Vanguard is given with regard to the location of the project infrastructure and the construction, operation and maintenance (O&M) and decommissioning;
- Section 4 – Approach to HRA: Provides an overview of the HRA Process and the approach taken by Norfolk Vanguard Limited;
- Section 5 - Screening: This section summarises the screening process that was consulted on previously through the Evidence Plan Process (EPP) and section 42 Preliminary Environmental Information (PEI) consultation. The offshore and onshore screening reports are provided in Appendix 5.1 and 5.2, respectively;
- Section 6 – Offshore SPAs/pSPAs;
- Section 7 – Offshore SACs Annex I Habitats;
- Section 8 - Offshore cSACs Annex II Species; and
- Section 9 – Onshore Natura 2000 Sites.

1.2. Consultation

6. This report is composed of several sections which have been informed by previous consultation over the course of the pre-application phase of Norfolk Vanguard. The vehicles for the consultation have been:

- The Scoping Report and request for a scoping opinion (October 2016);
- The EPP, including:
  - Consultation on the offshore HRA Screening (in June 2017, and provided as Appendix 10.4 of the Preliminary Environmental Information Report (PEIR) (Norfolk Vanguard Limited, 2017));
  - Consultation on the onshore HRA Screening (provided as Appendix 22.6 of the PEIR);
  - Consultation on the draft HRA (February 2018);
- The statutory consultation undertaken as part of the pre-application phase of consultation (i.e. the Preliminary Environmental Information Report (PEIR) under Section 42 of the Planning Act 2008) (October to December 2017).

7. The EPP is an initiative to provide a mechanism to help agree the information Norfolk Vanguard needs to supply to the Planning Inspectorate as part of a DCO application for the proposed Norfolk Vanguard project to help to ensure compliance with the Environmental Impact Assessment (EIA) and HRA.

8. The EPP process has been the key method for agreeing the scope of the EIA and HRA, data used and the assessment methodologies.

9. The parties engaged as part of the EPP were:

- Offshore ornithology expert topic group (ETG):

- Natural England; and
    - The Royal Society for The Protection of Birds (RSPB);

- Benthic Ecology and Marine Physical Processes ETG:
    - Natural England;
    - Marine Management Organisation (MMO);
    - Cefas;
    - Eastern Inshore Fisheries and Conservation Agency (EIFCA)
    - The Wildlife Trusts; and
    - Environment Agency.

- Marine Mammal ETG:
    - Natural England;
    - Cefas;
    - The Wildlife Trusts; and
    - Whale and Dolphin Conservation.

- Onshore ecology ETG:
    - Norfolk County Council;
    - Breckland Council;
    - Environment Agency;
    - Natural England;
    - North Norfolk District Council; and
    - Norfolk Wildlife Trust.

10. Table 1.1 provides a summary of consultation of relevance to the HRA. Full details of the consultation undertaken for the EPP are provided as appendices 9.1 to 9.26 and 25.1 to 25.12 of the Consultation Report (document 5.1) submitted with the DCO application.

Table 1.1 Key Consultation in relation to Habitats Regulations Assessment

Date	Contact Type	Organisation	Topic
22nd June 2017	Emails	EA, MMO, NE, TWT, NNDC, Cefas, WDC	Offshore HRA Screening (Appendix 5.1) provided for consultation
26th June 2017	Email	RSPB, EIFCA	Offshore HRA Screening (Appendix 5.1) provided for information
5th July 2017	Meeting	NE	Discussion of benthic HRA Screening. Offshore ornithology HRA feedback also provided by NE (minutes provided in Appendix 9.16 of the Consultation Report (document 5.1).

Date	Contact Type	Organisation	Topic
6th July 2017	Meeting	NE, TWT, WDC, Cefas	Marine mammal HRA Screening agreed and approach to HRA discussed (minutes provided in Appendix 9.24 of the Consultation Report (document 5.1).
14th July	Email	NE, NCC, NWT, EA	Onshore HRA Screening (Appendix 5.2) provided for consultation
18th July	Meeting	NE, NCC, NWT, EA	Onshore HRA Screening discussed and approach agreed (minutes provided in Appendix 9.19 of the Consultation Report (document 5.1)
8th December 2017	Meeting	NE, WT, Cefas	Proposed approach to marine mammal HRA discussed (minutes provided in Appendix 9.24 of the Consultation Report (document 5.1)
15th December 2017	S42 feedback	Various	A report to inform HRA was not available at the time of s42 consultation, however a number of responses in relation to the PEIR are applicable to the HRA and so have been incorporated in this report. Further responses to Onshore HRA Screening received during s42 feedback have been taken into consideration
3rd January 2018	Email	NE	Written advice following meeting on the 8th December
22nd January 2018	Meeting	NE, NCC, NWT, EA, NNDC	Meeting to discuss PEIR responses, including Onshore HRA Screening submitted with PEIR. Approach to Onshore HRA also discussed (minutes provided in Appendix 25.1 of the Consultation Report (document 5.1).
31st January 2018	Meeting	NE, Cefas, MMO, EIFCA	Meeting to discuss technical reports supporting assessment of the Haisborough, Hammond and Winterton SAC and the approach to the HRA (minutes provided in Appendix 25.6 of the Consultation Report (document 5.1).
23rd March 2018	Email	NE	Written advice following submission of draft HRA Report.
26th March 2018	Meeting	NE, WT, WDC, MMO	Meeting to marine mammal aspects of HRA Report provided on 23rd March 2018 (minutes provided in Appendix 25.9 of the Consultation

Date	Contact Type	Organisation	Topic
			Report (document 5.1).
26th March 2018	Meeting	NE, RSPB	Meeting to discuss offshore ornithology aspects of HRA Report provided on 23rd March 2018 (minutes provided in Appendix 25.8 of the Consultation Report (document 5.1).
23rd April 2018	Meeting	NE	Meeting to discuss written advice on onshore aspects of HRA Report provided on 23rd March 2018 (minutes provided in Appendix 25.1 of the Consultation Report (document 5.1)

2. LEGISLATION, POLICY AND GUIDANCE

2.1. Legislative Context

11. The HRA process covers features designated under the European Council Directive 2009/147/EC on the conservation of wild birds (the 'Birds Directive') and Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (the 'Habitats Directive'). These are implemented into UK legislation by the Conservation of Habitats and Species Regulations 2017.

2.1.1. The Birds Directive

12. The EU Directive on the Conservation of Wild Birds (2009/147/EC) (hereafter called the Birds Directive) provides a framework for the conservation and management of wild birds in Europe. The relevant provisions of the Directive are the identification and classification of SPAs for rare or vulnerable species listed in Annex I of the Directive and for all regularly occurring migratory species (required by Article 4). The Directive requires national Governments to establish SPAs and to have in place mechanisms to protect and manage them. The SPA protection procedures originally set out in Article 4 of the Birds Directive have been replaced by the Article 6 provisions of the Habitats Directive.

2.1.2. The Habitats Directive

13. The EU Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (hereafter called the Habitats Directive) provides a framework for the conservation and management of natural habitats, wild fauna (except birds) and flora in Europe. Its aim is to maintain or restore natural habitats and wild species at a favourable conservation status. The relevant provisions of the Directive are the identification and classification of SACs (Article 4) and procedures for the protection of SACs and SPAs (Article 6). SACs are identified based on the presence of natural habitat types listed in Annex I and populations of the species listed in Annex II. The Directive requires national Governments to establish SACs and to have in place mechanisms to protect and manage them.

2.1.3. The Conservation of Habitats and Species Regulations 2017 and Conservation of Offshore Marine Habitats and Species Regulations 2017

14. In November 2017, the Conservation of Habitats and Species Regulations 2010 (and amendments) were updated and consolidated into the Conservation of Habitats and Species Regulations 2017.

15. In addition, the Conservation of Offshore Marine Habitats and Species Regulations 2017 update the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (collectively referred to as 'the Habitats Regulations 2017').

16. The Habitats Regulations 2017 transpose the Habitats Directive into national law. The Habitats Regulations place an obligation on 'competent authorities' to carry out an appropriate assessment of any proposal likely to affect a Natura 2000 site, to seek advice from SNCBs and not to approve an application that would have an adverse effect on a Natura 2000 site except under very tightly constrained conditions that involve decisions by the Secretary of State. The competent authority in the case of the proposed project is the Secretary of State for Business Energy and Industrial Strategy (BEIS).

2.2. Policy and Guidance

17. In preparing this report, consideration has been given to relevant guidance issued by a number of Governmental, statutory and industry bodies.

18. In relation to guidance from Government bodies, this includes:

- European Commission: Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites.
- European Commission: EU Guidance on wind energy development in accordance with EU nature directives.
- Department of Communities and Local Government: Guidance on 'Planning for the Protection of European Sites: Appropriate Assessment'.
- The Planning Inspectorate Advice Note Nine: Rochdale Envelope.
- The Planning Inspectorate Advice Note Ten: Habitat Regulations Assessment relevant to nationally significant infrastructure projects.
- Department Of Energy and Climate Change: Guidelines on the Assessment of Transboundary Impacts of Energy Developments on Natura 2000 Sites outside the UK.
- Overarching National Policy Statement (NPS) for Energy (EN-1) (Department of Energy and Climate Change (DECC), 2011a);
- NPS for Renewable Energy Infrastructure (EN-3) (DECC, 2011b); and
- NPS for Electricity Networks Infrastructure (EN-5) (DECC, 2011c).

19. In relation to guidance from Statutory Nature Conservation Bodies (SNCBs) this includes:

- English Nature: Habitats Regulations Guidance Note (HRGN 1): The Appropriate Assessment (Regulation 48) The Conservation (Natural Habitats &c) Regulations, 1994.

- English Nature: Habitats Regulations Guidance Note (HRGN 3): The Determination of Likely Significant Effect under the Conservation (Natural Habitats &c) Regulations, 1994.
- English Nature: Habitats Regulations Guidance Note (HRGN 4): Alone or in-combination.
- Natural England and JNCC: Interim advice on HRA screening for seabirds in the non-breeding season.
- Natural England and JNCC: Advice on HRA screening for seabirds in the breeding season.
- Natural England and JNCC: Interim Advice Note – Presenting information to inform assessment of the potential magnitude and consequences of displacement of seabirds in relation to Offshore Windfarm Developments.

20. In relation to guidance from industry this includes:

- Developing Guidance on Ornithological Cumulative Impact Assessment for Offshore Wind Farm Developers (King *et al.* 2009).
- Cumulative Impact Assessment Guidelines – Guiding Principles for Cumulative Impacts Assessment in Offshore Wind Farms (RenewableUK 2013).

3. PROJECT OVERVIEW

21. Norfolk Vanguard Limited ('the Applicant' an affiliate company of Vattenfall Wind Power Ltd (VWPL)) is seeking a Development Consent Order for Norfolk Vanguard, an offshore wind farm (OWF) in the southern North Sea.

22. The OWF comprises two distinct areas, Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) ('the OWF sites'), within which wind turbines, offshore electrical platforms, accomnmodation platforms and array cables will be located. The offshore wind farm will be connected to the shore by offshore export cables installed within the offshore cable corridor from the wind farm to a landfall point at Happisburgh South, Norfolk. From there, onshore cables would transport power over approximately 60km to the onshore project substation and the National Grid substation at Necton, Norfolk. A full project description is given in the Environmental Statement, Chapter 5 Project Description.

23. Once built, Norfolk Vanguard would have an export capacity of up to 1800MW, with the offshore components comprising:

- Wind turbines;
- Offshore electrical platforms;
- Accommodation platforms;
- Met masts;
- Lidar;
- Array cables;
- Inter-connector cables; and
- Export cables.

24. The key onshore components of the project are as follows:

- Landfall;
- Onshore cable route, accesses, trenchless crossing technique (e.g. Horizontal Directional Drilling (HDD)) zones and mobilisation areas;
- Onshore project substation; and
- Extension to the Necton National Grid substation and overhead line modifications.

25. Flexibility in terms of turbine capacity and parameters will be maintained to allow for potential evolution of technology prior to offshore construction which is anticipated to commence in 2024. Full details of the design of the proposed project are presented in the Environmental Statement (ES) (Chapter 5 Project Description). Details of the design, where relevant to the HRA, are presented in sections 6 to 9 of this report.

26. Norfolk Vanguard would have a total export capacity of up to 1800MW which is enough to power 1.3 million UK households[1].

27. Through one of its subsidiaries, Vattenfall Wind Power Ltd also has an Agreement for Lease (AfL) for a second offshore wind farm, Norfolk Boreas, which will be the subject of a separate DCO application and EIA process. Norfolk Boreas would also connect to the grid at the Necton National Grid substation. Subject to both Norfolk Vanguard and Norfolk Boreas receiving development consent and progressing to construction, onshore ducts will be installed for both projects at the same time, as part of the Norfolk Vanguard construction works. This would allow the main civil works for the cable route to be completed in one construction period and in advance of cable delivery, preventing the requirement to reopen the land in order to minimise disruption. Onshore cables would then be pulled through the pre-installed ducts in a phased approach at later stages. Other onshore infrastructure for Norfolk Boreas, for example the Norfolk Boreas onshore project substation, will be consented under a separate Norfolk Boreas DCO process and are considered in the in-combination assessment of this HRA where appropriate.

[1] Assuming a load factor of 34.88 http://www.renewableuk.com/page/UKWEDExplained

4. NORFOLK VANGUARD APPROACH TO HRA

4.1. HRA Process

28. The HRA process is carried out in a sequential manner by the Planning Inspectorate, acting on behalf of the Secretary of State for BEIS. The HRA process is informed and assisted by Norfolk Vanguard Limited. It is the responsibility of the developer to include 'sufficient information' within the DCO application to identify the European sites for which there is potential for a likely significant effect from the project and to enable an Appropriate Assessment to be undertaken. The purpose of this Information to Support HRA report is therefore to provide suitable information to support an Appropriate Assessment of the Norfolk Vanguard project as proposed.

29. The stages of that sequence are described in Planning Inspectorate Advice Note 10 (Planning Inspectorate 2013a), as follows:

- Stage 1 - Screening;
  - European and Ramsar sites are screened for Likely Significant Effects (LSE), both from the project alone and in-combination with other projects.
  - An Offshore Screening Report and Onshore Screening Report were submitted for consultation through the EPP and Preliminary Environmental Information (PEI); these are provided as Appendix 5.1 and 5.2 to this report and summarised in section 5 of this report. Any changes to screening as a result of ongoing consultation are discussed in this report.
- Stage 2 - Appropriate Assessment;
  - For those sites where LSE on a European or Ramsar site could not be excluded in Stage 1 then further information to inform the assessment has been prepared (this report). A test is applied of whether the project alone or in combination could adversely affect the integrity of the site in view of its conservation objectives.
  - These tests form sections 6 to 8 of this report and the methodologies for these full assessments were developed and agreed through the EPP (section 1.2).

30. In those cases where the conclusion of an HRA Report is that an adverse effect on the integrity of a European or Ramsar site has been identified then the assessment would proceed to two further stages:

- Stage 3 - Assessment of Alternatives;
  - The alternatives that have been considered will be assessed. The Planning Inspectorate advises that alternative solutions can include a proposal of a

different scale, a different location and an option of not having the scheme at all – the 'do nothing' approach.

- Stage 4 – Assessment of Imperative Reasons of Overriding Public Interest (IROPI).
    - If it is demonstrated that there are no alternative solutions to the proposal that would have a lesser effect or avoid an adverse effect on the integrity of the site(s), then a justified case will be prepared that the scheme must be carried out for IROPI.

31. If the conclusion of Stages 3 and 4 is that there is no alternative and that the project has demonstrated IROPI then the project may proceed with a requirement that appropriate compensatory measures are delivered.

4.2. In-Combination Assessment

32. The Habitats Regulations 2017 require consideration of the potential effects of a project on European sites (and on Ramsar sites as a matter of Government policy) both alone and in-combination with other plans or projects.

33. The identification of plans and projects to include in the in-combination assessment has been based on:

- Projects that are under construction;
- Permitted application(s) not yet implemented;
- Submitted application(s) not yet determined;
- All refusals subject to appeal procedures not yet determined;
- Projects on the National Infrastructure's programme of projects; and
- Projects identified in the relevant development plan (and emerging development plans with appropriate weight being given as they move closer to adoption) recognising that much information on any relevant proposals will be limited.

34. The types of projects that could potentially be considered for the in-combination assessment include:

- Offshore wind farms;
- Onshore wind farms;
- Marine aggregate extraction;
- Oil and gas exploration and extraction;
- Sub-sea cables and pipelines;
- Commercial shipping;
- Recreational boating; and
- Onshore major residential, commercial and industrial development.

35. This assessment presents relevant in-combination impacts of projects in a tiered form as advised by Natural England (JNCC and Natural England, 2013).

36. Norfolk Vanguard Limited has interpreted the JNCC and Natural England advice and, for the proposed Norfolk Vanguard project, followed the approach outlined for East Anglia THREE during its examination. Projects are included in the quantitative assessment where there is sufficient certainty and data confidence that they make a meaningful contribution to the assessment process.

5. SCREENING

5.1. Offshore ornithology

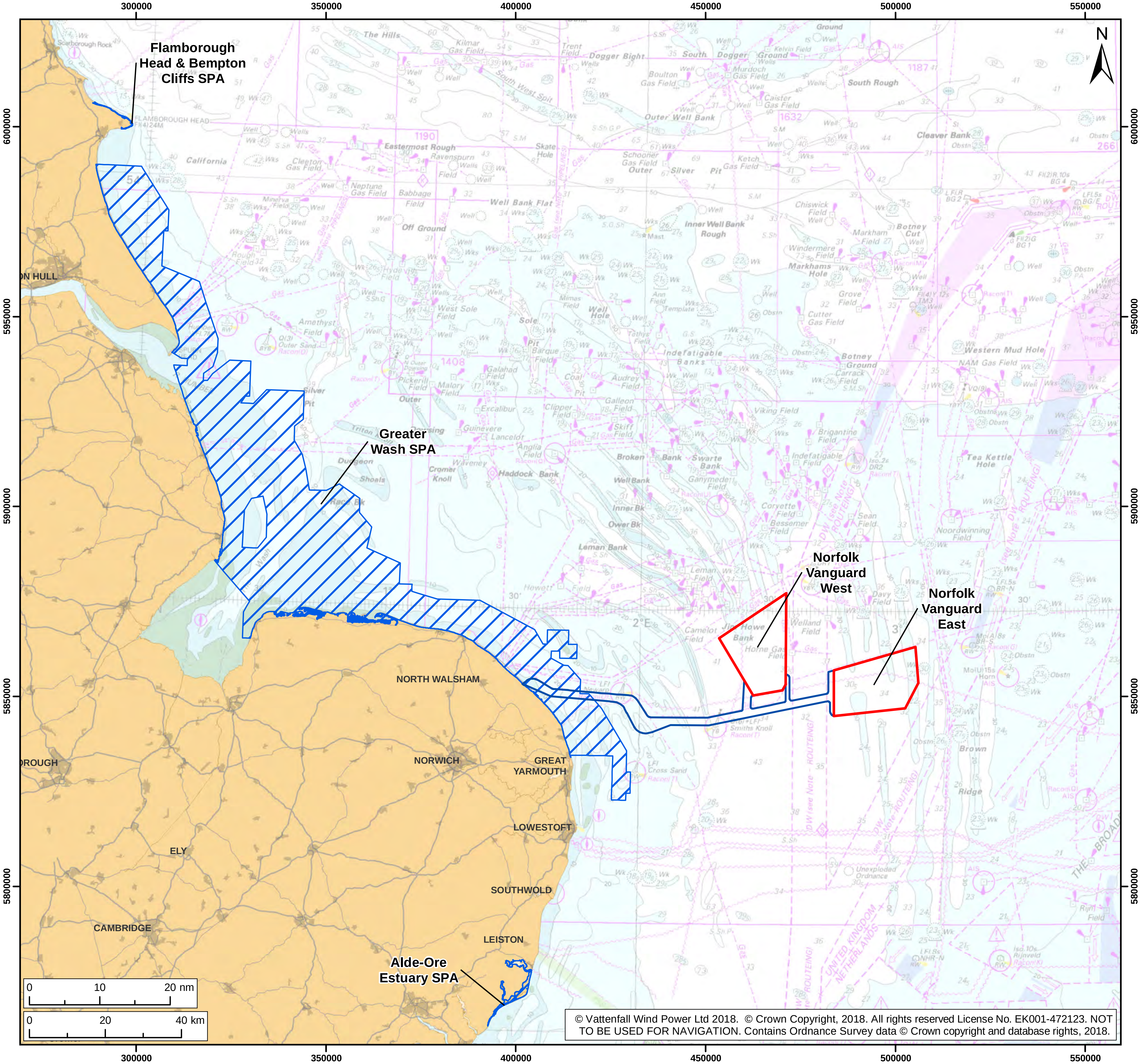
37. The Norfolk Vanguard HRA Offshore Screening Report (Appendix 5.1), produced in consultation with Natural England and the Royal Society for the Protection of Birds (RSPB) (see section 1.2), identified SPAs and features for further assessment on the basis that it was not possible to rule out the potential for LSE as a result of activities during construction, O&M and decommissioning of Norfolk Vanguard.

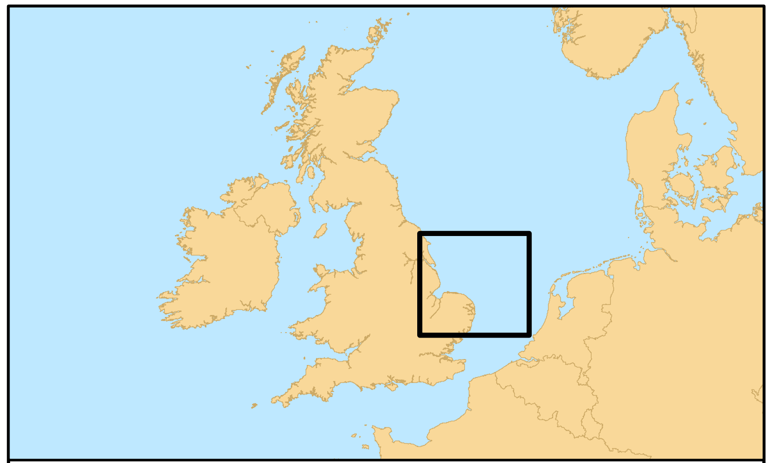
38. The following sections provide discussion on the potential for LSE due to the Norfolk Vanguard OWF, both alone and in-combination, on the sites and features identified in the screening report. The SPAs under consideration are:

- Outer Thames Estuary SPA;
- Alde-Ore Estuary SPA;
- Flamborough and Filey Coast pSPA;
- Flamborough Head and Bempton Cliffs SPA; and
- Greater Wash SPA.

5.1.1. Outer Thames Estuary SPA

39. During consultation with Natural England, the Outer Thames Estuary SPA was identified for consideration due to the potential for disturbance to red-throated divers resulting from movements of construction vessels through part of that SPA to and from Great Yarmouth (which may be used as a construction port for Norfolk Vanguard). However, Great Yarmouth is located very near to the northern edge of the SPA and is outside the main concentrations of divers (as reported in the SPA evidence, e.g. Webb *et al.* 2009). In addition, given the extent of existing vessel movements in the region, the additional movements resulting from the construction of Norfolk Vanguard will represent a very small change from the baseline. Therefore, the potential for an LSE is considered to be negligible; no further consideration is required and this SPA has been scoped out.





Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Special Protection Area[1]

[1] Natural England, 2018

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title: SPAs screened in to HRA

Figure: 5.1 Drawing No: PB4476-006-001-017

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
03	30/05/18	BH	GK	A3	1:1,000,000
02	21/02/18	NJ	GK	A3	1:1,000,000

Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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5.1.2. Alde-Ore Estuary SPA

40. Lesser black-backed gulls (a breeding feature) and herring gulls (a component of the breeding seabird assemblage) are unlikely to show displacement or barrier effects as a result of Norfolk Vanguard as they have not been found to be displaced by existing offshore wind farms where responses of seabirds have been monitored (Dierschke *et al.* 2016). Furthermore, breeding birds are unlikely to regularly travel past the Norfolk Vanguard site to forage at sea further from this colony as the site is beyond the mean foraging ranges of these species (Thaxter *et al.* 2012a). Consequently, the risk of an LSE on the Alde-Ore Estuary SPA populations of lesser black-backed gull and herring gull due to displacement or barrier effects at Norfolk Vanguard either alone or in-combination is considered to be negligible and no further assessment of these aspects is required.

41. Lesser black-backed gulls and herring gulls are thought to be at relatively high risk of collisions with offshore wind turbines on account of their flight height distributions.

42. For herring gull, the mean foraging range is 10.5km, the mean maximum foraging range is 61.1km and the greatest maximum foraging range reported by Thaxter *et al.* (2012a) is 92km. Therefore, the possibility that herring gulls breeding at Alde-Ore Estuary SPA would reach the Norfolk Vanguard site can be excluded as Norfolk Vanguard is located 92km from the Alde-Ore Estuary colony at its closest point.

43. Herring gulls migrating from the Alde-Ore Estuary colony may pass the Norfolk Vanguard site during migration, however herring gulls from UK colonies tend to remain close to their colonies, and predominantly near the coast, meaning it is unlikely that birds from the Alde-Ore Estuary colony will pass through the Norfolk Vanguard site during migration. Consequently, the risk of an LSE on the Alde-Ore Estuary SPA population of herring gull due to collisions at Norfolk Vanguard either alone or in-combination is considered to be negligible and no further assessment of this aspect is required.

44. Lesser black-backed gulls have a mean maximum foraging range of 141km, and with Norfolk Vanguard located 92km from the Alde-Ore Estuary colony at its closest point connectivity with the breeding colony cannot be ruled out. Therefore, there is potential for an LSE on lesser black-backed gull due to collisions at Norfolk Vanguard and further consideration is provided in the following sections.

5.1.3. Flamborough and Filey Coast pSPA

45. The Norfolk Vanguard site is located c.200km from Flamborough and Filey Coast pSPA and is therefore well beyond the typical foraging ranges for breeding common

guillemots, razorbills and puffins, and at or beyond even the maximum recorded ranges reported (Thaxter *et al.* (2012a; Table 5.1).

Table 5.1 Foraging ranges of breeding auks reported by Thaxter *et al.* (2012a) in relation to the distance between the Flamborough and Filey Coast pSPA colony and the site (200km)

Species	Foraging range (km)		
	Mean	Mean maximum	Maximum
Common guillemot	37.8	84.2	135
Razorbill	23.7	48.5	95
Atlantic puffin	4	105.4	200

46. It can be concluded that auks breeding at the Flamborough and Filey Coast pSPA are very unlikely to reach Norfolk Vanguard while on foraging trips from the colony. Therefore, breeding seasons connectivity can be excluded for these species. When birds disperse from the colony in late summer, they may pass Norfolk Vanguard, and there is therefore potential for connectivity during the nonbreeding season. Because auks fly low over the sea, collision risk is very low. Consequently, potential impacts from Norfolk Vanguard on auks breeding at the Flamborough and Filey Coast pSPA are in relation to displacement or barrier effects.

47. In the context of the large scale of movements of auks post-breeding (many puffins migrate into the mid-Atlantic, razorbills may move as far as north Africa and guillemots to Norway or France), barrier effects or displacement are more appropriately considered in relation to the regional population of a species rather than individual colonies. Given the estimated size of the relevant nonbreeding populations of these species in the southern North Sea (guillemot 1.6 million, razorbill up to 600,000 and puffin up to 230,000; Furness 2015), the contributions to the regional populations from the Flamborough and Filey coast pSPA populations are small (FFC populations are, guillemot: 40,000 pairs, razorbill: 10,000 pairs, puffin: 1,000 pairs, which equate to 5%, 3.3% and 0.9% of the relevant BDMPS respectively). No significant cumulative displacement impacts were identified for these species, even with the application of highly precautionary assumptions about displacement effects. The same conclusion about the risk of displacement effects applies to the pSPA population, therefore the potential for an LSE on the pSPA populations of these species due to nonbreeding season displacement or barrier effects from the project alone or in-combination is considered to be negligible and no further assessment is required.

48. Gannet and kittiwake spend a proportion of their time flying at rotor swept heights therefore putting them at risk of collisions with turbines. Given the distance between Norfolk Vanguard and the Flamborough and Filey pSPA colony (200km), this risk relates primarily to the migration and nonbreeding seasons, however there is also potential for a low level of connectivity during the breeding season. Consequently,

impacts on the Flamborough and Filey pSPA gannet and kittiwake populations due to collision risk are considered in greater detail in the following sections.

49. Kittiwakes have been found to exhibit either very low rates of displacement from offshore wind farms, or none at all (Kriiggsveld *et al.* 2011, Leopold *et al.* 2011, Walls *et al.* 2013). Hence there is no potential for an LSE for kittiwakes from Flamborough and Filey coast pSPA due to displacement and the same conclusion applies to the potential for an LSE due to barrier effects.

50. Gannets have been found to have a high macro avoidance rate of offshore wind farms (Dierschke *et al.* 2016). The assessment of displacement effects on gannet concluded no significant impacts due to either displacement or barrier effects (Norfolk Vanguard ES Chapter 13 Offshore Ornithology), alone or cumulatively during any period of the year, including with reference to the Flamborough and Filey Coast pSPA population in the breeding season. Therefore, no potential for an LSE is concluded in relation to displacement effects for gannets from Flamborough and Filey Coast pSPA.

51. For species which undertake seasonal migrations of several thousand kilometres (such as gannet), the impact of diversions around offshore wind farms (i.e. barrier effects) has been demonstrated to be very small (Masden *et al.* 2010). Therefore, the potential for an LSE for gannet from Flamborough and Filey Coast pSPA due to barrier effects is considered to be negligible, and no further assessment is required.

5.1.4. Flamborough Head and Bempton Cliffs SPA

52. Flamborough Head and Bempton Cliffs SPA is entirely within the Flamborough and Filey Coast pSPA and relevant features of the former are features of the larger, latter pSPA. Therefore, these are considered under Flamborough and Filey Coast pSPA and not unnecessarily repeated.

5.1.5. Greater Wash SPA

53. The Greater Wash SPA has been designated for nonbreeding red-throated diver, common scoter and little gull and breeding populations of Sandwich tern, little tern and common tern. The closest point in Norfolk Vanguard is c. 35km from the closest point in the Greater Wash SPA (N.B. this figure is taken as the edge of the marine extent of the SPA, not the coast).

54. The foraging ranges of breeding terns tend to be short, and tend to be restricted to coastal waters (Wilson *et al.* 2014). The mean maximum foraging range of breeding terns was reported by Thaxter *et al.* (2012a) to be 6.3km for little tern, 15.2km for common tern and 49km for Sandwich tern. Although this suggests that Sandwich

tern could reach Norfolk Vanguard, the nearest colony (located at Blakeney Point on the north Norfolk coast) is a minimum of 90km from Norfolk Vanguard. Furthermore, Sandwich terns are more likely to forage along the coast rather than directly out into the open sea (Wilson *et al.* 2014, Natural England 2015b), with modelling of Sandwich tern foraging distributions from colonies in the Greater Wash SPA demonstrating that higher tern numbers are found closer to shore as well as closer to the colonies (Wilson *et al.* 2014). It can therefore be concluded that Sandwich terns from Greater Wash SPA colonies are very unlikely to reach the Norfolk Vanguard wind farm while breeding. During migration, terns tend to move along coasts, but will cross open sea when necessary. Terns over winter along the western coast of Africa and thus terns which pass Norfolk Vanguard are likely to come from many different populations, with minimal representation from North Norfolk colonies.

55. The cable route will pass through the Greater Wash SPA, making landfall to the south of Happisburgh. The extent of the corridor within which the cable will be laid has been compared with the individual species boundaries provided in the Greater Wash SPA departmental brief (Natural England and JNCC 2016). The corridor does not overlap with the foraging distributions for any of the designated tern species (little tern, common tern and Sandwich tern) and therefore, although these species are considered to be sensitive to disturbance by cable installation activities, the absence of spatial overlap means there is no potential for an LSE for these species in relation to this effect.

56. Aerial surveys of common scoters in the Greater Wash SPA (Wilson *et al.* 2009, DECC 2009) revealed that most common scoters were within 3km of the coast and that this species was concentrated in areas immediately adjacent to the Inner Wash, with a small population to the north of Great Yarmouth. No common scoters were recorded during the aerial surveys of Norfolk Vanguard (between March 2012 and August 2017). This corresponds to findings from previous studies (e.g. Wilson *et al.* 2009, Natural England 2015b) which have demonstrated that these ducks tend to remain on shallow areas closer to the coast, so are unlikely to visit the Norfolk Vanguard site. Consequently, there is no risk of an LSE on the common scoter population of the Greater Wash SPA as a result of displacement from the wind farm.

57. While construction activity along the cable route could have the potential to cause disturbance to common scoter, the cable corridor does not overlap with the species boundary identified for the SPA (Natural England and JNCC 2016). Therefore, there is no risk of an LSE on the common scoter population from the Greater Wash SPA as a result of disturbance and displacement during cable installation.

58. Little gulls are mainly seen in the Greater Wash SPA during autumn migration from east European breeding grounds to wintering grounds that are not yet well described (Wilson *et al.* 2009, Natural England 2015b). Small numbers of little gulls may overwinter in the Greater Wash SPA, however most of the birds present in autumn move on to other areas (Wilson *et al.* 2009). Aerial surveys suggest that little gulls are primarily concentrated in the area adjacent to the seaward edge of the Inner Wash (Wilson *et al.* 2009, Natural England 2015b). During the nonbreeding season little gull are characterised by unpredictable and sporadic movements and distributions. Therefore, it is possible that individuals from the Greater Wash SPA population will have connectivity to Norfolk Vanguard. Little gull has a low sensitivity to disturbance and displacement, therefore no potential for an LSE for displacement is predicted. This low sensitivity also excludes the potential for an LSE in relation to barrier effects. However, as this species spends a proportion of their time in flight at potential collision height there is potential for an LSE in relation to collision risk and further consideration of this potential impact on the SPA population has been undertaken.

59. Red-throated diver has been identified as being particularly sensitive to human activities in marine areas (Dierschke *et al.,* 2016), including through the disturbance effects of vessel traffic (Garthe and Hüppop, 2004; Schwemmer *et al.,* 2011; Furness *et al.,* 2013; Bradbury *et al.,* 2014; Diershcke *et al.,* 2017). The area of the Greater Wash SPA through which the cable route will be installed is included in this species' boundary (Natural England and JNCC 2016). Therefore, there is potential for an LSE on the Greater Wash SPA population due to disturbance and displacement resulting from the presence of a vessel installing the offshore cables for Norfolk Vanguard and further consideration of this potential impact on the red-throated diver population has been undertaken. Red-throated diver typically fly below collision height and the project collision assessment (Norfolk Vanguard ES Chapter 13 Offshore Ornithology) reported very low collision risks. Therefore, no LSE is predicted for red-throated diver from the Greater Wash SPA in relation to collision risk. Although red-throated diver could modify their migration routes to avoid entering Norfolk Vanguard, the additional distance this could add to their migration route would be very small. Consequently, there is no potential for an LSE for red-throated diver from the Greater Wash SPA in relation to barrier effects.

Table 5.2 SPAs and features identified at risk of potential LSE and for which further assessment of potential impacts from the proposed Norfolk Vanguard project alone or in-combination with other plans and projects has been undertaken (section Table 5.2).

SPA (see Figure 5.1)	Feature	Impact with potential to create an LSE	Project alone	In-combination
Alde-Ore Estuary	Lesser black-backed gull	Collision risk	Y	Y
Flamborough and Filey Coast[2]	Gannet Kittiwake	Collision risk	Y	Y
Greater Wash	Red-throated diver	Construction disturbance and displacement due to cable laying	Y	Y
	Little gull	Collision risk	Y	Y

5.2. Annex I Habitats

60. The Norfolk Vanguard HRA Offshore Screening Report (Appendix 5.1) in consultation with Natural England, as part of the Norfolk Vanguard EPP, identified the Haisborough, Hammond and Winterton SAC (Figure 5.2) as the only site where a LSE associated with the activities during construction, O&M and decommissioning of Norfolk Vanguard could not be ruled out.

61. The Haisborough, Hammond and Winterton SAC is located to the west of Norfolk Vanguard West and the offshore cable corridor passes through the site. The SAC is designated for Annex I Sandbanks which are slightly covered by seawater all the time and Reefs.

62. The sandbank ridges consist of sinusoidal banks which have evolved over the last 5,000 years and comprise of Haisborough Sand, Haisborough Tail, Hammond Knoll, Winterton Ridge and Hearty Knoll. Older sandbanks, Hewett Ridge and Smiths Knoll, are present along the outer site boundary and have formed over the last 7,000 years. The more geologically recent sandbanks of Newarp Banks and North and Middle Cross Sands lie on the south west corner of the SAC (JNCC, 2018).

63. The reef-forming tube worm *Sabellaria spinulosa* (*S. spinulosa*) is distributed across the site and is prevalent in the troughs between closely-spaced sandbanks, with *S. spinulosa* reefs located at Haisborough Tail, Haisborough Gat and between Winterton Ridge and Hewett Ridge. *S. spinulosa* reefs within the Haisborough,

[2] Flamborough Head and Bempton Cliffs SPA is considered together with Flamborough and Filey Coast pSPA as it is not completely contained within that pSPA. it is clear from statements in the HRA for the East Anglia ONE project that the SoS (Secretary of State) was satisfied there was no requirement to assess both the original SPA (Flamborough Head and Bempton Cliffs SPA) and its successor (Flamborough and Filey Coast pSPA) since the interest features of the former are included in their entirety in those of the latter.

Hammond and Winterton SAC have an elevation of 5cm to 10cm and patchiness of between 30% to 100% coverage within areas of reef (JNCC, 2018).

64. The Haisborough, Hammond and Winterton SAC overlaps with the offshore cable corridor, and therefore there is potential for its designated features, Sandbanks which are slightly covered by sea water all the time and Reefs, to be impacted during construction, O&M or decommissioning of Norfolk Vanguard.

65. The HRA Screening Report (Appendix 5.1) identified the following effects to be screened in for further consideration:

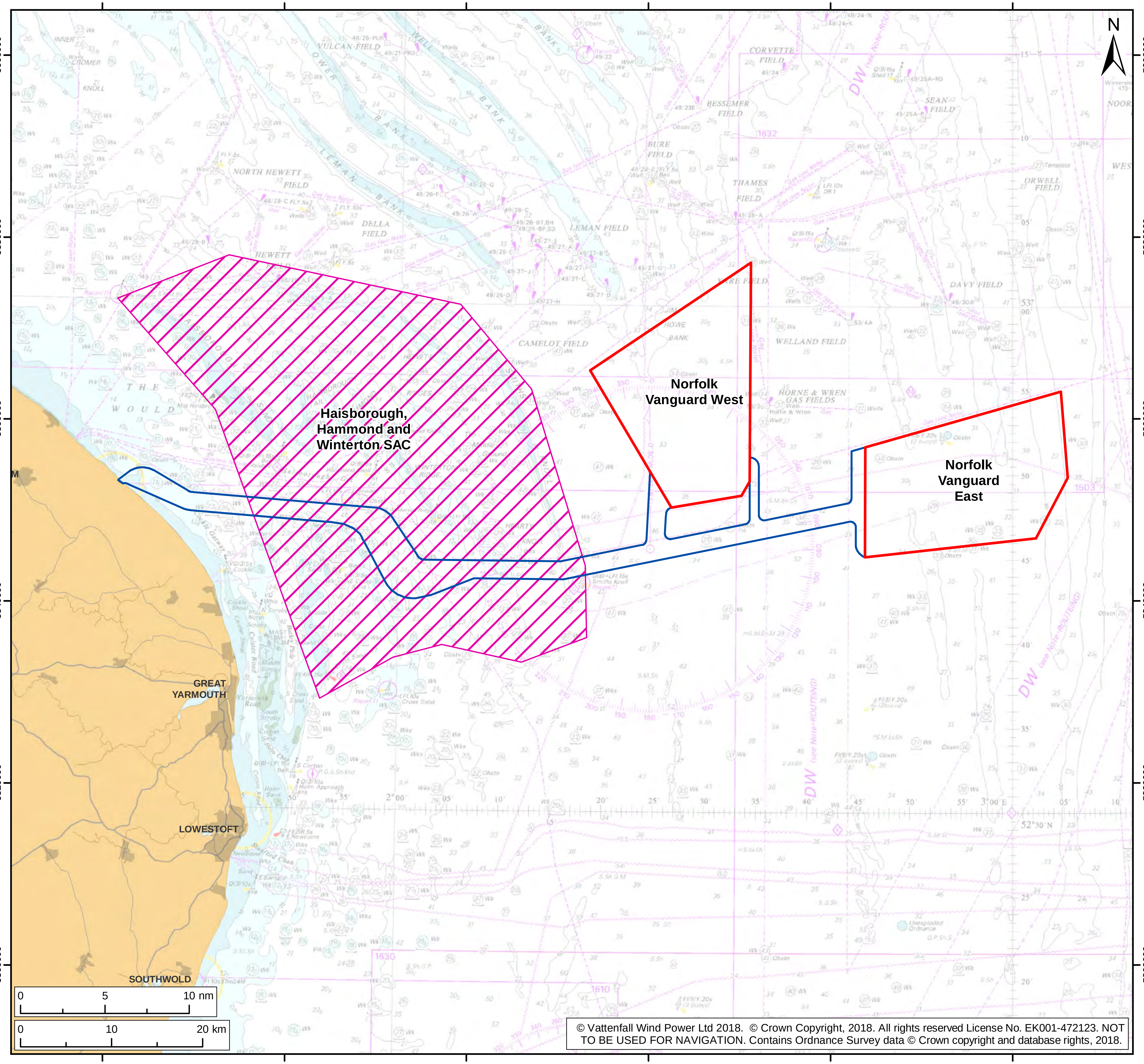
- Temporary physical disturbance;
- Increased suspended sediment and smothering;
- Permanent habitat loss; and
- Introduction of new substrate.

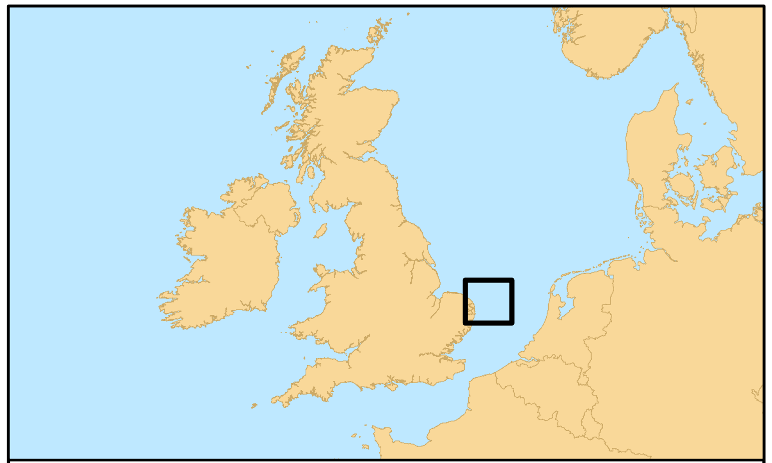
66. Through the EPP (meeting date: 31/01/18), it was agreed with Natural England that the following potential effects of Norfolk Vanguard have the potential for LSE on the Haisborough, Hammond and Winterton SAC and therefore require further assessment:

- Annex I Sandbank
  - Temporary physical disturbance during construction;
  - Temporary physical disturbance during O&M;
  - Permanent habitat loss;
  - Introduction of new substrate; and
  - Temporary physical disturbance during decommissioning;
- Annex I Reef
  - Temporary physical disturbance during construction;
  - Increased suspended sediment and smothering during construction;
  - Temporary physical disturbance during O&M;
  - Increased suspended sediment and smothering during O&M;
  - Introduction of new substrate;
  - Temporary physical disturbance during decommissioning; and
  - Increased suspended sediment and smothering during decommissioning.

67. It was agreed through the EPP that there would be no permanent loss of Annex I Reef due to the embedded mitigation to microsite where possible to avoid reef and the fact that *S. spinulosa* is ephemeral and can be expected to recover from cable installation works.

68. In addition, increased suspended sediment (i.e. turbidity) and smothering would not have a physical impact on the sandbank as the material resuspended would be the same as that currently present and the communities associated with the sandbank are habituated to this sediment type. The suspension of sediment could represent disturbance to the sandbank and this is assessed as temporary physical disturbance.





Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Special Area of Conservation (SAC)[1]

[1] JNCC, 2017

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title:

Haisborough Hammond and Winterton SAC

Figure: 5.2 Drawing No: PB4476-006-001-018

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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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5.3. Annex II Marine Mammals

69. The Norfolk Vanguard HRA Offshore Screening Report (Appendix 5.1), in consultation with Natural England, the Marine Management Organisation, Cefas, The Wildlife Trusts (TWT) and Whale and Dolphin Conservation (WDC), as part of the Norfolk Vanguard marine mammal EPP (see section 1.2) identified the following designated sites for marine mammals where no LSE associated with the activities during the construction, operation, maintenance and decommissioning of Norfolk Vanguard could be ruled out. The following Natura 2000 designated sites were therefore "screened in" for further assessment:

- The Southern North Sea cSAC for harbour porpoise *Phocoena phocoena*;
- The Humber Estuary SAC for grey seal *Halichoerus grypus*; and
- The Wash and North Norfolk Coast SAC for harbour seal *Phoca vitulina*.

70. It was also agreed as part of the EPP (see section 1.2), that, while grey seal are not currently a qualifying feature at the North Norfolk SAC (which includes Blakeney Point) or Winterton-Horsey Dunes SAC, it is recognised that these sites are important for the population, as breeding, moulting and haul-out sites. Therefore, the information for the HRA gives consideration to grey seal as part of the North Norfolk SAC or Winterton-Horsey Dunes SAC, to determine if there is the potential for any disturbance at these sites.

71. Bottlenose dolphin *Tursiops truncatus* was not identified during Norfolk Vanguard aerial surveys and no bottlenose dolphin were positively sighted during the aerial surveys of the adjacent East Anglia THREE site (EATL, 2015). During SCANS-III surveys in summer 2016, no bottlenose dolphin were recorded in or around the area of Norfolk Vanguard (Hammond *et al.,* 2016). During the SCANS-II surveys, only two bottlenose dolphin groups were sighted within the survey block which encompasses the East Anglia Zone; resulting in an estimated density of 0.0032 (CV = 0.74) individuals per km^2 (Hammond *et al.,* 2013). There are currently seven Management Units (MU) for bottlenose dolphin in UK waters; Norfolk Vanguard is located in the Greater North Sea (GNS) MU, which has an estimated population size of zero (IAMMWG, 2015). Taking into account the very low occurrence of sightings in and around Norfolk Vanguard and the assessment of the GNS MU population size by the IAMMWG, this species was screened out from further assessment for the HRA as it was determined that there would be no potential for any LSE (Appendix 5.1).

5.3.1. Southern North Sea cSAC

72. The Southern North Sea cSAC has been recognised as an area with persistent high densities of harbour porpoise (JNCC, 2017a; Heinänen and Skov, 2015). The cSAC has a surface area of 36,951km^2 and covers both winter and summer habitats of

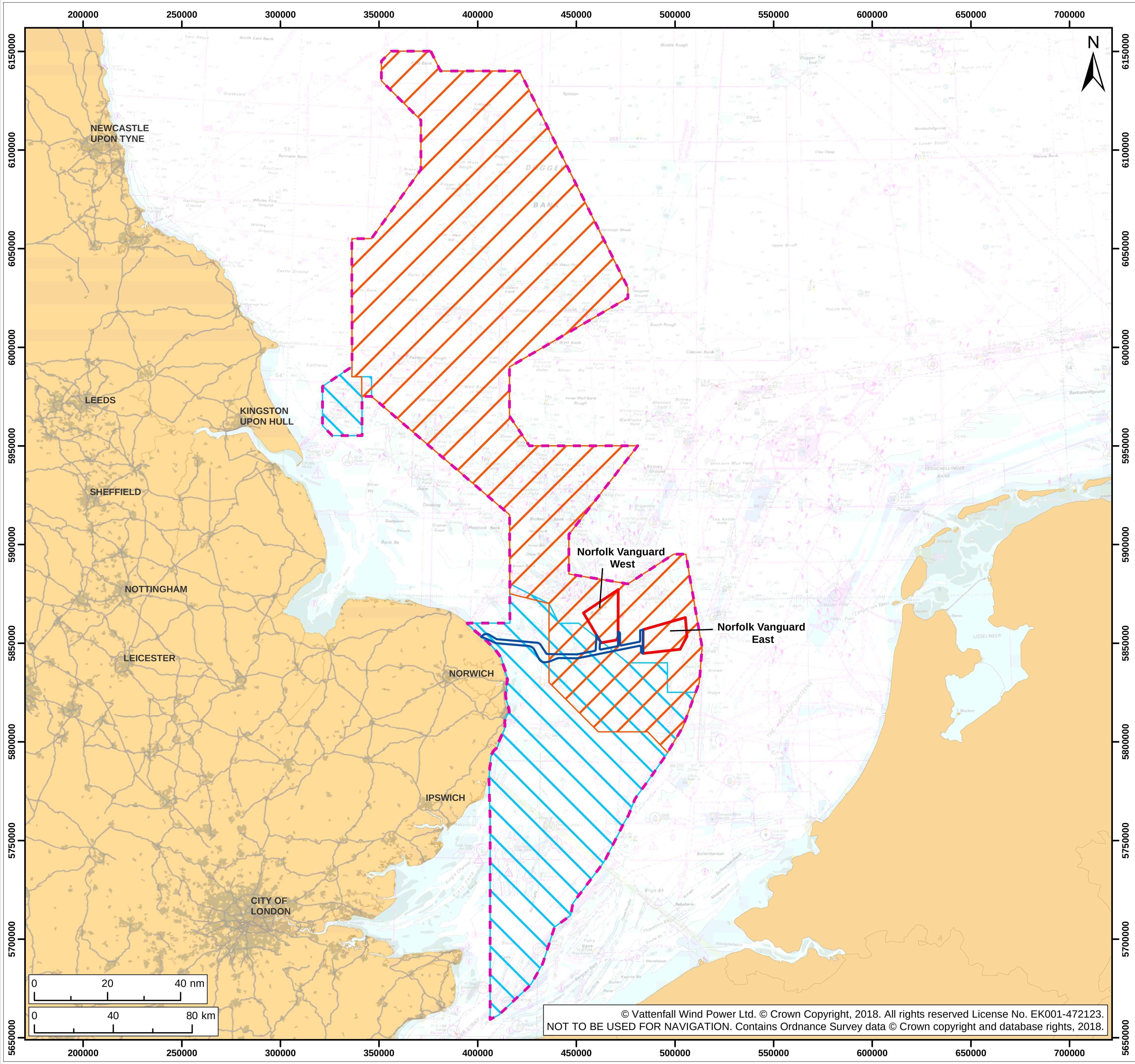
importance to harbour porpoise, with approximately 66% of the cSAC being important in the summer and the remaining 33% of the site being important in the winter period (Figure 5.3; JNCC, 2017a).

73. Norfolk Vanguard is located within the Southern North Sea cSAC (Figure 5.3).

74. Assessment of potential effects on the Southern North Sea cSAC in the Norfolk Vanguard HRA Offshore Screening Report (Appendix 5.1), identified that the following potential effects during construction, operation and maintenance and decommissioning of Norfolk Vanguard to be considered in the HRA are:

- Underwater noise;
- Vessel interactions; and
- Indirect effects through effects on prey species.

75. In addition, although initially screened out in the Norfolk Vanguard HRA Offshore Screening Report (Appendix 5.1), the potential for any effects from any changes in water quality were also assessed.



Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Southern North Sea Candidate Special Area of Conservation (cSAC)[1]
- Summer Area[1]
- Winter Area[1]

[1] JNCC (2017).

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title:

Southern North Sea cSAC for harbour porpoise

Figure: 5.3 Drawing No: PB4476-006-001-005

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5.3.2. Humber Estuary SAC

76. The Humber is the second-largest coastal plain estuary in the UK, and the largest coastal plain estuary on the east coast of Britain. Grey seal (Annex II species) are present as a qualifying feature, but not a primary reason for site selection (JNCC, 2017b).

77. The Humber Estuary SAC is located 150km from Norfolk Vanguard OWF sites and 112km from the offshore cable corridor (at closest point; Figure 5.4).

78. The HRA screening (Appendix 5.1) identified potential for vessels associated with Norfolk Vanguard to increase disturbance and/ or interact with grey seals from the Humber Estuary SAC. Whilst no decision regarding the construction or operation and maintenance port for the project has been taken, it is possible that vessels travelling between the offshore project area and the port may transit past the Humber Estuary SAC.

79. In addition, the potential disturbance of grey seal foraging at sea has also been assessed, as requested by Natural England on 23rd March 2018 in response to the draft information to support the HRA.

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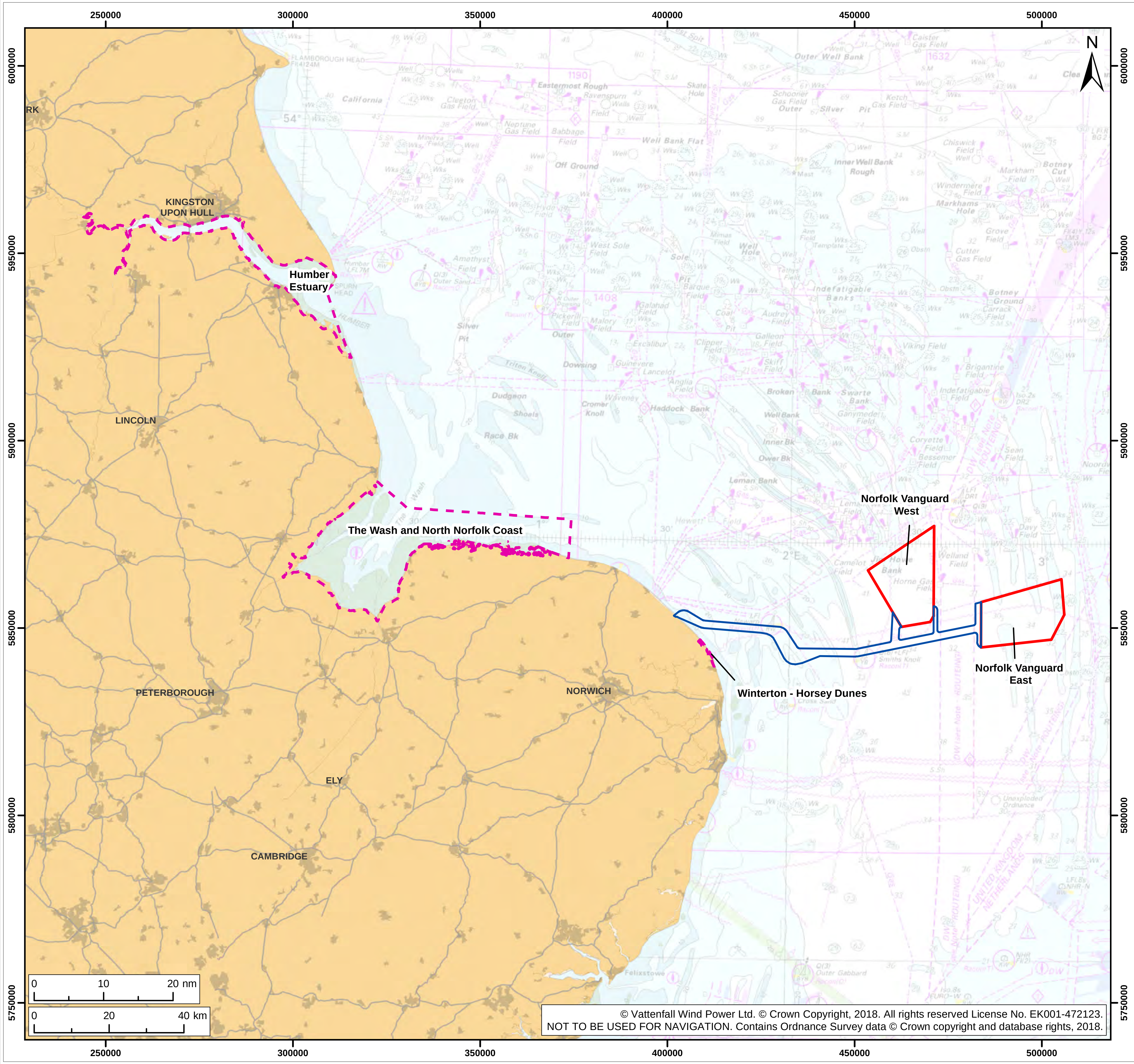

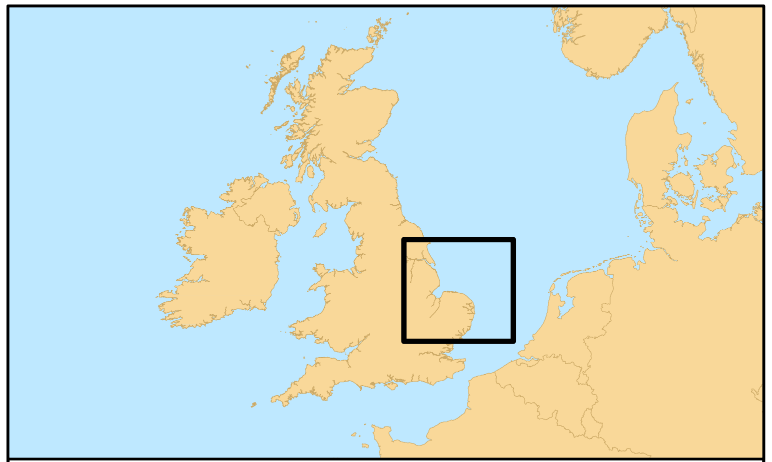

Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Seal Special Area of Conservation sites screened in[1]

[1] JNCC (2017).

Project: Norfolk Vanguard

Report: Habitats Regulation Assessment Report

Title: Special Areas of Conservation that list seal species as features of the site in proximity to Norfolk Vanguard

Figure: 5.4 Drawing No: PB4476-006-001-001

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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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5.3.3. The Wash and North Norfolk SAC

80. The Wash, on the east coast of England, is the largest embayment in the UK. The extensive intertidal flats here and on the North Norfolk Coast provide ideal conditions for harbour seal breeding and hauling-out. Harbour seal (Annex II species) are a primary reason for selection of the Wash and North Norfolk Coast SAC site (JNCC, 2017c). As outlined above, it is recognised that, while grey seal are not currently a qualifying feature of the Wash and North Norfolk SAC (which includes Blakeney Point) the site is important for grey seal and therefore this will be taken into account in the HRA.

81. The Wash and North Norfolk Coast SAC is located approximately 82km from NV West and 33km from the offshore cable corridor. The distance to Blakeney Point National Nature Reserve (NNR) is approximately 88km (Figure 5.4).

82. The HRA screening Appendix 5.1) identified potential for vessels associated with Norfolk Vanguard to increase disturbance and/ or interact with harbour seal and grey seal from the Wash and North Norfolk Coast SAC depending on the location of the port. Whilst no decision regarding the construction or operation and maintenance port for the project has been taken, it is possible that vessels travelling between the offshore project area and the port may transit past the Wash and North Norfolk Coast SAC.

83. In addition, the potential disturbance of harbour and grey seal foraging at sea has also been assessed, as requested by Natural England on 23rd March 2018 in response to the draft information to support the HRA.

5.3.4. Winterton-Horsey Dunes SAC

84. The Winterton–Horsey Dunes is the only significant area of dune heath on the east coast of England and the SAC has been designated to protect the dunes. As outlined above, it is recognised that, while grey seal are not currently a qualifying feature of the Winterton-Horsey Dunes SAC, the site is important for grey seal and therefore this will be taken into account in the HRA, including the potential for any disturbance and / or interaction with vessels and cable installation activities.

85. Norfolk Vanguard is located approximately 47km offshore (at the closest point to shore). The landfall for the Norfolk Vanguard offshore export cables will be at Happisburgh South, approximately 11km from the Horsey seal haul-out site to the south (Figure 5.4).

86. In addition, the potential disturbance of grey seal in the offshore cable corridor has also been assessed, as requested by Natural England on 23rd March 2018 in response to the draft information to support the HRA.

5.3.5. Screening summary

87. Table 5.3 provides a summary of the sites screened into the HRA process and potential effects for further consideration in the HRA.

Table 5.3 Designated sites where marine mammals are a qualifying (or important) feature and potential effects assessed for the HRA

Site	Species	Reason for screening decision
Southern North Sea cSAC	Harbour porpoise	The potential effects from underwater noise; vessel interactions; indirect effects through effects on prey species and any changes in water quality. Norfolk Vanguard is within the cSAC. It is assumed that all harbour porpoise in this area are associated with this cSAC.
Humber Estuary SAC [UK0030170]	Grey seal	Potential for vessel disturbance / interaction, if a port to the north of Norfolk Vanguard is selected. The potential for disturbance of grey seal foraging at sea.
The Wash and North Norfolk Coast SAC [UK0017075]	Harbour seal (and grey seal)	Potential for vessel disturbance / interaction, if a port to the north of Norfolk Vanguard is selected. The potential for disturbance of harbour and grey seal foraging at sea.
Winterton-Horsey Dunes SAC [UK0013043]	(Grey seal)	Potential for cable laying and vessel disturbance / interaction, depending on distance from landfall and vessel routes. The potential for disturbance of grey seal in the offshore cable corridor area.

5.4. Onshore Natura 2000 sites

88. The Norfolk Vanguard HRA Onshore Screening Report (herein the 'Onshore Screening Report') (Appendix 5.2), in consultation with Natural England (as part of the Norfolk Vanguard onshore ecology and ornithology EPP (see section 1.2)), identified the following onshore Natura 2000 designated sites where the possibility of LSE arising from the activities associated with the construction, operation, maintenance and decommissioning of the Norfolk Vanguard onshore project area could not be ruled out. These Natura 2000 designated sites were therefore "screened in" for further assessment and include:

- River Wensum SAC;
- Paston Great Barn SAC; and
- Norfolk Valley Fens SAC.

89. These sites were screened in for further consideration within the HRA process for specific potential effects only. A summary of those potential effects for which each of these sites were screened in, is provided in Table 5.5.

90. Following consultation with Natural England in March 2018, The Broads SAC has now also been screened in to the HRA process for further assessment. This site was previously excluded from the Onshore Screening Report as although this site falls within the 5km buffer zone, as a site it does not contain qualifying features which are associated with 'ex-situ' habitats outside of the site boundary (e.g. commuting and foraging barbastelle bat *Barbastella barbastellus* of the Paston Great Barn SAC or qualifying goose and swan species of Broadland SPA and Ramsar site). This reasoning was not included within the Onshore Screening Report. Therefore, and for completeness, a more detailed screening assessment has been conducted for The Broads SAC and is presented in section 5.4.5 below. The methodology used within the screening assessment is set out in the Onshore Screening Report in Appendix 5.2.

5.4.1. River Wensum SAC

91. The River Wensum is designated as a SAC and is intersected by the Norfolk Vanguard onshore cable route at Elsing, Norfolk. This SAC is afforded designation for the following qualifying features:

- Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation;
- White-clawed (or Atlantic stream) crayfish *Austropotamobius pallipes*;
- Desmoulin's whorl snail *Vertigo moulinsiana*;
- Brook lamprey *Lampetra planeri*; and
- Bullhead Cottus gobio.

92. It has been assumed that these qualifying features are present throughout the River Wensum SAC.

5.4.1.1. Potential effects

93. Only the onshore cable route element of the onshore project area is located within 5km of the River Wensum SAC, and so only potential effects arising from the onshore cable route construction, operation and maintenance and decommissioning have been screened in.

94. Direct impacts on the River Wensum SAC have been screened out following the selection of method used to cross the feature, namely the use of trenchless cable burial techniques (e.g. Horizontal Directional Drilling (HDD)). The use of this technique will ensure no direct effects upon any of the qualifying features of the SAC.

95. It is acknowledged that there may be potential effects on the following qualifying features which may be located outside of the SAC boundary but are within areas of land which is considered to be functionally connected to the River Wensum SAC, including floodplain and grazing marsh habitat:

- Ranunculion fluitantis and Callitricho-Batrachion vegetation; and
- Desmoulin’s whorl snail.

96. Trenchless crossing techniques are envisaged to be located within the coastal floodplain grazing marsh area which is adjacent to the River Wensum at Elsing. Therefore, potential direct impacts on these qualifying features may occur. Potential effects upon these qualifying features of the River Wensum SAC and the SAC boundary features have therefore been screened in for further assessment.

97. Potential indirect effects arising from land contamination and perturbations to the groundwater/hydrology regime have been screened in for further assessment whilst impacts arising from noise, air quality, light and visual disturbance have been screened out. This is primarily because the qualifying features of the River Wensum SAC are not sensitive to effects arising from these sources.

98. White-clawed crayfish was identified as absent at the trenchless crossing area at Elsing so therefore would not experience impacts associated with the construction in this area (Environment Agency, pers. comm. 24 March 2017). Furthermore, ex-situ habitats suitable for supporting brook lamprey and bullhead have not been identified within the onshore project area. As such white-clawed (or Atlantic stream) crayfish, brook lamprey and bullhead have been screened out of further assessment.

5.4.2. Paston Great Barn SAC

99. Paston Great Barn is a designated SAC as it is the only known example of a building supporting a maternity roost of barbastelle bats within the UK. This SAC is situated 2.9km from the onshore project area associated with the Norfolk Vanguard project.

5.4.2.1. Potential effects

100. Only the onshore cable route element of the onshore project area is located within 5km of the Paston Great Barn SAC, so only potential effects arising from the onshore cable route construction, operation and maintenance and decommissioning have been screened in.

101. Field surveys to record the movements of the barbastelle bats have identified that the colony uses six areas as foraging routes within the onshore project area. These areas are expected to be directly affected by the project construction and operational phases, so have been screened in for further assessment.

102. Potential effects arising from air quality and visual disturbance have been screened out of further assessment as the qualifying features of Paston Great Barn SAC are not sensitive to potential effects from these sources. Construction noise effects will be restricted to project working hours of 7am-7pm Monday-Friday[3] and therefore have also been screened out from further consideration. Likewise, the ex-situ habitats that support commuting and foraging barbastelle bats (hedgerows, open grassland, woodland, ponds and watercourses) will not be affected by alterations to the geology or land contamination regime, therefore potential effects arising from these sources have also been screened out. Potential effects arising from light and groundwater/hydrology have been screened in for further assessment as barbastelle commuting and foraging habitat is sensitive to potential effects from these sources.

103. As the boundary of the Paston Great Barn SAC is located 2.9km from the onshore project area, direct effects on the SAC have been screened out from further assessment.

5.4.3. Norfolk Valley Fens SAC

104. Norfolk Valley Fens SAC comprises 17 individual sites spread across 70km of Norfolk, which collectively support the following features:

- Alkaline fens;
- Northern Atlantic wet heaths with *Erica tetralix*;
- European dry heaths;
- Semi-natural dry grassland and scrubland facies on calcareous substrates (*Festuco-Brometalia*);
- Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*);
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*;
- Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae);
- Narrow-mouthed whorl snail *Vertigo angustior*; and
- Desmoulin’s whorl snail.

105. The qualifying features listed above are indicative of the Norfolk Valley Fens SAC and not all species have been recorded at every site. Five sites of the Norfolk Valley Fens SAC have been identified within 5km of the Norfolk Vanguard onshore project area. One of these, Booton Common (which is also a designated Site of Special Scientific Interest (SSSI)) is located within 1km of the onshore project area. The qualifying features identified at Booton Common include:

[3] 7 day working may be required during specific periods of the installation, such as following periods of poor weather, but will be reserved where programme acceleration is required.

- Alkaline fens;
- Northern Atlantic wet heaths with *Erica tetralix*; and
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*.

5.4.3.1. Potential effects

106. Only the onshore cable route element of the onshore project area is located within 5km of the Norfolk Valley Fens SAC, and so only potential effects arising from the onshore cable route construction, operation and decommissioning have been screened in.

107. Direct impacts on the boundary features of the Norfolk Valley Fens SAC have been screened out of further assessment as all sites associated with this designation are located more than 600m from the onshore project area. Similarly, effects of the project on ex-situ habitats functionally connected to the SAC have been screened out from further assessment as qualifying features of the SAC are all habitats or non-mobile species.

108. Potential indirect effects of the project are alterations to the groundwater/hydrology regime and air quality effect upon qualifying habitats of the SAC present at the Booton Common site. As such, these potential indirect impacts have been screened in for further assessment.[4]

5.4.4. Sites screened out from further assessment

109. The following sites were considered within the Onshore Screening Report (Appendix 5.2) and they are located within 5km of the onshore project area:

- Broadland SPA; and
- Broadland Ramsar site.

110. These sites are both located 3.6km from the onshore project area, and as such direct effects upon these sites were screened out from further assessment.

111. Available wintering bird survey data for land within 5km of these sites indicated that counts of all qualifying features of both sites within the onshore project area and within a precautionary 1km disturbance buffer from the onshore project area were waterbird counts, which are considered to not be of a scale of national or greater importance to be a significant feature of the Broadland SPA or Ramsar site. As such indirect potential effects upon these sites were screened out from further assessment.

[4] Following consultation undertaken on a draft version of this report, all component SSSIs of the Norfolk Valley Fens SAC located within 5km of the onshore project area (five in total), not just Booton Common, have been screened in for further assessment.

112. Full details of the screening assessment for these sites are presented in Appendix 5.2.

5.4.5. Amendment to the Onshore Screening Report – The Broads SAC

5.4.5.1. The Broads SAC qualifying features and conservation objectives

113. The Broads SAC is located 3.6km south of the onshore project area, with its boundary concurrent with that of the Broadland SPA and Ramsar site.

114. The Broads in East Anglia contain several examples of naturally nutrient-rich lakes which support relict vegetation of the original Fenland flora, and collectively this site contains one of the richest assemblages of rare and local aquatic species in the UK. The broads are the richest area for stoneworts (charophytes) in Britain, contain the largest blocks of alder *Alnus glutinosa* wood in England, and contain the largest example of calcareous fens in the UK. The qualifying features of the Broads SAC are set out in Table 5.4.

Table 5.4 The Broads SAC qualifying features

Qualifying features/reasons for notification
Annex I habitats that are a primary reason for selection of this site: • Hard oligo-mesotrophic waters with benthic vegetation of *Chara spp.* • Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation • Transition mires and quaking bogs • Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* [Priority feature] • Alkaline fens • Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) [Priority feature] Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site • *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) Annex II species that are a primary reason for selection of this site • Desmoulin's whorl snail • Fen orchid *Liparis loeselii* • Ramshorn snail *Anisus vorticulus* Annex II species present as a qualifying feature, but not a primary reason for site selection • Otter *Lutra lutra*

115. The Broads SAC's conservation objectives are as follows:

Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring:

- The extent and distribution of qualifying natural habitats and habitats of qualifying species;
- The structure and function (including typical species) of qualifying natural habitats;
- The structure and function of the habitats of qualifying species;

- The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;
- The populations of qualifying species; and
- The distribution of qualifying species within the site.

5.4.5.2. Screening assessment

5.4.5.2.1. Direct effects within SAC boundary

116. The Broads SAC is located 3.6km from the onshore project area. Therefore, direct effects upon the boundary are screened out from further assessment.

5.4.5.2.2. Direct effects upon ex-situ habitats

117. The Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a) and the Norfolk Living Map have identified the following habitats within the onshore project area and within 5km of The Broads SAC as being present:

- Arable;
- Hedgerows (species poor / rich, with / without trees, defunct and intact);
- Continuous and scattered scrub;
- Lowland mixed deciduous woodland;
- Improved, semi-improved and poor semi-improved grassland;
- Running water;
- Amenity grassland;
- Intertidal; and
- Dune grassland.

118. These habitats are not suitable for supporting Annex II qualifying features Desmoulin's whorl snail, fen orchid or ramshorn snail. Habitats suitable for supporting these species, including wetland habitats and unimproved grassland, were not recorded within the onshore project area or within 5km of The Broads SAC during the Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a) or using the Norfolk Living Map. Direct effects upon these Annex II qualifying features are therefore screened out from further assessment. Habitats suitable for supporting otter *Lutra lutra* (i.e. running water connected to the watercourses located within The Broads SAC) were recorded within the onshore project area and within 5km of The Broads SAC at two locations during the Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a) or using the Norfolk Living Map (North Walsham and Dilham Canal, and the Hundred Stream[5]). As such, direct effects upon the Annex II qualifying feature, i.e. otter, are screened in for further assessment.

[5] Also referred to as the East Rushton Stream in its lower reaches

119. This assessment considers ex-situ habitats which may support Annex II qualifying features of the SAC. The Annex I qualifying features of The Broads SAC are habitats and not mobile species, and as such are considered to be restricted primarily to the SAC boundary. These features are therefore not considered to be subject to potential effects arising from the onshore project area given the distance between the onshore project area and the SAC boundary. As such, direct effects upon these qualifying features are screened out from further assessment.

5.4.5.2.3. Indirect effects within SAC boundary

120. The Broads SAC is located 3.6km from the onshore project area. Although this is outside of the Zone of Influence[6] (ZOI) of any of the environmental parameters associated with the construction and operation of the project, following a request from Natural England raised during consultation on a draft version of this report (23rd March 2018), the potential ZOI for effects arising from local changes in surface and groundwater hydrology has been extended to encompass those watercourses located within 5km of the Broads SAC. Therefore, indirect effects upon qualifying features of The Broads SAC within the site boundary arising from local changes in surface and groundwater hydrology are screened in for further assessment.

5.4.5.2.4. Indirect effects upon ex-situ habitats

121. The Norfolk Living Map has identified the following habitats within 1km (the maximum ZOI of indirect effects arising from the Norfolk Vanguard onshore project area) of the onshore project area and within 5km of The Broads SAC:

- Arable;
- Hedgerows;
- Scrub;
- Lowland mixed deciduous woodland;
- Improved, semi-improved and poor semi-improved grassland;
- Running water
- Amenity grassland;
- Intertidal; and
- Dune grassland.

122. These habitats are considered unsuitable to support Annex II qualifying features, i.e. Desmoulin's whorl snail, fen orchid or ramshorn snail. Habitats suitable for supporting these species typically include wetland habitats and unimproved grassland. These habitats were not recorded within the onshore project area or within 5km of The Broads SAC during the Extended Phase 1 Habitat Survey (Royal

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[6] The maximum ZOI for indirect effects was identified as 1km within the Onshore Screening Report. Please see Section 1.6 of the Onshore Screening Report (**Appendix 5.2**) for full details on the ZOIs used.

HaskoningDHV, 2017a) or using the Norfolk Living Map. Indirect effects upon these Annex II qualifying features are therefore screened out from further assessment. Habitats suitable for supporting otter, i.e. running water connected to the watercourses located within The Broads SAC, were recorded within the onshore project area and within 5km of The Broads SAC at two locations during the Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a) or using the Norfolk Living Map (North Walsham and Dilham Canal, and the Hundred Stream). As such, indirect effects upon the Annex II qualifying feature otter are screened in for further assessment.

123. This assessment considers ex-situ habitats which may support Annex II qualifying features of the SAC. The Annex I qualifying features of The Broads SAC are habitats and not mobile species, and as such are considered to be restricted primarily to the SAC boundary. These features are therefore not considered to be subject to potential effects arising from the onshore project area given the distance between the onshore project area and the SAC boundary. As such, indirect effects upon these qualifying features are screened out from further assessment.

5.4.5.2.5. Summary of Screening Assessment

124. In summary, although The Broads SAC is located 3.6km from the onshore project area, the following potential effects have been screened in for further consideration:

- Direct effects upon ex-situ habitats which may support the qualifying feature, i.e. otter, due to suitable ex-situ habitats for this feature being present;
- Indirect effects within the SAC boundary arising from groundwater / hydrology effects due to lying within an extended the ZOI for this parameter; and
- Indirect effects upon ex-situ habitats which may support the qualifying feature, i.e. otter, arising from groundwater / hydrology effects due to lying within the ZOI for this parameter.

125. Due to the distance of The Broads SAC from the onshore project area (i.e. 3.6km) and the absence of suitable ex-situ habitats within the vicinity of the onshore project area for supporting other qualifying features of the SAC, the screening assessment has not identified any potential LSE upon other qualifying features of The Broads SAC and therefore this site has been screened out from further assessment.

5.4.6. Summary of Onshore Screening for LSE

126. The onshore Natura 2000 sites (shown in Figure 5.5) screened in to the appropriate assessment stage of the HRA are summarised in Table 5.5.

Table 5.5 Potential effects upon onshore Natura 2000 sites screened in to the next stage of assessment

Designated site	Distance to onshore project area	Potential effects screened in
River Wensum SAC	0km	• Direct effects on ex-situ habitats for *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation and Desmoulin's whorl snail qualifying features due to suitable ex-situ habitats for these features being present. • Indirect effects within SAC boundary arising from geology / contamination and groundwater / hydrology effects due to lying within the ZOI for these parameters. • Indirect effects upon ex-situ habitats arising from geology / contamination and groundwater / hydrology effects due to lying within the ZOI for these parameters.
Norfolk Valley Fens SAC	0.6km	• Indirect effects within SAC boundary arising from air quality and groundwater/hydrology due to lying within the ZOI for these parameters. [Effects on Alkaline fens, Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*, Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*, European dry heaths, Molinia meadows on calcareous, peaty or clayey-silt-laden soils, Northern Atlantic wet heaths with Erica tetralix only screened in]
Paston Great Barn SAC	2.9km	• Direct effects upon ex-situ habitats due to known ex-situ habitats of barbastelle (hedgerows / watercourses) being present within the onshore project area. • Indirect effects upon ex-situ habitats arising from light and groundwater/hydrology effects due to lying within the ZOI for these parameters.
The Broads SAC	3.6km	• Direct effects upon ex-situ habitats which may support the qualifying feature otter, due to suitable ex-situ habitats for this feature being present. • Indirect effects upon habitats and species within the SAC boundary arising from changes in local groundwater / hydrology conditions. • Indirect effects upon ex-situ habitats which may support the qualifying feature otter, arising from changes in groundwater / hydrology conditions.

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Legend:

- Norfolk Vanguard onshore red line boundary
- 5km buffer zone

Landfall

- Landfall zone
- Landfall compound zone
- Indicative landfall compound

Onshore cable route

- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound
- Mobilisation zone
- Indicative mobilisation area compound

Access

- Construction access
- Operation access

Environmental Designation

- Special Protection Area (SPA)[1]
- Ramsar[1]
- Special Area of Conservation (SAC)[1]

[1] Natural England, 2018.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

European and Ramsar sites potentially affected by the project (map 1 of 5)

Figure: 5.5 Drawing No: PB4476-006-001-010

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	16/05/2018	PS	GC	A3	1:60,000
01	22/02/2018	LB	GC	A3	1:60,000

Co-ordinate system: British National Grid **EPSG:** 27700

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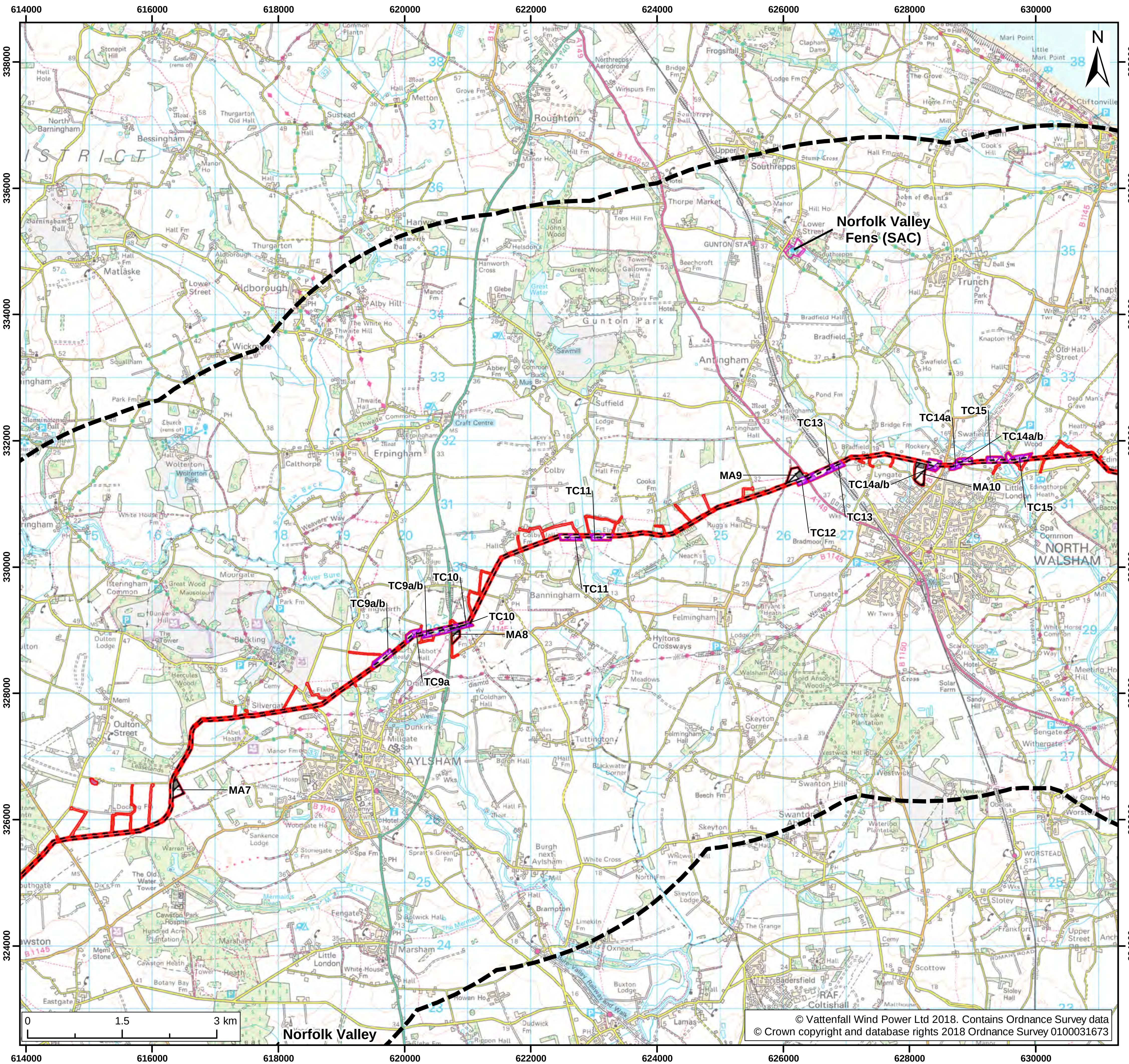

Legend:
- Norfolk Vanguard onshore red line boundary
- 5km buffer zone

Onshore cable route
- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound
- Mobilisation zone
- Indicative mobilisation area compound
- Cable logistics area

Access
- Construction access
- Operation access

Environmental Designation
- Special Area of Conservation (SAC)[1]

[1] Natural England, 2018.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

European and Ramsar sites potentially affected by the project (map 2 of 5)

Figure: 5.5 Drawing No: PB4476-006-001-010

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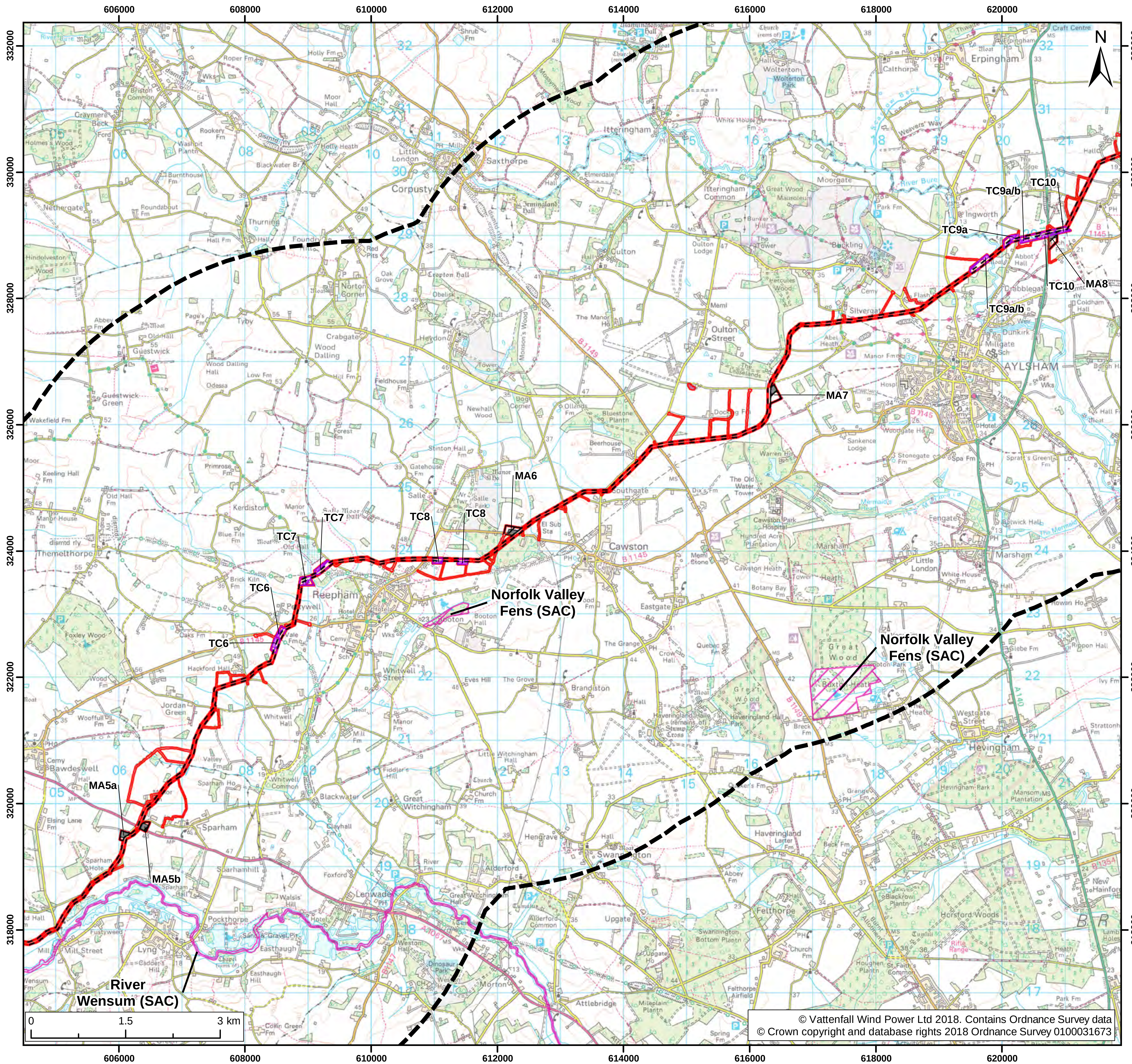

Legend:

- Norfolk Vanguard onshore red line boundary
- 5km buffer zone

Onshore cable route

- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound
- Mobilisation zone
- Indicative mobilisation area compound
- Cable logistics area

Access

- Construction access
- Operation access

Environmental Designation

- Special Area of Conservation (SAC)¹

¹ Natural England, 2018.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

European and Ramsar sites potentially affected by the project (map 3 of 5)

Figure: 5.5 | Drawing No: PB4476-006-001-010

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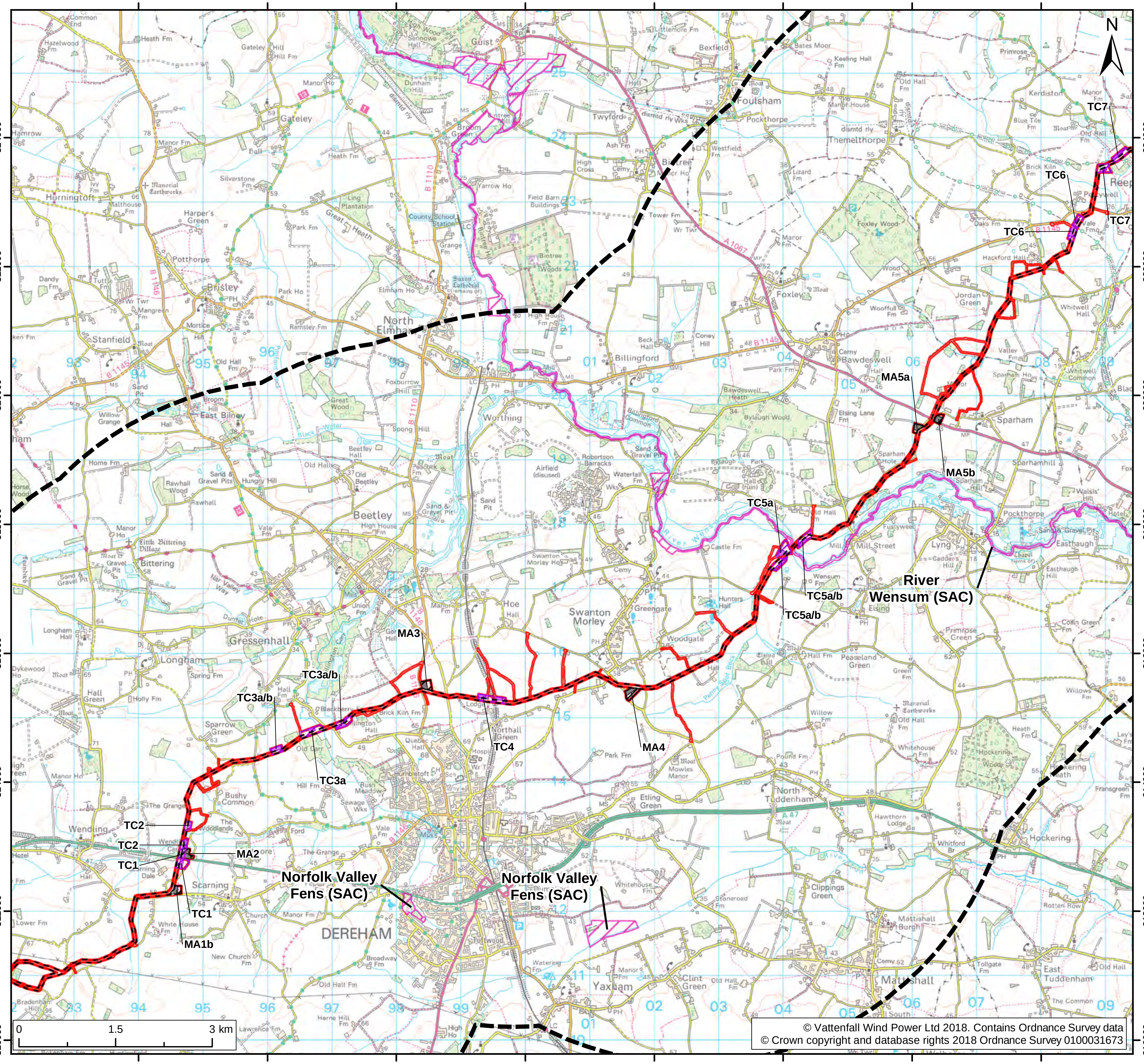

Legend:

- Norfolk Vanguard onshore red line boundary
- 5km buffer zone

Onshore cable route

- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound
- Mobilisation zone
- Indicative mobilisation area compound

Access

- Construction access
- Operation access

Environmental Designation

- Special Area of Conservation (SAC)[1]

[1] Natural England, 2018.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

European and Ramsar sites potentially affected by the project (map 4 of 5)

Figure: 5.5 | Drawing No: PB4476-006-001-010

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01	22/02/2018	LB	GC	A3	1:60,000

Co-ordinate system: British National Grid **EPSG:** 27700

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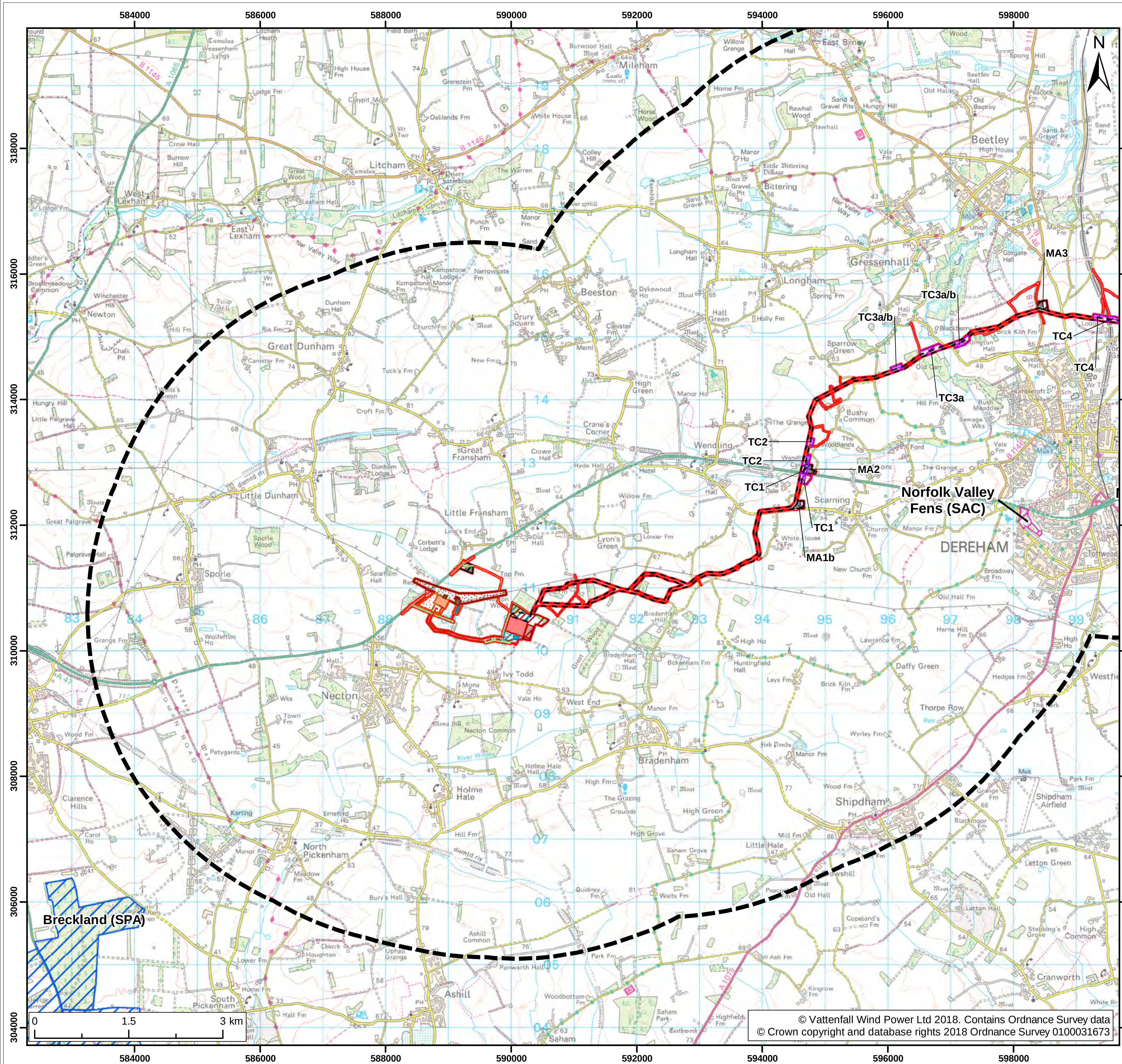

Legend:

- Norfolk Vanguard onshore red line boundary
- 5km buffer zone

Onshore cable route

- Onshore cable route
- Onshore 400kv cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound
- Mobilisation zone
- Indicative mobilisation area compound

Access

- Permanent access
- Construction access
- Operation access

Onshore project substation

- Onshore project substation
- Onshore project substation temporary construction compound zone
- Indicative onshore project substation temporary construction compound

National Grid

- National Grid substation extension
- National Grid new / replacement overhead line tower
- National Grid temporary works
- Overhead line temporary works

Mitigation areas

- Attenuation pond zone
- Indicative attenuation pond
- Indicative mitigation planting

Environmental Designation

- Special Protection Area (SPA)[1]
- Special Area of Conservation (SAC)[1]

[1] Natural England, 2018.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

European and Ramsar sites potentially affected by the project (map 5 of 5)

Figure: 5.5 Drawing No: PB4476-006-001-010

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6. SPECIAL PROTECTION AREAS

6.1. Baseline/Current Conservation Status

127. The following sections provide an overview of the relevant baseline information and current conservation status for the designated sites screened into the HRA.

6.1.1. Alde-Ore Estuary SPA

128. The Alde-Ore Estuary SPA covers 2,417ha and is located on and around the Suffolk coast, 92km from the proposed Norfolk Vanguard offshore wind farm at its closest point. The SPA comprises an estuarine complex of the rivers Alde, Butley and Ore. The Alde-Ore Estuary was also listed as a Ramsar site in October 1996 for its internationally important wetland assemblage. The SPA citation was published in January 1996 and the site was classified by the UK Government as an SPA under the provisions of the Birds Directive in August 1998. The site is coincident with the Alde-Ore Estuary SSSI, which was notified in 1952, with the SSSI boundary being identical to that of the SPA and Ramsar sites. The SPA/Ramsar site also forms part of the Alde-Ore and Butley European Marine Site.

129. There are several important habitats within the Alde-Ore Estuary site, including intertidal mud-flats, saltmarsh, vegetated shingle (including the second-largest and best-preserved area in Britain at Orfordness), saline lagoons and semi-intensified grazing marsh. The diversity of wetland habitat types present is of particular significance to the birds occurring on the site, as these provide a range of opportunities for feeding, roosting and nesting within the site complex. At different times of the year, the site supports notable assemblages of wetland birds including seabirds, wildfowl and waders. As well as being an important wintering area for waterbirds, the Alde-Ore Estuary provides important breeding habitat for several species of seabird, wader and birds of prey. During the breeding season, gulls and terns feed substantially outside the SPA (JNCC 2011a). The Suffolk Wildlife Trust, the National Trust and the RSPB have nature reserves within the SPA.

130. JNCC's SPA site description (as published in 2001) indicates that the Alde-Ore Estuary qualifies as an SPA under Article 4.1 of the Birds Directive (79/409/EEC) by regularly supporting populations of Annex I species of European importance: breeding populations of little tern, marsh harrier and Sandwich tern, and avocet (both breeding and wintering). The site also qualifies under Article 4.2 of the Birds Directive by supporting two Annex II species - a wintering population of redshanks, and a breeding population of lesser black-backed gulls, the designation of the lesser black-backed gulls being based on 14,074 breeding pairs (4 year mean peak, 1994-1997). At designation, the site regularly supported 59,118 individual seabirds during

the breeding season, including: herring gull, black-headed gull, lesser black-backed gull, little tern and Sandwich tern.

131. Following the UK SPA review (Stroud *et al.* 2001) additional Article 4.2 qualifying features were identified as needing protection: a breeding seabird assemblage of international importance (at least 20,000 seabirds) and a wintering waterbird assemblage of international importance (at least 20,000 waterbirds).

132. The conservation objectives of the site include:

- Avoid the deterioration of the habitats of the qualifying features,
- Avoid significant disturbance of the qualifying features,
- Ensuring the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds Directive.
- Subject to natural change, to maintain or restore [for each qualifying feature]:
  - The extent and distribution of the habitats of the qualifying features;
  - The structure and function of the habitats of the qualifying features;
  - The supporting processes on which the habitats of the qualifying features rely;
  - The populations of the qualifying features; and
  - The distribution of the qualifying features within the site.

6.1.1.1. Lesser Black-backed gull

133. The lesser black-backed gull breeds in large numbers in England, mostly in coastal areas but also in urban sites (Mitchell *et al.* 2004). It is primarily a summer visitor, with most birds migrating to southern Europe or north Africa for the winter (Wernham *et al.* 2002). However, increasing numbers have taken to overwintering in the southern North Sea in recent decades (Wernham *et al.* 2002). Breeding numbers increased considerably during the 20th century, probably in part due to provision of fishery discards (Camphuysen 2013). Male lesser black-backed gulls forage mostly at sea, whereas females forage more in terrestrial habitats (Camphuysen *et al.* 2015). Habitat use is also seasonal, with greater use of inland foraging early and late in the breeding season, and peak marine foraging activity during chick-rearing (Thaxter *et al.* 2015).

134. The changing fortunes of gulls at the Alde-Ore Estuary SPA and reasons for the current unfavourable declining status have been documented in the Appropriate Assessment for Galloper Offshore Wind Farm (Department of Energy and Climate Change 2013a) and elsewhere, for example, Mason (2010). The colony was first formed in the early 1960s, when a few pairs nested (Stroud *et al.* 2001). Numbers then increased rapidly, apparently due to immigration of birds from elsewhere

(Stroud *et al.* 2001). Although most of the colony was at Orfordness, numbers there have declined since 2000. As numbers declined at Orfordness, numbers increased at Havergate Island (RSPB reserve and also part of the Alde-Ore Estuary SPA), suggesting that colony relocation was in part related to impacts of predators or disturbance. Flooding of breeding areas has also contributed to breeding failures at Orfordness in some years, for example together with predator impacts causing total breeding failures in 2010 and 2012 (Thaxter *et al.* 2015). Counts of breeding pairs at these two sites are available from the JNCC Seabird Colony Monitoring database and are summarised in Table 6.1.

Table 6.1 Numbers of breeding pairs of lesser black-backed gulls counted at the colonies at Orfordness and at Havergate Island (data from JNCC Seabird Colony Monitoring database)

Year	Colony	
	Orfordness	Havergate
1961	No data	2
1968	140	No data
1969	150	No data
1986-93	5000-9043	0-7
1994	9981	27
1995	11221	35
1996	14814	3
1997	20216	2
1998	21700	4
1999	22500	14
2000	23000	400
2001	5500	290
2002	6500	338
2003	6000	249
2004	6000	264
2005	4500	208
2006	5000	325
2007	1678	768
2008	1584	1185
2009	900	1074
2010	550	1053
2011	550	1030
2012	640	1267
2013	No data	1747
2014	No data	2070
2015	No data	2399
2016	No data	1668

6.1.2. Flamborough and Filey Coast pSPA

135. Between 20 January 2014 and 14 April 2014, Natural England held a formal public consultation on the designation of the Flamborough and Filey Coast pSPA. This pSPA, if confirmed by the Secretary of State for the Environment, Food and Rural Affairs, would represent a geographical extension to the existing Flamborough Head and Bempton Cliffs SPA and add several species to the citation list.

136. It is Government policy to treat pSPAs as if they were a fully designated European site under the Habitats Regulations. It is therefore important to consider the impacts of the proposed project on features of Flamborough and Filey Coast pSPA, and whether or not LSEs can be ruled out. Compared to its predecessor, Flamborough Head and Bempton Cliffs SPA, the Flamborough and Filey Coast pSPA consists of a landward extension to the north west of the existing site to incorporate important breeding colonies of seabirds and marine extensions out to 2km in order to protect adjacent areas of water which are important to these species of breeding birds. There are also modifications of the landward boundary of the existing SPA such that the features of the pSPA are protected in the future, and the addition of the following migratory features to the pSPA citation; gannet, common guillemot and razorbill. The pSPA citation also incorporates an update to the published population figures for kittiwake.

137. The predecessor site, Flamborough Head and Bempton Cliffs SPA was designated in 1993 and holds what was at the time the only mainland breeding colony of gannets in the UK as well as supporting large numbers of other breeding seabirds, including kittiwake, common guillemot and razorbill. The seabirds feed and raft in the waters around the cliffs, and outside the SPA more distantly in the North Sea. The intertidal chalk platforms are also used as roosting sites, particularly at low water and notably by juvenile kittiwakes. The majority of the SPA comprises shingle and sea cliff habitat, with dry grassland and deciduous woodland (JNCC 2011b).

138. The Flamborough Head and Bempton Cliffs site qualifies as an SPA under Article 4.2 of the Birds Directive (79/409/EEC) by supporting populations of European importance of breeding kittiwakes, and a seabird assemblage of international importance (at least 20,000 seabirds) including breeding gannet, kittiwake, herring gull, common guillemot and razorbill. At the time of citation, the site was thought to support 83,370 breeding pairs of kittiwakes (2.6% of the breeding Eastern Atlantic population) (count as of 1987) and 305,784 individual seabirds. However, there were 37,617 pairs or 75,234 breeding adults recorded in 2008 (JNCC Seabird Colony Register). The citation (JNCC 2011b) notes that the SPA designations were reviewed in 2000, at which point kittiwakes were the only notified feature of the site. The seabird assemblage of international importance was added in 2001 as part of the UK

SPA Review (Stroud *et al.* 2001). There is some uncertainty as to whether there were ever as many as 83,370 pairs of kittiwakes at this site; this number has been challenged repeatedly by the world's leading expert on kittiwake biology (Coulson, 2011), most recently by noting that this colony should have been increasing in numbers based on monitoring data on its productivity. The apparent decline from 83,370 pairs in 1987 to 37,617 pairs in 2008 is out of line with population trajectories elsewhere based on the influence of productivity on population change (Coulson 2017). Recent counts by RSPB indeed show a small increase in kittiwake breeding numbers in the years since 2008 (RSPB data), as predicted by Coulson (2017).

139. The conservation objectives of the site include:

- Avoid the deterioration of the habitats of the qualifying features,
- Avoid significant disturbance of the qualifying features,
- Ensuring the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds Directive.
- Subject to natural change, to maintain or restore [for each qualifying feature]:
    - The extent and distribution of the habitats of the qualifying features;
    - The structure and function of the habitats of the qualifying features;
    - The supporting processes on which the habitats of the qualifying features rely;
    - The populations of the qualifying features; and
    - The distribution of the qualifying features within the site.

6.1.2.1. Gannet

140. Gannets are the largest breeding seabird in the British Isles and are able to swallow fish up to at least the size of adult herring and mackerel (Nelson 1978). As a result, they can feed on a wide range of fish, from sandeels to mackerel and discards from fishing vessels (Nelson 1978, Garthe *et al.* 1996). They are also aggressive at sea, displacing smaller seabirds from food and so can access discards from fishing vessels more efficiently than other scavenging seabirds (Garthe *et al.* 1996). Gannets dive for fish, often from considerable height, and so can be at risk of collision with wind turbine blades while foraging. Foraging activity is by sight and hence birds do not forage during the dark, but spend the night either in the colony or sitting on the sea surface (Nelson 1978, Hamer *et al.* 2000, Hamer *et al.* 2007, Garthe *et al.* 2012).

141. Gannets breed in a relatively small number of colonies, many of which are very large, and all of which are in locations relatively remote from human disturbance and from predatory mammals. Breeding gannets are easy to count, and counts have been undertaken at almost all colonies every ten years (and at many colonies more frequently). This means that the population size of this species is extremely well

documented. About 60% of the entire population of the species breeds in Great Britain, and all of the larger colonies are designated as SPAs for breeding gannets; over 90% of gannets in Great Britain therefore breed in SPAs (Furness 2015).

142. Breeding adults have efficient commuting flight and can travel long distances while searching for food. Numerous tracking studies show foraging ranges of breeding adults and overwinter migrations from many different colonies. Breeding adults tend to remain within a foraging area that is discrete to the individual colony (i.e. birds rarely overlap in foraging distribution with birds from neighbouring colonies; Wakefield *et al.* 2013). Gannet numbers have increased continuously from 1900 to the present, although the rate of population increase has been slowing in the last few years (Murray *et al.* 2015). Gannets migrate, with birds from Britain mainly wintering off west Africa and southern Europe, and many of the birds wintering in UK waters are adults from colonies in Norway or Iceland (Fort *et al.* 2012, Garthe *et al.* 2016).

6.1.2.2. Kittiwake

143. The kittiwake is a small cliff-nesting gull. It breeds in a large number of colonies around the coast of the British Isles, though there are very few colonies along the coast of south east England owing to the lack of suitable nesting habitat (Coulson 2011). Kittiwake numbers increased dramatically between 1900 and 1985, however started to decline during the 1980s in Shetland when the local sandeel stock suffered recruitment failure (Mitchell *et al.* 2004). Numbers have declined considerably since the 1980s, although this decline has been less severe in England than in Scotland, and also less in the west of Great Britain than in North Sea colonies (Mitchell *et al.* 2004). Within regions, declines have been greatest in SPA populations (of which there are many) (Furness 2015) because they are the largest colonies and furthermore, food shortage affects breeding success and recruitment at large colonies more than at small ones (Coulson 2011). In contrast to the declining trend in much of the UK, breeding numbers of kittiwakes have increased slightly at Flamborough and Filey Coast pSPA between 2008 and 2017 (RSPB data).

144. Kittiwakes feed on marine invertebrates, small fish (especially sandeels), and fishing vessel waste (mostly fragments of offal and fish as they are unable to swallow large fish). Sandeels are a key prey during the breeding season (Furness and Tasker 2000, Coulson 2011) whereas fishery waste is taken mostly during winter (Garthe *et al.* 1996).

145. Breeding success of kittiwakes at North Sea colonies is closely linked with sandeel stock abundance in the area near the colony (Frederiksen *et al.* 2004, 2005, Cook *et al.* 2014). There is evidence that breeding success of kittiwakes at Flamborough and Filey Coast pSPA has been reduced considerably in recent years as a consequence of

unsustainably high fishing effort for sandeels on Dogger Bank which has depleted the stock size of sandeels (BirdLife International 2015, Carroll *et al.* 2017). Breeding kittiwakes mostly feed close to their colony; the mean foraging range is 25km, the mean maximum foraging range is 60km, and the longest foraging range recorded up to 2011 was 120km (Thaxter *et al.* 2012a). Several tracking studies provide evidence on foraging ranges of breeding kittiwakes and winter movements from different populations. Tracking studies by RSPB show that chick-rearing kittiwakes from Flamborough and Filey Coast pSPA mainly feed within 50km of that colony, but sometimes may travel as far as the Dogger Bank to forage (Carroll *et al.* 2017).

146. Kittiwakes disperse from colonies in late summer and may migrate from British colonies as far as Canada, the central North Atlantic the Bay of Biscay and the Barents Sea. In the nonbreeding season UK waters hold a mixture of birds from many breeding areas (Frederiksen *et al.* 2012).

6.1.3. Greater Wash SPA

147. The Greater Wash SPA was designated in March 2018 following the completion of consultations in January 2017. The Greater Wash SPA is located off the coast of Eastern England, extending seaward from mean high water to a maximum of approximately 30km offshore. The SPA covers the marine environment from Bridlington Bay in the north to approximately Great Yarmouth in the south. The Greater Wash SPA has been proposed to protect areas of importance for over-wintering red-throated diver, little gull and common scoter during the winter period (October to April), and would also provide protection to important foraging areas for common, Sandwich and little tern, which breed along the adjacent coastline.

148. The seaward extent of the boundary is a composite of the seaward distribution of red throated diver and the tern species. It will encompass the foraging areas of breeding little tern, breeding Sandwich tern and breeding common tern, all of which breed in colonies within existing SPAs (Humber Estuary, Gibraltar Point, North Norfolk Coast, Breydon Water and Great Yarmouth North Denes). The boundary also includes areas with high densities of common scoter and little gull, and so these two species are also included as features of the pSPA.

149. The Norfolk Vanguard site does not overlap with the Greater Wash SPA, although the cable route will pass through the southern end of the site.

150. The conservation objectives of the site include:

- Ensuring that the integrity of the site is maintained or restored as appropriate, and ensuring that the site contributes to achieving the aims of the Birds Directive, by maintaining or restoring:

- o The extent and distribution of the habitats of the qualifying features;
- o The structure and function of the habitats of the qualifying features;
- o The supporting processes on which the habitats of the qualifying features rely;
- o The populations of each of the qualifying features; and
- o The distribution of the qualifying features within the site.

151. The features of this SPA for which assessment of potential effects due to the proposed Norfolk Vanguard project are considered necessary are nonbreeding red-throated diver and nonbreeding little gull.

6.1.3.1. Red-throated diver

152. In the UK, wintering red-throated divers are associated with shallow inshore waters (normally between 2 and 20m deep), often occurring within sandy bays (Poot *et al.* 2009), firths and sea lochs, although open coastline is also frequently used (Skov *et al.* 1995; Stone *et al.* 1995). Knowledge of red-throated diver distribution in the UK was transformed during the 2000s following the advent of aerial and boat surveys for offshore development (e.g. Percival *et al.* 2004; O'Brien *et al.* 2008). The bulk of the UK distribution of wintering red-throated divers is found off the coast of east England, with the area between Kent and North Yorkshire supporting 59% of the UK total and 8.9% of the UK total is in the Greater Wash SPA (Natural England and JNCC 2016). The distribution and concentrations of red-throated divers will at least in part be determined by the presence, abundance, and availability of their prey fish species (Poot *et al.* 2009), especially sprats and young herring in winter, although a wide variety of small fish species can be taken (Guse *et al.* 2009).

153. Red-throated divers arrive in the Greater Wash SPA area from September to November and depart towards breeding areas from February to April (Brown and Grice 2005). Small numbers, mostly of birds in their first year of life, remain in the wintering areas through summer (Furness 2015). Recent tracking studies suggest that red-throated divers wintering in the southern North Sea mostly originate from breeding grounds in Russia (Dierschke *et al.* 2017, German tracking study www.divertracking.com).

6.1.3.2. Little gull

154. Little gull is a species about which very little is known. The main breeding population is in central Asia but extends to western Europe where it has been increasing in numbers in recent decades. BirdLife International (2004) suggest that about 24,000 to 58,000 pairs breed in Europe and that this represents 25 to 49% of the global population; thereby implying a global population of 49,000 to 232,000 pairs.

155. Considerably increasing numbers of little gull pass through UK waters on migration, perhaps reflecting a more westerly migration route developing in this species as well as increasing breeding numbers particularly in Finland (del Hoyo *et al.* 1996; Brown and Grice 2005). Musgrove *et al.* (2013) and British Trust for Ornithology (BTO) BirdFacts were unable to give an estimate of numbers occurring in the UK, but Skov *et al.* (2007) estimated that 5,400 birds winter in the North Sea although this represents only a small fraction of the numbers passing though on migration.

156. Brown and Grice (2005) report that the little gull is most numerous in English waters during spring and autumn migration and that 'numbers passing through England have increased enormously since the 1950s'. They report also that 'outside the breeding season, little gulls are largely coastal'.

157. Large numbers of little gull may occur on passage. For example, 4,100 were seen at Flamborough Head on 21 September 1995, 5,413 passed Flamborough Head between 24 September and 7 October 1982 (Brown and Grice 2005), and 10,000 were seen off Spurn on 11 September 2003 (Hartley 2004). The species is recorded along the entire English coastline in autumn, winter and spring, with largest counts in autumn, and often associated with onshore gales (Balmer *et al.* 2013).

158. The population of little gull in the Greater Wash SPA in winter was estimated at 1,303 (mean of peak counts in the winter period for 2004-05 and 2005-06; Natural England and JNCC 2016).

159. The little gull population estimates are highly uncertain for several reasons. Firstly, little gull counts were made in late October or November. However, little gull numbers peak in autumn, with relatively few birds remaining in the North Sea during winter (Brown and Grice 2005, Skov *et al.* 2007). This is clearly demonstrated by the Trektellen data (downloaded from trektellen web page) which show that numbers of little gulls seen at UK North Sea sea-watching sites (which are mostly in areas from Yorkshire to Kent and therefore highly relevant here) reported about 5 times as many little gulls in September as in late October or November (Plate 6-1).

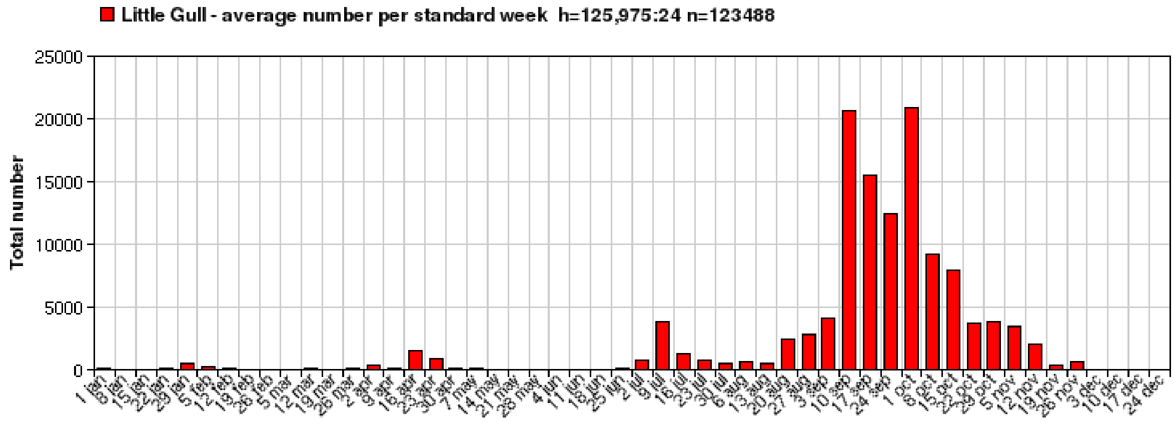

Plate 6-1 Counts of little gulls seen from sea watching vantage points on the east coast of England. Data from the Trektellen web page, summed for all years and sites

160. Therefore, numbers of little gulls within the Greater Wash SPA are likely to be much higher in September than in late October or November when JNCC's aerial surveys which were used to inform the designation of the pSPA were carried out.

161. Secondly, little gull numbers and distribution show considerable variability between both years and days (Natural England and JNCC 2016), with birds apparently showing little site-fidelity (Brown and Grice 2005). Thus, a population estimate based on aerial surveys conducted across just two winters and covering what almost certainly represents a relatively small portion of their range is unlikely to provide a reliable estimate of population size.

162. Thirdly, it is evident that the aerial survey technique used by JNCC for the Greater Wash SPA designation was unable to provide an accurate count of little gulls. According to Natural England and JNCC (2016): "*Little gulls are difficult to distinguish from other small gull species on aerial surveys so many little gulls may have been recorded as 'small gull species' or the birds missed altogether by less experienced observers. Little gulls were certainly under recorded on some aerial surveys but it is impossible to estimate the proportion of birds recorded as 'small gull species' that were actually little gulls. Only birds identified as little gulls were included in the analyses*". Use of this approach to assessment therefore means that little gull numbers are likely to be significantly underestimated. According to Natural England and JNCC (2016): "*The true numbers of little gull within the survey area may have been at least double that recorded*".

163. Taken together, these factors therefore suggest that the winter population of little gulls in the Area of Search (a larger area than the SPA within which surveys were conducted) is likely to be at least twice as large as that presented in the Greater Wash SPA citation (as acknowledged by Natural England and JNCC 2016), and so the

actual population is likely to exceed 4,300 birds. Indeed, the little gull population during peak migration in autumn is likely to be even larger than this winter estimate (perhaps five times larger, based on coastal observations). Combined with a high turnover of individuals, it is likely that several tens of thousands of little gulls pass through the Greater Wash SPA area each year, however the total cannot be estimated with any confidence. It should be noted that even a population estimate of 20,000 therefore remains precautionary: Stienen *et al.* (2007) reported that the flyway population with potential connectivity to the southern North Sea was up to 75,000. However, the current assessment has been conducted on the basis of the more precautionary population sizes of 10,000 to 20,000.

6.2. Assessment Scenarios

164. The Norfolk Vanguard Wind Farm may be split between the Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) sites. The total export capacity for the project will be up to 1800MW. For the purposes of the offshore ornithology impact assessment, two potential turbine installation options have been considered (Table 6.2). Hereafter these are referred to as scenarios 1 and 2.

165. For potential impacts at the wind farm itself (collision risk for lesser black-backed gull, gannet, kittiwake and little gull), this assessment is based on whichever of the two scenarios has the higher predicted collision mortality (i.e. either for all turbines in NV East or all in NV West) as any split of turbines between the two sites will result in lower collision rates. The results of assessment calculations (e.g. collision risk modelling) for both scenarios are presented in the technical appendices for the Norfolk Vanguard ES (Technical Appendix 13.1). However, to ensure clarity in the consideration of potential impacts, within both the ES offshore ornithology chapter and this HRA only the worst case scenario for each receptor has been discussed.

Table 6.2 Wind farm generating scenarios across NV East and NV west assessed for ornithological impacts up to a maximum capacity of 1800MW

Scenario	NV West (MW capacity)	NV East (MW capacity)
1	1800	0
2	0	1800

166. Identification of projects for inclusion in the in-combination assessment is dependent on the species and season. Breeding season connectivity uses evidence on foraging ranges (e.g. Thaxter *et al.* 2012a), while non-breeding season connectivity is based on evidence provided in Furness (2015).

6.2.1. Embedded mitigation

167. The Norfolk Vanguard site was identified through the Zonal Appraisal and Planning process and the site is located a considerable distance from European protected sites for birds (e.g. Flamborough and Filey Coast pSPA is more than 210km from the OWF sites and Alde-Ore Estuary SPA is over 92km from the OWF sites). This means the project site is beyond the foraging range of almost all seabird species during the breeding season, with the exceptions of gannet and lesser black-backed gull with mean maximum ranges of up to 229km and 141km respectively (Thaxter *et al.* 2012a). Tracking of breeding gannets from Flamborough Head (the only colony within the maximum foraging range) has revealed a very low degree of connectivity, with most foraging trips occurring to the north of the site (Langston *et al.* 2013). Recent tracking of breeding kittiwakes from Flamborough and Filey Coast pSPA by the RSPB has indicated that foraging trips from this colony may extend as far as Norfolk Vanguard. However, these results have not been made publicly available and it is therefore not currently possible to determine the extent to which such trips should be considered to be representative of this population. Tracking of breeding lesser black-backed gulls has indicated the potential for connectivity with the Norfolk Vanguard site (Thaxter *et al.* 2012b, 2015) and therefore this aspect has been considered in more detail below.

6.2.2. Worst Case Scenario

168. The worst case scenarios with regard to potential impacts of the proposed project on offshore ornithology receptors from the construction, operation and decommissioning phases are dependent on the survey results for each species, as some species were found to be more abundant in NV West and some more abundant in NV East.

169. To maximise the clarity of this assessment the worst case scenario is identified for each impact-species combination assessed (Table 6.3).

Table 6.3 Worst case scenario for relevant SPA/pSPA features screened in for assessment

Impact	Worst case parameter	Rationale
Disturbance and displacement caused by vessels during construction of the export cable.	Up to two vessels operating within the SPA at the same time during one nonbreeding period.	Species such as red-throated diver have been found to be particularly sensitive to vessel movements and construction activities.
Collision risk	Maximum of 200 x 9 MW turbines	Collision risk modelling shows that 200 x 9 MW turbines have the largest potential collision impact risk. Other development options (e.g. 15 MW turbines) comprise a reduced total rotor swept area with lower collision risks.

6.3. Assessment of Potential Effects

6.3.1. Alde-Ore Estuary SPA

170. Lesser black-backed gull (a breeding feature of the SPA) is a seabird species thought to be at relatively high risk of collisions with offshore wind turbines on account of its flight height distributions. This species is unlikely to show displacement or barrier effects as it has not been found to be displaced by existing offshore wind farms where responses of seabirds have been monitored (Dierschke *et al.* 2016), and furthermore breeding birds are unlikely to regularly travel beyond the Norfolk Vanguard site to forage at sea as the site is beyond the mean foraging ranges of this species (Thaxter *et al.* 2012a).

6.3.1.1. Lesser black-backed gull

6.3.1.1.1. Potential effects of Norfolk Vanguard

171. No works for the proposed Norfolk Vanguard project will take place within the Alde-Ore Estuary SPA site boundary. The main potential impact for lesser black-backed gull is therefore in relation to collision risk when birds are outside of the SPA site boundary; these gulls fly partly within the height range where they may encounter rotating turbine blades.

172. Alde-Ore Estuary SPA is located 92km from the closest point of the Norfolk Vanguard OWF sites. The lesser black-backed gull is estimated to have a mean breeding season foraging range of 72km from colonies, a mean maximum foraging range of 141km, and a maximum recorded foraging range of 181km (Thaxter *et al.* 2012a). Therefore, breeding adults from Alde-Ore Estuary SPA may forage over an area that includes the Norfolk Vanguard site, although the site is further from the colony than most likely foraging activity of this population. Other breeding lesser black-backed gull SPAs in Britain are located more than 181km from the Norfolk Vanguard site. The Alde-Ore Estuary SPA is therefore the only British lesser black-backed gull SPA colony that is within maximum foraging range.

173. Non-SPA colonies of lesser black-backed gulls are also located within foraging range of Norfolk Vanguard, including rooftop nesting gulls in several towns in Suffolk and Norfolk. The JNCC's Seabird Monitoring Programme (SMP; http://jncc.defra.gov.uk/smp) includes the following lesser black-backed gull counts:

- Felixstowe Docks (2013) - 1,401 occupied territories,
- Ipswich (several sites; 2001) – 99 occupied nests, and
- Lowestoft (Town; 2000) – 750 occupied nests.

174. Counts have been undertaken in Norwich since 2008, although these have not been entered in the SMP, with a population estimate in the 2017 breeding season described as 'over 900 birds'[7].

175. Piotrowski (2012) reported on a survey of Suffolk breeding colonies undertaken in May 2012. Across all sites surveyed (within foraging range of Norfolk Vanguard), a total lesser black-backed gull breeding population of 4,694 pairs was estimated. However, the report noted that numbers were considered to be low due to poor weather prior to and during the survey. This would appear to be borne out in the estimate for Felixstowe which was 675 pairs in 2012, but reported as 1,400 occupied territories a year later (SMP).

176. Using the SMP data, the urban adult lesser black-backed gull population in Norfolk and Suffolk with potential connectivity to Norfolk Vanguard can be conservatively estimated as 5,400 (= 2,800 + 200 + 1500 + 900), noting that the Lowestoft, Ipswich and Felixstowe estimates were from 2000, 2001 and 2013 respectively and would therefore almost certainly have increased substantially in the interim.

177. Using the 2012 survey data (Piotrowski 2012), the Suffolk population excluding that at the Alde-Ore Estuary colonies was estimated at 2,900 pairs, yielding a Suffolk only estimate of the breeding adult population of 5,800.

178. There is also potential for connectivity between the project and colonies of lesser black-backed gulls in the Netherlands which are within 181km. However, extensive colour ringing and tracking of breeding lesser black-backed gulls from multiple colonies in the Netherlands has shown that there is no connectivity during the breeding season between birds breeding in the Dutch colonies and the UK, and indeed that there is remarkably little migration of birds from the colonies in the Netherlands through UK waters even after the breeding season in autumn, winter or spring (Camphuysen 2013). Not only do breeding adult lesser black-backed gulls from colonies in the Netherlands normally remain on the continental side of the North Sea while breeding, but 95% of their foraging trips in the 1990s and 2000s were less than 135km from those colonies (Camphuysen 1995, 2013), and between 2008 and 2011 95% of foraging trips were within 60.5km of the colony (Camphuysen *et al.* 2015). Based on these foraging ranges, breeding adult lesser black-backed gulls from colonies in the Netherlands would be very unlikely to reach the Norfolk Vanguard site. Therefore, during the breeding season, it is likely that adult lesser black-backed gulls at the Norfolk Vanguard site will originate from Alde-Ore Estuary SPA and from non-SPA colonies in East Anglia only. However, these birds may be

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[7] http://www.edp24.co.uk/news/environment/they-are-the-new-pigeon-seagull-numbers-triple-in-norwich-and-experts-warn-there-is-no-solution-1-5122565; quote attributed to Dr. Iain Barr from the University of East Anglia

mixed with non-breeding birds from a variety of sources, so that any impact on lesser black-backed gulls due to the proposed Norfolk Vanguard project will be on a mixture of breeding birds from Alde-Ore Estuary, breeding birds from non-SPA colonies and immatures/nonbreeders from many different sources.

179. Thaxter *et al.* (2012b, 2015) tracked breeding adult lesser black-backed gulls from the Alde-Ore Estuary SPA and showed that birds differed in feeding habitat and area use both within and between seasons, as well as individually. Marine foraging occurred more during chick-rearing, suggesting that connectivity with the Norfolk Vanguard site would be most likely during the chick-rearing part of the breeding season, whereas early and late in the breeding season these birds foraged more in terrestrial and coastal habitats. Despite these trends, these tracking studies suggest that connectivity during the breeding season between Alde-Ore Estuary SPA adult lesser black-backed gulls and the Norfolk Vanguard site is low (see Norfolk Vanguard ES Technical Appendix 13.1 Annex 8 for further details). As discussed above, the non-SPA adult lesser black-backed gull population with potential for connectivity to Norfolk Vanguard is likely to be at least 5,400 and could easily be twice this figure when allowance is made for population increases since surveys were last conducted. This estimate which is derived from partial coverage (e.g. Norfolk appears to have had very limited coverage) of urban locations at which gulls may breed which, together with the fact that there is over 230km of coastline within foraging range of Norfolk Vanguard, also suggests the actual non-SPA lesser black-backed gull population within range of Norfolk Vanguard could be twice the estimate of 5,400 (e.g. approx. 11,000 adults) which would represent an all age class population in excess of 19,000 individuals (on the basis that adults comprise approximately 58% of the population, Furness 2015).

180. The Alde-Ore SPA lesser black-backed gull breeding population has been around 2,000 pairs between 2007 and 2014 (minimum 1,580 pairs in 2011, maximum 2,769 pairs in 2008; Table 6.1). This estimate for the breeding population size is considered robust since it takes into account observed inter-annual variations over a span of representative years for which data are available. This suggests that the total population (all age classes) associated with the SPA is around 6,700 individuals.

181. Incorporating all of the above evidence, a worst case (precautionary) assumption has been made that 25% (~ 6,700 / (19000 + 6700)) of birds recorded on the Norfolk Vanguard site in the breeding season originate from the Alde-Ore SPA population (tracking data suggest a much lower value than this however do not permit a robust quantification).

182. Studies in the Netherlands indicated that most foraging by lesser black-backed gulls at sea was by males, whereas females tended to feed mainly onshore, suggesting

that collision mortality might affect male lesser black-backed gulls more than females during the breeding season (Camphuysen *et al.* 2015).

183. During migration, lesser black-backed gulls of all age classes will pass through the southern North Sea, with a small proportion of these passing through the Norfolk Vanguard site. Therefore, during migration, birds from many different local populations within the region may be at risk of collision mortality and the Alde-Ore Estuary SPA population represents only a very small fraction of the regional population potentially at risk. The lesser black-backed gull Biologically Defined Minimum Population Scales (BDMPS) population in UK North Sea and Channel waters in autumn (August-October) is estimated to be 209,000 birds, while the spring (March-April) population is estimated to be 197,000 birds (Furness 2015). The total Alde-Ore SPA lesser black-backed gull population has been estimated at around 6,700 individuals (assuming adults comprise 58% of the population, Furness 2015). This indicates that birds associated with the Alde-Ore SPA represent about 3.3% of these BDMPS populations. Therefore, it is likely that about 3.3% of the estimated collision mortality during the autumn and spring migration periods would affect birds associated with the Alde-Ore SPA population, of which around 58% would be breeding adults (i.e. 2% of the total collision mortality would be breeding adults from Alde-Ore Estuary SPA). This percentage applies both for estimated mortality due to the proposed Norfolk Vanguard project alone, and to in-combination effects within the region.

184. During winter, lesser black-backed gulls are present in UK waters in smaller numbers than during migration; the estimated BDMPS winter population of lesser black-backed gulls in the UK North Sea and Channel waters is about 39,000 birds (Furness 2015). Adults from the Alde-Ore SPA lesser black-backed gull breeding population may represent a higher proportion of the winter BDMPS than they do during the migration seasons BDMPS populations because a higher proportion of the overwintering birds are likely to be adults (most immatures migrate further south). Furness (2015) considered that around 50% of breeding adults from the SPA remain in the region (a precautionary assumption), hence the proportion of birds from the Alde-Ore SPA will be approximately 5% (Furness 2015). Hence, no more than 5% of the estimated collision mortality on the lesser black-backed gull population during winter would be apportioned to the Alde-Ore SPA breeding population, either for estimated mortality due to the proposed Norfolk Vanguard project alone, or in-combination for the region. The true percentage is an unknown amount below 5%, but is likely to be greater than the 3.3% estimated during migration seasons.

185. The predicted monthly numbers of lesser black-backed gull collision mortalities based on Band Option 2 (Band 2012), with an avoidance rate of 99.5% (the

avoidance rate as agreed with Natural England for use in Band model Option 1 or 2 collision risk modelling) for the proposed Norfolk Vanguard project, are shown in Table 6.4 (data from the Norfolk Vanguard ES Chapter 13 Offshore Ornithology Technical Appendix 13.1).

Table 6.4 Predicted monthly numbers collision estimates for lesser black-backed gull at the Norfolk Vanguard site calculated using Band Option 2 (generic flight heights) for the worst case turbine option (9MW) with uncertainty in seabird density, avoidance rates. Months in bold indicate the migration free breeding months (note that the full breeding season is also considered in the assessment).

Month	Development scenario	
	Scenario 1 (median and 95% c.i.)	Scenario 2 (median and 95% c.i.)
January	0 (0-0)	2.29 (0-16.19)
February	0 (0-0)	0 (0-7.29)
March	0 (0-6.15)	0 (0-6.63)
April	0 (0-5.91)	0 (0-6.93)
May	**0 (0-0)**	**0 (0-0)**
June	**6.18 (0-24.78)**	**0 (0-0)**
July	**6.5 (0 -32.24)**	**0 (0-8.91)**
August	10.6 (0-40.5)	6.81 (0-33.69)
September	0 (0-16.9)	0 (0-0)
October	4.07 (0-23.6)	0 (0-3.73)
November	0 (0-0)	0 (0-7.27)
December	0 (0-0)	0 (0-8.86)
Total	27.35 (0-150.08)	9.1 (0-99.5)

186. NV West had higher predicted collision mortality than NV East, with the majority of collisions predicted during the second half of the breeding season and early autumn (June to October). This indicates wider movements of failed and nonbreeding individuals and birds on migration through the southern North Sea.

187. Between 12.7 (scenario 1) and 0 (scenario 2) collisions are predicted during the migration-free breeding season (May to July). On the basis of the seasonal percentages of Alde-Ore SPA birds predicted to be on the Norfolk Vanguard site (figures derived above) and using the migration-free breeding season, the attributable mortality using the higher scenario 1 figure would be:

- Autumn (August-October): 14.7 x 3.3% = 0.5
- Winter (November-February): 0 x 5% = 0

- Spring (March-April): 0 x 3.3% = 0
- Migration-free breeding season (May-July): 12.7 x 25% = 3.2
- Total for Alde-Ore SPA = 3.7

188. The annual figure would be slightly higher if the extended breeding season is applied, with April (0 collisions) and August (10.6) being reassigned to breeding the annual total increases to 6 individuals.

189. Natural mortality for the SPA population (assuming approximately 6,666 birds of all ages) would be around 940 individuals at an average all age class mortality rate of 14.10% (using immature and adult survival rates from Horswill and Robinson 2015). A total additional worst case mortality of between 3.7 and 6 birds due to collisions at the Norfolk Vanguard site would increase the total mortality rate by 0.4% to 0.6% (from 0.141 to 0.01415 and 0.0142). Following SNCB recommendations, an increase in mortality of less than 1% is considered to be undetectable against the range of background variation. Therefore, since the increased mortality predicted as a result of Norfolk Vanguard is below the agreed threshold at which increases in mortality are detectable, this means that no significant impact can be attributed to this level of impact arising from the proposed Norfolk Vanguard project alone.

190. It is therefore reasonable to conclude that there will be no adverse effect on the integrity of the Alde-Ore Estuary SPA as a result of lesser black-backed gull collisions at the proposed Norfolk Vanguard project alone.

6.3.1.1.2. In-combination effect

191. The cumulative lesser black-backed gull collision risk prediction has been calculated using a tiered approach for all wind farms in the North Sea (Table 6.5), including preliminary estimates for the Hornsea Project Three and Thanet Extension wind farms.

Table 6.5 Lesser black-backed gull collision mortality for all wind farms (nonbreeding) and those with potential connectivity during the breeding season with the Alde-Ore SPA

Tier	Wind farm	Predicted collisions (@ 99.5% avoidance rate, Band Model option 2)			
		Annual	Nonbreeding	Breeding (Annual minus nonbreeding)	Breeding within 141km of Alde Ore SPA
1	Beatrice Demonstrator	0.0	0.0	0.0	-
1	Greater Gabbard	62.0	49.6	12.4	12.4
1	Gunfleet Sands	1.0	0.0	1.0	1.0
1	Kentish Flats	1.6	1.3	0.3	0.3

Tier	Wind farm	Predicted collisions (@ 99.5% avoidance rate, Band Model option 2)			
		Annual	Nonbreeding	Breeding (Annual minus nonbreeding)	Breeding within 141km of Alde Ore SPA
1	Lincs	8.5	6.8	1.7	-
1	London Array	0.0	0.0	0.0	0
1	Lynn and Inner Dowsing	0.0	0.0	0.0	-
1	Scroby Sands	0.0	0.0	0.0	0
1	Sheringham Shoal	8.3	6.6	1.7	1.7
1	Teesside	0.0	0.0	0.0	-
1	Thanet	16.0	12.8	3.2	3.2
1	Humber Gateway	1.3	1.1	0.3	-
1	Westermost Rough	0.3	0.3	0.1	-
2	Beatrice	0.0	0.0	0.0	-
2	Dudgeon	38.3	30.6	7.7	7.7
2	Galloper	138.8	111.0	27.8	27.8
2	Race Bank	54.0	10.8	43.2	-
2	Rampion	7.9	6.3	1.6	-
2	Hornsea Project One	21.8	17.4	4.4	-
3	Blyth Demonstration Project	0.0	0.0	0.0	-
3	Dogger Bank Creyke Beck Projects A and B	13.0	10.4	2.6	-
3	East Anglia ONE	27.0	23.0	4.0	4.0
3	European Offshore Wind Deployment Centre	0.0	0.0	0.0	-
3	Firth of Forth Alpha and Bravo	10.5	8.4	2.1	-
3	Inch Cape	0.0	0.0	0.0	-
3	Moray Firth (EDA)	0.0	0.0	0.0	-
3	Neart na Gaoithe	1.5	1.2	0.3	-
3	Dogger Bank Teesside Projects A and B	12.0	9.6	2.4	-
3	Triton Knoll	37.0	29.6	7.4	-
3	Hornsea Project Two	4.0	2.0	2.0	-
3	East Anglia THREE	10.0	8.2	1.8	1.8
5	*Hornsea Project Three*	*22.5*	*0.9*	*21.6*	-
5	*Thanet Extension*	*5.5*	*3.6*	*1.9*	*1.9*

Tier	Wind farm	Predicted collisions (@ 99.5% avoidance rate, Band Model option 2)			
		Annual	Nonbreeding	Breeding (Annual minus nonbreeding)	Breeding within 141km of Alde Ore SPA
	Total	**502.6**	**351.4**	**151.2**	**61.8**
5	NV Scenario 1 (assuming extended breeding season)	27.4	4.1	23.3	23.3
5	NV Scenario 2 (assuming extended breeding season)	9.1	2.3	6.8	6.8
	Total inc. NV Scenario 1	**529.9**	**355.5**	**174.5**	**85.1**
	Total inc. NV Scenario 2	**511.7**	**353.7**	**158.0**	**68.6**

192. It should be noted that it was not possible to estimate mortality for each of the three non-breeding seasons (autumn, winter, spring) as defined by Furness (2015) because the required breakdown of estimates by month is not available for this species for most wind farms. Hence, it was necessary to define mortality as either annual or non-breeding season and from these calculate the breeding season mortality. Cumulative lesser black-backed gull non-breeding season mortality is estimated at 354 to 355 birds (of all age classes), of which the proposed Norfolk Vanguard project contributes 2 to 4 birds.

193. Cumulative breeding season mortality has been estimated as 158 to 174. Given that tracking studies have revealed low connectivity for the Alde-Ore SPA population with the Norfolk Vanguard site (Thaxter *et al.* 2012b, 2015), it is questionable both whether the proposed Norfolk Vanguard project would contribute to an in-combination total during the breeding season, and also if all of the wind farms within 141km should be considered. However, as a precautionary assessment with respect to the Alde-Ore SPA population, wind farms within 141km of the Alde-Ore SPA have been considered during the breeding season, on the grounds that only these wind farms have the potential to contribute to mortality on the SPA population at this time of year. Hence the breeding season mortality has been summed for Greater Gabbard, Gunfleet Sands, Kentish Flats, London Array, Scroby Sands, Sheringham Shoal, Thanet, Thanet Extension, Dudgeon, East Anglia ONE, Galloper, East Anglia THREE and Norfolk Vanguard. The total breeding season mortality for these wind farms is 69 to 85 birds (although, it is more likely that the breeding season total should be based on wind farms within the mean foraging range of 72km (Greater Gabbard, East Anglia ONE, Galloper, London Array) which indicate a total breeding season mortality estimate of 44 collisions).

194. As discussed above, given the large geographical area from which lesser black-backed gulls migrating through the Norfolk Vanguard site originate, it is only possible to apportion mortality to the Alde-Ore SPA population on the basis of its size relative to the wider lesser black-backed gull population. Across all age classes the Alde-Ore Estuary SPA represents approximately 3.3% of the BDMPS autumn population, about 3.3% of the BDMPS spring population and a maximum of 5% of the BDMPS winter population. As noted above, for many wind farms there is insufficient information to determine in which months nonbreeding season collisions occur. Therefore, on the basis of the whole period a weighted Alde-Ore Estuary SPA percentage of 4% has been calculated (5 months at 3.3% and 4 months at 5%). This indicates that up to 14 birds (355 x 4%) could die from the Alde-Ore Estuary SPA population during the nonbreeding season.

195. The annual mortality of lesser black-backed gulls from the Alde-Ore SPA is therefore 14 during the nonbreeding season and 21 (85 x 25%, allowing for non-SPA birds in Norfolk and Suffolk) during the breeding season, 35 in total (of which Norfolk Vanguard contributes up to 6).

196. In-combination mortality of up to 35 birds attributable to the Alde-Ore SPA population of lesser black-backed gulls compares with estimated natural mortality of about 940 birds per year. Thus, the additional in-combination mortality would increase this to 975 which represents an increase in mortality rate from 14.10% to 14.6%, an increase of 3.7%. This level of additional mortality would be expected to result in an adverse effect on the integrity of the SPA, although notably approximately one third of this annual total is attributable to the estimated collisions at the Galloper wind farm alone.

197. Recent work has highlighted the reduction in collisions which results from updating consented assessments to reflect as-built wind farm designs in comparison to the original full consent envelopes (MacArthur Green 2017, unpubl. report). Updating from the consented design to the as-built design typically reduces predicted mortality by at least 40%, which would reduce the in-combination mortality prediction to around 20, equating to an increase in background mortality of 2%.

198. Population modelling conducted for the Galloper Wind Farm (GWF 2011) considered three sets of demographic rates, referred to as low, medium and high against which the effects on the population additional mortality was considered. These indicated that for an additional mortality of 25 the reduction in population growth rate was between 0.1% and 1.1%, with the most likely reduction, from the medium scenario, being 0.3% (this set of demographic rates reflected the rates expected as a result of management measures which were being implemented at the SPA). It is also worth noting that the in-combination collision total predicted for the Galloper Wind Farm

was 85 (at a 99.5% avoidance rate), which was more than double the more precautionary estimate of 35 above, and more than four times the more likely prediction of 20.

6.3.1.1.3. Conclusion

199. The relevant conservation objective is to restore breeding numbers of lesser black-backed gulls from the present level of about 2,000 pairs back to the population size at designation which was about 14,000 pairs. The annual number of predicted lesser black-backed gull collisions at the Norfolk Vanguard site, including the precautionary assumption of an extended breeding season, which can be attributed to the Alde Ore SPA is very small (3.7 to 6) and therefore not considered to materially alter the natural mortality rate for this population. **Therefore, no adverse effect on the integrity of the Alde-Ore SPA lesser black-backed gull population is predicted as a result of the proposed Norfolk Vanguard project alone**.

200. It is more difficult to determine the risk of an adverse effect on the integrity of the Alde-Ore SPA lesser black-backed gull population for in-combination collisions. However, **given the degree of precaution in collision assessments, including the use of the much higher mortality predictions estimated for consented wind farm designs rather than for the as built wind farm designs, the likelihood of an adverse effect due to in-combination collisions is considered sufficiently small that it can be ruled out.**

201. Furthermore, the context for the status of this population is relevant to the significance of potential collision mortality. The breeding success, and hence the population trend, of lesser black-backed gulls in the Alde-Ore SPA population appears to be mainly determined by the amount of predation, disturbance and flooding occurring at this site (Department of Energy and Climate Change 2013a, Thaxter *et al.* 2015). Increased predation and disturbance by foxes has been considered the main factor causing reductions in breeding numbers. Management measures to reduce access by foxes has resulted in some recovery of numbers of gulls. The main driver of gull numbers in this SPA therefore appears to be suitable management at the colonies to protect gulls from predators (Department of Energy and Climate Change 2013a). Further efforts in this regard could readily offset the in-combination collision mortality, and Norfolk Vanguard Limited would welcome discussions with Natural England on this matter.

6.3.2. Flamborough and Filey Coast pSPA

6.3.2.1. Gannet

6.3.2.1.1. Potential effects of Norfolk Vanguard

202. There is mounting evidence to suggest that gannets show strong macro-avoidance of offshore wind farms (Leopold *et al.* 2013, Vanermen *et al.* 2013, APEM, 2014, Dierschke *et al.* 2016, Vanermen *et al.* 2016, Garthe *et al.* 2017a,b) and therefore that the avoidance rate used in collision risk assessment is likely to be highly precautionary, overestimating numbers of gannets that might be killed by collision (Garthe *et al.* 2017b). Higher levels of avoidance could increase impacts from displacement and barrier effects (Garthe *et al.* 2017b), however displacement and barrier effects are relatively unlikely for this species. Gannets travel very large distances when foraging meaning small additions to flight distance are trivial in the ecology of this species unless offshore wind farms are located close to breeding colonies and so require repeated avoidance by breeding birds (Masden *et al.* 2009, 2010).

203. Gannets fly at a range of heights that includes the rotor swept area of wind turbines, and so there is concern over collision risk (Cook *et al.* 2012). Collisions appear to be much more likely when gannets are foraging rather than when they are commuting or migrating, as foraging gannets fly higher over the sea (Cleasby *et al.* 2015). There are suggestions that flight height also varies depending on the fish species gannets are hunting; for example, dives tend to be from a greater height when attacking mackerel, and from a low height when diving on sandeels (Nelson 1978). The collision risk is therefore likely to differ depending on whether gannets are foraging or commuting/migrating, and (if birds are engaged in foraging behaviour) which species are being targeted.

204. The Norfolk Vanguard site is located within the maximum foraging range of breeding gannets (590km, Thaxter *et al.* 2012a) from Forth Islands SPA (Bass Rock, 480km), Flamborough & Filey Coast pSPA (Bempton, 202km), and colonies in Germany, France and the Channel Islands. However, tracking studies show that breeding birds from colonies in Germany, France and the Channel Islands do not visit the Norfolk Vanguard area while breeding (Stefan Garthe, pers. comm., Wakefield *et al.* 2013, Amelineau *et al.* 2014, Garthe *et al.* 2017a, b). Breeding gannets from the Bass Rock, now the largest gannet colony in the world, show the longest breeding season foraging range, but do not normally visit the area around the Norfolk Vanguard site, their long trips mostly tending to head into Norwegian waters rather than the southern North Sea (Wakefield *et al.* 2013). Therefore, it is likely that breeding gannets visiting the Norfolk Vanguard site, originate from the Bempton colony within Flamborough & Filey Coast pSPA (see also RSPB 2012, Langston *et al.* 2013). It would,

therefore, be appropriate to allocate all breeding season mortality of breeding adults to the Flamborough & Filey Coast pSPA gannet population. However, it is likely that nonbreeding adult gannets and immature gannets forage during summer in areas distant from breeding colonies in order to avoid competition for food with breeding adults (Wakefield *et al.* 2017) which are likely to be more experienced and possibly in better body condition so more competitive (Votier *et al.* 2017). Therefore, some proportion of gannets occurring in the Norfolk Vanguard site will most likely be nonbreeders or immatures from a variety of more distant colonies (Votier *et al.* 2017, Wakefield *et al.* 2017).

205. Collision mortality of gannets at the Norfolk Vanguard site based on Band Option 2 and an avoidance rate of 98.9% (as recommended by Natural England and other SNCBs) was estimated at between 45 and 111 birds per year across the two development scenarios, with approximately 60% occurring in autumn (Norfolk Vanguard ES Chapter 13 Offshore Ornithology Technical Appendix 13.1).

206. Estimates of the proportion of birds present in the Norfolk Vanguard site which originate from Flamborough & Filey Coast pSPA during the breeding season and on migration in autumn and spring have been calculated (MacArthur Green 2015b), making use of Furness (2015) and updated colony estimates in Murray *et al.* (2015). For the breeding season, a precautionary approach has been adopted with the assumption that all birds present on the Norfolk Vanguard site originate from Flamborough & Filey Coast pSPA. During migration in autumn and spring, 4.2% and 5.6% (respectively) of the birds observed are predicted to originate from Flamborough & Filey Coast pSPA, based on numbers at the SPA and in the BDMPS population estimate (following the same method applied above for lesser black-backed gull).

207. Applying these percentages to the collision estimates based on Band Option 2 and assuming the higher scenario 1 figures (Table 6.6), generates the following mortality estimates for the Flamborough & Filey Coast pSPA population:

- Migration-free breeding season (April-August): 18 x 100% = 18
- Autumn migration (September-November): 62 x 4.2% = 3
- Spring migration (December-March): 30 x 5.6% = 2
- **Total** **= 23**

208. The SPA population is approximately 48,700 (derived from the 2017 the population estimate of 13,391 pairs, multiplied by 2 and divided by the adult proportion of 0.55 to estimate the total population size). At an average natural mortality rate of 0.191 (derived as a weighted average across all age classes, see ES Chapter 13 Offshore Ornithology for details), the natural annual mortality of the population is 9,300. The

addition of 23 individuals would therefore increase the mortality rate by 0.24% to 0.192

209. Following SNCB recommendations, an increase in mortality of less than 1% is considered to be undetectable against the range of background variation. Therefore, this increase, which is below the threshold at which increases in mortality are detectable, means that no significant impact can be attributed to this level of impact arising from the proposed Norfolk Vanguard project alone.

210. It is, therefore, reasonable to conclude that there will be no adverse effect on the integrity of the Flamborough and Filey Coast pSPA as a result of gannet collisions at the proposed Norfolk Vanguard project alone.

6.3.2.1.2. In-combination effect

211. The in-combination total collision mortality estimates for gannet during the breeding season, autumn migration and spring migration and the numbers assigned to Flamborough and Filey Coast pSPA are presented in Table 6.6.

Table 6.6 Gannet collision mortality for all wind farms with potential connectivity to the Flamborough and Filey Coast pSPA

Tier	Wind farm	Predicted collisions (@ 98.9% avoidance rate, Band Model option 1 or 2)					
		Breeding season		Autumn migration		Spring migration	
		Total	FFC pSPA	Total	FFC pSPA	Total	FFC pSPA
1	Beatrice Demonstrator	0.6	0.0	0.9	0.02	0.7	0.02
1	Greater Gabbard	14.0	0.0	8.8	0.37	4.8	0.27
1	Gunfleet Sands	0.0	0.0	0.0	0.00	0.0	0.00
1	Kentish Flats	1.4	0.0	0.8	0.03	1.1	0.06
1	Lincs	2.1	2.1	1.3	0.05	1.7	0.09
1	London Array (Phase 1)	2.3	0.0	1.4	0.06	1.8	0.10
1	Lynn and Inner Dowsing	0.2	0.2	0.1	0.01	0.2	0.01
1	Scroby Sands	0.0	0.0	0.0	0.00	0.0	0.00
1	Sheringham Shoal	14.1	14.1	3.5	0.15	0.0	0.00
1	Teesside	4.9	2.4	1.7	0.03	0.0	0.00
1	Thanet	1.1	0.0	0.0	0.00	0.0	0.00
1	Humber Gateway	1.9	1.9	1.1	0.05	1.5	0.08
1	Westermost Rough	0.2	0.2	0.1	0.00	0.2	0.01
2	Beatrice	37.4	0.0	48.8	0.93	9.5	0.31
2	Dudgeon	22.3	22.3	38.9	1.64	19.1	1.07
2	Galloper	18.1	0.0	30.9	1.30	12.6	0.71
2	Race Bank	33.7	33.7	11.7	0.49	4.1	0.23
2	Rampion	36.2	0.0	63.5	2.67	2.1	0.12

Tier	Wind farm	Predicted collisions (@ 98.9% avoidance rate, Band Model option 1 or 2)					
		Breeding season		Autumn migration		Spring migration	
		Total	FFC pSPA	Total	FFC pSPA	Total	FFC pSPA
2	Hornsea Project 1	11.5	11.5	32.0	1.34	22.5	1.26
3	Blyth (NaREC Demonstration)	3.5	0.0	2.1	0.03	2.8	0.16
3	Dogger Bank Creyke Beck A & B	5.6	2.8	6.6	0.10	4.3	0.24
3	East Anglia ONE	2.3	2.3	89.1	3.74	4.3	0.24
3	EOWDC (Aberdeen OWF)	4.2	0.0	5.1	0.09	0.1	0.00
3	Firth of Forth Alpha and Bravo	800.8	0.0	49.3	0.89	65.8	2.24
3	Inch Cape	336.9	0.0	29.2	0.53	5.2	0.18
3	Moray Firth (EDA)	80.6	0.0	35.4	0.67	8.9	0.29
3	Neart na Goethe	143.0	0.0	47.0	0.85	23.0	0.78
3	Dogger Bank Teesside A & B	14.8	7.4	10.1	0.15	10.8	0.61
3	Triton Knoll	26.8	26.8	64.1	2.69	30.1	1.69
3	Hornsea Project 2	7.0	7.0	14.0	0.59	6.0	0.34
3	East Anglia THREE	6.1	6.1	33.3	1.40	9.6	0.54
5	*Hornsea Project Three*	*13.9*	*13.9*	*6.2*	*0.26*	*12.8*	*0.72*
5	*Thanet Extension*	*0*	*0*	*0*	*0*	*10.8*	*0.6*
	Total	**1647.2**	**154.6**	**637.2**	**21.1**	**276.3**	**13.0**
5	NV Scenario 1	10.2	10.2	33.6	1.4	1	0.1
5	NV Scenario 2	18.4	18.4	62.3	2.6	30.0	1.7
	Total inc. NV Scenario 1	**1657.4**	**151**	**664.6**	**22.3**	**253.8**	**11.7**
	Total inc. NV Scenario 2	**1665.6**	**159.2**	**693.3**	**23.5**	**282.8**	**13.3**

212. In autumn, the cumulative gannet collisions were estimated to be between 665 and 693, in spring between 254 and 283 and in the breeding season between 1,657 and 1,666. Using the Flamborough & Filey Coast pSPA proportions for all the wind farms with potential connectivity to the Flamborough and Filey Coast pSPA (MacArthur Green 2015a), the proportions of the mortality attributed to the Flamborough and Filey Coast pSPA population were 22 to 23 (autumn), 12 to 13 (spring) and 151 to 159 (breeding). Of these totals, the proposed Norfolk Vanguard project contributed a maximum (scenario 2) of 3, 2 and 18 individuals within each period respectively. Therefore, as discussed above, irrespective of the potential total impact on the Flamborough and Filey Coast pSPA gannet population, the contribution from the proposed Norfolk Vanguard project is very small and would have an undetectable effect on the population. The annual increase in background mortality from the in-combination total of 196 is 2.1% (from 0.191 to 0.195).

213. Population modelling of the Flamborough and Filey Coast pSPA gannet population conducted for the Hornsea Project Two Offshore Wind Farm (MacArthur Green

2014) indicated that an annual mortality of 200 individuals would reduce the median population growth rate by approximately 1% from the current rate (using the more precautionary density independent model). The gannet population has grown at a much higher rate than this over the last 25 years (at least 10% per year). Therefore, a reduction of 1% would generate a negligible risk to the population's status, and continued population growth would be predicted from this modelling.

214. An individual-based modelling approach used by Warwick-Evans *et al.* (2017) may be more useful for assessing impacts of offshore wind farms on gannet populations, but that approach depends on knowledge of a large number of parameters for which there is, at present, a shortage of evidence.

215. Natural England's assessment for East Anglia ONE included consideration of the level of annual mortality which the Flamborough and Filey Coast pSPA population could sustain, which was reported as between 286 and 361 (Natural England 2013a). This was derived using Potential Biological Removal (PBR), a method which Natural England no longer recommend is used for assessing seabird impacts. However, it is informative to note that when the increase in population size (7,859 AON to 13,391 AON between 2008 and 2017) is taken into account, a revised threshold of between 487 and 615 individuals is obtained. Thus, while the in-combination total estimated for this SPA has remained around the same (202 at 98.9%, Natural England 2013b) the population is now 1.7 times larger.

216. The in-combination mortality of up to 196 individuals predicted for Norfolk Vanguard (all age classes, using the worst case mortality for scenario 2) apportioned to the Flamborough and Filey Coast pSPA is clearly well below both the previously accepted threshold for collisions (286-361) and also the revised thresholds (487-615). It is also important to note that the threshold figures quoted above relate only to the breeding adult component of the population. Of the total current predicted in-combination mortality of 196, breeding adults would be estimated to be only 108 (55% of the population, Furness 2015). Thus, the threshold of 286 to 361 applies only to the adult total and this is between two and three times higher than the predicted in-combination adult mortality of 108.

217. It is, therefore, reasonable to assess that there will be no adverse effect on the integrity of Flamborough and Filey Coast pSPA as a result of gannet collisions at the proposed Norfolk Vanguard project in-combination with other projects.

218. This conclusion is consistent with evidence from other gannet populations. Numbers are increasing at all gannet colonies in the North Atlantic, and new colonies are being founded every few years, including in areas not previously colonised by the species, such as Bear Island in the Norwegian Arctic. Furthermore, evidence clearly

indicates that gannet colonies are relatively robust to human impacts compared to other UK seabirds. For example, at Sula Sgeir SPA, where breeding gannet is an SPA feature, numbers have continued to increase at a rate of 2.2% per annum from 2004 to 2014 (Murray *et al.* 2015) despite a licenced harvest from that colony of up to 2,000 fully grown chicks per year from that SPA (Trinder 2016). Population modelling (Trinder 2016) indicates that the breeding numbers there would continue to increase if the harvest there was increased to as many as 3,500 fledglings per year. While the impact of harvesting fledglings is less than the impact of harvesting adults because survival rates of adults are higher, this example clearly shows how robust populations of gannets are to human impacts.

6.3.2.1.3. Conclusion

219. The gannet breeding numbers in the Flamborough and Filey Coast pSPA are continuing to increase and the gannet population is therefore clearly in favourable conservation status. The relevant conservation objective is to maintain favourable conservation status of the gannet population, subject to natural change.

220. In view of the small impact of predicted collision mortality of gannets at the Norfolk Vanguard site and the small proportion of individuals seen on the Norfolk Vanguard site during migration seasons which are estimated to originate from the Flamborough and Filey Coast pSPA population **it can be concluded that there will be no adverse effect on the integrity of Flamborough & Filey Coast pSPA from impacts on gannets due to the proposed Norfolk Vanguard project alone**.

221. The number of predicted in-combination gannet collisions attributed to the Flamborough & Filey Coast pSPA remains below the sustainable levels estimated by Natural England and is not at a level which would trigger a risk of population decline. Therefore, **it can be concluded that there will be no adverse effect on the integrity of Flamborough & Filey Coast pSPA from impacts on gannet due to the proposed Norfolk Vanguard project in-combination with other projects**. Furthermore, population modelling indicates that the cumulative mortality predicted would only slow, rather than halt, the population increase currently seen at this colony, and so would **not have an adverse effect on integrity of the SPA**.

6.3.2.2. Kittiwake

222. The following assessment has been conducted in relation to the kittiwake feature of the Flamborough and Filey coast pSPA, however it applies equally to the kittiwake feature of the Flamborough Head and Bempton Cliffs SPA.

6.3.2.2.1. Potential effects of Norfolk Vanguard

223. The main concern regarding kittiwakes is risk of collision mortality, especially the in-combination mortality at offshore wind farms throughout the region. Displacement

and barrier effects on kittiwakes are unlikely, as the Norfolk Vanguard site is far from breeding colonies and so will not regularly affect commuting foraging birds, and represents a relatively small barrier for birds that may migrate from UK colonies as far as Canada (Bogdanova *et al.* 2017).

224. During the breeding season, adult kittiwakes forage a mean of 25km from their colony, with a mean maximum foraging range of 60km and a maximum recorded foraging range of 120km (Thaxter *et al.* 2012a). Some more recent tracking studies of kittiwakes by RSPB (Future of the Atlantic Marine Environment (FAME) and Seabird Tracking and Research (STAR) projects) have recorded longer foraging distances for kittiwakes of up to 231km, although the longer distances tended to be from colonies where breeding success was zero or close to zero due to food shortage; long trips therefore tend to represent abnormal conditions of severe food shortage. Furthermore, study birds tend to be those most readily caught at the periphery of colonies or the base of cliffs. This typically means tagged individuals are of lower quality and are more likely to suffer breeding failure which will result in longer duration trips due to the absence of a need to return to the colony to feed chicks (although it should be noted that since not all of the FAME and STAR data are yet to be published it can be difficult to fully understand the methods used and which areas of the colony are sufficiently accessible to permit catching).

225. The FAME and STAR tracking studies (and many others) have deployed loggers on kittiwakes that weigh about 4 to 5% of body weight. Phillips *et al.* (2003) reported on studies deploying loggers on seabirds and concluded that adverse effects were especially likely to be evident where devices weighed more than 3% of the body weight of the bird. Chivers *et al.* (2016) found that loggers deployed for 3 days on breeding adult kittiwakes resulted in a 30% reduction in flight activity compared to controls equipped with much smaller devices. Heggøy *et al.* (2015) found that kittiwakes equipped with loggers had higher levels of corticosterone (stress hormone) at recapture and made longer foraging trips compared to controls. Kittiwakes with low body condition index attended nests less than controls, and this pattern was most pronounced among birds carrying loggers. They concluded that data obtained from kittiwakes carrying loggers were therefore not representative of the behaviour of unequipped birds and that the bias was especially strong among poor quality adults, such as those nesting at the edge of a colony (Coulson 2011).

226. There is evidence therefore, that the long trips recorded by these studies may be an artefact caused by the loggers themselves. Similarly, Kidawa *et al.* (2012) found that seabirds equipped with loggers weighing 0.9 to 3.4% of body mass showed longer and more distant foraging trips than controls, and lower chick growth rates, although breeding success was similar (and high) in both tagged and control individuals.

Passos *et al.* (2010) found that attaching loggers to the back of seabirds increased duration of foraging trips and reduced mass gain while on foraging trips. Birds with loads travelled greater distances while foraging, increased maximum foraging range, and spent longer resting on the sea surface than did controls.

227. Long trips can also be a consequence of breeding failure, which is particularly likely among the tracked birds. Ponchon *et al.* (2015) showed that kittiwakes that lose their eggs or chicks tend to make large scale prospecting movements far from their breeding site, which are qualitatively different from the foraging trips of birds that are breeding successfully.

228. It is therefore not possible to assume that data obtained from tracking breeding kittiwakes is unbiased; the evidence is that kittiwakes carrying loggers are likely to undertake much longer trips than are normal for the species, and to travel to areas that are not normally visited by breeding adults (i.e. when not fitted with loggers). This is especially a problem where loggers are above the 3% of body weight indicated as a maximum by Phillips *et al.* (2003) and where birds caught to fit loggers are from the edges of colonies so are likely to be low quality birds. Vandenabeele *et al.* (2012) found that devices weighing 3% of bird body mass increase energy cost of flight by between 4.7% and 5.7% depending on the anatomy of the species. This increase in flight cost can be predicted to reduce the flight speed of birds equipped with loggers, and to alter their foraging flight behaviour, providing an energetics explanation for impacts on behaviour of equipped birds.

229. RSPB tracking data from the Flamborough & Filey Coast pSPA colony conducted between 2010 and 2013 (and subject to the biases described above) have been made available to Natural England, although not made public. According to Natural England (2015a) the data indicate that breeding birds from the colony were foraging up to a maximum of 219km from the colony. The mean maximum foraging range varied considerably between years, ranging from 58km in 2011 to 156km in 2012 (Natural England 2015a). On the basis of these data, Natural England suggest that kittiwakes from Flamborough & Filey Coast pSPA colony should be assumed to forage within 156km of the colony for impact assessments for offshore wind farms (Natural England 2015a). Since Flamborough & Filey Coast pSPA is 204km from the Norfolk Vanguard site, following Natural England guidance it is reasonable to assume that only a very small percentage of breeding adults from Flamborough & Filey Coast pSPA colony will be at risk of collision mortality at the Norfolk Vanguard site during the breeding season.

230. An analysis of the relationship between kittiwake breeding success and the North Sea sandeel fishery (Carroll *et al.* 2017) presents foraging areas for birds tagged at both Filey (2012-2015, 50 birds) and Flamborough (2010-2015, 104 birds) as 95%

Kernal Denisty Estimates (KDE). A figure presenting the results of this analysis does not indicate any overlap with either the former East Anglia Zone or Norfolk Vanguard (Figure 1b, Carroll *et al.* 2017). Therefore, while breeding season connectivity between Norfolk Vanguard and the colony cannot be completely ruled out, the weight of evidence available indicates that this is likely to be both highly unlikely and, if it does occur, very infrequent.

231. Kittiwakes from the Flamborough & Filey Coast pSPA colony may be at risk of collision when they migrate, or during winter. During the autumn migration, large numbers of kittiwakes move from the vicinity of breeding colonies in coastal areas to wintering areas offshore. Birds from the Flamborough & Filey Coast pSPA colony represent a small fraction of this large scale migratory movement. In winter, kittiwake distribution is pelagic, with many birds far offshore in the mid-Atlantic (Bogdanova *et al.* 2017), where they will be at no risk of collision at offshore wind farms. In spring, birds return from offshore waters to coastal areas, with breeders returning to colonies and immatures tending to move towards breeding areas but not necessarily to the colonies themselves.

232. Whereas the winter distribution of birds is more pelagic, Natural England (2015a) cite Coulson (1966) as stating that kittiwakes of all ages vacate the mid-Atlantic pelagic zone by mid-May and concentrate over shallow continental shelves around islands and coasts. This change to a coastal distribution is associated with changes in the diet of birds with an increase in the consumption of fish. Coulson's study based on ring recovery data from the 1930s to 1960s, is consistent with more recent work deploying loggers on adult kittiwakes (Frederiksen *et al.* 2012).

233. Natural England (2015a) cite Coulson (1966) as providing evidence that young birds are found closer to their natal colony in the summer months compared to winter and that the distribution of immature birds varies with age such that birds tend to occupy waters closer to their natal colony in summer as they get older. Therefore, Natural England (2015a) suggest that it seems likely that some of the immature birds present in offshore wind farms during the breeding season months will be birds deriving from colonies closest to the offshore wind farm. It is worth pointing out that the mean distance of 2nd year and 3rd year birds from their natal colony during summer was 600km, while 4th year birds were an average of 400km from their natal colony (Coulson 1966).

234. These distances suggest that immatures in summer at the Norfolk Vanguard site are as likely to originate from Scotland as from the Flamborough & Filey Coast pSPA colony. For example, a 2nd year or 3rd year bird at the average distance of 600km north of Flamborough & Filey Coast pSPA would be near Fair Isle, Shetland. Therefore, the average 2nd or 3rd year kittiwake from Orkney is likely to be near the

Norfolk Vanguard site (or alternatively near north Norway or Iceland or the west coast of Ireland). Furthermore, in later work, Coulson (2011) points out:

'for many years, there has been an assumption that colonies of seabirds are virtually self-reproducing units or closed populations which produce their own young to replace the adult mortality. This requires that all of the young return to the colony of their birth, a behaviour that is called philopatry. However, this concept of a colony is clearly incorrect'.

235. In fact, kittiwakes show a low philopatry and high degree of emigration. Young fledged from Coulson's study colony in North-east England were subsequently found breeding in northern France, Sweden, Germany and Scotland. Ringed birds immigrating into his colony included birds ringed as chicks in Norway and Scotland, and 91% of recruiting females were birds immigrating from elsewhere (Coulson 2011).

236. Analysis of ring recovery data shows that kittiwakes recruited to breed in colonies up to 1,000km from their birthplace, with 18% moving more than 300km from their natal colony. It is therefore inappropriate to define young birds reared at Flamborough & Filey Coast pSPA colony as 'belonging' to that population and to assume that these birds will be present within the vicinity of the breeding colony. Most birds reared at Flamborough & Filey Coast pSPA will breed in a different 'population' and not at Flamborough & Filey Coast pSPA colony. Apportioning immature birds at risk of collision mortality at the Norfolk Vanguard site to the Flamborough & Filey Coast pSPA colony is therefore difficult and probably inappropriate, other than to suggest that most immature birds present at Norfolk Vanguard may be associated (loosely) with kittiwake populations from within about 500 to 1,000km of the Norfolk Vanguard site.

237. A proportion of the birds at the Norfolk Vanguard site in summer will be immatures from higher latitude colonies. Since there are very large populations of kittiwakes at higher latitudes, the proportion of kittiwakes at the Norfolk Vanguard site during summer that originate from high latitude colonies may be quite high, but cannot accurately be quantified based on current knowledge. It is therefore difficult to apportion assessed impacts during the breeding season to immatures and nonbreeders 'associated with' Flamborough & Filey Coast pSPA colony, as the numbers from elsewhere are uncertain, and any 'association' of immature birds with the Flamborough & Filey Coast pSPA colony is at best tenuous, at least until they obtain a site within the colony and so are in the process of recruiting into that population. Wakefield *et al.* (2017) point out that immature kittiwakes are very likely to be dispersed widely at sea, and perhaps particularly in areas beyond the foraging range of adults from breeding colonies because immature birds are likely to be less

competitive so would likely avoid competing for food with adults in areas close to colonies. This suggests that there is likely to be an increasing proportion of immature and nonbreeding birds over marine areas further from breeding sites.

238. Collision mortality of kittiwakes at the Norfolk Vanguard site (based on Band Option 2 with an avoidance rate of 98.9% and covering the two alternative development scenarios) was estimated at between 15 and 76 birds in spring, 20 and 21 in summer and 24 to 61 in autumn, giving an annual total between 59 and 158 birds (Norfolk Vanguard ES Chapter 13 Offshore Ornithology; note that there is no mid-winter BDMPS defined for kittiwake, with autumn and spring migration periods adjacent).

239. Estimates of the proportion of birds present on wind farms in the North Sea which originate from Flamborough & Filey Coast pSPA during the breeding season and on migration in autumn and spring have previously been calculated (MacArthur Green 2015b), making use of the population estimates and movement data summarised in Furness (2015). This work has reported that, for wind farms at the equivalent distance from the colony as Norfolk Vanguard, a precautionary estimate of the proportion of birds present during the breeding season expected to originate from Flamborough & Filey Coast pSPA would be 16.8%. Similarly, during migration in autumn and spring, 5.4% and 7.2% (respectively) of the birds observed are predicted to originate from Flamborough & Filey Coast pSPA.

240. Applying these percentages to the collision estimates stated above generates the following mortality estimates for the Flamborough & Filey Coast pSPA population:

- Migration-free breeding season (May-July): 21 x 16.8% = 3.6
- Autumn migration (August-December): 61 x 5.4% = 3.3
- Spring migration (January-April) 76 x 7.2% = 5.5
- **Total = 12.4**

241. These sum to an annual total maximum collision mortality of approximately 12 individuals, from a population of approximately 141,000 (37,618 pairs multiplied by 2 and divided by the adult proportion of 0.532 to estimate the total population size). It should also be noted that the population of kittiwake has increased since this estimate was obtained and now stands at around 51,000 pairs (RSPB unpublished report of 2017 census), which increases the total population to approximately 191,700.

242. At an average natural mortality rate of 0.156 (derived as a weighted average across all age classes, see Norfolk Vanguard ES Chapter 13 Offshore Ornithology for details), the natural mortality of the population is 22,000 (based on the designated

population size). The addition of a maximum of 12 individuals to this would increase the mortality rate by 0.05% to 0.1562

243. Following SNCB recommendations, an increase in mortality of less than 1% is considered to be undetectable against the range of background variation. Therefore, this increase, which is below the threshold at which increases in mortality are detectable, demonstrates that no significant impact can be attributed to this level of impact arising from the proposed Norfolk Vanguard project alone.

244. It is, therefore, reasonable to conclude that there will be no adverse effect on the integrity of the Flamborough and Filey Coast pSPA as a result of kittiwake collisions at the proposed Norfolk Vanguard project alone.

6.3.2.2.2. In-combination effect

245. In-combination collision risk mortality estimates for kittiwake during the breeding season, autumn migration and spring migration and the numbers assigned to Flamborough and Filey Coast pSPA are presented in Table 6.7.

Table 6.7 Kittiwake collision mortality for all wind farms with potential connectivity to the Flamborough and Filey Coast pSPA

Tier	Wind farm	Predicted collisions (@ 98.9% avoidance rate, Band Model option 1 or 2)					
		Breeding season		Autumn migration		Spring migration	
		Total	FFC pSPA	Total	FFC pSPA	Total	FFC pSPA
1	Beatrice Demonstrator	0	0.0	2.1	0.11	1.7	0.12
1	Greater Gabbard	1.1	0.2	15	0.81	11.4	0.82
1	Gunfleet Sands	0	0.0	0	0.00	0	0.00
1	Kentish Flats	0	0.0	0.9	0.05	0.7	0.05
1	Lincs	0.70	0.1	1.16	0.06	0.69	0.05
1	London Array (Phase 1)	1.4	0.2	2.3	0.12	1.8	0.13
1	Lynn and Inner Dowsing	0	0.0	0	0.00	0	0.00
1	Scroby Sands	0	0.0	0	0.00	0	0.00
1	Sheringham Shoal	0	0.0	0	0.00	0	0.00
1	Teesside	38.4	6.5	24	1.30	2.5	0.18
1	Thanet	0.3	0.1	0.5	0.03	0.4	0.03
1	Humber Gateway	1.9	1.9	3.19	0.17	1.9	0.14
1	Westermost Rough	0.10	0.1	0.22	0.01	0.132	0.01
2	Beatrice	94.7	15.9	10.7	0.58	39.8	2.87
2	Dudgeon	0.0	0.0	0	0.00	0	0.00
2	Galloper	6.3	1.1	27.8	1.50	31.8	2.29
2	Race Bank	1.90	0.3	23.9	1.29	5.59	0.40
2	Rampion	54.40	9.1	37.4	2.02	29.7	2.14

Tier	Wind farm	Predicted collisions (@ 98.9% avoidance rate, Band Model option 1 or 2)					
		Breeding season		Autumn migration		Spring migration	
		Total	FFC pSPA	Total	FFC pSPA	Total	FFC pSPA
2	Hornsea Project 1	44.0	7.4	55.9	3.02	20.9	1.50
3	Blyth (NaREC Demonstration)	1.4	0.2	2.3	0.12	1.4	0.10
3	Dogger Bank Creyke Beck A & B	288.0	48.4	135	7.29	295	21.24
3	East Anglia ONE	0.9	0.2	108.4	5.85	31.5	2.27
3	EOWDC (Aberdeen OWF)	11.8	2.0	5.8	0.31	1.1	0.08
3	Firth of Forth Alpha and Bravo	153.1	25.7	313.1	16.91	247.6	17.83
3	Inch Cape	13.1	2.2	224.8	12.14	63.5	4.57
3	Moray Firth (EDA)	43.6	7.3	2	0.11	19.3	1.39
3	Neart na Goethe	32.9	5.5	56.1	3.03	4.4	0.32
3	Dogger Bank Teesside A & B	136.9	23.0	90.7	4.90	216.9	15.62
3	Triton Knoll	24.60	4.1	139	7.51	45.4	3.27
3	Hornsea Project 2	16.0	2.7	9	0.49	3	0.22
3	East Anglia THREE	6.14	1.0	69	3.73	37.6	3.08
5	Hornsea Project Three	230.1	38.7	93.9	5.1	17.2	1.24
5	Thanet Extension	0.3	0.1	0.9	0.05	4.8	0.35
	Total	**1204.0**	**203.9**	**1455.1**	**78.6**	**1137.7**	**81.9**
4	NV Scenario 1	20	3.4	23.7	1.5	14.9	1.2
4	NV Scenario 2	20.8	3.5	61.3	3.3	76.3	5.5
	Total inc. NV Scenario 1	**1224**	**207.3**	**1478.8**	**80.1**	**1152.6**	**83.1**
	Total inc. NV Scenario 2	**1224.9**	**207.4**	**1516.4**	**81.9**	**1214.0**	**87.4**

246. Across the two development scenarios, the cumulative total kittiwake collisions in autumn were estimated to be between 1,479 and 1,516, in spring between 1,152 and 1,214, and in the breeding season between 1,224 and 1,225. Using the Flamborough & Filey Coast pSPA proportions for all the wind farms with potential connectivity to the Flamborough and Filey Coast pSPA (MacArthur Green 2015b), the mortality attributed to the Flamborough and Filey Coast pSPA population was 80 to 82 (autumn), 83 to 87 (spring) and 207 (breeding) respectively (annual mortality of 370 to 377 birds).

247. Of these, the proposed Norfolk Vanguard project contributed a maximum of 3.3, 5.5 and 3.5 individuals, respectively. Therefore, irrespective of the potential total impact on the Flamborough and Filey Coast pSPA kittiwake population, the contribution from the proposed Norfolk Vanguard project is small (<=4%, <=6% and <=2% in each season respectively, <=3% annually) and (as discussed above) would have an undetectable effect on total mortality. However, addition of the in-combination total

of 377 individuals to the background mortality of 22,000 would increase the mortality rate by 1.7% from 0.156 to 0.159.

248. Population modelling of the Flamborough and Filey Coast pSPA kittiwake population conducted for the Hornsea Project One wind farm (MacArthur Green 2014) indicated that an annual mortality of 375 individuals would reduce the median population growth rate by a maximum of approximately 0.5% (derived from density independent simulations using the worst case suite of demographic rates). This growth rate reduction was approximately 0.43% for the alternative set of demographic rates and less than 0.1% with the incorporation of density dependence. Even at the maximum predicted decline in growth rate (0.5%) this represents a very small risk to the population's conservation status.

249. Natural England's assessment for the Hornsea Project One development included consideration of the level of annual mortality which the Flamborough and Filey Coast pSPA population could sustain. Natural England advised that the outputs from a precautionary Potential Biological Removal (PBR) calculation (using a recovery factor of 0.1) indicated that the mortality threshold for the Flamborough and Filey Coast pSPA population should be 512 (Planning Inspectorate 2014). Although Natural England no longer advocate the use of PBR for wind farm assessments, the results remain informative in terms of the relative predicted impacts.

250. The in-combination mortality of 377 individuals (all age classes) apportioned to the Flamborough and Filey Coast pSPA is clearly well below this threshold. Note also that the PBR figure of 512 related only to the breeding adult component of the population. Of the total predicted mortality of 377, the breeding adults would be estimated to comprise 200 (53% of the population, Furness 2015). Thus, the adult threshold of 512 is more than two and a half times the equivalent in-combination adult mortality of 200.

251. It is, therefore, reasonable to assess that there will be no adverse effect on the integrity of Flamborough and Filey Coast pSPA as a result of kittiwake collisions at the proposed Norfolk Vanguard project in-combination with other projects.

6.3.2.2.3. Conclusion

252. The decline in the kittiwake population observed since the population was designated for Flamborough Head & Bempton Cliffs SPA (assuming a decline has in fact occurred) is most likely due to a combination of climate change impacts and effects of high fishing effort depleting sandeel stocks on Dogger Bank (Frederiksen *et al.* 2004, Cook *et al.* 2014, BirdLife International 2015, Carroll *et al.* 2017) and cannot be attributed to offshore wind farm development as the decline occurred before offshore wind farm construction. In the last few years, breeding numbers of

kittiwakes at Flamborough and Filey Coast pSPA have increased slightly (RSPB data), which is consistent with the relatively high breeding success of that colony (Coulson 2017). However, the large size of this colony, the increase in breeding numbers in recent years and the continued relatively high breeding success make this colony especially important for the conservation of kittiwakes throughout the UK, as most populations in the UK have shown large declines and poor productivity for the last few decades.

253. In view of the small impact of predicted collision mortality of kittiwakes at the Norfolk Vanguard site and the small proportion of individuals seen on the Norfolk Vanguard site which are estimated to originate from the Flamborough and Filey Coast pSPA population **it can be concluded that there will be no adverse effect on the integrity of Flamborough & Filey Coast pSPA from impacts on kittiwake due to the proposed Norfolk Vanguard project alone**.

254. The number of predicted in-combination kittiwake collisions attributed to the Flamborough & Filey Coast pSPA remains below the sustainable levels estimated using PBR and this level would not trigger a risk of population decline based on population viability analysis modelling and despite the precautionary nature of collision risk assessments. Furthermore, the impact on the Flamborough and Filey Coast pSPA kittiwake population resulting from in-combination collisions is below the thresholds of concern as proposed for recently consented developments. Therefore, it **can be concluded that there will be no adverse effect on the integrity of Flamborough & Filey Coast pSPA from impacts on kittiwake due to the proposed Norfolk Vanguard project in-combination with other projects**.

6.3.3. Greater Wash pSPA

6.3.3.1. Little gull

6.3.3.1.1. Potential effects of Norfolk Vanguard

255. Little gulls are mainly seen in the Greater Wash pSPA in autumn during migration from east European breeding grounds to wintering grounds that are not yet well described (Wilson *et al.* 2009, Natural England 2015b). Small numbers of little gull may overwinter in the Greater Wash pSPA, but most of the birds present in autumn move on to other areas (Wilson *et al.* 2009). Aerial surveys suggest that little gulls are primarily concentrated in the area adjacent to the seaward edge of the Inner Wash (Wilson *et al.* 2009, Natural England 2015b). Birds in the Greater Wash pSPA are unlikely to show regular connectivity with Norfolk Vanguard, although some may possibly pass through the site as little gulls are thought to be rather nomadic and unpredictable in their movements and distribution (Wilson *et al.* 2009). Given the high uncertainty about little gull population sizes, population origin and seasonal

movements, it is difficult to assess with any certainty whether there is any connectivity between little gulls seen in the Norfolk Vanguard area and those seen in the Greater Wash pSPA.

256. Little gulls tend to fly low over the water. According to Johnston *et al.* (2014), based on modelling data from numerous boat-based surveys at proposed offshore wind farm sites the mean percentage of little gull flying at collision risk height (defined as above 22m) is 12.5%.

257. The worst case collision mortality for the Norfolk Vanguard site (scenario 1) was 2 individuals, derived from option 2 of the Band model estimated with uncertainty in seabird density, avoidance rate and flight height (see Norfolk Vanguard ES Chapter 13 for details). As described in section 6.1.3.2, a precautionary estimate of the population size of little gulls visiting the Greater Wash Area of Search is around 10,000 individuals per year, while a more realistic (but still precautionary) estimate is likely to be around 20,000 individuals per year. The only published estimate of little gull survival suggests a survival rate of adults of 0.8 (Horswill and Robinson 2015). At this survival rate, natural annual mortality for little gull will be between 2,000 and 4,000 birds. The estimated maximum Norfolk Vanguard collision mortality of 2 birds represents an increase in mortality of 0.05% to 0.1%. Following SNCB recommendations, an increase in mortality of less than 1% is considered to be undetectable against the range of background variation. Therefore, this increase, which is below the threshold at which increases in mortality are detectable, means that no significant impact can be attributed to this level of impact arising from the proposed Norfolk Vanguard project alone.

258. The Greater Wash pSPA designated population of little gull is 1,303, which is 13% of a population of 10,000 or 6.5% of a population of 20,000. On this basis, and assuming collisions would be distributed uniformly throughout the population, this would imply that a maximum of 0.3 individuals from the Greater Wash pSPA population of little gull could be killed by collisions (13% of 2), which would be even reduced further on the basis of the more realistic wider population (of 20,000).

259. Thus, it can be concluded that the maximum additional mortality of 2 individuals from the pSPA population will be undetectable and **there will be no adverse effect on the integrity of the Greater Wash pSPA as a result of collisions at the Norfolk Vanguard project alone**.

260. There is very little consistent evidence regarding displacement of little gulls by offshore wind farms. Leopold *et al.* (2011) found significant displacement of little gulls by Dutch offshore wind farms in one survey but was not observed in six other surveys at the same wind farms. Petersen *et al.* (2006) tentatively suggest that little

gulls were attracted by Horns Rev offshore wind farm after construction, but the data are somewhat inconclusive. Vanermen *et al.* (2016) present evidence that little gull numbers increased significantly at Thorntonbank offshore wind farm post-construction, but that there was no change in little gull numbers at Blighbank offshore wind farm post-construction. Displacement of little gulls by offshore wind farms would therefore appear to be negligible.

6.3.3.1.2. In-combination effect

261. Given the extremely small potential impact on little gull due to collisions at Norfolk Vanguard it is apparent that the project will not contribute to an in-combination impact.

262. Thus, the likelihood of an adverse effect on the integrity of the Greater Wash pSPA population of little gull can be ruled out for the proposed Norfolk Vanguard project in-combination with other projects.

6.3.3.2. Red-throated diver

6.3.3.2.1. Potential effects of Norfolk Vanguard

263. Red-throated diver has been identified as being particularly sensitive to human activities in marine areas (Dierschke *et al.* 2016), including through the disturbance effects of ship and helicopter traffic (Garthe and Hüppop 2004, Schwemmer *et al.* 2011, Furness *et al.* 2013, Bradbury *et al.* 2014, Dierschke *et al.* 2017). Red-throated divers are highly sensitive to non-physical disturbance by noise and visual presence during the winter (Garthe and Hüppop 2004, Furness *et al.* 2013, Dierschke *et al.* 2017). Locally, significant disturbance and displacement effects are predicted to arise from noise and visual impacts from wind farm construction, maintenance traffic and visually from the turbines themselves (Natural England and JNCC 2010). Disturbance and displacement effects may also arise from shipping (including recreational boating) and boat movements associated with marine aggregate and fishing activities. Marine aggregate activities tend to be temporary and localised. Dredging and shipping activities are expected to be confined to existing shipping channels, which are already known to be avoided by divers (Natural England and JNCC 2010).

264. There is potential for disturbance and displacement of non-breeding red-throated divers resulting from the presence of vessels installing the offshore cables for Norfolk Vanguard, including when cables are laid through the Greater Wash SPA. However, cable laying vessels are static for large periods of time, and move only short distances as cable installation takes place. Offshore cable installation activity is also a relatively low noise emitting operation, particularly when compared to activities such as piling.

265. The magnitude of disturbance to red-throated diver for Norfolk Vanguard has been estimated on a 'worst case' basis. This assumes that there would be 100% displacement of birds within a 2km buffer around the source, in this case from two cable laying vessels. This 100% displacement is consistent with suggestions in Garthe and Hüppop (2004) and Schwemmer *et al.* (2011) that all red-throated divers present fly away from approaching vessels at a distance of more than 1km.

266. In order to calculate the number of red-throated divers that would potentially be at risk of displacement from the Norfolk Vanguard offshore cable corridor during the cable laying process, the density of red-throated divers in the Greater Wash SPA along the section crossed by the offshore cable corridor was estimated. This was derived from a review of the Greater Wash SPA proposal details (Natural England and JNCC 2016) which indicated that the peak density of birds in the region of the pSPA crossed by the cable route was between 1.36 and 3.38 per km^2.

267. The worst case area from which birds could be displaced was 25.13km^2, calculated as the summed area within 2km of two cable laying vessels. If 100% displacement is assumed to occur within this area, then between 34.2 and 84.9 divers could be displaced at any given time (but only if both vessels are within the SPA at the same time). This would lead to an increase of around 0.7% in diver density in the remaining areas of the SPA, if it is assumed that displaced birds all remain within the SPA. As the vessels move, it has been assumed that displaced birds return and therefore any individual will be subjected to only a brief period of impact. It is considered reasonable to assume that birds will return following passage of the vessel since the cable laying vessels will move at 300-400m per hour if surface laying, 150-300m per hour for ploughing or jetting and 30-80m per hour if trenching; this represents a maximum speed of 7m per minute. For context, a modest tidal flow rate for the region would be in the region of 1m per second (i.e. 60 m per minute). The tide would therefore be flowing at least nine times faster than the cable laying vessel. Therefore, for the purposes of estimating displacement the vessels can be considered as effectively stationary (i.e. from the perspective of the birds affected). Consequently, it can be assumed that the estimated number displaced represents the total number displaced over the course of a single winter, since the zone of exclusion can be treated as fixed.

268. Definitive mortality rates associated with displacement for red-throated divers (or for any other seabird species) are not known and precautionary estimates must be used. There is no evidence that birds displaced from wind farms suffer any mortality as a consequence of displacement (Dierschke *et al.* 2017); any mortality due to displacement would be most likely a result of increased density in areas outside the affected area, resulting in increased competition for food where density was

elevated (Dierschke *et al.* 2017). Such impacts are most likely to be negligible, and below levels that could be quantified, as the available evidence suggests that red-throated divers are unlikely to be affected by density-dependent competition for resources during the non-breeding period (Dierschke *et al.* 2017). Impacts of displacement are also likely to be context-dependent. In years when food supply has been severely depleted, as for example by unsustainably high fishing mortality of sandeel stocks as has occurred several times in recent decades (ICES, 2013), displacement of sandeel-dependent seabirds from optimal habitat may increase mortality. In years when food supply is good, displacement is unlikely to have any negative effect on seabird populations. Red-throated divers may feed on sandeels, but sandeel availability is generally low in winter, and they take a wide diversity of small fish prey, so would be buffered to an extent from fluctuations in abundance of individual fish species. It is also not possible for the proposed project to predict future fishing effort. However, this assessment has assumed a highly precautionary maximum mortality rate associated with the displacement of red-throated diver by vessels in the wintering period of 5% (i.e. 5% of displaced individuals suffer mortality as a direct consequence). This leads to a highly precautionary assumption that a single instance of displacement is equivalent to nearly half the total annual adult mortality rate. At this level of additional mortality, a maximum of between 2 and 4 birds would be expected to die across the entire winter period (September to April) as a result of any potential displacement effects from the offshore cable installation activities. However, owing to the Rochdale envelope approach and the nature of the calculations employed, this almost certainly over-estimates the duration of cable laying by a factor of around 7, since even travelling at the minimum speed of 30m per hour, if a working day lasts for 12 hours the vessel would traverse the SPA in approximately 40 days (assuming the cable route through the SPA is around 15km). From these considerations it is clear that the assumption of 5% mortality is highly precautionary in relation to disturbance by cable laying vessels.

269. Baseline annual mortality ranges from about 12% for adults, up to about 40% for juveniles (Dierschke *et al.* 2017). With an assumed proportion of juveniles of 30% (based on Furness 2015), the estimated natural mortality for the SPA population (1,511), would be approximately 300 (calculated using a composite all age class mortality rate of 0.2). The addition of a maximum of 2 to 4 to this total during a single year would increase the mortality rate in that year by approximately 0.67% to 1.3%. However, as this is based on highly precautionary assumptions about the magnitude and impact of displacement and would only be expected to apply during a single nonbreeding season (and only then if cable laying by two vessels occurs simultaneously within the SPA during the nonbreeding period), **it is reasonable to conclude that there will be no adverse effect on the integrity of the Greater Wash**

SPA as a result of red-throated diver displacement due to cable laying for the proposed Norfolk Vanguard project alone.

6.3.3.2.2. In-combination effect

270. The Greater Wash SPA contains shipping channels within the site that will continue to be subject to maintenance dredging. There may also be a requirement for capital dredging in association with newly developed and future port developments (Defra 2016).

271. Shipping already affects the distribution of red-throated divers within the SPA and these birds tend to avoid shipping lanes due to disturbance by boats (Defra 2016). This represents a background established situation following many decades of shipping activity in the area. While any increase in shipping activity will constitute an in-combination impact on divers, the low level of project alone risk and absence of other developments in the vicinity of the Norfolk Vanguard offshore cable route indicate that the likelihood of an in-combination disturbance effect is negligible.

272. The Greater Wash SPA contains several constructed or consented offshore wind farms. Red-throated divers show strong avoidance of offshore wind farms and so the construction or operation of further offshore wind farms would also represent an in-combination impact on divers through foraging habitat loss. Since the Triton Knoll wind farm decision, no additional projects have received consent that would directly impact the Greater Wash SPA and it is considered unlikely that any future developments would be sited close enough to the coast to directly impact the SPA during the same time frame as cable installation for Norfolk Vanguard. The only future wind farm development in the former East Anglia zone which is expected to have a cable route which cross the Greater Wash SPA is the Norfolk Boreas Wind Farm, but cable installation for this project will almost certainly not overlap with that for Norfolk Vanguard. Therefore, it can be **concluded that there will be no adverse effect on the integrity of the Greater Wash SPA from impacts on red-throated diver due to the proposed Norfolk Vanguard project in-combination with other projects**.

6.3.4. Summary of Potential Effects

273. Following screening, three SPAs and five features were identified for further assessment for the proposed Norfolk Vanguard project on the basis of potential impacts either alone or in-combination with other plans or projects (Table 6.8).

Table 6.8 SPAs and features for which further assessment was required in relation to potential impacts from the proposed Norfolk Vanguard project alone or in-combination with other plans and projects

SPA	Feature	Potential impact
Alde-Ore Estuary	Lesser black-backed gull	Collision risk
Flamborough and Filey Coast (proposed)	Gannet	Collision risk
	Kittiwake	Collision risk
Greater Wash	Red-throated diver	Construction disturbance and displacement due to cable laying (project alone and in-combination)
	Little gull	Collision risk

274. A full assessment was undertaken for all the sites and features listed in Table 6.9. The assessment considered that there was **no likelihood of an adverse effect on integrity being concluded for any site or feature in an Appropriate Assessment**. The results of the assessment are summarised in Table 6.9.

Table 6.9 Conclusions of the full assessment

SPA	Feature	Potential impact	Conclusion
Alde-Ore Estuary	Lesser black-backed gull	**In-combination collision risk** The in-combination mortality attributable to the Alde-Ore SPA population is a precautionary figure of 35 individuals, which represents an increase in mortality of 3.7% over natural mortality. Since annual mortality at the proposed Norfolk Vanguard project is estimated to be fewer than 6 individuals, even if it is concluded that there will be an adverse effect on the integrity of the SPA due to in-combination collision mortality it is clear that the contribution of the proposed Norfolk Vanguard project is such that, in the light of the site's conservation objectives there will be no adverse effect on the integrity of the Alde-Ore Estuary SPA from impacts on lesser black-backed gull due to the Norfolk Vanguard project in-combination with other projects.	**Project alone and in-combination: No AEoI**
Flamborough and Filey Coast	Gannet	**In-combination collision risk** The number of predicted in-combination gannet collisions attributed to the Flamborough & Filey Coast pSPA is a precautionary 196 which remains below the sustainable levels estimated using potential biological removal and is not at a level which would trigger a risk of population decline. Furthermore, the impact on the Flamborough and Filey Coast pSPA gannet population resulting from in-combination collisions is below the thresholds of concern proposed for recently consented developments, and population modelling indicates that the precautionary estimates of collision numbers would lead to reduced rate of population increase rather than a decline in numbers.	**Project alone and in-combination: No AEoI**

SPA	Feature	Potential impact	Conclusion
		Therefore, it can be concluded that there will be no adverse effect on the integrity of Flamborough & Filey Coast pSPA from impacts on gannet due to the proposed Norfolk Vanguard project in-combination with other projects.	
	Kittiwake	**In-combination collision risk** The number of predicted in-combination kittiwake collisions attributed to the Flamborough & Filey Coast pSPA is 377 which remains below the sustainable levels estimated using PBR and on the basis of population modelling is not at a level which would trigger a risk of significant population decline. The impact on the Flamborough and Filey Coast pSPA kittiwake population resulting from in-combination collisions is below the thresholds of concern proposed for recently consented developments and furthermore the contribution to the in-combination total deriving from the proposed Norfolk Vanguard project is such that, in the light of the site's conservation objectives, there would be no adverse effect on the integrity of Flamborough & Filey Coast pSPA from impacts on kittiwake due to the proposed Norfolk Vanguard project in-combination with other projects.	**Project alone and in-combination: No AEoI**
Greater Wash	Red-throated diver	**Project alone** At a predicted maximum mortality level of 4 birds for the proposed Norfolk Vanguard project, it can be concluded with confidence for red-throated diver that there will be no adverse effect on the integrity of the Greater Wash SPA.	**No AEoI**
		In-combination At a predicted maximum mortality level of 4, the potential for the proposed Norfolk Vanguard project to contribute to an in-combination impact on the red-throated diver population of the Greater Wash pSPA is also considered to be such that, in the light of the site's conservation objectives, there would be no adverse effect on the integrity of the Greater Wash SPA from impacts on red-throated diver due to the proposed Norfolk Vanguard project in-combination with other projects.	**No AEoI**
	Little gull	**Project alone** The predicted mortality of little gull associated with the Greater Wash SPA is less than 1 (0.3). This would have no effect on the SPA population. **In-combination** Norfolk Vanguard has virtually no effect on the little gull population of the Greater Wash SPA and therefore the project's potential to contribute to an in-combination effect can be excluded.	**Project alone and in-combination: No AEoI**

7. OFFSHORE SAC ANNEX I HABITATS

7.1. Baseline/Current Conservation Status

275. The following sections provide an overview of the relevant baseline information and current conservation status for the sites designated features screened into the HRA:

- Sandbanks; and
- *S. spinulosa* reefs.

276. Further details on the baseline information for these habitats are also provided in the Norfolk Vanguard HRA Offshore Screening Report (Appendix 5.1), Chapters 9 and 10 of the ES (Document 6.1), the Fugro Environmental Investigation Report Norfolk Vanguard Benthic Characterisation Report (Appendix 10.1 of the ES), the ABPmer Norfolk Vanguard and Norfolk Boreas Export Cable Route Sandwave Bed Levelling Report (Appendix 7.1) the Envision Mapping Norfolk Vanguard and Norfolk Boreas *Sabellaria* Review (Appendix 7.2).

7.1.1. Sandbanks

277. The Haisborough sand bank system comprises a series of north-west to south-east oriented en-echelon (approximately parallel to the coast) alternating ridge headland associated sandbanks, which have evolved over the last 5,000 years in response to shoreline recession and sea-level rise (Cooper *et al.,* 2008). The sand bank system consists of: Haisborough Sand, Haisborough Tail, Hammond Knoll, Winterton Ridge and Hearty Knoll (Figure 7.1). These sandbank features are a primary reason for the designation of the Haisborough, Hammond and Winterton SAC (JNCC and Natural England, 2010). The offshore cable corridor for Norfolk Vanguard passes through the southern end of this sand bank system (Figure 7.1).

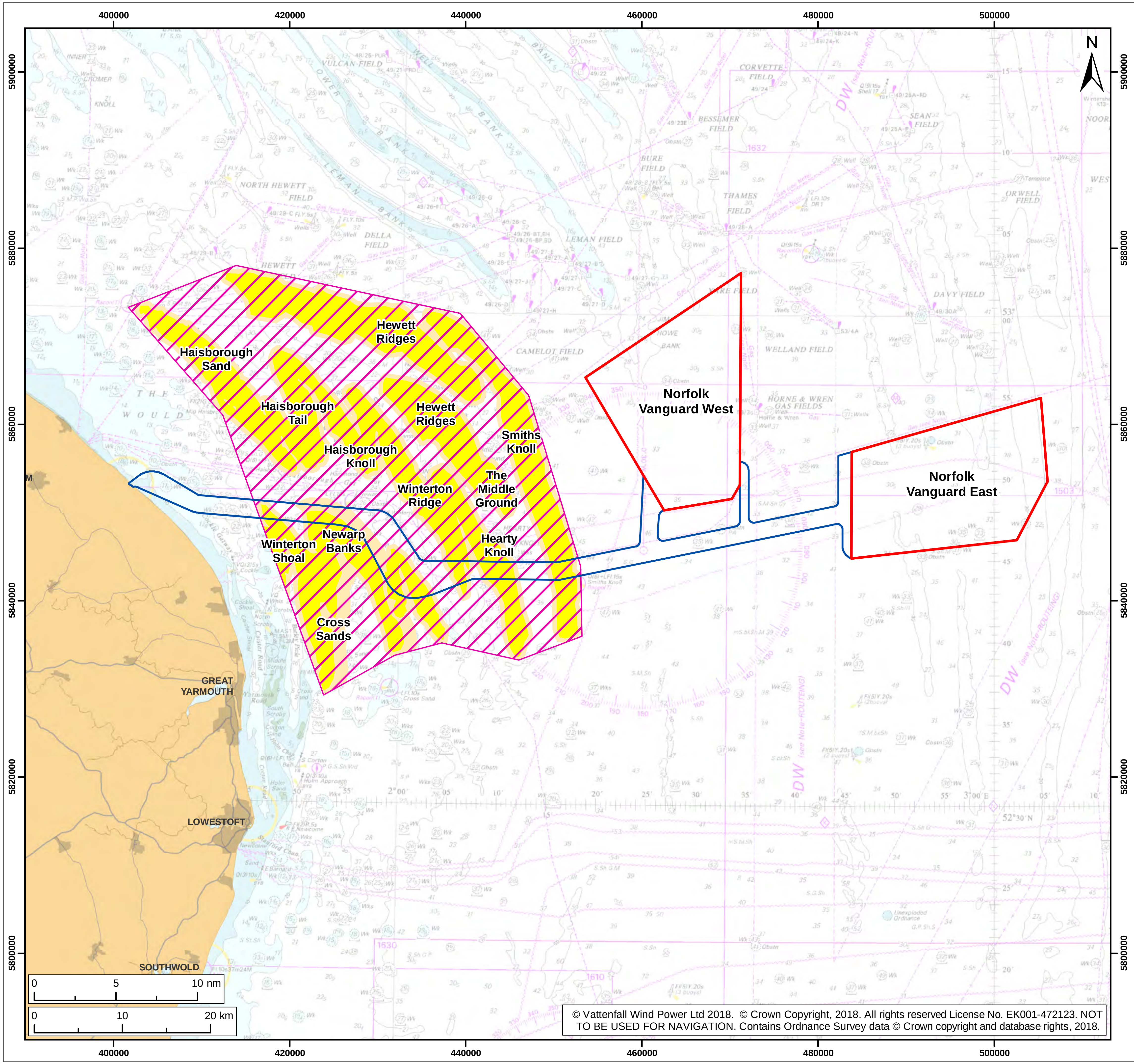
278. Water depths within the Haisborough, Hammond and Winterton SAC range between approximately 12m and 51.8m Lowest Astronomical Tide (LAT). Approximately two thirds of the sandbank habitat occurs in more than 20m water depth. The summits of the sandbanks are in water shallower than 20m LAT; however, the flanks of the sandbanks extend into waters up to 40m LAT deep (Appendix 7.1). Although the Annex I qualifying habitat is Sandbanks which are ‘slightly’ covered by seawater all the time, indicating shallow sandbanks only, those sandbanks in water depths greater than 20m are also considered to fall within the Annex I criteria of the Haisborough, Hammond and Winterton SAC.

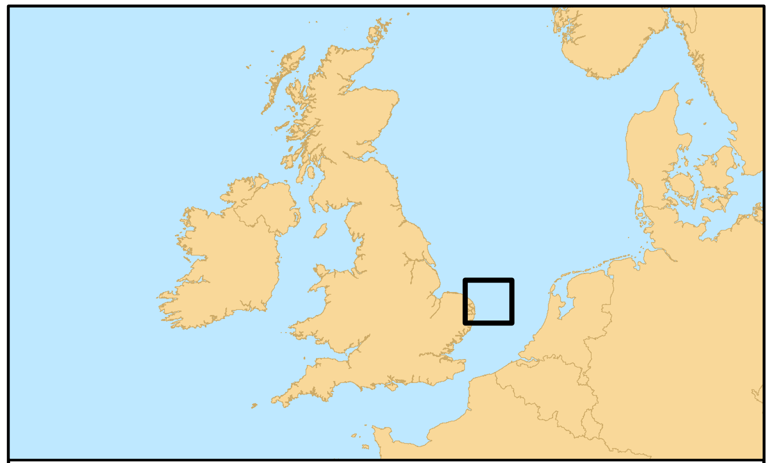
279. Areas of the seabed permanently submerged and rising to a depth of less than 20m LAT were recorded within the offshore cable corridor (Fugro, 2016 Benthic

Characterisation Report, Appendix 10.1 of the ES). These form part of the Annex I Sandbanks known to occur within the Haisborough, Hammond and Winterton SAC.

280. A number of tidally aligned sandwaves are superimposed on the sandbanks in proximity to the cable corridor and along the flanks. The sandwaves range between 50m to 200m in wavelength and 3m to 7m in height (Appendix 7.1).

281. At the time of identifying the site as an SCI in 2010, Annex I sandbank habitat occupied a maximum area of 66,900ha of the Haisborough, Hammond and Winterton SAC. This is equivalent to 0.84% of the UK total Annex I sandbank resource (Natura 2000, 2015).





Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]

Annex 1 Sandbanks[2]

- Annex 1 Sandbank Area
- Potential Annex 1 Sandbank

[1] JNCC, 2017.
[2] JNCC, 2016.

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title:

Annex I Sandbanks in the Haisborough Hammond and Winterton SAC

Figure: 7.1 Drawing No: PB4476-006-001-019

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
04	30/05/18	BH	GK	A3	1:425,000
03	25/05/18	NJ	GK	A3	1:425,000

Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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7.1.1.1. Bedload sediment transport

282. ABPmer has undertaken an assessment of sandwave bed levelling within the Norfolk Vanguard and Norfolk Boreas offshore cable corridor which includes a review of baseline conditions (Appendix 7.1). Further information on bedload and suspended sediment transport can be found within this appendix.

283. Key driving mechanisms for the formation and maintenance of the sandbanks include tidal currents, waves and sea-level change, whilst sediment transport (supply to/loss from) is also important in enabling growth or decay of sandbanks. Morphological change of the Haisborough sand bank system and their interconnecting seabed was analysed by Burningham and French (2016) using historical charts from six distinct time periods; 1840s, 1880s, 1910s, 1930s, 1950s and 1990s. The results show that the gross morphology of the banks has remained relatively consistent over the 160-year period, indicating that on a macro scale the system is relatively stable. However, net change of seabed bathymetry describes erosion and accretion around the banks with a dominance of erosion over the wider seabed.

284. The patterns of erosion and accretion around Haisborough Sand describe a small clockwise rotation (accretion at its north-east and south-west ends with associated erosion on the opposite sides of the bank from the accretion) of its along-bank orientation. The southern part of the bank has moved shoreward and the northern part has moved seaward by similar average rates of 9m/year over 160 years (Burningham and French, 2016).

285. The analysis of Burningham and French (2016) shows that Haisborough Sand is an active and very dynamic feature, with historic large-scale natural changes having occurred over decadal periods.

7.1.1.2. Suspended sediment transport

286. Suspended sediment concentrations across Norfolk Vanguard could range from 1 to 35mg/l. During the Land Ocean Interaction Study (NERC, 2016), measurements in the vicinity of Norfolk Vanguard recorded a maximum concentration of 83mg/l, but a mean value of only 15mg/l during an 18-month deployment.

287. Eisma and Kalf (1987) carried out a water sampling programme in the North Sea in January 1980 and differentiated general surface concentrations from bottom concentrations. They showed that in the vicinity of Norfolk Vanguard, the concentrations were similar at both elevations, ranging from 5 to 10mg/l.

288. Measurements of suspended sediment concentrations were carried out at the Acoustic Wave and Current Meter (AWAC) station in NV East between December

2012 and December 2013. Overall, suspended sediment concentrations (SSC) were between 0.3 and 108mg/l throughout that year. Concentrations were less than 30mg/l for 95% of the time and less than 10mg/l for 70% of the time.

7.1.1.3. Conservation status

289. The Annex I sandbank feature of the Haisborough, Hammond and Winterton SAC is graded B (good conservation value) (JNCC and Natural England, 2010).

7.1.2. Sabellaria spinulosa

7.1.2.1. *S. spinulosa* biology and habitat preferences

290. *S. spinulosa* is a tube-dwelling polychaete worm which under certain conditions can form biogenic reefs. It is found globally and is common on exposed, open coasts where there is sand available for tube building (Jackson and Hiscock, 2008). *S. spinulosa* is widely distributed throughout UK waters and can form dense aggregations on the seabed, which can take the form of crusts or reef where aggregations are up to several metres across and up to 60cm in depth (Gubbay, 2007).

291. *S. spinulosa* is an R-strategist, a life strategy which involves a high rate of reproduction in order to live in unstable environments (Jackson and Hiscock, 2008). *S. spinulosa* occurs in high densities in subtidal environments that are disturbed regularly (ideally approximately every 1 to 3 years) due to storms and in polluted conditions (Jackson and Hiscock, 2008).

292. Biogenic reefs stabilise sediments, provide hard substrata for attachment of sessile organisms, provide crevices and surfaces for colonisation, and provide an important food source for other organisms through accumulation of faeces, pseudofaeces and sediments (JNCC and Natural England, 2013). As a result, several studies have found there to be a very rich flora and fauna associated with *S. spinulosa* reefs, which is often more diverse and richer than surrounding areas, with even relatively sparse areas of the tube worm strongly influencing community structure (Holt *et al.,* 1998).

7.1.2.2. *S. spinulosa* in the Haisborough, Hammond and Winterton SAC

293. At the time of identifying the site as an SCI in 2010, the total mapped extent of *S. spinulosa* reef within the SAC was reported as 88.06ha (Natura 2000, 2015).

294. During the East Coast Regional Environmental Characterisation (REC) (Limpenny *et al.,* 2011), *S. spinulosa* was found to be the most numerous macrofaunal species, with the SAC hosting moderately dense aggregations of *S. spinulosa*.

295. *S. spinulosa* reefs within the SAC have been reported by JNCC (2018) at Haisborough Tail, Haisborough Gat and between Winterton Ridge and Hewett Ridge which are

located outside the Norfolk Vanguard offshore project area. Areas within the Haisborough Tail and Winterton Ridge features (Appendix 7.1, Figure 2) were classified under a byelaw in 2013 (MMO, 2014), resulting in the closure of these areas to bottom towed fishing gear in order to protect *S. spinulosa* reef. The combined area of these byelaw areas is 0.91km^2 (91ha).

296. JNCC, Natural England, Cefas and the Environment Agency conducted a survey of the SAC in 2016 (McIlwaine *et al.,* 2017). The survey included determining the presence and condition of *S. spinulosa* reef in specific areas within the SAC, including around Haisborough Tail, Haisborough Gat and an area towards the south west of the SAC. In Appendix 7.2 of this HRA Report, Envision Mapping has reviewed and used the available data to inform the study but since this data has not been finalised were not used within the mapping process. McIlwaine *et al.* (2017) recorded reef around Haisborough Tail and in the south west, slightly outside the SAC boundary. *S. spinulosa* in non-reef form was recorded around Haisborough Gat, to the north of the Norfolk Vanguard offshore cable corridor (see Appendix 7.2, Figures 6 and 8).

297. A survey campaign (Fugro, 2016), including geophysical, drop down video and grab sampling of the proposed cable corridor for Norfolk Vanguard identified potential areas where *S. spinulosa* on stable circalittoral mixed sediment (biotope SS.SBR.PoR.SspiMx) may be present within the offshore cable corridor (see Appendix 7.2, Figure 6 and 8). Further analysis of the Fugro (2016) survey data and other available data sources by Envision Mapping (see Appendix 7.2) has identified the likely extent of *S. spinulosa* reef within the offshore cable corridor (Figure 7.2). The area of reef that has been identified with moderate to high confidence (Figure 7.2) within the section of the offshore cable corridor which overlaps with the SAC is estimated to be approximately 8.37km^2.

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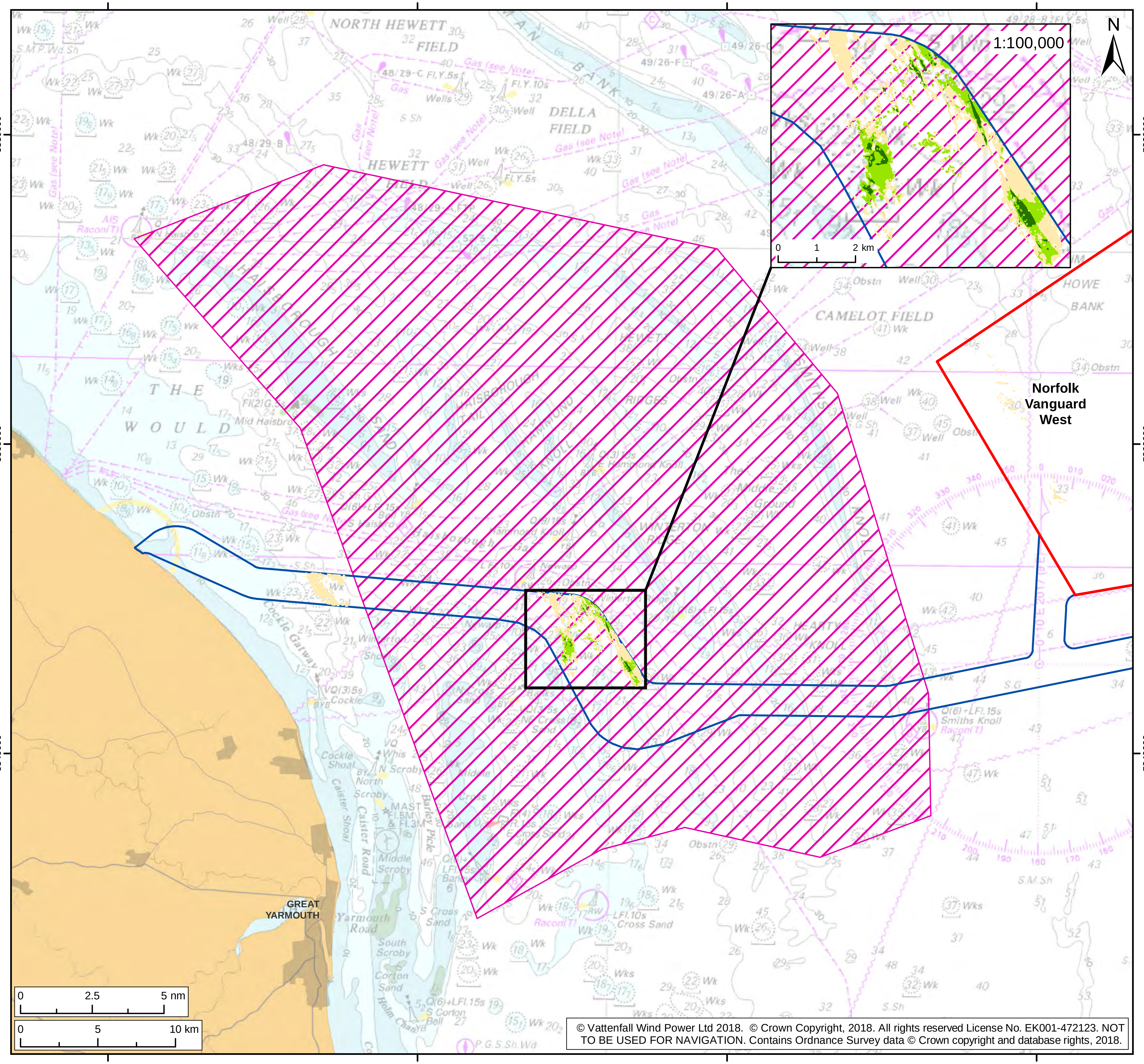

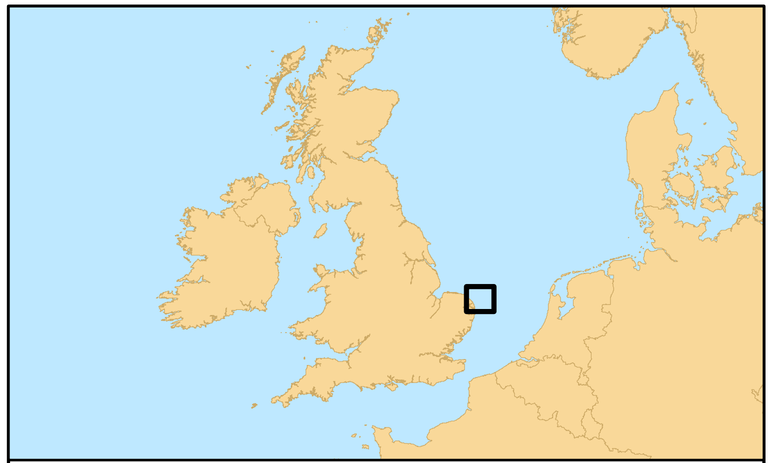

Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]

Reef Extent Confidence[2]

- 3 - Moderate
- 4
- 5 - Highest

[1] JNCC, 2017
[2] Envision, 2018

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title:

Annex I Reef identified in the Norfolk Vanguard offshore cable corridor within the SAC (see also Appendix 7.2)

Figure: 7.2 Drawing No: PB4476-006-001-020

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
05	23/05/18	BH	GK	A3	1:250,000
04	21/05/18	BH	GK	A3	1:250,000

Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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7.1.2.3. Conservation status

298. The biological and physical structure of the reef in the Haisborough, Hammond and Winterton SAC is largely intact; however, there is evidence of trawl scars associated with the Haisborough Gat reef (JNCC and Natural England, 2010).

299. The Annex I reef feature of the Haisborough, Hammond and Winterton SAC has been graded A (excellent conservation value) (JNCC and Natural England, 2010).

7.2. Conservation Objectives

7.2.1. Overview

300. Conservation objectives are set to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring:

- The extent and distribution of qualifying natural habitats and habitats of the qualifying species;
- The structure and function (including typical species) of qualifying natural habitats;
- The structure and function of the habitats of the qualifying species;
- The supporting processes on which qualifying natural habitats and habitats of qualifying species rely;
- The population of qualifying species;
- The distribution of qualifying species within the site.

301. The Conservation Objectives for the Haisborough, Hammond and Winterton SAC is to, subject to natural change, maintain the Annex I Sandbanks which are slightly covered by seawater all the time in Favourable Condition, and maintain or restore the Annex I reefs in Favourable Condition[8].

302. 'Favourable Condition' is the term used in the UK to represent 'Favourable Conservation Status' for the interest features of SACs. For an Annex I habitat, Favourable Conservation Status occurs under the Habitats Directive when (JNCC and Natural England, 2013):

- Its natural range and area it covers within that range are stable or increasing;
- The specific structure and functions, which are necessary for its long-term maintenance, exist and are likely to continue to exist for the foreseeable future; and

[8] Restore implies that the Reef feature is degraded to some degree and that activities will have to be managed to reduce or eliminate negative impacts.

- The conservation status of its typical species is favourable.

303. Favourable condition of the sandbanks and reefs is assessed based on the long-term maintenance of the following:

- Extent of the habitat (and elevation and patchiness for reef);
- Diversity of the habitat;
- Community structure of the habitat (population structure of individual species and their contribution to the functioning of the habitat); and
- Natural environmental quality (e.g. water quality, suspended sediment levels).

7.2.2. Management Measures

304. The management status of the Haisborough, Hammond and Winterton SAC is currently '*Progressing towards being well managed*'. JNCC consider well-managed to mean the progress within the MPA management cycle, which includes:

- Documentation of appropriate management information;
- Implementation of management measures;
- Site condition monitoring programmes; and
- Assessment of progress towards conservation objectives.

305. The management measures (regulatory and voluntary) that are currently in place to either directly or indirectly help to protect the features of the SAC are all related to Inshore Fisheries Conservation Authority and MMO byelaws (as described in Section 7.1.2.2); however, additional management measures are being collated and will be published in future (Natural England, 2017).

306. Although no specific management measures are in place for activities related to Norfolk Vanguard, JNCC and Natural England have prepared joint formal conservation advice for the SAC (JNCC and Natural England, 2013), which identifies six pressure categories which may cause deterioration of natural habitats within SACs, either alone or in combination (and thus affect Favourable Condition). These have been identified as:

- Physical loss;
- Physical damage;
- Non-physical disturbance;
- Toxic contamination;
- Non-toxic-contamination[9]; and
- Biological disturbance[10].

[9] For some sites this includes changes in nutrient and / or organic enrichment and / or in salinity.

307. Natural England has identified large areas within or close to the Haisborough, Hammond and Winterton SAC which are to be managed as *S. spinulosa* reef (Figure 1 of Appendix 7.2).

308. The sensitivity, exposure and vulnerability of Annex I Sandbank features (and supporting sub-features) of the Haisborough, Hammond and Winterton SAC to the above pressures is provided in Table 7.1.

Table 7.1. Sensitivity, exposure and vulnerability of Annex I Sandbank features (JNCC and Natural England, 2013)

	Sensitivity	Current Exposure	Vulnerability
Physical loss			
Removal	Moderate	Low	Low
Obstruction	High	Low	Moderate
Smothering	Low	Low	Low
Physical damage			
Changes in suspended sediment	Low	Low	Low
Surface abrasion (<25mm)	Low	Low	Low
Shallow abrasion (<25mm)	Low	Low	Low
Non-physical disturbance			
Noise	None	Unknown	None detectable
Visual presence	None	None	None detectable
Toxic contamination			
Introduction of synthetic compounds	Low	Low	Low
Introduction of non-synthetic compounds	Low	Low	Low
Introduction of radio-nuclides	Insufficient information	Unknown	Insufficient information
Non-toxic contamination			
Changes in nutrient loading	Low	None	None
Changes in organic loading	Low	None	None
Changes in thermal regime	Low	None	None
Changes in turbidity	Low	Low	Low
Changes in salinity	Moderate	None	None
Biological disturbance			
Introduction of microbial pathogens	Low	Unknown	Insufficient information
Introduction of non-native species and translocation	None	Unknown	None
Selective extraction of species	Moderate	Unknown	Vulnerability identified but not quantified

309. The sensitivity, exposure and vulnerability of Annex I Reef features (and supporting sub-features) of the Haisborough, Hammond and Winterton SAC to the above pressures is provided in Table 7.2.

[10] For some sites this includes the introduction of non-native species and / or the selective extraction of species.

Table 7.2. Sensitivity, exposure and vulnerability of Annex I Reef features (JNCC and Natural England, 2013)

	Sensitivity	Current Exposure	Vulnerability
Physical loss			
Removal	High	None	None
Obstruction*	High	Moderate	High
Smothering	None	None	None
Physical damage			
Changes in suspended sediment	None	Low	None detectable
Surface abrasion (<25mm)	High	Low	Moderate
Shallow abrasion (<25mm)	High	Low	Moderate
Non-physical disturbance			
Noise	None	Unknown	Insufficient information
Visual presence	None	None	None detectable
Toxic contamination			
Introduction of synthetic compounds	Low	Low	None
Introduction of non-synthetic compounds	Low	Low	None
Introduction of radio-nuclides	None	Unknown	None
Non-toxic contamination			
Changes in nutrient loading	None	None	None
Changes in organic loading	None	None	None
Changes in thermal regime	None	None	None
Changes in turbidity	None	Low	Low
Changes in salinity	Low	None	None
Biological disturbance			
Introduction of microbial pathogens	None	Unknown	None
Introduction of non-native species and translocation	None	Unknown	None
Selective extraction of species	Moderate	Unknown	Vulnerability identified but not quantified

* e.g. permanent constructions (oil & gas infrastructure, windfarms, cables & wrecks)

7.3. Assessment Scenarios

310. The detailed design of Norfolk Vanguard (e.g. exact cable routes within the offshore cable corridor and the requirement for cable protection) has not yet been determined and will not be known until pre-construction surveys have taken place after the DCO has been granted. Therefore, realistic worst case scenarios in relation to effects on the Haisborough, Hammond and Winterton SAC are adopted which have been informed by a number of engineering studies undertaken or commissioned by Norfolk Vanguard Limited.

7.3.1. Embedded mitigation

311. This section describes various decisions by Norfolk Vanguard Limited which have been built in to the project design in order to mitigate potential effects on the Haisborough, Hammond and Winterton SAC.

7.3.1.1. Minimising export cabling

312. Norfolk Vanguard Limited has taken the decision to use an HVDC solution in order to reduce the number of cables and cable protection. This results in the following mitigating features:

- There will be two cable trenches instead of six for Norfolk Vanguard (and the same for Norfolk Boreas);
- The volume of sediment arising from pre-sweeping and cable installation works is reduced;
- The area of disturbance for pre-sweeping and cable installation is reduced;
- The space required for cable installation is reduced, increasing the space available within the cable corridor for micrositing;
- The potential requirement for cable protection in the unlikely event that cables cannot be buried is reduced; and
- The number of export cables required to cross existing cables and pipelines and the associated cable protection is reduced.

7.3.1.2. Pre-construction survey

313. A pre-construction survey would be undertaken in advance of any cable installation works. The methodology for the pre-construction surveys would be agreed with the relevant SNCBs. The results of this survey would be used to plan the routing of all Norfolk Vanguard cables including micrositing where possible. The routes would then be discussed and agreed with the relevant SNCBs.

7.3.1.2.1. Micrositing

314. As discussed above, should important seabed features or obstacles (e.g. Annex 1 reef and Unexploded Ordnance (UXO)) be identified on the proposed cable routes during the pre-construction surveys, micrositing will be undertaken where possible, to minimise potential impacts.

315. Norfolk Vanguard Limited commissioned a Cable Constructability Assessment by Global Marine Systems Ltd (GMSL, 2016 unpublished, provided in Appendix 4.2 of the ES) to determine an appropriate cable corridor (a combined corridor for Norfolk Vanguard and Norfolk Boreas). This includes a contingency (shown in Plate 7-1) in order to allow micrositing around seabed obstacles (e.g. Annex 1 reef).

316. The space available for micrositing within the offshore cable corridor where it overlaps with the SAC is approximately 1.05km along most of the route (2km corridor width), with up to 3.75km of micrositing available in the ‘dog-leg’ area (4.7km corridor width). This takes into account the space required for Norfolk Boreas export cables. This HRA is for Norfolk Vanguard alone, however the worst case

scenario for space availability within the cable corridor must take account of Norfolk Boreas. Norfolk Boreas will be considered further in the in-combination assessment. The space available for micrositing is based on the following:

- Up to four export cable trenches (four cables in 2 trenches for Norfolk Vanguard and four cables in two trenches for Norfolk Boreas) with spacing as shown in Plate 7-1[11];
- The cable corridor is typically 2km in width, with a wider section of up to 4.7km where there is a dog-leg in the corridor within the SAC;
- A total width of approximately 1.35km is required for Norfolk Vanguard and Norfolk Boreas; which includes up to four cables for each project, a contingency of 440m (0.4km), an anchor placement zone, and a buffer for potential anchor placement and cable replacement works (GMSL, 2016 unpublished; Plate 7-1); and
- The remaining width of the offshore cable corridor within the SAC is therefore approximately 0.65km to 3.35km plus the built-in contingency of 0.4km, resulting in approximately 1.05km to 3.75km available for micrositing.

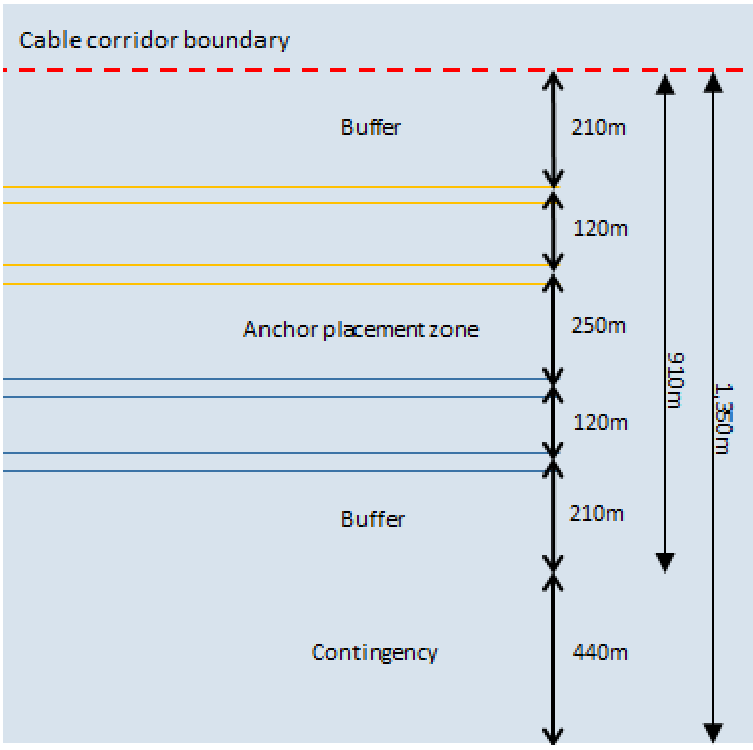

Plate 7-1 Export cables layout (two pairs of cables for Norfolk Vanguard (yellow) and two pairs of cables for Norfolk Boreas (blue)) based on 48m water depth[12]

[11] This HRA is for Norfolk Vanguard alone, however the worst case scenario for space availability within the cable corridor must take account of the space required for Norfolk Boreas export cables. Norfolk Boreas will be considered further in the in-combination assessment.

7.3.1.3. Minimising cable protection

317. Norfolk Vanguard Limited is committed to burying offshore export cables where possible, therefore reducing the need for surface cable protection. A detailed export cable installation study (CWind 2017 unpublished, provided in Appendix 5.1 of the ES) was commissioned by Norfolk Vanguard Limited which confirmed that cable burial is expected to be possible throughout the offshore cable corridor, with the exception of cable and pipeline crossing locations.

318. The exact method for cable crossings will be subject to crossings agreements however worst case scenario cable protection is described in Section 7.3.2.2.5.

7.3.1.3.1. Sand wave levelling

319. The option of sand wave levelling (pre-sweeping) to a stable reference seabed level would reduce the potential that cables become unburied over the life of the project. CWind (2017 unpublished) analysed geophysical survey data of the offshore cable corridor to determine areas of sand waves which could require levelling and the depth of the reference level (variable throughout the corridor) in order to calculate the total volume of sediment associated with pre-sweeping (discussed in Section 7.3.2.2.1). If pre-sweeping is used this would reduce the likelihood of any cables becoming unburied and therefore avoid the potential requirement for additional cable protection during O&M.

7.3.1.3.2. Cable protection contingency

320. While it is expected that cable burial will be possible throughout the offshore cable corridor, a contingency for cable protection requirement is discussed in section 7.3.2.2.5 in order to provide a conservative and future proofed assessment.

321. As previously discussed, analysis of geophysical data has shown that the substrate along the entire offshore cable corridor, including the section within the SAC, is expected to be suitable for cable burial. In the unlikely event that burial is not possible, this would be because hard substrate is encountered, in which case the seabed where cable protection would be placed would not be Annex 1 Sandbank.

322. Cable protection would also be required where Norfolk Vanguard cables cross other cables or pipelines (see section 7.3.2.2.5).

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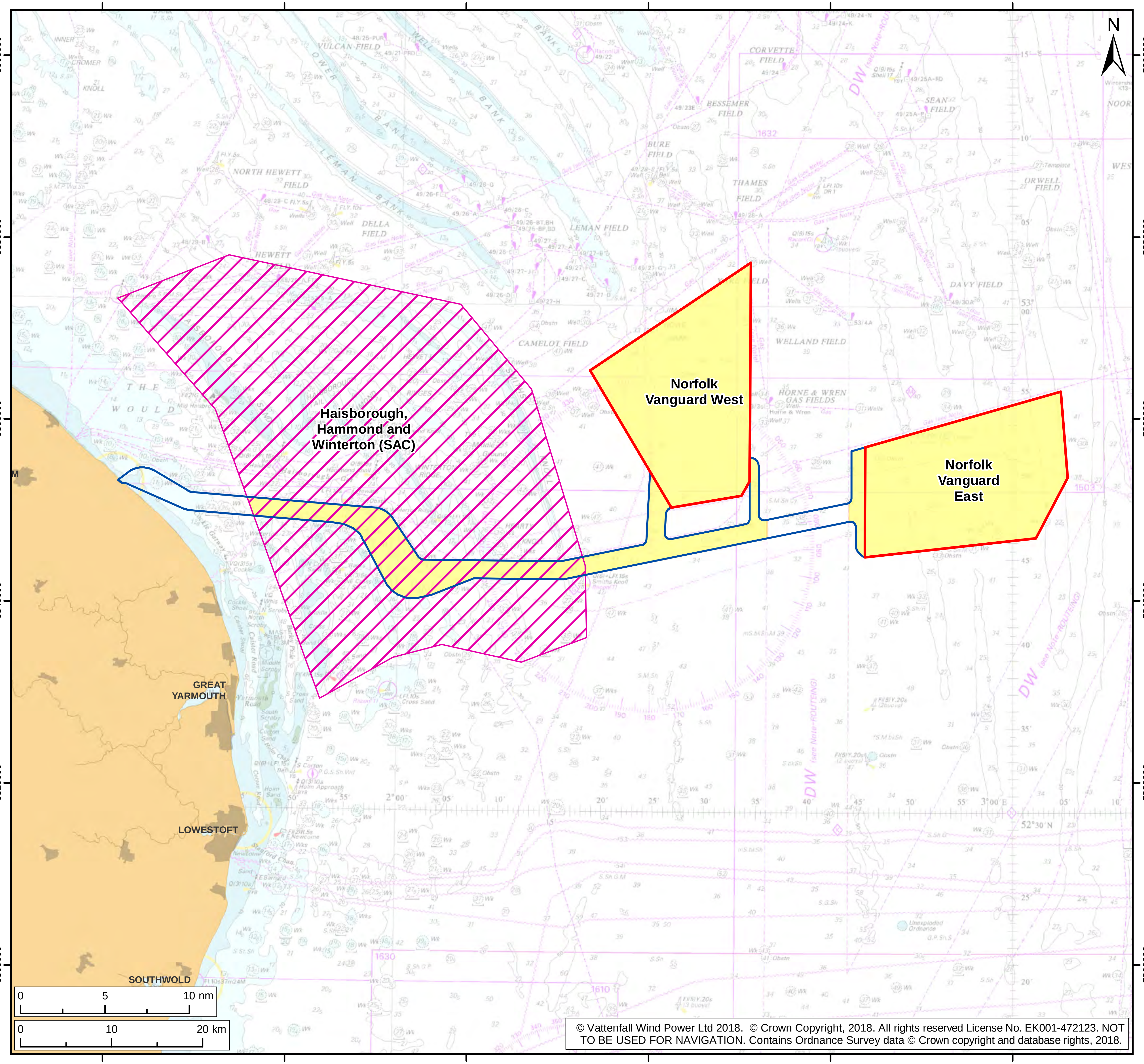
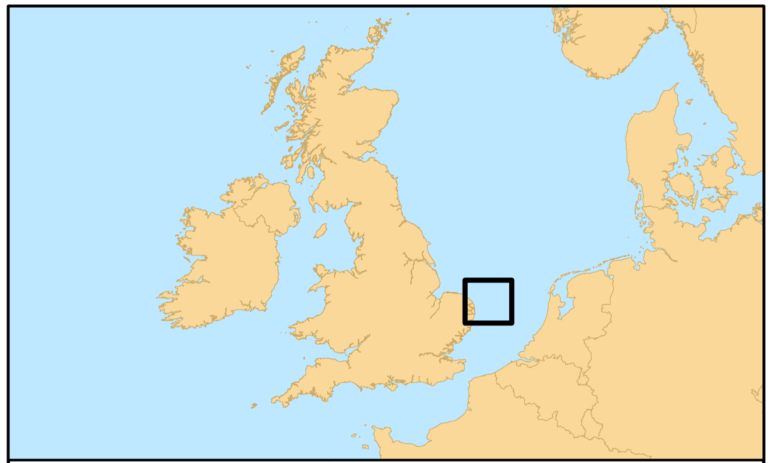
[12] The separation between cables is determined by the potential space required to undertake a cable repair which is a factor of the water depth. Depth in the SAC is less than 48m and therefore this represents a conservative worst case scenario

7.3.1.4. Sediment disposal

323. All seabed material arising from the Haisborough, Hammond and Winterton SAC during cable installation would be placed back into the SAC (Figure 7.3) using an approach, to be agreed with the relevant SNCBs, which would ensure that the sediment is available to replenish the sandbank features (see Appendix 7.1).

324. Sediment would not be disposed of within 100m of *Sabellaria* reef in accordance with advice from Natural England (Expert Topic Group meeting 31st January 2018).





Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Special Area of Conservation
- Disposal site

[1] JNCC, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title:

Disposal site

Figure: 7.3 | Drawing No: PB4476-006-001-021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
03	25/05/18	NJ	GK	A3	1:425,000
02	21/02/18	NJ	GK	A3	1:425,000

Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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7.3.2. Worst Case Scenario

325. The following sections provide an overview of the parameters which are of relevance to the assessment of effects associated with Norfolk Vanguard on the Haisborough, Hammond and Winterton SAC. A summary of the worst case scenario is provided in Table 7.4. It should be noted that certain elements of the worst case scenario would not be encountered together, for example the worst case scenario footprint during cable installation takes into account pre-sweeping of the sand waves to install the cables at a reference seabed level, whereas the worst case scenario in relation to reburial during O&M relates to no pre-sweeping having taken place during cable installation. Where applicable, this is outlined in Table 7.4.

7.3.2.1. Construction programme and phasing

326. Norfolk Vanguard Limited is currently considering constructing the proposed project in the following phase options of up to 1800MW total export capacity.

- A single phase (four export cables in two trenches); or
- Two 900MW phases (two export cables in one trench per phase).

327. The indicative programme for offshore construction of up to 1800MW is expected to be up to 4 years depending on the time between commencements of phases. Within this construction window, laying of the offshore export cables is expected to take around six months under the single phase, or three months per phase under if constructed in two phases.

328. The maximum infrastructure parameters are the same for each phased scenario. Phasing is therefore only applicable to the assessment of construction and decommissioning impacts and not the assessment of impacts during the O&M phase.

7.3.2.2. Cable installation footprints

7.3.2.2.1. Pre-installation works

Boulder clearance

329. Pre-construction surveys will also identify any requirement for boulder clearance within the SAC. Norfolk Vanguard Limited has reviewed the 2016 survey data and, given a low proportion of boulders in the area, it is likely that micrositing around boulders will be possible however an allowance for clearing 22 boulders of up to 5m in diameter has been included in the assessment in order to be conservative. Boulders would be relocated within the offshore cable corridor boundary, outside the route of the cable installation.

Pre-lay grapnel run

330. A pre-lay grapnel run would be undertaken to clear any identified debris in advance of each phase of installation. The maximum width of seabed disturbance along the pre-grapnel run would be 20m. This is encompassed by the maximum footprint of cable installation works associated with ploughing (30m disturbance width).

Pre-sweeping

331. The potential for sand wave levelling (pre-sweeping) has been assessed as a potential strategy for cable installation to ensure the cables are installed at a depth below the seabed surface that is unlikely to require reburial throughout the life of the project. A final decision on this would be made after the DCO application has been determined, and the approach would be detailed in the Cable Specification, Installation and Monitoring Plan (as required under [condition 14(1)(g)] of the Deemed Marine Licence (DML), based on information from pre-construction surveys and final design.

332. Indicative pre-sweeping volumes and areas for the offshore cable corridor are outlined in Table 7.3. The sediment released at any one time would be subject to the capacity of the dredger. The maximum width of pre-sweeping in the offshore cable corridor would be approximately 37m depending on the depth of sand waves[13]. This would be in discrete areas and not along the full length of the corridor. It is assumed that approximately 80% of the pre-sweeping area[14] shown in Table 7.3 would overlap with the 30m ploughing disturbance area as a worst case scenario, resulting in 50,000m^2 pre-sweeping footprint to be added to the trenching footprint when calculating the total disturbance footprint for cable installation (see Table 7.4).

333. Sediment arising from pre-sweeping in the Haisborough, Hammond and Winterton SAC would be disposed of in an area within the section of the offshore cable corridor overlapping the SAC. The exact location(s) for disposal of sediment would be determined in consultation with the MMO and relevant SNCBs following the pre-construction surveys.

Table 7.3 Parameters for pre-sweeping activity within the section of offshore cable corridor within the Haisborough, Hammond and Winterton SAC (CWind, 2017 unpublished)

Parameter	Max. quantity for the section of export corridor within the Haisborough, Hammond and Winterton SAC
Volume of material to be moved	
Per trench (pair of export cables) (m^3)	250,000

[13] 37m pre-sweeping width is based on sand wave depth of approximately 5m with a slope gradient of 1:3 and a width of 7m at the base of the dredged area.

[14] Based on the 30m proportion of the maximum 37m pre-sweep width that would be overlapping the ploughing footprint

Parameter	Max. quantity for the section of export corridor within the Haisborough, Hammond and Winterton SAC
Total for two trenches (m^3)	500,000
Area of pre-sweeping	
Per trench (pair of export cables) (m^2)	125,000
Total for two trenches (m^2)	250,000

7.3.2.2.2. Removal of existing disused cables

334. There are seven out of service cables in the SAC:

- Four are intact and span the offshore cable corridor; it is assumed that these will be crossed subject to agreement with the cable owners;
- Two appear to have been cut previously and stop within the offshore cable corridor; it is proposed that these will be further cut subject to agreement with the cable owners and clump weights of approximately $5m^2$ will be placed on the cut ends; and
- One enters and exits the southern edge of the corridor which will be avoided where possible.

7.3.2.2.3. Cable burial

335. Following the pre-lay works described above, the cables would be installed and buried. The method used for cable burial would be dependent on the results of the pre-construction survey and post-consent procurement of the cable installation contractor. The following options are considered in the assessment and described in Annex A:

- Ploughing (worst case scenario disturbance width of 30m);
- Trenching or cutting; or
- Jetting.

336. The length of the offshore cable corridor within the SAC is approximately 40km and therefore the total length of trenches would be 80km based on two trenches (each with a pair of cables).

7.3.2.2.4. Anchor placement

337. Anchor placement may be required during jointing of the offshore export cable, as a worst case scenario it is estimated that there may be one joint per cable pair in the SAC. The seabed footprint associated with anchor placement would be approximately $150m^2$ (based on 6 anchors per vessel) resulting in a total anchoring footprint in the SAC of $300m^2$.

7.3.2.2.5. *Cable protection*

Unburied cable

338. As discussed in section 7.3.1, cable burial is expected to be possible throughout the offshore cable corridor with the exception of cable crossing locations. In order to provide a conservative and future-proof impact assessment, a contingency estimate of up to 4km of protection per cable (8km in total) within the SAC is included in the assessment should cable burial not be possible due to hard substrate (i.e. not Annex 1 Sandbank). The maximum width and height of cable protection for unburied cable would be 5m and 0.5m, respectively.

Crossings

339. There are up to five existing cables and one pipeline within the SAC which each Norfolk Vanguard export cables would need to cross. Each crossing would require a carefully agreed procedure between the cable owners.

340. Where each Norfolk Vanguard export cable is required to cross an obstacle such as an existing pipeline or cable, protection would be installed to protect the obstacle being crossed. Each Norfolk Vanguard cable would then be placed on top of the layer of protection with a further layer of cable protection placed on top.

341. The maximum width and length of cable protection for cable crossings would be 10m and 100m, respectively. The maximum height of cable crossings is 0.9m.

Types of cable protection

342. Cable protection options include:

- Rock placement - the laying of rocks on top of the cable;
- Concrete mattresses - prefabricated flexible concrete coverings that are laid on top of the cable. The placement of mattresses is slow and as such is only used for short sections of cable;
- Grout or sand bags - bags filled with grout or sand could be placed over the cable. This method is also generally applied on smaller scale applications;
- Frond mattresses - used to provide protection by stimulating the settlement of sediment over the cable. This method develops a sandbank over time protecting the cable but is only suitable in certain water conditions. This method may be used in close proximity to offshore structures; and
- Uraduct or similar - a protective shell which can be fixed around the cable to provide mechanical protection. Uraduct is generally used for short spans at crossings or near offshore structures where there is a high risk from falling objects. Uraduct does not provide protection from damage due to fishing trawls or anchor drags.

7.3.2.3. Maintenance of export cables

343. During the life of the project, there should be no need for scheduled repair or replacement of the subsea cables, however periodic inspection would be required and where necessary, reactive repairs and reburial would be undertaken.

7.3.2.3.1. Cable repairs

344. While it is not possible to determine the number and location of repair works that may be required during the life of the project, an estimate of one export cable repair every 10 years within the SAC is included in the assessment.

345. In most cases a failure would lead to the following operation:

- Vessel anchor placement (150m^2 footprint)
- Exposing/unburying the damaged part of the cable, assumed to be approximately 300m length subject to the nature of the repair;
- Cutting the cable;
- Lifting the cable ends to the repair vessel;
- Jointing a new segment of cable to the old cable;
- Lowering the cable (and joints) back to the seabed; and
- Cable burial, where possible.

7.3.2.3.2. Cable reburial

346. As previously discussed, cables could become exposed due to moving sand waves, however if cables are buried to the reference seabed level the likelihood of this extremely low. During the life of the project, periodic surveys would be required to ensure the cables remain buried and if they do become exposed, re-burial works would be undertaken.

347. Reburial of up to 10km per cable within the SAC at approximately 5 year intervals has been estimated based on a worst case scenario that no pre-sweeping is undertaken.

7.3.2.4. Summary of worst case scenarios

Table 7.4 Worst case scenario for offshore SAC Annex I habitats

Impact	Parameter	Rationale
Construction		
Temporary physical disturbance on: • Annex 1 Reef • Annex 1 Sandbank	Boulder clearance – 0.002km^2 (up to 100 boulders of 5m diameter) Pre-sweeping area which could be outside the area – 0.05km^2 (based on minimum overlap of pre-sweeping area and ploughing footprint as	Disturbance footprints in the offshore cable corridor due to cable laying operations

Impact	Parameter	Rationale
	described above) Sediment disposal – 7km^2 (based on maximum area described above) Cable installation - 2.4km^2 (based on maximum potential disturbance width of 30m along 80km of export cable trenching within the SAC) Anchor placement – 0.0003km^2 (based on two cable joints in the SAC, one per cable pair with a footprint of 150m^2 each, assuming up to 6 anchors per vessel) Other works associated with cable installation would be encompassed by the footprints outlined above. Therefore the total footprint for temporary disturbance on sandbanks is 9.5km^2 (0.6% of the 1468km^2 SAC area).	
Increased suspended sediment and smothering: • Annex 1 Reef	The sediment released due to disposal of pre-swept sediment in the SAC would equate to approximately 500,000m^3. The sediment released at any one time would be subject to the capacity of the dredger. Disposal would be at least 50m from Sabellaria reef identified during pre-construction surveys. The sediment released due to trenching for the offshore export cables would equate to approximately 1,200,000m^3 within the SAC (based on a worst case of up to 10m trench width with a V shaped profile x 3m maximum average depth x 2 trenches x 40km length in the SAC). This would be back filled naturally or manually.	Suspended sediment concentrations and associated sediment deposition from cable installation in the offshore cable corridor
Operation		
Temporary physical disturbance on: • Annex 1 Reef • Annex 1 Sandbank	One repair per export cable pair every 10 years is estimated within the SAC. It is estimated that 300m sections would be removed and replaced per repair. Disturbance width of 10m = 3,000m^2 (0.003km^2) per repair Anchor placement associated with repair works – 150m^2 based on 6 anchors per vessel Reburial of up to up to 10% of the cable length (4km per pair) every 5 years may be required should pre-sweeping not be undertaken. The disturbance width would be approximately 10m and therefore the total disturbance would be 80,000m^2 (0.08km^2) every 5 years or	Estimated cable repairs and reburial requirements based on Vattenfall Wind Power Ltd's (a parent company of Norfolk Vanguard Limited) experience.

Impact	Parameter	Rationale
	approximately 400,000m^2 (0.4km^2) over the indicative 25 year project life. If reburial is required, it is likely that this would be in relatively short sections (e.g. 1km) at any one time. If pre-sweeping is undertaken the requirement for cable reburial would be significantly reduced.	
Permanent habitat loss on: • Annex 1 Sandbank	Total habitat loss within the Haisborough, Hammond and Winterton SAC could be 0.05km^2 (0.003% of the 1468km^2 SAC area) based on the following: • <0.001km^2 clump weights based on cutting two existing disused cables and placing clump weights of up to 5m^2 on either end of the disused cables. • Six crossings for each of the export cable pairs (12 crossings in total) within the Haisborough, Hammond and Winterton SAC with a total footprint of 12,000m^2 in the SAC (100m length per crossing and 10m width of protection). • A contingency of up to 4km of cable protection per cable pair could be required in the Haisborough, Hammond and Winterton SAC in the unlikely event that hard substrate (i.e. not an Annex 1 feature) is encountered, resulting in a footprint of 40,000m^2 (5m width of cable protection).	Maximum potential cable protection in the SAC. Due to the commitment to avoid Sabellaria reef where possible and the known recoverability of *S. spinulosa,* no permanent loss of *Sabellaria* reef is anticipated and so this is assessed for sandbanks only.
Introduction of new substrate/colonisation of cable protection: • Annex 1 Reef • Annex 1 Sandbank	Areas as per cable protection above. Maximum volume of new substrate would be: • Crossings footprint of 12,000m^2 x height of 0.9m = 10,800m^3 • Cable protection contingency footprint of 40,000m^2 x height 0.5m = 20,000m^3.	Maximum potential cable protection in the SAC, including a contingency.
Decommissioning		
Temporary physical disturbance	Some or all of the offshore export cables may be removed. Cable protection would likely be left *in situ*.	
Increased suspended sediment and smothering: • Annex 1 Reef	The volume of sediment disturbed during decommissioning would be less than during construction due to no sandwave levelling works being required. The effects of decommissioning on suspended sediment and smothering would therefore be less than the construction.	

7.4. Assessment of Potential Effects

348. The Haisborough, Hammond and Winterton SAC overlaps with the Norfolk Vanguard offshore cable corridor (Figure 7.1) and therefore there is potential for LSE on its

designated features, Annex I Sandbanks which are slightly covered by sea water all the time and Annex 1 Reefs, during construction, O&M or decommissioning of Norfolk Vanguard. This resulted in the Haisborough, Hammond and Winterton SAC being screened into the assessment (section 5.1) through the Norfolk Vanguard HRA Offshore Screening Report (Appendix 5.1).

349. Through the EPP and specifically a meeting in January 2018, it was agreed with Natural England that the following potential effects associated with Norfolk Vanguard have the potential for LSE on the Haisborough, Hammond and Winterton SAC and therefore require further assessment:

- Temporary physical disturbance (Annex I Sandbank and Reef during construction, operation and decommissioning);
- Increased suspended sediment and smothering (Annex I Reef, during construction , maintenance and decommissioning);
- Permanent habitat loss (Annex I Sandbank, during operation); and
- Introduction of new substrate (Annex I Sandbank and Reef, during operation).

7.4.1. Sandbanks

7.4.1.1. Potential effects of Norfolk Vanguard

350. As discussed in Section 7.2, the formal Conservation Objective for the Haisborough, Hammond and Winterton SAC Annex I Sandbank feature is to, subject to natural change, maintain the Annex I Sandbanks which are slightly covered by seawater all the time in Favourable Condition, in particular the sub-features:

- Low diversity dynamic sand communities; and
- Gravelly muddy sand communities.

351. The assessment of the potential effects on the Annex I Sandbank feature is based on the following targets set by JNCC and Natural England (2013) for achieving Favourable Condition:

- No decrease in extent from established baseline, subject to natural change.
  - Consideration of changes in extent will need to take account of the dynamic nature of the sandbank.
- No alteration in topography of the sandbanks, subject to natural change.
  - The depth and distribution of the sandbanks reflects the energy conditions and stability of the sediment, which are key to the structure of the feature. However, it should be noted that subtidal sandbanks are naturally dynamic environments and sections of them may be subject to significant fluctuations in height over time, while other sections are more stable.

- Maintain distribution of dynamic and stable sand and mixed sediments, allowing for natural fluctuations. Average PSA (particle size distribution) parameters should not deviate significantly from the baseline established, subject to natural change.
  - Sediment character is key to the structure of the sandbank, and reflects the physical processes acting on it. In addition to this, the sediment character is instrumental in determining the biological communities present on the sandbank.
- Maintain the distribution of subtidal sandbank communities, subject to natural change.
  - Where a biotope is lost from a baseline known area of presence (outside expected natural variation), leading to a loss of the conservation interest of the site, then condition should be considered unfavourable.
- No decline in biotope quality as a result of reduction in species richness or loss of species of ecological importance, subject to natural change.
  - Whilst some change in community composition over time is expected (for example, as part of cyclic changes or successional trends) changes in the overall nature of communities across the key representative biotopes, may indicate deterioration in the condition of the biodiversity of the sandbanks. Where there is a change in biotope quality outside the expected variation or a loss of the conservation interest of the site, then condition should be considered unfavourable.

7.4.1.1.1. Potential effects during construction

Temporary physical disturbance

352. As described in Section 0, there is potential for temporary physical disturbance to Annex I Sandbank in the offshore cable corridor due to cable laying operations. The key components of cable laying in relation to effects on sandbanks include a pre-lay grapnel run, pre-sweeping (as an option), sediment disposal following pre-sweeping and cable burial (ploughing represents the worst case burial method due to having the greatest disturbance width). The footprint of these works will largely be overlapping and the maximum potential disturbance width of 30m (for ploughing) along the length of the trenching provides a footprint of 2.4km^2 based on two 40km cable trenches within the SAC. The maximum volume associated with trenching for the export cables would be 1,200,000m^3 within the SAC (based on 10m trench width with a V shaped profile x 3m maximum average depth x 2 trenches x 40km). This would be back filled naturally or manually.

353. As discussed in Section 0, 0.05km^2 of the pre-sweeping footprint may be outside the ploughing footprint. The maximum volume of sediment arising as a result of pre-sweeping in the SAC would equate to approximately 500,000m^3. As mitigation, all sediment arising from the SAC during cable installation would be placed back into the SAC, ensuring that the sediment is not lost from the system (see Appendix 7.1). The total area of sandbanks within the SAC is 678km^2 and the area of the SAC as a whole is 1,468km^2, so the maximum area of temporary physical disturbance (9.5km^2) due to cable laying operations therefore equates to 1.4% of the sandbanks and 0.6% of the total area of the SAC.

Sandbank extent, topography and sediment composition

354. Lowering of the seabed through sand wave clearing (pre-sweeping) can cause hydrographic changes which has the potential to impact sandbank form and function (JNCC and Natural England, 2013). Pre-sweeping may be undertaken prior to burying the Norfolk Vanguard cables, to ensure the cables can be installed at a depth that is unlikely to require reburial throughout the life of the project. Pre-sweeping will result in sediment being displaced, in order to create a corridor through the sand waves in which the cable burial tool can be used.

355. Strong sediment recirculation patterns have been identified along the cable corridor, with both northerly and southerly sediment movement at different locations (Section 7.1.1 and Appendix 7.1). During construction, the seabed would be mobilised and any transported sediment would tend to move in these same broad directions. The dredged trenches may act as a localised, temporary sediment sink; however, this will not affect the wider sediment transport process as any effect from the trenches on the flow will be minimal and localised to the levelled seabed area (Appendix 7.1).

356. All the pre-swept sediment removed from the cable corridor within the SAC would be disposed of back into the SAC. The thickness of the disposed sediment would be dependent on the footprint of placement and the volume deposited at any one time. Phasing the disposal would increase the likelihood that the initial disposed sediment would be incorporated back into the natural system before the sediment from the next phase of installation is deposited.

357. ABPmer (Appendix 7.1) were commissioned by Norfolk Vanguard Limited, to undertake an assessment of the possible effects of the project on sand waves. The assessment considers the possible phased construction of the project as a worst case scenario.

358. Appendix 7.1 considers the potential deposition thickness based on an indicative disposal site of 2.4km^2 in area. Based on initial analysis it is considered that a

disposal site of this size could easily be accommodated within the offshore cable corridor and SAC whilst avoiding sensitive habitats such as Sabellaria reef and ensuring that the deposited material remain within the SAC. The final location of the disposal site would be agreed with relevant SNCBs following pre-construction surveys. Appendix 7.1 concludes that, the deposition area (within the disposal site) would vary with each disposal event due to variations in the tidal states and hydrodynamic conditions, meaning the overlap from each disposal plume would vary so the actual thickness per cable pair, would be less than 0.3 m at initial deposition. Also, although the deposition extents may be larger per disposal event, the actual resulting thickness would be far smaller (closer to. 0.02 m).

359. Given the neighbouring sand waves have heights of several metres, the minimal deposited thickness would be indiscernible and is not considered to be able to interfere with the active sediment transport processes across the area (Appendix 7.1).

360. Keeping the dredged sediment within the sandbank system enables the sediment to become re-established within the local sediment transport system by natural processes and encourages the re-establishment of the SAC bedform features. ABPmer (Appendix 7.1) estimate transport rates for sand within the SAC of between $0.01m^3$/m/ hr to $3.4m^3$/m/ hr, which are also within the range modelled for the wider region of the Southern North Sea (HR Wallingford, 2012). It is therefore considered that if sediment mounds are formed during disposal, they would be of low heights (due to small volumes) and would be quickly (within a matter of days to a year) winnowed down to levels resembling nearby bedforms.

361. The ABPmer study (Appendix 7.1) also concluded that as in most cases, the cable corridor is oriented transverse to the sand wave crests which require levelling only a small width (up to approximately 37m) of each sand wave would be disturbed with the sand wave continuing to evolve and migrate along most of its length. As a result, the overall form and functioning of any particular sand wave, or the SAC sandbank system as a whole, is not disrupted.

362. Where sand wave crests occur that run roughly parallel to the cable corridor, broader sections of the longitudinal form of individual sand waves would require levelling; however, the area and volume of sediment affected would be minimal in the context of the sandbank system of the SAC as a whole. In addition, the cable corridor is in an active and highly dynamic environment, governed by current flow speeds, water depth and sediment supply, all of which are conducive for the development and maintenance of sandbanks. Therefore, despite the disturbance to sand waves intersecting the cable corridor, the Haisborough, Hammond and Winterton SAC sandbank system will remain undisturbed as new sand waves will

continue to be formed and older ones destroyed as they progress down the length of the supporting sandbank (Appendix 7.1).

363. The ABPmer study also found that the sediment would be naturally transported back into the dredged area within a short period of time given the local favourable conditions that enable sand wave development. The dredged area will naturally act as a sink for sediment in transport and will be replenished in the order of a few days to a year (Appendix 7.1).

364. The conclusions of the ABPmer study were supported by existing evidence from Orsted's Race Bank wind farm (DONG, 2017), where bathymetry monitoring is providing evidence that sand waves are showing signs of recovery within five months of export cable installation.

365. It is evident that the governing sediment transport processes within the SAC occur at a much larger scale than the temporary physical disturbance which would occur as a result of cable installation. The sediment volume that would be affected is small in comparison to the volume of sediment within the local sandbank systems (i.e. the Newarp Banks system) and the SAC as a whole (Appendix 7.1). As all the sediment will remain within the boundaries of the SAC, presenting minimal impacts on local sediment availability, there will be no significant change to sandbank extent, topography and sediment composition. Once re-deposited on the seabed at the proposed disposal site, the sediment will immediately re-join the local and regional sediment transport system, and will not affect the form or function of the sandbanks. Therefore, there is **no potential LSE or an adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to temporary physical disturbance during construction**.

<u>Sandbank communities</u>

366. There is potential for temporary physical disturbance to sandbank benthic and fish communities within the offshore cable corridor due to cable laying operations.

367. The sandbanks within Haisborough, Hammond and Winterton SAC consist of the following sub-features (JNCC and Natural England, 2013):

- Low diversity dynamic sand communities; and
- Moderate diversity gravelly muddy sand communities.

368. Low diversity dynamic sand communities experience frequent disturbance by tidal currents, and therefore contain organisms which are adapted to recurrent erosion and accretion (for example, polychaetes and amphipods which are able to re-burrow rapidly following disturbance) (JNCC and Natural England, 2013). Communities found

within low diversity dynamic sand are therefore largely composed of opportunistic species and can re-establish relatively quickly following disturbance, usually within a few tidal cycles (JNCC and Natural England, 2013).

369. The majority of the offshore cable corridor where it overlaps the SAC was classified as the biotope circalittoral fine sand during the Norfolk Vanguard characterisation surveys (Fugro, 2016). Infaunal abundance and diversity was generally low, excluding the area identified as *S. spinulosa* reef.

370. Although also exposed to frequent disturbance by tidal currents, gravelly muddy sand communities are more sensitive to physical damage and disturbance. They comprise stable sediments with high levels of organic matter and as a result the habitats associated with gravelly muddy sand tend to be more diverse. It takes longer for gravelly muddy sand communities to re-establish following disturbance (JNCC and Natural England, 2013). Furthermore, although gravelly muddy sand communities will take longer to re-establish than the low diversity dynamic sand communities, the JNCC and Natural England (2013) conservation advice states that the overall vulnerability of dynamic sandbank communities within the SAC to physical damage is considered to be low (Table 7.1). Few areas of gravelly muddy sand were recorded in the section of the offshore cable corridor where it overlaps the SAC (Fugro, 2016).

371. Given this capacity for recoverability, combined with the small total area of the SAC that will be temporarily affected by Norfolk Vanguard cable installation, it is considered that temporary physical disturbance would not give rise to any significant alteration to the communities of the sandbanks feature of the SAC. It is therefore reasonable to conclude that there will be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to temporary physical disturbance during construction.**

7.4.1.1.2. Potential effects during operation

Temporary physical disturbance

372. There is potential for temporary physical disturbance to Annex I Sandbanks in the offshore cable corridor due to cable maintenance and repair operations (as discussed in Section 7.3.2.2).

373. Based on Vattenfall Wind Power Ltd experience (a parent company of Norfolk Vanguard Limited) an average of one export cable repair per cable pair every 10 years is estimated to be the worst case scenario within the SAC.

374. As discussed in section 7.3.2.3 it is estimated that the maximum disturbance area would be 3,150m^2 (0.003km^2) for each cable repair. This equates to less than 0.001% of the total SAC area (1,468km^2) and the sandbank area (678km^2). It is highly likely that the sandbank would have recovered from any temporary disturbance from one repair before any other repairs are required.

375. The maximum disturbance area for cable reburial activities within the SAC has been estimated as 0.4km^2 over the life of the project (0.03% of the total area of the SAC or 0.06% of the sandbank area). This is estimated from 4km per cable pair within the SAC, with a disturbance width of 10m. However, if reburial is required, it is likely that this would be for shorter sections (e.g. 1km) at any one time.

Sandbank extent, topography and sediment composition

376. As discussed in section 7.4.1.1.1, the governing processes for sediment movement within the SAC occur at a much larger scale than the potential temporary physical disturbance which may occur as a result of cable installation. Temporary physical disturbance as a result of cable operations and maintenance is likely to be intermittent and on a much smaller scale than during cable installation. The volume and area affected would be very small in comparison to the volume of sediment within the local sandbank systems (i.e. the Newarp Banks system) and the Haisborough, Hammond and Winterton SAC as a whole.

377. The assessment indicates that temporary physical disturbance may occur within the offshore cable corridor, with a maximum disturbance area of 0.4km^2 (0.03% of the total area of the SAC or 0.06% of the sandbank area), based on the worst-case scenario. Although temporary physical disturbance may occur, this area is a very small part of the SAC, and the need for cable repairs is likely to be intermittent in nature. In addition, no sediment would be removed from the SAC during maintenance activities. Due to the short duration and small scale of any maintenance works (if required) there will be no effect on the form or function of the sandbank systems. It is therefore reasonable to conclude that there will be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to temporary physical disturbance during operation.**

Sandbank communities

378. As discussed in Section 7.4.1.1.1, Haisborough, Hammond and Winterton SAC sandbank sub-features (low diversity dynamic sand communities and moderate diversity gravelly muddy sand communities) are adapted to frequent disturbance during tidal cycles and are therefore likely to be able to recover within a few tidal cycles.

379. Given this capacity for recoverability, combined with the small total area of the SAC and communities affected by temporary physical disturbance during O&M, it is considered that temporary physical disturbance during operation would not give rise to any significant alteration to the communities of the sandbanks feature of the SAC. It is therefore reasonable to conclude that there will be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to temporary physical disturbance during operation.**

Permanent habitat loss

380. As described in section 7.3.2.2.5, there is potential for permanent habitat loss to Annex I Sandbanks in the offshore cable corridor due to the presence of cable protection. The worst case total area of cable protection installed within the SAC could be $0.05km^2$ based on the following:

- $0.00002km^2$ of clump weights based on cutting two existing disused cables and placing clump weights of up to $5m^2$ on either end of the dis-used cables;
- Six crossings for each of the two cable pairs within the SAC with a total footprint of $12,000m^2$ ($0.012km^2$) (100m length and 10m width of protection); and
- A contingency of up to 4km of cable protection per cable pair, resulting in a footprint of $40,000m^2$ ($0.04km^2$) based on 5m width of cable protection.

381. Analysis of geophysical data has shown that the substrate along the entire offshore cable corridor is expected to be suitable for cable burial. In the unlikely event that cable burial is not possible, this would as a result of encountering areas of the SAC that are hard substrate (i.e. not Annex I Sandbank).

<u>Sandbank extent, topography and sediment composition</u>

382. As Sandbank features would not be present in the areas where cable protection contingency could be required (i.e. on hard substrate), it is considered that the area of potential habitat loss to Sandbank features relates only to the cable crossings and clump weights. The total footprint of cable protection at crossings equates to less than 0.001% of the total area of the SAC ($1,468km^2$) and 0.002% of the area of sandbanks within the SAC ($678km^2$).

383. The assessment indicates that the extent of potential habitat loss is very small in comparison to the total area available within the SAC. There will be no change to the physical processes associated with the sandbank form and function. It is therefore reasonable to conclude that there will be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to permanent habitat loss.**

Sandbank communities

384. As discussed in Section 7.4.1.1.1, the SAC sandbanks support low abundance and low diversity communities and the removal of up to or 0.001% of the SAC or 0.002% of the sandbank area in the SAC would not be significant. It is therefore reasonable to conclude that there will be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to permanent habitat loss.**

Introduction of new substrate

385. In parallel with the habitat loss described above, there would be the addition of new artificial substrate, in the form of cable protection.

Sandbank extent, topography and sediment composition

386. It is considered that the extremely small areas associated with the new substrate (0.001% of the total area of the Haisborough, Hammond and Winterton SAC and 0.002% of the area of sandbanks within the SAC) would have no significant effect on the governing processes of the SAC. It is therefore reasonable to conclude that there will be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to the introduction of new substrate.**

Sandbank communities

387. There is potential that artificial substrate will become colonised by communities not present within the sandbank. However, these changes will be isolated to colonisation of the cable protection and therefore the extent of change would be limited to less than 0.001% of the total area of the Haisborough, Hammond and Winterton SAC (1,468km^2) and 0.002% of the area of sandbanks within the SAC (678km^2). It is therefore reasonable to conclude that there will be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to the introduction of new substrate.**

7.4.1.1.3. Potential effects during decommissioning

Temporary physical disturbance

388. During decommissioning, some or all of the offshore export cables may be removed. Therefore, decommissioning impacts will be primarily caused by the removal of structures from the seabed. It is anticipated that decommissioning would cause similar (or less) impacts to those identified during construction. Therefore, there is **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to temporary physical disturbance during decommissioning**.

389. Cable protection would likely be left *in situ* which has been assessed as a permanent impact in section 7.4.1.1.1.

7.4.1.2. In-combination effect

390. The in-combination assessment considers other developments (plans or projects) in planning, construction or operation where the predicted effects on the Haisborough, Hammond and Winterton SAC may have the potential to interact with effects from the proposed construction, operation and maintenance or decommissioning of Norfolk Vanguard.

391. Chapter 8 Marine Geology, Oceanography and Physical Processes of the ES states that theoretical bed level changes of up to 2mm are estimated as a result of cumulative impacts of Norfolk Vanguard cable installation and dredging at nearby aggregate sites. This level of effect has no potential to affect the SAC and therefore the only project screened in to the in-combination assessment is Norfolk Boreas.

392. As Norfolk Vanguard and Norfolk Boreas share an offshore cable corridor there is potential for in-combination effects associated with construction, operation and maintenance, and decommissioning of the projects.

393. It is likely that installation of the Norfolk Boreas export cables will follow the Norfolk Vanguard export cables (by approximately one year) with no temporal overlap. The spatial footprint of installation works for both Norfolk Vanguard and Norfolk Boreas is likely to be double that of Norfolk Vanguard as a worst case scenario; although some elements of the seabed preparation may overlap and will therefore reduce the overall combined footprint.

7.4.1.2.1. Temporary physical disturbance during construction, O&M, and decommissioning

394. The assessment of sand wave levelling by ABPmer (Appendix 7.1) considers the cumulative worst case pre-sweeping requirements of both Norfolk Vanguard and Norfolk Boreas based on a gap of between six and 24 months between projects. The study concludes that given the minimum spacing required between export cables from the two projects and the likely timing of construction there will not be enough time for sand waves levelled for the Norfolk Vanguard project to migrate into the area to be levelled for the Norfolk Boreas project. Therefore, there should be no additional impact on the sand waves due to the in-combination effect of both projects. The overall result of the installation of Norfolk Vanguard and Norfolk Boreas would be a series of sand waves that have been levelled and would naturally reshape and migrate on in the same form or converge or bifurcate in relation to governing processes.

395. The APBmer report (Appendix 7.1) also concludes that due to the very limited potential for cumulative effects, the likelihood of altering the form and function of the sand wave field and the wider sandbank system is considered to be minimal and would not be beyond that described for each individual project.

396. In summary, as all sediment will be kept within the boundaries of the SAC, the proposed bed levelling works are not considered likely to disrupt the form and function of the sand waves locally or at the sandbank system scale within the SAC. The sand waves are expected to continue to evolve in response to the natural regional scale processes and so there will be no significant change to sandbank extent, topography and sediment composition. Once redeposited to the seabed, the disturbed sediment will re-join the local and regional sediment transport system. Therefore, there **is no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to in-combination effects.**

7.4.1.2.2. Permanent habitat loss

397. There is potential for permanent habitat loss to Annex I Sandbanks in the shared Norfolk Vanguard and Norfolk Boreas offshore cable corridor due to the presence of cable protection. The worst case total area of cable protection installed within the SAC could be $0.26km^2$ for Norfolk Vanguard and Norfolk Boreas based on the following:

- $0.00002km^2$ of clump weights based on cutting two existing dis-used cables and placing clump weights of up to $5m^2$ on either end of the dis-used cables (would be cut once to allow for both projects);
- Six crossings for each of the four cable pairs (two per project) within the SAC with a total footprint of $24,000m^2$ ($0.024km^2$) (100m length and 10m width of protection); and
- A contingency of up to 4km of cable protection per cable pair, resulting in a footprint of $80,000m^2$ (5m width of cable protection).

398. As discussed in section 7.4.1.1.2, the cable protection contingency would only be required in the unlikely event that areas of hard substrate are encountered within the SAC (i.e. not Annex I Sandbank). Therefore, the area of potential habitat loss to Sandbank features relates only to the crossing locations and clump weights. Therefore the total permanent footprint on sandbanks equates to less than 0.002% of the total area of the SAC ($1,468km^2$) and 0.004% of the area of sandbanks within the SAC ($678km^2$).

399. The extent of potential habitat loss is very small in comparison to the total area available within the SAC and therefore there will be no change to the physical

processes associated with the sandbank form and function or the sandbank communities. Therefore, there is **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due in-combination effects.**

7.4.1.2.3. Introduction of new substrate

400. The maximum volume of cable protection installed within the SAC for Norfolk Vanguard and Norfolk Boreas would be:

- Clump weights $20m^2$ x height of 0.5m = $10m^3$ (would be cut once to allow for both projects)
- Crossings footprint of $24,000m^2$ x height of 0.9m = $21,600m^3$.
- Cable protection contingency footprint of $240,000m^2$ x height of 0.5m = $120,000m^3$ (should cable burial not be possible).

401. This contingency for cable protection is very conservative as cable burial is expected to be possible throughout the cable corridor for both projects, with the exception of cable crossing locations.

402. It is considered that the extremely small areas associated with the new substrate (0.02% of the total area of SAC and 0.04% of the area of sandbanks within the SAC) would have no significant effect on the governing processes or sandbank communities of the SAC. Therefore, there is **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I Sandbanks due to in-combination effects**.

7.4.2. Sabellaria spinulosa

7.4.2.1. Potential effects of Norfolk Vanguard

403. As discussed in Section 7.2, the formal Conservation Objective for the Haisborough, Hammond and Winterton SAC Annex I Reef feature is to, subject to natural change, maintain or restore the Annex I *S. spinulosa* reefs in Favourable Condition.

404. The assessment of the potential effects on the SAC for *S. spinulosa*, is based on the following targets set by JNCC and Natural England (2013) for achieving Favourable Condition:

- No reduction in the extent of *S. spinulosa* reef, subject to natural change.
    - Three core attributes need to be considered when assessing extent: extent of the reef itself, patchiness of the reef and elevation of the reef. Consideration of changes in extent should take account of the dynamic nature of the habitat itself and the sandbank habitats that support the reef.

- No significant decline in community with different growth phases present, subject to natural change
  - Whilst some change in community composition over time is expected (for example, as part of seasonal changes or successional trends) changes in the overall nature of the community across the reef, may indicate deterioration in its condition.
- No decline in the abundance of specified species from an established baseline, subject to natural change.
  - Whilst some change in community structure over time is expected (for example, as part of seasonal changes or successional trends) changes in the overall nature of communities (including mobile species) associated with the reefs, e.g. fish and crustacean species, may indicate deterioration in the condition of the biodiversity of the reefs.
- Maintain age/size class structure of individual species, subject to natural change.
  - In a stable or increasing population all age phases are likely to be present. The presence of areas of variable stages of growth is important in ensuring larval supply and enhances the species diversity of the reef.

7.4.2.1.1. Potential effects during construction

Temporary physical disturbance

405. *S. spinulosa* reef has been recorded within the Norfolk Vanguard offshore cable corridor and therefore there is potential for temporary physical disturbance to Annex I Reef in the offshore cable corridor due to cable laying operations.

406. As described in section 7.3.1, should *S. spinulosa* reef be identified on the proposed cable routes during the pre-construction surveys, micrositing will be undertaken where possible to minimise potential impacts.

407. The cable corridor width within the SAC is 2km at the narrowest point and 4.7km at the widest point. The cable corridor is approximately 4km wide at the location where *S. spinulosa* reef has been recorded within the SAC (see Figure 7.2).

408. A total width of approximately 1.35km is required for Norfolk Vanguard and Norfolk Boreas; including up to two trenches (four cables laid as pairs) for each project, a contingency of 440m, an anchor placement zone, and a buffer (GMSL, 2016 unpublished).

409. The remaining width of the offshore cable corridor within the SAC is therefore approximately 0.65km to 3.35km; adding in the contingency of 0.4km, results in a

cable corridor in which approximately 1.05km to 3.75km may be available for micrositing.

410. Due to the considerable width available for micrositing to avoid core *S. spinulosa* reef where identified during pre-construction surveys, it is likely that no temporary physical disturbance will occur in the offshore cable corridor. The export cable corridor is approximately 4km wide at the point where *S. spinulosa* reef has been recorded to date. A total width of approximately 1.35km is required for Norfolk Vanguard and Norfolk Boreas; therefore, 2.65km is likely to be available for micrositing at this location within the cable corridor. As a result, based on the likely scenario that micrositing is possible, there would be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to temporary physical disturbance during construction.**

411. In the unlikely event that *S. spinulosa* has colonised the full 2 to 4.7km width of the offshore cable corridor and micrositing is not possible, there is a theoretical potential for temporary physical disturbance to Annex I Reef to occur.

412. Due to the ephemeral nature of *S. spinulosa*, a hypothetical, contingency scenario has been considered as requested by Natural England during the EPP, to assess the worst case effects of temporary physical disturbance should *S. spinulosa* have colonised the full width of the cable corridor and therefore no micrositing is possible.

413. Gubbay (2007) provides a report of an inter-agency workshop on defining and managing *S. spinulosa* reef and concludes that patchiness of between 10% and >30% would represent reef. The participants agreed that patchiness appears to be a feature of *S. spinulosa* reefs and therefore 100% coverage should not to be expected. The typical spatial extents of *S. spinulosa* reef in UK waters are difficult to determine; however, reef areas of a few square metres up to around $1km^2$ are the most common (Gubbay, 2007). Based on the likely patchiness of *S. spinulosa* reef it is highly unlikely that a scenario would ever exist that reef would entirely bisect the Norfolk Vanguard offshore cable corridor which is 2 to 4.7km in width. However, this has been considered, as requested Natural England in order to provide a highly conservative assessment and a contingency for *S. spinulosa* disturbance.

414. JNCC and Natural England (2013) classified *S. spinulosa* reef as highly sensitive to both physical disturbance or abrasion, and displacement. If the physical structure of the reef is damaged or destroyed the habitat will reduce in diversity.

415. *S. spinulosa* reefs have varying levels of vulnerability to disturbances, depending on the type of reef present and the type/extent of the disturbance. Thin crusts are more

fragile than mature reefs and are easily broken up by storms or other physical disturbances. Reefs are particularly vulnerable to physical anthropogenic disturbances such as mobile fishing gear, although recovery back to original extent is possible after cessation of destructive activities (Tillin and Marshall, 2015).

416. Despite the vulnerability of reefs to physical damage, high recruitment rates of *S. spinulosa* allow for rapid recovery and regrowth of reefs in the right conditions. As a result, *S. spinulosa* is often one of the first species to settle on newly exposed and suitable surfaces (OSPAR Commission, 2010).

417. Tillin and Marshall (2015) observed that recovery of *S. spinulosa* reefs relies on larval recolonisation when extensively damaged or removed. For subtidal populations, this means that *S. spinulosa* may be capable of rapid growth to approach adult biomass in a number of months due to the speed at which subtidal populations can reach sexual maturity (Pearce *et al.,* 2007).

418. Evidence suggests that recovery of thin encrusting reefs may be rapid, as demonstrated by surveys on the North Yorkshire coast whereby areas of *S. spinulosa* that had been lost due to storms had recolonised up to the maximum thickness (2 - 3cm) during the following summer (Holt, 1998). Studies within the Hastings Single Bank aggregate extraction area also found there to be rapid recolonisation of reefs (Cooper *et al.,* 2007; Pearce *et al.,* 2007). Pearce *et al.* (2007) undertook surveys in the same location and recorded large numbers of *S. spinulosa* in one area during the summer following cessation of dredging activities, and found another area to be recolonised within 1.5 years, suggesting annual recruitment in this area. *S. spinulosa* has been found to colonise a dredge site within 6 months of cessation of extraction activities (Pearce *et al.,* 2011a). It is understood that recovery to high adult density and biomass of more mature reefs would take 3 to 5 years with successful annual larval recruitment (Pearce *et al.,* 2007).

419. Pearce *et al.* (2011b) conducted a number of laboratory experiments and found that gamete release was induced when adult worms were separated from the tubes, suggesting that they spawn in response to disturbance as a means of potentially securing the future population. Zucco *et al.* (2006) suggests that as long as worms are not killed or removed from their tubes, their natural growth and resilience allows them to repair the tubes within days.

420. Despite this evidence of *S. spinulosa* recovery, there have been some cases when *S. spinulosa* reefs have been unable to recover after removal, for example, there has been widespread decline of *S. spinulosa* reefs in the Wadden Sea over the past few decades, which have shown little sign of recovery. Ecosystem changes (such as

climate change, substrate alterations, and hydrodynamic changes) have been thought to be partly responsible for the lack of recovery (Tillin and Marshall, 2015).

421. This suggests that recovery rates are determined by a range of factors including:

- Degree of impact (from minimal tube damage to complete removal);
- Larval supply and recruitment; and
- Local environmental conditions (hydrodynamics, water quality, substrate).

422. In general, whilst *S. spinulosa* reef is able to recover, this recovery may take some time, and is dependent on the prevailing environmental conditions (Pearce *et al.* 2007; Limpenny *et al.,* 2010; Hendrick *et al.*, 2011). It can be inferred from this that recovery of reefs from significant impacts (such as physical loss or abrasion of the substratum surface) may take between 2 and 10 years for full pre-impact recovery (Tillin and Marshall, 2015).

423. During the East Coast Regional Environmental Characterisation (REC) (Limpenny *et al.,* 2011), it was found that sample stations with moderate to high 'reefiness' scores were distributed widely across the REC study area, suggesting that the regional environmental conditions are well-suited to reef development (Limpenny *et al.,* 2011). This indicates that rapid recovery rates, as discussed above, may be possible within the export cable corridor.

424. There are other parts of the offshore cable corridor within the SAC where *S.spinulosa* reef has been identified by previous studies, however these were assessed as being of low confidence (Appendix 7.2) with only 1 or 2 data sources indicating that reef maybe present and 3 or 4 data sources indicating that it was not.

425. In the unlikely event that reef is unavoidable in the Norfolk Vanguard offshore cable corridor, the maximum disturbance width would be 74m based on a disturbance width of approximately 37m for pre-sweeping each of the two cable trenches for Norfolk Vanguard (section 7.3.2.2.1).

426. The proportion of temporary disturbance across the width of the offshore cable corridor would be 3.7% or 1.6% (based on 74m disturbance in the 2 to 4.7km corridor width). However the proportion of *S. spinulosa* reef disturbance would be significantly lower in the context of reef extent within the entire SAC.

427. In addition, and as discussed above, *S. spinulosa* shows good recoverability to disturbance, depending on the degree of impact and local conditions. Local environmental conditions in the area are thought to be suitable for good *S. spinulosa* recovery.

428. Therefore, given the very small proportion of temporary disturbance and the high recoverability, the conservation objective of maintaining or restoring extent would be sustained. It is therefore reasonable to conclude that there will be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to temporary physical disturbance during construction.**

429. Regardless of the phasing scenario selected, the two trenches would be installed sequentially and on new ground (with 120m between each trench); therefore, no direct recurring disturbance impact to *S. spinulosa* is anticipated.

Increased suspended sediment and smothering

430. As discussed in section 7.3.2.2.1, pre-sweeping may be undertaken prior to burying the cables. Increased suspended sediment concentrations and associated sediment deposition may also occur from cable installation activities within the offshore cable corridor.

431. Based on the worst case scenario, approximately 500,000m^3 of sediment would be deposited back into the SAC following pre-sweeping; however, the volume of sediment released at one time would be dependent on the capacity of the dredger. Approximately 1,200,000m^3 of sediment would be deposited back into the SAC due to trenching and backfilled either naturally or manually.

432. All sediment arising from within the SAC would be deposited within the offshore cable corridor and all dredged sediment will be kept within SAC boundaries. The exact disposal location is still to be finalised; however, the material will be deposited within designated disposal zones agreed in consultation with the relevant SNCB following pre-construction surveys. Sediment would not be disposed of within 50m of *S. spinulosa* reef identified during pre-construction surveys.

433. *S. spinulosa* reefs are most frequently found in disturbed conditions and are adapted to moderate sediment loads. *S. spinulosa* are evolved to exist in disturbed conditions and are dependent on such waters to promote growth. As a result, high suspended sediment loads would be unlikely to affect *S. spinulosa* reef and the species is not considered sensitive to increased suspended sediment loads or smothering through sediment deposition (JNCC and Natural England, 2013).

434. Riesen and Riesen (1982) found that *S. spinulosa* and associated structures are considered resilient to increased sediment loads, being able to tolerate smothering for a number of weeks. *S. spinulosa* tube growth is dependent on the presence of suspended particles, hence an increase in suspended sediment may facilitate tube construction and result in increased populations (Jackson and Hiscock, 2008). Tillin

and Marshall (2015) conclude that *S. spinulosa* can persevere in turbid conditions and reefs located in the vicinity of dredging areas appear unaffected by dredging operations.

435. As part of the embedded mitigation, sediment would not be disposed of within 50m of *S. spinulosa* reef. As a result, sediment would not be disposed of directly on top of, or immediately adjacent to *S. spinulosa* reef and changes to the extent or structure of the reef due to increased suspended solids and smothering are not anticipated. Therefore, the conservation objective of maintaining or restoring *S. spinulosa* reef in favourable condition would be met and there is **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to increased suspended sediment and smothering during construction.**

7.4.2.1.2. Potential effects during operation

Temporary physical disturbance

436. There is potential for temporary physical disturbance to Annex I Reef in the offshore cable corridor due to unscheduled cable maintenance and repair operations in the event that *S. spinulosa* reef has colonised the cable route following cable installation.

437. Based on Vattenfall Wind Power Ltd experience (a parent company of Norfolk Vanguard Limited) , an average of one export cable repair per cable pair every 10 years is estimated to be the worst case scenario within the SAC.

438. As discussed in section 7.3.2.3.1, it is estimated that the maximum disturbance area would be 3,150m^2 (0.003km^2) for each cable repair. This equates to less than 0.001% of the total SAC area (1,468km^2).

439. The maximum disturbance area for cable reburial activities within the SAC has been estimated as 100,000m^2 per cable over the life of the project (6.8% of the total area of the SAC). This is estimated at up to 10km per cable within the SAC, with a disturbance width of 10m. However, if reburial is required it is likely that this would be shorter sections (e.g. 1km) at any one time.

440. As discussed in section 7.4.2.1.1, *S. spinulosa* are most frequently found in disturbed conditions and show good recoverability to disturbance. In some areas *S. spinulosa* has been shown to recolonise within six months of physical disturbance (Pearce *et al.,* 2011a).

441. Although temporary physical disturbance may occur during cable maintenance and repair activities, the area affected is a very small extent of the total area of the SAC and the extent of *S. spinulosa* present in the location of the repair/remedial works is

likely to be very small, if present at all. In addition, and as discussed in section 7.4.1.1.1, *S. spinulosa* shows good recoverability to disturbance, depending on the degree of impact and local conditions. Local environmental conditions are suitable for *S. spinulosa* recovery and cable repairs are likely to be infrequent, with two export cable repairs occurring within the SAC per year being a conservative worst case scenario.

442. As a result, changes to the extent of the reef due to temporary physical disturbance during operation are highly unlikely to occur. Therefore, the conservation objective of maintaining or restoring *S. spinulosa* reef in favourable condition would be met and there is **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to temporary physical disturbance during operation.**

Introduction of new substrate

443. As described in section 7.3.2.2, there is potential for the introduction of new substrate in the offshore cable corridor due to the presence of cable protection.

444. The total cable protection installed within the SAC is described in section 7.3.2.2.5. The contingency for cable protection is very conservative, as cable burial is expected to be possible throughout the cable corridor, with the exception of cable crossing locations. Based on the known cable crossings along the route and the worst case scenario for cable protection, the maximum volume of new substrate would be:

- 0.00002km^2 of clump weights based on cutting two existing disused cables and placing clump weights of up to 5m^2 on either end of the dis-used cables.
- Crossings footprint of 12,000m^2 x height of 0.9m = 10,800m^3.
- Cable protection contingency footprint of 40,000m^2 x height of 0.5m = 20,000m^3 (should cable burial not be possible, or cable becoming unburied during operation).

445. JNCC and Natural England (2013) classified *S. spinulosa* reef as highly sensitive to obstruction as permanent infrastructure may prevent natural recovery. However, *S. spinulosa* has been found to colonise new hard substrata (Spence, 2015, JNCC and Defra 2016) rapidly, including some forms of cable protection, indicating that any new substrata created by cable protection may provide a larger area of suitable reef substrate than was previously present.

446. Boulders and mattresses used in cable protection have been found to add habitat complexity in otherwise barren sediment dominated seafloors, increasing the heterogeneity of the environment in and around offshore wind farms (Lindeboom *et al.,* 2011; Goriup, 2017).

447. Although there is little information available on the growth and development of *S. spinulosa* reefs on subsea cables and cable protection, there has been some monitoring of growth on artificial hard substrates, which may be compared to the artificial hard substrate created by cable protection.

448. Leonhard and Pedersen (2005) recorded *S. spinulosa* on the newly introduced artificial hard substrate at Horns Rev wind farm, suggesting that artificial hard bottoms created by the construction of offshore wind farms offer suitable substrates for *S. spinulosa* colonisation.

449. Several wind farm developments have had post-construction monitoring requirements relating to *S. spinulosa.* During post-construction monitoring at the Greater Gabbard wind farm, *S. spinulosa* was the second most numerous benthic species identified in the benthic drop-down video survey, although not in reef form (CMACS, 2014). In the first year of monitoring following construction of the London Array offshore wind farm, *S. spinulosa* was in the top ten most abundant taxa, and there was an area along the export cable route where a large number of individuals were found (MarineSpace, 2015).

450. In the two years of post-construction monitoring at Gunfleet Sands 1 and 2, the number of *S. spinulosa* individuals more than doubled, and numbers of *S. spinulosa* found in the export cable route samples were much higher in the second year (CMACS 2010; 2012). In year 1 (2010), *S. spinulosa* were found to be the 8^{th} most abundant species, with 120 individuals recorded. Individuals were recorded at 3 sites along the export route with up to 6 individuals in a grab sample.

451. In year 2 (2011), *S. spinulosa* had increased in number to be the 5^{th} most abundant species at Gunfleet Sands 1 and 2 with 285 individuals. At one of the export cable sample locations, 71 individuals were recorded from the three grabs taken, with the average number per grab being 23.67. This location had the largest number of *S. spinulosa* recorded out of all the sample locations within the wind farm boundary (CMACS, 2012).

452. The assessment indicates that any new substrata created by cable protection may provide a larger area of suitable *S. spinulosa* substrate and potentially reed substrate than was previously present. The maximum volume of new substrate could be up to 30,800m^3. Therefore, there **is no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to introduction of a new substrate during operation.**

7.4.2.1.3. Potential effects during decommissioning

Temporary physical disturbance

453. During decommissioning, some or all of the offshore export cables may be removed. Cable protection would likely be left *in situ*. Therefore, decommissioning impacts will be primarily caused by the removal of structures from the seabed. It is anticipated that decommissioning would cause similar impacts to those identified during construction.

454. As a result, the assessment indicates that although temporary physical disturbance may occur, the area of disturbance is a very small extent of the SAC. In addition, and as discussed in section 7.4.2.1.1, *S. spinulosa* shows good recoverability to disturbance, with the local environmental conditions considered to be suitable for good *S. spinulosa* recovery. Therefore, there is **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to temporary physical disturbance during decommissioning.**

Increased suspended sediment and smothering

455. Increased suspended sediment concentrations and associated sediment deposition may occur during decommissioning activities within the offshore cable corridor.

456. As discussed in section 7.4.2.1.1, *S. spinulosa* reefs are most frequently found in disturbed conditions. As a result, high suspended sediment loads would be unlikely to affect *S. spinulosa* reef and the species is not considered sensitive to increased suspended sediment loads or smothering through sediment deposition (JNCC and Natural England, 2013).

457. The volume of sediment disturbed during decommissioning would be less that during construction due to no sand wave levelling works (pre-sweeping) being required. The effects of decommissioning on suspended sediment smothering would therefore be less than during construction. In addition, *S. spinulosa* are not considered to be sensitive to increased suspended sediment loads or smothering. Therefore, there is **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to increased suspended sediment and smothering during decommissioning.**

7.4.2.2. In-combination effect

458. As discussed in section 7.4.1.2, the only project screened in to the in-combination assessment is Norfolk Boreas.

459. As Norfolk Vanguard and Norfolk Boreas share an offshore cable corridor there is potential for in-combination effects associated with construction, O&M and decommissioning of the projects.

460. It is likely that installation of the Norfolk Boreas export cables will follow (by approximately one year) the Norfolk Vanguard export cables with no temporal overlap. The spatial footprint of installation works for both Norfolk Vanguard and Norfolk Boreas is likely to be double that of Norfolk Vanguard as a worst case scenario; although some elements of the seabed preparation may overlap and therefore reduce the overall combined footprint.

7.4.2.2.1. Potential in-combination effects during construction

Temporary physical disturbance

461. A total width of approximately 1.35km is required for Norfolk Vanguard and Norfolk Boreas; including up to two trenches (four cables laid as pairs) for each project, a contingency of 440m, an anchor placement zone, and a buffer (GMSL, 2016 unpublished).

462. As discussed in section 7.3.1.2.1, micrositing will be undertaken for both Norfolk Vanguard and Norfolk Boreas, where possible. The assessment indicates that no temporary physical disturbance will occur in the export cable corridor, as micrositing is likely to be possible to avoid the *S. spinulosa* reef as currently recorded within the shared cable corridor.

463. However, in the unlikely event that *S. spinulosa* has colonised the full width of the offshore cable corridor and micrositing is not possible, there is potential for temporary physical disturbance to Annex I Reef to occur as a result of in-combination effects from Norfolk Vanguard and Norfolk Boreas.

464. As discussed in section 7.4.2.1.1, a hypothetical, contingency scenario has been considered, as requested by Natural England during the EPP, to assess the worst case effects of temporary physical disturbance should *S. spinulosa* have colonised the full width of the cable corridor and therefore no micrositing is possible.

465. In the unlikely event that reef is unavoidable in the Norfolk Vanguard and Norfolk Boreas offshore cable corridor, the maximum disturbance width would be 148m based on disturbance width of approximately 37m for pre-sweeping each of the two cable trenches for Norfolk Vanguard and approximately 37m for pre-sweeping each of the two cable trenches for Norfolk Boreas.

466. If *S. spinulosa* has colonised the full width of the cable corridor at the location where an area of reef is currently present (4km), this would result in a disturbance to 3.7% of the *S. spinulosa* reef.

467. Should *S. spinulosa* reef colonise a 2km wide section of the offshore cable corridor or a 4.5km wide section, the proportion of temporary reef disturbance resulting from the 148m wider area of disturbance would be 7.4% or 3.3%, respectively. In the context of reef growth that would have occurred relative to the extent of reef recorded in 2016, the conservation objective of maintaining or restoring extent would have been met and exceeded. In addition, there will be approximately 12 months between the installation of the Norfolk Vanguard export cables and installation of the Norfolk Boreas cables which may allow recovery of *S. spinulosa* to occur. Therefore, with no temporal overlap between the projects, the total disturbance width used for this assessment is highly conservative.

468. As discussed in section 7.4.2.1.1, *S. spinulosa* shows good recoverability to disturbance, depending on the degree of impact and local conditions. Local environmental conditions in the area are thought to be suitable for good *S. spinulosa* recovery. Therefore, there would be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to in-combination effects**.

Increased suspended sediment and smothering

469. Based on the worst case scenario, approximately 500,000m^3 of sediment would be deposited back into the Haisborough, Hammond and Winterton SAC following pre-sweeping of Norfolk Vanguard and 500,000m^3 of sediment following pre-sweeping of Norfolk Boreas (1,000,000m^3 in total); however, the volume of sediment released at one time would be dependent on the capacity of the dredger. Approximately 2,400,000m^3 of sediment would be deposited back into the SAC due to trenching of Norfolk Vanguard and Norfolk Boreas export cables and backfilled either naturally or manually.

470. As discussed in section 7.4.1.1.1, all sediment arising from within the SAC would be deposited within the offshore cable corridor and kept within the SAC boundaries. The exact disposal location for each project will be defined based on the pre-construction surveys and in consultation with Natural England and the MMO. Sediment would not be disposed of within 50m of *S. spinulosa* reef identified during pre-construction surveys.

471. In-combination effects may occur where construction works are within range of potential overlap of sediment deposition. However, construction of Norfolk Boreas will follow Norfolk Vanguard; therefore, installation works will not be concurrent. In

addition, the sensitivity of *S. spinulosa* to increased suspended sediment and smothering would be as described in section 7.4.1.1.1 (resilient to increased sediment loads and most frequently found in disturbed conditions). Therefore, there would be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to in-combination effects.**

7.4.2.2.2. Potential in-combination effects during operation

Temporary physical disturbance

472. As discussed in section 7.3.2.3, an average of one repair per Norfolk Vanguard cable pair every 10 years is estimated to be the worst case scenario within the SAC. This is also likely to represent a worst case for Norfolk Boreas.

473. In the worst case scenario that *S. spinulosa* reef has colonised the cable route, the maximum disturbance area would be 3,150m^2 (0.003km^2) for each cable repair. This equates to less than 0.001% of the total SAC area (1,468km^2) at any one time. It is likely that any *S. spinulosa* reef would have recovered from temporary disturbance from one repair before other repairs are required.

474. Although temporary physical disturbance may occur during Norfolk Vanguard and Norfolk Boreas cable maintenance and repair activities, the area affected is a very small extent of the total area of the SAC and the likelihood of cable repairs being required in an area of reef is relatively low given the small extent of *S. spinulosa* reef compared within the cable corridor area. In addition, and as discussed in section 7.4.2.1.1, *S. spinulosa* shows good recoverability to disturbance in environments that are suitable for *S. spinulosa* growth such as the Haisborough, Hammond and Winterton SAC. Therefore, there would be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to in-combination effects.**

Introduction of new substrate

475. The total cable protection installed within the SAC is described in section 7.3.2.2.5. Based on the known cable crossings along the route and the worst case scenario for cable protection, the maximum volume of new substrate would be:

- 0.00002km^2 of clump weights based on cutting two existing disused cables and placing clump weights of up to 5m^2 on either end of the dis-used cables (would be cut once to allow for both projects).
- Crossings footprint of 12,000m^2 x height of 0.9m = 10,800m^3.

- Cable protection contingency footprint of 40,000m^2 x height of 0.5m = 20,000m^3 (should cable burial not be possible, or cable becoming unburied during operation).

476. The contingency for cable protection is very conservative, as cable burial is expected to be possible throughout the cable corridor, with the exception of cable crossing locations.

477. The sensitivity of *S. spinulosa* to the introduction of new substrate would be as described in Table 7.2. The assessment indicates that any new substrata created by cable protection may provide a larger area of suitable reef substrate than was previously present. The maximum volume of new substrate could be up to 30,800m^3. Therefore, there would be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to in-combination effects**.

7.4.2.2.3. Potential in-combination effects during decommissioning

Temporary physical disturbance

478. It is anticipated that decommissioning would cause similar impacts to those identified during construction.

479. As a result, the assessment indicates that although temporary physical disturbance may occur, the area of disturbance is a very small extent of the SAC. In addition, and as discussed in section 7.4.2.1.1, *S. spinulosa* shows good recoverability to disturbance, with the local environmental conditions considered to be suitable for good *S. spinulosa* recovery. Therefore, there would be **no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to in-combination effects.**

Increased suspended sediment and smothering

480. The volume of sediment disturbed during decommissioning would be less that during construction, therefore the effects of decommissioning on increased suspended sediment and smothering would be less than during construction. In addition, *S. spinulosa* are not considered to be sensitive to increased suspended sediment loads or smothering. Therefore, there would **be no adverse effect on the integrity of the Haisborough, Hammond and Winterton SAC in relation to the conservation objectives for Annex I *S. spinulosa* reefs due to in-combination effects.**

7.4.3. Summary of Potential Effects

Table 7.5 Summary of potential effects of Norfolk Vanguard alone or in-combination on the Haisborough Hammond and Winterton SAC.

Qualifying feature	Potential effect	Potential for adverse effect on the integrity alone?	Potential for adverse effect on the integrity in-combination?
Annex I Sandbank	Temporary disturbance during construction	×	×
Annex I Sandbank	Temporary disturbance during operation	×	×
Annex I Sandbank	Permanent habitat loss	×	×
Annex I Sandbank	Introduction of new substrate	×	×
Annex I Sandbank	Temporary disturbance during decommissioning	×	×
Annex I Reef	Temporary disturbance during construction	×	×
Annex I Reef	Increased suspended sediment during construction	×	×
Annex I Reef	Temporary disturbance during operation	×	×
Annex I Reef	Introduction of new substrate	×	×
Annex I Reef	Temporary disturbance during decommissioning	×	×
Annex I Reef	Increased suspended sediment during decommissioning	×	×

× = no potential for any adverse effect on the integrity of the site in relation to the conservation objectives.

8. OFFSHORE cSAC ANNEX II SPECIES (MARINE MAMMALS)

8.1. Baseline/Current Conservation Status

481. The following sections provide an overview of the relevant baseline information, current conservation status and designated sites for the marine mammal species screened into the HRA:

- Harbour porpoise *Phocoena phocoena*;
- Grey seal Halichoerus grypus; and
- Harbour seal *Phoca vitulina*.

482. Further details on the baseline information for marine mammal species are also provided in the Norfolk Vanguard HRA Offshore Screening Report (Appendix 5.1), the HRA Marine Mammal Method Statement (Royal HaskoningDHV, 2017), and the ES (document 6.1).

8.1.1. Harbour Porpoise

8.1.1.1. Distribution

483. Initial data from the SCANS-III survey indicates that the occurrence of harbour porpoise is greater in the central and southern areas of the North Sea compared to the northern North Sea (Hammond *et al.,* 2017), which is consistent with SCANS-II (Hammond *et al.,* 2013). Modelling of the new data from 2016 to investigate fine scale distribution and habitat use is in progress (Hammond *et al.,* 2017).

484. Within the southern North Sea, Heinänen and Skov (2015) identified one area of high harbour porpoise density; from the western slopes of Dogger Bank south along a 30m depth contour towards an area off the Norfolk coast. This was further split into three areas due to inter-annual variations:

- North-western edge of Dogger Bank (summer);
- Inner Silver Pit; and
- Offshore area east of Norfolk and east of outer Thames Estuary (winter).

485. The Heinänen and Skov (2015) analysis was used in the identification of potential SACs for harbour porpoise in UK waters.

486. Gilles *et al.* (2016) assessed nine years of harbour porpoise survey data (2005 to 2013) collected in the UK (SCANS-II, Dogger Bank), Belgium, the Netherlands, Germany, and Denmark, to develop seasonal habitat-based density models for the central and southern North Sea. The highest harbour porpoise density occurred 150km offshore and at depths between 25 and 40m. Harbour porpoise densities

also increased with higher probability for sea surface temperature (SST) fronts and decreased with distance to sandeel grounds.

487. The spring seasonal density map produced by Gilles *et al.* (2016) indicated major hotspots in the southern and south-eastern part of the North Sea, mainly inshore close to the Belgian and Dutch coasts extending toward the German coast off the East Frisian Islands. The model also predicted high densities in the area of the Sylt Outer Reef in the German North Sea as well as north off the coast of Jutland in Denmark. Another potential hotspot in spring was at Dogger Bank and the area north-west of this large sandbank (Gilles *et al.,* 2016). In summer, there was an apparent shift, compared to spring, toward offshore and western areas, with a large hotspot present off the German and Danish west coast that extended toward the Dogger Bank. The seasonal model for autumn indicated lower densities compared to spring and summer, the distribution was spatially heterogeneous and areas with higher densities were predicted north-west of the Dogger Bank and off the German and Danish west coasts (Gilles *et al.,* 2016).

488. The Joint Cetacean Protocol (JCP) Phase-III report (Paxton *et al.,* 2016) indicated that for the Norfolk Bank development area (an area comprising the former East Anglia Zone), abundances of harbour porpoise ranged from 5,300 (CI = 2,600-15,600) in the spring and 13,700 (CI = 7,000-26,200) in the winter, with numbers in summer and autumn being in between. The Norfolk Bank development area covers 2.4% of the North Sea MU, but the abundance estimate of harbour porpoise in this area equates to 13.9% (CI = 8.9-19.2%) of the North Sea MU, indicating a high use of the area (Paxton *et al.,* 2016).

8.1.1.2. Diet

489. The distribution and occurrence of harbour porpoise and other marine mammals is most likely to be related to the availability and distribution of their prey species. For example, sandeels *Ammodytidae*, which are known prey for harbour porpoise, exhibit a strong association with particular surface sediments (Gilles *et al.,* 2016).

490. Harbour porpoises are generalists and their diet varies geographically, seasonally and annually, reflecting changes in available food resources and differences in diet between sexes or age classes may also exist (Berrow and Rogan, 1995; Kastelein *et al.,* 1997; Börjesson *et al.* 2003; Santos and Pierce, 2003; Santos *et al.,* 2004; Pierce *et al.,* 2007).

491. The main prey fish species of harbour porpoise typically include sandeels, whiting *Merlangius merlangus*, herring *Clupea harengus*, mackerel *Scomber scombrus*, sprat *Sprattus sprattus*, cod *Gadus morhua*, haddock *Melanogrammus aeglefinus*, saithe *Pollachius virens*, pollack *Pollachius pollachius*, Norway pout *Trisopterus esmarkii* as

well as flat fish such as flounder *Platichthys flesus* and sole *Solea solea* (Rogan and Berrow, 1996; Reid *et al.,* 2003; Santos and Pierce, 2003; Santos *et al.,* 2004).

492. Harbour porpoise have relatively high daily energy demands and need to consume between 4% and 9.5% of their body weight in food per day (Kastelein *et al.,* 1997). If a harbour porpoise does not capture enough prey to meet its daily energy requirements it has been estimated that it can only rely on stored energy (primarily blubber) for three to five days, depending on body condition (Kastelein *et al.,* 1997).

8.1.1.3. Movements

493. The seasonal movements and migratory patterns of harbour porpoise are not well understood. Seasonal movement is thought to correspond with prey availability and the calving and mating seasons.

494. Peak harbour porpoise density with the Southern North Sea has been shown to vary seasonally (Heinänen and Skov, 2015). This variation in seasonal densities is linked to water depth and other variables within the water column. The winter and summer areas for Southern North Sea cSAC were based on the modelling undertaken by Heinänen and Skov (2015).

495. Satellite telemetry studies of 52 harbour porpoise undertaken in the Danish North Sea in 2002, revealed that harbour porpoise are highly mobile, with individuals travelling more than 1,000km from Danish waters to east of the Shetland Islands (Teilmann *et al.,* 2004). Individual harbour porpoise had varying areas of concentrated movement, ranging from 400 to 1,600km^2 (Teilmann *et al.,* 2004). The study also indicated that home range areas varied with location and sex, with porpoises tagged in Skagen having larger ranges compared porpoises from the Inner Danish Waters and females generally having a larger home range than males (Teilmann *et al.,* 2004).

8.1.1.4. Abundance

8.1.1.4.1. Abundance in North Sea

496. The Inter-Agency Marine Mammal Working Group (IAMMWG) defined three management units (MU) for harbour porpoise: North Sea (NS); West Scotland (WS); and the Celtic and Irish Sea (CIS). Norfolk Vanguard is located in the North Sea MU (Plate 8-1; IAMMWG, 2015).

497. The latest SCANS-III survey estimated harbour porpoise abundance in the North Sea Assessment Unit (AU) to be 345,373 (Coefficient of Variation (CV) = 0.18; 95% Confidence Interval (CI) = 246,526-495,752; Hammond *et al.,* 2017). The ICES Assessment Unit (AU) for the North Sea in the SCANS-III report is the same area as

the IAMMWG North Sea MU. This is the reference population for harbour porpoise, as agreed with Natural England as part of the EPP (letter dated 03/01/2018).

498. NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O.

- The estimated abundance of harbour porpoise in SCANS-III survey block L is 19,064 harbour porpoise (CV=0.38; 95% CI = 6,933-35,703), with an estimated density of 0.607 harbour porpoise/km^2 (CV=0.38; Hammond *et al.,* 2017).
- The estimated abundance of harbour porpoise in SCANS-III survey block O is 53,485 harbour porpoise (CV=0.21; 95% CI = 37,413-81,695), with an estimated density of 0.888 harbour porpoise/km^2 (CV=0.21; Hammond *et al.,* 2017).

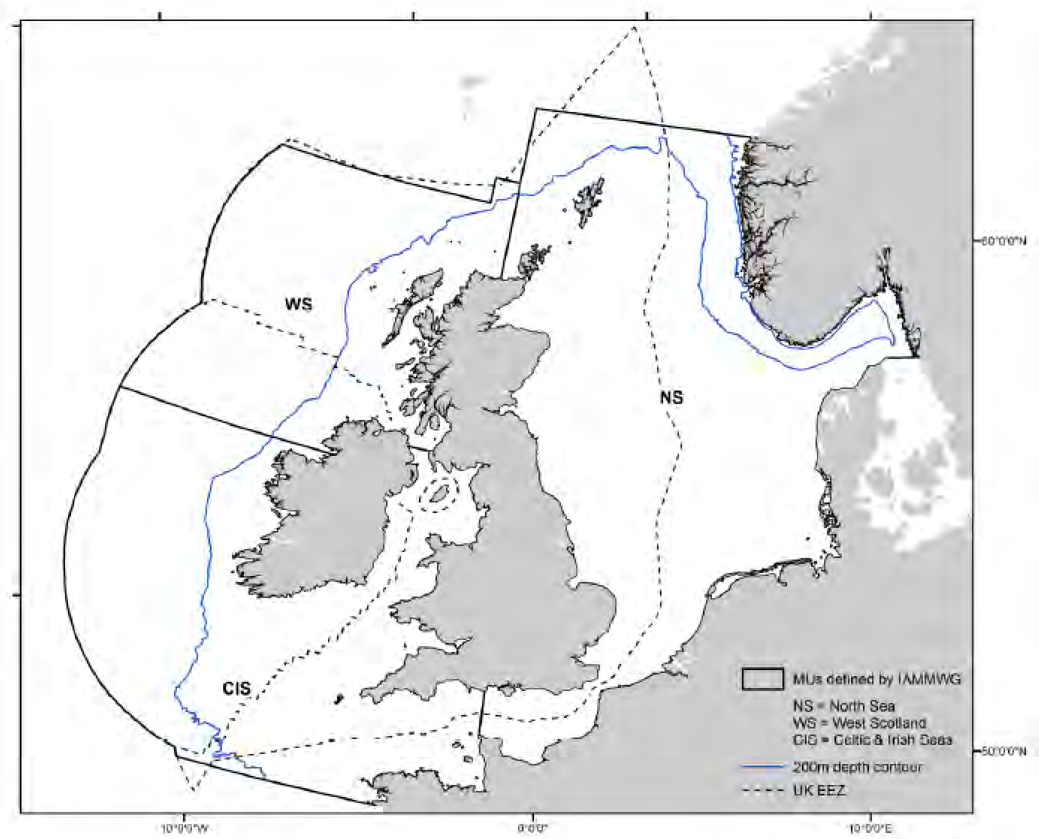

Plate 8-1 Harbour porpoise MUs (IAMMWG, 2015)

8.1.1.4.2. Density in the Norfolk Vanguard OWF sites

499. APEM collected high resolution aerial digital still imagery for marine mammals over NV East (and the former East Anglia FOUR) and NV West, with a 4km buffer area, covering a total of 645km^2. The monthly surveys collected imagery data at 2cm Ground Sampling Distance (GSD) on a 500m by 400m irregular grid-based survey to achieve a minimum of 10% coverage in each survey period (each month). Coverage of the Norfolk Vanguard OWF sites and 4km buffer was between approximately

121% and 13% per month. There are 32 months of survey data for NV East (East Anglia Four (EA4) surveys (March 2012 – February 2014) and the NV East surveys (September 2015 – April 2016)) and 24 months site specific survey data for NV West (September 2015 – August 2017).

500. All images were analysed to enumerate marine mammals to species level, where possible. APEM undertook internal quality assurance to check for missed animals and to ensure the correct species were identified, followed by external quality assurance (QA) by the Sea Mammal Research Unit (SMRU).

501. It is possible for aerial imagery to capture marine mammals at the sea surface and just below. Correction factors are applied to the raw data counts for each species to take into account individuals that could be below the depth of visibility.

502. Voet *et al.* (2017) determine seasonal correction factors for harbour porpoise that can be used to determine abundance and density estimates obtained from aerial digital surveys (Table 8.1), based on published dive profile data from harbour porpoise tagged in the North Sea.

503. The Teilmann *et al.* (2013) tagging study indicated significant differences in the percentage of time that each harbour porpoise spent between 0 and 2m water depth with the time of year. Spring and summer had a higher average time spent between 0 and 2m compared autumn and winter. Therefore, to take this into account, Teilmann *et al.* (2013) suggest that aerial survey data should be corrected for time submerged as well as for seasonal effects.

504. The seasonal correction factors in Table 8.1 were applied to the monthly data to take into account for the probability of harbour porpoise being below the water surface or detection zone (i.e. below 2m for harbour porpoise) and being undetectable by aerial surveys.

505. Turbidity can affect the ability to detect marine mammals in the 2m detection zone below the surface. However, measurements of suspended sediment concentrations were carried out at the Acoustic Wave and Current (AWAC) station in NV East between December 2012 and December 2013. Overall, suspended sediment concentrations were between 0.3 and 108mg/l throughout that year. Concentrations were less than 30mg/l for 95% of the time and less than 10mg/l for 70% of the time.

506. Water clarity (Secchi depth) in the North Sea varies with water depth and distance from the coast (Dupont and Aksnes, 2013). Long-term overall measurements of Secchi depth for the southern and central North Sea area indicate means of between

5.52m^{-1} (SD = 1.06) and 3.27m^{-1} (SD=2.22) in summer, 2.70m^{-1} (SD = 2.41) in spring / autumn and 1.66m^{-1} (SD = 0.93) in winter (Capuzzo *et al.,* 2015).

507. There is no indication of any limitations in observing marine mammals up to 2m below the surface at Norfolk Vanguard. The correction factors take into account the number of animals that could be below 2m from the surface and not detected during the aerial surveys.

Table 8.1 Harbour porpoise seasonal correction factors

Season	Correction Factor
Spring (Mar – May)	0.571
Summer (Jun – Aug)	0.547
Autumn (Sept – Nov)	0.455
Winter (Dec - Feb)	0.472

508. At NV East (without buffer, as this provides the worst-case scenario), when unidentified small cetaceans[15] are included with the harbour porpoise data, the highest monthly density estimate, using the seasonal correction factor, is 3.65/km^2. However, the other monthly density estimates for harbour porpoise, including unidentified small cetaceans, are considerably lower than the February estimate at NV East OWF site (Table 8.2). The annual mean density estimate, when using the seasonal correction factor (without buffer), is 1.26/km^2 for NV East OWF area.

509. The seasonal mean density for the summer period (April-September) is 0.73/km^2 and for the winter period (October-March) is 1.80/km^2.

Table 8.2 The highest monthly density estimates for Norfolk Vanguard East for harbour porpoise and unidentified small cetacean with and without seasonal correction factors

By Month	Density Estimate (individuals / km^2) based on raw data (CI)	Density Estimate (individuals / km^2) with seasonal correction factor
Jan	1.06 (0.55-1.61)	2.25
Feb	1.73 (1.16-2.32)	3.65
Mar	0.79 (0.50-1.35)	1.38
Apr	0.27 (0.11-0.56)	0.48
May	0.45 (0.15-0.97)	0.79
Jun	0.19 (0.02-0.37)	0.59
Jul	0.22 (0.04-0.46)	0.69
Aug	0.24 (0.09-0.42)	0.74
Sep	0.49 (0.29-0.80)	1.07

[15] As a worst-case scenario, the maximum possible density estimate for harbour porpoise has been obtained by adding the number of harbour porpoise recorded to the number of unidentified small cetaceans.

By Month	Density Estimate (individuals / km^2) based on raw data (CI)	Density Estimate (individuals / km^2) with seasonal correction factor
Oct	0.21 (0.08-0.36)	0.46
Nov	0.60 (0.31-0.91)	1.31
Dec	0.83 (0.35-1.34)	1.75
Annual	0.59 (0.31-0.96)	**1.26**

510. At NV West (without buffer as this represents the worst-case scenario), when unidentified small cetaceans are included with the harbour porpoise data, the highest density estimate was in September, with a monthly density estimate, using the seasonal correction factor, of 2.29/km^2. However, the other monthly density estimates for harbour porpoise, including unidentified small cetaceans, are considerably lower than the September estimate (Table 8.3). The annual mean density estimate when using the seasonal correction factor (without buffer) is 0.79/km^2 for the NV West OWF area.

511. The seasonal mean density for the summer period (April-September) is 0.57/km^2 and for the winter period (October-March) is 1.01/km^2.

512. The NV East and NV West density estimates of 1.26/km^2 and 0.79/km^2, respectively, based on the mean annual density and using the seasonal correction factors (Table 8.2 and Table 8.3) will be used in the assessment[16].

513. Using the mean annual density allows for seasonal variation in the number of harbour porpoise that could be present. It should also be noted that NV East is located wholly within the summer area for the SNS cSAC. The majority of NV West is located within the summer area of the SNS cSAC, with a small segment of the southern edge of the site being located within the winter area of the SNS cSAC (Figure 5.3). In addition, it anticipated that the majority of the offshore construction work would occur during summer months when the density estimates are lower, therefore using the annual density estimates is a precautionary approach.

[16] The assessment of the number of harbour porpoise that could potentially be affected has been based on the mean annual density, rather than seasonal density, as the assessment is in relation the North Sea MU reference population (rather than the cSAC seasonal areas) and so the annual average provides an appropriate density estimate (see **Section 8.1.1.5**). The spatial assessment in relation to the seasonal areas of the cSAC has also been conducted however this does not include quantification of the number of harbour porpoise and so seasonal density estimates are not required (see **Section 8.3.1**).

Table 8.3 The highest monthly density estimates for Norfolk Vanguard West for harbour porpoise and unidentified small cetaceans with and without seasonal correction factors

By Month	Density Estimate (individuals / km^2) based on raw data (CI)	Density Estimate (individuals / km^2) with seasonal correction factor
Jan	0.85 (0.55-1.18)	1.80
Feb	0.62 (0.28-1.02)	1.31
Mar	0.12 (0-0.31)	0.22
Apr	0.28 (0.06-0.56)	0.49
May	0.06 (0-0.14)	0.11
Jun	0 (0-0)	0.00
Jul	0.03 (0-0.10)	0.06
Aug	0.25 (0.11-0.40)	0.45
Sep	1.04 (0.61-1.29)	2.29
Oct	0.18 (0.06-0.33)	0.39
Nov	0.76 (0.38-1.20)	1.67
Dec	0.33 (0.18-0.47)	0.69
Annual	0.38 (0.19-0.58)	**0.79**

8.1.1.5. Reference Population

514. The reference population for harbour porpoise used in the assessment is the North Sea MU (Plate 8-1), which, based on the latest SCANS-III survey has an estimated abundance of 345,373 harbour porpoise (CV = 0.18; 95% CI = 246,526-495,752; Hammond *et al.,* 2017). This reference population has been agreed with Natural England (letter dated 3rd January 2018; Ref: 10430 Consultation 234941).

8.1.1.6. Conservation Status

515. Member states report back to the EU every six years on the Conservation Status of marine EPS. The current conservation status of harbour porpoise is ‘favourable’ based on the 2007-2012 reporting (JNCC, 2013).

8.1.1.7. Southern North Sea cSAC

516. In January 2017, the Southern North Sea cSAC was submitted to the European Commission to become designated as a SAC. As a cSAC it is legally afforded the same protection as a SAC. Harbour porpoise is the primary and only listed feature of the site.

517. The Southern North Sea site has important habitat areas for the harbour porpoise both in summer and winter. The majority of the site is less than 40m in depth, reaching up to 75m in the northern most areas. The seabed is mainly sublittoral sand and sublittoral coarse sediment (JNCC, 2017a). The site overlaps with a number

of existing Natura 2000 sites, including the Dogger Bank cSAC/SCI, Margate and Long Sands SAC, Haisborough, Hammond and Winterton cSAC/SCI and North Norfolk Sandbanks and Saturn Reef cSAC/SCI, all of which have important sandbank and gravel beds.

518. Norfolk Vanguard is located within the Southern North Sea cSAC (Figure 5.3). NV East is located wholly within the summer area. The majority of NV West is located within the summer area, with a small segment of the southern edge of the site being located within the winter area (Figure 5.3).

8.1.1.7.1. Conservation Objectives

519. The draft Conservation Objectives for the Southern North Sea cSAC are designed to ensure that the obligations of the Habitats Directive can be met. Article 6(2) of the Directive requires that there should be no deterioration or significant disturbance of the qualifying species or to the habitats upon which they rely.

520. The draft Conservation Objectives for the site are (JNCC and Natural England, 2016):

To avoid deterioration of the habitats of the harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to maintaining Favourable Conservation Status (FCS) for the UK harbour porpoise.

To ensure for harbour porpoise that, subject to natural change, the following attributes are maintained or restored in the long term:

1. The species is a viable component of the site;

2. There is no significant disturbance of the species; and

3. The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.

521. These draft Conservation Objectives 'are based on considerations of the ecological requirements of the species within the site, yet their interpretation is contextualised in their contribution to maintaining[17] FCS at a wider scale. With regard the Southern North Sea site, harbour porpoise need to be maintained rather than restored' (JNCC and Natural England, 2016).

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[17] Maintain implies that, based on our existing understanding, the feature is regarded as being in favourable condition and will, subject to natural change, remain in this condition after designation (JNCC and Natural England 2016).

1. The species is a viable component of the site.

522. This Conservation Objective is designed to minimise risk posed to harbour porpoise viability by activities within the site, such as activities that could kill, injure or significantly disturb harbour porpoise.

523. Harbour porpoise are considered to a *viable component of the site* if they are able to live successfully within it. As this site has been selected for its long term preferential use by harbour porpoise within the North Sea, it is assumed that it provides optimal habitat for breeding, calving and foraging (JNCC and Natural England, 2016).

524. Harbour porpoise are listed as European Protected Species (EPS) under Annex IV of the Habitats Directive, and are therefore protected from the deliberate killing (or injury), capture and disturbance throughout their range. Within the UK, The Habitats Directive is enacted through The Habitats Regulations 2017. Under these Regulations, it is deemed an offence if harbour porpoise are deliberately disturbed in such a way as to:

a) Impair their ability to survive, to breed or reproduce, or to rear or nurture their young; or

b) To affect significantly the local distribution or abundance of that species.

525. The term *deliberate* is defined as any action that is shown to be any action '*by a person who knows, in the light of the relevant legislation that applies to the species involved, and the general information delivered to the public, that his action will most likely lead to an offence against a species, but intends this offence or, if not, consciously accepts the foreseeable results of his action*'.

2. There is no significant disturbance of the species.

526. The aim of this Conservation Objective is to ensure that the site contributes, as best as it can, to maintaining the FCS of the wider harbour porpoise population in the North Sea. Therefore, JNCC and Natural England (2016) state that 'it is how the impacts within the site translate into effects on the North Sea MU population that are of greatest concern'.

527. As outlined in Section 8.1.1.5, JNCC and Natural England (2016) note that due the mobile nature of this species the concept of a 'site population' may not be appropriate for this species. JNCC (2017a) therefore advise that assessments of effects of plans or projects (i.e. HRA) need to take into consideration population estimates at the MU level, to account for daily and seasonal movements of the animals.

528. Disturbance of harbour porpoise may lead to displacement from an area, and the temporary loss of habitat. As such, JNCC and Natural England (2016) suggest that activities within the cSAC should be managed to ensure access to the site; and any disturbance should not lead to the exclusion of harbour porpoise from a significant portion of the site for a significant period of time.

529. Natural England's current advice to Norfolk Vanguard on the assessment of impacts on the SNS harbour porpoise cSAC (Natural England, June 2017) is that:

- Displacement of harbour porpoise should not exceed 20% of the seasonal component of the cSAC area at any one time and / or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.
- The effect of the project should be considered in the context of the seasonal components of the cSAC, rather than the cSAC as a whole.

3. The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.

530. Harbour porpoise are strongly reliant on the availability of prey species due to their high energy demands, and are highly dependent on being able to access prey species year-round.

531. This Conservation Objective is designed to ensure that harbour porpoise are able to access food resources year round, and that activities occurring in the cSAC will not affect this.

8.1.1.7.2. Management measures

532. Specific management measures are yet to be developed for the cSAC, however JNCC and Natural England (2016) advise that 'the site should be managed in a way that ensures that its contribution to the maintenance of the harbour porpoise population at FCS is optimised, and that this may require management of human activities occurring in or around the site if they are likely to have an adverse impact on the site's Conservation Objectives either directly or indirectly identified through the assessment process'.

533. JNCC and Natural England (2016) also state that 'management measures are the responsibility of the relevant regulatory bodies, which consider the SNCBs' advice and hold appropriate discussions with the sector concerned, but the scale and type of mitigation is decided by the Regulators'.

8.1.1.7.3. Advice on activities

534. JNCC and Natural England (2016) have provided draft advice on activities that specifically occur within or near to the Southern North Sea cSAC site that could be

expected to impact on the site's integrity. The key impacts and activities that JNCC and Natural England (2016) consider to have the greatest impact on the population of UK harbour porpoise and therefore the Southern North Sea cSAC are:

- Commercial fisheries with by-catch of harbour porpoise;
- Increased contaminants from discharge / run-off from land fill, terrestrial and offshore industries;
- Increased anthropogenic underwater noise from shipping, drilling, dredging and disposal, aggregate extraction, pile driving, acoustic surveys, underwater explosion, military activity, acoustic deterrent devices and recreational boating;
- Death or injury by collision with, shipping, recreational boating and tidal energy installations; and
- Reduction in prey resources by commercial fisheries.

535. The aim is that the advice should help identify the extent to which existing activities are, or can be made, consistent with the Conservation Objectives, and thereby focus the attention of Relevant and Competent Authorities and surveillance programmes to areas that may need management measures (JNCC and Natural England, 2016).

536. For the purposes of this assessment, the potential effects are considered in relation to the cSAC draft Conservation Objectives; as outlined in Table 8.4.

Table 8.4 Potential effects of Norfolk Vanguard in relation to the draft Conservation Objectives for the Southern North Sea cSAC

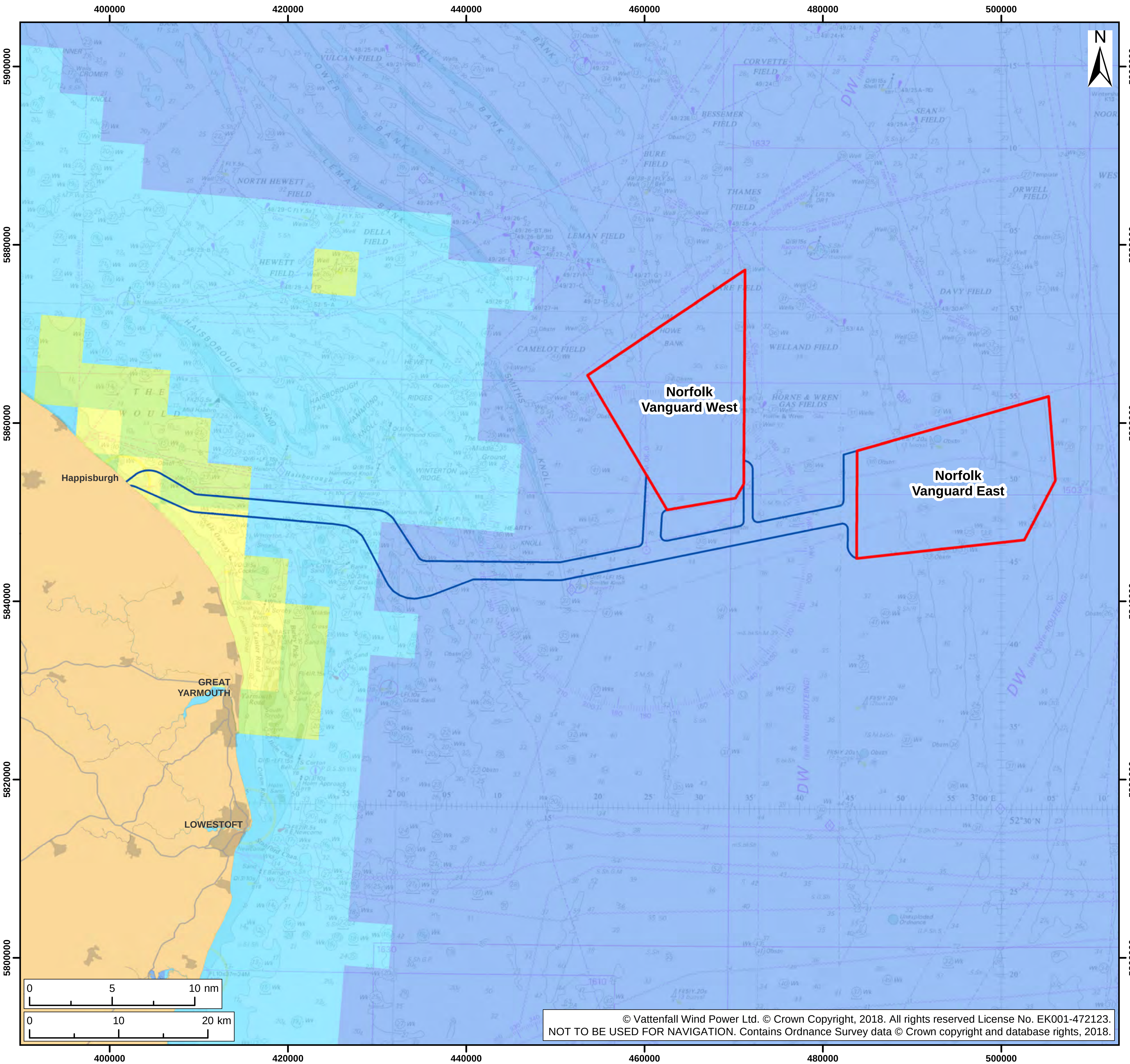
Draft Conservation Objective	Potential effect
The species is a viable component of the site	Lethal effects and permanent auditory injury from piling and the clearance of unexploded Ordnance (UXO will be mitigated and therefore there is no potential for LSE.
	Disturbance and displacement as a result of increased underwater noise levels (e.g. from UXO clearance, piling, other construction activities, vessels, operational and maintenance (O&M) noise, and noise associated with decommissioning works) have the potential to have an effect on the site and will be considered further.
	Increased collision risk with vessels during installation, operation and decommissioning has the potential to have an effect on the site and will be considered further.
There is no significant disturbance of the species	Significant disturbance and displacement as a result of increased underwater noise levels (e.g. from UXO clearance, piling, other construction activities, vessels, O&M noise, and noise associated with decommissioning phase works) have the potential to have an effect on the site and will be considered further.
The supporting habitats and processes relevant to harbour porpoises and their prey are maintained	Changes in prey availability have potential to affect the site and will be considered further.

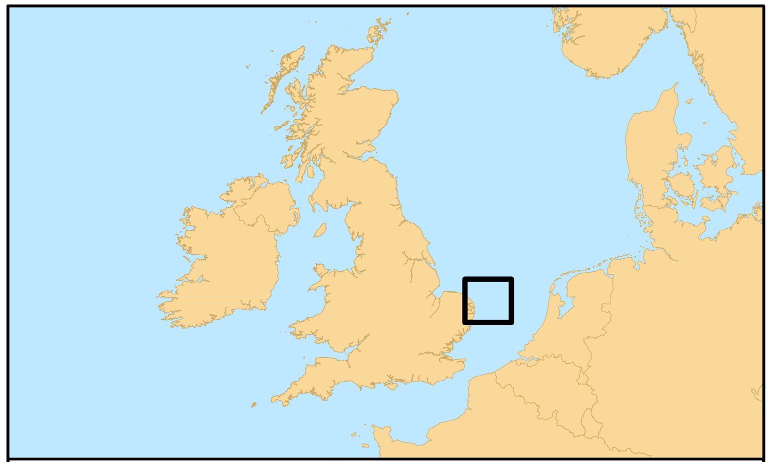
8.1.2. Grey Seal

8.1.2.1. Distribution

537. Spatial distributions indicate that grey seals have homogeneous usage near-shore, that they typically range widely and frequently travel over 100km between haul-out sites, and that they tend to spend approximately 15% of their time far-offshore, e.g. more than 50km from the coast (Russell and McConnell, 2014; SCOS, 2017).

538. SMRU produced maps of grey seal distribution in UK waters (Russell *et al.,* 2017) by combining information about the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites. The resulting maps show estimates of mean seal usage (seals per 5 km x 5 km grid cell) within UK waters. The maps indicate that grey seal usage is relatively low in and around the Norfolk Vanguard offshore project area (Figure 8.1; Russell *et al.,* 2017).





Legend:

- Norfolk Vanguard
- Offshore cable corridor

Grey Seal at-sea usage[1]

(Density of seals per 25km^2)

- 0-1
- 1-5
- 5-10
- 10-50
- 50-100
- 100-150
- 150+

[1]Russell et al. (2017).

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title:

Mean grey seal at-sea usage around Norfolk Vanguard offshore project area

Figure: 8.1 Drawing No: PB4476-004-001-003

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	16/05/2018	GS	GK	A3	1:425,000
01	26/01/2018	GS	GK	A3	1:425,000

Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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539. The SMRU, in collaboration with others, has deployed around 269 telemetry tags on grey seals around the UK between 1988 and 2010 (Russell and McConnell, 2014). The telemetry data for grey seal adults and pups indicate that very few tagged grey seals have been recorded in and around the Norfolk Vanguard offshore project area (OWF sites and offshore cable corridor), with the tracks of only one grey seal pup tagged at the Isle of May in 2002 and one adult grey seal in the vicinity of the Norfolk Vanguard offshore project area (Russell and McConnell, 2014).

540. Tags were deployed on eleven grey seals at Donna Nook and ten grey seals at Blakeney Point in May 2015, at the end of their moult periods (Russel, 2016). Of the 21 tagged individuals, 16 used multiple haul-out sites; one hauling out in the Netherlands and one in Northern France (Russel, 2016). Plate 8-2 shows the tagged seal movements along the east coast of England and indicates that grey seal travel between haul-out sites along the east coast of England, as well as to the north of France and up to the Firth of Forth and across Fladden Ground and Dogger Bank (Russell, 2016). Russell *et al.* (2013) found that between 21% and 58% of female grey seals used different regions for breeding and foraging.

541. For the East Anglia THREE EIA (EATL, 2015), East Anglia THREE Ltd (EATL) commissioned SMRU Marine Ltd to investigate the connectivity between tagged grey seal and the East Anglia THREE site plus a 20km buffer area (Appendix 12.3 of the East Anglia THREE ES; EATL, 2015[18]). The study was based on the SMRU database of telemetry data of tagged grey seal pups and adults from important breeding locations in UK, including the Farne Islands, Donna Nook, Abertay Sands and the Isle of May from 1988 to 2008. The study indicated that none of the 92 tagged grey seals aged one year or over entered the East Anglia THREE site plus a 20km buffer area or surrounding area. However, the tracks did indicate the movement of grey seals between MUs on the east coast of England and Scotland.

542. The north Dutch coastline is an important foraging zone and migration route for grey seal (Brasseur *et al.,* 2010). A study on the grey seal development in the Dutch part of the Wadden Sea shows that the growth of the breeding population is fuelled by the annual immigration of grey seals from the UK (Brasseur *et al.* 2014).

543. For the East Anglia THREE ES (EATL, 2015), EATL also commissioned IMARES to explore connectivity between tagged grey seal at haul out sites at Dutch colonies and the East Anglia THREE site plus a 20km buffer area (Appendix 12.4 of the East

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[18] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-000296-6.3.12%20(3)%20Volume%203%20Chapter%2012%20Marine%20Mammal%20Ecology%20Appendix%2012.3.pdf

Anglia THREE ES; EATL, 2015[19]. From the Dutch telemetry studies a total of 77 grey seal were tagged at haul out sites in the Netherlands between 2005 and 2013. Of these seals, six were found to travel within 20km of the East Anglia THREE site. Of these six seals, three entered the offshore cable corridor and two were within the East Anglia THREE site. Although, it is likely all grey seals from Dutch sites spent less than 2% of their 'time-at-sea' within the East Anglia THREE site. However, the study did indicate the movement of grey seal between the UK and Dutch sites.

544. There is a considerable amount of movement of grey seals that occurs (as observed from telemetry data) among the different areas and regional subunits of the North Sea and no evidence to suggest that grey seals on the North Sea coasts of Denmark, Germany, the Netherlands or France are independent from those in the UK (SCOS, 2017).

545. Grey seals will typically forage in the open sea and return regularly to land to haul-out, although they may frequently travel up to 100km between haul-out sites. Foraging trips can last anywhere between one and 30 days and most trips will occur within 100km of their haul-out sites, although grey seal can travel up to several hundred kilometres offshore to forage (SCOS, 2017). Grey seal generally travel between known foraging areas and back to the same haul-out site, but will occasionally move to a new site (SCOS, 2017).

[19] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-000297-6.3.12%20(4)%20Volume%203%20Chapter%2012%20Marine%20Mammal%20Ecology%20Appendix%2012.4.pdf

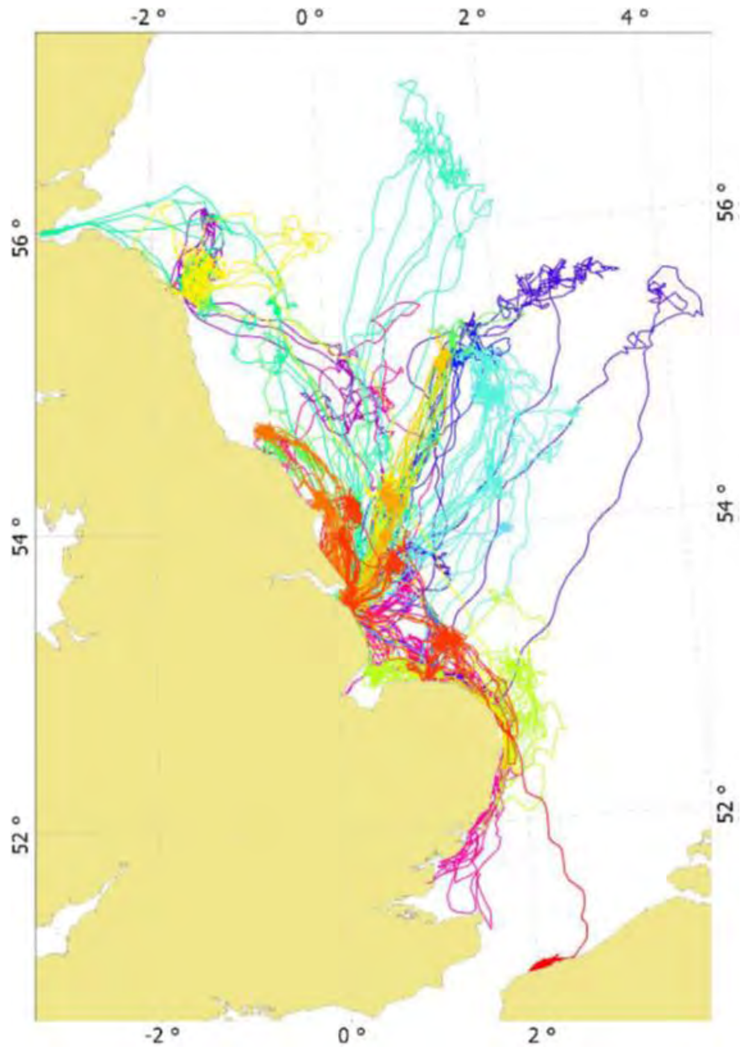


Plate 8-2 Tagged grey seal movements along the East coast of England (Russel, 2016)

8.1.2.2. Haul-out sites

546. Compared with other times of the year, grey seals in the UK spend longer hauled out during their annual moult (between December and April) and during their breeding season (SCOS, 2017).

547. In eastern England, pupping occurs mainly between early November and mid-December (SCOS, 2017). Pups are typically weaned 17 to 23 days after birth, when they moult their white natal coat, and then remain on the breeding colony for up to two or three weeks before going to sea. Mating occurs at the end of lactation and then adult females depart to sea and provide no further parental care (SCOS, 2017).

548. In the UK, grey seals typically breed on remote uninhabited islands or coasts and in small numbers in sea caves, where they can avoid busy beaches and storm surges, although they are also known to breed on some exposed beaches. For example, at Donna Nook in Lincolnshire, grey seals have become habituated to human

disturbance and over 70,000 people visit this colony during the breeding season with no apparent impact on the breeding seals (SCOS, 2017).

549. NV West is located approximately 47km offshore (at the closest point). Principal grey seal haul-out sites are at Horsey, approximately 47km for the offshore wind farm sites and approximately 11km from the landfall for the offshore export cable (Figure 5.4), Scroby Sands is approximately 47km from the offshore wind farm sites, Blakeney Point National Nature Reserve (NNR) approximately 88km from the offshore wind farm sites, The Wash approximately 79km from the offshore wind farm sites and Donna Nook is located approximately 149km from the Norfolk Vanguard offshore wind farm sites.

550. Historically, Donna Nook has been the most important breeding site for grey seals on the east coast of England, however, there has been a considerable increase in the number of pups born at Blakeney Point, with this site now the biggest grey seal breeding colony in England, overtaking Donna Nook (SCOS, 2016).

551. Donna Nook is located in the Humber Estuary SAC which is designated for grey seal. Blakeney Point is located within the Wash and North Norfolk Coast SAC which is designated for harbour seal and Horsey is located in the Winterton-Horsey Dunes SAC, although grey seal are not currently listed as a qualifying feature. While grey seal are not currently a qualifying feature at the Wash and North Norfolk SAC (which includes Blakeney Point) or Winterton-Horsey Dunes SAC, it is recognised that these sites are important for the population, as breeding, moulting and haul-out sites. Therefore consideration will be given to grey seal as part of the Wash and North Norfolk SAC or Winterton-Horsey Dunes SAC in the HRA, to determine if there is the potential for any disturbance at these sites.

552. At Horsey on the Norfolk coastline from Winterton to Waxham, grey seal use the haul-out sites for breeding and moulting. Counts undertaken by the Friends of Horsey Seals wardens in the 2016-17 breeding season indicated that the overall numbers of births increased from 1,236 in 2015-2016 to 1,487. The first births were recorded in early November and birth rate peaked on the 2nd December 2016 (Rothney, 2017). Counts undertaken in the 2017-18 breeding season indicated that the total pups born this season were 1,825 (Friends of Horsey, 2018). Counts in 2015-16, during a 15 week period from 15th October 2015 to 21st January 2016, indicate that the number of adult grey seals recorded varied with the stage in the breeding cycle. The recent counts indicate that the breeding colony of grey seals at Horsey-Winterton is continuing to increase in numbers and expand its distribution (Rothney, 2016).

553. The landfall for the Norfolk Vanguard offshore export cables will be at Happisburgh South, approximately 11km from the Horsey seal haul-out site to the south and 43km from the Blakeney Point haul-out site to the north (Figure 5.4).

8.1.2.3. Abundance

554. Approximately 38% of the world's population of grey seal breed within UK waters. Although the number of pups born in UK waters has been growing steadily since records began in 1960, the population growth is now steadying in all areas, except for the central and southern North Sea where population growth remains high (SCOS, 2017).

555. Grey seal population trends are assessed from the counts of pups born during the autumn breeding season, when females congregate on land to give birth (SCOS, 2017). The pup production estimates are converted to estimates of total population size (1+ aged population) using a mathematical model and projected forward (SCOS, 2017).

556. The most recent surveys of the principal grey seal breeding sites Scotland, Wales, Northern Ireland and south-west England, resulted in an estimate of 60,500 pups (95% CI = 53,900-66,900; SCOS, 2017). When the pup production estimates are converted to estimates of total population size, there were an estimated 139,800 UK grey seals in 2015 (approximate 95% CI = 116,500-167,100; SCOS, 2016, 2017). Projecting the model forward one year, using the same pup production time series and prior distributions for the demographic parameters provided an estimate of 141,000 (approximate 95% CI = 117,500-168,500) in 2016 (SCOS, 2017).

557. The estimated adult UK grey seal population size in regularly monitored colonies in 2016 is 128,200 (95% CI = 106,200-154,400), an increase of approximately 1% on the 2015 estimate (SCOS, 2017).

558. The most recent August counts (2016) of grey seal at haul-out sites in the south-east England MU provide an estimated abundance of 6,085 grey seal (SCOS, 2017). This includes 3,964 grey seals at Donna Nook, 431 grey seals at The Wash, 355 grey seals at Blakeney Point, 642 grey seals at Scroby Sands and 481 grey seals along the Essex and Kent coast (SCOS, 2017).

559. For the north-east MU there is an estimated 6,948 grey seal, based on the most recent counts in 2016 (SCOS, 2017). This includes 6,767 grey seals in Northumberland and 22 at The Tees (SCOS, 2017).

560. The north Dutch coastline is an important foraging zone and migration route for grey seal. Annual surveys are conducted in the Wadden Sea, during the moult and breeding season by the Trilateral Seal Expert Group (TSEG). The most recent TSEG

counts for adult grey seals were conducted by aerial surveys during the moulting period in the spring of 2017. Studies show that in moult period the animals present are not necessarily animals breeding in the Wadden Sea and considerable exchange occurs with the much larger UK population (Brasseur *et al.,* 2015). In total, the number of grey seal recorded in 2017 increased by 10% compared to 2016, to 5,445 in the Wadden Sea area (TSEG, 2017a).

561. The grey seal density estimates for Norfolk Vanguard have been calculated from the grey seal at sea usage maps (5km x 5km cells; Russell *et al.,* 2017), based on the area of overlap with the Norfolk Vanguard offshore project area. Within the offshore wind farm sites (592km^2) the upper at-sea density of grey seal is estimated to be 0.002/km^2. Within the offshore cable corridor area (237km^2) the upper at-sea density of grey seal is estimated to be 0.2/km^2.

8.1.2.4. Reference population

562. In accordance with the approach agreed with the marine mammals ETG, the reference population extent for grey seal incorporates the south-east England, north-east England and east coast of Scotland MUs (IAMMWG, 2013; SCOS, 2017) and the Waddenzee region (TSEG, 2017a).

563. The telemetry studies outlined in section 8.1.2.1, justify the inclusion of UK south-east England MU, north east England MU, east coast of Scotland MU and the Waddenzee region in the reference population for this assessment.

564. It is acknowledged that the UK grey seal counts are based on surveys conducted in August and the Waddenzee population is based on counts in winter / spring (and is not a population estimate). As outlined in section 8.1.2.3, when the pup production estimates from autumn counts are converted to estimates of total population size, there was an estimated 141,000 grey seals in 2016 (approximate 95% CI = 117,500-168,500; SCOS, 2017). The most recent counts of grey seal in the August surveys 2008-2016, estimated that the total count of grey seals in the UK was 40,662 (SCOS, 2017). Therefore, using the August grey seal counts for the reference population is a precautionary approach and is likely to be an underestimate of the number of grey seals in the UK MUs.

565. The reference population is therefore based on the most recent estimates for the:

- Waddenzee population = 5,445 grey seal (TSEG, 2017a);
- South-east England MU = 6,085 grey seal (SCOS, 2017);
- North-east England MU = 6,948 grey seal (SCOS, 2017); and
- East Coast Scotland MU = 3,812 grey seal (SCOS 2017).

566. The total reference population for the assessment is therefore 22,290 grey seal. The assessment also considers any potential effects on the south-east England MU of 6,085 grey seal.

8.1.2.5. Humber Estuary SAC

567. The Humber is the second-largest coastal plain estuary in the UK, and the largest coastal plain estuary on the east coast of Britain. Grey seal (Annex II species) are present as a qualifying feature, but not a primary reason for site selection (JNCC, 2017c).

568. The Humber Estuary SAC is located 150km from Norfolk Vanguard OWF sites and 112km from the offshore cable corridor (at closest point).

569. Donna Nook is located in the Humber Estuary SAC and the most recent August count at the site in 2016 was 3,964 grey seals (SCOS, 2017).

570. The reference population for grey seal that encompasses Humber Estuary SAC is the south-east England MU (IAMMWG, 2013). The latest grey seal count from the south-east England MU in August 2016 was 6,085 (SCOS, 2017). The reference population to be used in the assessment for the Humber Estuary SAC will be the south-east England MU of 6,085 grey seal.

571. For the purposes of this assessment, the potential effects are considered in relation to the SAC Conservation Objectives; as outlined in Table 8.5.

Table 8.5 Potential effects of Norfolk Vanguard in relation to the Conservation Objectives for the Humber Estuary SAC

Conservation Objective	Potential effect
The extent and distribution of qualifying natural habitats and habitats of qualifying species.	No potential LSE. There will be no significant change to the extent and distribution of the habitats of qualifying species in the SAC.
The structure and function (including typical species) of qualifying natural habitats.	No potential LSE. There will be no significant change to the structure and function (including typical species) of qualifying natural habitats.
The structure and function of the habitats of qualifying species.	No potential LSE. There will be no significant change to the structure and function) of the habitats of the qualifying species.
The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.	No potential LSE. There will be no significant change to the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.
The populations of qualifying species.	Increased collision risk with vessels associated with Norfolk Vanguard may cause a potential LSE which will be considered further.

Conservation Objective	Potential effect
The distribution of qualifying species within the site.	No potential LSE. There will be no significant change to the distribution of qualifying species within the site. However, significant disturbance and displacement as a result of increased underwater noise levels (e.g. from UXO clearance, piling, other construction activities, vessels, O&M noise, and noise associated with decommissioning phase works) have the potential to have an effect on the seals foraging at sea and will be considered further.

8.1.2.6. Winterton-Horsey Dunes SAC

572. As outlined in Section 8.1.2.2, while grey seal are not currently a qualifying feature at the Winterton-Horsey Dunes SAC, it is recognised that this site is important for the population, as breeding, moulting and haul-out sites. Therefore in the HRA, consideration is given to grey seal as part of the Winterton-Horsey Dunes SAC, to determine if there is the potential for any disturbance at this site.

573. The Winterton-Horsey Dunes SAC is located in the south-east England MU (IAMMWG, 2013), therefore the reference population to be used in the assessment will be the south-east England MU of 6,085 grey seal (SCOS, 2017). Taking into account that grey seal give birth to a single pup and based on the number of pups counted in the 2017-18 breeding season, a minimum of 1,825 grey seal could be present at the Winterton-Horsey Dunes SAC.

574. As the Winterton-Horsey Dunes SAC is not designated for grey seal, the relevant Conservation Objectives for the Humber Estuary SAC will be used in the assessment (Table 8.5).

575. The reference population for grey seal that encompasses Winterton-Horsey Dunes SAC is the south-east England MU (IAMMWG, 2013). The latest grey seal count from the south-east England MU in August 2016 was 6,085 (SCOS, 2017). The reference population to be used in the assessment for the Winterton-Horsey Dunes SAC will be the south-east England MU of 6,085 grey seal.

8.1.2.7. The Wash and North Norfolk Coast SAC

576. As outlined in section 8.1.2.2, while grey seal are not currently a qualifying feature of the site, this site is important for breeding, moulting and haul-out sites. Therefore in the HRA, consideration is given to grey seal as part of the Wash and North Norfolk Coast SAC, to determine if there is the potential for any disturbance at these sites.

577. The site is located in the south-east England MU (IAMMWG, 2013), therefore the reference population to be used in the assessment will be the south-east England

MU of 6,085 grey seal (SCOS, 2017). The most recent August count (2016) of grey seal at haul-out sites at The Wash was 431 (SCOS, 2017).

578. As the Wash and North Norfolk Coast SAC is not designated for grey seal, the relevant Conservation Objectives for the Humber Estuary SAC will be used in the assessment (Table 8.5).

8.1.3. Harbour Seal

8.1.3.1. Distribution

579. On the east coast of Britain harbour seal distribution is generally restricted, with concentrations in the major estuaries of the Thames, The Wash and the Moray Firth (SCOS, 2017).

580. Spatial distributions indicate harbour seals persist in discrete regional populations, display heterogeneous usage and generally stay within 50km of the coast (Russell and McConnell, 2014).

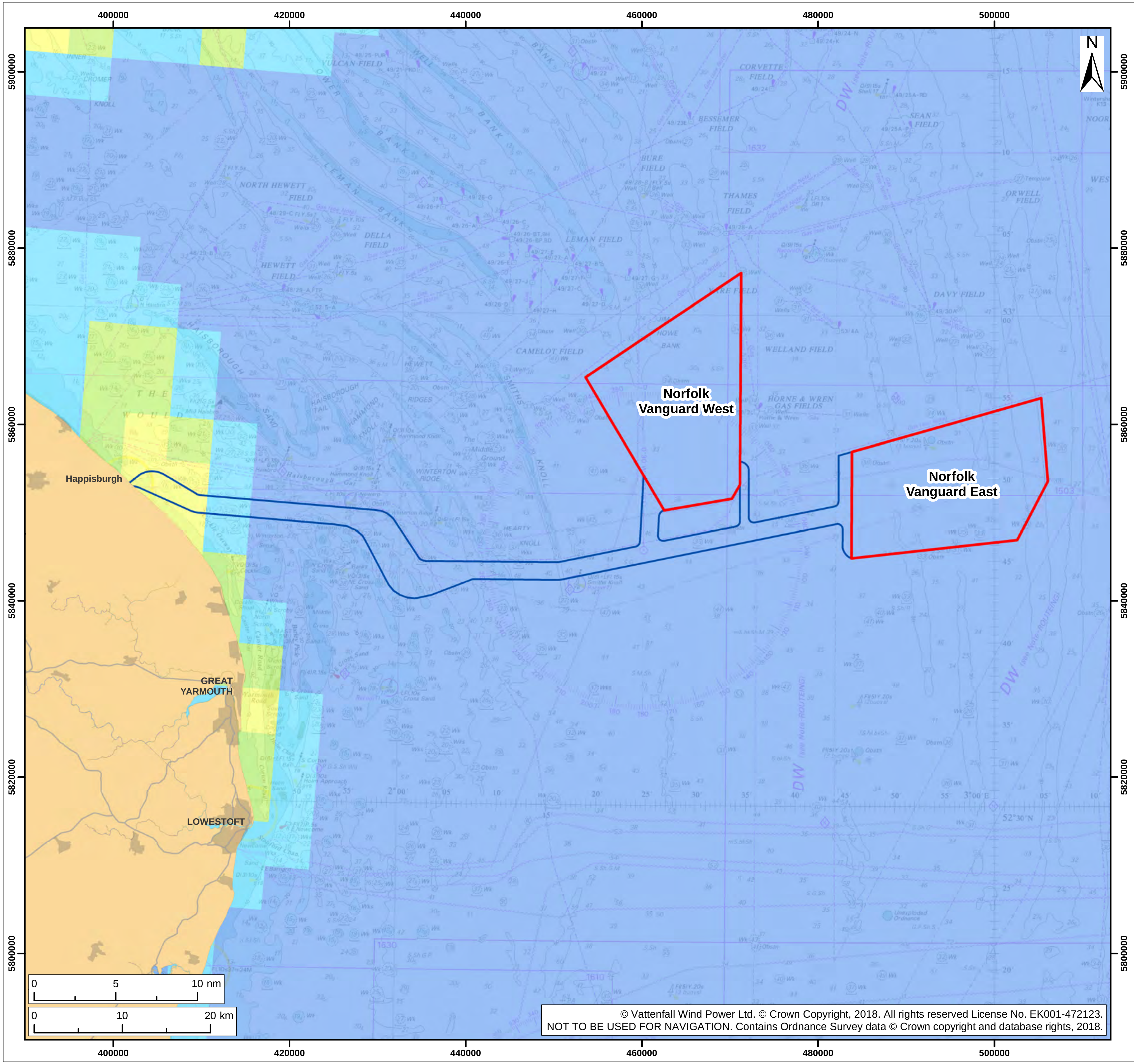
581. The SMRU maps of harbour seal distribution in UK waters (Russell *et al.,* 2017), based on the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites, indicate that harbour seal usage is relatively low in and around the Norfolk Vanguard offshore project area and slightly higher along the coast (Figure 8.2; Russell *et al.,* 2017).

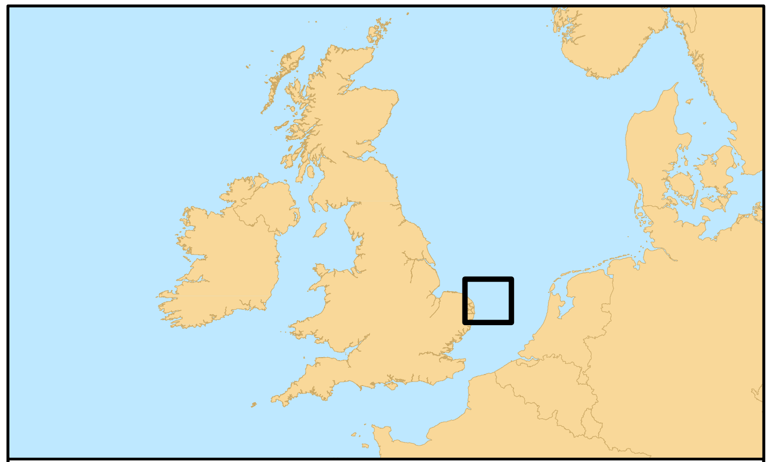
582. SMRU, in collaboration with others, has deployed around 344 telemetry tags on harbour seals around the UK between 2001 and 2012 (Russell and McConnell, 2014). The tracks indicate that very few tagged harbour seals have been recorded in the immediate vicinity of NV East and NV West, with tracks moving along the coast between The Wash and the Thames estuaries. This is reflected in the harbour seal density estimates for the Norfolk Vanguard OWF sites compared to the offshore cable corridor, see below, although harbour seal numbers in both Norfolk Vanguard OWF sites and the offshore cable corridor are very low (Figure 8.2). Most tracks of seals tagged in The Wash appear to move directly out to sea or to the north of The Wash (Russell and McConnell, 2014).

583. For the East Anglia THREE EIA (EATL, 2015), EATL commissioned SMRU Marine Ltd to investigate the connectivity between tagged harbour seal and the East Anglia THREE site plus a 20km buffer area (Appendix 12.3 of the East Anglia THREE ES; EATL, 2015). The study was based on the SMRU database of telemetry data of harbour seal juveniles and adults from tagging locations including the Wash and the Thames Estuary from 2003 to 2012, including data from the Zoological Society of London seal tagging study. The study indicated that none of the 43 tagged harbour seals aged one or above entered the East Anglia THREE site plus a 20km buffer area or

surrounding area. The study indicated that movements of harbour seal were mostly restricted to the south-east MU.

584. For the East Anglia THREE ES (EATL, 2015), EATL also commissioned IMARES to explore connectivity between tagged harbour seal at haul out sites at Dutch colonies and the East Anglia THREE site plus a 20km buffer area (Appendix 12.4 of the East Anglia THREE ES; EATL, 2015). From the Dutch telemetry studies, a total of 273 harbour seal were tagged at sites in the Netherlands between 1997 and 2013. Of these seals, 10 were found to travel within 20km of the EA3 site. Of these 10 seals, six entered the offshore cable corridor and two were within the East Anglia THREE site. Although, it is likely all but one harbour seal spent less than 2% of their 'time-at-sea' within the area, with an exception being a harbour seal tagged in 2007 which spent at least 2% and up to 17% of its 'time-at-sea' within the offshore cable corridor. The Dutch tagging data illustrate the long ranging movements of harbour seal and levels of connectivity between Dutch haul out sites and those on the east coast of England.





Legend:

- Norfolk Vanguard
- Offshore cable corridor

Harbour Seal at-sea usage[1]

(Density of seals per 25km^2)

- 0-1
- 1-5
- 5-10
- 10-50
- 50-100
- 100-150
- 150+

[1]Russell et al. (2017).

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title:

Mean harbour seal at-sea usage around Norfolk Vanguard offshore project area

Figure: 8.2 Drawing No: PB4476-004-001-002

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	16/05/2018	GS	GK	A3	1:425,000
01	26/01/2018	GS	GK	A3	1:425,000

Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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585. Harbour seals generally make smaller foraging trips than grey seal, typically travelling 40-50km from their haul-out sites to foraging areas (SCOS, 2017). Tracking studies have shown that harbour seal travel 50-100km offshore and can travel 200km between haul-out sites (Lowry *et al.,* 2001; Sharples *et al.,* 2012). The range of these trips varies depending on the location and surrounding marine habitat. Tagging studies undertaken on harbour seal at The Wash (2003-2005) have shown that this population travels larger distances for their foraging trips than for other harbour seal populations and repeatedly forage between 75km and 120km offshore (average was 80km), with one seal travelling 220km (Sharples *et al.,* 2012). Telemetry studies indicate that the tracks of tagged harbour seals have a more coastal distribution than grey seals and do not travel as far from haul-outs (Russell and McConnell, 2014).

586. Tagging studies of 118 harbour seals from seven major populations around the UK included 24 seals from The Wash (Sharples *et al.,* 2012; Plate 8-3). The tracks indicate that most harbour seals are moving along the coastline and not in the Norfolk Vanguard OWF sites.

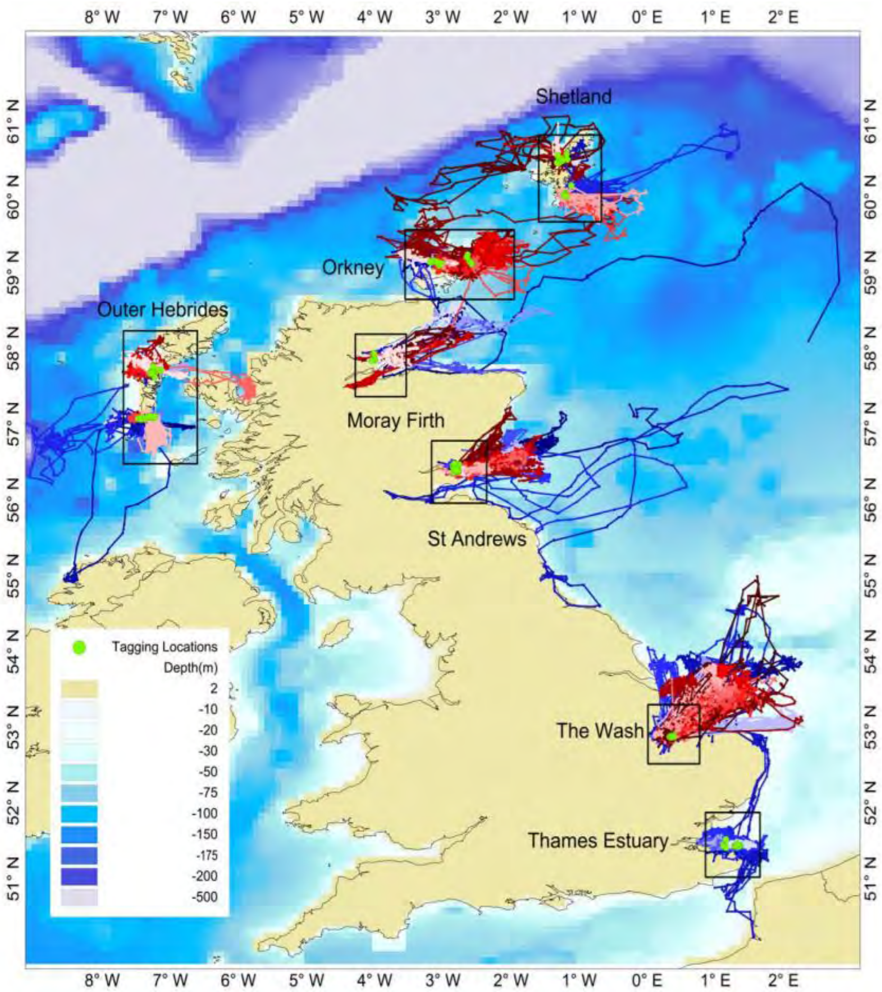


Plate 8-3 Results of the harbour seal tagging study showing large foraging ranges for the population in The Wash (Sharples *et al.,* 2012)

8.1.3.2. Haul-out sites

587. Harbour seal come ashore in sheltered waters, typically on sandbanks and in estuaries, but also in rocky areas. Harbour seal regularly haul-out on land in a pattern that is often related to the tidal cycle (SCOS, 2017).

588. Harbour seal give birth to their pups in June and July and pups can swim almost immediately after birth (SCOS, 2017). Harbour seals moult in August and spend a higher proportion of their time on land during the moult than at other times (SCOS, 2017).

589. As previously discussed, NV West is located approximately 47km offshore (at the closest point). There are principal harbour seal haul-out sites at Scroby Sands which is approximately 47km from the site, at Blakeney Point which is approximately 88km from the site and The Wash, approximately 79km from the Norfolk Vanguard OWF sites (Figure 5.4). The main breeding site for harbour seal on the east coast of England is in The Wash (SCOS, 2017).

590. As previously discussed, the Happisburgh South landfall location is approximately 11km from the Horsey seal haul-out site to the south and 43km from the Blakeney Point haul-out site to the north. These are the closest haul-out sites to the landfall location. The closest point of the Wash and North Norfolk SAC boundary (in which The Wash haul-out sites are located) is 33km from the landfall site (Figure 5.4).

8.1.3.3. Abundance

591. Approximately 30% of European harbour seal are found in the UK (SCOS, 2017).

592. There is an estimated 5,061 harbour seal in the south-east England MU, based on the most recent August counts (2016) at haul-out sites (SCOS, 2017).

593. August 2015 counts of harbour seal at haul-out sites on the south-east coast of England were 369 at Donna Nook, 3,377 at The Wash, 424 at Blakeney Point, 198 at Scroby Sands and 694 along the Essex and Kent coast (SCOS, 2017).

594. Harbour seal are also routinely surveyed in the Wadden Sea, as part of the TSEG coordinated aerial surveys in Denmark, Germany and the Netherlands. The estimate for the total Wadden Sea harbour seal population, including seals being in the water during the survey, in 2017 was estimated to be 38,100 (TSEG, 2017b).

595. The harbour seal density estimates for Norfolk Vanguard have been calculated from the harbour seal at sea usage maps (5km x 5km cells; Russell *et al.,* 2017), based on the area of overlap with the Norfolk Vanguard offshore project area. Within the offshore wind farm sites (592km^2) the upper at-sea density of harbour seal is

estimated to be 0.0001/km^2. Within the offshore cable corridor area (237km^2) the upper at-sea density of harbour seal is estimated to be 0.1/km^2.

8.1.3.4. Reference population

596. In accordance with the approach agreed with the marine mammal ETG, the reference population for harbour seal will incorporate the south-east England MU and the Waddenzee region.

597. The telemetry studies outlined in section 8.1.3.1, justify the inclusion of UK south-east England MU and the Waddenzee region in the reference population for this assessment.

598. The UK harbour seal counts are based on surveys conducted in August during the moult period and the Waddenzee population is based on harbour seal counts in June during the pupping season (TSEG, 2017b). Given that harbour seal in the UK also give birth to their pups in June and July (SCOS, 2017), there is unlikely to be double counting of seals during these surveys.

599. The reference population is therefore based on the following most recent counts:

- South-east England MU = 5,061 harbour seal (SCOS, 2017); and
- The Waddenzee region = 38,100 harbour seal (TSEG, 2017b).

600. The total harbour seal reference population for the assessment is therefore 43,161. The assessment also considers any potential effects on the south-east England MU of 5,061 harbour seal.

8.1.3.5. The Wash and North Norfolk Coast SAC

601. The Wash, on the east coast of England, is the largest embayment in the UK. The extensive intertidal flats here and on the North Norfolk Coast provide ideal conditions for harbour seal breeding and hauling-out. Harbour seal (Annex II species) are a primary reason for selection of this site (JNCC, 2017d).

602. The Wash and North Norfolk Coast SAC is located approximately 82km from NV West and 33km from the offshore cable corridor.

603. The mean harbour seal count for the Wash in 2016 was 3,377 (SCOS, 2017). The reference population for harbour seal that encompasses the Wash and North Norfolk Coast SAC is the south-east England MU. The reference population proposed to be used in the assessment of the Wash and North Norfolk Coast SAC will be the south-east England MU of 5,061 harbour seal (SCOS, 2017).

604. For the purposes of this assessment, the potential effects are considered in relation to the SAC Conservation Objectives; as outlined in Table 8.6.

Table 8.6 Potential effects of Norfolk Vanguard in relation to the Conservation Objectives for the Wash and North Norfolk Coast SAC

Conservation Objective	Potential effect
The extent and distribution of qualifying natural habitats and habitats of qualifying species.	No potential LSE. There will be no significant change to the extent and distribution of the habitats of qualifying species in the SAC.
The structure and function (including typical species) of qualifying natural habitats.	No potential LSE. There will be no significant change to the structure and function (including typical species) of qualifying natural habitats.
The structure and function of the habitats of qualifying species.	No potential LSE. There will be no significant change to the structure and function) of the habitats of the qualifying species.
The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.	No potential LSE. There will be no significant change to the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.
The populations of qualifying species.	Increased collision risk with vessels associated with Norfolk Vanguard may cause a potential LSE which will be considered further.
The distribution of qualifying species within the site.	No potential LSE. There will be no significant change to the distribution of qualifying species within the site. However, significant disturbance and displacement as a result of increased underwater noise levels (e.g. from UXO clearance, piling, other construction activities, vessels, O&M noise, and noise associated with decommissioning phase works) have the potential to have an effect on the seals foraging at sea and will be considered further.

8.2. Assessment Scenarios

605. The offshore project area consists of:

- The offshore cable corridor with landfall at Happisburgh South;
- Norfolk Vanguard West (NV West); and
- Norfolk Vanguard East (NV East).

606. Norfolk Vanguard Limited is currently considering the project in either a single phase or two phases (up to a maximum of 1,800MW). The layout of the wind turbines will be defined post-consent, but would be based on the following maxima:

- 1,800MW in NV East and 0MW in NV West; or
- 1,800MW in NV West and 0MW in NV East.

607. Any other potential layouts that are considered up to a maximum of 1,800MW (e.g. 1,200MW in NV West and 600MW in NV East; 600MW in NV West and 1,200MW in NV East; or 900MW in NV West and 900MW in NV East) lie within the envelope of these scenarios.

608. The infrastructure would be the same for each phasing scenario and therefore the total time for construction activities (e.g. active piling time) would be the same.

609. Consideration is given to the effects on marine mammals over the full construction window which is expected to be up to four years for the full 1800MW capacity (Table 8.7 and Table 8.8).

610. Within Norfolk Vanguard, several different sizes of wind turbine are being considered in the range of 9MW and 20MW. In order to achieve the maximum 1,800MW export capacity, there would be between:

- 90 x 20MW wind turbines; and
- 200 x 9MW wind turbines.

611. The worst-case scenario for each effect is outlined in Table 8.9.

612. In addition, up to two offshore electrical platforms, two accommodation platforms, two meteorological masts, two LiDAR platforms and two wave buoys, plus offshore cables are considered as part of the worst-case scenario.

613. A range of foundation options are currently being considered.

- For wind turbines these include:
  - monopiles (either piled or with suction caisson);
  - quadropod or tripod jackets (either pin-piles or suction caissons);
  - gravity base structure (GBS);and
  - tension leg floating platforms (with piled or gravity anchors).
- For the electrical platforms these include GBS, or pin-pile;
- For the accommodation platforms these include GBS or pin-pile;
- For the met masts the options are GBS, monopile or pin-pile; and
- For the LiDAR (Light Detection and Ranging) platforms the foundations could be floating with anchors or monopile.

614. The worst-case scenario for parameters relevant to the potential effect on marine mammals is outlined in Table 8.9.

Table 8.7 Indicative Norfolk Vanguard construction programme – single phase

		2024				2025				2026				2027				2028			
Indicative Programme	Approximate duration	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Foundation installation	20 months																				
Array & interconnector cable installation	19 months																				
Export cable installation	19 months																				
Wind turbine installation	20 months																				
Total construction works	23 months																				

Table 8.8 Indicative Norfolk Vanguard construction programme – two phase

		2024				2025				2026				2027				2028			
Indicative Programme	Approximate duration	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Foundation installation	2 x 8 months																				
Array & interconnector cable installation	2 x 7 months																				
Export cable installation	2 x 7 months																				
Wind turbine installation	2 x 8 months																				
Total construction works	2 x 12 months																				

8.2.1. Mitigation

8.2.1.1. Embedded mitigation

615. A number of embedded mitigation measures have been incorporated into the design of the development to prevent or reduce any potentially significant adverse effects where possible.

616. Where possible, the embedded mitigation has been taken into account in each relevant assessment when assessing the potential magnitude of the effect.

617. In addition to embedded mitigation, if further mitigation is required and possible, (i.e. those measures to prevent or reduce any remaining potentially significant adverse effects) these are discussed in the relevant sections and the post-mitigation residual effect is provided. A summary of all proposed mitigation is provided in Section 8.4.

8.2.1.1.1. Reduction of turbine numbers

618. Following PEIR, Norfolk Vanguard Limited has reduced the maximum number of turbines from 257 to 200, while maintaining the maximum export capacity of 1,800MW by committing to using 9MW to 20MW turbines.

619. This reduction in the maximum number of turbines reduces the number of foundations that could require piling, thereby reducing the overall potential underwater impacts on marine mammals. The reduction in the maximum number of turbines also reduces the potential maximum duration for turbine foundation installation, therefore again reducing the overall potential underwater impacts on marine mammals. In addition, the reduction in the maximum number of turbines would also reduce the overall physical footprint and any potential habitat loss for prey species.

8.2.1.1.2. Underwater noise

620. Norfolk Vanguard Limited has committed to the following embedded mitigation which have been incorporated into the project design in order to reduce potential effects on marine mammals:

- The use of a soft-start and ramp-up protocol:
    - Each piling event would commence with soft-start for a minimum of 10 minutes at 10% of the maximum hammer energy followed by a gradual ramp-up for at least 20 minutes to the maximum hammer energy (although maximum hammer energy is only likely to be required at a few of the piling installation locations).

- This minimum 30 minute soft-start and ramp-up duration is more precautionary than the current JNCC (2010a) guidance, which recommends that the soft-start and ramp-up duration should be a period of not less than 20 minutes.
- During the 30 minutes for the soft-start and ramp-up it is estimated that animals would move over 2.7km away from the piling location, based on a precautionary average marine mammal swimming speed of 1.5m/s Otani *et al.,* 2000). Based on a precautionary swimming speed of 1.8m/s which is more representative of a fleeing animal (e.g. Kastelein *et al.* (2018) recorded harbour porpoise swimming speeds of 1.97m/s during playbacks of pile driving sounds), the distance covered would be 3.2km. However, as a precautionary approach the assessment has been based on the average marine mammal swimming speed of 1.5m/s.
- During the minimum 10 minute soft-start it is estimated that marine mammals would move at least 0.9km from the piling location.
- During the minimum 20 minute ramp-up it is estimated that marine mammals would move at least 1.8km.

8.2.1.2. Further mitigation

8.2.1.2.1. MMMP for piling

621. The MMMP for piling will be developed in the pre-construction period and based upon best available information and methodologies. A draft MMMP for piling (document 8.13) is submitted with the DCO Application. The MMMP for piling will be developed in consultation with the relevant SNCBs and the MMO, detailing the proposed mitigation measures to reduce the risk of any physical or permanent auditory injury (Permanent Threshold Shift; PTS) to marine mammals during all piling operations. This will include details of the embedded mitigation, for the soft-start and ramp-up, as well as details of the mitigation zone in order to minimise potential impacts on physical and auditory injury and additional mitigation measures that could be required, for example, the activation of acoustic deterrent devices (ADDs) prior to the soft-start.

622. A mitigation zone, based on instantaneous PTS and cumulative PTS impact ranges, will be established. Mitigation measures would aim to remove marine mammals from the mitigation zone prior to the start of piling to reduce the risk of any physical or auditory injury.

623. The methods for achieving the mitigation zone would be agreed with the MMO in consultation with the relevant SNCBs and secured as commitments within the MMMP for piling.

8.2.1.2.2. MMMP for UXO clearance

624. A detailed MMMP would also be prepared for UXO clearance following the pre-construction UXO survey when there is more detailed information on the UXO clearance which could be required. The UXO MMMP will take account of the most suitable mitigation measures at that time and will be based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and MMO. The MMMP for UXO clearance will ensure there are adequate mitigation measures to minimise the risk of any physical or permanent auditory injury (PTS) to marine mammals as a result of UXO clearance.

8.2.1.2.3. In Principle Site Integrity Plan

625. In addition to the MMMPs for piling and UXO clearance, a Norfolk Vanguard Southern North Sea cSAC Site Integrity Plan (SIP) will be developed and an In Principle SIP (document 8.17) is provided with the DCO application. The SIP will set out the approach to deliver any project mitigation or management measures in relation to the SNS cSAC.

8.2.2. Worst Case Scenario

626. The realistic worst-case scenario for each potential effect has been determined. For this assessment, the realistic worst-case scenario involves consideration of both the relative timing, as well as the potential worst-case parameters that define the project design envelope for Norfolk Vanguard.

627. Table 8.9 provides a summary of the worst-case parameters of Norfolk Vanguard that could have a potential effect on marine mammals.

Table 8.9 Worst-case parameters for marine mammal receptors

Impact	Parameter	Maximum worst-case	Rationale
Construction			
Underwater noise from UXO clearance	Number of UXO	• 9 in NV East • 5 in NV West • 28 in offshore cable corridor Total = 42	Estimated worst-case of nine clearance operations in NV East, five in NV West and 28 in the offshore cable corridor based on initial geophysical data (Fugro, 2016) but numbers will be determined by a pre-construction UXO survey.
	Type and size of UXO	• German LMB (GC) Ground Mine (up to 700kg NEQ)) • British A Mk6 Ground Mine (up to 430 kg NEQ) • German E series buoyant mine (up to 150kg NEQ)) • British MK14 Buoyant mine (up to 227kg NEQ) • 250lb HE Bomb (up to 55kg NEQ)) • 500lb HE Bomb (up to 120kg NEQ)) 1000lb HE Bomb (up to 250kg NEQ))	A detailed UXO survey would be completed prior to construction. The type, size (net explosive quantities (NEQ)) and number of possible detonations and duration of UXO clearance operations is therefore not known at this stage
Underwater noise from pile driving (alternative foundation types are also considered but do not represent the worst-case scenario for underwater noise)	Number of wind turbines	200 (9MW turbines) 90 (20MW turbines)	The maximum number of piled foundations would represent the **temporal** worst-case scenario. The maximum predicted impact range for underwater noise for piled foundations would represent the **spatial** worst-case scenario. The maximum potential disturbance range is 26km, for all sizes piles and hammer energies, based on current SNCB guidance.
	Number of other offshore platforms	2 x offshore electrical platforms 2 x Met masts 2 x LiDAR 2 x Accommodation = 8	The maximum number of offshore platforms represents the worst-case scenario in addition to turbine scenarios above.
	Proportion of foundations that are piled	100%	The maximum proportion of piled foundations represents the worst-case scenario for underwater noise.

Impact	Parameter	Maximum worst-case	Rationale
	Number of piles per foundation	1 (monopile) 3 (tripod with pin-piles of the same diameter as the quadropod and therefore this will not be the worst-case scenario) 4 (quadropod with pin-piles or tension leg floating platform with up to 4 anchors) 6 legged jacket – offshore electrical platforms and accommodation platforms only	The maximum number of piles would represent the **temporal** worst-case scenario however the maximum number of the largest piles (monopiles) would represent the greatest **spatial** impact.
	Maximum number of piles - Wind turbines	200 x 4 (9MW quadropod) = 800	The 9MW quadropod will represent the worst-case temporal impact due to having the greatest number of piles.
	Maximum number of piles - Other offshore platforms	2 x offshore electrical platforms with 6 piles = 12 2 x Met masts quadropod = 8 2 x LiDAR monopile = 2 2 x Accommodation platform with 6 piles = 12 Total = 34	Assumes a worst-case of 6 pin-piles/piled anchors per OCP and accommodation platform.
	Total number of piled foundations	834	The maximum number of piles would represent the temporal worst-case scenario.
	Hammer energies	Maximum hammer energy: • 2,700kJ (9MW-20MW pin-pile) • 5,000kJ (20MW monopile) Starting hammer energies of 10% will be used followed by ramp-up to the maximum hammer energy.	5,000kJ hammer energy represents the worst-case scenario for the noise impact at any one time. Consideration will also be given to the increased temporal impact associated with the 9MW quadropod foundations with pin-piles.
	Pile diameter	• 10m (9MW monopile) • 3m (9MW pin-pile) • 15m (20MW monopile) • 5m (20MW pin-pile)	The largest pile (20MW monopile) requires the maximum hammer energy and will represent the worst-case spatial impact.

Impact	Parameter	Maximum worst-case	Rationale
	Total piling time – per turbine foundation (providing allowance for soft start and issues such as low blow rate, refusal)	• 6hrs per pile (9MW monopile) x 200 piles = 1,200 hours (4,000kJ hammer) • 1.5hrs per pile (9MW quadropod) x 800 piles = 1,200 hours (2,700kJ hammer) • 6hrs per pile (20MW monopile) x 90 piles = 540 hours (5,000kJ hammer) • 3hrs per pile (20MW quadropod) x 360 turbines = 1,080 hours (2,700kJ hammer)	The maximum piling duration of 1,200 hours associated with 9MW monopile or 9MW quadropod represents the temporal worst case scenario.
	Total piling time – per platform foundation (providing allowance for soft start and issues such as low blow rate, refusal)	• 1.5hrs per pile (six pin-piles for OCP) x 12 piles = 18 hours • 1.5hrs (six pin-piles for accommodation platforms) x 12 piles = 18 hours • 1.5hrs per pile (Met masts quadropod) x 8 = 12 hours • 6hrs per pile (LiDAR monopiles) x 2 = 12 hours • Total = 60 hours	Assumes a worst-case of 6 pin-piles/piled anchors per offshore electrical platform and accommodation platform.
	Foundation installation period within construction period	• Single phase = 20 months • Two phase = 2 x 8 months	This is an indicative period within which foundation installation, including piling is anticipated to occur.
	Number of concurrent piling events	2	The maximum number of concurrent piling events represents the worst case spatial impact.
	Min. spacing between piling vessels	680m	Based on the closest turbine spacing.
	Max. spacing between piling vessels	Approximately 27km	Based on the limits of the Offshore Wind Farm (OWF) site (including NV East and NV West) boundaries. The maximum spacing represents the worst-case spatial impact.

Impact	Parameter	Maximum worst-case	Rationale
Underwater noise from seabed preparation, rock dumping and cable installation	Cable installation methods	• Surface laid with cable protection where burial is not possible; • Ploughing; • Jetting; • Dredging; • Mass flow excavation; and • Trenching.	
	Array cable length	600km	Maximum potential for underwater noise impacts.
	Max no. of array cable laying vessels on site	3	
	Max no. of export cable laying vessels on site	3	
	Indicative duration of cable installation	• Single phase = 19 months • Two phase=– 2 x 7 months = 14 months	19 months represents the indicative maximum cable installation duration.
	Interconnection cable length	Up to 50km length. Based on turbine capacity being split between NV East and NV West	Maximum potential for underwater noise impacts during installation.
	Total export cable length	4 x approximately 100km cables based on all capacity being in NV East. Laid as pairs with a total of 2 trenches, up to 200km trench length.	
Vessels • Underwater noise and disturbance	Maximum number of vessels on site at any one time during construction	Maximum = 57	Maximum potential for disturbance or collision risk.

Impact	Parameter	Maximum worst-case	Rationale
from vessels • Collision risk • Disturbance at seal haul-out sites	Indicative number of movements	Single phase = 1,180 Two phase = 590 x 2 phases = 1,180 in total	
	Vessel types	Vessel types that could be on site during construction include: • Seabed preparation vessels • Transition piece installation vessels • Scour Installation Vessels • Number of vessels engaged in foundations • WTG installation vessels • Commissioning vessels • Accommodation vessels • Inter-array cable laying vessels • Export cable laying vessels • Landfall cable installation vessels • Substation / collector station installation vessels • Other vessels	
	Port locations	Will be determined post consent. Assessment will consider Great Yarmouth, Lowestoft and Hull.	A local port on the east coast of England is likely scenario. Vessel traffic to and from port would likely become integrated in existing shipping routes.
Operation and maintenance			
Underwater noise from turbines	Number of wind turbines	200 (9MW devices) 90 (20MW devices)	
	Wind turbine size	9-20MW	
Underwater noise from maintenance activities, such as any additional	Unplanned repairs and reburial of cables may be required during O&M: • Reburial of up to 20km length per export cable pair.		Maximum potential for disturbance.

Impact	Parameter	Maximum worst-case	Rationale
rock dumping and cable re-burial	• Reburial of 25% of array cable is estimated once every 5 years. • Two array cable repairs per year are estimated. • One interconnector repair per year is estimated. Rock dumping may be required should reburial not be possible.		
Vessels • Underwater noise and disturbance from vessels • Collision risk • Disturbance at seal haul-out sites	Number of wind farm support vessel trips per year.	440	Maximum potential for disturbance or collision risk.
Entanglement in floating foundation tension mooring lines	Diameter of Floating Structure (m)	9MW turbine = 45m 20MW turbine = 70m	
	Minimum water penetration depth (m) of floating structure	3m	
	Maximum water penetration depth (m) of floating structure	35m	
	Maximum number of anchor lines	12 (up to 4 anchors)	
	Anchor line thickness (m)	9MW turbine = 0.3m 20 MW turbine = 0.65m	
	Anchor line material	Steel	

Impact	Parameter	Maximum worst-case	Rationale
	Anchor line length - 40m water depth (m)	20m	
	Angle of mooring line from structure to seabed	Vertical or up to 30°	
	Anchor material	Steel-reinforced-Concrete	
	Maximum movement at surface (m)	10m	
Permanent loss of sea bed habitat – changes in prey availability	Permanent footprint of offshore infrastructure.	Turbines Total worst case turbine footprint (1800MW) with scour protection, based on 90 x 20MW tension floating platform with a gravity anchor of 70 x 70m (350 x 350m with scour protection) = 11,025,000m^2. Array cable protection Up to 60km of cable protection may be required in the unlikely event that array cables cannot be buried (based on 10% of the length) resulting in a footprint of 300,000m^2 (based on protection width of 5m). Array cable protection at turbines 100m cable length x 5m width x 200 turbines = 100,000m^2 Array cable crossings protection 10 crossings x 100m x 10m = 10,000m^2 Interconnector cable protection Interconnector cable protection approaching platforms 100m cable length x 5m width x 2	

Impact	Parameter	Maximum worst-case	Rationale
		platforms = 1,000m^2 Surface laid interconnector cable protection 5m width x 15,000m (10% of the length) = 75,000m^2 Interconnector cable crossings protection crossings – captured within export cable/array cable crossing total <u>Platforms and other infrastructure</u> Two offshore electrical platforms with scour protection = 35,000m^2 Two accommodation platforms with scour protection = 35,000m^2 Two met masts with scour protection = 15,708m^2 Two wave buoys = 300m^2 Two LiDAR monopiles with scour protection = 157m^2 **Total WCS footprint in the OWF sites = 11.6km^2** <u>Export cables</u> *Crossings:* A total of eleven crossings are required for each cable pair (up to 22 crossings) resulting in a total footprint of 22,000m^2 (based on a width of 10m and length of 100m of cable protection per crossing). *Nearshore (within 10m depth contour):* Cable protection may be required at each of the landfall HDD exit points. This would entail one mattress (6m length x 3m width x 0.3m height) plus rock dumping (5m length x 5m width x 0.5m height) at each exit point (up to two cable pairs) resulting in a footprint of 36m^2	

Impact	Parameter	Maximum worst-case	Rationale
		Unburied cables: In the unlikely event that cable burial is not possible due to hard substrate being encountered, up to 28km of additional protection resulting in a footprint of 140,000m^2 (based on protection width of 5m). **Total** **WCS footprint in the offshore cable corridor = 0.16km^2**	
Decommissioning			
Underwater noise from foundation removal (e.g. cutting)	Assumed to be as construction (with no pile driving). Assumed piles cut off below seabed level and all wind turbine components above seabed level removed. Some or all of the array cables, interconnector cables, and offshore export cables would be removed. Scour and cable protection would likely be left *in situ*.		
Vessels • Underwater noise and disturbance from vessels • Collision risk • Disturbance at seal haul-out sites	Assumed to be similar vessel types, numbers and movements to construction phase (or less).		

8.3. Assessment of Potential Effects

8.3.1. Southern North Sea cSAC

628. Assessment of the potential effects on the Southern North Sea cSAC for harbour porpoise, is based on SNCB's current advice to Norfolk Vanguard (Natural England, June 2017) that:

- Displacement of harbour porpoise should not exceed 20% of the seasonal component of the cSAC area at any one time and / or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.
- The effect of the project should be considered in the context of the seasonal components of the cSAC area, rather than the cSAC area as a whole.
- A distance of 26km from an individual percussive piling location should be used to assess the area of cSAC habitat harbour porpoise may be disturbed from during piling operations.
- A buffer of 10km around seismic operations and 26km around UXO detonations used to assess the area of cSAC habitat harbour porpoise may be disturbed.

629. The total Southern North Sea cSAC area is 36,951km^2 (JNCC, 2017a). The northern 'summer' area is approximately 27,088km^2 and covers the period from April to September (183 days). The southern 'winter' area is approximately 13,366km^2 and covers the period from October to March (182 days) (Heinänen and Skov, 2015)[20].

630. The maximum and minimum potential overlap on the seasonal cSAC areas has been calculated to enable an average potential effect to be approximated.

631. The seasonal averages have been calculated by multiplying the average of the minimum and maximum effect on any one day by the proportion of days within the season on which piling could occur. This was the agreed approach used in the East Anglia THREE HRA (EATL, 2016) and has been agreed with Natural England for Norfolk Vanguard (letter dated 3rd January 2018; Ref: 10430 Consultation 234941).

632. As outlined in Section 8.1.1.5, the potential effects have also been assessed and put into the context of the most recent harbour porpoise abundance estimate for the North Sea MU of 345,373 (CV = 0.18; 95% CI = 246,526-495,752) from the latest SCANS-III survey (Hammond *et al.,* 2017).

633. The SNS cSAC Site Selection Report (JNCC, 2017b) identifies that the SNS cSAC site could support approximately 17.5% of the UK North Sea reference population for at least part of the year (JNCC, 2017b). However, JNCC (2017b) states that because this

[20] Summer and winter areas of these have been estimated using GIS overlays and based on areas in BEIS HRA scoping report

estimate is from a one-month survey in a single year (the SCANS-II survey in July 2005) it cannot be considered as an estimated population for the site. It is therefore not appropriate to use site population estimates in any assessments of effects of plans or projects on the site (i.e. HRA), as these need to take into consideration population estimates at the MU level, to account for daily and seasonal movements of the animals (JNCC, 2017b).

634. However, it was agreed with the marine mammal ETG at the EPP meeting on 15th February 2017 that the estimate that the SNS cSAC could support 17.5% of the UK North Sea reference population could be considered in the assessments for the HRA alongside the North Sea MU reference population and the SNS cSAC winter and summer areas. Therefore, for information purposes, Appendix 8.1 presents an assessment on the estimated number of harbour porpoise that the SNS cSAC site could support of 29,384 harbour porpoise. This estimate is based on the UK North Sea MU area (322,897km^2), the overall harbour porpoise density estimate of 0.52/km2 (CV = 0.18) for the North Sea MU area from the SCANS-III survey (Hammond *et al.,* 2017) and the estimated UK North Sea MU population of 167,906 harbour porpoise, with 17.5% of the population within the UK part of the North Sea MU of approximately 29,384 harbour porpoise.

635. The potential effects during the construction, operation and decommissioning of the proposed Norfolk Vanguard project to be assessed as part of the HRA process for the Southern North Sea cSAC have been agreed in consultation with the marine mammal ETG as part of the EPP.

636. The potential effects during construction of the proposed Norfolk Vanguard project that have the potential to adversely affect the integrity of the site in relation to the Conservation Objectives are:

- The risk of permenant auditory injury from the underwater noise associated with the clearance of UXO;
- Disturbance resulting from the underwater noise associated with the clearance of UXO;
- The risk of permenant auditory injury from the underwater noise during piling;
- Disturbance resulting from underwater noise during piling;
- Disturbance resulting from underwater noise during other construction activities, for example, seabed preparation, rock dumping and cable installation;
- Disturbance resulting from underwater noise and disturbance from vessels;
- Vessel interaction (collision risk);
- Changes to prey resource; and
- Changes to water quality.

637. The potential effects during operation and maintenance of the proposed Norfolk Vanguard project that have the potential to adversely affect the integrity of the site in relation to the Conservation Objectives are:

- Disturbance resulting from the underwater noise associated with operational turbines;
- Disturbance resulting from the underwater noise associated with maintenance activities, such as any additional rock dumping and cable re-burial;
- Disturbance resulting from underwater noise and disturbance from vessels;
- Vessel interaction (collision risk); and
- Changes to prey resource.

638. The potential effects during decommissioning of the proposed Norfolk Vanguard project that have the potential to adversely affect the integrity of the site in relation to the Conservation Objectives are:

- Disturbance resulting from the noise associated with foundation removal (e.g. cutting);
- Disturbance resulting from underwater noise and disturbance from vessels;
- Vessel interaction (collision risk); and
- Changes to prey resource.

8.3.1.1. Potential effects during construction of Norfolk Vanguard

639. The realistic worst-case scenario on which the assessment is based for harbour porpoise is outlined in Table 8.9.

8.3.1.1.1. Potential effects resulting from the underwater noise associated with clearance of UXO at Norfolk Vanguard (alone)

640. There is the potential requirement for UXO clearance prior to construction. Whilst any underwater UXO that are identified would preferentially be avoided or removed from the seabed and disposed of onshore in a suitable area, it is necessary to consider the requirement for underwater UXO detonation where it is deemed unsafe to retrieve the UXO from the seafloor.

641. A detailed UXO survey would be completed prior to construction. The number of possible detonations and duration of UXO clearance operations is therefore not known at this stage. However, a strategic UXO risk management assessment has been conducted for Norfolk Vanguard to determine the potential seabed effects during Explosive Ordnance Disposal (EOD) (Ordtek, 2018 provided in Appendix 5.2 of the (ES document 6.1)).

642. In the technical note Ordtek (2018) has:

- Assessed typical UXO items, likely to be recommended for high order disposal.
- Assumed that all items found are live and the maximum explosive content is present.
- Assumed that approximately 5kg donor charge will be used during the EOD phase.

643. The technical note is drawn both from practical offshore industry experience, open-source studies and principles applied by military EOD specialists.

644. Other items of UXO may be encountered, however the wide range of net explosive quantities (NEQ) of the items above provide a good baseline for predicting and measuring the effects of any other items that could be encountered at Norfolk Vanguard. Table 8.10 illustrates the NEQ of the potential types of UXO that may be encountered at Norfolk Vanguard.

Table 8.10 Potential UXO that could be located at Norfolk Vanguard

UXO item	Nominal NEQ (kg)	TNT Equivalent (kg)
German LMB (GC) Ground Mine (Hexanite)	700	770
British A Mk6 Ground Mine	430	525
German E series buoyant mine (Wet Gun Cotton / TNT - worst case)	150	150
British MK14 Buoyant mine	227	261
250lb HE Bomb (Amatol / TNT)	55	55
500lb HE Bomb (Amatol / TNT)	120	120
1000lb HE Bomb (Amatol / TNT)	250	150

Permanent auditory injury

645. A MMMP for UXO clearance would be developed post-consent in consultation with the MMO and relevant SNCBs and will be based on the latest scientific understanding and guidance, pre-construction UXO surveys at the Norfolk Vanguard offshore project area, and detailed project design. The MMMP for UXO clearance will detail the proposed mitigation measures to reduce the risk of permanent auditory injury (Permanent Threshold Shift; PTS) to harbour porpoise during any underwater detonations. With the commitment to the MMMP for UXO clearance, the potential for permanent auditory injury (PTS) was screened out of this assessment (HRA Screening provided in Appendix 5.1), as there would be no potential for any LSE with effective mitigation. However, an assessment on the potential for PTS has been included.

646. Subacoustech has undertaken predictive underwater noise modelling (Appendix 5.4 of the ES (document 6.1)) to estimate the potential impact ranges for marine

mammals likely to arise during UXO clearance Norfolk Vanguard, based on the UXO that could be located at Norfolk Vanguard (Table 8.10).

647. As outlined above, a number of UXOs with a range of charge weights could be located within the boundary of the Norfolk Vanguard site. There is expected to be a variety of explosive types, which will have been subject to degradation and burying over time. Two otherwise identical explosive devices are therefore likely to produce different blasts where one has spent an extended period on the sea bed.

648. The noise produced by the detonation of explosives is affected by a number of different elements, only one of which, the charge weight, can easily be factored into a calculation. In this case the charge weight is based on the equivalent weight of TNT. Many other elements relating to its situation (e.g. its design, composition, age, position, orientation, whether it is covered by sediment) are unknown and cannot be directly considered in an assessment. This leads to a high degree of uncertainty in the estimation of the source noise level (i.e. the noise level at the position of the UXO). A worst-case estimation has therefore been used for calculations, assuming that the UXO to be detonated is not buried, degraded or subject to any other significant attenuation.

649. The consequence of this is that the noise levels produced, particularly by the larger explosives under consideration, are likely to be over-estimated as they are likely to be covered by sediment and degraded.

650. The impact criteria use thresholds and weightings based on the NOAA (NMFS, 2016) criteria. The thresholds indicate the onset of PTS, or the point at which there is an increase in risk of permanent hearing damage. These are simple indicators and do not take into account the spreading of underwater sound over long distances, and thus there is a greater likelihood of accuracy where the ranges are small.

651. Harbour porpoise are classed as high-frequency cetaceans, as they are more sensitive to high frequency sound. The thresholds are weighted, which adjusts the sound present at the receiver based on the sensitivity of the receiver. Blast noise is fairly broadband, comprising a wide range of low to high frequency sound, although the majority is at low frequency.

652. The number of harbour porpoise that could potentially be affected has been estimated for Norfolk Vanguard, based on the maximum potential PTS impact ranges of UXO clearance (Table 8.11).

653. Caution should also be raised over the longer range SPL_{peak} values. Peak noise levels are difficult to predict accurately in a shallow water environment (von Benda Beckmann, 2015) and would tend to be significantly over-estimated over ranges of

the order of 3,000m compared to real data. Therefore, the use of NMFS weighted SEL is considered preferential at long range (Subacoustech, 2018 provided in Appendix 5.4 of the ES). However, as a precautionary approach and based on the current Natural England advice (20180209 NE position on NOAA UXOs and EPS) the assessment has been based on the worst-case scenarios for the unweighted SPL_{peak} predicted PTS impact ranges (Table 8.11).

Table 8.11 Potential effects of permanent auditory injury (PTS) on marine mammals during UXO clearance without mitigation

Species	Potential Effect	TNT Equivalent / Charge weights SOURCE LEVEL, SPL_{PEAK}	55 kg 287.4 dB	120 kg 290.0 dB	150 kg 290.7 dB	250 kg 292.4 dB	261 kg 292.5 dB	525 kg 294.8 dB	770 kg 296.1 dB
Harbour porpoise (high-frequency cetacean)	PTS SPL_{peak} Unweighted (NMFS, 2016)	202 dB re 1 µPa	5.4 km	6.8 km	7.3 km	8.4 km	8.5 km	10.4 km	11.5 km
	PTS SEL Weighted (NMFS, 2016)	155 dB re 1 $\mu Pa^2 s$	1.2 km	1. 7km	1.9 km	2.4 km	2.4 km	3.3 km	3.9 km
	Number of harbour porpoise and % of reference population based on maximum impact range (11.5km) for PTS unweighted SPL_{peak} (NMFS, 2016)		Maximum impact area* based on unweighted SPL_{peak} = 415.5km^2 368.5 harbour porpoise (0.1% of NS MU) based on SCANS-III survey density (0.888/km^2). 523.5 harbour porpoise (0.15% of NS MU) based on site specific survey density (1.26/km^2) at NV East+						

*Maximum area based on area of circle with maximum impact range for radius; +Worst-case scenario based on greatest density estimate for the NV West and NV East sites.

Mitigation

654. As outlined above, a MMMP for UXO clearance will be produced post-consent in consultation with the MMO and relevant SNCBs and will be based on the latest scientific understanding and guidance, pre-construction UXO surveys at the Norfolk Vanguard offshore project area and detailed project design. The MMMP for UXO clearance will detail the proposed mitigation measures to reduce the risk of permanent auditory injury (PTS) to harbour porpoise during any underwater detonations.

655. The MMMP for UXO clearance will involve the establishment of a suitable mitigation zone around the UXO location before any detonation. Norfolk Vanguard Limited will ensure that the mitigation measures are adequate to ensure no marine mammals

are present within the mitigation zone prior to any UXO detonation, to reduce the risk of any physical or permanent auditory injury (PTS).

656. The methods for achieving the mitigation zone will be agreed in consultation with the relevant SNCBs and secured as commitments within the final MMMP for UXO clearance, based on the most suitable techniques and current guidance.

657. The MMMP for UXO clearance will include details of all the required mitigation measures to minimise the potential risk of physical and auditory injury (PTS) as a result of underwater noise during UXO clearance, for example, this would consider the options, suitability and effectiveness of mitigation measures such as, but not limited to:

- The activation of acoustic deterrent devices (ADDs).
- If required and where possible and safe to do so, a soft-start procedure using scare charges.
- Noise reduction mitigation measures, such as bubble curtains.
- Monitoring of the mitigation zone by marine mammal observers (MMOs) during daylight hours and when conditions allow suitable visibility, pre- and post-detonation.
- Deployment of passive acoustic monitoring (PAM) devices, if required, for example during poor visibility and if the equipment can be safely deployed and retrieved prior to detonation.
- All detonations taking place in daylight and, when possible, in favourable conditions with good visibility.
- The controlled explosions of the UXO, undertaken by specialist contractors, using the minimum amount of explosives required in order to achieve safe disposal of the device.
- The sequencing of detonations, if there are multiple UXO in close proximity to be disposed of near simultaneously, where practicable, will start with the smallest detonation and end with the larger detonations.

658. The effective implementation of a UXO MMMP will reduce the risk of permanent auditory injury (PTS) to harbour porpoise during any underwater detonations at Norfolk Vanguard (alone), therefore, there would be **no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.**

659. An EPS licence application, if required, will be submitted post-consent. At this time, pre-construction UXO surveys will have been conducted, as well as full consideration of the mitigation measures that will be in place following the development of the MMMP for UXO clearance.

Disturbance during UXO clearance

660. Although implementation of mitigation measure in the MMMP for UXO clearance will increase the distance of harbour porpoise from any UXO detonations, it cannot mitigate the potential disturbance to harbour porpoise.

<u>Spatial assessment</u>

661. The SNCBs (Natural England, 2017) currently recommend that a potential disturbance range of 26km (approximate area of 2,124km^2) around UXO detonations is used to assess the area that harbour porpoise may be disturbed in the Southern North Sea (SNS) cSAC. This approach has been used in this assessment taking into account the potential maximum and average area of possible displacement of harbour porpoise based on the worst-case scenario for UXO clearance at NV East, NV West and the offshore cable corridor (Table 8.12).

662. Only one UXO would be detonated at a time during UXO clearance operation at Norfolk Vanguard; there would be no concurrent UXO detonations.

Table 8.12 Estimated area of SNS cSAC that harbour porpoise could potentially be disturbed from during UXO clearance at Norfolk Vanguard

UXO clearance	Maximum potential overlap with SNS cSAC	Average potential overlap with SNS cSAC	Potential adverse effect on site integrity
UXO detonation is located in NV West	1,112km^2 in the winter SNS cSAC area (approximately 8% of the winter SNS cSAC area); or 2,124km^2 in the summer SNS cSAC area (approximately 8% of the summer SNS cSAC area).	559km^2 in the winter SNS cSAC area (approximately 4% of the winter SNS cSAC area); or 1,776km^2 in the summer SNS cSAC area (approximately 7% of the summer SNS cSAC area).	No Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS cSAC area at any one time during any UXO clearance at Norfolk Vanguard (alone), based on the worst-case scenario.
UXO detonation is located in NV East	832km^2 in the winter SNS cSAC area (approximately 6% of the winter SNS cSAC area); or 2,124km^2 in the summer SNS cSAC area (approximately 8% of the summer SNS cSAC area).	418km^2 in the winter SNS cSAC area (approximately 3% of the winter SNS cSAC area); or 1,739km^2 in the summer SNS cSAC area (approximately 6% of the summer SNS cSAC area).	
UXO detonation in the cable corridor	2,124km^2 in the winter SNS cSAC area (approximately 16% of the winter SNS cSAC area). or 2,124km^2 in the summer SNS cSAC area (approximately 8% of the summer SNS cSAC area).		

663. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the Southern North Sea cSAC area at any one time during any UXO

clearance at Norfolk Vanguard (alone), based on the worst-case scenario (Table 8.12). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

<u>Seasonal averages</u>

664. It is currently not possible to determine the number of days per season that UXO clearance would be undertaken, if required, at Norfolk Vanguard. An estimated worst-case of nine clearance operations in NV East, five in NV West and 28 in the offshore cable corridor has been included in the assessment based on a review of the site specific geophysical data (Fugro, 2016) and Vattenfall Wind Power Limited experience (a parent company of Norfolk Vanguard Limited). The number of days of UXO clearance is based on a worst-case scenario of only one detonation per day although this could be over a period of 2-3 months.

665. Disturbance from a UXO detonations would be temporary and for a short-duration (i.e. the detonation). For the estimated worst-case (Table 8.13), the maximum number of days of UXO clearance could be up to 42 days, based on one detonation per day.

666. The seasonal averages have been calculated by multiplying the average of the minimum and maximum effect on any one day by the proportion of days within the season on which UXO clearance could occur (i.e. taking into account the average of effect / area of overlap with cSAC and number of UXO clearance days per season).

667. The assessment indicates, on average, less than 10% of the seasonal component of the Southern North Sea cSAC over the duration of that season could be affected during any UXO clearance at Norfolk Vanguard (alone), based on the worst-case scenario (Table 8.13). Therefore, under these circumstances, **there would be no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

668. However, based on a more realistic, but precautionary scenario that there could be up to 4 detonations per day (e.g. in a 12 hour period based on average daylight hours), the maximum number of days of UXO clearance could be up to a maximum of 19 days. The assessment indicates, on average, less than 10% of the seasonal component of the Southern North Sea cSAC over the duration of that season could be affected during any UXO clearance at Norfolk Vanguard (alone), based on the precautionary scenario (Table 8.13). Therefore, under these circumstances, **there would be no significant disturbance and no potential adverse effect on the**

integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.

Table 8.13 Estimated seasonal area averages for the SNS cSAC winter and summer areas during UXO clearance at Norfolk Vanguard

UXO clearance	Number of UXO clearance days per season	Area within SNS cSAC seasonal areas	Estimated seasonal area average	Potential adverse effect on site integrity
One detonation per day				
UXO detonation is located in NV West	• 5 days	• Summer SNS cSAC area = 7% • Winter SNS cSAC area = 4%	• Summer SNS cSAC area = 0.2% • Winter SNS cSAC area = 0.1%	No Temporary effect. Displacement of harbour porpoise would not exceed 10% of the seasonal component of the SNS cSAC over the duration of that season during any UXO clearance at Norfolk Vanguard (alone), based on the worst-case scenario.
UXO detonation is located in NV East	• 9 days	• Summer SNS cSAC area = 6% • Winter SNS cSAC area = 3%	• Summer SNS cSAC area = 0.3% • Winter SNS cSAC area = 0.2%	
UXO detonation located in cable corridor	• 28 days in summer area; or • 28 days in winter area	• Summer SNS cSAC area = 8%; or • Winter SNS cSAC area = 16%	• Summer SNS cSAC area = 1.2%; or • Winter SNS cSAC area = 2.5%	
Four detonations per day				
UXO detonation is located in NV West	• Up to 2 days	• Summer SNS cSAC area = 7% • Winter SNS cSAC area = 4%	• Summer SNS cSAC area = 0.08% • Winter SNS cSAC area = 0.04%	No Temporary effect. Displacement of harbour porpoise would not exceed 10% of the seasonal component of the SNS cSAC over the duration of that season during any UXO clearance at Norfolk Vanguard (alone), based on the precautionary scenario.
UXO detonation is located in NV East	• Up to 3 days	• Summer SNS cSAC area = 6% • Winter SNS cSAC area = 3%	• Summer SNS cSAC area = 0.1% • Winter SNS cSAC area = 0.05%	
UXO detonation located in cable corridor	• 7 days in summer area; or • 7 days in winter area	• Summer SNS cSAC area = 8%; or • Winter SNS cSAC area = 16%	• Summer SNS cSAC area = 0.31%; or • Winter SNS cSAC area = 0.62%	

Assessment in relation to North Sea MU

669. The estimated number of harbour porpoise that could be disturbed during underwater UXO clearance at Norfolk Vanguard is presented in Table 8.14. As outlined above, only one UXO would be detonated at a time during UXO clearance operation at Norfolk Vanguard, there would be no concurrent UXO detonations.

Table 8.14 Estimated number of harbour porpoise potentially disturbed during UXO clearance at Norfolk Vanguard

Potential Effect	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
Area of disturbance (2,124km^2) during underwater UXO clearance	1,886 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,676 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 1,678 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.55% of NS MU based on SCANS-III density. 0.8% of NS MU based on the site specific survey density at NV East. 0.5% of NS MU based on the site specific survey density at NV West.	No Temporary effect. Less than 1% of the reference population could be temporarily displaced during any UXO clearance at Norfolk Vanguard (alone), based on the worst-case scenario.

[1]Based on density estimates and reference populations (see section 8.1.1).

670. The assessment indicates that less than 1% of the North Sea MU reference population could be temporarily displaced during any UXO clearance at Norfolk Vanguard (alone), based on the worst-case scenario (Table 8.14). Therefore, under these circumstances, **there is no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.1.2. Potential effects resulting from underwater noise during piling at Norfolk Vanguard (alone)

Permanent auditory injury

671. As with the MMMP for UXO clearance, a MMMP for piling will be developed post-consent in consultation with the MMO and relevant SNCBs and will be based on the latest scientific understanding and guidance, and detailed project design. A draft MMMP for piling (document 8.13) is submitted with the DCO Application. This will reduce the risk of permanent auditory injury (PTS) to harbour porpoise as a result of underwater noise during piling. With the commitment to the MMMP for piling, permanent auditory (PTS) injury was screened out of this assessment (HRA Screening; Appendix 5.1), as there would be no potential for any LSE with effective mitigation. However, an assessment on the potential for PTS has been included.

672. Subacoustech has undertaken predictive underwater noise modelling to estimate the noise levels likely to arise during construction of Norfolk Vanguard (Appendix 5.3 of the ES (document 6.1)) and hence determine the potential effects on harbour porpoise.

673. The underwater noise modelling results for the maximum predicted ranges (and areas) for permanent auditory injury (PTS) in harbour porpoise, based on the NOAA (NMFS, 2016) criteria for unweighted SPL_{peak} and PTS from cumulative exposure (weighted SEL_{cum}) are presented in Table 8.15.

674. Without any mitigation, the estimated maximum number of harbour porpoise that could potentially be at risk of PTS as a result of a single strike of the maximum monopile hammer energy of 5,000kJ is 24 individuals (0.007% of the North Sea MU reference population), based on the site specific density for NV East (1.26 harbour porpoise per km^2).

675. The indicative maximum number of harbour porpoise that could potentially be at risk of PTS from cumulative SEL as a result of the maximum monopile hammer energy of 5,000kJ is up to 0.25 individuals (0.00007% of the North Sea MU reference population). As a result of the maximum pin-pile hammer energy of 2,700kJ, the estimated maximum number of harbour porpoise that could potentially be at risk of PTS from cumulative SEL is up to 4.3 harbour porpoise (up to 0.001% of the North Sea MU reference population), based on the site specific density for NV East (1.26 harbour porpoise per km^2).

Table 8.15 Maximum predicted impact ranges (and areas) for permanent auditory injury (PTS) from a single strike and from cumulative exposure based on NOAA (NMFS, 2016) criteria

Potential Effect	Receptor	Criteria and threshold	Maximum predicted impact range (km) and area* (km^2)			
			Monopile starting hammer energy of 500kJ	Monopile with maximum hammer energy of 5,000kJ	Pin-pile starting hammer energy of 270kJ	Pin-pile with maximum hammer energy of 2,700kJ
PTS without mitigation – single strike	Harbour porpoise	NMFS (2016) unweighted SPL_{peak} 202 dB re 1 µPa	0.42km (0.55km^2)	2.8km (19.2km^2)	0.17km (0.09km^2)	1.9km (9.5km^2)
PTS from cumulative SEL(including soft-start and ramp-up)	Harbour porpoise	NMFS (2016) SEL_{cum} Weighted 155 dB re 1 µPa^{2}s	N/A	0.42km (0.55km^2)	N/A	1.5km (7.07km^2)

*areas for maximum hammer energies for monopile and pin-pile based on modelled contour area; area for starting hammer energy based on precautionary area of circle with maximum impact range as radius.

Mitigation

676. As outlined above, the MMMP for piling will be developed post-consent in consultation with the MMO and relevant SNCBs and will be based on the latest

scientific understanding and guidance, and detailed project design. The MMMP for piling will detail the proposed mitigation measures to reduce the risk of permanent auditory injury (PTS) to harbour porpoise during piling. A potential example of mitigation is:

- The activation of ADDs for 10 minutes prior to a 30 minutes soft-start and ramp-up.

677. This would enable harbour porpoise to move at least 3.6km from the piling location (2.7km during the 30 minute soft-start and ramp-up (as outlined in Section 8.2.1) plus 0.9km during ADD activation for 10 minutes) (based on a precautionary average marine mammal swimming speed of 1.5m/s). This would therefore be greater than the maximum predicted distance of 2.8km for PTS from a single strike at the maximum hammer energy for monopiles of 5,000kJ, based on the unweighted SPL_{peak} NOAA (NMFS, 2016) criteria (Table 8.15).

678. The MMMP for piling will reduce the risk of permanent auditory injury to harbour porpoise as a result of underwater noise during piling at Norfolk Vanguard (alone), therefore, **there would be no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

679. Although the mitigation will increase the distance of harbour porpoise from the piling location, it cannot mitigate the potential disturbance to harbour porpoise.

Disturbance during proposed mitigation

680. During the implementation of the proposed mitigation, for example the activation of ADDs for 10 minutes and the 30 minutes for the soft-start and ramp-up it is estimated that animals would move 3.6km (based on a precautionary average marine mammal swimming speed of 1.5m/s), a potential disturbance area of 41km^2. This is approximately 0.31% of the winter Southern North Sea cSAC area or 0.15% of the summer Southern North Sea cSAC area. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC at any one time and / or on average exceed 10% of the seasonal component of the cSAC over the duration of that season as a result of the proposed mitigation for piling at Norfolk Vanguard (alone). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

681. The number of harbour porpoise that could potentially be disturbed as a result of the proposed mitigation would be up to 52 individuals (0.015% of the NS MU reference population), based on the site specific density for NV East (1.26 harbour porpoise per km^2) as a worst-case scenario. The assessment indicates that less than

0.02% of the NS MU reference population could be temporarily affected as a result of the proposed mitigation for piling at Norfolk Vanguard (alone). Therefore there is **no predicted LSE or anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

682. It should be noted that the disturbance of harbour porpoise as a result of the proposed mitigation prior to piling would be part of the 26km disturbance range for piling and is therefore not an additive effect to the overall area of potential disturbance. However, the duration of the proposed mitigation prior to piling has been taken into account, as a worst-case scenario, in the assessment of the duration of potential disturbance.

Disturbance during single pile installation

Spatial assessment

683. The SNCBs (Natural England, 2017) currently recommend that a potential disturbance range of 26km (approximate area of 2,124km^2) around an individual percussive piling location is used to assess the area that harbour porpoise may be disturbed in the Southern North Sea (SNS) cSAC. This approach has been used in this assessment for:

- Single piling at NV West; or
- Single piling at NV East.

684. The assessment takes into account the potential maximum and average area of possible displacement of harbour porpoise based on the worst-case scenario for single pile installation at the NV East and NV West (Table 8.16).

Table 8.16 Estimated area of SNS cSAC that harbour porpoise could potentially be disturbed from during single pile installation at Norfolk Vanguard

Single pile installation	Maximum potential overlap with SNS cSAC	Average potential overlap with SNS cSAC	Potential adverse effect on site integrity
Single pile installation is located in NV West	1,112km^2 in the winter SNS cSAC area (approximately 8% of the winter SNS cSAC area); or 2,124km^2 in the summer SNS cSAC area (approximately 8% of the summer SNS cSAC area).	559km^2 in the winter SNS cSAC area (approximately 4% of the winter SNS cSAC area); or 1,776km^2 in the summer SNS cSAC area (approximately 7% of the summer SNS cSAC area).	No Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS cSAC area at any one time during any single pile installation at Norfolk Vanguard (alone), based on the worst-case scenario
Single pile installation is located in NV East	832km^2 in the winter SNS cSAC area (approximately 6% of the winter SNS cSAC area); or 2,124km^2 in the summer SNS cSAC area (approximately 8%	418km^2 in the winter SNS cSAC area (approximately 3% of the winter SNS cSAC area); or 1,739km^2 in the summer SNS cSAC area	

Single pile installation	Maximum potential overlap with SNS cSAC	Average potential overlap with SNS cSAC	Potential adverse effect on site integrity
	of the summer SNS cSAC area).	(approximately 6% of the summer SNS cSAC area).	

685. Disturbance of harbour porpoise would not exceed 20% of the seasonal component of the Southern North Sea cSAC area at any one time during single pile installation at Norfolk Vanguard (alone), based on the worst-case scenario (Table 8.16). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

686. Indicative installation programmes for the different phasing options (Table 8.7 and Table 8.8) include:

- Single phase – up to 20 months of foundation installation and 23 months for overall construction; or
- Two phase – up to 8 months of foundation installation and 12 months for overall construction per phase within a construction window of four years.

687. The maximum piling duration for Norfolk Vanguard would be up to 1,399 hours (equivalent of up to 58 days) based on the following (Table 8.9):

- Installation of the turbine foundations, based on the maximum piling duration would be up to 1,200 hours for 200 9MW turbines based on 6 hours of piling per foundation;
- 133 hours for 10 minute ADD activation per turbine pile (up to 800 piles),
- Resulting in approximately 1,333 hours of disturbance within the overall construction programme;
- Piling for the eight offshore platforms would be up to 60 hours; and
- Six hours for 10 minute ADD activation per pile for the 34 platform piles.

688. Table 8.17 presents the worst cases for each of the single and two phase options per season, assuming the maximum number of possible days of piling (58 days) spread over the phases. The summer season is assumed to be 183 days (April-September) and the winter season is assumed to be 182 days (October-March). The table also presents the estimated maximum seasonal averages for each phasing option.

689. It should be noted that this assessment is based on the unlikely worst-case scenario that for the single phase option that all piling could occur during a single season, however foundation installation could in reality be around 20 months.

690. The seasonal averages have been calculated by multiplying the maximum effect on any one day by the proportion of days within the season on which piling could occur (i.e. taking into account the average of effect / area of overlap with seasonal area of the Southern North Sea cSAC and number of days piling per season).

Table 8.17 Estimated worst-case scenarios for seasonal area averages for single and two phase options using pin-piles for 9MW turbines and offshore platforms (including ADD activation)

Phasing option	Duration based on worst-case scenario	Maximum seasonal area averages	Potential adverse effect on site integrity
Single Phase option	All 59 days in one season: • 32% of the summer period; or • 32% of the winter period.	• 2.6% of SNS cSAC summer area for single piling in NV East; • 2.6% of SNS cSAC summer area for single piling in NV West; • 1.95% of SNS cSAC winter area for single piling in NV East; or • 1.3% of SNS cSAC winter area for single piling in NV West.	No Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.
Two Phase option	Approximately 29 days for either season over two seasons: • 15.8% of the summer period; or • 15.9% of the winter period.	• 1.3% of SNS cSAC summer area for single piling in NV East; • 1.3% of SNS cSAC summer area for single piling in NV West; • 0.96% of SNS cSAC winter area for single piling in NV East; or • 0.64% of SNS cSAC winter area for single piling in NV West.	No Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.

691. For the installation of 20MW turbines with monopile foundations using the worst case scenario hammer energy of 5,000kJ, the maximum total piling duration for 90 turbines would be 540 hours (equivalent of 22.5 days, including soft start and ramp up) plus an estimated 15 hours for 10 minute ADD activation per monopile, resulting in approximately 55 hours (equivalent of 23 days in total) within the overall construction programme. In addition, piling for the eight offshore platforms (based on up to six hours for each monopile installation; Table 8.9) would be up to 48 hours plus an estimated 1.5 hours for 10 minute ADD activation per pile, resulting in approximately two days of potential disturbance. Therefore the estimated total duration would be a total of 25 days.

692. For the single phase monopile option, the worst-case scenario is that all 25 days are in one season, e.g. all in summer or all in winter. Therefore, approximately 25 days (14%) of the 183 days in the summer period (April-September) or 25 days (14%) of the 182 days in the winter period (October-March). The estimated seasonal averages for single phase option with monopiles are presented in Table 8.18.

693. It should be noted, as outlined above, that this is based on the unlikely worst-case scenario that all piling could occur during a single season, however for the single phase option foundation installation would actually be over a 20 month period. As outlined below, the assessment does not take into account that piling would not be constant and there will be gaps between the installations of individual piles and potential down-time for weather or other technical issues.

694. The two phase option would have lower seasonal averages than the single phase option, as shown for the pin-piles.

Table 8.18 Estimated worst-case scenarios for seasonal area averages for single phase option using monopiles for 20MW turbines and offshore platforms (including ADD activation)

Phasing option	Duration based on worst-case scenario	Maximum seasonal area averages	Potential adverse effect on site integrity
Single Phase option	All 25 days were in one season: • 14% of the summer period; or • 14% of the winter period.	• 1.09% of SNS cSAC summer area for single piling in NV East; • 1.09% of SNS cSAC summer area for single piling in NV West; • 0.82% of SNS cSAC winter area for single piling in NV East; or • 0.55% of SNS cSAC winter area for single piling in NV West.	No Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.
Two Phase option	The two phase option would have lower seasonal averages than the single phase option, as shown for the pin-piles (Table 8.17).		

695. The phases could either be constructed consecutively, condensing the overall construction programme (similar to that of a single phased installation) or could require gaps of a number of years between each phase, up to an overall construction programme of approximately seven years.

696. Piling would not be constant during the piling phases and construction periods. There will be gaps between the installations of individual piles and if installed in groups there could be time periods when piling is not taking place as piles are

brought out to the site. There will also be potential down-time for weather or other technical issues.

697. The duration of piling is based on a worst-case scenario and a very precautionary approach and, as has been shown at other offshore wind farms, the duration used in the assessment can be overestimated. For example, during the installation of monopile foundations at the Dudgeon Offshore Wind Farm (DOW) the assessment was based on estimated piling period of 93 days, time to install each monopile was estimated to be up to 4.5 hours and the estimated duration of active piling was 301.5 hours (approximately 13 days). However, the actual total duration of active piling to install the 67 monopiles was 65 hours (approximately 3 days) with the average time for installation per monopile of 71 minutes (DOWL, 2016). Therefore, the actual piling duration was approximately 21% of the predicated maximum piling duration.

698. The results indicate that for single piling at Norfolk Vanguard (alone), based on the worst-case scenarios (Table 8.17 and Table 8.18) displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the seasonal Southern North Sea cSAC area over the duration of that season. Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

699. The estimated number of harbour porpoise that could be disturbed during single pile installation at Norfolk Vanguard is presented in Table 8.19.

Table 8.19 Estimated number of harbour porpoise potentially disturbed during piling based on 26km range from a single piling location at Norfolk Vanguard

Potential Effect	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
Area of disturbance (2,124km^2) from underwater noise during single pile installation	1,886 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,676 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 1,678 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.55% of NS MU based on SCANS-III density. 0.8% of NS MU based on site specific survey density at NV East. 0.5% of NS MU based on site specific survey density at NV West.	No Temporary effect Less than 1% of the reference population could be temporarily displaced during any single pile installation at Norfolk Vanguard (alone), based on the worst-case scenario.

[1]Based on density estimates and reference populations (see section 8.1.1).

700. The assessment indicates that less than 1% of the North Sea MU reference population could be temporarily displaced during any single pile installation at Norfolk Vanguard (alone), based on the worst-case scenario (Table 8.19). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Disturbance during concurrent piling

Spatial assessment

701. The maximum potential area of disturbance, based on 26km range (area of 2,124km^2 around each piling location), has been estimated for the worst-case concurrent piling scenarios (e.g. maximum distance between piling vessels within each site and least amount of overlap in potential areas) for:

- Two concurrent piling events in NV West;
- Two concurrent piling events in NV East; or
- Two concurrent piling events based on one worst-case location in NV East and one worst-case location in NV West.

702. Table 8.20 summarises the spatial assessment for the concurrent piling options in relation to the Southern North Sea cSAC summer and winter areas. The maximum potential area of effect is based on the maximum possible overlap with the Southern North Sea cSAC winter or summer areas, taking into account the overlap in disturbance areas of the concurrent piling events. The average has been estimated based on the maximum and minimum potential overlap with the Southern North Sea cSAC winter or summer areas.

Table 8.20 Spatial assessment for the concurrent piling options in relation to the Southern North Sea cSAC summer and winter areas

Concurrent piling option	Maximum potential area of effect in summer SNS cSAC area	Maximum potential area of effect in winter SNS cSAC area	Average potential area of effect in summer SNS cSAC area	Average potential area of effect in winter SNS cSAC area
Two concurrent piling events in NV West	2,833km^2 (10%)	1,302km^2 (10%)	2,241km^2 (8%)	599km^2 (5%)
Two concurrent piling events in NV East	2,732km^2 (10%)	832km^2 (6%)	2,123km^2 (8%)	435km^2 (3%)
Two concurrent piling events based one in NV East and one in NV West	3,681km^2 (14%)	1,476km^2 (11%)	3,043km^2 (11%)	800km^2 (6%)

703. During concurrent piling at Norfolk Vanguard (alone) and based on the worst-case scenarios (Table 8.20), the temporary displacement of harbour porpoise would not exceed 20% of the seasonal component of the Southern North Sea cSAC area at any one time. Therefore, under these circumstances, **there would be no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

704. The duration of concurrent piling, for two concurrent locations would be approximately half the total maximum duration for single pile installation, as well as reducing the overall construction window.

705. For two concurrent piling events using pin-piles for the single phase option the total piling duration would be up to 29 days per season (e.g. half the duration for single piling using pin-piles). The estimated seasonal averages for the worst-case scenarios are presented in Table 8.21.

706. For two concurrent piling events for 20MW turbines using monopiles for the single phase option, the total piling duration would be up to 12.5 days (e.g. half the duration for single piling and ADD for 20MW turbines with monopile foundations). The estimated seasonal averages for the worst-case scenarios are presented in Table 8.21.

707. The two phase option would have lower seasonal averages than the single phase option, as demonstrated for single piling.

Table 8.21 Estimated worst-case scenarios for seasonal area averages for single phase option based on concurrent piling of pin-piles or monopiles

Phasing and concurrent piling option	Duration based on worst-case scenario	Maximum seasonal area averages	Potential adverse effect on site integrity
Single Phase option with two concurrent piling events for pin-piles	All 29 days were in one season: • 15.8% of the summer period; or • 15.9% of the winter period.	• 1.6% of SNS cSAC summer area for two concurrent piling events in NV East; • 1.6% of SNS cSAC summer area for two concurrent piling events in NV West; • 1.6% of SNS cSAC winter area for two concurrent piling events in NV East; or • 0.96% of SNS cSAC winter area for two concurrent piling events in NV West.	No Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SNS cSAC area over the duration of that season.

Phasing and concurrent piling option	Duration based on worst-case scenario	Maximum seasonal area averages	Potential adverse effect on site integrity
		• 2.22% of the SNS cSAC summer area for two concurrent piling events with one in NV East and one in NV West. • 1.75% of the SNS cSAC winter area for two concurrent piling events with one in NV East and one in NV West.	
Single Phase option with two concurrent piling events for monopiles	All 12.5 days were in one season: • 6.8% of the summer period; or • 6.9% of the winter period.	• 0.68% of SNS cSAC summer area for two concurrent piling events in NV East; • 0.68% of SNS cSAC summer area for two concurrent piling events in NV West; • 0.69% of SNS cSAC winter area for two concurrent piling events in NV East; or • 0.41% of SNS cSAC winter area for two concurrent piling events in NV West. • 0.96% of the SNS cSAC summer area for two concurrent piling events with one in NV East and one in NV West. • 0.76% of the SNS cSAC winter area for two concurrent piling events with one in NV East and one in NV West.	No Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.
Two Phase option	The two phase option would have lower seasonal averages than the single phase option.		

708. The seasonal averages, based on the worst-case scenarios, indicate that for concurrent piling at Norfolk Vanguard (alone), displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the cSAC area over the duration of that season (Table 8.21). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

709. The estimated number of harbour porpoise that could be disturbed during concurrent pile installation at Norfolk Vanguard is presented in Table 8.22 based on the maximum disturbance areas for the North Sea MU.

Table 8.22: Estimated number of harbour porpoise potentially disturbed during concurrent piling based on 26km range from each piling location

Potential Effect	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
Two concurrent piling events in NV West (3,520km^2)	3,126 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,781 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.9% of NS MU based on SCANS-III density. 0.8% of NS MU based on site specific survey density at NV West.	No Temporary effect Less than 1% of the reference population could be temporarily displaced during concurrent piling at NV West, based on the worst-case scenario.
Two concurrent piling events in NV East (3,508km^2)	3,115 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 4,420 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.9% of NS MU based on SCANS-III density. 1.3% of NS MU based on site specific survey density at NV East.	No Temporary effect Up to 1.3% of the reference population could be temporarily displaced during concurrent piling at NV East, based on the worst-case scenario.
Two concurrent piling events based on one worst-case location in NV East and one worst-case location NV West (4,248km^2)	3,772 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 4,354 harbour porpoise based on site specific survey density at NV East and NV West.	1.1% of NS MU based on SCANS-III density. 1.3% of NS MU based on site specific survey density at NV East & NV West.	No Temporary effect Up to 1.3% of the reference population could be temporarily displaced during concurrent piling at NV West and NV East, based on the worst-case scenario.

[1]Based on density estimates and reference populations (see Section 8.1.1).

710. The assessment indicates that 1.3% or less of the North Sea MU reference population could be temporarily disturbed during concurrent piling at Norfolk

Vanguard (alone), based on the worst-case scenario (Table 8.22). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.1.3. Disturbance from underwater noise during construction activities, other than piling, at Norfolk Vanguard (alone)

711. Potential sources of underwater noise during other construction activities, include seabed preparation, rock dumping and cable installation.

712. The construction activity likely to have the greatest potential noise effects, other than piling, is cable installation and has therefore been assessed as a worst-case scenario (Table 8.9).

713. The behavioural responses of harbour porpoise to dredging, an activity emitting comparatively higher underwater noise levels, are predicted to be similar to those during cable installation (e.g. OSPAR, 2009).

714. Reviews of published sources of underwater noise during dredging activity (e.g. Thomsen *et al.,* 2006; Theobald *et al.,* 2011; Todd *et al.,* 2014), indicate that the sound levels that marine mammals may be exposed to during dredging activities are below auditory injury thresholds (PTS) exposure criteria (as defined in Southall *et al.,* 2007). Therefore the potential risk of any auditory injury in marine mammals as a result of dredging activity is highly unlikely.

715. The thresholds for temporary hearing loss (e.g. TTS) could be exceeded during dredging, however, only if marine mammals remain in close proximity to the active dredger for extended periods, which is highly unlikely (Todd *et al.,* 2014).

716. Underwater noise as a result of dredging activity has the potential to disturb marine mammals (e.g. Diederichs *et al.,* 2010; Pirotta *et al.,* 2013). Therefore there is the potential for behavioural reactions and disturbance to harbour porpoise in the area during construction activities, such as cable installation. Disturbance is therefore the only potential underwater noise effect associated with construction activities, other than piling.

717. As a precautionary worst-case scenario, the assessment for the disturbance as a result of underwater noise during construction from activities other than piling and vessel movements has been assessed based on the wind farm area and the offshore cable corridor area and the number of harbour porpoise that could be present in these areas. This is very precautionary, as it is highly unlikely that construction activities, other than piling activity, could result in disturbance from the entire wind

farm area and the offshore cable corridor. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

Spatial assessment

718. The NV West area (295km^2) is approximately 1% of the summer cSAC area; the NV East area (297km^2) is also approximately 1% of the summer cSAC area; and for the total offshore cable corridor area (237km^2), approximately 50% is located in the summer cSAC area (0.4% of the summer cSAC area) and approximately 50% of the entire offshore cable corridor area is located in the winter cSAC area (1.8% of the winter cSAC area) (Figure 5.3).

719. Disturbance of harbour porpoise would not exceed 20% of the seasonal component of the Southern North Sea cSAC at any one time during any construction activities, other than piling, at Norfolk Vanguard (alone), based on the worst-case scenario of 100% disturbance from the offshore wind farm areas and offshore cable corridor area. Therefore, under these circumstances, there is no significant disturbance and **no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

720. The indicative duration of the cable installation (Table 8.7 and Table 8.8), is estimated to be:

- o 19 months for single phase option; and
- o 7 months per phase for two phase option.

721. The indicative total programme for construction of the full 1,800MW capacity is estimated to be up to four years.

722. The potential effects that could result from underwater noise during other construction activities, including cable laying and protection would be temporary in nature, not consistent throughout these periods and would be limited to only part of the overall construction period and to the area in which construction works are being undertaken.

723. For the worst-case scenario, it is assumed that construction activities, other than piling could occur throughout each season (e.g. all 183 days in summer period and all 182 days in winter period) and that the disturbance as a result of underwater noise during construction from activities other than piling and vessel movements could be, as a worst-case scenario, from the entire wind farm areas and the offshore cable corridor area (i.e. 100% disturbance from the offshore wind farm areas and offshore cable corridor area) (Table 8.23).

Table 8.23 Estimated worst-case scenarios for seasonal area averages for construction activities, other than piling in Norfolk Vanguard

Potential Effect Area	Duration based on worst-case scenario	Maximum seasonal area averages	Potential adverse effect on site integrity
NV West area (approximately 1% of the summer cSAC area)	Throughout the summer period (183 days).	• 1% of the SNS cSAC summer area	No Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.
NV East area (approximately 1% of the summer cSAC area)	Throughout the summer period (183 days).	• 1% of the SNS cSAC summer area	
Total offshore cable corridor area (less than 1% of the summer cSAC area)	Throughout the summer period (183 days).	• 1% of the SNS cSAC summer area	
Total offshore cable corridor area (less than 2% of the winter cSAC area)	Throughout the winter period (182 days).	• 2% of the SNS cSAC winter area	
Two Phase option	The two phase option would have the same seasonal averages as the single phase option for each phase.		

724. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the Southern North Sea cSAC over the duration of that season during any construction activities, other than piling at Norfolk Vanguard (alone). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

<u>Assessment in relation to North Sea MU</u>

725. The estimated maximum number of harbour porpoise that could be disturbed during construction activities, other than piling at Norfolk Vanguard (alone) is presented in Table 8.24. The assessment indicates that less than 0.3% of the North Sea MU reference population could be temporarily disturbed from the total offshore project area for Norfolk Vanguard (alone), based on the worst-case scenario. Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.24 Estimated number of harbour porpoise that could be present in the Norfolk Vanguard offshore area (wind farm sites and cable corridor)

Potential Effect Area	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
NV East area (297km^2)	264 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 374 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.08% of NS MU based on SCANS-III density. 0.1% of NS MU based on site specific survey density at NV East.	No Temporary effect. Maximum of 0.1% of the reference population could be temporarily displaced during construction activities, other than piling, at NV East based on the worst-case scenario.
NV West area (295km^2)	262 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 233 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.075% of NS MU based on SCANS-III density. 0.07% of NS MU based on site specific survey density at NV West.	No Temporary effect. Maximum of 0.075%% of the reference population could be temporarily displaced during construction activities, other than piling, at NV West based on the worst-case scenario.
Offshore cable corridor (237km^2)	210.5 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 299 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.06% of NS MU based on SCANS-III density. 0.09% of NS MU based on site specific survey density at NV East.	No Temporary effect. Maximum of 0.09% of the reference population could be temporarily displaced during construction activities, other than piling, in the offshore cable corridor, based on the worst-case scenario.
Total offshore project area (829km^2)	736.5 harbour porpoise based on SCANS-III survey block O density. 906 harbour porpoise based on site specific survey densities for NV East and NV West.	0.2% of NS MU based on SCANS-III density. 0.26% of NS MU based on site specific survey density.	No Temporary effect. Maximum of 0.26% of the reference population could be temporarily displaced during construction activities, other than

Potential Effect Area	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
			piling, for the total offshore project area, based on the worst-case scenario.

[1]Based on density estimates and reference populations (see Section 8.1.1).

8.3.1.1.4. Disturbance from construction vessels at Norfolk Vanguard (alone)

726. During the construction phase there will be an increase in the number of vessels associated with installation of the turbine foundations and associated sub-structures and also with the installation of the array and export cables. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore any increase in disturbance as a result of underwater noise from vessels during construction will be within the wind farm site and offshore cable corridor.

727. The vessels within the site during construction will be slow moving (or stationary) and most noise emitted is likely to be of a low frequency. Noise levels reported by Malme *et al.* (1989) and Richardson *et al.* (1995) for large surface vessels indicate that physiological damage to auditory sensitive marine mammals is unlikely. However, the levels could be sufficient to cause local disturbance to sensitive marine mammals in the immediate vicinity of the vessel, depending on ambient noise levels.

728. Underwater noise generated by vessels would not be sufficient to cause PTS or other injury to marine mammals. The potential for TTS is only likely if the animal remains in very close proximity to a vessel for a prolonged period of time, which is highly unlikely. Disturbance is therefore the only potential underwater noise effect associated with vessels.

729. Modelling by Heinänen and Skov (2015) indicates that the number of ships represents a relatively important factor determining the density of harbour porpoise in the North Sea MU during both seasons. Responses to number of ships per year indicate markedly lower densities with increasing levels of traffic. A threshold level in terms of impact seems to be approximately 20,000 ships per year (approximately 80 vessels per day).

730. Baseline surveys for shipping and navigation indicate that throughout the summer period of the marine traffic survey, there were on average 69, 46 and 96 unique vessels per day recorded within NV East, NV West and the offshore cable corridor respectively. Throughout the winter period of the marine traffic survey, there were on average 63, 39 and 92 unique vessels per day recorded within NV East, NV West and the offshore cable corridor respectively. The majority of vessels recorded were large cargo vessels and tankers, with most of these vessels utilising the IMO Routeing

Measures in the area; however other main routes were identified out with the deep water routes (DWRs), including routes which intersected the OWF sites. Fishing activity was also notable in the area, indicating an already relatively high shipping activity in and around Norfolk Vanguard.

731. During the construction there will be an increase in vessels within the site associated with installation of the foundations, the wind turbines, array and export cables, despite the potential displacement of existing vessel traffic. Table 8.9 provides details of the worst-case scenario for vessels during construction.

732. The maximum number of vessels on site at any one time during construction is estimated to be 57 vessels. It should be noted that these vessels will be of various sizes and types. This could therefore represent up to a 27% increase in the number of vessels during the summer period and 29% increase in the number of vessels during the winter periods, compared to current baseline vessel numbers. However, during construction other vessels would be restricted from entering the immediate construction site (with a 500m safety zone around construction vessels and partially installed foundations), therefore, the maximum number of 57 vessels at any one time in the offshore project area ($829km^2$) during construction would be significantly less than the Heinänen and Skov (2015) threshold of 80 vessels per day within an area of $5km^2$. Underwater noise and disturbance from additional vessels during construction are likely to be localised in comparison to existing shipping noise. The disturbance of marine mammals from the presence of the underwater noise from vessels would be temporary as the vessels move in and out of the site and move between different locations within the site; marine mammals would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

733. As per the assessment of underwater noise during construction from activities other than piling, the assessment for vessels also assumes a very precautionary worst-case scenario, that harbour porpoise in the wind farm area and the offshore cable corridor could be disturbed. However, any disturbance is likely to be limited to the immediate vicinity around the vessel.

Spatial assessment

734. As outlined above, the NV West area ($295km^2$) is approximately 1% of the summer Southern North Sea cSAC area, the NV East area ($297km^2$) is also approximately 1% of the summer cSAC area. The total offshore cable corridor area ($237km^2$) is less than 1% of the summer cSAC area and less than 2% of the winter cSAC area.

735. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the Southern North Sea cSAC at any one time, based on the worst-

case scenario of 100% disturbance from the offshore wind farm areas and offshore cable corridor area. Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

<u>Seasonal averages</u>

736. The indicative duration of the overall construction activity is estimated to be:

- o 23 months for single phase option; and
- o 12 months per phase for two phase option.

737. The indicative total programme for construction of the full 1,800MW capacity is estimated to be four years.

738. It has been assumed that vessels could be present on the site for the duration of these construction periods and throughout each season (e.g. all 183 days in summer period and all 183 days in winter period) and that the disturbance from vessels could be, as a worst-case scenario, from the entire wind farm areas and the offshore cable corridor area (i.e. 100% disturbance from the offshore wind farm areas and offshore cable corridor area) (Table 8.23).

739. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the Southern North Sea cSAC over the duration of that season as a result of vessels on site during construction activities at Norfolk Vanguard (alone). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

<u>Assessment in relation to North Sea MU</u>

740. The estimated number of harbour porpoise that could be disturbed as a result of construction vessels at Norfolk Vanguard is presented in Table 8.24. The assessment indicates that less than 0.3% of the North Sea MU reference population could be temporarily disturbed from the total offshore project area, based on the worst-case scenario for Norfolk Vanguard (alone). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.1.5. Vessel interaction (collision risk) during construction at Norfolk Vanguard (alone)

741. During the construction of Norfolk Vanguard there will be an increase in vessel traffic. Vessels will follow established shipping routes utilising the shipping lane between NV East and NV West and routes to the relevant ports in order to minimise vessel traffic in the wider area.

742. For Norfolk Vanguard West and Norfolk Vanguard East, alone or for the two sites combined, the overall worst-case scenarios for vessel movements during construction would be:

- Up to 1,180 two-way vessel movements based on a Single Phase approach; or
- Up to 1,180 (590 x2) two-way vessel movements for a Two Phased approach.

743. The construction port to be used for Norfolk Vanguard is not yet known. Indicative daily vessel movements (return trips to a local port) during construction of Norfolk Vanguard are estimated to be an average of two per day. The maximum number of vessels on site at any one time would be 57.

744. The baseline conditions indicate an already relatively high level of shipping activity in and around Norfolk Vanguard. Therefore based on the worst-case scenario of an average of two vessel movements per day, the increase in vessels movements per day at the Norfolk Vanguard site during construction is going to be relatively small compared to existing vessel traffic. Although there could be a maximum of 57 vessels on site at any one time, most vessels once on site would remain within the site area.

745. The additional vessel movements associated with the construction of Norfolk Vanguard could have the potential to increase the collision risk with harbour porpoise.

746. Harbour porpoise are able to detect and avoid vessels. However, vessel strikes are known to occur, possibly due to distraction whilst foraging and socially interacting (Wilson *et al.,* 2007). Therefore, increased vessel movements, especially those out-with recognised vessel routes, can pose an increased risk of vessel collision to harbour porpoise.

747. Harbour porpoises are small and highly mobile, and given their responses to vessel noise (e.g. Thomsen *et al.,* 2006; Evans *et al.,* 1993; Polacheck and Thorpe, 1990), are expected to largely avoid vessel collisions. Heinänen and Skov (2015) indicated a negative relationship between the number of ships and the distribution of harbour porpoises in the North Sea suggesting potential avoidance behaviour. However, harbour porpoises have been observed with signs of physical trauma (blunt trauma or propeller cuts) indicating vessel strike.

748. Of the 273 reported harbour porpoise strandings in 2015 (latest UK Cetacean Strandings Investigation Programme Report currently available), 53 were investigated at post mortem (27 were conducted in England, 13 in Scotland and 13 in

Wales). A cause of death was established in 51 examined individuals (approximately 96% of examined cases). Of these, four (8%) had died from physical trauma of unknown cause, which could have been vessel strikes (CSIP, 2015). Approximately 4% of all harbour porpoise post mortem examinations from the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS area) are thought to have evidence of interaction with vessels (Evans *et al.,* 2011).

749. As a precautionary worst-case scenario approach the number of harbour porpoise that could be at increased collision risk with vessels during construction has been assessed based on the number of animals that could be present in the wind farm areas and the offshore cable corridor and the number that could potentially be at increased collision risk based on 90-95% avoidance rates (Table 8.25).

750. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the Norfolk Vanguard area would be at increased collision risk with vessels during construction, especially taking into account the relatively small increase in number of vessel movements compared to existing vessel movements in the area.

751. The estimated number of harbour porpoise that could be at increased risk of collision with vessels during construction is presented in Table 8.25. The assessment indicates that 0.03% or less of the North Sea MU reference population could be at increased risk based on the worst-case scenario. However, it is highly unlikely that harbour porpoise will experience any increased collision risk with vessels during construction, especially taking into account the fact that any harbour porpoise in the area will be accustomed to the presence of vessels and able to detect and avoid vessels.

752. Vessel movements, where possible, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk. All vessel movements will be kept to the minimum number that is required to reduce any potential collision risk. Additionally, vessel operators will use good practice to reduce any risk of collisions with harbour porpoise.

753. In addition, based on the assumption that harbour porpoise would be disturbed from a 26km radius during piling and disturbed from the Norfolk Vanguard offshore wind farm site and cable corridor as a result of underwater noise from construction activities and vessels, as assessed above, there should be no potential for increased collision risk with vessels at Norfolk Vanguard during the construction period.

754. Therefore, under these circumstances, there is no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.

Table 8.25 Estimated number of harbour porpoise that could be present in the Norfolk Vanguard offshore area (wind farm sites and cable corridor) at potential increased collision risk based on 90-95% avoidance

Potential Effect Area	Estimated number at potential increased collision risk based on 90-95% avoidance	% of reference population[1]	Potential adverse effect on site integrity
Total offshore project area ($829km^2$)	37-74 harbour porpoise based on SCANS-III survey block O density. 45-91 harbour porpoise based on site specific survey densities for NV East and NV West.	0.01-0.02% of NS MU based on SCANS-III density. 0.01-0.03% of NS MU based on site specific survey density.	No Maximum of 0.03% of the reference population at potential increased risk.

[1]Based on density estimates and reference populations (see Section 8.1.1).

8.3.1.1.6. Changes to prey resource during construction at Norfolk Vanguard (alone)

755. Potential effects on fish species during construction can result from physical disturbance and temporary loss of seabed habitat; increased suspended sediment concentrations and sediment re-deposition; and underwater noise (that could lead to mortality, physical injury, auditory injury or behavioural responses). Although, none of these potential effects were assessed as being significant (they were either negligible or minor adverse) in the ES (document 6.1).

756. Potential sources of underwater noise and vibration during construction include piling, increased vessel traffic, seabed preparation, rock dumping, and cable installation. Of these, piling is considered to produce the highest levels of underwater noise and therefore has the greatest potential to result in adverse effects on fish. Underwater noise modelling (Appendix 5.3 of the ES (document 6.1)) indicates that fish species in which the swim bladder is involved in hearing are the most sensitive to piling noise with ranges of up to 3.7km for mortality and potential mortal injury and up to 8.3km for recoverable injury, based on maximum potential ranges for cumulative exposure (SEL_{cum}). Taking into account their wide distribution ranges, including areas used as spawning grounds, in the context of the potential ranges where TTS and behavioural effects could occur, the assessment in the ES (document 6.1), determined that any potential effect would not be significant.

757. As outlined in the ES (document 6.1), the maximum (worst-case scenario) potential area of physical disturbance and/or temporary loss of habitat to fish during construction could be $15.7km^2$ in total for the OWF sites (this would account for a very small proportion (2.7%) of the area of the OWF sites) and $13km^2$ for the offshore cable corridor. The assessment determined that with the low magnitude of impact, the impact on fish species, including sandeel and herring, would be of minor adverse significance (not significant).

758. Similarly, the magnitude of impact on prey from any increased suspended sediment concentrations and sediment re-deposition would be low, with only a small proportion of fine sand and mud staying in suspension long enough to form a passive plume. Therefore, the assessment in the ES (document 6.1) determined that with the low magnitude of impact, the impact on fish species, including sandeel and herring, would be minor adverse significance (not significant).

759. However, as a precautionary worst-case scenario, the number of harbour porpoise that could be affected as a result of changes to prey resources during construction has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 8.24). This is very precautionary, as it is highly unlikely that any changes in prey resources could occur over the entire wind farm area and the offshore cable corridor during construction. It is more likely that effects would be restricted to an area around the working sites.

Spatial assessment

760. The NV West area (295km^2) is approximately 1% of the summer cSAC area, the NV East area (297km^2) is also approximately 1% of the summer cSAC area and the total offshore cable corridor area (237km^2) is less than 1% of the summer cSAC area and less than 2% of the winter cSAC area. Therefore, as a precautionary approach, changes in prey resource across the whole area of the wind farm and offshore cable corridor, would be approximately 2% and 3% for the winter or summer areas of the cSAC, respectively.

761. Any changes to prey availability at Norfolk Vanguard (alone) resulting in the displacement of all harbour porpoise from the entire wind farm sites and cable corridor area would not exceed 20% of the seasonal component of the Southern North Sea cSAC at any one time. Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

762. For the assessment, it is assumed, as the worst-case scenario that changes to prey availability could occur throughout each season (e.g. all 183 days in summer period and all 182 days in winter period) and that the changes in prey availability could, as a worst-case scenario, be across the entire wind farm areas and the offshore cable corridor area (Table 8.23).

763. Displacement of harbour porpoise as a result of any changes in prey availability would not on average exceed 10% of the seasonal component of the Southern North Sea cSAC over the duration of that season during construction at Norfolk Vanguard

(alone). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

764. The estimated maximum number of harbour porpoise that could potentially be affected by any potential changes to prey availability during construction at Norfolk Vanguard (alone) is less than 0.3% of the NS MU reference population, based on the worst-case scenario (Table 8.24). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.1.7. Changes to water quality during construction at Norfolk Vanguard (alone)

765. The risk of accidental release of contaminants (e.g. through spillage) will be mitigated through appropriate contingency planning and remediation measures for the control of pollution. As outlined in Section 8.4.1.3 and the ES Chapter 9 Marine Water and Sediment Quality (document 6.1), Norfolk Vanguard Limited is committed to the use of best practice techniques and due diligence regarding the potential for pollution throughout all construction, operation, maintenance and decommissioning activities. A draft Project Environmental Management Plan (PEMP) (document reference 8.14) has been submitted with the DCO application. This includes the appropriate mitigation measures to reduce the risk of any accidental spills or release of contaminants. In addition, a Marine Pollution Contingency Plan (MPCP) will be developed and agreed post-consent. Therefore, the risk of any changes to water quality as a result of any accidental release of contaminants (e.g. through spillage or vessel collision) is negligible.

766. Disturbance of seabed sediments during construction has the potential to release any sediment-bound contaminants, such as heavy metals and hydrocarbons that may be present within them into the water column. However, data from the site specific surveys undertaken in 2016 indicates that levels of contaminants within NV East, NV West and the offshore cable corridor are very low. There were only two of the 13 locations sampled, exceeding Cefas Action Level 1 for concentrations of arsenic only, these exceedances are marginal as they are only just over the Action Level 1 concentration. All organotin and PCB results were below the limits of detection (0.004 mg/kg and 0.0001 mg/kg respectively). Therefore, the re-suspension of contaminated sediment from construction activities is anticipated to be negligible (see ES Chapter 9 Marine Water and Sediment Quality; document 6.1).

767. There is the potential for increased suspended sediments as a result of construction activities, such as installation of foundations (for wind turbines, accommodation and electrical substation platforms), cable installation and during any levelling or

dredging activities. However, as outlined in ES Chapter 8 Marine Physical Processes and ES Chapter 9 Marine Water and Sediment Quality (document 6.1), modelling indicates that the majority of the sediment released during seabed preparation would be coarse and would fall within minutes/ tens of minutes) to the seabed as a highly turbid dynamic plume immediately upon its discharge (within tens of metres along the axis of tidal flow).

768. The small proportion of fine sand/mud would stay in suspension for longer and form a passive plume. This plume (tens of mg/l) is likely to exist for around half a tidal cycle. Sediment would settle to the seabed within a few hundred metres up to around a kilometre along the axis of tidal flow, within a short period of time (hours). Within the passive plume, suspended solids concentrations were predicted to be within the range of natural variability. Suspended solids concentrations rapidly returned to background levels after cessation of the release into the water column. The deposits across the wider seabed would be very thin (millimetres) and would occur within Norfolk Vanguard. The assessment in ES Chapter 9 Marine Water and Sediment Quality (document 6.1) determined that any changes in suspended sediment concentrations were low due to the localised and short term nature of the predicted sediment plumes.

769. However, as a precautionary worst-case scenario, the number of harbour porpoise that could be affected as a result of any changes to water quality during construction has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 8.24). This is very precautionary, as it is highly unlikely that any changes in water quality could occur over the entire wind farm area and the offshore cable corridor during construction. It is more likely that effects would be restricted to an area around the working sites.

Spatial assessment

770. The NV West area (295km^2) is approximately 1% of the summer cSAC area, the NV East area (297km^2) is also approximately 1% of the summer cSAC area and the total offshore cable corridor area (237km^2) is less than 1% of the summer cSAC area and less than 2% of the winter cSAC area. Therefore, as a precautionary approach, changes in water quality across the whole area of the wind farm and offshore cable corridor, would be approximately 2% and 3% for the winter or summer areas of the cSAC, respectively.

771. Any changes to water quality at Norfolk Vanguard (alone) that could result in the displacement of all harbour porpoise from the entire wind farm sites and cable corridor area would not exceed 20% of the seasonal component of the Southern North Sea cSAC at any one time. Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the**

Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.

Seasonal averages

772. For the assessment, it is assumed, as the worst-case scenario that changes to water quality could occur throughout each season (e.g. all 183 days in summer period and all 182 days in winter period) and that the changes in water quality could, as a worst-case scenario, be across the entire wind farm areas and the offshore cable corridor area (Table 8.23).

773. Displacement of harbour porpoise as a result of any changes in prey availability would not on average exceed 10% of the seasonal component of the Southern North Sea cSAC over the duration of that season during construction at Norfolk Vanguard (alone). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

774. The estimated maximum number of harbour porpoise that could potentially be affected by any potential changes to water quality during construction at Norfolk Vanguard (alone) is less than 0.3% of the NS MU reference population, based on the worst-case scenario (Table 8.24). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.1.8. Potential in-combination effects during construction of Norfolk Vanguard (alone)

Potential in-combination effects during UXO clearance at Norfolk Vanguard (alone)

775. Only one UXO would be detonated at a time during UXO clearance operations at Norfolk Vanguard; there would be no concurrent UXO detonations.

776. It is not anticipated that piling would be undertaken at the same time as UXO clearance, however, as a worst-case scenario it has been assumed that UXO clearance could be undertaken at one site while piling could be undertaken at the other.

777. The maximum potential area of disturbance is 2,124km^2, based on 26km disturbance range around each piling location and UXO location, therefore the potential effects would be the same as those estimated for the worst-case concurrent piling scenarios (Table 8.20, Table 8.21 and Table 8.22). Therefore, under these circumstances, **there is no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Potential in-combination effects during piling at Norfolk Vanguard (alone)

778. As a worst-case scenario, it is assumed the piling is undertaken at one site and construction activities, including vessels, are underway at the other site and cable corridor with no overlap in the areas of potential disturbance.

Spatial assessment

779. Disturbance of all harbour porpoise during piling and in-combination with other construction activities and vessels would not exceed 20% of the seasonal component of the Southern North Sea cSAC at any one time during any construction activities, other than piling, at Norfolk Vanguard (alone), based on the worst-case scenario (Table 8.26). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.26 Estimated area of SNS cSAC that harbour porpoise could potentially be disturbed from during single pile installation and other construction actives, including vessels, at Norfolk Vanguard

Maximum potential overlap with SNS cSAC for single pile installation	Additional area of potential disturbance at other site	Additional area of potential disturbance at cable corridor	Total maximum potential area of disturbance	Potential adverse effect on site integrity
Single pile installation is located in NV West = 1,112km^2 in the winter SNS cSAC area; or 2,124km^2 in the summer SNS cSAC area.	Construction and vessels in NV East = 0km^2 in the winter SNS cSAC area 297km^2 in the summer SNS cSAC area	Construction and vessels in cable corridor = 237km^2 in the winter SNS cSAC area or 118.5km^2 in the summer SNS cSAC area	Total = 1,349km^2 in the winter SNS cSAC area (10% of winter SNS cSAC area) or 2,539.5km^2 in the summer SNS cSAC area (9.4% of the summer SNS cSAC area)	No Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS cSAC area at any one time during any single pile installation and in-combination with other construction activities and vessels at Norfolk Vanguard (alone), based on the worst-case scenario
Single pile installation is located in NV East = 832km^2 in the winter SNS cSAC area; or 2,124km^2 in the summer SNS cSAC area	Construction and vessels in NV West = 0km^2 in the winter SNS cSAC area 295km^2 in the summer SNS cSAC area	Construction and vessels in cable corridor = 237km^2 in the winter SNS cSAC area or 118.5km^2 in the summer SNS cSAC area	Total = 1,069km^2 in the winter SNS cSAC area (8% of winter SNS cSAC area) or 2,537.5km^2 in the summer SNS cSAC area (9.4% of the summer SNS cSAC area)	

Seasonal averages

780. The seasonal average for the disturbance of harbour porpoise during piling and in-combination with other construction activities and vessels has been assessed based on the maximum potential area of disturbance (Table 8.26) and worst-case scenario for single phased option using pin-piles for 9MW turbines and offshore platforms (see section 8.3.1.1.2).

781. Disturbance of all harbour porpoise during piling and in-combination with other construction activities and vessels would not on average exceed 10% of the seasonal component of the Southern North Sea cSAC area over the duration of that season at Norfolk Vanguard (alone), based on the worst-case scenario (Table 8.27). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.27 Estimated worst-case scenarios for seasonal averages for single phase options using pin-piles for 9MW turbines and offshore platforms (including ADD activation) in-combination with other construction activities and vessels

Phasing option	Duration based on worst-case scenario for piling	Maximum seasonal averages	Potential adverse effect on site integrity
Single Phase option	All 59 days in one season: • 32% of the summer period; or • 32% of the winter period.	• 3% of SNS cSAC summer area for single piling in NV East and other construction activities and vessels at NV West; • 3% of SNS cSAC summer area for single piling in NV West and other construction activities and vessels at NV East; • 3% of SNS cSAC winter area for single piling in NV East and other construction activities and vessels at NV West; or • 3% of SNS cSAC winter area for single piling in NV West and other construction activities and vessels at NV East.	No Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.

Assessment in relation to North Sea MU

782. The estimated number of harbour porpoise that could be disturbed during single pile installation at Norfolk Vanguard in-combination with other construction activities

and vessels, based on 100% of all harbour porpoise in the wind farm and cable corridor areas being disturbed is presented in Table 8.28.

783. The assessment indicates that less than 1% of the North Sea MU reference population could be temporarily displaced during any single pile installation in-combination with construction and vessels at Norfolk Vanguard (alone), based on the worst-case scenario (Table 8.28). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.28 Estimated number of harbour porpoise potentially disturbed during piling in-combination with other construction activities and vessels at Norfolk Vanguard

Potential Effect	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
Area of disturbance (2,124km^2) from underwater noise during single pile installation at NV West, plus disturbance at NV East (297km^2) and cable corridor (237km^2)	2,360 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). or 2,351 harbour porpoise based on 1,678 harbour porpoise at NV West (site specific survey density of 0.79/km^2) and 673 harbour porpoise at NV East and cable route (site specific survey density of 1.26/km^2).	0.7% of NS MU based on SCANS-III density. or 0.7% of NS MU based on site specific survey density at NV West and NV East.	No Temporary effect Less than 1% of the reference population could be temporarily displaced during any single pile installation in-combination with construction and vessels at Norfolk Vanguard (alone), based on the worst-case scenario.
Area of disturbance (2,124km^2) from underwater noise during single pile installation at NV East, plus disturbance at NV West (295km^2) and cable corridor (237km^2)	2,359 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). or 3,096 harbour porpoise based on 2,676 harbour porpoise at NV East (site specific survey density of 1.26/km^2) and 420 harbour porpoise at NV West and cable route (site specific survey density of 0.79/km^2).	0.7% of NS MU based on SCANS-III density. or 0.9% of NS MU based on site specific survey density at NV West and NV East.	

[1]Based on density estimates and reference populations (see section 8.1.1).

Potential in-combination effects during construction at Norfolk Vanguard (alone)

784. There would be no further in-combination effects during construction other than those assessed above, as the potential disturbance from underwater noise during construction has been based on the entire wind farm and cable corridor area, as has any potential disturbance from vessels and any changes in prey availability and water quality. Therefore, under these circumstances, **there is no significant**

disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.

8.3.1.2. Potential effects during operation and maintenance at Norfolk Vanguard (alone)

8.3.1.2.1. Disturbance from the underwater noise associated with operational turbines

785. Currently available data suggests that there is no lasting disturbance or exclusion of harbour porpoise around wind farm sites during operation (e.g. Tougaard *et al.,* 2005, 2006, 2009a, 2009b; Diederichs *et al.,* 2008; Scheidat *et al.,* 2011).

786. The Marine Management Organisation (2014) review found that data on the operational turbine noise, from the UK and abroad, generally showed that noise levels radiated from operational wind turbines are low and the spatial extent of the potential effect of the operational wind turbine noise on marine receptors is generally estimated to be small, with behavioural response only likely at ranges close to the turbine. It is however noted that the early measured data were mainly for smaller capacity wind turbines.

787. Comprehensive environmental monitoring has been carried out at the Horns Rev and Nysted wind farms in Denmark during the operation between 1999 and 2006 (Diederichs *et al*., 2008). Numbers of harbour porpoise within Horns Rev were thought to be slightly reduced compared to the wider area during the first two years of operation it was, however, it was not possible to conclude that the wind farm was solely responsible for this change in abundance without analysing other dynamic environmental variables (Tougaard *et al*., 2009b). Later studies (Diederichs *et al*., 2008) recorded no noticeable effect on the abundances of harbour porpoise at varying wind velocities at both of the offshore wind farms studied, following two years of operation.

788. Harbour porpoise have been shown to forage within operational windfarm sites (e.g. Lindeboom *et al*., 2011), indicating no restriction to movements in operational offshore windfarm sites. Lindeboom *et al*. (2011) found that relatively more porpoises are found in the wind farm area compared to the two reference areas (Scheidat *et al*., 2011). It was established that this effect is genuinely linked to the presence of the wind farm. The most likely explanations are increased food availability due to the attached fauna on and in the hard substrates (reef effect) as well as the exclusion of fisheries and reduced vessel traffic in the wind farm (shelter effect) (Lindeboom *et al*., 2011).

<u>Spatial assessment</u>

789. The NV West area (295km^2) is approximately 1% of the summer cSAC area and the NV East area (297km^2) is also approximately 1% of the summer cSAC area. Therefore, as a precautionary approach, disturbance from the entire area of the

wind farm as a result of operational turbines would be approximately 2% of the summer area of the cSAC.

790. Any disturbance of harbour porpoise as a result of underwater noise from operational turbines at Norfolk Vanguard (alone) would not exceed 20% of the seasonal component of the cSAC at any one time. Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

<u>Seasonal averages</u>

791. The potential disturbance of harbour porpoise as a result of underwater noise from operational turbines at Norfolk Vanguard (alone) has been assessed, based on the worst-case scenario, that disturbance could occur throughout each season (i.e. all 183 days in summer period and all 182 days in winter period) and that, as a worst-case scenario, all harbour porpoise could be disturbed from the entire wind farm area (Table 8.29).

Table 8.29 Estimated worst-case scenarios for seasonal averages for potential disturbance from operational turbines

Potential Effect Area	Duration based on worst-case scenario	Maximum seasonal averages	Potential adverse effect on site integrity
NV West area (approximately 1% of the summer cSAC area)	Throughout the summer period (183 days).	• 1% of the SNS cSAC summer area	No Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.
NV East area (approximately 1% of the summer cSAC area)	Throughout the summer period (183 days).	• 1% of the SNS cSAC summer area	
Total offshore windfarm area (approximately 2% of the summer cSAC area)	Throughout the summer period (183 days).	• 2% of the SNS cSAC summer area	

792. Disturbance of harbour porpoise as a result of underwater noise from operational turbines at Norfolk Vanguard (alone) would not on average exceed 10% of the seasonal component of the Southern North Sea cSAC, based on the worst-case scenario (Table 8.29). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

793. The estimated maximum number of harbour porpoise that could potentially be disturbed as a result of underwater noise from operational turbines at Norfolk Vanguard (alone) is 0.2% or less of the NS MU reference population, based on the worst-case scenario (Table 8.30). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.30 Estimated number of harbour porpoise that could be present in the Norfolk Vanguard offshore wind farm areas during operation

Potential Effect Area	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
NV East area ($297km^2$)	264 harbour porpoise based on SCANS-III survey block O density ($0.888/km^2$). 374 harbour porpoise based on site specific survey density ($1.26/km^2$) at NV East.	0.08% of NS MU based on SCANS-III density. 0.1% of NS MU based on site specific survey density at NV East.	No Long-term (not permanent) effect. Maximum of 0.1% of the reference population could be disturbed.
NV West area ($295km^2$)	262 harbour porpoise based on SCANS-III survey block O density ($0.888/km^2$). 233 harbour porpoise based on site specific survey density ($0.79/km^2$) at NV West.	0.08% of NS MU based on SCANS-III density. 0.07% of NS MU based on site specific survey density at NV West.	No Long-term (not permanent) effect. Maximum of 0.08% of the reference population could be disturbed.
Total offshore wind farm area ($592km^2$)	526 harbour porpoise based on SCANS-III survey block O density ($0.888/km^2$). 607 harbour porpoise based on site specific survey densities at each site.	0.2% of NS MU based on SCANS-III density. 0.2% of NS MU based on site specific survey densities at each site.	No Long-term (not permanent) effect. Maximum of 0.2% of the reference population could be disturbed.

[1]Based on density estimates and reference populations (see section 8.1.1).

8.3.1.2.2. Disturbance from the underwater noise associated with maintenance activities

794. The requirements for any potential maintenance work, such as additional rock dumping or cable re-burial, are currently unknown, however the work required and associated effects would be less than those during construction.

795. The effects from additional cable laying and protection are temporary in nature, and will be limited to relatively short-periods during the operational and maintenance phase. Disturbance responses are likely to occur at significantly shorter ranges than

construction noise and any disturbance is likely to be limited to the area in and around where the actual activity is taking place.

796. As per the assessment of underwater noise during construction from activities other than piling and vessels, a very precautionary worst-case scenario approach assumes disturbance as a result of underwater noise during maintenance activities could cover the wind farm area and the offshore cable corridor area. However, any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

Spatial assessment

797. The NV West area (295km^2) is approximately 1% of the summer cSAC area, the NV East area (297km^2) is also approximately 1% of the summer cSAC area and the total offshore cable corridor area (237km^2) is less than 1% of the summer cSAC area and less than 2% of the winter cSAC area. Therefore, using this worst-case scenario approach, potential effects would be approximately 2% and 3% for the winter or summer areas of the cSAC, respectively.

798. Disturbance of harbour porpoise as a result of underwater noise during maintenance activities at Norfolk Vanguard (alone) would not exceed 20% of the seasonal component of the Southern North Sea cSAC at any one time, based on the worst-case scenario. Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

799. For the assessment, it is assumed, as the worst-case scenario, that disturbance of harbour porpoise as a result of underwater noise during maintenance activities at Norfolk Vanguard (alone) could occur throughout each season (e.g. all 183 days in summer period and all 182 days in winter period) and that all harbour porpoise could be, as a worst-case scenario, disturbed from the entire wind farm areas and the offshore cable corridor area (Table 8.23).

800. Disturbance of harbour porpoise as a result of underwater noise during maintenance activities at Norfolk Vanguard (alone) would not on average exceed 10% of the seasonal component of the Southern North Sea cSAC over the duration of that season during any maintenance activities at Norfolk Vanguard (alone). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

801. The estimated maximum number of harbour porpoise that could potentially be disturbed during maintenance activities at Norfolk Vanguard (alone) is less than 0.3% of the NS MU reference population, based on the worst-case scenario (Table 8.24). Therefore, under these circumstances, **there is no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.2.3. Disturbance from maintenance vessels

802. The requirements for any potential maintenance work are currently unknown, however the work required and effects associated with underwater noise and disturbance from vessels during operation and maintenance would be less than those during construction. However it estimated that there could be up to 480 support vessel round trips per year, with an average of 1-2 vessel movements per day, during operation and maintenance.

803. The potential effects as a result of underwater noise and disturbance from additional vessels during operation and maintenance would be short-term and temporary in nature. Disturbance responses are likely to be limited to the area in the immediate vicinity of the vessel. Marine mammals would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

804. Taking into account the existing vessel movements in around the Norfolk Vanguard area (see section 8.3.1.1.3) and the potential 1-2 vessel movements per day during operation and maintenance, the number of vessels would not exceed the Heinänen and Skov (2015) threshold level of approximately 80 vessels per day. Therefore, there is no increase in the potential for disturbance to harbour porpoise as a result of the increased number of vessels during operation and maintenance at Norfolk Vanguard.

Spatial assessment

805. Using the worst-case scenario, of the disturbance of all harbour porpoise over the entire area of the wind farm and offshore cable corridor, as outlined above, potential effects would be approximately 2% and 3% for the winter or summer areas of the Southern North Sea cSAC, respectively.

806. Disturbance of harbour porpoise as a result of underwater noise from maintenance vessels at Norfolk Vanguard (alone), based on the worst-case scenario, would not exceed 20% of the seasonal component of the Southern North Sea cSAC at any one time. Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

807. For the worst-case scenario it is assumed that disturbance of harbour porpoise as a result of maintenance vessels at Norfolk Vanguard (alone) could occur throughout each season (e.g. all 183 days in summer period and all 182 days in winter period) and that all harbour porpoise could be, as a worst-case scenario, disturbed from the entire wind farm areas and the offshore cable corridor area (Table 8.23).

808. Disturbance of harbour porpoise as a result of maintenance vessels at Norfolk Vanguard (alone) would not on average exceed 10% of the seasonal component of the Southern North Sea cSAC over the duration of that season during any operation and maintenance at Norfolk Vanguard (alone). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

809. The estimated maximum number of harbour porpoise that could potentially be disturbed as a result of maintenance vessels at Norfolk Vanguard (alone) is less than 0.3% of the NS MU reference population, based on the worst-case scenario (Table 8.24). Therefore, under these circumstances**, there is no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.2.4. Vessel interaction (collision risk)

810. The operation and maintenance ports to be used for Norfolk Vanguard are not yet known. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore the increased risk for any vessel interaction is primarily within the wind farm site and cable route. Indicative operational and maintenance vessel movements suggest that there could be up to a total of 480 vessel movements per year, with an average of approximately 1-2 vessel movements per day.

811. Current shipping activity in and around Norfolk Vanguard is relatively high. Therefore based on the worst-case scenario of an average of two vessel movements per day, the increase in vessel movements per day at the Norfolk Vanguard site (up to approximately 480 round trips per year) during operation and maintenance is relatively small compared to existing vessel traffic.

812. However, as a very precautionary approach, the worst-case scenario for the assessment of the potential increased collision with vessels during maintenance activities has been based on the assessment for construction vessels. The assessment has been based on the wind farm and the offshore cable corridor areas,

the number of animals that could be present in these areas and 90-95% avoidance rates (Table 8.25).

813. This is very precautionary, as it is highly unlikely that all marine mammals present in the Norfolk Vanguard area would be at increased collision risk with vessels during maintenance, especially taking into account the relatively small increase in number of vessel movements compared to existing vessel movements in the area.

814. The estimated number of harbour porpoise that could be at increased risk of collision with vessels during maintenance is 0.03% or less of the NS MU reference population, based on the worst-case scenario.

815. Therefore, under these circumstances, there is no predicted adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.

816. As outlined in the assessment for construction vessels, all vessel movements, where possible, will be incorporated into recognised vessel routes where marine mammals are accustomed to vessels, in order to reduce any disturbance and any increased collision risk. All vessel movements will be kept to the minimum number that is required to reduce any potential collision risk. Additionally, vessel operators will use good practice to reduce any risk of collisions with marine mammals.

817. In addition, based on the assumption that harbour porpoise would be disturbed from the Norfolk Vanguard offshore wind farm site and cable corridor as a result of underwater noise from operational and maintenance activities and vessels, as assessed above, in this scenario there should be no potential for increased collision risk with vessels at Norfolk Vanguard during the operation and maintenance period.

8.3.1.2.5. Entanglement in floating foundations

818. Harbour porpoise have a high ability to avoid entanglement. The likelihood of harbour porpoise, or any marine mammal, to become entangled in tension moorings lines is low due to the very low risk of the lines to become 'looped'.

819. To date, there have been no recorded instances of marine mammal entanglement from mooring systems of renewable devices (Sparling *et al.,* 2013; Isaacman and Daborn, 2011), or for anchored floating production, storage and offloading (FPSO) vessels in the oil and gas industry (Benjamins *et al.,* 2014) with similar mooring lines as proposed for floating turbine structures.

820. Taking into account the risk to each marine mammal species and the worst-case parameters for the tension mooring lines, it is unlikely for any marine mammal, including harbour porpoise to become entangled within the floating turbines as all lines are taut at all times.

821. Therefore there is considered to be no potential risk to harbour porpoise and it has not been assessed further.

8.3.1.2.6. Changes to prey resource

822. Potential effects on fish species during operation and maintenance can result from permanent loss of habitat; introduction of hard substrate; operational noise; and electromagnetic fields (EMF). None of the potential effects were assessed as being significant (negligible or minor adverse) in the ES (document 6.1).

823. The introduction of hard substrate, such as turbines, foundations and associated scour protection as well as cable protection, associated with Norfolk Vanguard would increase habitat heterogeneity through the introduction of hard structures in an area predominantly characterised by soft substrate habitat. However, any hard substrate would occupy discrete areas and the relatively small areas of the infrastructure. During operation, the worst-case total area of habitat loss has been estimated to be up to 11.75km^2 in total (Table 8.9).

824. Operational noise would include wind turbine vibration, the contact of waves with offshore structures and noise associated with increased vessel movement, which could result in increase in underwater noise in respect of the existing baseline (i.e. pre-construction). However, based on studies at operational offshore wind farms, any increase above background noise levels during operation is expected to be small and localised, therefore there would be no significant effect on fish species.

825. The areas potentially affected by EMFs generated by the worst-case scenario offshore cables are expected to be small, limited to the area of the OWF sites and the offshore cable corridor and restricted to the immediate vicinity of the cables (i.e. within metres). In addition, EMFs are expected to attenuate rapidly in both horizontal and vertical plains with distance from the source. Therefore any potential effect of EMF on fish species would not be significant.

826. The potential effects as a result of changes to prey resources during operation and maintenance has been assessed based on the maximum loss of seabed habitat to prey species, up to 11.75km^2 (Table 8.9). If it is assumed that the worst-case scenario foot print (11.75km^2) is located entirely in the summer cSAC area (Figure 5.3), the potential effects would be approximately 0.04% of the summer cSAC area.

827. The area of seabed loss for the export cables would also be very small, being limited to areas where cable protection measures may be required, particularly those associated with cable crossings, up to 0.15km^2 along the entire export cable route (Table 8.9). The cable route is located within both the summer and winter cSAC areas (Figure 5.3). If, as a worst-case scenario, the loss of seabed along the cable route was all in the summer cSAC area or all in the winter cSAC area, the potential

effects would be approximately 0.0006% of the summer area or 0.001% of the winter area, respectively.

Spatial assessment

828. As a worse-case scenario, the changes to prey resources during operation and maintenance have also been assessed based on the entire wind farm area and the offshore cable corridor area. This is very precautionary, as outlined above it is highly unlikely that any changes in prey resources could occur over the entire wind farm area and the offshore cable corridor. It is more likely that effects would be restricted to an area of any habitat loss, which is a small percentage of the wind farm and cable corridor areas.

829. Using the approach for construction, potential effects could be up to 2% and 3% for the winter or summer areas of the cSAC, respectively.

830. Any changes to prey availability resulting in the displacement of all harbour porpoise from the entire wind farm sites and cable corridor area would not exceed 20% of the seasonal component of the Southern North Sea cSAC at any one time. Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

831. For the assessment, it is assumed, as the worst-case scenario that changes to prey availability could occur throughout each season (e.g. all 183 days in summer period and all 182 days in winter period) and that the changes in prey availability could, as a worst-case scenario, be across the entire wind farm areas and the offshore cable corridor area (Table 8.23).

832. Displacement of all harbour porpoise as a result of any changes in prey availability from the entire wind farm sites and cable corridor area would not on average exceed 10% of the seasonal component of the Southern North Sea cSAC over the duration of that season during operation and maintenance at Norfolk Vanguard (alone). Therefore, under these circumstances, **there is no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

833. The estimated maximum number of harbour porpoise that could potentially be affected by any potential changes to prey availability at Norfolk Vanguard (alone) during operation and maintenance is less than 0.3% of the NS MU reference population, based on the worst-case scenario (Table 8.24). Therefore, under these circumstances, **there is no anticipated adverse effect on the integrity of the**

Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.

8.3.1.2.7. Potential in-combination effects during operation and maintenance at Norfolk Vanguard (alone)

834. There would be no in-combination effects during operation and maintenance, as the potential disturbance from underwater noise from operational turbines, during maintenance activities, vessels and any changes to prey availability have all been based on the entire wind farm and cable corridor area. Therefore, under these circumstances, **there is no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3. Potential effects during decommissioning

835. Possible effects on harbour porpoise associated with the decommissioning stage(s) have been summarised; however a further assessment will be carried out ahead of any decommissioning works to be undertaken taking account of known information at that time, including relevant guidelines and requirements.

8.3.1.3.1. Disturbance from the underwater noise associated with foundation removal

836. Decommissioning would most likely involve the accessible installed components comprising: all of the wind turbine components; part of the foundations (those above sea bed level); and the sections of the inter-array cables close to the offshore structures, as well as sections of the export cables. The process for removal of foundations is generally the reverse of the installation process. There would be no piling, and foundations may be cut to an appropriate level.

837. It is not possible to provide details of the methods that will be used during decommissioning at this time. However, is it expected that the activity levels will be comparable to construction (with the exception of pile driving noise).

838. A detailed decommissioning plan will be provided prior to decommissioning that will give details of the techniques to be employed and any relevant mitigation measures.

839. For this assessment it is assumed that the potential effects from underwater noise during decommissioning would be less than those assessed for piling and comparable to those assessed for other construction activities. Therefore, under these circumstances, **there is no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3.2. Disturbance from vessels

840. For this assessment it is assumed that the potential effects would be the same as for construction. Therefore, under these circumstances, **there is no anticipated adverse**

effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.

8.3.1.3.3. Vessel interaction (collision risk)

841. For this assessment it is assumed that the potential effects would be the same as for construction. Therefore, under these circumstances, **there is no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3.4. Changes to prey resource

842. For this assessment it is assumed that the potential effects would be the same as for construction. Therefore, under these circumstances, **there is no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3.5. Changes to water quality

843. For this assessment it is assumed that the potential effects would be the same as for construction. Therefore, under these circumstances, **there is no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3.6. Potential in-combination effects during decommissioning at Norfolk Vanguard (alone)

844. There would be no in-combination effects during decommissioning, as the potential disturbance from underwater noise during foundation removal, disturbance from vessels and any changes to prey availability have all been based on the entire wind farm and cable corridor area. Therefore, under these circumstances, **there is no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.4. Summary of Potential Effects of Norfolk Vanguard Alone

845. Table 8.31 summarises the potential effects of Norfolk Vanguard alone.

Table 8.31 Summary of the potential effects of Norfolk Vanguard alone

Potential Effect	Assessment in relation to the North Sea MU population	Spatial assessment and seasonal averages in relation to the cSAC summer and winter areas	Potential adverse effect on site integrity
During Construction at Norfolk Vanguard (alone)			
Permanent auditory injury associated with clearance of UXO	Without mitigation, 0.15% of NS MU reference population could be affected.	N/A Assessment based on number of individuals at potential risk. Potential area of effect would be less than area of potential disturbance.	**No** **will be mitigated through the implentation of MMMP for UXO clearance**
Disturbance from the underwater noise associated with clearance of UXO	Less than 1% of the NS MU reference population could be temporarily disturbed.	Temporary displacement of harbour porpoise would be less than 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
Permanent auditory injury associated during piling	Without mitigation, 0.007% of the NS MU reference population could be affected.	N/A Assessment based on number of individuals at potential risk. Potential area of effect would be less than area of potential disturbance.	**No** **will be mitigated through the implentation of MMMP for piling**
Disturbance from underwater noise during single piling	Less than 1% of the NS MU reference population could be temporarily disturbed.	Temporary displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
Disturbance from underwater noise during concurrent piling	1.3% or less of the NS MU reference population could be temporarily disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
Disturbance from underwater noise during construction activities, other than piling	Less than 0.3% or the NS MU reference population could be temporarily disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
Disturbance from vessels	Less than 0.3% of the NS MU reference	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one	**No**

Potential Effect	Assessment in relation to the North Sea MU population	Spatial assessment and seasonal averages in relation to the cSAC summer and winter areas	Potential adverse effect on site integrity
	population could be temporarily disturbed.	time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	
Vessel interaction (collision risk)	0.03% or less of the NS MU reference population could be at increased risk	N/A	**No**
Changes to prey resource	Less than 0.3% of the NS MU reference population could be temporarily displaced.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
Changes to water quality	Less than 0.3% of the NS MU reference population could be temporarily displaced.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
In-combination effects during UXO clearance	1.3% or less of the NS MU reference population could be temporarily disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
In-combination effects during piling	Less than 1% of the NS MU reference population could be temporarily disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
In-combination effects during construction, other than piling	Less than 0.3% of the NS MU reference population could be temporarily disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
During Operation and Maintenance at Norfolk Vanguard (alone)			
Disturbance from the underwater noise associated with operational turbines.	0.2% or less of the NS MU reference population could be disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**

Potential Effect	Assessment in relation to the North Sea MU population	Spatial assessment and seasonal averages in relation to the cSAC summer and winter areas	Potential adverse effect on site integrity
Disturbance from the underwater noise associated with maintenance activities	Less than 0.3% of the NS MU reference population could be temporarily disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
Disturbance from vessels	Less than 0.3% of the NS MU reference population could be temporarily disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
Vessel interaction (collision risk)	0.03% or less of the NS MU reference population could be at increased risk.	N/A	**No**
Entanglement in floating foundations	No potential risk to harbour porpoise.	N/A	**No**
Changes to prey resource	Less than 0.3% of the NS MU reference population could be displaced.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
In-combination effects during operation and maintenance	Less than 0.3% of the NS MU reference population could be disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
During Decommissioning at Norfolk Vanguard (alone)			
Disturbance from the noise associated with foundation removal	Less than 0.3% of the NS MU reference population could be temporarily disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
Disturbance from underwater noise and disturbance from vessels	Less than 0.3% of the NS MU reference population could be temporarily disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**

Potential Effect	Assessment in relation to the North Sea MU population	Spatial assessment and seasonal averages in relation to the cSAC summer and winter areas	Potential adverse effect on site integrity
Vessel interaction (collision risk)	0.03% or less of the NS MU reference population could be at increased risk.	N/A	**No**
Changes to prey resource	Less than 0.3% of the NS MU reference population could be temporarily displaced.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
Changes to water quality	Less than 0.3% of the NS MU reference population could be temporarily displaced.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**
In-combination effects during operation and maintenance	Less than 0.3% of the NS MU reference population could be disturbed.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season.	**No**

8.3.1.5. In-combination effects

846. The in-combination assessment considers plans or projects where the predicted effects have the potential to interact with effects from the proposed construction, operation and maintenance or decommissioning of the Norfolk Vanguard project.

847. The plans and projects screened in to the in-combination assessment (see HRA Screening Appendix 5.1) are located in the relevant marine mammal MU population reference areas for harbour porpoise, grey seal and harbour seal (as defined in section 8.1).

848. The types of plans and projects included in this in-combination assessment, and the approach to screening, is based on the stage of the plan or project (accounting for uncertainty in the tiered approach described in HRA Screening Appendix 5.1), as well as the quality of the data available. The approach to the HRA screening has also been summarised in Appendix 5.1.

849. This approach and definitions of the Tiers used (as outlined in Table 8.32) was agreed at the EPP meeting in February 2017. This tiered approach is analogous to that

outlined by Joint Nature Conservation Committee (JNCC) and Natural England (undated) in the document 'Suggested Tiers for Cumulative Impact Assessment'.

850. The current stage or tier of each plan and project has been used to determine what stage the project will be at for the in-combination assessment, e.g. where relevant, at the time of Norfolk Vanguard construction.

Table 8.32 Tiers for undertaking a staged in-combination assessment (JNCC and Natural England)

Tier Description	Consenting or Construction Phase	Data Availability
Tier 1	Built and operational projects should be included within the cumulative assessment where they have not been included within the environmental characterisation survey, i.e. they were not operational when baseline surveys were undertaken, and/or any residual impact may not have yet fed through to and been captured in estimates of "baseline" conditions e.g. "background" distribution or mortality rate for birds.	Pre-construction (and possibly post-construction) survey data from the built project(s) and environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project).
Tier 2	Tier 1 + projects under construction.	As Tier 1 but not including post-construction survey data.
Tier 3	Tier 2 + projects that have been consented (but construction has not yet commenced).	Environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project) and possibly pre-construction.
Tier 4	Tier 3 + projects that have an application submitted to the appropriate regulatory body that have not yet been determined.	Environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project).
Tier 5	Tier 4 + projects that the regulatory body are expecting an application to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects).	Possibly environmental characterisation survey data (but strong likelihood that this data will not be publicly available at this stage).
Tier 6	Tier 5 + projects that have been identified in relevant strategic plans or programmes (e.g. projects identified in Round 3 wind farm zone appraisal and planning (ZAP) documents).	Historic survey data collected for other purposes/by other projects or industries or at a strategic level.

851. The types of effect considered in the in-combination assessment have been agreed as part of the EPP with the marine mammal ETG. This in-combination assessment considers three types of effect (underwater noise, indirect effects and direct interaction) from all stages of any plan or project where there is the potential to overlap with the proposed Norfolk Vanguard project. The plans and projects assessed for potential in-combination effects are located within (i) the agreed

reference population boundary of the North Sea MU for harbour porpoise; and (ii) the SNS cSAC or within 26km of the SNS cSAC boundary.

852. It should be noted that a large amount of uncertainty is inherent in the completion of an in-combination assessment. For example, the potential for effects over wide spatial and temporal scales means that the uncertainty of a large number of plans or projects can lead to low confidence in the information used in the assessment, but also the conclusions of the assessment itself. To take this uncertainty into account, where possible, a precautionary approach has been taken at multiple stages of the assessment process. However, it should be noted that building precaution on precaution can lead to unrealistic worst-case scenarios within the assessment.

853. Therefore, the assessment will be based on the most realistic worst-case scenario (the 'potential worst-case' scenario). To help reduce any uncertainty and highly unrealistic worst-case scenarios while still providing a conservative assessment. Careful consideration has been undertaken to determine this 'potential worst-case' scenario for the in-combination assessment.

854. The level of uncertainty in completing an in-combination assessment further supports the need for strategic assessment rather than developer or project led assessment. Population models, such as the Disturbance Effects on the Harbour Porpoise Population in the North Sea (DEPONS) and the Population Consequences of Disturbance (PCoD) used at a strategic level would allow consideration of the biological fitness consequences of disturbance from underwater noise, and the conclusions of a quantitative assessment to be put into a population level context (e.g. Nabe-Nielsen *et al*., 2018). Norfolk Vanguard Limited is supportive of these strategic initiatives, and will continue to work alongside other developers, Regulators and Statutory Nature Conservation Bodies (SNCBs) in order to further understand the potential for significant in-combination effects, and how to reduce these effects, where appropriate.

855. The aim would be to strive for a more evidence based and realistic assessment of the potential in-combination population effects as a result of the disturbance to harbour porpoise from piling noise.

8.3.1.5.1. Disturbance from underwater noise during OWF piling

856. The in-combination assessment determines the potential for disturbance to harbour porpoise from underwater noise sources during the construction period, operational and maintenance period and decommissioning of Norfolk Vanguard.

857. The commitment to the MMMP for piling (based on the draft MMMP provided with the DCO application ((document reference 8.13) and a MMMP for UXO clearance to be developed pre-construction would result in no potential effects for lethal injury,

physical injury and permanent auditory injury (PTS). No other activities were identified that could lead to these effects in this receptor. As such, the proposed Norfolk Vanguard project would not contribute to any in-combination effects for lethal injury, physical injury and permanent auditory injury (PTS), therefore the in-combination assessment for underwater noise only considers behavioural effects.

858. The approach to the in-combination assessment for disturbance from underwater noise follows the current advice from the SNCBs on the assessment of impacts on the SNS harbour porpoise cSAC. This approach has been used for the Norfolk Vanguard ES (document 6.1), including the CIA, and has been based on the following parameter:

- A distance of 26km from an individual percussive piling location has been used to assess the area that harbour porpoise could potentially be disturbed during piling, for both single and concurrent piling operations.

859. The potential disturbance of harbour porpoise has been estimated for each individual project based on:

- The potential disturbance area during single pile installation, based on a radius of 26km from each piling location (2,124km^2 per project); and
- The potential disturbance area during concurrent pile installation, based on a radius of 26km from two piling locations per project with no overlap in disturbance areas (4,248km^2 per project).

860. There is a high level of uncertainty in relation to the in-combination scenarios that will arise by the time of Norfolk Vanguard construction. The approach taken to this in-combination assessment is based on a range of indicative single piling and concurrent scenarios.

861. The following indicative scenarios for potential in-combination effects of disturbance due to underwater noise from piling during offshore wind farm construction have been assessed:

- The in-combination assessment has been undertaken based on the ‘potential worst-case’ scenario of the offshore wind farm developments that could be piling at the same time as Norfolk Vanguard. This scenario is based on a precautionary approach using the maximum duration of piling periods.
- In addition, a ‘theoretical worst-case’ scenario, based on potential construction periods which allows for any delays and changes in project development is presented in Appendix 8.2.

862. The UK Tier 3, 4 and 5 OWF projects (see Table 8.32 for definitions) considered for the potential worst-case scenario to assess the potential for in-combination effects

of disturbance to harbour porpoise during OWF piling, based on the periods of piling are outlined in Table 8.33. The European Tier 3 OWF projects considered for the potential worst-case scenario, based on the periods of piling, where available, are also included in Table 8.33.

863. The OWF projects included in the potential worst-case scenario are located within the SNS cSAC or up to 26km from the SNS cSAC boundary (Table 8.33).

864. The potential worst-case scenario takes into account the most likely and most efficient build scenarios, in that developers of more than one site are likely to develop one site at a time, as it is more efficient and cost effective to develop one site and have it operational prior to constructing the next site. It has therefore been assumed that there will be no overlap in the piling of Norfolk Vanguard, Thanet Extension and Norfolk Boreas, or between the East Anglia THREE, ONE North and TWO projects, and that two of the Dogger Bank projects could be constructed at the same time (as they now have different developers).

865. As a highly precautionary approach Appendix 8.2 includes a further iteration adding Norfolk Boreas to the potential worst-case scenario for Norfolk Vanguard.

866. The in-combination assessment has been based on single or concurrent piling in NV West (which has greater overlap with the cSAC than NV East).

867. For the in-combination assessment, the potential construction period of Norfolk Vanguard has been based on the widest likely range of construction dates between 2024 and 2028, based on a worst-case four year construction period.

868. As a precautionary worst-case, it has been assumed that piling could occur at any time during the potential Norfolk Vanguard construction period, although it would not be continuous for the duration of the construction period. In reality, as outlined in section 8.3.1.1.2, active piling and ADD activation would only be for a relatively short period, up to 58 days, approximately 4% of the four year construction period.

869. These figures are typical of offshore wind projects and when comparing the potential in-combination effects of several projects it is important to note that the likelihood of several projects all piling at the same time is comparatively low as the length of piling time per project construction period is very low (typically in the order 3-5% depending on construction programme). The likelihood of concurrent piling occurring is also affected by other factors including seasonality, vessel market conditions and by weather in the North Sea.

Table 8.33 Offshore wind farms included in the in-combination assessment for the potential disturbance of harbour during piling for the potential worst-case scenario for OWF projects where there is the potential of piling occurring at the same time as piling at Norfolk Vanguard. All details presented are based on the most up to date information for each project at the time of writing.

Name and country of project	Distance from SNS cSAC	Size (MW)	Maximum number of turbines	Month/year consent authorised/ expected (indicative consent window)	Dates of offshore construction / piling[1]	Potential worst-case scenario of piling occurring at the same time as Norfolk Vanguard piling[2]
Norfolk Vanguard	**Within SNS cSAC**	**1,800**	**120-257**	**2019 (2019-2024)**	**Construction and piling: 2024 – 2028**	**Yes**
Tier 3: consented						
Creyke Beck A, UK	**Within SNS cSAC**	500-600	200	Feb-15 (2015-2022)	2021-2027	No[3]
Creyke Beck B, UK	**Within SNS cSAC**	500-600	200	Feb-15 (2015-2022)	2021-2028	**Yes[3]**
Teesside A, UK	**Less than 26km**	1,200	200	Aug-15 (2015-2022)	2021-2028	**No[3]**
Sofia, UK (formerly Teesside B)	**Within SNS cSAC**	1,200	200	Aug-15 (2015-2022)	2020-2028	**Yes[3]**
East Anglia One, UK	**Within SNS cSAC**	714	102	Jun-14 (2014-2021)	Piling: 2018-2019	No
East Anglia THREE, UK	**Within SNS cSAC**	1,200	172	Aug-17 (2017-2024)	Piling: 2020 – 2022	No
Hornsea Project Two, UK	**Within SNS cSAC**	1,800	225	Aug-16 (2016-2023)	2018-2021 Piling: 2018-2020	No
Triton Knoll phase 1-3, UK	**Less than 26km**	1,200	288	Jul-13 (2013-2020)	2018-2021	No
Kincardine	More than 26km	49.6	8	2017 (2017-2024)	2018-2019	No
Mermaid (Belgium)	**Less than 26km**	366-288	24-48	2015 (2015-2022)	2017-2019	No
Northwester 2 (Belgium)	**Less than 26km**	224	22-38	2015 (2015-2022)	Unknown	No

Name and country of project	Distance from SNS cSAC	Size (MW)	Maximum number of turbines	Month/year consent authorised/ expected (indicative consent window)	Dates of offshore construction / piling[1]	Potential worst-case scenario of piling occurring at the same time as Norfolk Vanguard piling[2]
Delta Nordsee 1 (Germany)	More than 26km	210	35	2005	Piling to commence in 2023	No
Delta Nordsee 2 (Germany)	More than 26km	192	32	2009	Piling to commence in 2023	No
Borssele I and II (Netherlands)	**Less than 26km**	350+350	95+95	May-16 (2016-2023)	2019	No
Borssele III and IV (Netherlands)	More than 26km	360+340	95+95	May-16 (2016-2023)	2020	No
Borssele Site V - Leeghwater - Innovation Plot (Netherlands)	More than 26km	20	2	May-16 (2016-2023)	2020	No
Tier 4: application submitted and project on-hold						
Firth of Forth Phase 1 Seagreen Alpha and Bravo, UK	More than 26km	1,050	150	Oct-14 (2014-2021)	Unknown – on-hold	No
Inch Cape, UK	More than 26km	784	110	Oct-14 (2014-2021)	Unknown – on-hold	No
Neart na Gaoithe, UK	More than 26km	448	75	Oct-14 (2014-2021)	Unknown – on-hold	No
Moray Firth Western Development Area	More than 26km	750	90	2014 (2014-2021)	Unknown – on-hold	No
Dounreay Tri	More than 26km	10	2	2017 (2017-2024)	Unknown – project postponed	No
Tier 5: application in preparation						
Norfolk Boreas	**Within SNS cSAC**	1,800	257	2020 TBC (2020-2027)	Possible piling: 2025-2029	No[4]
Hornsea Project Three	**Less than 26km**	2,400	342	2018 TBC (2018-2025)	Possible piling: 2022-2023 and 2029-2030	Yes
Thanet Extension	**Within SNS cSAC**	340	34	2018 TBC (2018-2025)	2020-2023	No[4]
East Anglia ONE North	**Within SNS cSAC**	Up to 800	Up to 67		2026 - 2029	No[5]

Name and country of project	Distance from SNS cSAC	Size (MW)	Maximum number of turbines	Month/year consent authorised/ expected (indicative consent window)	Dates of offshore construction / piling[1]	Potential worst-case scenario of piling occurring at the same time as Norfolk Vanguard piling[2]
East Anglia TWO	**Within SNS cSAC**	Up to 900	Up to 75		2025 - 2029	Yes[5]

[1]Piling and offshore construction dates are based on the latest dates and information available.
[2] Potential worst-case scenarios: projects for which consent has been granted (Tier 3 projects) and proposed piling is likely to overlap with the proposed piling of Norfolk Vanguard.
[3]It is highly unlikely that all four Dogger Bank projects would be piling at the same time; therefore the two projects that could be constructed at the same time (i.e. they have different developers) have been included in the potential worst-case scenario.
[4] Based on the most efficient and most likely build scenario and as outlined in Section 8.4, to limit the potential for in-combination disturbance effects, taking into account the current SNCB guidance for the assessment of the potential effects on the Southern North Sea cSAC for harbour porpoise, concurrent piling with Thanet Extension and Norfolk Boreas would be avoided where possible, subject to construction milestones associated with The Crown Estate Agreement for Lease.
[5] Based on the most efficient and most likely build scenario, SPR would construct only one site at a time, with EA1N following EA2.

Assessment in relation to the North Sea MU population

870. For each project, the number of harbour porpoise in the potential area of disturbance for single and concurrent piling, has been estimated using the latest SCANS-III density estimates (Hammond *et al.,* 2017) for the relevant survey block that the project is located within. The number of harbour porpoise that could potentially be disturbed has been put into the context of the reference population for the North Sea MU.

871. The OWFs that were considered in this assessment were those located within the North Sea MU, not just in the SNS cSAC or within 26km of the SNS cSAC (Table 8.33).

872. The potential worst-case scenario takes into account the most likely and most efficient build scenarios. It is assumed that developers of more than one site would generally develop one site at a time, as it is more efficient and cost effective to develop one site and have it operational prior to constructing the next site. It has therefore been assumed, for example, that there will be no overlap in the piling of Norfolk Vanguard and Thanet Extension.

873. It should be noted that the potential areas of disturbance have not taken into account the potential overlap in the areas of disturbance between different projects when calculating the number of harbour porpoise in the MU that could be affected and therefore this assessment is highly conservative.

874. This highly conservative potential worst-case scenario for OWFs that could be piling at the same time as Norfolk Vanguard in the North Sea MU includes four other UK OWFs (Table 8.33):

- Creyke Beck B;
- Sofia (formerly Teesside B);
- Hornsea Project 3; and
- East Anglia TWO.

875. In this potential worst-case scenario, for concurrent piling the estimated maximum area of potential disturbance is 21,240km^2, without any overlap in the potential areas of disturbance at each wind farm or between wind farms. Therefore, maximum number of harbour porpoise that could potentially be temporarily disturbed is 17,667 individuals, which represents approximately 5% of the North Sea MU reference population (Table 8.34).

876. Based on a single pile installation at each of the five OWFs, the estimated maximum area of potential disturbance is 10,620km^2, without any overlap in the potential areas of disturbance at each wind farm or between wind farms. Therefore, the maximum number of harbour porpoise that could potentially be temporarily

disturbed is 8,833 individuals which represent approximately 3% of the North Sea MU reference population (Table 8.34).

877. The assessment indicates that approximately 3-5% of the NS MU reference population could be affected based on the potential worst-case scenario for the maximum number of harbour porpoise that could be temporarily disturbed as a result of the in-combination effects of OWF piling at the same time as Norfolk Vanguard, with single or concurrent pile installation at each site.

878. The approach to the in-combination assessment, based on the five UK OWFs single piling, would allow for some of these sites not to be piling at the same time while others, including Norfolk Vanguard, could be concurrent piling. This is also more realistic, as five OWFs concurrently piling at exactly the same time is overly precautionary.

879. As outlined above, although the potential piling duration for Norfolk Vanguard has been assessed based on a precautionary maximum duration for construction, the actual piling time and ADD activation which could disturb harbour porpoise is only a very small proportion of this time, of up to approximately 59 days within the maximum possible construction period (approximately 4% of the estimated four year construction period), based on the estimated maximum duration to install individual piles. Any displaced harbour porpoise would have access to alternative foraging areas throughout the North Sea MU.

880. The potential temporary effects would be less than those assessed in this assessment as there is likely to be a great deal of variation in timing, duration, and hammer energy used throughout the various OWF project construction periods. In addition, not all harbour porpoise would be displaced over the entire 26km potential disturbance range. For example, the study of harbour porpoise at Horns Rev (Brandt *et al.,* 2011), indicated that at closer distances (2.5 to 4.8km) there was 100% avoidance, however, this proportion decreased significantly moving away from the pile driving activity and at distances of 10km to 18km avoidance was 32% to 49% of the population and at 21km the abundance was reduced by just 2%.

881. Norfolk Vanguard Limited is committed to working with the SNCBs and MMO in the development of a possible strategic approach to mitigation, if required subject to the final design and programme of Norfolk Vanguard and other OWF projects. This would be addressed through the development and agreement of both a MMMP and Site Integrity Plan.

882. With the use of appropriate strategic mitigation measures which will be developed and agreed within the Site Integrity Plan, including review of the piling schedules and

updated assessment pre-construction, there would be **no significant disturbance and no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise as a result of in-combination effects from underwater noise during OWF piling.**

Table 8.34: Quantified in-combination assessment for the potential disturbance of harbour porpoise during single and concurrent piling of OWFs for the potential worst-case scenario based on the OWF projects which could be piling at the same time as Norfolk Vanguard.

Name of Project	Tier	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Potential number of harbour porpoise disturbed during single piling (2,124km^2)	Potential number of harbour porpoise disturbed during concurrent piling with no overlap (4,248km^2)
Norfolk Vanguard	5	0	O[1]	0.888	1,886	3,772
Creyke Beck B	3	193	O	0.888	1,886	3,772
Sofia	3	180	O[2]	0.837	1,886	3,772
Hornsea Project 3	5	80	O	0.888	1,886	3,772
East Anglia TWO	5	45	L	0.607	1,289	2,579
Total					**8,833**	**17,667**
% of North Sea MU reference population (345,373 harbour porpoise)					**2.6%**	**5.1%**

[1]NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O; therefore higher density estimate from survey block O is used.
[2]Dogger Bank Zone Teesside B now Sofia overlaps SCANS-III survey block O & N, but majority of site is in block O.

Spatial assessment in relation to the cSAC summer and winter areas

883. For each project, the area of potential disturbance for single and concurrent piling that overlaps the cSAC winter and summer areas has been estimated, based on the worst-case scenarios for the maximum, minimum and average overlap with the SNS cSAC winter and summer areas.

884. The OWFs included in the assessment are located within the SNS cSAC or less than 26km from the boundary of the SNS cSAC (Table 8.33).

885. As outlined above, the potential worst-case scenario takes into account the most likely and most efficient build scenarios, in that developers of more than one site will develop one site at a time, as it is more efficient and cost effective to develop one site and have it operational prior to constructing the next site.

886. This assessment takes into account the overlap in the potential areas of disturbance based on the 26km radius at piling locations for each project and within each project for concurrent piling.

887. For Norfolk Vanguard it has been assumed that both concurrent piling locations are located within the NV West site as this provides the maximum overlap with the cSAC.

888. The conservative potential worst-case scenario for OWFs piling at the same time as Norfolk Vanguard in and within 26km of the SNS cSAC include four other OWFs, identified in Table 8.33:

- Creyke Beck B;
- Sofia;
- Hornsea Project 3; and
- East Anglia TWO.

889. The estimated maximum, minimum and average overlap with the SNS cSAC winter and summer areas if all five OWFs were piling at exactly the same time, using single piling on each OWF site is outlined in Table 8.35, taking into account the overlap in disturbance areas (Figure 8.3).

890. In the case of concurrent piling with two locations at each OWF site, the estimated maximum, minimum and average overlap with the SNS cSAC winter and summer areas is outlined in Table 8.35, taking into account the overlap in disturbance areas (Figure 8.4).

Table 8.35 Estimated maximum, minimum and average overlap with SNS cSAC winter and summer areas for potential worst-case scenarios (Sofia, Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for single and concurrent piling

In-combination assessment scenario	Maximum overlap with SNS cSAC	Minimum overlap with SNS cSAC	Average overlap with SNS cSAC
Potential worst-case scenario (5 OWFs) – single piling	Maximum overlap with summer SNS cSAC area = 5,458.09km^2 (20.15%) Maximum overlap with winter SNS cSAC area = 3,056.07km^2 (22.86%)	Minimum overlap with summer SNS cSAC area = 3,077.53km^2 (11.36%) Minimum overlap with winter SNS cSAC area = 2,129.47km^2 (15.93%)	Average overlap with summer SNS cSAC area = 4,267.81km^2 (15.76%) Average overlap with winter SNS cSAC area = 2,592.77km^2 (19.4%)
Potential worst-case scenario (5 OWFs) – concurrent piling	Maximum overlap with summer SNS cSAC area = 7,331.77km^2 (27.06%) Maximum overlap with winter SNS cSAC area = 4,834.42km^2 (36.17%)	Minimum overlap with summer SNS cSAC area = 3,149.93km^2 (11.63%) Minimum overlap with winter SNS cSAC area = 2,213.75km^2 (16.56%)	Average overlap with summer SNS cSAC area = 5,240.85km^2 (19.35%) Average overlap with winter SNS cSAC area = 3,524.59km^2 (26.37%)

891. The assessment indicates that less than 20% of the SNS cSAC summer area and SNS cSAC winter area could be affected based on the minimum and average potential overlap of the potential worst-case scenario with single piling at the five OWFs.

892. However, the assessment also indicates that there is the potential for more than 20% of the SNS cSAC summer area and SNS cSAC winter area to be affected based on the maximum potential overlap for single and concurrent piling; or more than 20% of the SNS cSAC winter area could be affected based on the average potential overlap of the potential worst-case scenario with concurrent piling at each of the five OWFs.

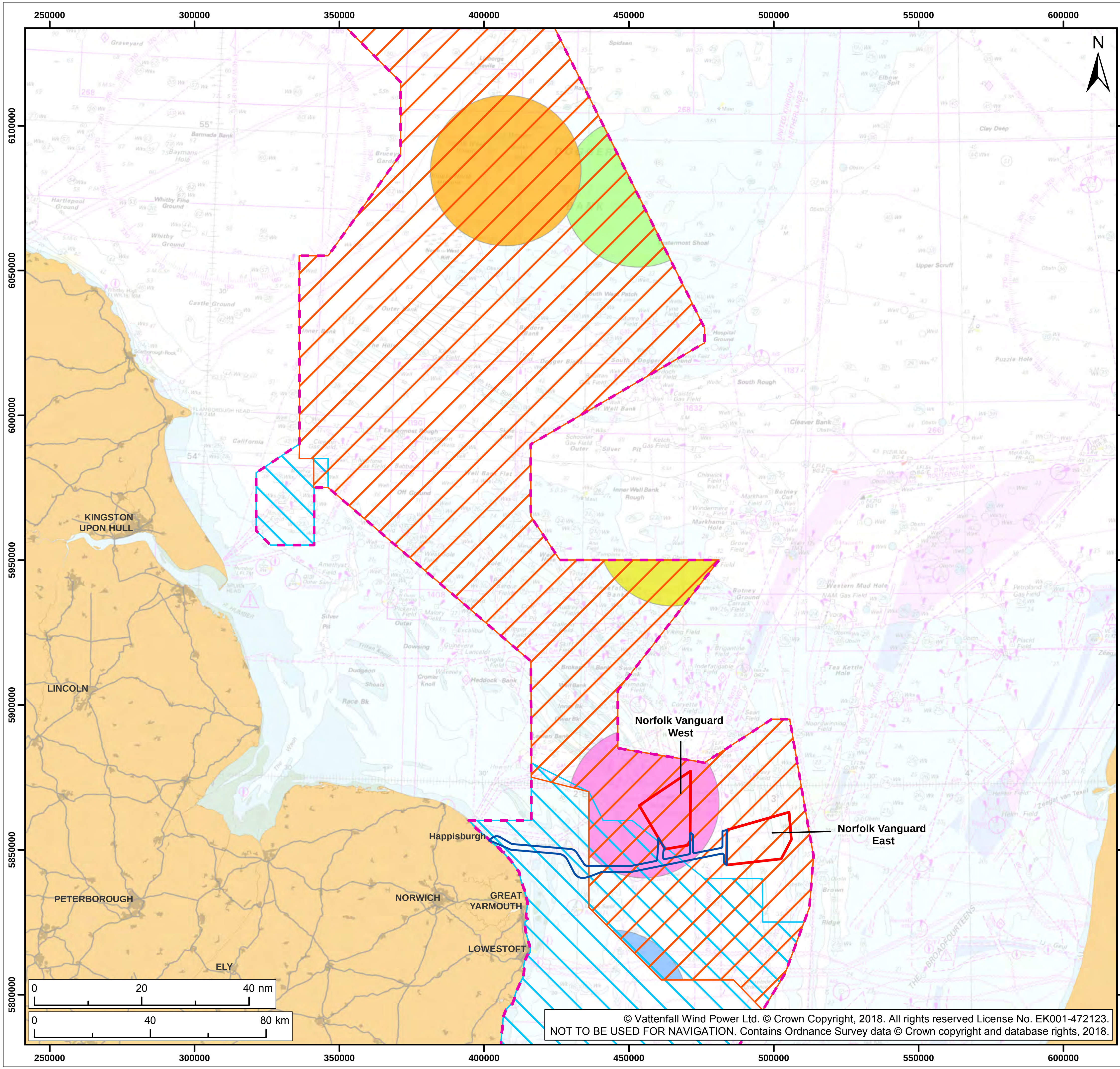
893. The scenarios presented in this assessment are indicative of what the actual in-combination scenarios could be and it is considered unlikely that concurrent piling would occur at all five sites at exactly the same time. Therefore the assessment based on the concurrent piling scenario is highly conservative.

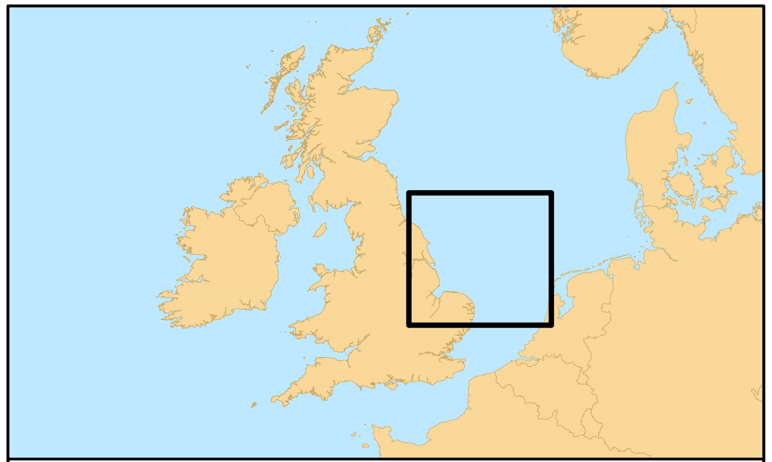
894. As outlined above, Norfolk Vanguard Limited intends to work with the SNCBs and Regulators in the development of a possible strategic approach to mitigation, if required subject to the final design and programme of Norfolk Vanguard and other OWF projects. This would be addressed through the MMMP and Site Integrity Plan.

895. With the use of strategic mitigation and the proposed approach outlined in the Site Integrity Plan, a scenario can be reached that would not exceed 20% disturbance of the winter or summer cSAC areas. Therefore, with the appropriate measures in place, review of the piling schedules and updated assessment pre-construction, there would be no significant disturbance and **no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour**

porpoise as a result of in-combination effects from underwater noise during OWF piling.

896. Section 8.4 outlines the proposed management and mitigation of the potential effects on harbour porpoise.





Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Southern North Sea Candidate Special Area of Conservation (cSAC)[1]
- Summer Area[1]
- Winter Area[1]

Maximum Overlap of Single Piling Events of 5 Offshore Wind Farms and the Southern North Sea Winter Area

- Dogger Bank Creyke Beck B
- Sofia
- East Anglia TWO
- Hornsea Project 3
- Norfolk Vanguard West

[1] JNCC (2017).

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title:
Estimated maximum overlap with SNS cSAC summer area for 'most likely' scenario (Sofia, Dogger Bank Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for single piling.

Figure: 8.3 | Drawing No: PB4476-006-001-006

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	16/05/2018	GS	JL	A3	1:1,300,000
01	14/02/2018	GS	JL	A3	1:1,300,000

Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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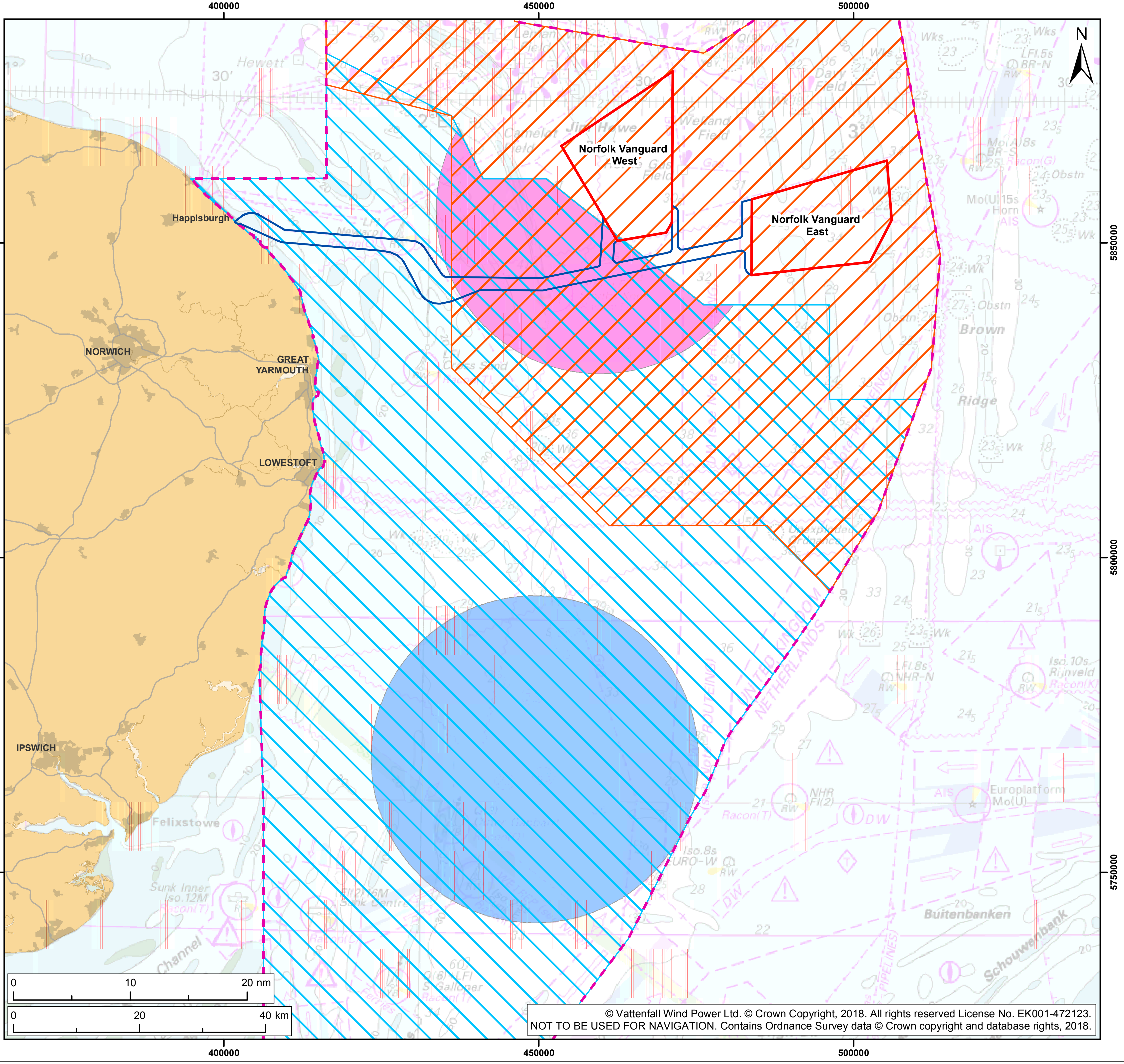

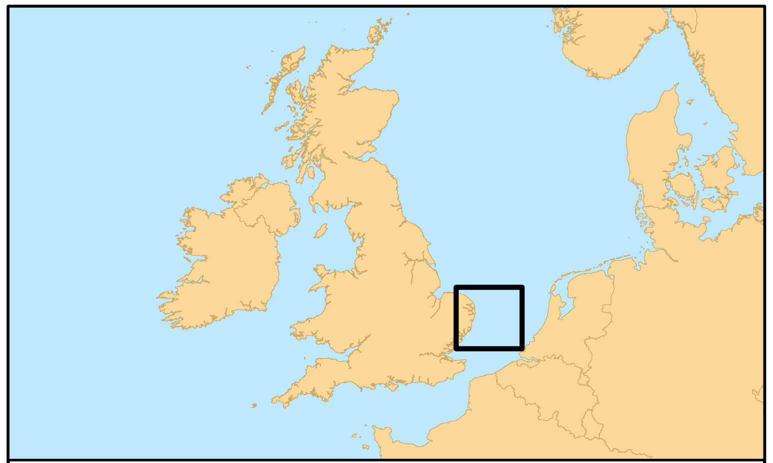

Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Southern North Sea Candidate Special Area of Conservation (cSAC)[1]
- Summer Area[1]
- Winter Area[1]

Maximum Overlap of Single Piling Events of 5 Offshore Wind Farms and the Southern North Sea Winter Area

- East Anglia TWO
- Norfolk Vanguard West

[1] JNCC (2017).

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title:

Estimated maximum overlap with SNS cSAC winter area for 'most likely' scenarios (Sofia, Dogger Bank Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for single piling.

Figure: 8.4 Drawing No: PB4476-006-001-007

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	16/05/2018	GS	JL	A3	1:600,000
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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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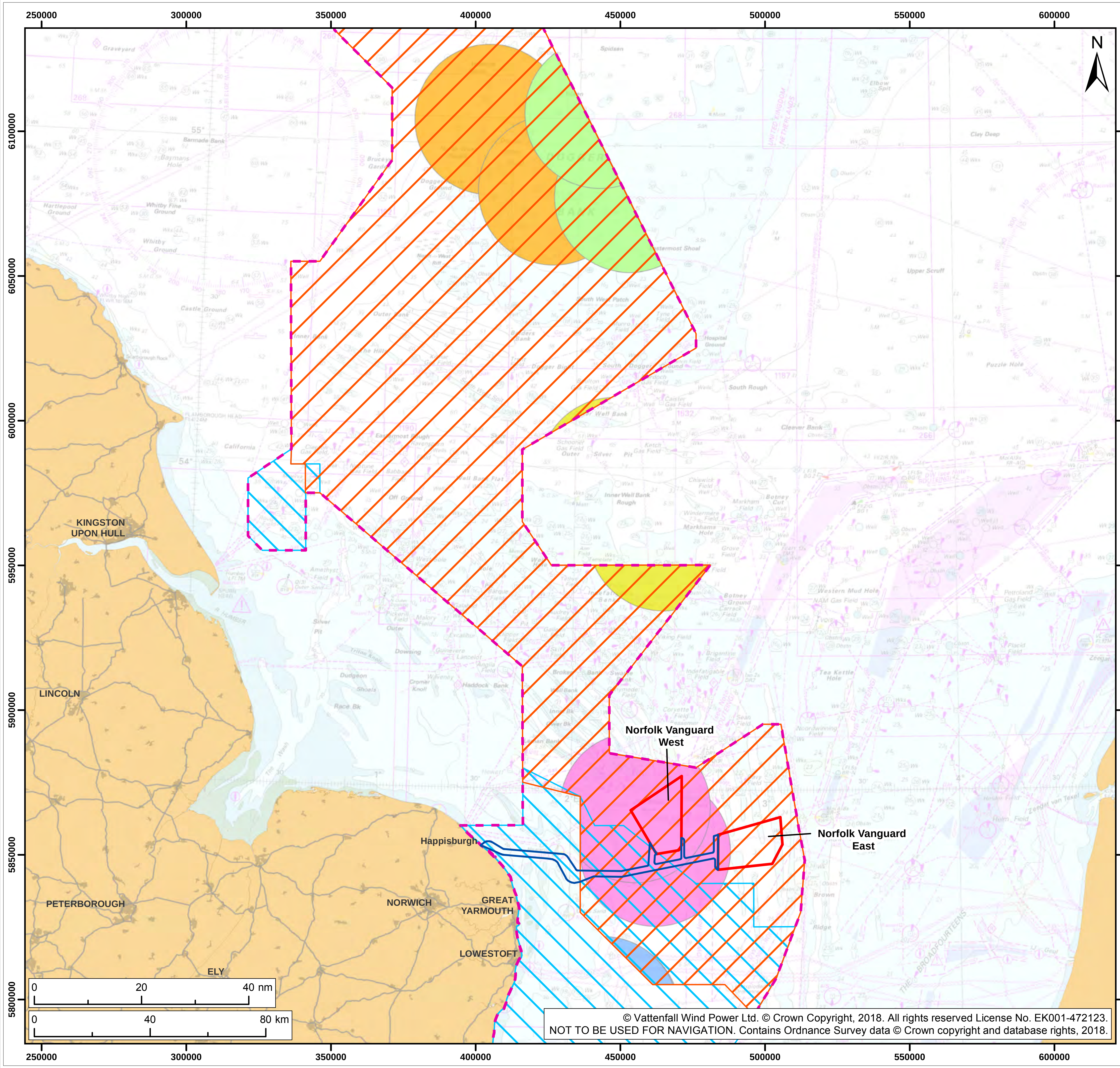

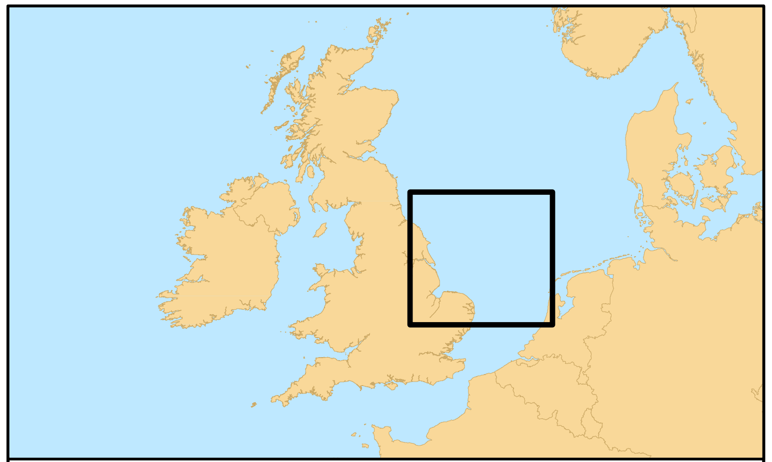

Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Southern North Sea Candidate Special Area of Conservation (cSAC)[1]
- Summer Area[1]
- Winter Area[1]

Maximum Overlap of Two Concurrent Piling Events of 5 Offshore Wind Farms and the Southern North Sea Summer Area

- Dogger Bank Creyke Beck B
- Sofia
- East Anglia TWO
- Hornsea Project 3
- Norfolk Vanguard West

[1] JNCC (2017).

Project:	Report:
Norfolk Vanguard	Habitats Regulation Assessment Report

Title:
Estimated maximum overlap with SNS cSAC summer area for 'most likely' scenarios (Sofia, Dogger Bank Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for two piling events.

Figure: 8.5 Drawing No: PB4476-006-001-008

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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01	14/02/2018	GS	JL	A3	1:1,300,000

Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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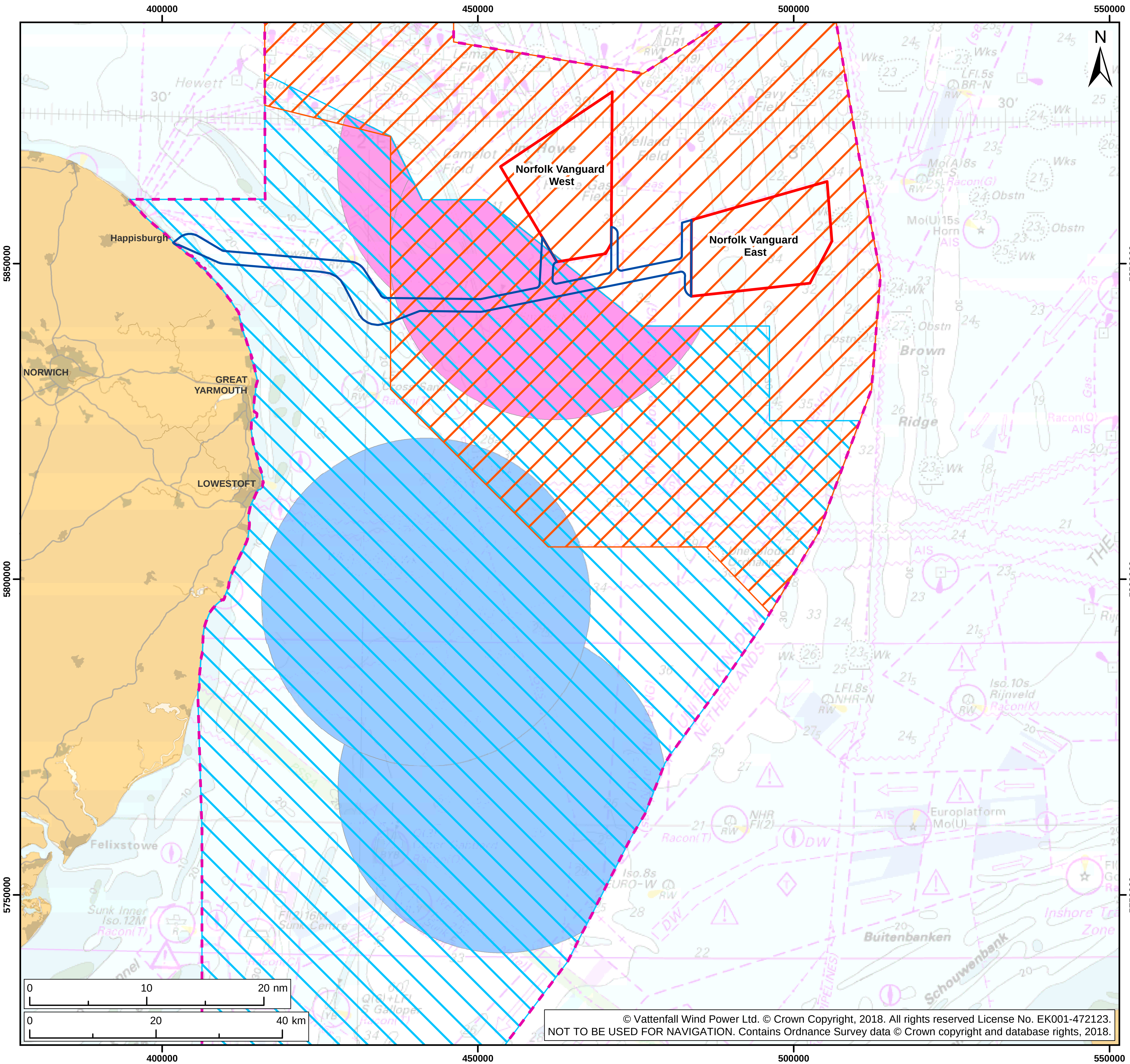

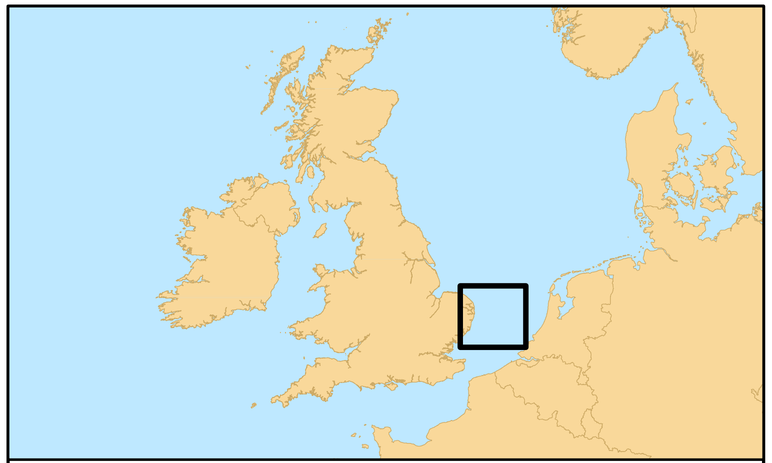

Legend:

- Norfolk Vanguard
- Offshore cable corridor
- Southern North Sea Candidate Special Area of Conservation (cSAC)[1]
- Summer Area[1]
- Winter Area[1]

Maximum Overlap of Two Concurrent Piling Events of 5 Offshore Wind Farms and the Southern North Sea Winter Area

- East Anglia TWO
- Norfolk Vanguard West

[1] JNCC (2017).

Project: Norfolk Vanguard

Report: Habitats Regulation Assessment Report

Title: Estimated maximum overlap with SNS cSAC winter area for 'most likely' scenarios (Sofia, Dogger Bank Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for two piling events.

Figure: 8.6 | Drawing No: PB4476-006-001-009

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	16/05/2018	GS	JL	A3	1:600,000
01	14/02/2018	GS	JL	A3	1:600,000

Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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Seasonal averages

897. The seasonal averages have been calculated by multiplying the average of the minimum and maximum effect on any one day by the proportion of days within the season on which piling could occur (i.e. taking into account the average of effect / area of overlap with cSAC and number of days piling per season).

898. This assessment follows the same approach as the East Anglia THREE HRA (EATL, 2016) and is based on the following assumptions:

- The summer season (1st April – 30th September) is 183 days. It is assumed that at least a minimum of 5% of days would be lost due to poor weather during this season. This gives 173 full days on which pile driving could occur;
- The winter season (1st October – 31st March) is 182 days (leap years have been ignored in the assessment). It is assumed that at least a minimum of 15% of days would be lost due to poor weather during this season. This gives a total of 154 full days on which pile driving could occur; and
- No allowance has been made for downtime as a result of technical issues and no assumptions have been made for reloading of piling vessels with foundations.

899. The assessment indicates on average more than 10% of the seasonal component of the cSAC over the duration of that season could be affected (Table 8.36), based on the average potential overlap of the SNS cSAC summer area and SNS cSAC winter area for piling at the five OWFs occurring at the same time.

900. However the assumptions outlined above are highly conservative and with the use of strategic mitigation and the proposed approach outlined in the Site Integrity Plan, the number of piling days in each season could be managed. Therefore, with the appropriate measures in place, review of the piling schedules and updated assessment pre-construction, **there would be no significant disturbance and no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise as a result of in-combination effects from underwater noise during OWF piling.**

Table 8.36 Estimated seasonal averages based on average overlap with SNS cSAC winter and summer areas taking into account number of potential piling days per season for potential worst-case scenarios for single and concurrent piling

SNS cSAC area	Number of potential piling days per season	Average overlap with SNS cSAC	Estimated seasonal average
Summer area	173 days	• Single piling = 16% • Concurrent piling = 19%	• Single piling = 15% • Concurrent piling = 18%

SNS cSAC area	Number of potential piling days per season	Average overlap with SNS cSAC	Estimated seasonal average
Winter area	154 days	• Single piling = 19% • Concurrent piling = 26%	• Single piling = 16% • Concurrent piling = 22%

8.3.1.5.2. Disturbance from all other noise sources

901. During the construction period at Norfolk Vanguard, there are other potential noise sources in addition to OWF piling that could also disturb harbour porpoise, these sources include:

- UXO clearance;
- Seismic surveys;
- OWF construction activities and vessels (excluding piling); and
- OWF operation and maintenance, including vessels.

902. The HRA screening (Appendix 5.1) determined it was highly unlikely that the following activities could contribute significantly to the in-combination effects of the disturbance of harbour porpoise from underwater noise:

- Tidal and wave marine renewables developments (construction, operation and maintenance);
- Aggregate extraction and dredging;
- Offshore mining;
- Oil and gas projects, other than potential seismic surveys;
- Licenced disposal sites;
- Navigation and shipping operations; and
- Carbon capture projects.

UXO clearance

903. The commitment to the MMMP for UXO clearance for Norfolk Vanguard would result in no potential effects for lethal injury, physical injury and permanent auditory injury (PTS). As such, the proposed Norfolk Vanguard project would not contribute to any in-combination effects for lethal injury, physical injury and permanent auditory injury (PTS), therefore the in-combination assessment for underwater noise only considers behavioural avoidance effects.

904. The approach to the in-combination assessment for disturbance from underwater noise follows the current advice from SNCBs on the assessment of impacts on the SNS harbour porpoise cSAC and has been based on the following parameter:

- A distance of 26km around UXO clearance has been used to assess the area that harbour porpoise could potentially be disturbed.

Assessment in relation to the North Sea MU population

905. It is currently not possible to estimate the number of potential UXO clearance operations that could be undertaken in the harbour porpoise NS MU. It is therefore been assumed as a worst-case scenario that there could potentially be:

- Up to one UXO clearance operation in the UK northern North Sea area;
- Up to one UXO clearance operation in the UK southern North Sea area;
- Up to one UXO clearance operation in the Netherlands / Belgium area of the North Sea; and
- Up to one UXO clearance operation in the German / Denmark area of the North Sea.

906. The potential disturbance area during a single UXO detonation, based on a radius of 26km from each location is 2,124km^2. Therefore for the maximum of up to four UXO clearance events being undertaken at the same time the potential disturbance area would be 8,496km^2.

907. The SCANS-III harbour porpoise density estimate for the North Sea MU is 0.52/km^2 (Hammond *et al.,* 2017). Without knowing the actual location for any UXO clearance this has been used to estimate the number of harbour porpoise that could potentially be disturbed (Table 8.37).

908. The number of harbour porpoise that could potentially be disturbed during one UXO clearance operation would be up to 1,105 harbour porpoise (0.3% of the North Sea MU reference population).

909. The maximum number of harbour porpoise that could potentially be temporarily disturbed during up to four UXO clearance operations would be up to 4,420 harbour porpoise, which represents up to 1.3% of the North Sea MU reference population (Table 8.37).

910. However, it is highly unlikely that up to four UXO clearance operations would be undertaken at the same time, therefore a more likely worst-case scenario would be for two UXO operations, which could potentially disturb up to 2,210 harbour porpoise (approximately 0.6% of the North Sea MU reference population; Table 8.37). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.37 Quantified in-combination assessment for the potential disturbance of harbour porpoise during up to four UXO clearance operations in the North Sea

UXO clearance	SCANS-III density estimate (No/km^2)	Area of potential disturbance	Potential number of harbour porpoise disturbed (% of reference population)
Up to one UXO clearance operation	0.52	2,124km^2	1,105 (0.3%)
Up to two UXO clearance operations	0.52	4,248km^2	2,210 (0.6%)
Up to four UXO clearance operations	0.52	8,496km^2	4,420 (1.3%)

<u>Spatial assessment in relation to the cSAC summer and winter areas</u>

911. It is currently not possible to estimate the number of potential UXO clearance operations that could be undertaken in the SNS cSAC. It is therefore been assumed as a worst-case scenario that there could potentially be up to two UXO detonations at any one time. The possible scenarios are that (i) both are in the summer cSAC area; (ii) both are in the winter cSAC area; or (iii) one is in the summer cSAC area and one is in the winter cSAC area.

912. If two UXO detonations were undertaken at the same time the potential area of disturbance could be 4,248km^2, which is approximately 16% of summer cSAC area (27,088km^2) and 32% of the winter cSAC area (13,366km^2).

913. If one UXO detonation was undertaken, the potential area of disturbance could be (2,124km^2) which would be approximately 8% of summer cSAC area and 16% of the winter cSAC area.

914. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time during single UXO detonations in the summer and winter cSAC areas, or if two detonations were undertaken at the same time in the summer cSAC area. Therefore, under these circumstances, there would be **no significant disturbance and no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

915. However, if two UXO detonations were conducted at the same time in the winter cSAC area, the potential area of disturbance could be up to a maximum of 32% of the winter cSAC area, depending on the locations of the UXO. Therefore, the displacement of harbour porpoise could exceed 20% of the seasonal component of the cSAC winter area and so there is the potential for significant disturbance. However, if required, the use of strategic mitigation could result in no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.

Seasonal averages

916. It is currently not possible to determine the number of days per season that UXO clearance, if undertaken, would be in the SNS cSAC summer and winter areas. Therefore, it has been assumed, as worst-case that each could be approximately 40 days. Although, the programme of works for UXO inspection, removal or detonation at each site could be 2-3 months, it has been assumed that there could be up to 40 potential UXO at each site, with one detonation per day.

917. The seasonal averages have been calculated by multiplying the average of the minimum and maximum effect on any one day by the proportion of days within the season on which piling could occur (i.e. taking into account the average of effect / area of overlap with cSAC and number of days piling per season).

918. The assessment indicates on average less than 10% of the seasonal component of the cSAC over the duration of that season could be affected, if there were one UXO operation in the summer and winter cSAC areas or two UXO operations in the summer cSAC area (Table 8.38). Therefore, under these circumstances, there would be **no significant disturbance and no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.**

919. The assessment indicates that if there were two UXO operations in the winter area of the cSAC, based on the worst-case scenario for the number of days per operation, there is the potential for more than 10% of the seasonal component of the cSAC over the duration of that season could be affected. However, if required, the use of strategic mitigation **would be able to result in no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.**

Table 8.38 Estimated seasonal averages based on one or two UXO clearance operations within the SNS cSAC winter and summer areas

SNS cSAC area	Number of UXO clearance days per season	Area within SNS cSAC	Estimated seasonal average
Summer area	• One UXO operation = 40 days • Two UXO operations = 80 days	• One UXO operation = 8% • Two UXO operations = 16%	• One UXO operation = 1.8% • Two UXO operations = 6.9%
Winter area	• One UXO operation = 40 days • Two UXO operations = 80 days	• One UXO operation = 16% • Two UXO operations = 32%	• One UXO operation = 3.5% • Two UXO operations = 14%

Seismic surveys

920. The approach to the in-combination assessment for disturbance from underwater noise follows the current advice from the SNCBs on the assessment of impacts on the SNS harbour porpoise cSAC and has been based on the following parameter:

- A distance of 10km around seismic operations has been used to assess the area that harbour porpoise could potentially be disturbed.

921. It should be noted that this assessment is based on the potential impacts for seismic surveys required by the oil and gas industry. Geophysical surveys conducted for offshore wind farms generally use multi-beam surveys in shallow waters. Therefore, the higher frequencies typically used fall outside the hearing frequencies of cetaceans and the sounds produced are likely to attenuate more quickly than the lower frequencies used in deeper waters (JNCC, 2017e). JNCC (2071e) do not, therefore, advise mitigation is required for multi-beam surveys in shallow waters as there is no risk to EPS in relation to deliberate injury or disturbance offences.

Assessment in relation to the North Sea MU population

922. It is currently not possible to estimate the number of potential seismic surveys that could be undertaken in the harbour porpoise NS MU during the construction and potential piling activity at Norfolk Vanguard.

923. It is therefore been assumed as a worst-case scenario that there could potentially be:

- Up to one seismic survey in the UK northern North Sea area;
- Up to one seismic survey in the UK southern North Sea area;
- Up to one seismic survey in the Netherlands / Belgium area of the North Sea; and
- Up to one seismic survey in the German / Denmark area of the North Sea.

924. The potential disturbance area during a single seismic survey, based on a radius of 10km from each location is 314km^2. Therefore for the maximum of up to four seismic surveys being undertaken at the same time the potential disturbance area would be 1,256km^2.

925. The SCANS-III harbour porpoise density estimate for the North Sea MU is 0.52/km^2 (Hammond *et al.,* 2017). Without knowing the actual location for any seismic surveys this has been used to estimate the potential number of harbour porpoise that could potentially be disturbed (Table 8.39).

926. The number of harbour porpoise that could potentially be disturbed during one seismic survey would be up to 163 harbour porpoise (0.05% of the North Sea MU reference population).

927. The maximum number of harbour porpoise that could potentially be disturbed during up to four seismic surveys would be up to 652 harbour porpoise, which represents up to 0.2% of the North Sea MU reference population (Table 8.39). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

928. However, it is highly unlikely that up to four seismic surveys would be undertaken at the same time, therefore a more likely worst-case scenario would be for two seismic surveys, which could potentially disturb up to 326 harbour porpoise (approximately 0.09% of the North Sea MU reference population; Table 8.39). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.39 Quantified in-combination assessment for the potential disturbance of harbour porpoise during up to four seismic surveys in the North Sea

Seismic surveys	SCANS-III density estimate (No/km^2)	Area of potential disturbance	Potential number of harbour porpoise disturbed (% of reference population)
Up to one seismic survey	0.52	314	163 (0.05%)
Up to two seismic surveys	0.52	628	326 (0.09%)
Up to four seismic surveys	0.52	1,256	652 (0.19%)

Spatial assessment in relation to the cSAC summer and winter areas

929. It is currently not possible to estimate the number of potential seismic surveys that could be undertaken in the SNS cSAC. It is therefore been assumed as a very worst-case scenario that there could potentially be up to two seismic surveys in the summer cSAC area and / or winter cSAC area at any one time.

930. If two seismic surveys were undertaken at the same time the potential area of disturbance could be 628km^2, which is less than 2.5% of summer cSAC area (27,088km^2) and less than 5% of winter cSAC area (13,366km^2).

931. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time. Therefore, under these circumstances, there would be no significant disturbance and **no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

932. However, it is more likely that only one seismic survey would be conducted in each seasonal area during one season. Therefore, the potential area of disturbance would be 314km^2, which is less than 1.2% of summer cSAC area (27,088km^2) and less than 2.4% of winter cSAC area (13,366km^2). Therefore, under these circumstances, there would be no significant disturbance and **no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

933. It is currently not possible to determine the number of days per season that seismic surveys, if undertaken, would be in the SNS cSAC summer and winter areas. Therefore, it has been assumed, as worst-case that each seismic survey could be up to 10 days. For example, seismic surveys were conducted over 10 days in two areas within the central Moray Firth, northeast Scotland in 2011 (Thompson *et al.,* 2013). It should be noted that, the short-term disturbance by the seismic surveys did not lead to long-term displacement of harbour porpoise, with animals typically detected at surveyed sites within a few hours, and the level of response declined through the 10 day survey (Thompson *et al.,* 2013).

934. The seasonal averages have been calculated by multiplying the average of the minimum and maximum effect on any one day by the proportion of days within the season on which piling could occur (i.e. taking into account the average of effect / area of overlap with cSAC and number of days piling per season).

935. The assessment indicates on average less than 10% of the seasonal component of the cSAC over the duration of that season could be affected (Table 8.40). Therefore, under these circumstances, there is no significant disturbance and **no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.40 Estimated seasonal averages based on one or two seismic surveys within the SNS cSAC winter and summer areas

SNS cSAC area	Number of potential seismic survey days per season	Average overlap with SNS cSAC area	Estimated seasonal average overlap with SNS cSAC area
Summer area	• One survey = 10 days • Two surveys = 20 days	• One survey = 1.2% • Two surveys = 2.5%	• One survey = 0.07% • Two surveys = 0.3%
Winter area	• One survey = 10 days • Two surveys = 20 days	• One survey = 2.4% • Two surveys = 5%	• One survey = 0.1% • Two surveys = 0.6%

OWF construction, other than piling

936. During the construction of Norfolk Vanguard there is the potential overlap with effects from the construction activities, other than piling, with other offshore wind farms. Noise sources which could cause potential disturbance during OWF

construction activities, other than pile driving, can include vessels, seabed preparation, ploughing / jetting / pre-trenching or cutting for installation of cables and rock dumping for protection of the cable.

937. The potential ranges of these noise sources during OWF construction will be localised and significantly less than the ranges predicted for piling. There could be potential in-combination effects from construction of OWFs in and around the area of Norfolk Vanguard.

938. As a precautionary approach the in-combination assessment considered all UK and European OWFs in the southern North Sea which could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period. This is based on the 'theoretical worst-case' scenario, which includes all Tier 3 UK and European OWF projects, taking into account a potential seven year construction window and the Tier 5 UK OWF projects (see Appendix 5.1).

939. This highly conservative approach for OWFs that could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period includes six UK OWFs (Table 8.33):

- Creyke Beck A
- Teesside A
- East Anglia THREE
- East Anglia ONE North
- Thanet Extension
- Norfolk Boreas

940. The potential temporary disturbance during OWF construction activities, other than pile driving noise sources, has been based on the area of the OWF sites. This is a very precautionary approach, as it is highly unlikely that construction activities, other than piling activity would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the activity is actually taking place. In addition, it is likely, as outlined for the in-combination assessment for piling, that developers of more than one site will develop one site at a time, as it is more efficient and cost effective to develop one site and have it operational prior to constructing the next site.

<u>Assessment in relation to the North Sea MU population</u>

941. For each project, the number of harbour porpoise in the area of each OWF site has been estimated using the latest SCANS-III density estimates (Hammond *et al.,* 2017) for the relevant survey block that the project is located within. The number of

harbour porpoise that could potentially be disturbed has been put into the context of the reference population for the North Sea MU.

942. The in-combination assessment indicates that if all six of these OWFs in the southern North Sea were conducting construction activities, other than piling, at the same time, the estimated maximum in-combination area of disturbance is 2,384km^2 and the maximum number of harbour porpoise that could potentially be disturbed is 1,925 individuals, which represents approximately 0.6% of the North Sea MU reference population (Table 8.41). Therefore there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.41 Quantified in-combination assessment for the potential disturbance of harbour porpoise during construction activities (other than piling) at UK and European OWFs in the southern North Sea during construction at Norfolk Vanguard

Name of Project	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of harbour porpoise disturbed
Dogger Bank Zone Creyke Beck A	163	O	0.888	515	457
Dogger Bank Zone Teesside A	180	N	0.837	562	470
East Anglia THREE	0	L	0.607	301	183
Norfolk Boreas	30	O[3]	0.888	727	646
Thanet Extension	165	L	0.607	73	44
East Anglia ONE North	30	L	0.607	206	125
Total				**2,384**	**1,925**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.6%**

*Source: http://www.4coffshore.com/

[3]Norfolk Boreas overlaps SCANS-III survey block O & L; therefore higher density estimate from survey block O is used.

Spatial assessment in relation to the cSAC summer and winter areas

943. For each project within (wholly or partly) the SNS cSAC, the area of the OWF that overlaps the cSAC winter and summer areas has been estimated (Table 8.33). Based on this potential worst-case scenario, five UK OWFs located in the SNS cSAC potentially have construction activities, other than piling, during the Norfolk Vanguard construction (Table 8.42).

944. The in-combination assessment indicates that if all five of these OWFs, within (wholly or partly) the SNS cSAC, were conducting construction activities, other than piling, the estimated maximum in-combination area of disturbance, based on the worst-case scenario of the entire OWF area, is 1,822km^2 (Table 8.42).

945. Four of these OWFs are located in or overlap with the summer cSAC area and the estimated maximum in-combination area of disturbance for the summer cSAC area is 1,567km^2, which represents approximately 5.8% of the summer cSAC area (Table 8.42).

946. Three of these OWFs are located in or overlap with the winter cSAC area and the estimated maximum in-combination area of disturbance for the winter cSAC area is 482km^2, which represents approximately 3.6% of the winter cSAC area (Table 8.42).

947. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time. Therefore, under these circumstances, there is no significant disturbance and **no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.42 Quantified in-combination assessment for the potential disturbance of harbour porpoise during construction activities (other than piling) at OWFs in the SNS cSAC during construction at Norfolk Vanguard

Name of Project	Area of OWF site (km^2)*	Area in summer cSAC area (km^2)	Area in winter cSAC area (km^2)
Dogger Bank Zone Creyke Beck A	515	515	0
Dogger Bank Zone Teesside A		0	0
East Anglia THREE	301	301	203
Norfolk Boreas	727	704	0
Thanet Extension	73	0	73
East Anglia ONE North	206	47	206
Total area	**1,822km^2**	**1,567km^2**	**482km^2**
% of cSAC area		**5.8%**	**3.6%**

<u>Seasonal averages</u>

948. It is currently not possible to determine the number of days per season that construction activities, other than piling, could be conducted, therefore it has been assumed that they could be undertaken throughout both seasonal periods (e.g. 183 days in summer and 182 days in winter).

949. The seasonal averages have been calculated by multiplying the average of the minimum and maximum effect on any one day by the proportion of days within the season on which piling could occur (i.e. taking into account the average of effect / area of overlap with cSAC and number of days piling per season).

950. The assessment indicates on average less than 10% of the seasonal component of the cSAC over the duration of that season could be affected, based on 100% disturbance from the offshore wind farm areas (Table 8.44). Therefore, under these circumstances, there is no significant disturbance and **no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.43 Estimated seasonal averages based on construction activities, other than piling, at other OWFs in the SNS cSAC summer and winter areas during construction at Norfolk Vanguard

SNS cSAC area	Number of days per season	Average overlap with SNS cSAC	Estimated seasonal average
Summer area	183 days	5.8%	5.8%
Winter area	182 days	3.6%	3.6%

OWF operation and maintenance

951. There is the potential for disturbance from other OWFs that have already been constructed as a result of any operational and maintenance activities, including vessels, during the Norfolk Vanguard construction period. The potential disturbance from operational OWFs and maintenance activities could include the operational turbines, vessels, any rock dumping or cable re-burial.

952. The potential disturbance from operational OWFs and maintenance activities has also been based on the worst-case scenario of the entire area of the OWF sites. This is again a very precautionary approach, as it is highly unlikely that operational OWFs and maintenance activities, including vessels, would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

Assessment in relation to the North Sea MU population

953. Operational UK and European OWFs in the southern North Sea that could have potential in-combination effects during the Norfolk Vanguard construction period have an estimated maximum potential in-combination area up to 2,2761km^2 and the maximum number of harbour porpoise that could be temporarily disturbed would be up to 1,495 individuals which represents approximately 0.4% of the North Sea MU reference population (Table 8.44). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.44 Quantified in-combination assessment for the potential disturbance of harbour porpoise during operation and maintenance activities at OWFs in the southern North Sea during construction at Norfolk Vanguard

Name of Project	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of harbour porpoise disturbed
Greater Gabbard	96	L	0.607	146	89
Gunfleet Sands 3 (Demo Zone)	148	L	0.607	3	2
Gunfleet Sands I	143	L	0.607	16	10
Humber Gateway	156	O	0.888	27	24
Inner Dowsing	127	O	0.888	10	9
Kentish Flats	174	L	0.607	10	6
Kentish Flats Extension	175	L	0.607	8	5
Lincs	122	O	0.888	41	36
London Array	138	L	0.607	122	74
Lynn	127	O	0.888	10	9
Scroby Sands	45	L	0.607	4	2
Sheringham Shoal	75	O	0.888	35	31
Teesside	292	O	0.888	4	4
Thanet	159	L	0.607	35	21
Westermost Rough	169	O	0.888	35	31
Dudgeon	66	O	0.888	55	49
Galloper	93	L	0.607	113	69
Hornsea Project One	95	O	0.888	407	361
Race Bank	94	O	0.888	62	55
East Anglia ONE	40	L	0.607	205	124
Belwind	116	N	0.837	13	11
Belwind Alstom Haliade Demonstration	118	N	0.837	N/A	N/A
Nobelwind	1168	N	0.837	22	18
Northwind	124	L	0.607	14	12
Thornton Bank phase I	134	N	0.837	N/A	N/A
Thornton Bank phase II	131	N	0.837	12	10
Thornton Bank phase III	133	N	0.837	7	6
Haliade	633	P	0.823	N/A	N/A
Horns Rev 1	419	M	0.277	21	6
Horns Rev 2	414	M	0.277	33	9
Rønland	531	P	0.823	<10	8
Nissum Bredning Vind	555	P	0.823	5	4
Vesterhav Nord/Syd	560	P	0.823	105	29
Alpha Ventus	263	N	0.837	4	3

Name of Project	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of harbour porpoise disturbed
Amrumbank West	349	M	0.277	33	28
BARD Offshore 1	244	N	0.837	59	49
Borkum Riffgrund I	255	N	0.837	36	30
Butendiek (Offshore-Bürger- windpark)	384	M	0.277	33	9
Dan Tysk	360	M	0.277	66	18
ENVA Ems Emden	270	M[1]	0.277	<1	0
Global Tech I	277	M	0.277	42	12
Gode Wind 1 and 2	283	M	0.277	70	19
Meerwind Ost Sud	341	M	0.277	40	11
Nordsee Ost	344	M	0.277	36	10
Riffgat	240	N	0.837	6	5
Sandbank	347	M	0.277	47	13
Trianel Windpark Borkum Phase 1 (Borkum West II phase 1)	254	M	0.277	23	6
Veja Mate	236	N	0.837	51	43
Egmond aan Zee (aka OWEZ)	88	N	0.837	24	20
Eneco Luchterduinen	84	N	0.837	16	13
Gemini	221	N	0.837	70	59
Irene Vorrink	168	N[1]	0.837	2	2
Prinses Amalia Windpark (formerly Q7)	79	N	0.837	17	14
Westermeerwind	168	N[1]	0.837	8	7
Hywind - Metcentre	696	V	0.137	2	0
Total (100%)				**2,276km^2**	**1,495**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.4%**

*Source: http://www.4coffshore.com/
[1]closest block, but is not actually within the SCANS-III area.

Spatial assessment in relation to the cSAC summer and winter areas

954. For operational UK and European OWFs within (wholly or partly) the SNS cSAC that could have potential in-combination effects during the Norfolk Vanguard construction period, the area of the OWF that overlaps the cSAC winter and summer areas has been estimated.

955. The in-combination assessment indicates that, based on the potential worst-case scenario, six UK OWFs located in the SNS cSAC could potentially have disturbance from operational OWFs and maintenance activities that overlap with construction of

Norfolk Vanguard, the estimated maximum in-combination area of disturbance is 915km^2 (Table 8.45).

956. One of these OWFs is located in the summer cSAC area and the estimated maximum area of disturbance for the summer cSAC area is 52km^2, which represents approximately 0.2% of the summer cSAC area (Table 8.45).

957. Five of these OWFs are located in the winter cSAC area and the estimated maximum in-combination area of disturbance for the winter cSAC area is 482km^2, which represents approximately 4% of the winter cSAC area (Table 8.45).

958. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the cSAC area at any one time, based on 100% disturbance for the entire offshore wind farm area of operational OWFs. Therefore, under these circumstances, there is no significant disturbance and **no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.45 Quantified in-combination assessment for the potential disturbance of harbour porpoise during operation and maintenance activities at UK OWFs in the southern North Sea during construction at Norfolk Vanguard

Name of Project	Area of OWF site (km^2)*	Area in summer cSAC area (km^2)	Area in winter cSAC area (km^2)
Greater Gabbard	146	0	146
Scroby Sands	9	0	9
Thanet	35	0	9
Galloper	113	0	113
Hornsea Project One	407	52	0
East Anglia ONE	205	0	205
Total	**915**	**52**	**482**
% of cSAC area		**0.2%**	**3.6%**

*Source: http://www.4coffshore.com/

Seasonal averages

959. It has been assumed that underwater noise from operational and maintenance activities could be throughout both seasonal periods (e.g. 183 days in summer and 182 days in winter).

960. The seasonal averages have been calculated by multiplying the average of the minimum and maximum effect on any one day by the proportion of days within the season on which piling could occur (i.e. taking into account the average of effect / area of overlap with cSAC and number of days piling per season).

961. The assessment indicates on average less than 10% of the seasonal component of the cSAC over the duration of that season could be affected, based on 100% disturbance from the offshore wind farm areas (Table 8.46). Therefore, under these circumstances, there is **no significant disturbance and no potential adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.46 Estimated seasonal averages for operational and maintenance activities at other OWFs in the SNS cSAC summer and winter areas during construction at Norfolk Vanguard

SNS cSAC area	Number of days per season	Average overlap with SNS cSAC	Estimated seasonal average
Summer area	183 days	0.2%	0.2%
Winter area	182 days	4%	4%

8.3.1.5.3. In-combination effects from underwater noise for OWF piling and all other noise sources

962. The potential in-combination effects from all noise sources including OWF piling during construction at Norfolk Vanguard is summarised in Table 8.47. This assessment is based on highly conservative assumptions, including:

- Five OWFs piling at exactly the same time;
- Displacement of all harbour porpoise from the boundary of each of the remaining offshore wind farm that could have overlapping construction windows;
- The worst-case scenario that there is no overlap from the disturbance areas for the different activities, e.g. between disturbance areas for piling and disturbance areas from UXO clearance, and / or seismic surveys.

963. There would be no additional in-combination effects of underwater noise from other construction activities for those projects which also have overlapping piling with Norfolk Vanguard as the ranges for piling would be significantly greater than those from other construction noise sources.

964. The maximum number of harbour porpoise that could potentially be temporarily disturbed as a result of underwater noise from OWF piling and all other potential noise sources during piling at Norfolk Vanguard is 14,789 individuals, which represents approximately 4% of the North Sea MU reference population (Table 8.47).

965. The estimated maximum potential in-combination area of disturbance for the summer cSAC area is 8,335km^2, which represents approximately 31% of the summer cSAC area (Table 8.47). The estimated maximum in-combination area of disturbance for the winter cSAC area is 6,005km^2, which represents approximately 45% of the

winter cSAC area (Table 8.47). It is highly likely that with the refinement of build scenarios and the final design for each project, these areas would be significantly less.

966. Norfolk Vanguard Limited is committed to working with the MMO and relevant SNCBs in the development of a possible strategic approach to mitigation in order to ensure there is no potential adverse effect on the integrity of the site. This would be addressed through the development and agreement of a MMMP and SIP (based on the draft MMMP (document 8.13) and In Principle SIP (document 8.17) submitted with the DCO application).

967. With the use of strategic mitigation and the proposed approach that will be outlined in the Site Integrity Plan, including review of the piling schedules and updated assessment pre-construction, **there would be no significant disturbance and no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.**

968. Section 8.4 outlines the proposed management and mitigation of the potential effects on harbour porpoise.

Table 8.47 Quantified in-combination assessment for the potential disturbance of harbour porpoise in the North Sea MU and SNS cSAC summer and winter areas from all possible noise sources during piling at Norfolk Vanguard based on worst-case scenario

Potential noise sources during piling at Norfolk Vanguard	Potential number of harbour porpoise disturbed (% of reference population)	Area in summer cSAC area (km^2) (percentage of seasonal area)	Area in winter cSAC area (km^2) (percentage of seasonal area)	Seasonal average for summer cSAC area	Seasonal average for winter cSAC area
Piling at OWF projects, based on potential worst-case scenario of OWF projects that could be piling at the same time (Dogger Bank Teesside B (now Sofia), Dogger Bank Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for single pile installation at each site and average overlap with cSAC seasonal area (Table 8.34; Table 8.35 and Table 8.36)	8,833 (3%)	4,268km^2 (16%)	2,593km^2 (19%)	15%	16%
OWF construction activities, based on OWFs that are not piling but potential for other construction activities during piling at Norfolk Vanguard (Table 8.41; Table 8.42and Table 8.43) and 100% disturbance	1,925 (0.6%)	1,567km^2 (6%)	482km^2 (4%)	6%	4%
OWF operation and maintenance, based on constructed OWFs that could have O&M activities during piling at Norfolk Vanguard (**Table 8.44**; **Table 8.45** and **Table 8.46**) and 100% disturbance	1,495 (0.4%)	52km^2 (0.2%)	482km^2 (4%)	0.2%	4%
Sub-total (without UXO clearance and seismic surveys)	***12,253 (4%)***	***5,887km^2 (22%)***	***3,557km^2 (27%)***	***21%***	***24%***
UXO clearance, based on up two locations, one in each cSAC seasonal area (**Table 8.37** and **Table 8.38**)	2,210 (0.6%)	2,124km^2 (8%)	2,124km^2 (16%)	0.9%	2%
Seismic surveys, based on up two locations, one in each cSAC seasonal area (**Table 8.39** and **Table 8.40**)	326 (0.09%)	324km^2 (1%)	324km^2 (2%)	0.07%	0.1%
Total	**14,789 (4%)**	**8,335km^2 (31%)**	**6,005km2 (45%)**	**22%**	**26%**

8.3.1.5.4. Indirect effects – changes in prey resources

969. Potential effects on prey species during construction can result from increased suspended sediment concentrations and sediment re-deposition and underwater noise (leading to mortality, physical injury, auditory injury or behavioural responses); the potential effects on fish species during operation and maintenance can include physical disturbance and loss or changes of seabed habitat, introduction of hard substrate, operational noise, and EMF; and during decommissioning potential effects on fish species can include physical disturbance, loss or changes of habitat, increased suspended sediment concentrations, re-mobilisation of contaminated sediments and underwater noise. Some of the effects could be negative with fish species moving away or being lost from an area, while some effects could have a negative or positive effect, such as possible changes in species composition, and other effects could result in a positive effect, such as the aggregation of prey around seabed structures.

970. The potential effects on harbour porpoise as a result of any changes to prey availability can include changes in distribution, abundance and community structure, increased competition with other marine mammal species, increased susceptibility to disease and contaminants, and implications for reproductive success, which could potentially affect individuals throughout their range or at different times of the year. However, any changes to prey tend to be localised and temporary in nature. In addition, if prey species are disturbed from an area, it is highly likely that harbour porpoise will also be disturbed from the area over a potentially wider range than prey species.

971. The in-combination assessment on potential changes to prey availability has assumed that any potential effects on harbour porpoise prey species from underwater noise, including piling, would be the same or less than those for harbour porpoise as assessed in Sections 8.3.1.5.1, 8.3.1.5.2 and 8.3.1.5.3. Therefore there would be no additional effects other than those assessed harbour porpoise, i.e. if prey are disturbed from an area as a result of underwater noise, harbour porpoise will be disturbed from the same or greater area, therefore any changes to prey availability would not affect harbour porpoise as they would already be disturbed from the same area.

972. Any effects on prey species are likely to be intermittent, temporary and highly localised, with potential for recovery following cessation of the disturbance activity. Any permanent loss or changes of prey habitat will typically represent a small percentage of the potential habitat in the surrounding area. Consequently there would be **no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise arising from changes in prey resources**.

8.3.1.5.5. Direct interaction - collision risk

973. An increase in vessel movements and wave / tidal arrays can pose a potential collision risk for harbour porpoise.

974. During the construction of OWFs, vessel movements to and from any port will be incorporated within existing vessel routes and therefore the increased risk for any vessel interaction is within the wind farm site. Harbour porpoise in the area would be accustomed to the presence of vessels and therefore be expected to be able to detect and avoid construction vessels (see vessel interaction assessment in Section 8.3.1.1).

975. Any increase in vessel movements during the operation and maintenance of OWFs would be relatively small in relation to current ship movements in the area. Therefore there is unlikely to be a significant increase in collision risk during the operation and maintenance of OWFs and as a result this has not been included in the in-combination assessment.

976. Wave and tidal arrays can pose a potential collision risk for harbour porpoise. The likelihood for collision may depend on many variables such as underwater visibility, detectability of the devices, the size and type of devices, the location, water depth and the rotation speed of the rotor blades. However, if there is the potential for significant collision risk for harbour porpoise then the wave or tidal development would be required to implement suitable mitigation to reduce the risk and any potential significant effects at the population level. Therefore there should be no potential for any significant in-combination effects and as a result this has not been included in the in-combination assessment.

977. All projects screened into the in-combination assessment (Appendix 5.1) have the potential to increase the amount of vessel activity in the harbour porpoise North Sea MU and SNS cSAC. However, there are already large numbers of vessel movements across the area, therefore, for most of these projects any increase in vessel movements is likely to be relatively small in relation to current ship movements in the area. Therefore there is unlikely to be a significant increase in collision risk and as a result they have not been included in the in-combination assessment.

978. As a precautionary approach, the number of harbour porpoise that could be at increased collision risk with vessels has been assessed based on the number of animals that could be present in the wind farm areas taking into account 95% avoidance rates. This is very precautionary, as it is highly unlikely that all marine mammals present in the wind farm areas would be at increased collision risk with vessels.

979. In addition, based on the assumption that harbour porpoise would be disturbed as a result of underwater noise from piling, other construction activities, operational and maintenance activities and vessels, there should be no potential for increased collision risk with vessels.

980. The precautionary in-combination assessment has determined that the number of harbour porpoise that could have a potential increased collision risk with vessels in OWF sites in the North Sea MU during construction would be 214 individuals, which represents 0.06% of the North Sea MU reference population (Table 8.48). Therefore, under these circumstances, there is **no anticipated adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise**.

Table 8.48 Quantified in-combination assessment for the potential increased collision risk with vessels for harbour porpoise in the North Sea MU during the Norfolk Vanguard construction period

Name of Project	Tier	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site*	Potential number of harbour porpoise based on 95% avoidance
Norfolk Vanguard	5	0	O[1]	0.888	592	26
Dogger Bank Zone Creyke Beck A	3	163	O	0.888	515	23
Dogger Bank Zone Creyke Beck B	3	193	O	0.888	599	27
Dogger Bank Zone Teesside A	3	180	N	0.837	562	24
Dogger Bank Zone Teesside B (Sofia)	3	175	O[2]	0.888	593	26
East Anglia THREE	3	0	L	0.607	301	9
Norfolk Boreas	5	30	O[3]	0.888	727	32
Hornsea Project 3	5	80	O	0.888	695	31
Thanet Extension	5	165	L	0.607	73	2
East Anglia ONE North	5	30	L	0.607	206	6
East Anglia TWO	5	45	L	0.607	255	8
Total						**214**
% of North Sea MU reference population (345,373 harbour porpoise)						**0.06%**

[1]NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O; therefore higher density estimate from survey block O is used.
[2]Dogger Bank Zone Teesside B overlaps SCANS-III survey block O & N, but majority of site is in block O.
[3]Norfolk Boreas overlaps SCANS-III survey block O & L; therefore higher density estimate from survey block O is used.
*Source: http://www.4coffshore.com/

8.3.1.5.6. *Summary of potential in-combination effects for Norfolk Vanguard and all other projects and plans*

981. Table 8.49 summarises the potential in-combination effects for harbour porpoise during the construction period at Norfolk Vanguard. The in-combination effects during operation and maintenance or decommissioning would be less than those assessed for construction.

Table 8.49 Summary of the potential in-combination effects for Norfolk Vanguard

Potential Effect	Assessment in relation to the North Sea MU population	Spatial assessment in relation to the cSAC summer and winter areas	Potential adverse effect on site integrity
Disturbance from underwater noise	12,253 - 15,091 harbour porpoise (4-4.4% of NS MU)	Average overlap with summer SNS cSAC area = 5,887-8,335km^2 (22-31%) Average overlap with winter SNS cSAC area = 3,557-6,005km^2 (27-45%)	**Norfolk Vanguard Limited intends to work with the MMO and relevant SNCBs in the development of a strategic approach to mitigation, as required subject to the final design and programme of Norfolk Vanguard and other offshore wind farm projects. This would be addressed through the MMMP or a Site Integrity Plan.** **With the use of strategic mitigation and the proposed approach outlined in the Site Integrity Plan, there would be no significant disturbance and no adverse effect on the integrity of the Southern North Sea cSAC in relation to the conservation objectives for harbour porpoise.**
Indirect effects – changes in prey resources	No additional effects to those assessed for underwater noise		
Direct interaction - collision risk	Less than 0.1% of the NS MU reference population	N/A	**No** **Less than 0.1% of the NS MU reference population could be at increased collision risk, without taking into account the potential disturbance of harbour porpoise as a result of**

Potential Effect	Assessment in relation to the North Sea MU population	Spatial assessment in relation to the cSAC summer and winter areas	Potential adverse effect on site integrity
			underwater noise.

8.3.2. Humber Estuary SAC

982. The HRA screening identified the potential for vessels associated with Norfolk Vanguard to increase disturbance and / or interact with grey seals from the Humber Estuary SAC. Whilst no decision regarding the construction or operation and maintenance port for the project has been taken, it is possible that vessels travelling between the offshore project area and the port may transit past the Humber Estuary SAC.

983. Taking into account the proximity of shipping channels to and from existing ports, it is likely that grey seals hauled-out along these routes and in the area of the ports would be habituated to the noise, movements and presence of vessels.

8.3.2.1. Disturbance at seal haul-out sites

984. The response of seals to disturbance whilst utilising haul-out sites can range from increased alertness to moving into the water (Wilson, 2014). The potential effect on pupping groups can include temporary or permanent pup separation, disruption of suckling, energetic costs and energetic deficit to pups, physiological stress and sometimes enforced move to distant or suboptimal habitat. Potential effects on moulting groups can include energy loss and stress, while effects on other haul-out groups can cause loss of resting and digestion time and stress (Wilson, 2014). The potential effects will be determined by the response of the seals, the duration and proximity of the disturbance to the seals.

985. Studies on the distance of disturbance, on land or in the water, from hauled-out seals have found that the closer the disturbance, the more likely seals are to move into the water. The estimated distance between a disturbance and haul out site, at which most seal movements into the water occur, varies for different locations and type of disturbance, but has been estimated at typically less than 100m (Wilson, 2014). For the grey seal, mothers responded by moving into the water more due to boat speed than as a result of the distance, although movement into the water was generally observed to occur at distances of between 20 and 70m, with no detectable disturbance at 150m (Wilson, 2014; Strong and Morris, 2010). However, seals have also been reported to move into the water when vessels are at a distance of approximately 200m to 300m (Wilson, 2014).

986. Whether during construction, operation or decommissioning phases of the project vessels, when approaching the port, vessels would likely be within existing shipping

routes and would be highly unlikely to be within 300m of the coast where seals are hauled out, therefore there would be no potential to directly disturb seals hauled out at sites such as Donna Nook in the Humber Estuary SAC.

987. Therefore it is concluded that there would be no potential adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

8.3.2.2. Vessel interaction (collision risk)

988. The construction port to be used for Norfolk Vanguard is not yet known and could be located on the east coast of England. The operational phase base post for the project is likely to either Great Yarmouth or Lowestoft. Therefore it is unlikely that operational and maintenance vessels would be in the vicinity of the Humber Estuary SAC for normal operational duties.

989. Approximately 1,180 vessel movements are estimated over the two to four year indicative offshore construction window, an average of approximately two movements per day. Therefore, the increase in vessel movements during construction would be relatively small compared to existing vessel traffic. It is expected that seals would be able to detect the presence of vessels and, given that they are highly mobile, would be able to largely avoid vessel collision. Taking into account good practice, any increased collision risk is highly unlikely.

990. Therefore it is concluded that there would be no potential adverse effect on the integrity of the SAC in relation to the conservation objectives for grey seal.

8.3.2.3. Potential in-combination effects for disturbance at seal haul-out sites and vessel interaction

991. Vessels would be highly unlikely to be within 300m of the coast, in areas of close proximity to the seal haul-out sites within the Humber Estuary SAC, therefore there would be no potential for any in-combination effects on seals hauled out at sites in the Humber Estuary SAC.

992. During the construction of OWFs, vessel movements to and from any port will be incorporated within existing vessel routes. Seals in the area would be accustomed to the presence of vessels and any additional vessel movements associated with OWF construction would be part of the current baseline for vessels.

993. Any increase in vessel movements during the operation and maintenance of OWFs would be relatively small in relation to current ship movements in the area. Therefore there is unlikely to be any significant effect.

994. There are already large numbers of vessel movements in the area of the Humber Estuary SAC, therefore, for most of these projects any increase in vessel movements is likely to be relatively small in relation to current ship movements in the area.

995. The potential for any in-combination effects for vessels to increase disturbance and / or interact with grey seals from the Humber Estuary SAC is highly unlikely. Therefore, it is concluded that there would be **no potential adverse effect on the integrity of the SAC in relation to the conservation objectives for grey seal**.

8.3.2.4. Potential disturbance of seals foraging at sea

996. As a worst-case scenario the potential in-combination effects for the disturbance for grey seal at sea has been assessed.

8.3.2.4.1. Potential in-combination disturbance effects during UXO clearance at Norfolk Vanguard (alone)

997. Only one UXO would be detonated at a time during UXO clearance operation at Norfolk Vanguard; there would be no concurrent UXO detonations.

998. It is not anticipated that piling would be undertaken at the same time as UXO clearance, however, as a worst-case scenario it has been assumed that UXO clearance could be undertaken in the cable corridor and piling could concurrently be undertaken in the offshore wind farm area.

999. The maximum potential area of disturbance, based on a 26km range (area of 2,124km^2) around each piling location and UXO location, has been assessed in relation to the grey seal reference population, South-east MU and grey seal counts for Humber Estuary SAC (Table 8.50).

1000. The Humber Estuary SAC is located 150km from Norfolk Vanguard OWF sites and 112km from the offshore cable corridor (at closest point). It is highly unlikely, especially taking into account the movements of tagged seals (as outlined in Section 8.1.2.1), that all grey seal in the Norfolk Vanguard offshore wind farm and cable corridor area are all from the Humber Estuary SAC. It is also unlikely that UXO clearance and piling would be undertaken at the same time at Norfolk Vanguard, therefore, **there is no anticipated adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1001. There would be no direct effect or overlap with the Humber SAC area.

Table 8.50 Estimated maximum number of grey seal potentially disturbed during UXO clearance and piling based on 26km range for Norfolk Vanguard alone

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Piling in offshore wind farm area (2,124km^2) and UXO event in cable corridor (2,124km^2)	4 grey seal in offshore wind farm area (based on offshore wind farm density of 0.002/km^2); and 340 grey seal in offshore cable corridor (based on offshore cable corridor area density of 0.16/km^2).	1.5% of ref pop; or 5.6% of SE England MU; or 8.7% of Humber Estuary SAC.

8.3.2.4.2. Potential in-combination disturbance effects during piling at Norfolk Vanguard (alone)

1002. As a worst-case scenario, it is assumed that piling is undertaken at one site (e.g. NV East) and construction activities, including vessels, are underway at the other site (e.g. NV West) and the cable corridor. It is assumed that all seals are disturbed from these areas (Table 8.51). Under these circumstances, it is estimated that up to a maximum of 1% of grey seal from the Humber Estuary SAC would be temporarily disturbed, therefore **there is no anticipated adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1003. The Humber Estuary SAC is located 150km from Norfolk Vanguard OWF sites and 112km from the offshore cable corridor (at closest point). It is highly unlikely, especially taking into account the movements of tagged seals (as outlined in Section 8.1.2.1), that all grey seal in the Norfolk Vanguard offshore wind farm and cable corridor area are all from the Humber Estuary SAC, therefore **there is no anticipated adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1004. There would be no direct effect or overlap with the Humber SAC area.

Table 8.51 Estimated maximum number of grey seal potentially disturbed during piling in-combination with other construction activities and vessels at Norfolk Vanguard alone

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Area of disturbance (2,124km^2) from underwater noise during single pile installation at NV West or NV East, plus disturbance at NV East (297km^2) or NV West (295km^2) and cable corridor (237km^2)	5 grey seal in offshore wind farm area (based on offshore wind farm density of 0.002/km^2); and 38 grey seal in offshore cable corridor (based on offshore cable corridor area density of 0.16/km^2).	0.2% of ref pop; or 0.7% of SE England MU; or 1% of Humber Estuary SAC.

8.3.2.4.3. Potential disturbance during construction, other than UXO clearance and piling, at Norfolk Vanguard (alone)

1005. During construction activities, other than UXO clearance and piling, the potential disturbance from underwater noise during construction has been assessed based on the worst-case scenario that all grey seal could be disturbed from the entire wind farm and cable corridor area; this includes any potential disturbance from vessels and any changes in prey availability (Table 8.52). Under these circumstances, it is estimated that up to a maximum of 1% of grey seal from the potential Humber Estuary SAC would be temporarily disturbed, therefore, **there is no anticipated adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1006. The Humber Estuary SAC is located 150km from Norfolk Vanguard OWF sites and 112km from the offshore cable corridor (at closest point). It is highly unlikely, especially taking into account the movements of tagged seals (as outlined in Section 8.1.2.1), that all grey seal in the Norfolk Vanguard offshore wind farm and cable corridor area are all from the Humber Estuary SAC, therefore **there is no anticipated adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1007. There would be no direct effect or overlap with the Humber SAC area.

Table 8.52 Estimated maximum number of grey seal potentially disturbed from Norfolk Vanguard offshore wind farm areas and cable corridor area

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Area of disturbance from underwater noise during construction activity, including vessels at NV East (297km^2), NV West (295km^2) and cable corridor (237km^2)	1 grey seal in offshore wind farm areas (based on offshore wind farm density of 0.002/km^2); and 38 grey seal in offshore cable corridor (based on offshore cable corridor area density of 0.16/km^2).	0.2% of ref pop; or 0.6% of SE England MU; or 1% of Humber Estuary SAC.

8.3.2.4.4. Potential disturbance during operation and maintenance at Norfolk Vanguard (alone)

1008. During operation and maintenance, the potential disturbance from underwater noise has been assessed based on the worst-case scenario that grey seal could be disturbed from the entire wind farm and cable corridor area, this includes any potential disturbance from operational turbines, maintenance activities, vessels and any changes in prey availability (Table 8.52). Under these circumstances, it is estimated that up to a maximum of 1% of grey seal from the Humber Estuary SAC would be temporarily disturbed, therefore, **there is no potential adverse effect on**

the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

1009. The Humber Estuary SAC is located 150km from Norfolk Vanguard OWF sites and 112km from the offshore cable corridor (at closest point). It is highly unlikely, especially taking into account the movements of tagged seals (as outlined in Section 8.1.2.1), that all grey seal in the Norfolk Vanguard offshore wind farm and cable corridor area are from the Humber Estuary SAC, therefore **there is no anticipated adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1010. There would be no direct effect or overlap with the Humber SAC area.

8.3.2.4.5. Potential disturbance during decommissioning at Norfolk Vanguard (alone)

1011. During decommissioning, the potential disturbance from underwater noise has been assessed based on the worst-case scenario that grey seal could be disturbed from the entire wind farm and cable corridor area; this includes any potential disturbance from foundation removal, other activities, vessels and any changes in prey availability (Table 8.52). Under these circumstances, it is estimated that up to a maximum of 1%, based on worst-case scenarios, or 0.5%, based on precautionary more realistic scenario, of grey seal from the potential Humber Estuary SAC would be temporarily disturbed, therefore, **there is no potential adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1012. The Humber Estuary SAC is located 150km from Norfolk Vanguard OWF sites and 112km from the offshore cable corridor (at closest point). It is highly unlikely, especially taking into account the movements of tagged seals (as outlined in Section 8.1.2.1), that all grey seal in the Norfolk Vanguard offshore wind farm and cable corridor area are all from the Humber Estuary SAC, therefore **there is no anticipated adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1013. There would be no direct effect or overlap with the Humber SAC area.

8.3.2.4.6. Potential in-combination effects for Norfolk Vanguard and all other projects and plans

1014. Table 8.53 summarises the potential in-combination effects for grey seal, based on the same approach as assessed for harbour porpoise (Section 0), during the construction period at Norfolk Vanguard. The in-combination effects during operation and maintenance or decommissioning would be less than those assessed for construction.

1015. Given the wide range of locations over the Southern North Sea area used in this in-combination assessment it is highly unlikely that the grey seal that could potentially be disturbed would all be from the South-east MU or Humber Estuary SAC, therefore it is more appropriate the assessment is put into the context of the reference population. Therefore, a maximum of up to 6% of the reference population could be temporarily disturbed. Given the distance between the projects offshore and their distance from the coast, it is not anticipated that foraging grey seal would be significantly displaced from foraging areas or moving between haul-out sites and foraging areas, therefore **there is no anticipated adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

Table 8.53 In-combination effects for the potential disturbance of all grey seal from all other possible noise sources during piling at Norfolk Vanguard based on worst-case scenario

Potential noise sources during Norfolk Vanguard piling	Area of potential disturbance	Potential number of grey seal disturbed
UK and European OWF projects, including Norfolk Vanguard, with the potential of single piling at the same time	10,620km^2	593
UXO clearance (up to 2 operations)	4,248km^2	425
Seismic surveys (up to 2 surveys)	628km^2	63
UK and European OWF construction activities (i.e. OWFs that are not piling but potential construction activities) and 100% disturbance	2,384km^2	33
Operation and maintenance of UK and European OWFs and 100% disturbance	2,185km^2	257
Total		**1,371**
% of reference population (22,290 grey seal)		**6%**
% of South-east MU (6,085 grey seal)		**22.5%**
% of Humber Estuary SAC (3,964 grey seal)		**34.6%**

8.3.3. The Wash and North Norfolk Coast SAC

1016. The HRA screening identified the potential for vessels associated with Norfolk Vanguard to increase disturbance and / or interact with harbour seal and grey seal from the Wash and North Norfolk Coast SAC depending on the location of the port. The construction port to be used for Norfolk Vanguard is not yet known and could be located on the east coast of England and therefore vessels travelling between the offshore project area and the construction port may transit past the Wash and North Norfolk Coast SAC.

1017. Taking into account the proximity of shipping channels to and from existing ports, it is likely that harbour and grey seals hauled-out along these routes and in the area of the ports would be habituated to the noise, movements and presence of vessels.

8.3.3.1. Disturbance at seal haul-out sites

1018. As outlined above, vessels would be highly unlikely to be within 300m of the coast where seals are hauled out, therefore there would be no potential to directly disturb seals hauled out at sites in the Wash and North Norfolk Coast SAC.

1019. Therefore it is concluded that there would be no potential adverse effect on the integrity of the SAC in relation to the conservation objectives for harbour seal.

8.3.3.2. Vessel interaction (collision risk)

1020. The construction port to be used for Norfolk Vanguard is not yet known and could be located on the east coast of England. Indicative daily vessel movements (return trips to a local port) during construction of Norfolk Vanguard are estimated to be an average of two per day.

1021. As outlined above, the operational phase base port for the project is likely to either be Great Yarmouth or Lowestoft. It is estimated that an average of 1 to 2 vessel movements will be required daily during the operational phase of the project. It is unlikely that O&M vessels would be in the vicinity of the Wash and North Norfolk Coast SAC for normal operational duties.

1022. Therefore based on the worst-case scenario of an average of two vessel movements per day, the increase in vessel movements during construction is going to be relatively small compared to existing vessel traffic. It is expected that seals would be able to detect the presence of vessels and, given that they are highly mobile, would be able to largely avoid vessel collision. Taking into account good practice, any increased collision risk is highly unlikely.

1023. **Therefore it is concluded that there would be no potential adverse effect on the integrity of the SAC in relation to the conservation objectives for harbour seal**.

8.3.3.3. Potential in-combination effects for disturbance at seal haul-out sites and vessel interaction

1024. As outlined above, vessels would be highly unlikely to be within 300m of the coast where seals are hauled out therefore there would be no potential for any in-combination effects on seals hauled out at sites in the Wash and North Norfolk Coast SAC.

1025. There are already large numbers of vessel movements in the area of the Wash and North Norfolk Coast SAC, therefore, for most of these projects any increase in vessel movements is likely to be relatively small in relation to current ship movements in the area.

1026. The potential for any in-combination effects for vessels to increase disturbance and / or interact with harbour seals from the Wash and North Norfolk Coast SAC is highly unlikely. Therefore, it is concluded that there would be **no potential adverse effect on the integrity of the SAC in relation to the conservation objectives for harbour seal**.

8.3.3.4. Potential disturbance of seals foraging at sea

1027. As a worst-case scenario the potential in-combination effects for the disturbance for harbour seal and grey seal at sea has been assessed.

8.3.3.4.1. Potential in-combination disturbance effects during UXO clearance at Norfolk Vanguard (alone)

1028. Only one UXO would be detonated at a time during UXO clearance operations at Norfolk Vanguard; there would be no concurrent UXO detonations.

1029. It is not anticipated that piling would be undertaken at the same time as UXO clearance, however, as a worst-case scenario it has been assumed that UXO clearance could be undertaken in the cable corridor and piling could be undertaken concurrently in the offshore wind farm area.

1030. The maximum potential area of disturbance, based on a 26km range (area of 2,124km^2) around each piling location and UXO location), has been assessed in relation to the grey seal reference population, South-east MU and the Wash and North Norfolk Coast SAC (Table 8.54).

1031. The Wash and North Norfolk Coast SAC is located approximately 82km from Norfolk Vanguard OWF sites and 33km from the offshore cable corridor (at closest point). It is highly unlikely, especially taking into account the movements of tagged seals (as outlined in Section 8.1.2.1 and 8.1.3.1), that all harbour and grey seal in the Norfolk Vanguard offshore wind farm and cable corridor area are from the Wash and North Norfolk Coast SAC. It is also unlikely that UXO clearance and piling would be undertaken at the same time at Norfolk Vanguard, therefore, **there is no anticipated adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1032. There would be no direct effect or overlap with the Wash and North Norfolk Coast SAC area.

Table 8.54 Estimated maximum number of harbour and grey seal potentially disturbed during UXO clearance and piling based on 26km range for Norfolk Vanguard alone

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Piling in offshore wind farm area	0.2 harbour seal in offshore wind farm area (based on offshore wind farm	0.5% of ref pop; or 4.2% of SE England MU; or 6.3% of Wash

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
(2,124km^2) and UXO event in cable corridor (2,124km^2)	area density of 0.0001/km^2); and 212 harbour seal in cable corridor area (based on offshore cable corridor area density of 0.1/km^2)	and North Norfolk Coast SAC.
	4 grey seal in offshore wind farm area (based on offshore wind farm density of 0.002/km^2); and 340 grey seal in offshore cable corridor (based on offshore cable corridor area density of 0.16/km^2).	1.5% of ref pop; or 5.6% of SE England MU.

8.3.3.4.2. Potential in-combination disturbance effects during piling at Norfolk Vanguard (alone)

1033. As a worst-case scenario, it is assumed the piling is undertaken at one site and construction activities, including vessels, are underway at the other site and cable corridor with no overlap in the areas of potential disturbance and all seal are disturbed (Table 8.55). Under these circumstances, it is estimated that less than 1% of harbour seal from the Wash and North Norfolk Coast SAC or less than 1% of the grey seal South-east MU population would be temporarily disturbed, therefore **there is no anticipated adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1034. The Wash and North Norfolk Coast SAC is located approximately 82km from Norfolk Vanguard OWF sites and 33km from the offshore cable corridor (at closest point). It is highly unlikely, especially taking into account the movements of tagged seals (as outlined in section 8.1.2.1 and 8.1.3.1), that all harbour and grey seal in the Norfolk Vanguard offshore wind farm and cable corridor area are from the Wash and North Norfolk Coast SAC, therefore, **there is no anticipated adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1035. There would be no direct effect or overlap with the Wash and North Norfolk Coast SAC area.

Table 8.55 Estimated maximum number of harbour and grey seal potentially disturbed during piling in-combination with other construction activities and vessels at Norfolk Vanguard alone

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Area of disturbance (2,124km^2) from underwater noise during single pile installation at NV West or NV East, plus disturbance at NV	0.2 harbour seal in offshore wind farm area (based on offshore wind farm area density of 0.0001/km^2); and 24 harbour seal in cable corridor area (based on offshore cable corridor area	0.06% of ref pop; or 0.5% of SE England MU; or 0.7% of Wash and North Norfolk Coast SAC.

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
East (297km^2) or NV West (295km^2) and cable corridor (237km^2)	density of 0.1/km^2).	
	5 grey seal in offshore wind farm area (based on offshore wind farm density of 0.002/km^2); and 38 grey seal in offshore cable corridor (based on offshore cable corridor area density of 0.16/km^2).	0.2% of ref pop; or 0.7% of SE England MU.

8.3.3.4.3. Potential disturbance during construction, other than UXO clearance and piling, at Norfolk Vanguard (alone)

1036. During construction activities, other than UXO clearance and piling, the potential disturbance from underwater noise during construction has been assessed based on the worst-case scenario that harbour and grey seal could be disturbed from the entire wind farm and cable corridor area; this includes any potential disturbance from vessels and any changes in prey availability (Table 8.56). Under these circumstances, it is estimated that less than 1% of harbour seal from the Wash and North Norfolk Coast SAC or less than 1% of the grey seal South-east MU population would be temporarily disturbed, therefore, **there is no anticipated adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1037. The Wash and North Norfolk Coast SAC is located approximately 82km from Norfolk Vanguard OWF sites and 33km from the offshore cable corridor (at closest point). It is highly unlikely, especially taking into account the movements of tagged seals (as outlined in section 8.1.2.1 and 8.1.3.1), that all harbour and grey seal in the Norfolk Vanguard offshore wind farm and cable corridor area are from the Wash and North Norfolk Coast SAC, therefore, **there is no anticipated adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1038. There would be no direct effect or overlap with the Wash and North Norfolk Coast SAC area.

Table 8.56 Estimated maximum number of harbour and grey seal potentially disturbed from Norfolk Vanguard offshore wind farm areas and cable corridor area

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Area of disturbance from underwater noise during construction activity, including	0.06 harbour seal in offshore wind farm area (based on offshore wind farm area density of 0.0001/km^2); and	0.06% of ref pop; or 0.5% of SE England MU; or 0.7% of Wash and North Norfolk Coast SAC.

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
vessels at NV East (297km^2), NV West (295km^2) and cable corridor (237km^2)	24 harbour seal in cable corridor area (based on offshore cable corridor area density of 0.1/km^2).	
	1 grey seal in offshore wind farm areas (based on offshore wind farm density of 0.002/km^2); and 38 grey seal in offshore cable corridor (based on offshore cable corridor area density of 0.16/km^2).	0.2% of ref pop; or 0.6% of SE England MU.

8.3.3.4.4. Potential disturbance during operation and maintenance at Norfolk Vanguard (alone)

1039. During operation and maintenance, the potential disturbance from underwater noise has been assessed based on the worst-case scenario that harbour and grey seal could be disturbed from the entire wind farm and cable corridor area; this includes any potential disturbance from operational turbines, maintenance activities, vessels and any changes in prey availability (Table 8.56). Under these circumstances, it is estimated that less than 1% of harbour seal from the Wash and North Norfolk Coast SAC or less than 1% of then grey seal South-east MU population would be temporarily disturbed, therefore, **there is no anticipated adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1040. The Wash and North Norfolk Coast SAC is located approximately 82km from Norfolk Vanguard OWF sites and 33km from the offshore cable corridor (at closest point). It is highly unlikely, especially taking into account the movements of tagged seals (as outlined in section 8.1.2.1 and 8.1.3.1), that all harbour and grey seal in the Norfolk Vanguard offshore wind farm and cable corridor area are from the Wash and North Norfolk Coast SAC, therefore, **there is no anticipated adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1041. There would be no direct effect or overlap with the Wash and North Norfolk Coast SAC area.

8.3.3.4.5. Potential disturbance during decommissioning at Norfolk Vanguard (alone)

1042. During decommissioning, the potential disturbance from underwater noise has been assessed based on the worst-case scenario that harbour and grey seal could be disturbed from the entire wind farm and cable corridor area; this includes any potential disturbance from foundation removal, other activities, vessels and any changes in prey availability (Table 8.56). Under these circumstances, it is estimated that less than 1% of harbour seal from the Wash and North Norfolk Coast SAC harbour seal population or less than 1% of the grey seal South-east MU population would be temporarily disturbed, therefore, **there is no anticipated adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1043. The Wash and North Norfolk Coast SAC is located approximately 82km from Norfolk Vanguard OWF sites and 33km from the offshore cable corridor (at closest point). It is highly unlikely, especially taking into account the movements of tagged seals (as outlined in Section 8.1.2.1 and 8.1.3.1), that all harbour and grey seal in the Norfolk Vanguard offshore wind farm and cable corridor area are from the Wash and North Norfolk Coast SAC, therefore, **there is no anticipated adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1044. There would be no direct effect or overlap with the Wash and North Norfolk Coast SAC area.

8.3.3.4.6. Potential in-combination effects for Norfolk Vanguard and all other projects and plans

1045. Table 8.57 summarises the potential in-combination effects for harbour and grey seal, based on the same approach as assessed for harbour porpoise (Section 0), during the construction period at Norfolk Vanguard. The in-combination effects during operation and maintenance or decommissioning would be less than those assessed for construction.

1046. Given the wide range of locations over the Southern North Sea area used in this in-combination assessment it is highly unlikely that the harbour or grey seal that could potentially be disturbed would all be from the South-east MUs or Wash and North Norfolk Coast SAC, therefore it is more appropriate the assessment is put into the context of the reference population. Therefore, based on the worst-case scenario, a maximum of up to 0.5% and 6% of the harbour and grey seal reference populations, respectively, could be temporarily disturbed. Given the distance between the projects offshore and their distance from the coast, it is not anticipated that foraging grey seal would be significantly displaced from foraging areas or moving between haul-out sites and foraging areas, therefore **there is no anticipated adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

Table 8.57: In-combination effects for the potential disturbance of all harbour and grey seal from all other possible noise sources during piling at Norfolk Vanguard based on worst-case scenario

Potential noise sources during Norfolk Vanguard piling	Area of potential disturbance	Potential number of grey seal disturbed	Potential number of harbour seal disturbed
UK and European OWF projects, including Norfolk Vanguard, with the potential of single piling at the same time	10,620km^2	593	26
UXO clearance (up to 2 operations)	4,248km^2	425	85
Seismic surveys (up to 2 surveys)	628km^2	63	13
UK and European OWF construction activities (i.e. OWFs that are not piling but potential construction activities) and 100% disturbance	2,384km^2	33	5
Operation and maintenance of UK and European OWFs and 100% disturbance	2,185km^2	257	80
Total		**1,371**	**209**
% of reference population (22,290 grey seal; 43,161 harbour seal)		**6%**	**0.5%**
% of South-east MU (6,085 grey seal; 5,061 harbour seal)		**22.5%**	**4%**
% of Wash and North Norfolk Coast SAC (3,377 harbour seal)		**N/A**	**6%**

8.3.4. Winterton-Horsey Dunes SAC

1047. It is recognised that, while grey seal are not currently a qualifying feature of the Winterton-Horsey Dunes SAC, the site is used by grey seal. As part of the EPP the ETG requested that the potential for any disturbance and / or interaction with vessels and cable installation activities for the project should be taken into account within the HRA.

8.3.4.1. Disturbance at seal haul-out sites

1048. As outlined above, vessels would be highly unlikely to be within 300m of the coast, except within the cable corridor, therefore there would be no potential to directly disturb seals hauled out at sites in the Winterton-Horsey Dunes SAC.

1049. The landfall at Happisburgh South is approximately 11km from the Horsey seal haul-out site to the south of the landfall search area. Given the distances between the Norfolk Vanguard cable landfall area and the nearest known seal haul-out site there is no potential for any direct disturbance as a result of activities at the landfall site.

1050. Therefore it is concluded that there would be no potential for any significant effects on seals hauled-out at the site.

8.3.4.2. Vessel interaction (collision risk)

1051. The construction port to be used for Norfolk Vanguard is not yet known and could be located on the south east coast of England. Indicative daily vessel movements (return trips to a local port) during construction of Norfolk Vanguard are estimated to be an average of two per day.

1052. The operational base port for the project is likely to either Great Yarmouth or Lowestoft. It is assumed that 1-2 vessel movement will be required daily during the operational phase of the project. Therefore it is unlikely that O&M vessels would be in the vicinity of the Winterton-Horsey Dunes SAC for normal operational duties.

1053. Therefore based on the worst-case scenario of an average of two vessel movements per day, the increase in vessel movements during construction is going to be relatively small compared to existing vessel traffic. It is expected that seals would be able to detect the presence of vessels and, given that they are highly mobile, would be able to largely avoid vessel collision. Taking into account the embedded mitigation, including good practice, any increased collision risk is highly unlikely.

1054. Therefore it is concluded that there would be no potential for any significant effects on seals from the site.

8.3.4.3. Potential in-combination effects for disturbance at seal haul-out sites and vessel interaction

1055. Vessels would be highly unlikely to be within 300m of the coast where seals are hauled out, unless leaving and entering designated ports, therefore there would be **no potential for any in-combination effects on seals hauled out at sites in the Winterton-Horsey Dunes SAC**.

1056. There are already large numbers of vessel movements in the area of the Winterton-Horsey Dunes SAC, therefore, for most of these projects any increase in vessel movements is likely to be relatively small in relation to current ship movements in the area.

1057. The potential for any in-combination effects for vessels to increase disturbance and / or interact with seals from the Winterton-Horsey Dunes SAC is highly unlikely. Therefore, it is concluded that there should be **no potential for any significant effects on seals from the site**.

8.3.4.4. Potential disturbance of grey seal in the cable corridor

1058. As outlined above, the landfall at Happisburgh South is approximately 11km from the Horsey seal haul-out site to the south of the landfall search area. Given the distances between the Norfolk Vanguard cable landfall area and the nearest known seal haul-out site there is no potential for any direct disturbance as a result of activities at the landfall site.

1059. As a precautionary approach the total number of grey seals that could be disturbed as a result of activities and vessels in the cable corridor during construction, operation, maintenance and decommissioning has been assessed (Table 8.58). Under these circumstances, it is estimated that less than 2% of grey seal from Winterton-Horsey Dunes SAC or less than 1% of the grey seal South-east MU population would be temporarily and intermittently disturbed, therefore, **there is no anticipated adverse effect on the integrity of the Winterton-Horsey Dunes SAC in relation to grey seal using the site**.

1060. In addition, taking to account the movements of grey seal along the coast, as outlined in Section 8.1.2.1, it is unlikely that all grey seal in the Norfolk Vanguard offshore cable corridor area are all from the Winterton-Horsey Dunes SAC.

1061. There would be no direct effect or overlap with the Winterton-Horsey Dunes SAC area.

1062. There are currently no known or anticipated further activities, other than current baseline levels of vessel activity in the Norfolk Vanguard cable corridor area, therefore there are no further in-combination effects for grey seal in this area.

Table 8.58 Estimated maximum number of grey seal potentially disturbed from Norfolk Vanguard cable corridor area

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Area of disturbance / cable corridor (237km^2)	38 grey seal in offshore cable corridor (based on offshore cable corridor area density of 0.16/km^2).	0.2% of ref pop; or 0.6% of SE England MU; or 2% of Winterton-Horsey Dunes SAC.

8.4. Mitigation and Management

8.4.1. Proposed Management and Mitigation of Potential Effects on Harbour Porpoise

8.4.1.1. UXO Clearance

1063. A detailed MMMP will be prepared for UXO clearance following the pre-construction UXO survey when there is more detailed information on the UXO clearance which could be required. The UXO MMMP will take account of the most suitable mitigation measures at that time and will be based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and MMO. The MMMP for UXO clearance will ensure there are embedded mitigation measures, as well as any additional mitigation, if required, to prevent the risk of any physical or permanent auditory injury to marine mammals. The MMMP for UXO clearance will be developed in the pre-construction period, when there is more detailed information on what UXO clearance could be required and what the most suitable mitigation measures are, based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and MMO.

8.4.1.2. Piling

1064. A detailed MMMP will be prepared for piling. The MMMP for piling will detail the proposed mitigation measures to reduce the risk of any physical or permanent auditory injury to marine mammals during all piling operations.

1065. A draft MMMP for piling (document 8.13) is submitted with the DCO Application.

1066. The MMMP for piling will be developed in the pre-construction period and based upon best available information and methodologies. The MMMP for piling will be produced in consultation with the relevant SNCBs and MMO, detailing the proposed mitigation measures to reduce the risk of any physical or permanent auditory injury to marine mammals during all piling operations. This will include details of the embedded mitigation, for the soft-start, ramp-up in order to minimise potential effects of physical and auditory injury (as outlined in Section 8.2.1.1.1), as well as details the mitigation zone of any additional mitigation that could be required, for example, the activation of acoustic deterrent devices (ADDs) prior to the soft-start.

1067. In addition to the MMMP, a Norfolk Vanguard Southern North Sea cSAC SIPwill be developed (based on the In Principle SIP submitted with the DCO application (document 8.17)). The SIP will set out the approach to deliver any project mitigation or management measures in relation to the Southern North Sea cSAC and therefore allow the conclusion of 'no adverse effect beyond reasonable scientific doubt'.

8.4.1.3. Water quality

1068. As outlined in the ES Chapter 9 Marine Water and Sediment Quality (document 6.1), Norfolk Vanguard Limited is committed to the use of best practice techniques and due diligence regarding the potential for pollution throughout all construction, operation, maintenance and decommissioning activities. A draft Project Environmental Management Plan (PEMP) (document reference 8.14) has been submitted with the DCO application. This includes, but is not limited to, the following mitigation measures embedded into the design:

- Oils and lubricants used in the wind turbines would be biodegradable where possible and all chemicals would be certified to the relevant standard.
- All wind turbines would incorporate appropriate provisions to retain spilled fluids within the nacelle and tower. In addition, converter and collector stations

would be designed with a self-contained bund to contain any spills and prevent discharges to the environment.

- Best practice procedures would be put in place when transferring oil or fuel between converter or collector stations and service vessels.
- Appropriate spill plan procedures would also be implemented in order to appropriately manage any unexpected discharge into the marine environment, these would be included in a Marine Pollution Contingency Plan (MPCP) to be agreed post-consent. To avoid discharge or spillage of oils it is anticipated that the transformers would be filled for their operational life and would not need interim oil changes.
- Inclusion of control measures such as the requirement to carry spill kits and the requirement for vessel personnel to undergo training to ensure requirements of the PEMP are understood and communicated.
- All work practices and vessels will adhere to the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78; specifically Annex 1 Regulations for the prevention of pollution by oil concerning machine waters, bilge waters and deck drainage and Annex IV Regulations for the prevention of pollution by sewage from ships concerning black and grey waters.

8.4.1.4. In-combination effects

1069. Mitigation for in-combination disturbance effects will be discussed with the relevant SNCBs and MMO.

1070. Mitigation will be considered, if required, to limit the potential for in-combination disturbance effects, taking into account the current SNCB guidance for the assessment of the potential effects on the Southern North Sea cSAC for harbour porpoise (Natural England, June 2017) that:

- Displacement of harbour porpoise should not exceed 20% of the seasonal component of the cSAC area at any one time and / or on average exceed 10% of the seasonal component of the cSAC area over the duration of that season

1071. In order to address the overall potential in-combination effects, Norfolk Vanguard Limited is committed to working with the MMO and relevant SNCBs to develop and agree a possible strategic approach to mitigation as required. This would be addressed through the MMMP and SIP (based on the draft MMMP (document 8.13) and In Principle SIP (document 8.17) submitted with the DCO application) and would be based on the final design of Norfolk Vanguard and the actual in-combination scenarios resulting from the final design and programmes of other projects.

1072. In the absence of current management measures for the Southern North Sea cSAC, Norfolk Vanguard Limited is confident that their commitment to develop a MMMP and the Norfolk Vanguard Southern North Sea cSAC SIP in consultation with the relevant authorities during the pre-construction period will ensure that appropriate management measures, as deemed necessary, can be implemented to ensure no effect on the integrity of the Southern North Sea SAC as defined by its conservation objectives.

1073. If required, an EPS licence application for harbour porpoise will be completed post consent, once the project design is defined. The EPS licence will be agreed with the MMO and will be based on best available information at the time, including industry best practice.

8.5. Summary of Potential Effects

The assessment of the potential effects during the construction of Norfolk Vanguard alone and in-combination has been summarised in relation to the Conservation Objectives of the European Designated Sites where harbour porpoise (Table 8.59), grey seal (Table 8.60) and harbour seal (Table 8.61) are a qualifying feature.

Table 8.59 Summary of the assessment of the potential effects of Norfolk Vanguard (alone and in-combination) on the Southern North Sea cSAC in relation to the draft Conservation Objectives for harbour porpoise

Conservation Objectives	Disturbance from underwater noise - project alone	Increased collision risk – project alone	Changes to prey resources – project alone	Disturbance from underwater noise – in-combination	Increased collision risk – in-combination	Changes to prey resources – in-combination
The species is a viable component of the site	×	×	×	×	×	×
There is no significant disturbance of the species	×	×	×	×	×	×
The supporting habitats and processes relevant to harbour porpoises and their prey are maintained	×	×	×	×	×	×

× = no potential for any adverse effect on the integrity of the site in relation to the conservation objectives.

Table 8.60 Summary of the assessment of the potential effects of Norfolk Vanguard (alone and in-combination) on the Humber Estuary SAC, Wash and North Norfolk Coast SAC and Winterton-Horsey SAC in relation to the Conservation Objectives for grey seal at the Humber Estuary SAC

Conservation Objective	Disturbance at seal haul-out sites	Vessel interaction (increased collision risk)	In-combination
The extent and distribution of qualifying natural habitats and habitats of qualifying species.	×	×	×
The structure and function (including typical species) of qualifying natural habitats.	×	×	×
The structure and function of the habitats of qualifying species.	×	×	×
The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.	×	×	×
The populations of qualifying species.	×	×	×
The distribution of qualifying species within the site.	×	×	×

× = no potential for any adverse effect on the integrity of the site in relation to the conservation objectives

Table 8.61 Summary of the assessment of the potential effects of Norfolk Vanguard (alone and in-combination) on the Wash and North Norfolk Coast SAC in relation to the Conservation Objectives for harbour seal

Conservation Objective	Disturbance at seal haul-out sites	Vessel interaction (increased collision risk)	In-combination
The extent and distribution of qualifying natural habitats and habitats of qualifying species.	×	×	×
The structure and function (including typical species) of qualifying natural habitats.	×	×	×
The structure and function of the habitats of qualifying species.	×	×	×
The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.	×	×	×
The populations of qualifying species.	×	×	×
The distribution of qualifying species within the site.	×	×	×

× = no potential for any adverse effect on the integrity of the site in relation to the conservation objectives

9. ONSHORE NATURA 2000 SITES

9.1. Baseline and Current Conservation Status

1074. The following sections provide an overview of the relevant baseline information and current conservation status for the onshore Natura 2000 site designations which have been screened into the HRA. These sites are:

- River Wensum SAC;
- Paston Great Barn SAC;
- Norfolk Valley Fens SAC; and
- The Broads SAC

1075. Further details on the baseline information for onshore Natura 2000 sites are provided in the Onshore Screening Report (Appendix 5.2), and Chapter 22 Onshore Ecology of the ES.

9.1.1. River Wensum SAC

9.1.1.1. Description of Designation

1076. The River Wensum SAC occupies an area of 306.79ha, encompassing the River Wensum itself and also seasonally inundated grassland habitats adjacent to the watercourse in selected locations along its length. The river rises near Whissonsett and flows towards Fakenham before running south-eastwards to its confluence with the River Tud in Norwich. In the upper reaches, the river is fed by springs that rise from the chalk and by run-off from calcareous soils rich in plant nutrients. As such, beds of submerged and emergent vegetation characteristic of a chalk stream are observed within the SAC. Downstream, the chalk is overlain with boulder clay and river gravels, resulting in aquatic plant communities more typical of a slow-flowing river on mixed substrate. Adjacent land is predominantly managed for hay crops and by grazing and the resulting mosaic of meadow and marsh habitats provides niches for a wide variety of specialised plants and animals.

1077. The SAC is designated for supporting several Annex I habitats and Annex II species. The primary reasons underpinning this designation are the presence of Annex I habitat water courses of plain to montane levels with the *Ranunculion fluitantis* and *Caliitricho-Batrachion* vegetation, and the presence of white-clawed (or Atlantic stream) crayfish. Additional Annex II species which are qualifying features for this SAC, but are not a primary reason for its site selection include:

- Desmoulin’s whorl snail;
- Brook lamprey; and
- Bullhead.

9.1.1.2. Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

9.1.1.2.1. Details of the qualifying feature

1078. The site is described in the SAC citation as follows:

1079. "The Wensum is a naturally enriched, calcareous lowland river. The upper reaches are fed by springs that rise from the chalk and by run-off from calcareous soils rich in plant nutrients. This gives rise to beds of submerged and emergent vegetation characteristic of a chalk stream. Lower down, the chalk is overlain with boulder clay and river gravels, resulting in aquatic plant communities more typical of a slow-flowing river on mixed substrate. Much of the adjacent land is managed for hay crops and by grazing, and the resulting mosaic of meadow and marsh habitats, provides niches for a wide variety of specialised plants and animals.

1080. "*Ranunculus* vegetation occurs throughout much of the river's length. Stream water-crowfoot *R. penicillatus ssp. pseudofluitans* is the dominant *Ranunculus* species but thread-leaved watercrowfoot *R. trichophyllus* and fan-leaved water-crowfoot *R. circinatus* also occur in association with the wide range of aquatic and emergent species that contribute to this vegetation type." (English Nature, 2005).

9.1.1.2.2. Status of the qualifying feature within the onshore project area and adjacent habitats

1081. The SAC intersects the Norfolk Vanguard cable corridor at Elsing. At the point where the SAC is crossed by the cable corridor, the SAC boundary covers the River Wensum river channel only (i.e. no floodplain habitat), and as such approximately 0.5ha of the SAC are located within the cable corridor. The location of the onshore cable corridor with respect to the SAC boundary and its associated ex-situ habitats is shown in Figure 9.1.

1082. In addition to the SAC boundary, there is approximately 9.7ha of floodplain habitat of River Wensum on the right-hand (southern) bank of the River Wensum, and a further 1.3ha on the left-hand (northern) bank of the River Wensum, within the cable corridor. There are also four ditches within the floodplain habitat on the right-hand (southern) bank of the River Wensum, and one further ditch in the floodplain habitat on the left-hand (northern) bank.

1083. Following consultation with Natural England during the EPP in January 2017, a detailed survey of the River Wensum and its floodplain was proposed to understand any potential effects of the proposed works on the Annex I habitats of River Wensum SAC within both the SAC boundary and its adjacent floodplain habitats. A survey was subsequently undertaken in July 2017 with the following four aims:

- To identify the National Vegetation Classification (NVC) communities within the River Wensum SAC;
- To note if the following plants are growing within the River Wensum or ditches of the adjacent floodplain habitats:
  - pond water-crowfoot *Ranunculus peltatus*;
  - stream water-crowfoot Ranunculus penicillatus ssp. pseudofluitans;
  - river water-crowfoot *Ranunculus fluitans*.
- To identify the NVC communities within the floodplain habitats found adjacent to the River Wensum; and
- To look for presence of calcareous groundwater springs/seepage within the floodplain habitats.

1084. This survey covered the River Wensum within the SAC boundaries and the floodplain habitat on the right-hand (southern) bank of the River Wensum (herein referred to as the 'survey area'). The location of these surveys is shown in Figure 9.1. No surveys were conducted on the floodplain on the left-hand (northern) bank of the River Wensum due to landowner access restrictions. The scope for this survey was agreed with the Norfolk Vanguard ETG in March 2017 (Royal HaskoningDHV, 2017b).

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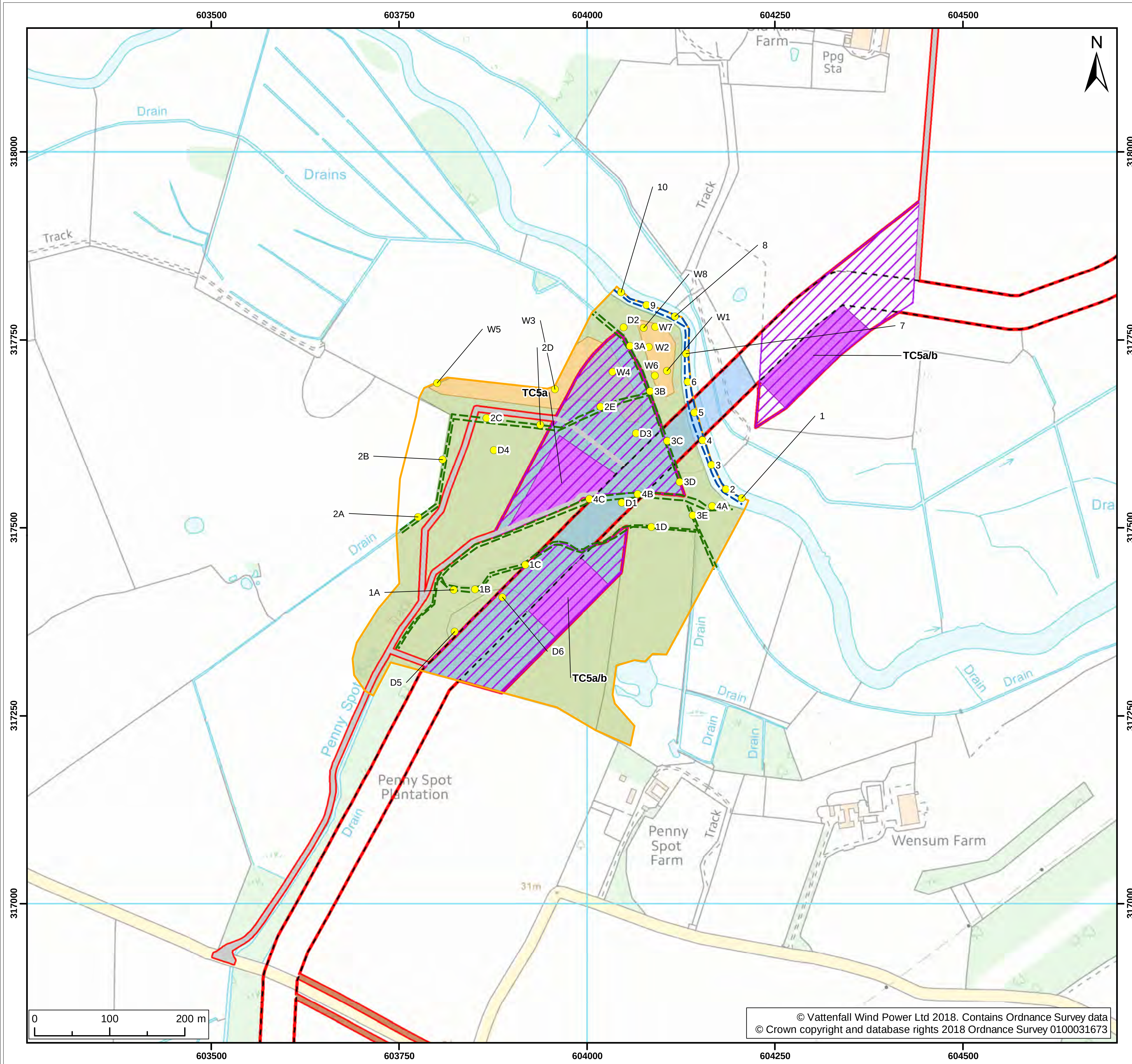

Legend:

- Norfolk Vanguard onshore red line boundary

Onshore cable route

- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound

Access

- Construction access
- Operation access

Survey Area

- 2017 Botanical Survey Area
- River Wensum floodplain located within the Norfolk Vanguard red line boundary
- River Wensum survey
- Ditch surveys

National Vegetation Classification (NVC) survey results[1]

- MG10
- MG6
- Sampling locations

[1] NWS, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

Botanical survey results

Figure: 9.1 | Drawing No: PB4476-006-001-011

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
04	31/05/2018	PS	GC	A3	1:5,000
03	16/05/2018	PS	GC	A3	1:5,000

Co-ordinate system: British National Grid **EPSG:** 27700

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1085. The River Wensum within the cable corridor is approximately 2m deep and 20m wide, with good marginal vegetation, often floating in dense mats. Tree coverage is sparse on the southern bank, with only the occasional white willow *Salix alba* recorded. More trees are present on the northern bank, comprising some oaks *Quercus robur* and alders *Alnus glutinosa*.

1086. Two main NVC communities (following Rodwell, 2006) were identified within the stretch of the River Wensum surveyed in July 2017:

- A8a-*Nuphar lutea* community, species-poor sub community; and
- S5-Glycerietum maximae swamp, Alisma plantago-aquatica-Sparganium erectum sub community.

1087. The semi-improved grassland adjacent to the River Wensum consisted of two main NVC communities (following Rodwell, 2006), which were often transitional to each other:

- MG6 – Lolium perenne-Cynosusus cristatus grassland; and
- MG10 – *Holco-Juncetum effusi* rush pasture.

1088. Five separate communities (following Doarks and Leach, 1990) were identified within the drain ditches of the River Wensum floodplain within the survey area:

- Aquatic End Group A5b – *Lemna minor-Lemna trisulca*-filamentous algae;
- Aquatic End Group A6 - Callitriche stagnalis/platycarpa;
- Aquatic End Group A7b - Potamogenton pectinatus-Myriophyllum spicatum;
- Emergent End Group E1 – Carex riparia/acutiformis-Phragmities australis;
- Emergent End Group E2 – Glyceria Maxima-Berula erecta; and
- Emergent End Group E3 - *Juncus effusus.*

1089. None of the following species, associated with the River Wensum SAC habitat were recorded during the botanical survey within the River Wensum or its floodplain: *R. peltatus, R. penicillatus ssp. pseudofluitans or R. fluitans*.

1090. There was no evidence of calcareous ground water spring or seepage activity with the survey area.

1091. The full findings of the botanical survey are shown in Appendix 9.1.

9.1.1.3. Desmoulin's whorl snail

9.1.1.3.1. Details of the qualifying feature

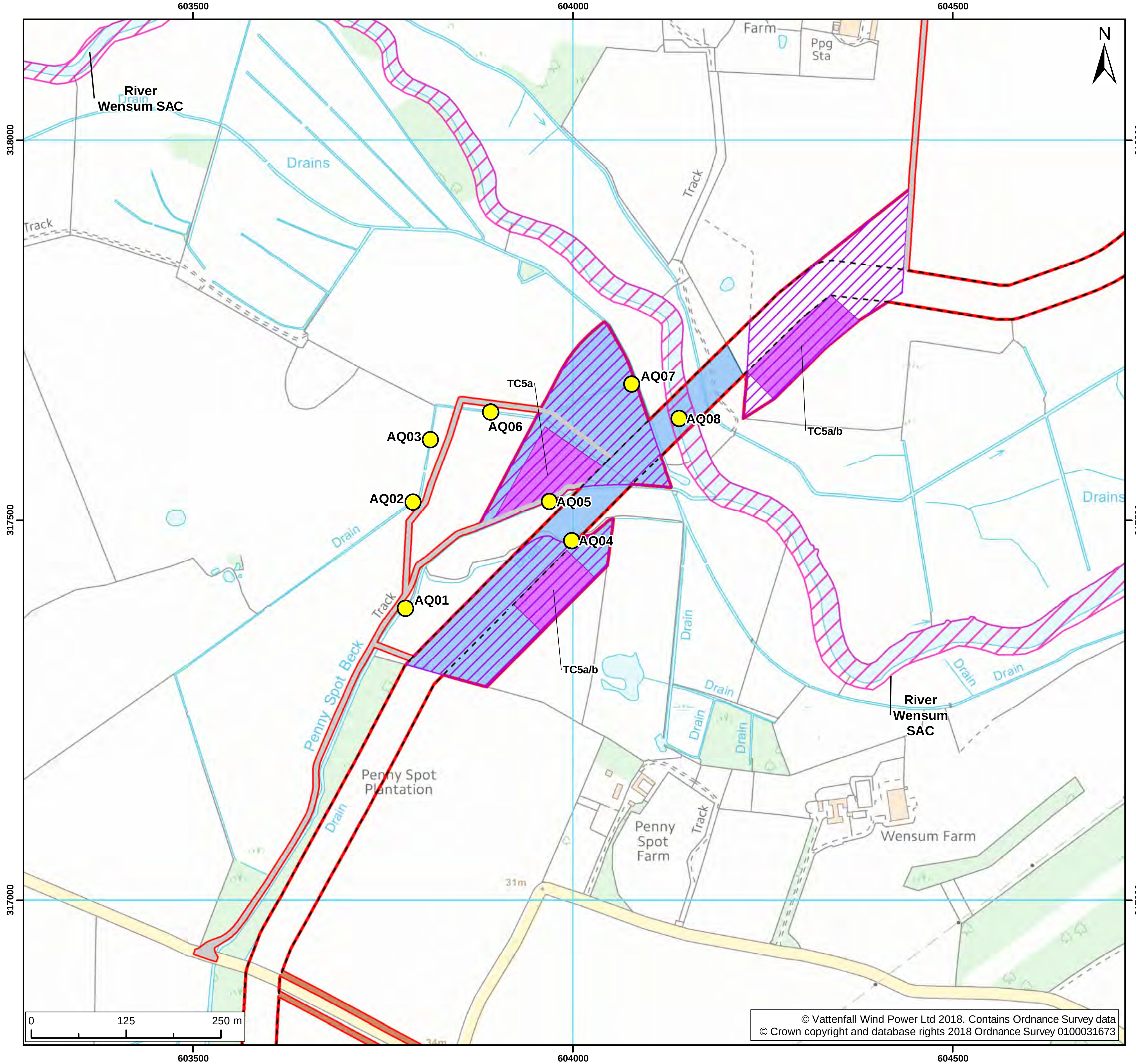
1092. The Desmoulin's whorl snail is a European Protected Species (EPS) listed on Annex II of the Habitats Directive (92/43/EEC) and implemented in the UK by the Conservation of Habitats and Species Regulations 2017 (as amended).

1093. The site is described in the SAC citation as follows:

1094. "The site has an abundant and diverse mollusc fauna which includes Desmoulin's whorl-snail *Vertigo moulinsiana*, which is associated with aquatic vegetation at the river edge and adjacent fens." (English Nature, 2005).

9.1.1.3.2. Status of the qualifying feature within the onshore project area and adjacent habitats

1095. As noted above, the SAC intersects the Norfolk Vanguard cable corridor at Elsing, and at the point where the SAC is crossed by the cable corridor, the SAC boundary covers the River Wensum river channel only (i.e. no floodplain habitat). The location of the onshore cable corridor with respect to the SAC boundary and its associated ex-situ habitats relevant to the Desmoulin's whorl snail are shown in Figure 9.2**.**



Legend:

- Norfolk Vanguard onshore red line boundary

Onshore cable route

- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound

Access

- Construction access
- Operation access

Environmental Designation

- Special Area of Conservation (SAC)[1]

Survey Results

- Invertebrate survey location[2]
- Desmoulin's whorl snail likely absent[2]
- River Wensum floodplain located within the Norfolk Vanguard red line boundary

[1] Natural England, 2017
[2] NWS, 2018

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

River Wensum SAC Desmoulin's whorl snail survey locations

Figure: 9.2 Drawing No: PB4476-006-001-012

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
03	25/05/2018	PS	GC	A3	1:5,000
02	23/05/2018	PS	GC	A3	1:5,000

Co-ordinate system: British National Grid **EPSG:** 27700

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1096. In addition to the SAC boundary, there are also four ditches within the floodplain habitat on the right-hand (southern) bank of the River Wensum, and one further ditch in the floodplain habitat on the left-hand (northern) bank.

1097. Following consultation with Natural England during the Evidence Plan Process in January 2017, a Desmoulin's whorl snail survey of the River Wensum and its associated ditches was proposed to understand any potential effects of the proposed works on this species within both the SAC boundary and its associated ditches.

1098. Desmoulin's whorl snail surveys of the southern bank of the River Wensum and the ditches of the floodplain on the southern bank of the River Wensum (the 'survey area') were carried out in August 2017, following the monitoring protocol developed by Killen and Morkens (2003). The location of the surveys is shown in Figure 9.2.

1099. Desmoulin's whorl snail was not recorded during any survey, and is therefore considered to be absent from the survey area. Furthermore, no records of Desmoulin's whorl snail were identified during the desk study, indicating that this species has not been recorded within 2km of the onshore project area previously.

1100. The full findings of the Desmoulin's whorl snail survey are shown in Appendix 9.2.

9.1.1.4. Other qualifying features

1101. Brook lamprey, bullhead and white-clawed crayfish are also listed as qualifying features of the River Wensum SAC. As set out in the Onshore Screening Report (Appendix 5.2), potential effects upon these features have been screened out due to the use of trenchless crossing techniques (e.g. HDD) at the River Wensum removing the risk of potential direct effects upon the SAC boundary and the qualifying features it supports. Furthermore, it is noted that advice received from the Environment Agency as part of the Evidence Plan Process indicated that white-clawed crayfish are not known to be present in any reaches located within the study area (Environment Agency, pers. comm. 24th March 2017).

9.1.1.5. Conservation Objectives

1102. Natural England's conservation objectives for the River Wensum SAC aim to implement the appropriate maintenance or restoration of the site to preserve or improve the integrity. The objectives also ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features. Specific actions to meet the objectives include maintaining and restoring:

- The extent and distribution of qualifying natural habitats and habitats of qualifying species;

- The structure and function (including typical species) of qualifying natural habitats;
- The structure and function of the habitats of qualifying species;
- The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;
- The populations of qualifying species; and,
- The distribution of qualifying species within the site.

9.1.2. Paston Great Barn SAC

9.1.2.1. Description of Designation

1103. The Paston Great Barn SAC includes the 16th century thatched Paston Great Barn and associated outbuildings located in Paston, Norfolk. The 0.95ha site is located approximately 2.9km from the onshore project area at its closest point. Paston Great Barn SAC is designated as it is the only known maternity roost of barbastelle bats in a building in the UK, and is one of just three known such roosts in any structure in the UK. It is also the only known barbastelle bat maternity roost in Norfolk.

9.1.2.2. Barbastelle bats

9.1.2.2.1. Details of the qualifying feature

1104. Barbastelle bats are a EPS and an Annex II species, and are the primary reason for this designation. There are no further qualifying features or supporting reasons for the designation.

1105. The barbastelle bat is rare in both Europe and the UK, with a population in the order of 5,000 adults estimated to reside within the UK (Harris *et al.* , 1995). Domestically it is found in southern England and Wales only, and is mainly associated with East Anglia and the south west of England (Bat Conservation Trust, 2010). East Anglia is considered to support a population that is highly significant in the context of national distribution (Norfolk County Council, 2009). The Norfolk population of barbastelle is particularly concentrated in the north and west of the county (Norfolk County Council, 2009).

1106. Barbastelle bats forage in mature woodland and woodland edges, feeding mostly on large moths (Andrea *et al.* 2012). Barbastelles can have large home ranges of up to 20km, but are more likely to forage within areas of closer to 6-7km from their colony (Zeale *et al.* 2012). Barbastelles also show a high fidelity to roosting and foraging areas but not to single trees, which are changed frequently (Zeale *et al.* 2012).

1107. The Norfolk Biodiversity Partnership species action plan for barbastelle identifies the following key threats to this species within the county (Norfolk County Council, 2009):

- Loss and fragmentation of a broad mosaic of habitats including ancient semi-natural woodland, mature species-rich hedgerows, ancient trees and wood pasture, invertebrate rich pasture land and sympathetically managed riparian habitats;
- Loss, destruction and disturbance of roosts or potential roosts in buildings, trees and underground sites; and
- A reduction in numbers of insect prey as a result of habitat simplification, stemming from factors such as insecticide use and intensive grazing.

9.1.2.2.2. Status of the qualifying feature within the onshore project area and adjacent habitats

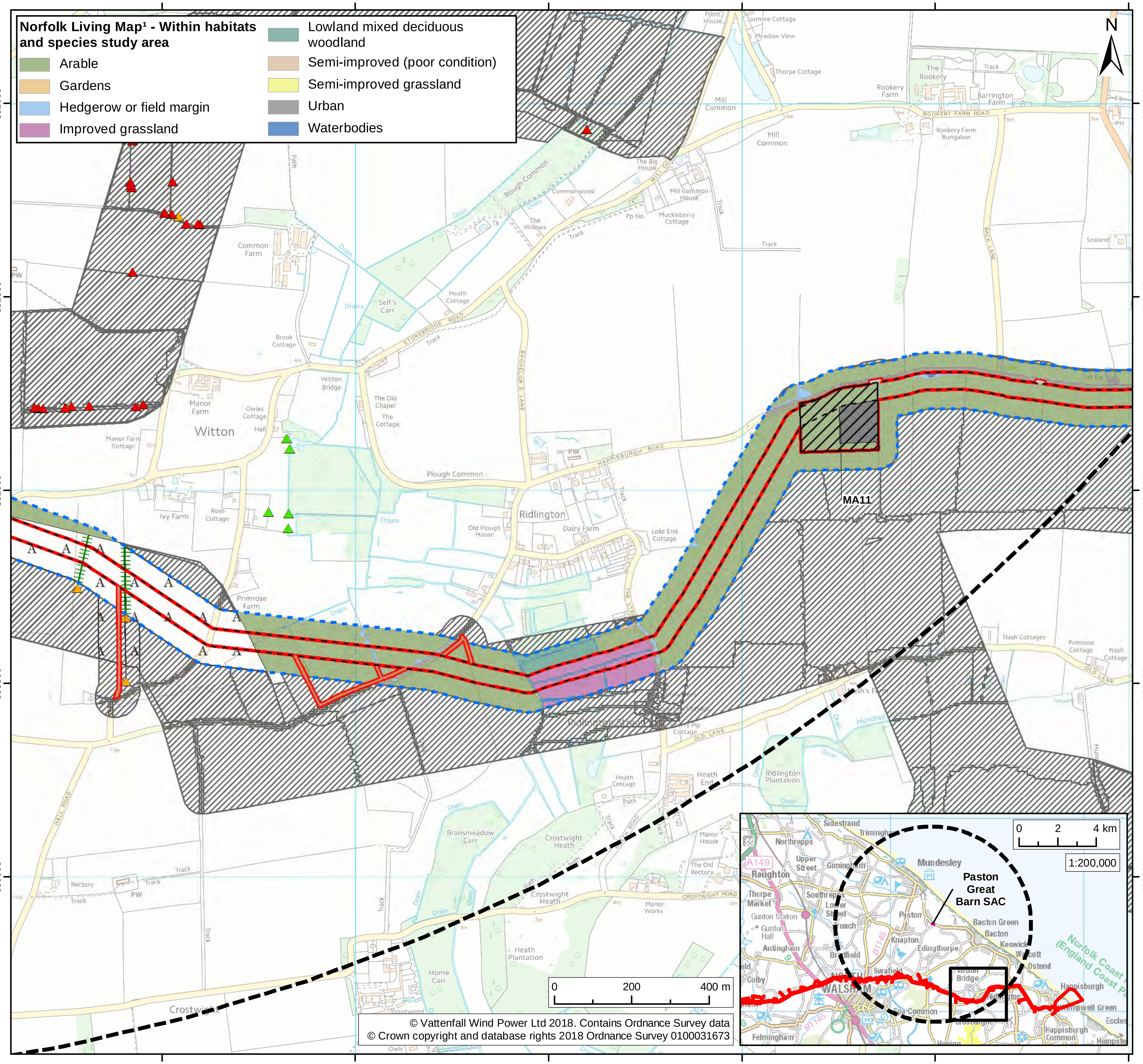
1108. The Paston Great Barn SAC is situated 2.9km from the onshore project area at its closest point (Edingthorpe Green). However approximately 80ha of the onshore project area is located within 5km of the Paston Great Barn SAC, covering land from Swafield in the west to Ridlington in the East. Within this 5km range, the land is predominantly arable crop and hedgerows. Table 9.1 summarises the habitats which are present within this 5km area and their approximate area in hectares (ha).

Table 9.1 Habitat footprints within the onshore project area within 5km of Paston Great Barn SAC

Habitat type	Area (ha)
Lowland Mixed Deciduous Woodland	0.32
Broadleaved woodland - semi-natural	0.04
Scrub - dense/continuous	0.05
Broadleaved Parkland/scattered trees	<0.01
Neutral grassland - semi-improved	0.03
Improved grassland	1.27
Marsh/marshy grassland	0.96
Poor semi-improved grassland	0.40
Standing water	0.23
Cultivated/disturbed land - arable	56.98
Gardens	<0.01
Urban	0.65
Habitat	**Length (m)**
Hedgerow or Field Margin	475

Habitat type	Area (ha)
Intact hedge - species-poor	68
Hedge with trees - native species-rich	240
Dry ditch	175

1109. The locations of these habitats within the onshore project area are shown on Figure 9.3.



Legend:

- Norfolk Vanguard onshore red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Onshore cable route

- Onshore cable route
- Mobilisation zone
- Indicative mobilisation area compound

Access

- Construction access
- Operation access

Environmental Designation

- Special Area of Conservation (SAC)¹

Survey Areas

- Habitats and Species Study Area
- 2017 Extended Phase 1 Habitat Survey data and Living Map data outside of habitats and species study area

Bat Roost Feature

- High suitability
- Moderate suitability
- Low suitability

Phase 1 Habitat Classification - Within habitats and species study area

- A Cultivated/disturbed land - arable
- Hedge with trees - Species-poor

¹ Natural England, 2017.
² NBIS, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - habitats located within onshore infrastructure (Map 1 of 3)

Figure: 9.3 Drawing No: PB4476-006-001-013

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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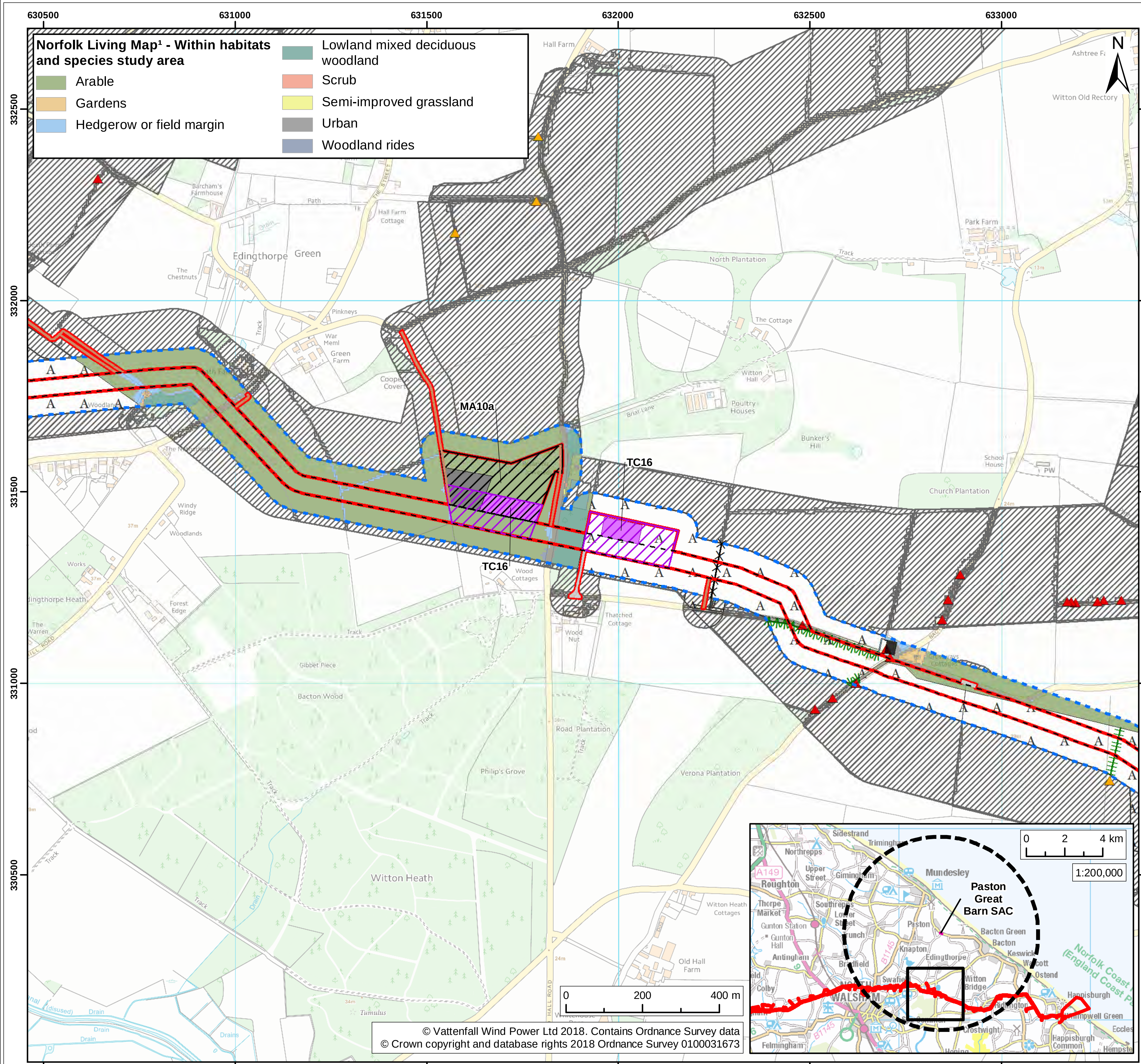

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Legend:

- Norfolk Vanguard onshore red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Onshore cable route

- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound
- Mobilisation zone
- Indicative mobilisation area compound

Access

- Construction access
- Operation access

Environmental Designation

- Special Area of Conservation (SAC)¹

Survey Areas

- Habitats and Species Study Area
- 2017 Extended Phase 1 Habitat Survey data and Living Map data outside of habitats and species study area

Bat Roost Feature

- Moderate suitability
- Low suitability

Phase 1 Habitat Classification - Within habitats and species study area

- Scrub - scattered
- Broadleaved Parkland/scattered trees
- Cultivated/disturbed land - arable
- Buildings
- Bare ground
- Hedge with trees - Native species-rich
- Hedge with trees - Species-poor
- Boundary removed

¹ Natural England, 2017.
² NBIS, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - habitats located within onshore infrastructure (Map 2 of 3)

Figure: 9.3 Drawing No: PB4476-006-001-013

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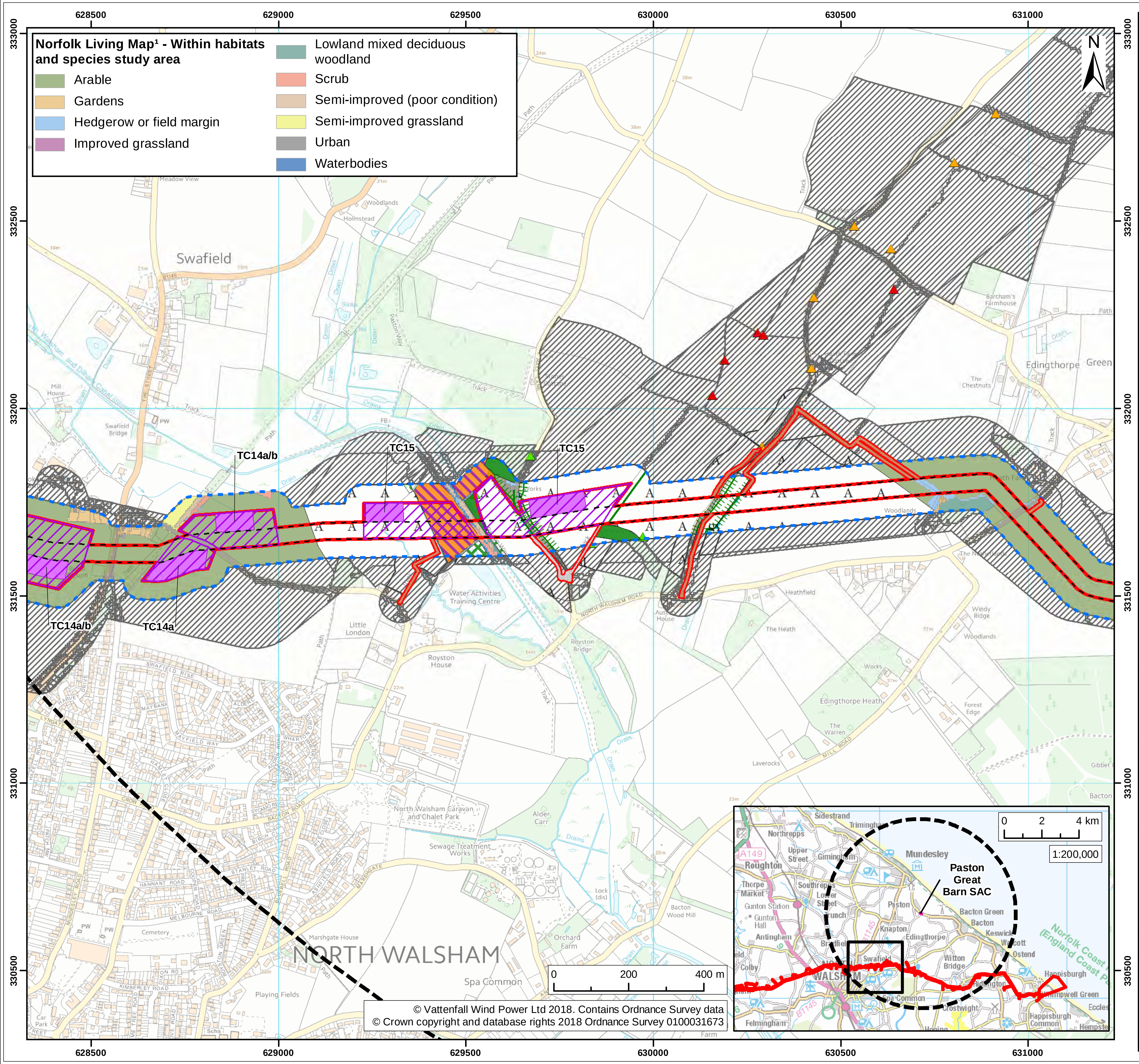

Legend:

Norfolk Vanguard onshore red line boundary

Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Onshore cable route

Onshore cable route

Trenchless crossing zone (e.g. HDD)

Indicative trenchless crossing compound

Access

Construction access

Operation access

Environmental Designation

Special Area of Conservation (SAC)¹

Survey Areas

Habitats and Species Study Area

2017 Extended Phase 1 Habitat Survey data and Living Map data outside of habitats and species study area

Bat Roost Feature

High suitability

Moderate suitability

Low suitability

Phase 1 Habitat Classification - Within habitats and species study area

Broadleaved woodland - semi-natural

Scrub - dense/continuous

Coniferous Parkland/scattered trees

Marsh/marshy grassland

SI Poor semi-improved grassland

A Cultivated/disturbed land - arable

Intact hedge - Species-poor

Hedge with trees - Species-poor

Dry ditch

¹ Natural England, 2017.
² NBIS, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - habitats located within onshore infrastructure (Map 3 of 3)

Figure: 9.3 Drawing No: PB4476-006-001-013

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1110. Norfolk Barbastelle Study Group (NBSG) has undertaken radio-tracking surveys of female barbastelle bats within the Paston Great Barn colony. Radio-tracking of between one and three females has been undertaken on six occasions between August 2013 and April 2015. The data obtained from this radio-tracking survey have been used to build up a picture of the home range for females which form part of the Paston Great Barn colony. The location of this home range is shown on Figure 3 in Appendix 5.2. The radio-tracking data indicate that the home range for the Paston Great Barn maternity colony covers an area which includes coastal habitat from Mundesley to Walcott in the east, Pigney's Wood and Dilham Canal in the west, and Bacton Wood and land around Witton in the south. This includes an area of approximately 70ha of the onshore project area footprint (see Appendix 5.2).

1111. The radio-tracking data have also been used by NSBG to identify commuting and foraging routes used by females of the Paston Great Barn maternity colony. Figures 5-6 and 11-12 in Appendix 5.2 show the foraging areas and commuting routes identified using the radio-tracking data. These are also shown on Appendix 5.2 of this report. These indicate that the following key commuting and foraging features of the Paston Great Barn maternity colony are located within the onshore project area:

- Dilham Canal and land east of Dilham Canal (foraging);
- Hedgerow along North Walsham Road from Edingthorpe Green to Edingthorpe Heath (commuting/foraging);
- Witton Hall Plantation along Old Hall Road (commuting/foraging);
- Road from Bacton Wood to Witton (commuting); and
- Two hedgerows between Witton and North Walsham Road (commuting/foraging).

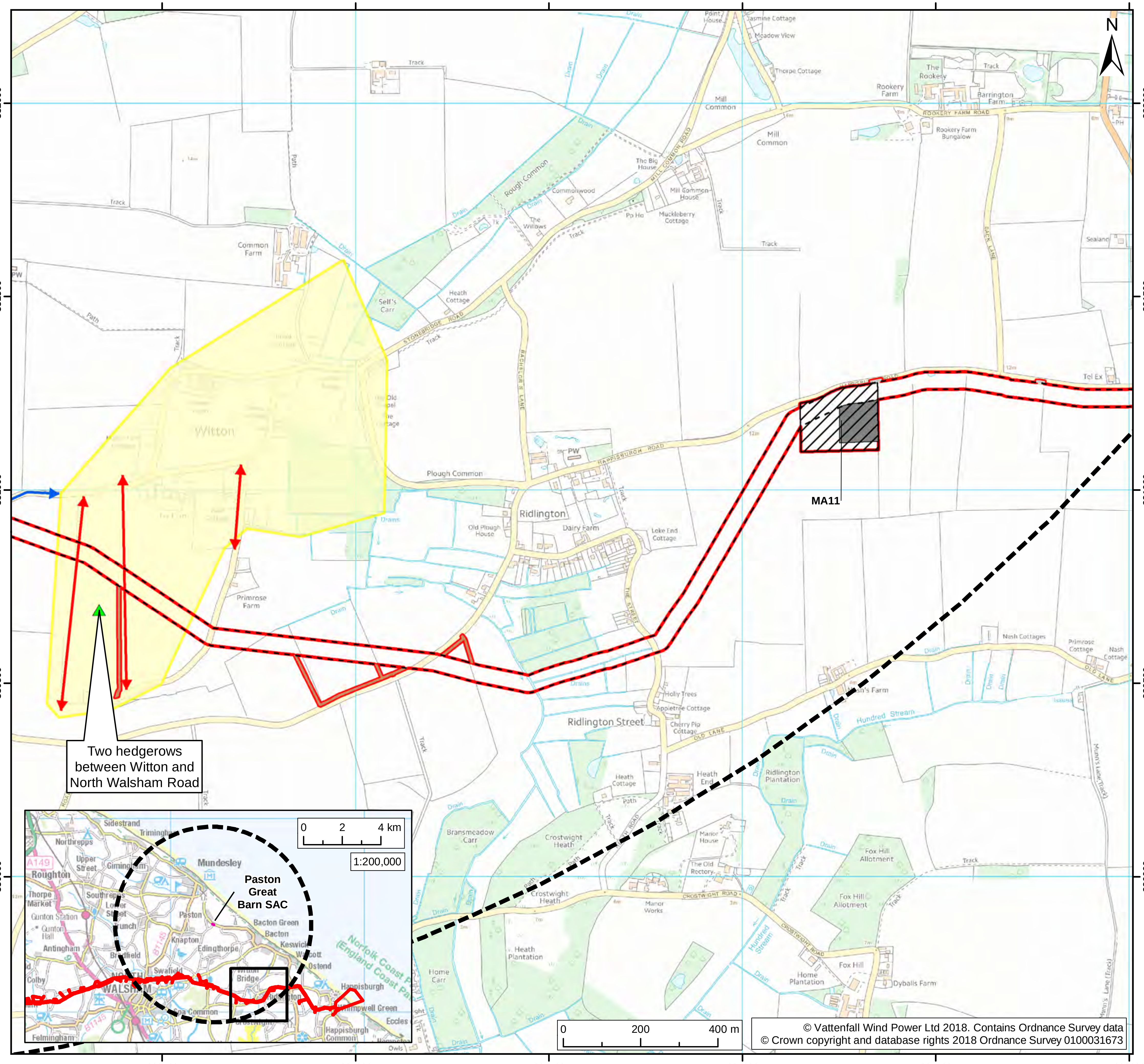
1112. Occasional foraging has also been recorded at the following location:

- Drains and hedgerows at Ridlington Street.

1113. The following points should be noted with regards to these data:

- The key foraging area identified by the radio-tracking data is the coastal cliffs at Mundesley. The inland foraging areas (including all of those listed above) were recorded during inclement weather conditions along the coast, making foraging at the cliffs unfavourable. Inland foraging was therefore also predominantly recorded in spring and autumn; and
- The radio-tracking data are based on data from up to three females from a maternity colony of between 20-55 individuals. Therefore, there are possible other commuting foraging routes used which have not been identified using the radio tracking data.

1114. During 2017, a suite of bat activity surveys were undertaken along 26 transects within the onshore project area between May and October. This included five transects within 5km of the Paston Great Barn SAC. The location of these transects is shown in Figure 9.4.



Legend:
- Norfolk Vanguard onshore red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer[1]

Onshore cable route
- Onshore cable route
- Mobilisation zone
- Indicative mobilisation area compound

Access
- Construction access
- Operation access

Environmental Designation
- Special Area of Conservation (SAC)[1]

Survey Results
- Commuting/foraging routes[2]
- Commuting routes[2]
- Core foraging areas[2]
- Important barbastelle features

[1] Natural England, 2017.
[2] Norfolk Barbastelle Study Group, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - location of important barbastelle features (Map 1 of 3)

Figure: 9.4 Drawing No: PB4476-006-001-014

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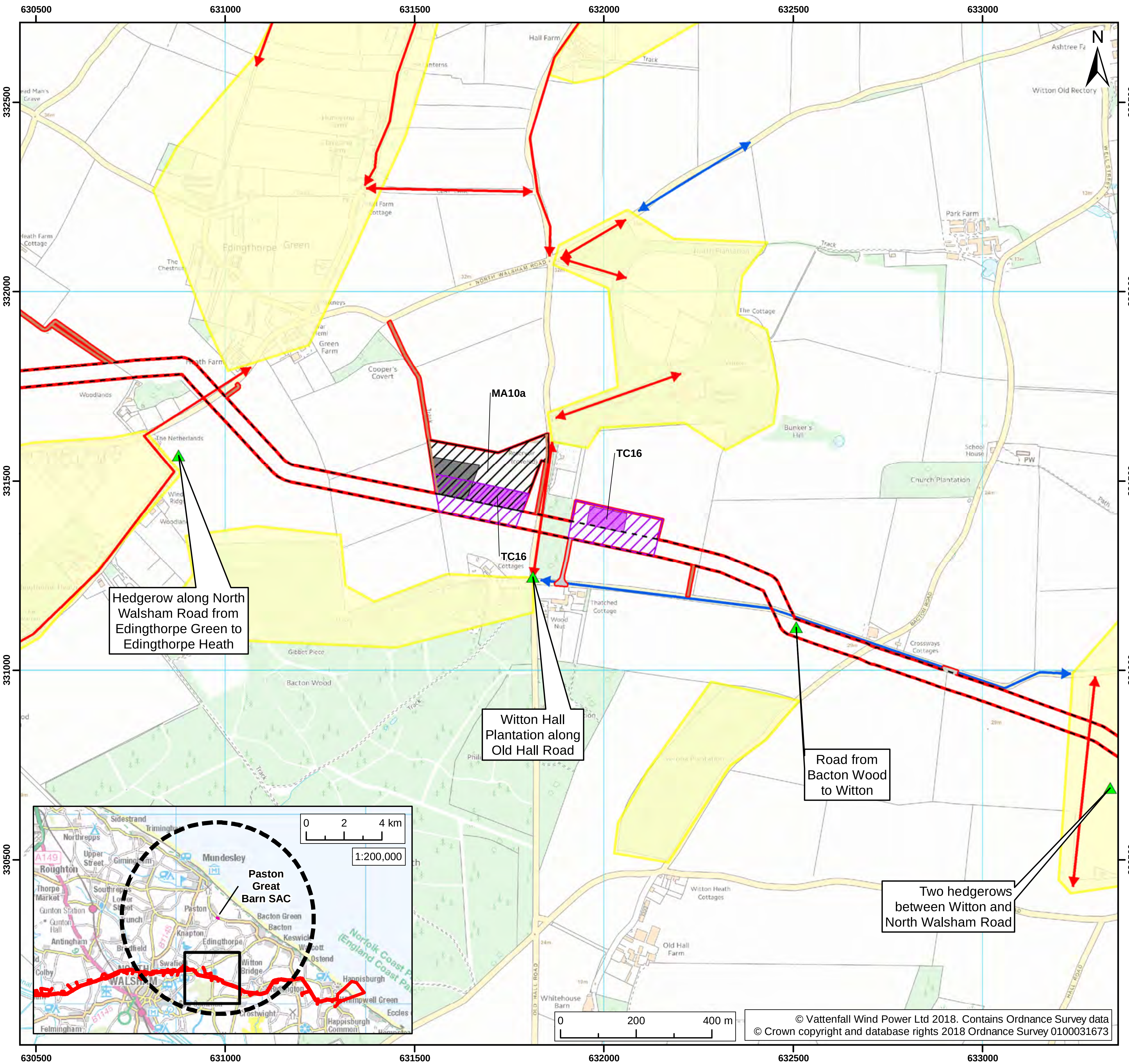

Legend:

- Norfolk Vanguard onshore red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer[1]

Onshore cable route

- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound
- Mobilisation zone
- Indicative mobilisation area compound

Access

- Construction access
- Operation access

Environmental Designation

- Special Area of Conservation (SAC)[1]

Survey Results

- Commuting/foraging routes[2]
- Commuting routes[2]
- Core foraging areas[2]
- Important barbastelle features

[1] Natural England, 2017.
[2] Norfolk Barbastelle Study Group, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - location of important barbastelle features (Map 2 of 3)

Figure: 9.4 Drawing No: PB4476-006-001-014

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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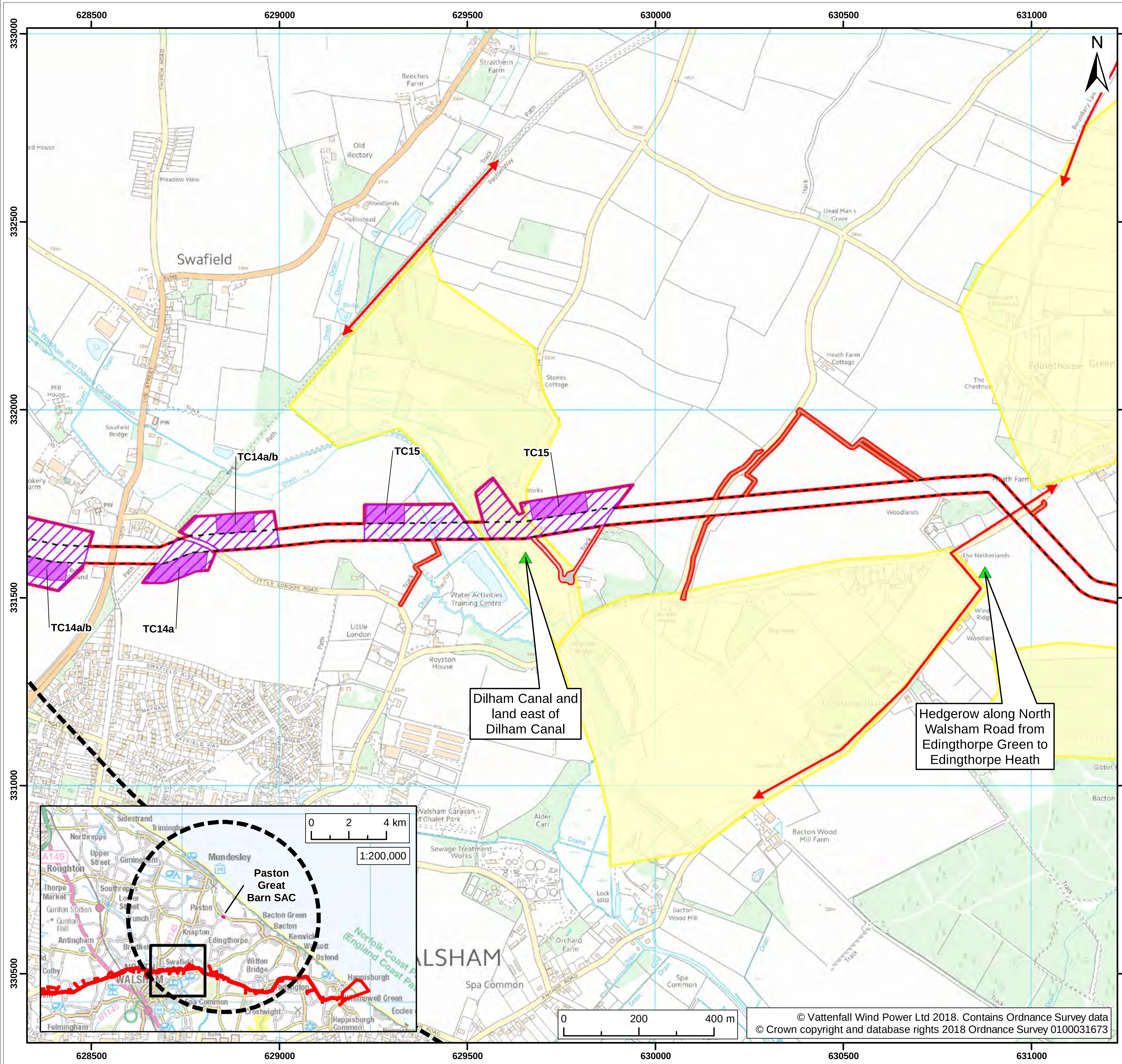

Legend:
- Norfolk Vanguard onshore red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer[1]

Onshore cable route
- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound

Access
- Construction access
- Operation access

Environmental Designation
- Special Area of Conservation (SAC)[1]

Survey Results
- Commuting/foraging routes[2]
- Core foraging areas[2]
- Important barbastelle features

[1] Natural England, 2017.
[2] Norfolk Barbastelle Study Group, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:
Paston Great Barn SAC - location of important barbastelle features
(Map 3 of 3)

Figure: 9.4 Drawing No: PB4476-006-001-014

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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1115. Data were collected over six months with the aim of providing a detailed understanding of the usage of potential commuting and foraging features within the onshore project area by bats. Transects were designed to cover all linear features which had been identified (and subsequently assessed) as providing 'moderate' or greater suitability for supporting commuting of foraging bats following the Bat Conservation Trust's *Bat Surveys for Professional Ecologists: Good Practice Guidelines* (Collins *et al.,* 2016). Where survey access was possible, all transects were walked bi-monthly and all bat echolocations recorded. Static detectors were also set out along each transect for five nights each month, with two or three detectors placed on transects covering linear features identified as providing 'moderate' or 'high' suitability for supporting commuting of foraging bats respectively. Full details of the 2017 bat activity surveys are provided within Appendix 9.3.

1116. These transects covered the following areas identified above by the NBSG's radio-tracking data:

- Dilham Canal (foraging);
- Witton Hall Plantation along Old Hall Road (commuting/foraging); and
- Road from Bacton Wood to Witton (commuting).

1117. Barbastelles were recorded commuting and foraging along all five transects. The key findings from the 2017 transect surveys are summarised in Table 9.2 below.

Table 9.2 Barbastelle records for all transects located within 5km of Paston Great Barn

Transect	Transect location	Total species peak count	Barbastelle peak count (per night)	Months barbastelle recorded	Further comments
BACT 19	Land between Walcott Green and Happisburgh	1188	3	July, September and October	Occasional barbastelle records only, barbastelles only associated with hedgerow at BA55
BACT 21	Dilham Canal and land east of Dilham Canal	529	2	October only	Occasional barbastelle record only, barbastelles only associated with hedgerow along Hall Lane
BACT 22	Witton Hall, Witton Hall Plantation and Edingthorpe Road	1650	13	Full survey period (May – October)	Barbastelles recorded throughout transect
BACT 24	Land south of Nash's Lane, Ridlington Street	30	1	June only	Partial surveys results only – access rescinded from July onwards Occasional barbastelle record only

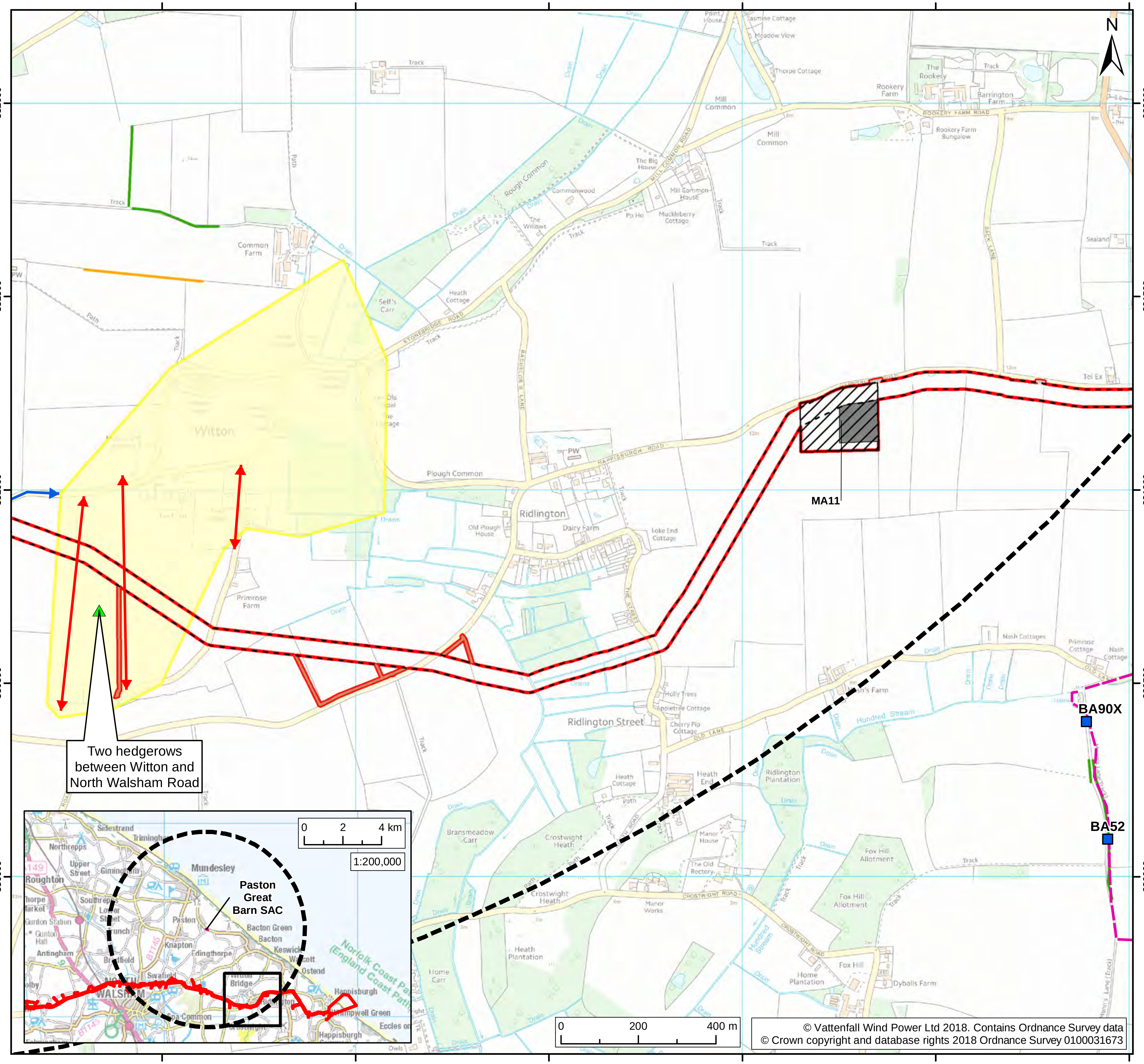
Transect	Transect location	Total species peak count	Barbastelle peak count (per night)	Months barbastelle recorded	Further comments
BACT 34	Land west of B1159, Walcott Green	3083	4	July, October and September	Barbastelles recorded along hedgerow at BA52

1118. Any commuting / foraging feature where bats have been recorded during more than a single visit (i.e. BACT 19, BACT 22 and BACT 34) are considered to be important features for supporting barbastelle bats. Although BACT 21 (Dilham Canal and land east of Dilham Canal) only recorded a single possible barbastelle record (two passes within a few minutes of each other, likely the same individual), given the radio-tracking data for this site it is also considered to be an important feature for bats. Two of these features, BACT 19 and BACT 34, are located outside 5km from Paston Great Barn SAC. Given their distance from Paston Great Barn SAC (6km and 6.1km respectively) it is assumed that the barbastelles they support are unlikely to be from the Paston Great Barn colony.

1119. Based on a combination of the radio-tracking data for Paston Great Barn and the activity data recorded during 2017, the following hedgerows have been identified as important for supporting commuting or foraging barbastelle within 5km of the Paston Great Barn SAC:

- Dilham Canal and land east of Dilham Canal (foraging);
- Hedgerow along North Walsham Road from Edingthorpe Green to Edingthorpe Heath (commuting/foraging);
- Witton Hall Plantation along Old Hall Road (commuting/foraging);
- Road from Bacton Wood to Witton (commuting); and
- Two hedgerows between Witton and North Walsham Road (commuting/foraging).

1120. The locations of these features can be seen on Figure 9.5.



Legend:

- Norfolk Vanguard onshore red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer[1]

Onshore cable route

- Onshore cable route
- Mobilisation zone
- Indicative mobilisation area compound

Access

- Construction access
- Operation access

Environmental Designation

- Special Area of Conservation (SAC)[1]

Bat activity transects surveyed during 2017[2]

- Important for commuting / foraging bats
- Static bat detectors[2]

Features with suitability to support commuting / foraging bats as identified with the Extended Phase 1 Habitat Survey

- Moderate suitability
- High suitability

Norfolk Barbastelle Study Group Survey Results

- Commuting/foraging routes[2]
- Commuting routes[2]
- Core foraging areas[2]
- Important barbastelle features

[1] Natural England, 2017.
[2] Norfolk Barbastelle Study Group, 2017.

Project:	Report:
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Title:

Paston Great Barn SAC - bat activity survey (Map 1 of 3)

Figure: 9.5 Drawing No: PB4476-006-001-015

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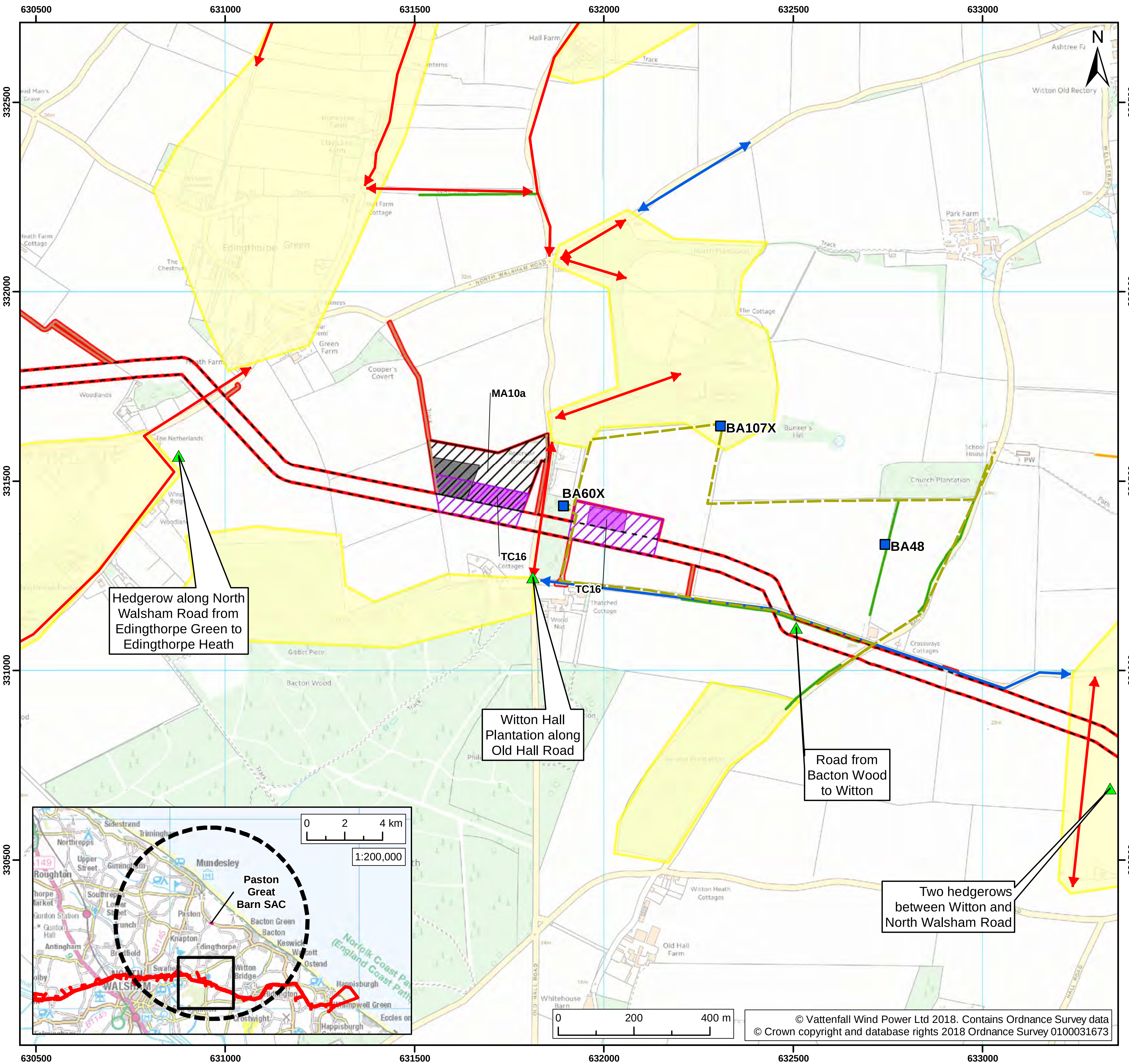

Legend:

- Norfolk Vanguard onshore red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer[1]

Onshore cable route

- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound
- Mobilisation zone
- Indicative mobilisation area compound

Access

- Construction access
- Operation access

Environmental Designation

- Special Area of Conservation (SAC)[1]

Bat activity transects surveyed during 2017[2]

- Important for commuting / foraging bats including barbastelle
- Static bat detectors[2]

Features with suitability to support commuting / foraging bats as identified with the Extended Phase 1 Habitat Survey

- Moderate suitability
- High suitability

Norfolk Barbastelle Study Group Survey Results

- Commuting/foraging routes[2]
- Commuting routes[2]
- Core foraging areas[2]
- Important barbastelle features

[1] Natural England, 2017.
[2] Norfolk Barbastelle Study Group, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - bat activity survey (Map 2 of 3)

Figure: 9.5 Drawing No: PB4476-006-001-015

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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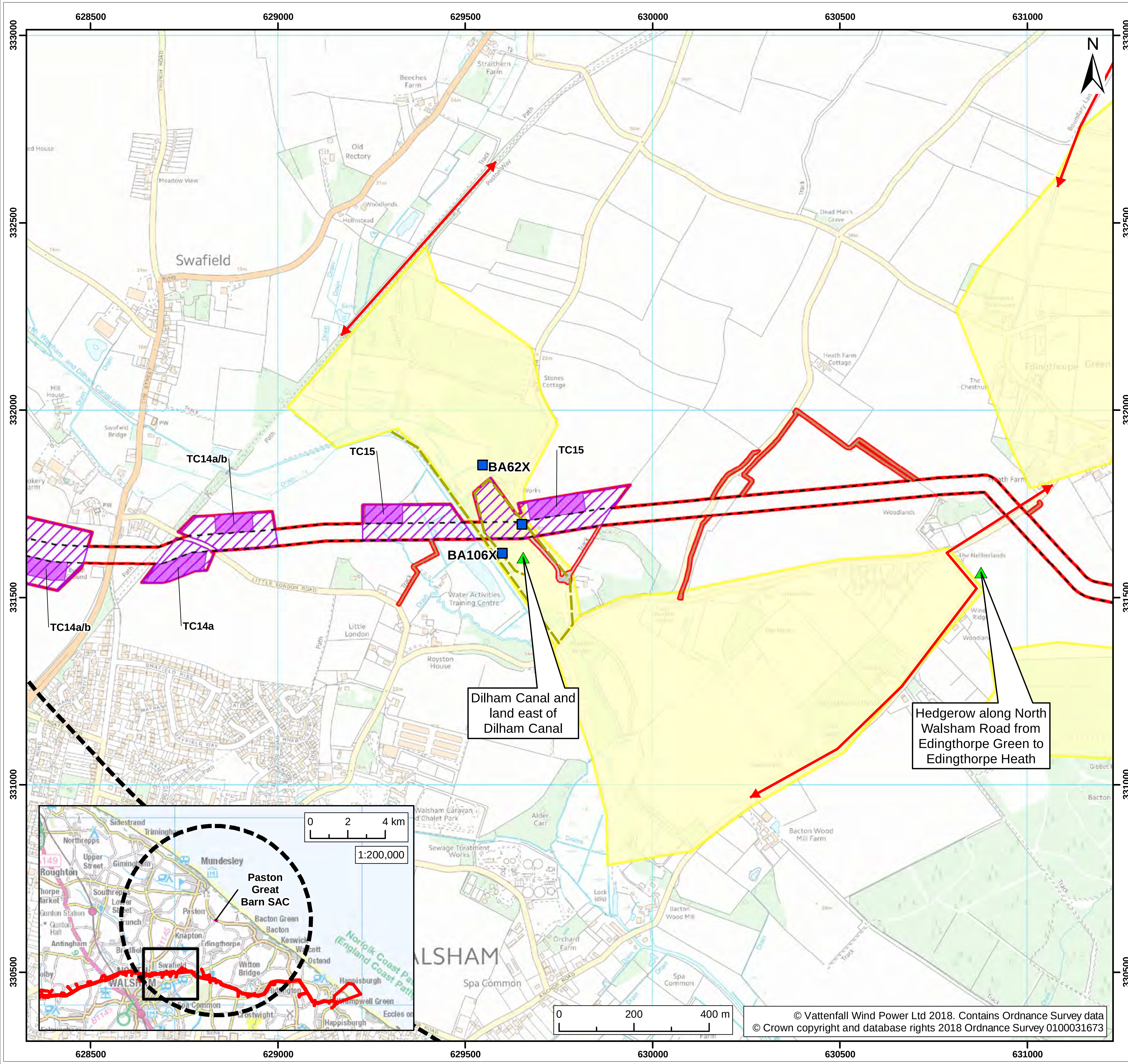

Legend:

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- Paston Great Barn Special Area of Conservation (SAC) 5km buffer[1]

Onshore cable route

- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound

Access

- Construction access
- Operation access

Environmental Designation

- Special Area of Conservation (SAC)[1]

Bat activity transects surveyed during 2017[2]

- Important for commuting / foraging bats including barbastelle
- Static bat detectors[2]

Norfolk Barbastelle Study Group Survey Results

- Commuting/foraging routes[2]
- Core foraging areas[2]
- Important barbastelle features

[1] Natural England, 2017.
[2] Norfolk Barbastelle Study Group, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - bat activity survey (Map 3 of 3)

Figure: 9.5 Drawing No: PB4476-006-001-015

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9.1.2.3. Conservation Objectives

1121. The conservation objectives identified for Paston Great Barn SAC, as detailed by Natural England, include maintaining or restoring:

- The extent and distribution of the habitats of qualifying species;
- The structure and function of the habitats of qualifying species;
- The supporting processes on which the habitats of qualifying species rely;
- The populations of qualifying species; and
- The distribution of qualifying species within the site.

1122. The implementation of these conservation objectives will ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features (i.e. barbastelle bats).

9.1.3. Norfolk Valley Fens SAC

9.1.3.1. Description of Designation

1123. In its entirety, the Norfolk Valley Fens SAC occupies an area of 616.48ha. The SAC is a composite designation formed of 17 individual SSSIs spread across Norfolk which support differing qualifying features, comprising a series of valley-head spring-fed flush fens. Such spring-fed flush fens are very rare in lowland areas. Spring-heads are dominated by the small sedge fen type, mainly referable to black-bog-rush – blunt-flowered rush (*Schoenus nigricans – Juncus subnodulosus*) mire, but there are transitions to reedswamp and other fen and wet grassland types. Individual sites vary in their structure depending on the intensity of management and provide a wide range of variation. There is a rich flora associated with these fens, including species such as grass-of-Parnassus *Parnassia palustris*, common butterwort *Pinguicula vulgaris*, marsh helleborine *Epipactis palustris* and narrow-leaved marsh-orchid *Dactylorhiza traunsteineri*.

1124. Five of the 17 SSSIs of the Norfolk Valley Fens SAC fall within 5km of the onshore project area. These sites are summarised in Table 9.3 below.

Table 9.3 Norfolk Valley Fens SAC component SSSIs

Site name	Distance to onshore project area	SAC qualifying features supported by the site
Badley Moor	3.6km	• Alkaline fens. (Calcium-rich springwater-fed fens) • Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae). (Purple moor-grass meadows)
Booton Common	0.6km	• Alkaline fens. (Calcium-rich springwater-fed fens) • Northern Atlantic wet heaths with Erica tetralix. (Wet heathland with cross-leaved heath)

Site name	Distance to onshore project area	SAC qualifying features supported by the site
Buxton Heath	3.9km	• Alkaline fens. (Calcium-rich springwater-fed fens) • Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnionincanae, Salicion albae). (Alder woodland on floodplains)Calcareous fens with Cladium mariscus and species of the Caricion davallianae. (Calcium-rich fen dominated by great fen sedge (saw sedge)) • European dry heaths • Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae). (Purple moor-grass meadows) • Northern Atlantic wet heaths with Erica tetralix. (Wet heathland with cross-leaved heath)
Potter & Scarning Fens, East Dereham	2.8km	• Calcareous fens with *Cladium mariscus* and species of the Caricion davallianae. (Calcium-rich fen dominated by great fen sedge (saw sedge)) • European dry heaths
Southrepps Common	3.4km	• Alkaline fens. (Calcium-rich springwater-fed fens) • Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnionincanae, Salicion albae). (Alder woodland on floodplains) • Calcareous fens with *Cladium mariscus* and species of the Caricion davallianae. (Calcium-rich fen dominated by great fen sedge (saw sedge))

1125. Only one of these units, Booton Common, is located within 1km, the typical maximum extent of the ZOIs of the potential indirect effects identified within the Onshore Screening Report (Appendix 5.2).

1126. In summary, the following Annex I habitats that are a primary reason for selection of the Norfolk Valley Fens SAC are located across these five sites:

- Alkaline fens. (Calcium-rich springwater-fed fens);
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, *Alnion incanae, Salicion albae*). (Alder woodland on floodplains);
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*. (Calcium-rich fen dominated by great fen sedge (saw sedge));
- European dry heaths;
- *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*). (Purple moor-grass meadows); and
- Northern Atlantic wet heaths with *Erica tetralix*. (Wet heathland with cross-leaved heath).

1127. The remaining Annex I habitats and Annex II species which are qualifying features of the Norfolk Valley Fens SAC are not present within these sites, and therefore are not considered further.

9.1.3.2. Qualifying features

9.1.3.2.1. Details of the qualifying features

1128. The site is described in the SAC citation as follows:

> "This site comprises a series of valley-head spring-fed fens. Such spring-fed flush fens are very rare in the lowlands. The spring-heads are dominated by the small sedge fen type, mainly referable to black-bog-rush – blunt-flowered rush (*Schoenus nigricans – Juncus subnodulosus*) mire, but there are transitions to reedswamp and other fen and wet grassland types. The individual fens vary in their structure according to intensity of management and provide a wide range of variation. There is a rich flora associated with these fens, including species such as grass-of-Parnassus *Parnassia palustris*, common butterwort *Pinguicula vulgaris*, marsh helleborine *Epipactis palustris* and narrow-leaved marsh-orchid *Dactylorhiza traunsteineri*.
>
> In places, the calcareous fens grade into acidic flush communities on the valley sides. Purple moor-grass *Molinia caerulea* is often dominant with a variety of mosses including thick carpets of bog-moss *Sphagnum spp*. Marshy grassland may be present on drier ground and purple moor-grass is again usually dominant but cross-leaved heath *Erica tetralix* can be frequent. Alder *Alnus glutinosa* forms carr woodland in places by streams. Wet and dry heaths and acid, neutral and calcareous grassland surround the mires." (English Nature, 2005).

9.1.3.2.2. Status of the qualifying features within the component SSSIs of Norfolk Valley Fens SAC

1129. The status of the qualifying features of Norfolk Valley Fens SAC within each of the component SSSIs located within 5km of the onshore project area is summarised in Table 9.4 below.

Table 9.4 Status of the qualifying features of the Norfolk Valley Fens SAC within the site's component SSSIs

Site name	Status of the SAC qualifying features supported by the site
Badley Moor	Badley Moor is predominantly a spring fed valley fen which feeds the adjacent River Tud. The community has remained undisturbed and is an excellent example of a very localised habitat and includes many uncommon plants. The rich, short-sward fen communities are of the type that is dominated by Black Bog-rush *Schoenus nigricans* and Blunt-flowered Rush *Juncus subnodulosus*. Many uncommon species are present in abundance and include Common Butterwort *Pinguicula vulgaris*, Great Sundew *Drosera anglica*, Marsh Helleborine *Epi*, Grass of Parnassus and Bog Pimpernel *Anagallis tenella*. These basic flushes grade into a zone of taller mixed fen vegetation dominated by Purple Moor-grass and Reed *Phragmites australis* with frequent Common Cotton-grass i, Bogbean *Menyanthes trifoliata*, Southern Marsh Orchid Dactylorhiza praetermissa and Marsh Lousewort i (English Nature, 1986).

Site name	Status of the SAC qualifying features supported by the site
Booton Common	Booton Common is comprised of a mixture of habitats types including woodland, calcareous fen and acid heath communities. Much of the site (approximately 5.6ha) is comprised of semi-natural deciduous woodland, which occupies the low-lying northern section of the site adjacent to the Blackwater Drain and a strip along the higher ground to the south of the site. The woodland comprises alder carr and ash. The primary interest of site is the calcareous fen and acid heath communities, which cover approximately 2.5ha of land in between these woodland strips. These communities have developed on the naturally undulating ground, with the calcareous fen occupying the lower-lying ground and the acid heath communities occupying the raised areas (English Nature, 1981). The wet hollows are floristically rich and support abundant bog-rush and blunt-flowered rush (NVC type M13 *Schoenus nigricans – Juncus subnodulosus* mire). These areas support the following species characteristic of the Annex I alkaline fen habitat: grass of parnassus, common cotton-grass *Eriophorum angustifolium*, common butterwort, marsh helleborine. Notable additional fen species include fragrant orchid i, adder's tongue fern i and the rare marsh fern i. The ridges between the hollows support a type of wet heathland with heather i and purple moor-grass i as the principal species. Gorse *i* and tormentil *Potentilla erecta* are also present. This habitat is maintained due to the high-water table associated with the Blackwater Drain running along the north of the site. Grazing is also necessary to maintain the habitat (English Nature, 2004).
Buxton Heath	• Alkaline fens. (Calcium-rich springwater-fed fens) • Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnionincanae, Salicion albae*). (Alder woodland on floodplains) Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*. (Calcium-rich fen dominated by great fen sedge (saw sedge)) • European dry heaths • *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*). (Purple moor-grass meadows) • Northern Atlantic wet heaths with *Erica tetralix*. (Wet heathland with cross-leaved heath) Buxton Heath is a diverse heath-with-fen area situated in a basin of glacial sands which forms one of the best examples of this rare habitat type in Norfolk. Although the majority of the site is comprised of woodland (approximately 31ha), the centre of the site supports calcareous fen communities (approximately 2ha) surrounding a small stream, which transition into wet heathland and the dry heathland across the remainder of the site. The calcareous fen is dominated by Blunt-flowered Rush and Quaking Grass *Briza media* with a discontinuous bryophyte carpet. Other species of interest include Grass of Parnassus, Marsh Lousewort *Pedicularis palustris*, Southern Marsh Orchid, Marsh Helleborine and the locally uncommon Marsh Fern *Thelypteris thelypteroides*. Acidic flush communities on the valley sides are dominated by Purple Moorgrass, while the wet heath is dominate by Cross-leaved Heath and the dry heath by Heather *Calluna vulgaris* (English Nature 1986).

Site name	Status of the SAC qualifying features supported by the site
Potter & Scarning Fens, East Dereham	Potter and Scarning Fens are small calcareous valley fens on shallow peat which grades from bryophyte-dominated communities on the open, wet parts of the site (approximately 0.8ha), through calcareous fen, to heathland on the drier ground. The flora is exceptionally diverse and a number of uncommon mosses and liverworts are present. The site is surrounded by alder carr, which comprises the majority of the site (approximately 4ha). The central, open area of the fen is dominated by bryophytes, Bog Rush *Schoenus nigricans* and Blunt Flowered Rush. The range of flowering plants is exceptional and includes Grass of Parnassus, Great Sundew *Drosera anglica*, Common Butterwort Pinguicula vulgaris, Marsh Helleborine, Common Twayblade *Listera ovata* and Bogbean. A tall calcareous fen community surrounds the central area and a number of interesting plants are present including Marsh Orchid, Marsh Lousewort, Marsh Pennywort *Hydrocotyle vulgaris*, Common Quaking Grass and Ragged Robin *Lychnis flos-cuculi*. On the highest ground is an area of grassy heath with much Gorse *Ulex europaeus* and some Heather (English Nature, 1984).
Southrepps Common	Southrepps Common supports a variety of damp grassland and calcareous valley fen types. The lower valley slopes are dominated by reedbed and calcareous fen (approximately 0.5ha), while the upper valley slopes support damp grassland (approximately 2ha). The south side of the Fox's beck also supports alder carr. Notable calcareous fen species present include grass of parnassus, bog pimpernel *Anagallis tenella*, marsh arrowgrass *Triglochin palustris*, common quaking grass and flea sedge *Carex pulicaris*.

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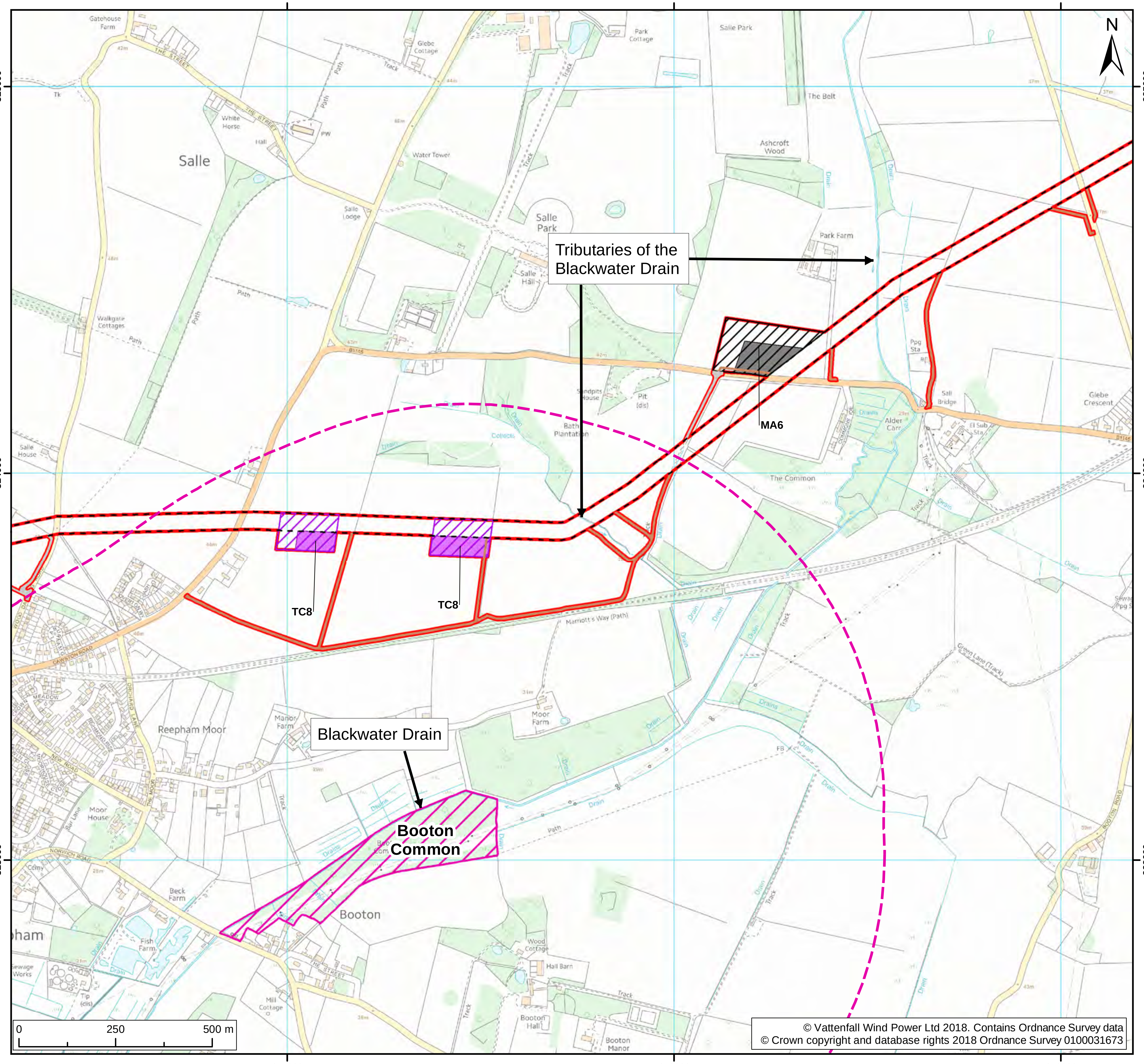

Legend:

- Norfolk Vanguard onshore red line boundary

Onshore cable route

- Onshore cable route
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound
- Mobilisation zone
- Indicative mobilisation area compound

Access

- Construction access
- Operation access

Environmental Designation

- Special Area of Conservation (SAC)[1]
- Booton Common 1km Zone of Influence buffer

[1] Natural England, 2017

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

Norfolk Valley Fens SAC - Booton Common and associated watercourses

Figure: 9.6 Drawing No: PB4476-006-001-016

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
03	23/05/2018	PS	GC	A3	1:10,000
02	22/02/2018	GC	GC	A3	1:10,000

Co-ordinate system: British National Grid **EPSG:** 27700

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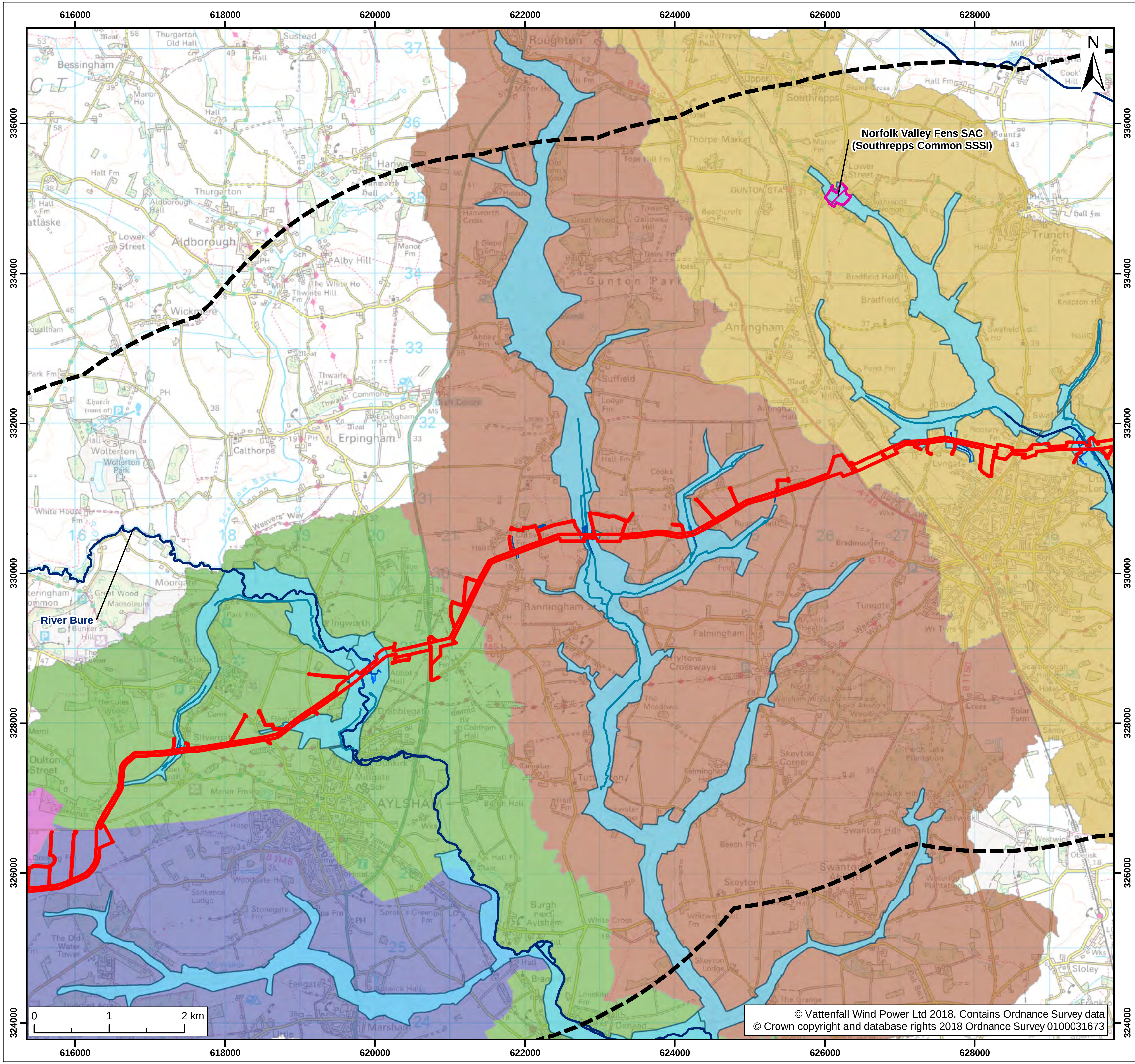

Legend:

Norfolk Vanguard onshore red line boundary

5km buffer zone

Environmental Designation

Norfolk Valley Fens Special Area of Conservation (SAC)[1]

Watercourses

IDB drain[2]

IDB catchment[2]

Other watercourses[3]

Main river[4]

WFD river water body catchments[4]

Blackwater Drain (Wensum)

Bure (Scarrow Beck to Horstead Mill)

King's Beck

Mermaid Stream

North Walsham and Dilham Canal (disused)

NOTE: IDB = Internal Drainage Board
WFD = Water Framework Directive
[1] Natural England, 2017
[2] Internal Drainage Board, 2017.
[3] Ordnance Survey, 2017.
[4] Environment Agency, 2017.

Project: Norfolk Vanguard

Report: Habitats Regulations Assessment Report

Title: Watercourses and their functional connectivity to the Norfolk Valley Fens SAC (map 1 of 3)

Figure: 9.7 Drawing No: PB4476-006-001-017

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	25/05/2018	NJ	GC	A3	1:50,000
01	24/05/2018	GC	GC	A3	1:50,000

Co-ordinate system: British National Grid **EPSG:** 27700

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9.1.3.3. Conservation Objectives

1130. The conservation objectives listed for the Norfolk Valley Fens SAC, as identified by Natural England, include maintaining or restoring:

- The extent and distribution of qualifying natural habitats and habitats of qualifying species;
- The structure and function (including typical species) of qualifying natural habitats;
- The structure and function of the habitats of qualifying species;
- The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;
- The populations of qualifying species; and
- The distribution of qualifying species within the site.

1131. The implementation of these conservation objectives will ensure the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features.

9.1.4. The Broads SAC

9.1.4.1. Description of Designation

1132. The Broads SAC covers a large area of 5865.30ha and comprises 28 separate competent SSSIs spread throughout the Norfolk Broads National Park. The component sites of the SAC include a range of important habitat types, including naturally nutrient-rich lakes containing one of the richest assemblages of rare and local aquatic species in the UK, the richest area for stoneworts (charophytes) in Britain, the largest blocks of alder *Alnus glutinosa* wood in England, and the largest example of calcareous fens in the UK.

1133. Of the 28 component SSSIs, two are located within 5km of the onshore project area. These are Calthorpe Broads SSSI and Broad Fen, Dilham SSSI. The former is located within the Thume catchment, downstream of the New Cut catchment, and the latter is located in the North Walsham and Dilham Canal (disused) catchment (see Figure 9.8). The onshore project area does not pass through any surface watercourses within the New Cut catchment and functional connectivity between the onshore project area and Calthope Broads component SSSI of The Broads SAC is considered unlikely.

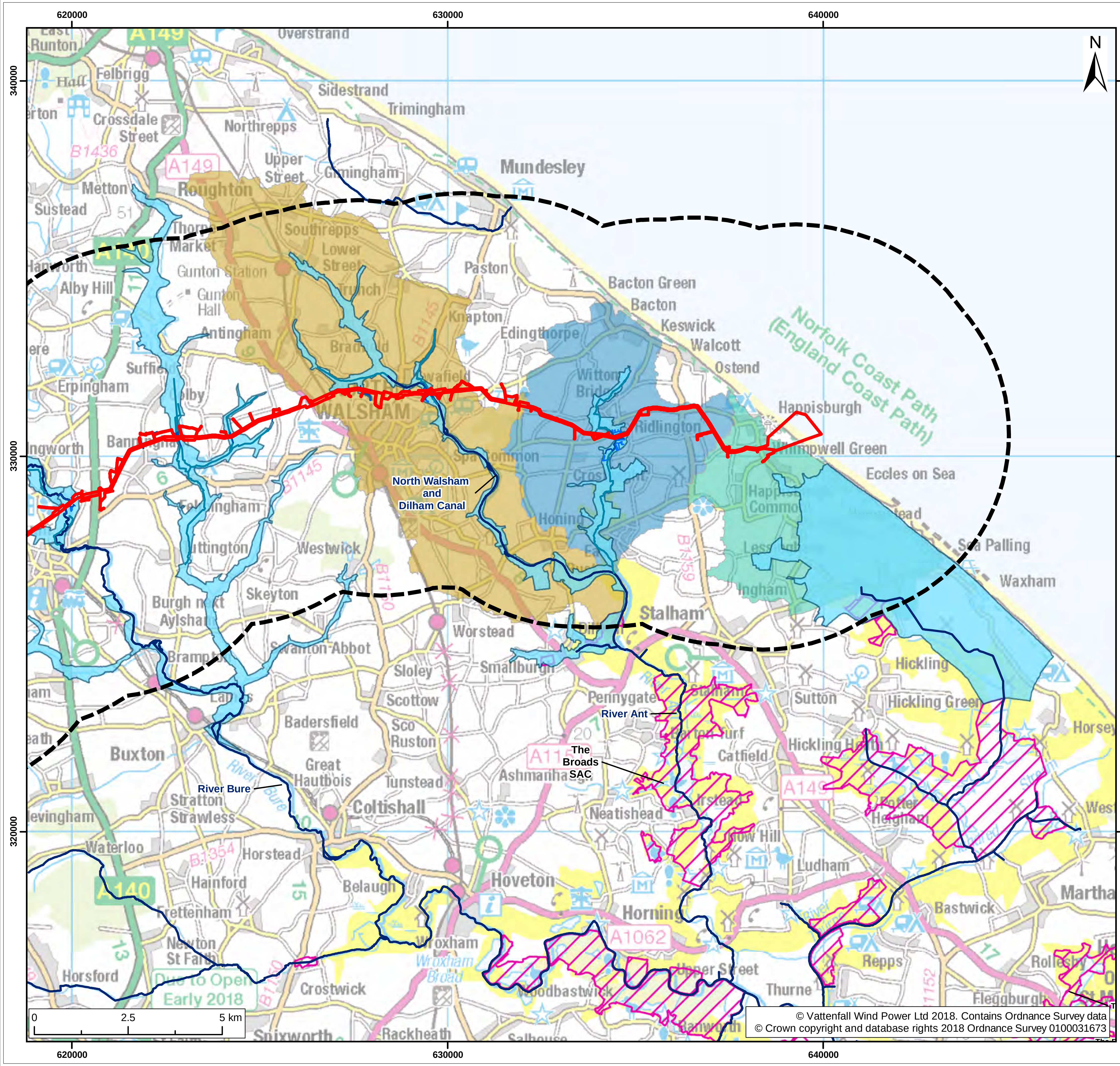
1134. The Broad Fen, Dilham component SSSI of The Broads SAC is located 3.6km from onshore project area at its closest point. Following a review of the Broad Fen, Dilham SSSI citation and accompanying condition assessment, the following Annex I habitats and Annex II species that are a primary reason for selection of The Broads SAC are present at Broad Fen, Dilham SSSI:

- Alkaline fens. (Calcium-rich spring water-fed fens);
- Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae). (Alder woodland on floodplains);
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*. (Calcium-rich fen dominated by great fen sedge (saw sedge)); and
- Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation. (Naturally nutrient-rich lakes or lochs which are often dominated by pondweed).

1135. The following Annex II species is not present at Broad Fen, Dilham, but given its large range is considered to potentially be present commuting through the site:

- Otter *Lutra lutra.*

1136. The remaining Annex I habitats which are qualifying features of The Broads SAC are not present within the Broad Fen, Dilham SSSI, and therefore are not considered further.



Legend:

- Norfolk Vanguard onshore red line boundary
- 5km buffer zone

Environmental Designation

- The Broads Special Area of Conservation (SAC)[1]

Watercourses

- IDB drain[2]
- IDB catchment[2]
- Other watercourses[3]
- Main river[4]

WFD river water body catchments[4]

- East Ruston Stream
- New Cut
- North Walsham and Dilham Canal (disused)

NOTE: IDB = Internal Drainage Board
WFD = Water Framework Directive
[1] Natural England, 2017
[2] Internal Drainage Board, 2017.
[3] Ordnance Survey, 2017.
[4] Environment Agency, 2017.

Project:	Report:
Norfolk Vanguard	Habitats Regulations Assessment Report

Title:

Watercourses and their functional connectivity to The Broads SAC

Figure: 9.8 Drawing No: PB4476-006-001-018

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
03	30/05/2018	PS	GC	A3	1:100,000
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Co-ordinate system: British National Grid **EPSG:** 27700

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9.1.4.2. Qualifying features

9.1.4.2.1. Details of the qualifying features

1137. The site is described in the SAC citation as follows:

> "The complex of sites contains the largest blocks of alder *Alnus glutinosa* wood in England. Within the complex complete successional sequences occur from open water through reedswamp to alder woodland, which has developed on fen peat. There is a correspondingly wide range of flora, including uncommon species such as marsh fern *Thelypteris palustris*.
>
> This site contains the largest example of calcareous fens in the UK. The great fen-sedge *Cladium mariscus* habitat occurs in a diverse set of conditions that maintain its species richness, including small sedge mires, and areas where great fen-sedge occurs at the limits of its ecological range. The habitat type forms large-scale mosaics with other fen types, fen meadows (with purple moor-grass *Moilinia caerulea*), open water and woodland, and contains important associated plants such as fen orchid *Liparis loeselii*, marsh helleborine *Epipactis palustris*, lesser tussock-sedge *Carex diandra*, slender sedge *C. lasiocarpa* and fibrous tussock-sedge *C. appropinquata*. There are also areas of short sedge fen (both black bog-rush – blunt-flowered rush *Schoenus nigricans – Juncus subnodulosus* mire and bottle sedge – moss *Carex rostrata – Calliergon cuspidatum/giganteum* mire), which in places form a mosaic with common reed – milk-parsley *Phragmites australis – Peucedanum palustris* fen.
>
> The Broads also contain examples of transition mire, that are relatively small, having developed in re-vegetated peat-cuttings as part of the complex habitat mosaic of fen, carr and open water.
>
> "The range of wetlands and associated habitats also provides suitable conditions for otters *Lutra lutra*." (English Nature, 2005).

9.1.4.2.2. Status of the qualifying features within Broad Fen, Dilham SSSI

1138. Broad Fen, Dilham, supports a mixture of fen, fen meadow, open water and carr woodland communities. The majority of the site (approximately 20ha is comprised of alder carr woodland), which surrounds a smaller area of lowland fen (approximately 14ha) interspersed with reedbeds (covering approximately 3ha). The site is crossed within drainage ditches and standing water bodies located throughout the site.

1139. Tall fen communities are dominated by reed *Phragmites australis* and Saw-Sedge *Cladium mariscus* often with abundant Purple Reed-Grass *Calamagrostis canescens* and herbs such as Yellow Loosestrife *Lysimachia vulgaris* and Milk Parsley *Peucedanum palustre*. A shorter more diverse fen vegetation occurs closer to the edge of the basin. These fen communities grade into fen meadow with abundant Fen

Rush. The open water areas consist of dykes, a section of the Dilham Canal and a series of ponds, most of which were dug to attract wildfowl. The Dilham Canal and dykes linked to it are nutrient enriched and with turbid water support rather few aquatic plants. The ponds away from this influence contain low nutrient, low alkalinity water, and aquatic plant development is limited to a few species which favour these conditions. Surrounding the open fen are large areas of semi-mature alder carr (English Nature, 1983).

9.1.4.3. Conservation objectives

1140. The conservation objectives listed for The Broads SAC, as identified by Natural England, include maintaining or restoring:

- The extent and distribution of qualifying natural habitats and habitats of qualifying species;
- The structure and function (including typical species) of qualifying natural habitats;
- The structure and function of the habitats of qualifying species;
- The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;
- The populations of qualifying species; and
- The distribution of qualifying species within the site.

1141. The implementation of these conservation objectives will ensure the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features.

9.2. Assessment Scenarios

1142. This section describes the project parameters upon which the assessment of potential adverse effect on the integrity of a European site will be carried out.

1143. Section 9.2.1 summarises the embedded mitigation relevant to onshore Natura 2000 sites, with any further mitigation, if required, outlined in the relevant section of the assessment. Section 9.2.2 outlines the worst-case scenarios used in the assessment.

9.2.1. Embedded Mitigation

1144. Norfolk Vanguard Limited has made a decision on a number of techniques and engineering designs/modifications inherent as part of the project, during the pre-application phase, in order to avoid a number of impacts or reduce impacts as far as possible.

1145. A range of different information sources has been considered as part of embedding mitigation into the design of the project (for further details see Chapter 5 Project

Description, Chapter 4 Site Selection and Assessment of Alternatives and the Consultation Report (document reference 5.1)) including engineering requirements, feedback from community and landowners, ongoing discussions with stakeholders and regulators, commercial considerations and environmental best practice.

1146. The following sections outline the key embedded mitigation measures relevant for this assessment. These measures are presented in Table 9.5. Where embedded mitigation measures have been developed into the design of the project with specific regard to onshore Natura 2000 sites, these are described in Table 9.6.

Table 9.5 Embedded mitigation

Parameter	Mitigation measures embedded into the project design	Notes
Strategic approach to delivering Norfolk Vanguard and Norfolk Boreas	Subject to both Norfolk Vanguard and Norfolk Boreas receiving development consent and progressing to construction, onshore ducts will be installed for both projects at the same time, as part of the Norfolk Vanguard construction works. This would allow the main civil works for the cable route to be completed in one construction period and in advance of cable delivery, preventing the requirement to reopen the land in order to minimise disruption. Onshore cables would then be pulled through the pre-installed ducts in a phased approach at later stages. In accordance with the Horlock Rules, the co-location of Norfolk Vanguard and Norfolk Boreas onshore project substations will keep these developments contained within a localised area and, in so doing, will contain the extent of potential impacts.	The strategic approach to delivering Norfolk Vanguard and Norfolk Boreas has been a consideration from the outset.
Commitment to HVDC technology	Commitment to HVDC technology minimises environmental impacts through the following design considerations; • HVDC requires fewer cables than the HVAC solution. During the duct installation phase this reduces the cable route working width (for Norfolk Vanguard and Norfolk Boreas combined) to 45m from the previously identified worst case of 100m. As a result, the overall footprint of the onshore cable route required for the duct installation phase is reduced from approx. 600ha to 270ha; • The width of permanent cable easement is also reduced from 54m to 20m; • Removes the requirement for a CRS; • Reduces the maximum duration of the cable pull phase from three years down to two years;	Norfolk Vanguard Limited has reviewed consultation received and in light of the feedback, has made a number of decisions in relation to the project design. One of these decisions is to deploy HVDC technology as the export system.

Parameter	Mitigation measures embedded into the project design	Notes
	• Reduces the total number of jointing bays for Norfolk Vanguard from 450 to 150; and • Reduces the number of drills needed at trenchless crossings (including landfall).	
Site Selection	The project has undergone an extensive site selection process which has involved incorporating environmental considerations in collaboration with the engineering design requirements. Considerations include (but are not limited to) adhering to the Horlock Rules for onshore project substations and National Grid infrastructure, a preference for the shortest route length (where practical) and developing construction methodologies to minimise potential impacts. Key design principles from the outset were followed (wherever practical) and further refined during the design process, including; • Avoiding proximity to residential dwellings; • Avoiding proximity to historic buildings; • Avoiding designated sites; • Minimising impacts to local residents in relation to access to services and road usage, including footpath closures; • Utilising open agricultural land, therefore reducing road carriageway works; • Minimising requirement for complex crossing arrangements, e.g. road, river and rail crossings; • Avoiding areas of important habitat, trees, ponds and agricultural ditches; • Installing cables in flat terrain maintaining a straight route where possible for ease of pulling cables through ducts; • Avoiding other services (e.g. gas pipelines) but aiming to cross at close to right angles where crossings are required; • Minimising the number of hedgerow crossings, utilising existing gaps in field boundaries; • Avoiding rendering parcels of agricultural land inaccessible; and • Utilising and upgrading existing accesses where possible to avoid impacting undisturbed ground.	Constraints mapping and sensitive site selection to avoid a number of impacts, or to reduce impacts as far as possible, is a type of primary mitigation and is an inherent aspect of the HRA process. Norfolk Vanguard Limited has reviewed consultation received to inform the site selection process (including local communities, landowners and regulators) and in response to feedback, has made a number of decisions in relation to the siting of project infrastructure. The site selection process is set out in Norfolk Vanguard ES Chapter 4 Site Selection and Assessment of Alternatives.
Duct Installation Strategy	The onshore cable duct installation strategy is proposed to be conducted in a sectionalised approach	This has been a project commitment from the

Parameter	Mitigation measures embedded into the project design	Notes
	in order to minimise impacts. Construction teams would work on a short length (approximately 150m section) and once the cable ducts have been installed, the section would be back filled and the top soil replaced before moving onto the next section. This would minimise the amount of land being worked on at any one time and would also minimise the duration of works on any given section of the route.	outset in response to lessons learnt on other similar NSIPs. Norfolk Vanguard ES Chapter 5 Project Description provides a detailed description of the process.
Long HDD at landfall	Use of long HDD at landfall to avoid restrictions or closures to Happisburgh beach and retain open access to the beach during construction. Norfolk Vanguard Limited have also agreed to not use the beach car park at Happisburgh South.	Norfolk Vanguard Limited has reviewed consultation received and in response to feedback, has made a number of decisions in relation to the project design. One of those decisions is to use long HDD at landfall.
Trenchless Crossings	Commitment to trenchless crossing techniques to minimise impacts to the following specific features; • Wendling Carr County Wildlife Site; • Little Wood County Wildlife Site; • Land South of Dillington Carr County Wildlife Site; • Kerdiston proposed County Wildlife Site; • Marriott's Way County Wildlife Site / Public Right of Way (PRoW); • Paston Way and Knapton Cutting County Wildlife Site; • Norfolk Coast Path; • Witton Hall Plantation along Old Hall Road; • King's Beck; • River Wensum; • River Bure; • Wendling Beck; • Wendling Carr; • North Walsham and Dilham Canal; • Network Rail line at North Walsham that runs from Norwich to Cromer; • Mid-Norfolk Railway line at Dereham that runs from Wymondham to North Elmham; and • Trunk Roads including A47, A140, A149.	A commitment to a number of trenchless crossings at certain sensitive locations was identified at the outset. However, Norfolk Vanguard Limited has committed to certain additional trenchless crossings as a direct response to stakeholder requests.

Table 9.6 Embedded mitigation for onshore Natura 2000 sites

Parameter	Embedded mitigation for onshore ecology	Notes
Designated sites	Constraints mapping was undertaken prior to the publication of the Norfolk Vanguard EIA Scoping Report (Royal HaskoningDHV, 2016). This constraints mapping exercise was used to determine the route options for the onshore project area for the project. The following ecological receptors were considered as part of the constraints mapping process: • International designated sites for nature conservation (SAC, SPA, Ramsar sites); • National designated site for nature conservation (The Broads National Park, SSSI, NNR, LNR); and • Ancient woodland. These ecological receptors have been avoided during the onshore project area route selection process.	More information can be found in Norfolk Vanguard ES Chapter 4 Site Selection and Assessment of Alternatives.
Route Refinement	Route refinements have included consideration of more detailed ecological constraints, and the following principles have been applied when refining the onshore project area: • Ancient woodland – following the Forestry Commission's Standing Advice on Ancient Woodland and Veteran Trees, a buffer of 15m around all ancient woodlands has been used (Forestry Commission, 2014); • Woodland – areas of woodland have been avoided where possible during the route selection process; • Habitat – standing water bodies, trees, and agricultural ditches have been avoided where possible; and • Hedgerows – the number of hedgerow crossings has been minimised as far as possible, taking other fixed constraints into account. When crossing hedgerows, the width of the cable easement will be reduced to the running track and cable trenches only to minimise the amount of hedgerow removal (see below).	Further information on the route refinement process can be found in Norfolk Vanguard ES Chapter 4 Site Selection and Assessment of Alternatives.
Hedgerow and watercourse crossings	The working width at hedgerow and watercourse crossings is 20m (reduced from 54m at PEIR) due to the selection of a HVDC electrical solution. This width assumes that the onshore cable route bisects each hedgerow in a perpendicular fashion. In reality, some hedgerows will be crossed at an angle, therefore increasing the maximum width of the gap required up to a possible 25m. Where this is the case for a particular receptor, it is noted within this report. Where hedgerow gaps are required beyond the two-year duct installation phase (i.e. for the duration of the subsequent two-year cable pull phase), the number of gaps required will be minimised as far as possible and will be no wider than 6m.	Further information can be found in Norfolk Vanguard ES Chapter 5 Project Description.

Parameter	Embedded mitigation for onshore ecology	Notes
Construction Programme	The construction programme for the onshore cables has been designed to minimise the duration and extent of impacts to ecological receptors at any given location along the onshore cable route. Specifically: • During the two-year duct installation phase, each duct installation team will work along a section of the cable route, tackling a short section (approximately 150m) at a time. Where possible, each 150m workfront (approximately 0.7ha in area) will be reinstated following duct installation, before works commence on the next section. The works at each section, including reinstatement, will take approximately one week (up to two in a worst case scenario). Within each section, a 6m wide strip will be retained for the running track, for up to the remainder of the two-year duct installation phase (i.e. as a worst case a 60km by 6m strip along the onshore cable route will be lost for the duration of the cable duct installation); • During the cable pulling phase, a reduced 12km by 6m strip along the onshore cable route is anticipated to be lost for up to approximately 16 weeks during the cable pull for the running track, thus minimising the number of hedgerow gaps required for the duration of construction down to approximately 20%; and • The majority of disturbance to watercourses will only occur during the two-year duct installation phase. Once the ducts are in the ground, subsequent cable pulling operations will not result in further disturbance to watercourses. There may be disturbance to a small number watercourses which need to be crossed when the running track is reinstated to facilitate the cable pulling operations.	For further details on the construction approach and programme, please see Norfolk Vanguard ES Chapter 5 Project Description.

9.2.1.1. Outline Landscape and Environmental Management Strategy

1147. The mitigation measures set out within this report and within the Norfolk Vanguard Ecological Impact Assessment (EcIA) will be delivered via an Outline Landscape and Environmental Management Strategy (OLEMS) (document 8.7). A draft of this document, submitted alongside the final ES, will be the primary document detailing the ecological mitigation measures required to ensure that all potential impacts identified within this report and within the EcIA are reduced to a non-significant level. The document will encapsulate those mitigation measures proposed for individual ecological receptors and will set out how they will fit into the wider approach to managing landscape impacts during construction and operation of the project.

1148. The OLEMS will aim to ensure that all mitigation proposed within this report and within EcIA is part of an integrated management strategy which will ensure that adverse impacts upon biodiversity and ecological networks are not treated in isolation. It is envisaged that final mitigation measures provided in the final ES (for submission in 2018) will be implemented via the OLEMS.

9.2.2. Worst Case Scenario

1149. The realistic worst-case scenario for each category of potential effects has been established as a basis for the subsequent assessment. For this assessment, the realistic worst-case scenario involves both a consideration of the relative timing of construction scenarios, as well as the particular design parameters of each project that define the project design envelope for this assessment.

1150. The onshore project area relevant to the HRA Report comprises the onshore cable corridor element of the onshore project area only.

1151. Other areas of the onshore project area including the landfall works, onshore project substation and National Grid substation and overhead line works are outside of the study area for the onshore HRA and are not relevant to the HRA Report.

1152. The assessment of potential effects upon European sites uses the Rochdale Envelope principle and assesses impacts against a defined project worst case scenario (or scenarios).

1153. This section sets out the realistic worst-case scenario with respect to onshore Natura 2000 site designations. The 'worst-case scenario' includes the parameters of the different potential construction options for the project which would result in the greatest potential impact upon the qualifying features (receptors) and threaten the conservation objectives described in Section 9.1.

1154. Table 9.7 sets out those parameters which comprise the worst-case scenario for onshore Natura 2000 site designations. This is based on the worst case of Norfolk Vanguard installing ducts for Norfolk Boreas. Table 9.7 contains information for the elements of the infrastructure relevant to onshore Natura 2000 sites only.

Table 9.7 Worst case scenario for onshore Natura 2000 sites

Worst case assumptions			
Parameter	**Worst case criteria**	**Worst case definition**	**Notes**
Landfall			
Construction	Construction method	Trenchless technique (e.g. HDD)	Worst case construction noise levels are as set out within Norfolk Vanguard ES Chapter 25

Worst case assumptions			
Parameter	**Worst case criteria**	**Worst case definition**	**Notes**
	Maximum drill length Temporary works footprint Maximum temporary works duration	1,000m 6,000m^2 20 weeks	Noise and Vibration.
HDD compounds	Maximum number and maximum land take for temporary HDD compounds	Assumes 2 at 3,000m^2 each to support parallel drill rigs	
Onshore cable route			
Construction	Construction method Maximum working width and length Cable installation maximum footprint Onshore cable route maximum footprint Total maximum duct installation footprint Gaps at hedgerow / other crossing points	Open cut trenching 45m and 60km 447,688m^2 2,700,000m^2 3,052,500m^2 20m	Mitigation by design with respect to hedgerows already included in Norfolk Vanguard ES Chapter 5 Project Description. The gap at hedgerows is indicative, depending on the angle of crossing. This width assumes that the onshore cable route bisects each hedgerow in a perpendicular fashion. In reality, some hedgerows will be crossed at an angle, therefore increasing the maximum width of the gap required up to a possible 25m. Where this is the case for a particular receptor, it is noted within this report. Cable installation footprints include the running track and joint bay (Norfolk Vanguard only). Onshore cable route footprint covers all works required for duct installation (trenching, spoil storage, etc.). Total maximum duct installation footprint covers the onshore cable route footprint plus all associated works footprints (mobilisation areas, trenchless launch and reception sites).

Worst case assumptions			
Parameter	**Worst case criteria**	**Worst case definition**	**Notes**
	Maximum hedgerows to be removed Running track excavated material Trench excavated material	165[21] 108,000m^3 360,000m^3	
Permanent joint pits	Maximum number and required dimensions	Assume 150 at 90m^2 and 2m deep each	Norfolk Vanguard only, spaced approximately one per circuit per 800m cable.
Mobilisation areas	Maximum number and required dimensions	Assumes 14 at 10,000m^2	
Trenchless launch and reception sites	Maximum number and maximum land take for trenchless launch and reception sites	Assumes 17 pairs at 7,500m^2 and 5,000m^2 respectively	
Construction programme - ducting	Ducting at any 150m workfront Trenchless works at each watercourse Running track topsoil storage area Total construction window	2 weeks 8 weeks 2 years 2 years	Where considered necessary, hedgerows will be reinstated immediately after each duct installation, with a small number left open to facilitate access for cable pulling. As the locations of these openings are not available at this time, the WCS assumes at this stage that no hedgerows will be reinstated during the construction phase, i.e. between trenching and cable pulling. Mitigation by design with respect to hedgerows is included in Norfolk Vanguard ES Chapter 5 Project Description.
Construction programme - cable pull, joint and commission	Hardstand area Running track topsoil storage area	10 weeks 16 weeks	

[21] Estimated based on 110 hedgerows surveyed within the onshore project area plus a further 55 identified from the Norfolk Living Map and aerial photography taken in 2017. The final number of hedgerows to be removed will be determined during surveys of the unsurveyed areas post-consent when access becomes available.

Worst case assumptions			
Parameter	**Worst case criteria**	**Worst case definition**	**Notes**
	Total construction window	2 years	
Construction programme	Total construction window	6 years	Includes 2 years pre-construction works.
Decommissioning		Joint pits and ducts left in situ	Where cables are in pre-installed ducts, cables may be extracted once de-energised.

9.3. Assessment of Potential Effects

9.3.1. River Wensum SAC

9.3.1.1. *Potential effects of Norfolk Vanguard*

1155. The potential effects during the construction, operation and decommissioning of Norfolk Vanguard that have been assessed as part of the HRA process for the River Wensum SAC have been agreed in consultation with the onshore ecology and ornithology Expert Topic Group as part of the Evidence Plan Process.

1156. The potential effects during construction of the proposed Norfolk Vanguard project that have the potential for adverse effect upon site integrity are:

Table 9.8 Summary of potential effects screened into the HRA

Qualifying feature	Potential effects
Ranunculion fluitantis and *Callitricho-Batrachion* vegetation	Direct effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation present within ex-situ habitats of the SAC
	Indirect effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation present within the SAC boundary arising from geology / contamination and groundwater / hydrology effects
	Indirect effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation present within ex-situ habitats of the SAC arising from geology / contamination and groundwater / hydrology effects
Desmoulin's whorl snail	Direct effects on Desmoulin's whorl snail present within ex-situ habitats of the SAC
	Indirect effects on Desmoulin's whorl snail present within the SAC boundary arising from geology / contamination and groundwater / hydrology effects
	Indirect effects on Desmoulin's whorl snail present within ex-situ habitats of the SAC arising from geology / contamination and groundwater / hydrology effects

1157. No potential effects during operation or decommissioning were screened in to the assessment.

9.3.1.2. *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

9.3.1.2.1. Direct effects on Ranunculion fluitantis and Callitricho-Batrachion vegetation present in ex-situ habitats of the SAC

1158. The 2017 botanical survey concluded that the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation for which the River Wensum SAC is designated is not present within the drains and ditches of the floodplain habitats of the River Wensum on the right-hand (southern) bank of the river (see Figure 9.1).

1159. Access to the single drain in the floodplain habitat of the River Wensum on the left-hand (northern) bank of the river (see Figure 9.1) was not possible during the 2017 survey due to survey access constraints (survey permission not granted). Due to route refinement and site selection which is ongoing as part of the project, this drain is also now located outside of the proposed trenchless crossing technique zone, as shown on Figure 9.1. Therefore, potential direct effects upon this habitat have been avoided at this location. Although it was not possible to survey this drain, given the absence of *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation from the other ex-situ habitats located within the onshore project area, it is considered unlikely that the vegetation is present within this drain.

1160. As the qualifying feature is not present within the onshore project area area or ex-situ habitats are being avoided through the use of trenchless techniques, with regards to direct effects, there is **no potential adverse effect on the integrity of the River Wensum SAC in relation to the conservation objectives for *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation.**

9.3.1.2.2. Indirect effects on Ranunculion fluitantis and Callitricho-Batrachion vegetation present within the SAC boundary arising from geology / contamination and groundwater / hydrology effects

1161. As described in section 9.3.1.2.1, the 2017 botanical survey concluded that the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation for which the River Wensum SAC is designated, is not present within the River Wensum SAC boundary (see Figure 9.1) within the onshore project area. Information is not available as to the distribution of these species within the River Wensum downstream of the onshore project area, and therefore for the purposes of this assessment it has been assumed that they may present within the reaches of the River Wensum immediately downstream of the onshore project area.

1162. Potential changes to local hydrological conditions from the construction and operation of Norfolk Vanguard have the potential to change the structure and function of the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation habitat downstream of the proposed works. The 2017 botanical survey concluded that there are no springs or seepages located within the floodplain habitats on the right-hand (southern) bank of the River Wensum. No information is available regarding springs or seepages within the floodplain on the left-hand (northern) bank. This floodplain on the left-hand (northern) bank will be avoided through the use of trenchless techniques (e.g. HDD), however a narrow section of the floodplain below ground in this location will be affected by the trenchless construction method. If springs or seepages are present in this area, they will be potentially disrupted by the below-ground trenchless construction works. As such, a pre-construction botanical survey of the left-hand (northern) floodplain habitat will be conducted to identify any springs or seepages. If any are identified within the onshore project area, these will be avoided by micro-siting of the location of the buried cables and cable installation works within the onshore project area. As such, works in this area will not result in direct changes to any springs directly connected to the River Wensum. Furthermore, areas of hardstanding are not required within the River Wensum floodplain as part of the proposed works, and therefore there will not be changes to the runoff rates associated with the proposed works.

1163. Cable ducts are expected to be up to 260mm in diameter, with eight cables required within the worst-case scenario, resulting in $0.42m^2$ cross-section area of impermeable material, or approximately $212m^3$ of volume of impermeable material beneath the River Wensum floodplain. This is a very small volume of impermeable material: the floodplain superficial deposits within which the ducts will be situated will contain approximately $50,000m^3$ of material within the onshore cable permanent easement alone (500m in length, minimum of 5m in depth and 20m in width), making the impermeable material accounting for only 0.4% of the total volume of the cable easement. Therefore, introduction of cable ducts is not anticipated to have any effect upon groundwater flows for the River Wensum. Furthermore, for a river crossing, HDD ducts would be installed 5-15m below the floodplain, and at least 2m below the river bed. As a result, the buried ducts will have no effect upon surface water flows.

1164. Given that the proposed works will take place adjacent to Penny Spot Beck and the associated drainage network which is functionally connected to the River Wensum, and within 10m of the single drain located on the left-hand (northern) bank of the River Wensum and also functionally connected to it, the potential exists for the accidental release of lubricants, fuels, oils and drilling fluid from construction machinery working in and adjacent to surface watercourses, through spillage, leakage and in-wash from vehicle storage areas after rainfall / sediment runoff due the proposed works in these locations. Furthermore, these activities have the potential to increase the potential for the erosion of soil particulates, resulting in an increase in the supply of fine sediment to surface watercourses through surface runoff and the erosion of exposed soils if unmitigated.

1165. The preferred option for construction of the trenchless crossing at the River Wensum is to avoid the floodplain habitats north of Penny Spot Beck, and to locate the trenchless crossing (e.g. HDD) exit point to the south of Penny Spot Beck (denoted by the purple oblong on Figure 9.1). However, prior to detailed design, there cannot be certainty that land in the River Wensum floodplain north of Penny Spot Beck will not be required, depending on local ground conditions, etc. Therefore, for the purposes of this assessment it has been assumed that works to facilitate the trenchless crossing of the River Wensum may take place within the River Wensum floodplain north of Penny Spot Beck. The proposed works will entail vehicle tracks and earthworks associated with trenchless crossing techniques at the River Wensum. Plant, including a drilling rig, haulage vehicles earth-moving equipment will be operating within the floodplain adjacent to Penny Spot Beck and the single drain located on the left-hand (northern) bank of the River Wensum for approximately eight weeks. The land would be levelled, topsoil removed and stored within the mobilisation area. The works will take place within a 0.75ha area on the northern side of the river, outside of the floodplain, and a 0.5ha area on the southern side within the floodplain (see Figure 9.1). Approximately 1,000m^2 of topsoil will be stripped and stored during construction within the floodplain, with a minimal amount of additional spoil generated during trenchless crossing techniques activities. A small amount of additional material will be brought into site for drilling fluid. This will be a mixture of water and natural clays (e.g. bentonite), which will be removed from site as waste upon completion of the works.

1166. The following mitigation measures will be put in place to minimise the risk of sediment or pollutant release into the watercourses which are functionally connected to the River Wensum:

- Best practice topsoil management practices will be followed. All topsoil will be reinstated and measures will be put in place to reinstate any damage to ground conditions caused by vehicle tracking. All sediment management measures used (e.g. sediment traps) will be removed and disposed of following construction. The practices to be followed will be detailed in a Code of Construction Practice (CoCP), the details and content of which will be agreed with stakeholders (including the Environment Agency and Natural England) in advance of construction.
- A pre-construction drainage plan will also be developed and implemented to minimise water within the cable trench and ensure ongoing drainage of surrounding land. Where water enters the trenches during installation, this will

be pumped via settling tanks or ponds to remove sediment, before being discharged into local ditches or drains via temporary interceptor drains in order to prevent increases in fine sediment supply to the watercourses.

- Existing tracks and roadways will be utilised for access where possible. Where temporary accesses are needed, topsoil and surface water management measures will be employed as defined in the Drainage Plan and CoCP.
- Geotextile, or other suitable material, will be used, where required, to allow the safe storage and movement of vehicles within the area, maintain required drainage, and prevent soil erosion and increased surface runoff.
- The working methodology will follow construction industry good practice guidance, as detailed in the Environment Agency's Pollution Prevention Guidance (PPG) notes (including PPG01, PPG05, PPG08 and PPG21)[22], and CIRIA's '*Control of water pollution from construction sites – A guide to good practice*' (2001), such as having spill kits on site at all times, checking equipment regularly to ensure leakages do not occur, and limiting refuelling of construction plant to designated impermeable areas. Where sediment traps are proposed to manage sediment runoff, the CoCP will set out how these will be disposed of post-construction.
- A break-out contingency plan will be drafted in case of break-out of drilling fluid during trenchless crossing construction. The details of this plan will be included in the CoCP.
- The project is aiming for a construction scenario whereby construction works within the River Wensum floodplain (i.e. land north of Penny Spot Beck) are not required, and the trenchless crossing at the River Wensum would run beneath this area. However, in advance of more detailed assessment of ground conditions, this possibility cannot be ruled out at this stage. If land north of Penny Spot Beck within the River Wensum floodplain is used during construction, then works will take place outside of the winter period (October – February inclusive).

1167. These mitigation measures are considered suitable for minimising the risk of sediment / pollutant release into watercourses functionally connected with the River Wensum down to a negligible level.

1168. In light of the negligible risk of the proposed works affecting local groundwater and hydrology following implementation of the mitigation measures outlined above, **no potential adverse effect on the integrity of the River Wensum SAC in relation to**

[22] The Environment Agency's PPG were formally withdrawn on 17 December 2015. However, the guidance contain the best reference source for good practice guidance regarding pollution prevention, and in the absence of any formal statutory guidance provide the best framework for managing pollution prevention.

the conservation objectives for *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation is anticipated.

9.3.1.2.3. Indirect effects on Ranunculion fluitantis and Callitricho-Batrachion vegetation present within ex-situ habitats of the SAC arising from geology / contamination and groundwater / hydrology effects

1169. The potential effects anticipated to arise as a result of the proposed works upon this qualifying feature are the same as those upon this feature within the SAC boundary (see section 9.3.1.2.2). Therefore, in light of the negligible risk of the proposed works affecting local groundwater and hydrology following implementation of the mitigation measures outlined above, **no potential adverse effect on the integrity of the River Wensum SAC in relation to the conservation objectives for *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation is anticipated.**

9.3.1.3. Desmoulin's whorl snail

9.3.1.3.1. Direct effects on Desmoulin's whorl snail present in ex-situ habitats of the SAC

1170. The 2017 Desmoulin's whorl snail survey concluded that this species is not present within the drains and ditches of the floodplain habitats of the River Wensum on the right-hand (southern) bank of the river (see Figure 9.2).

1171. Access to the single drain in the floodplain habitat of the River Wensum on the left-hand (northern) bank of the river (see Figure 9.2) was not possible during the 2017 survey due to survey access constraints (survey permission not granted). Due to route refinement and site selection which is ongoing as part of the project, this drain is also now located outside of the proposed trenchless crossing techniques zones, as shown on Figure 9.2. Therefore, potential direct effects upon this habitat have been avoided at this location.

1172. As the qualifying feature is neither present within the onshore project area or the onshore project area is being avoided, with regards to direct effects, there is **no potential adverse effect on the integrity of the River Wensum SAC in relation to the conservation objectives for Desmoulin's whorl snail.**

9.3.1.3.2. Indirect effects on Desmoulin's whorl snail present within the SAC boundary arising from geology / contamination and groundwater / hydrology effects

1173. As described in section 9.3.1.3.1, the 2017 Desmoulin's whorl snail survey concluded that this species is not present within the River Wensum SAC boundary (see Figure 9.2) within the onshore project area. Detailed information is not available as to the distribution of this species within one ditch on the left-hand (northern) bank of the Rivern Wensum or in the River Wensum downstream of the onshore project area, and therefore for the purposes of this assessment it has been assumed that they maybe present within the reaches of the River Wensum immediately downstream of the onshore project area.

1174. The potential for the proposed project to change local hydrological conditions during its construction and operation phases is covered above in section 9.3.1.2.2 for indirect effects on *Ranunculion fluitantis* and *Callitricho-Batrachion*. The conclusions and mitigation for potential effects are the same for Desmoulin's whorl snail.

1175. In light of the negligible risk of the proposed works affecting local groundwater and hydrology following implementation of the mitigation measures outlined above, **no potential adverse effect on the integrity of the River Wensum SAC in relation to the conservation objectives for Desmoulin's whorl snail is anticipated.**

9.3.1.3.3. Indirect effects on Desmoulin's whorl snail present within ex-situ habitats of the SAC arising from geology / contamination and groundwater / hydrology effects

1176. The potential effects anticipated to arise as a result of the proposed works upon this qualifying feature are the same as those upon this feature within the SAC boundary (see section 9.3.1.3.2). Therefore, in light of the negligible risk of the proposed works affecting local groundwater and hydrology following implementation of the mitigation measures outlined above, **no potential adverse effect on the integrity of the River Wensum SAC in relation to the conservation objectives for Desmoulin's whorl snail is anticipated.**

9.3.1.4. Potential effects of Norfolk Vanguard in-combination with other plans and projects

1177. The in-combination assessment for the onshore elements of this assessment for potential for adverse effect upon site integrity has adopted the following principle: in order for Norfolk Vanguard to be considered to have the potential to contribute to in-combination effects, there must be sufficient cause to consider that a relevant habitat or species is sensitive to effects due to the project itself (e.g. as a result of particular influence of sensitivity, or the presence of a species in notable numbers on at least one survey occasion, rather than simply being recorded within the site). Therefore, only where the project alone was determined to have the potential for adverse effect upon site integrity on European sites and features have these sites and features been included in the in-combination assessment. If a potential for adverse effect upon site integrity was not determined with respect to a site due to Norfolk Vanguard, there is no real prospect of an in-combination effect occurring with another plan or project.

1178. The assessment for the potential adverse effect upon site integrity to arise from the development of the Norfolk Vanguard Project alone, did not identify any potential for adverse effect upon site integrity upon the qualifying habitats and species of the

River Wensum SAC. As such, there is **no potential adverse effect on the integrity of the River Wensum SAC in relation to the conservation objectives for the site.**

9.3.1.5. Summary of potential for adverse effect on site integrity

1179. Table 9.9 below summarises the potential effects arising from the construction phase of the proposed Norfolk vanguard project.

Table 9.9 Summary of the potential effects of Norfolk Vanguard in relation to the River Wensum SAC

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?	Potential for adverse effect upon site integrity in-combination?
Ranunculion fluitantis and *Callitricho-Batrachion* vegetation	Direct effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation present within ex-situ habitats of the SAC	×	×
	Indirect effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation present within the SAC boundary arising from geology / contamination and groundwater / hydrology effects	×	×
	Indirect effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation present within ex-situ habitats of the SAC arising from geology / contamination and groundwater / hydrology effects	×	×
Desmoulin's whorl snail	Direct effects on Desmoulin's whorl snail present within ex-situ habitats of the SAC	×	×
	Indirect effects on Desmoulin's whorl snail present within the SAC boundary arising from geology / contamination and groundwater / hydrology effects	×	×
	Indirect effects on Desmoulin's whorl snail present within ex-situ habitats of the SAC arising from geology / contamination and groundwater / hydrology effects	×	×

× = no potential for any adverse effect on the integrity of the site in relation to the conservation objectives

9.3.2. Paston Great Barn SAC

9.3.2.1. *Potential effects of Norfolk Vanguard*

1180. The potential effects during the construction, operation and decommissioning of the proposed Norfolk Vanguard project to be assessed as part of the HRA process for the Paston Great Barn SAC have been agreed in consultation with the onshore ecology and ornithology ETG as part of the EPP.

1181. The potential effects during construction, operation and decommissioning of the proposed Norfolk Vanguard project that have the potential for adverse effect upon site integrity are:

- Direct effects on barbastelle present in ex-situ habitats of the SAC (hedgerows / watercourses); and
- Indirect effects on barbastelle present within ex-situ habitats of the SAC (hedgerows / watercourses) arising from light and groundwater / hydrology effects.

9.3.2.1.1. Potential effects during construction

Direct effects on barbastelle present in ex-situ habitats of the SAC (hedgerows / watercourses)

1182. A study area of all habitats located within 5km surrounding Paston Great Barn SAC has been determined for the assessment presented within this section. This study area has been determined based on barbastelle ecology and local conditions within the onshore project area. Females of barbastelle maternity colonies have been identified as typically foraging between 6-7km from the maternity roost (Zeale *et al.*2012), and the BCT's Core Sustenance Zone for barbastelles is set at 6km (BCT, 2016). Radio-tracking data from the NBSG indicates that the Paston Great Barn colonies' core foraging areas are at most approximately 4km from Paston Great Barn (NBSG, 2017). A study area of 5km has been considered within this report to ensure that a buffer zone around the known barbastelle core foraging areas is provided. All suitable barbastelle foraging habitats located within this 5km buffer area have been considered within this report. Habitats outside of this 5km buffer have not been considered further.

1183. The proposed works for Norfolk Vanguard involve hedgerow removal at four of the five important barbastelle features identified above. Features located at Witton Hall Plantation along Old Hall Road, i.e. the deciduous woodland habitat, will be subject to trenchless crossing techniques (i.e. HDD) in order to minimise impacts upon woodland habitats and the sensitive ecological features they support.

1184. Hedgerow removal is required at these four locations in advance of trenching activities required for duct installation works. To minimise the amount of potential foraging habitat lost during construction, the cable route working width has been reduced at these locations from 45m down to 20m. Where the cable route crosses the linear features at oblique angles, the actual length of hedgerow removal required can be greater than 20m (up to 25m). Table 9.10 summarises the length of hedgerow removal required for the project at each of these four important barbastelle locations. The total potential amount of hedgerow removal required is approximately 130m (<0.1ha of habitat). Of this, approximately 82m is used for foraging by barbastelles of the Paston Great Barn maternity colony. Radio-tracking data from the NBSG indicates that there is approximately 200ha of habitat within core bat foraging areas within the home range of the bats associated with the Paston Great Barn bat colony (this figure excludes habitats to the north of the colony, and along the coast – data for these habitats was not provided). The area of hedgerow habitat lost during the construction phase is <0.05% of the available commuting / foraging hedgerow habitat within the Paston Great Barn maternity colony home range.

1185. This length of hedgerow will be removed in advance of construction phase works at each important barbastelle feature, and the land will remain open during the construction phase works at each location (for approximately one week, with the exception of Dilham Canal and land east of Dilham Canal, where works will take place over up to eight weeks due to trenchless drilling techniques at this location). Hedgerows will be replanted following works at each location (replanting described in more detail below). Hedgerows are anticipated to take between 3-7 years to mature up to a standard whereby the hedgerow is providing value for commuting and foraging barbastelle bats (provision of shelter and invertebrate assemblage)[23], meaning that the effects of habitat loss will be temporary and will take place over the medium term (i.e. during the lifespan of one barbastelle). A gap of maximum 6m will be retained, if required, for 2 years to allow for the running track required for cable installation. All UK bat species are considered able to traverse gaps of 10m or less (JNCC, 2001; BCT, 2012).

1186. To minimise the potential effect upon commuting and foraging barbastelle arising from this temporary loss of habitat, the following mitigation measures will be implemented:

- Hedgerow removal will be programmed for winter where possible, to give bats time to adjust to the change prior to maternity period. Hedgerows will be removed as close to the onset of works as possible, and works will not commence after nights of poor weather (in case of bad weather roosts being used).
- Replanting will follow in the first winter after construction of all except the 6m gap required for the running track (BCT, 2012). Replanting will follow guidance

[23] It should be noted this this figure applies for instances where the existing hedgerow being removed is not at present optimal for supporting barbastelle bats (e.g. it is species poor, gappy, with trees). For the two hedgerows to be removed which are species rich with trees or for which no data is available (Hedgerow along North Walsham Road from Edingthorpe Green to Edingthorpe Heath and Road from Bacton Wood to Witton), it must be assumed that it may take longer than 3-7 years to recreate a hedgerow which provides all of the same attributes as the one that has been lost.

within the Norfolk hedgerow BAP and will include appropriate species for north-east Norfolk (NBP, 2009), including ground flora planting designed to encourage insect biomass (BCT, 2012). Future hedgerow management to include allowing standard trees to develop.

- Subject to landowner permissions, the six hedgerows that are important for foraging and commuting bats would be left to become overgrown either side of the section to be removed prior to construction. Hedgerows would be allowed to become overgrown within the onshore cable route width, therefore at each hedgerow a total of up to 25m will be left to become overgrown in this manner. This would be undertaken to improve the quality of the surrounding hedgerow as a resource for commuting and foraging bats (Bates, 2010).
- The replanting measures described above will be captured in the OLEMS (document reference 8.7).
- Pre-construction activity surveys at the hedgerow along North Walsham Road from Edingthorpe Green to Edingthorpe Heath and at two hedgerows between Witton and North Walsham Road will be undertaken to provide full baseline data for these features.

1187. In addition to the above mitigation measures, during detailed project design, the Norfolk Vanguard project will seek to avoid mature trees within hedgerows through the micro-siting of individual cables where possible, in order to retain as many mature trees as possible given the benefits they provide within linear commuting / foraging features (following Boughley *et al.,* 2011).

Table 9.10 Habitats to be removed during construction

Important barbastelle area	Use by barbastelle	Habitats present	Length / area of habitat directly affected	Area of known barbastelle foraging habitat isolated by habitat loss (number in brackets = % of Paston Great Barn maternity colony home range)
Dilham Canal and land east of Dilham Canal	Foraging	Species poor hedgerow with trees	22m	None
Hedgerow along North Walsham Road from Edingthorpe Green to Edingthorpe Heath	Commuting / foraging	Hedgerow (no detailed hedgerow information available)	20m	None
Witton Hall Plantation along Old Hall Road	Commuting / foraging	Mixed deciduous woodland	-	None (trenchless techniques used at this location)
Road from Bacton Wood to Witton	Commuting	Two species-rich hedgerows with trees	24m (each)	11ha (0.6%)
Two hedgerows between Witton and North Walsham Road	Commuting / foraging	Two species-poor hedgerows with trees	20m (each)	Negligible (<0.01ha)

1188. In addition to the area of habitat directly lost during the construction phase of Norfolk Vanguard, the proposed works have the potential to temporarily fragment the commuting and foraging habitats of barbastelle bats of the Paston Great Barn colony by severing commuting routes through the removal of hedgerows during the construction phase of the Norfolk Vanguard project. Although through iterations of the project design, the potential hedgerow gap created during construction of the project has been reduced down to 20m, any gap of 10m or more must be considered as potentially giving rise to habitat fragmentation for commuting bats (BCT, 2012). Consideration of the risk of habitat fragmentation caused by commuting route severance at each important feature for barbastelle located within the onshore project area is provided below. A summary is provided in Table 9.10.

1189. No habitat is estimated to be potentially subject to fragmentation at Dilham Canal and land east of Dilham Canal. Data obtained from the radio tracking and activity surveys has indicated that this habitat is not a core foraging area for barbastelles of the Paston Great Barn colony and that core foraging areas south of Dilham Canal are associated with the Old Hills colony. NBSG have indicated that despite this, barbastelle have been recorded foraging in these areas (J Harris, pers. comm., 31 January 2018).

1190. No habitat is estimated to be potentially subject to fragmentation at hedgerow along North Walsham Road from Edingthorpe Green to Edingthorpe Heath. Barbastelle have been recorded commuting here, but land to the south of this habitat has not been identified as core foraging habitat (NBSG, 2017).

1191. Approximately 18ha of broadleaved woodland foraging habitat used by barbastelles of the Paston Great Barn colony would be isolated if the commuting route along Witton Hall Plantation and along Old Hall Road is severed (NBSG, 2017). Trenchless crossing techniques (i.e. HDD) will be used at this location in order to minimise impacts upon woodland habitats and the sensitive ecological features they support. As such, no habitat is estimated to be potentially subject to fragmentation in this location. This habitat is located on the edge of the barbastelle home range.

1192. A mosaic of approximately 11ha of broadleaved woodland, rank grassland, hedgerows and drainage ditches around Witton is used by foraging barbastelles of the Paston Great Barn colony. This would be potentially isolated at the road from Bacton Wood to Witton if this commuting route is severed (NBSG, 2017). This habitat is located on the edge of the barbastelle home range. This habitat represents approximately 0.6% of the Paston Great Barn maternity colony home range.

1193. A negligible area (<0.01ha) of habitat is estimated to be potentially subject to fragmentation. These are namely two sections of hedgerows between Witton and

North Walsham Road. These features are located on the edge of foraging habitat used by barbastelles of the Paston Great Barn colony and no habitat would be isolated (NBSG, 2017).

1194. The total home range of barbastelle bats of the Paston Great Barn colony is estimated, based on the radio tracking data, to cover approximately 2,000ha from the coast between Mundeslesy and Keswick, to Knapton Cutting foraging habitat in the west and to day roosts at Spa Common and Witton in the south.

1195. Across the five important barbastelle habitat features potentially within the onshore project area, a total of approximately 11ha of habitat used by barbastelles of the Paston Great Barn maternity colony is anticipated to be isolated by hedgerow removal during the project construction phase. This represents approximately 0.6% of the home range of the Paston Great Barn maternity colony. This habitat is located on the edge of the Paston Great Barn maternity colony home range, and is not located within the main foraging area for the colony (the north Norfolk coast between Mundesley and Keswick). Given the scale of the available alternative habitat available within the Paston Great Barn maternity colony home range, this level of habitat fragmentation is not anticipated to comprise a likely significant effect.

1196. It should be noted that the territory of the Paston Great Barn colony overlaps with the Old Hills Wood colony within the onshore project area. Any potential effects on the Old Hills Wood colony arising from the construction and operation of the project may affect the wider Paston Great Barn colony, given the likelihood of a wider barbastelle metapopulation incorporating both these colonies existing. Chapter 22 Onshore Ecology of the Norfolk Vanguard ES (document 6.1) considers potential effects upon the Old Hills Wood colony as well as the Paston Great barn colony. The Chapter concludes that the Old Hills Wood colony overlaps with some, but not all, of the commuting and foraging features used by the Paston Great Barn colony, and that these features are, like the Paston Great Barn colony, located on the edge of that colony's home range. As a consequence, the effects upon the wider barbastelle metapopulation are considered to be the same or less than the effects upon the Paston Great Barn colony in isolation.

1197. The assessment for the potential for adverse effect upon site integrity arising from the development of the Norfolk Vanguard project alone has identified small-scale, temporary effects which, with mitigation, are not anticipated to result in any potential for adverse effect upon site integrity upon the qualifying habitats and species of the Paston Great Barn SAC. As such, there is **no potential adverse effect on the integrity of the Paston Great Barn SAC in relation to the conservation objectives for the site.**

Indirect effects on barbastelle present within ex-situ habitats of the SAC (hedgerows / watercourses) arising from light and groundwater / hydrology effects

1198. The proposed works will involve ground excavation, and therefore will have a small, localised effect upon surface water flows. Approximately 130m of commuting and foraging habitat located within the Paston Great Barn maternity colony home range will be temporarily lost for approximately 3-7 years due to the construction phase of Norfolk Vanguard and while reinstated hedgerow matures. As a consequence, the commuting and foraging habitats will not be present in these locations during the construction phase, and therefore the habitat within this location will not be affected. Furthermore, a pre-construction drainage plan will also be developed and implemented to minimise water within the cable trench and ensure ongoing drainage of surrounding land.

1199. Construction phase lighting for cable duct installation will be used between 7am-7pm, only if required (i.e. in low light conditions). Lighting will not be used overnight, except at trenchless crossing locations. In these instances lighting may be needed for eight weeks at Dilham Canal and land east of Dilham Canal. Any lighting used will be directional i.e. angled downwards and a cowl provided for the light to minimise light spill.

1200. As outlined earlier in this section, it has been assumed that the removal of hedgerow will potential results in small scale, localised and temporary habitat fragmentation and loss of approximately 130m of commuting and foraging habitat located within the Paston Great Barn maternity colony home range will be temporarily lost for approximately 3-7 years due to the construction phase of Norfolk Vanguard. Short-term lighting of these same sections of hedgerow will not alter this possible habitat fragmentation effect or the localised habitat loss caused by hedgerow removal. Therefore, in relation to potential indirect effects arising from lighting and ground water hydrology effects, there is **no potential adverse effect on the integrity of the Paston Great Barn SAC in relation to the conservation objectives for the site.**

9.3.2.1.2. Potential effects during operation

Direct effects on barbastelle present in ex-situ habitats of the SAC (hedgerows / watercourses)

1201. Once replanted hedgerows have reached maturity (expected to be 3-7 years following planting on completion of construction), they will provide an improved commuting and foraging habitat for bats. This in-combination with the use of grassland strips, will provide an improved Lepidoptera assemblage for commuting and foraging barbastelle bats. No further hedgerow removal is required during the operation of the Norfolk Vanguard project. As a consequence, there will be no indirect effects arising from lighting, and there is **no potential adverse effect on the**

integrity of the Paston Great Barn SAC in relation to the conservation objectives for the site.

Indirect effects on barbastelle present within ex-situ habitats of the SAC (hedgerows / watercourses) arising from light and groundwater / hydrology effects

1202. All earthworks will be reinstated following completion of the duct installation, and hydrological conditions are anticipated to return to their situation prior to the construction phase works.

1203. There will be no lighting required during the operational phase of the Norfolk Vanguard project.

1204. The potential indirect effects upon ex-situ habitats of the Paston Great Barn SAC screened in for further assessment will not occur during the operational phase of Norfolk Vanguard, and therefore there is **no potential adverse effect on the integrity of the Paston Great Barn SAC in relation to the conservation objectives for the site.**

9.3.2.1.3. Potential effects during decommissioning

1205. No decision has been made regarding the final decommissioning policy for the onshore cables within 5km of the Paston Great Barn, as it is recognised that industry best practice, rules and legislation change over time. It is likely the cables would be pulled through the ducts and removed, with the ducts themselves left in situ. The potential effects are therefore likely to be of the same magnitude as those outlined for construction. Therefore, **no potential adverse effect on the integrity of the Paston Great Barn SAC in relation to the conservation objectives for barbastelle is anticipated during the decommissioning phase of Norfolk Vanguard.**

1206. The decommissioning methodology will need to be finalised nearer to the end of the lifetime of the project so as to be in line with current guidance, policy and legislation at that point. Any such methodology would be agreed with the relevant authorities and statutory consultees. The decommissioning works could be subject to a separate licencing and consenting approach.

9.3.2.2. Potential effects of Norfolk Vanguard in-combination with other plans and projects

9.3.2.2.1. Introduction

1207. In-combination effects refer to effects on certain receptors from the Norfolk Vanguard project together with other developments (plans and projects) in the wider area. Other plans and projects considered include the following:

- Projects that are under construction;

- Permitted application(s) not yet implemented;
- Submitted application(s) not yet determined;
- All refusals subject to appeal procedures not yet determined;
- Projects on the national infrastructure's programme of projects;
- Projects identified in the relevant development plan (and emerging development plans); and,
- Proposals currently at the scoping stage.

1208. Table 9.11 summarises those projects which have been identified as potentially giving rise to effects upon Paston Great Barn SAC in-combination with the Norfolk Vanguard project, due to their temporal or spatial overlap with the potential effects arising from Norfolk Vanguard. The remainder of the section details the nature of the in-combination effects upon Paston Great Barn SAC.

Table 9.11 Summary of projects considered for the in-combination assessment

Project	Status	Development period	[24]Distance from Norfolk Vanguard (km)	Project data status	Rationale
Norfolk Boreas Offshore Wind Farm	Pre-Application	Expected construction 2026.	0	High	Overlapping proposed project boundaries may result in impacts of a direct and / or indirect nature during construction and operation
Bacton Gas Terminal coastal protection	Approved	Approved 18/11/2016. Expires 18/11/2019.	3.5	Complete/ high	Coastal protection scheme may result in localised changes to coastal habitats
Bacton Coastal Protection Scheme	Approved	Expected construction date 2018	3.5	Complete/ high	Coastal protection scheme may result in localised changes to coastal habitats

Direct effects on barbastelle present in ex-situ habitats of the SAC (hedgerows / watercourses)

1209. No additional hedgerow loss is required for the Norfolk Boreas project. Norfolk Boreas would use the cable ducts installed for Norfolk Vanguard, therefore the only effect would be a potential requirement for retaining the up to 6m gap for the project running track for an additional two years during the Norfolk Boreas construction phase. This would not change the effect identified for Norfolk Vanguard alone.

[24] Shortest distance between the considered project and Norfolk Vanguard – unless specified otherwise.

1210. The Bacton Gas Terminal coastal protection project and the Bacton Coastal Protection Scheme are both located along the coast between Mundesley and Keswick, where barbastelle from the Paston Great Barn maternity colony are known to forage in good weather. Both of these projects are due to be completed by 2019 at the latest. Pre-construction works for Norfolk Vanguard will not commence before 2020. Therefore, these projects will not overlap and barbastelles of Paston Great Barn will not encounter changes to their habitat in two areas of their home range in the same season.

1211. As a consequence, **no potential adverse effect on the integrity of the Paston Great Barn SAC in relation to the conservation objectives for barbastelle is anticipated due to in-combination effects**.

Indirect effects on barbastelle present within ex-situ habitats of the SAC (hedgerows / watercourses) arising from light and groundwater / hydrology effects

1212. The Norfolk Boreas project will use the cable ducts installed for Norfolk Vanguard. Therefore, there would not be a requirement for further trenching works during construction. Furthermore, any lighting requirements would adhere to those for Norfolk Vanguard (i.e. construction phase lighting will be used between 7am-7pm, only if required (i.e. in low light conditions)). This would not change the effects identified for Norfolk Vanguard alone.

1213. As for direct effects the Bacton Gas Terminal coastal protection project and the Bacton Coastal Protection Scheme construction will be completed prior to construction of Norfolk vanguard. Therefore these projects will not overlap and barbastelles of Paston Great Barn will not encounter changes to their habitat in two areas of their home range in the same season.

1214. As a consequence, **no potential adverse effect on the integrity of the Paston Great Barn SAC in relation to the conservation objectives for barbastelle is anticipated due to in-combination effects**.

9.3.2.3. Summary of potential for adverse effect on site integrity

1215. Table 9.12 below summarises the potential effects arising from the construction, operation and decommissioning phases of the proposed Norfolk Vanguard project.

Table 9.12 Summary of the potential effects of Norfolk Vanguard in relation to the River Wensum SAC

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?	Potential for adverse effect upon site integrity in-combination?
Construction phase			
Barbastelle bat	Direct effects on barbastelle present in ex-situ habitats of the SAC (hedgerows / watercourses)	×	×
	Indirect effects on barbastelle present within ex-situ habitats of the SAC (hedgerows / watercourses) arising from light and groundwater / hydrology effects	×	×
Operation phase			
Barbastelle bat	Direct effects on barbastelle present in ex-situ habitats of the SAC (hedgerows / watercourses)	×	×
	Indirect effects on barbastelle present within ex-situ habitats of the SAC (hedgerows / watercourses) arising from light and groundwater / hydrology effects	×	×
Decommissioning phase			
Barbastelle bat	Direct effects on barbastelle present in ex-situ habitats of the SAC (hedgerows / watercourses)	×	×
	Indirect effects on barbastelle present within ex-situ habitats of the SAC (hedgerows / watercourses) arising from light and groundwater / hydrology effects	×	×

× = no potential for any adverse effect on the integrity of the site in relation to the conservation objectives.

9.3.3. Norfolk Valley Fens SAC

9.3.3.1. *Potential effects of Norfolk Vanguard*

1216. The potential effects during the construction, operation and decommissioning of the proposed Norfolk Vanguard project that will be assessed as part of the HRA process for the Norfolk Valley Fens SAC have been agreed in consultation with the onshore ecology and ornithology ETG as part of the EPP.

1217. The potential effects during construction of the proposed Norfolk Vanguard project that have the potential for adverse effect upon site integrity are:

- Indirect effects on Alkaline fens, Alluvial forests with Alnus glutinosa and Fraxinus excelsior, Calcareous fens with Cladium mariscus and species of the Caricion davallianae, European dry heaths, Molinia meadows on calcareous, peaty or clayey-silt-laden soils, Northern Atlantic wet heaths with Erica tetralix (collectively referred to in this section as 'selected qualifying features of the

Norfolk Valley Fens SAC') present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects.

1218. No potential effects during operation or decommissioning were screened in to the assessment.

9.3.3.2. Selected qualifying features of the Norfolk Valley Fens SAC

9.3.3.2.1. Indirect effects on selected qualifying features of the Norfolk Valley Fens SAC present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects

1219. Of the five component SSSIs of the Norfolk Valley Fens SAC which are located within 5km of the onshore project area, four (Badley Moor, Buxton Heath, Potter & Scarning Fens, East Dereham and Southrepps Common) are located 2.8km or more from the onshore project area.

1220. The qualifying features of the Norfolk Valley Fens SAC present at the five component SSSIs located within 5km of the onshore project area are water-sensitive habitats, and are reliant on the surface and groundwater conditions to ensure a maintenance of water flow. Figure 9.7 shows the location of these sites within the local surface water catchments for the watercourses which support them. Table 9.13 summarises the location of these four sites in relation to the onshore project area.

Table 9.13 Location of Norfolk Valley Fens SAC component SSSIs in relation to the onshore project area

Qualifying feature	Distance from onshore project area	Name of catchment in which the site is located	Is the onshore project area located in this catchment?	Is the onshore project area located upstream of this site?
Badley Moor	3.6km	Tud	No	No
Booton Common	0.6km	Blackwater Drain (Wensum)	Yes	Yes
Buxton Heath	3.9km	Hevingham Watercourse	No	No
Potter & Scarning Fens, East Dereham	2.8km	Wendling Beck	Yes	No
Southrepps Common	3.4km	North Walsham and Dilham Canal (disused)	Yes	No

1221. As indicated in Figure 9.7 and Table 9.13, two component SSSIs, Badley Moor and Buxton Heath have no functional connection to the onshore project area. Southrepps Common is located approximately 3.4km upstream of the onshore project area on the North Walsham and Dilham Canal (disused), and Potter &

Scarning Fens, East Dereham is located 2.8km upstream of the onshore project area on a tributary of the Wendling Beck, and these sites also have no functional connection to the onshore project area. These four sites are therefore not considered to be subject from any effects arising from the construction phase of the project.

1222. Booton Common SSSI, the only component SSSI of Norfolk Valley Fens SAC within 1km of the proposed works, is located immediately southeast of Reepham and approximately 600m south of the onshore project area.

1223. The qualifying features of the Norfolk Valley Fens SAC present at Booton Common are water-sensitive habitats, reliant on the Blackwater drain to maintain their structure and function. The proposed works are not located within the Blackwater Drain, but do cross two tributaries of the Blackwater Drain, 1.5km and 1.8km upstream respectively (see Figure 9.6). Trenched water crossings are proposed at these locations. These crossings would employ a 'dam and divert' construction method (please refer to section 9.3.4 for further details of this methodology): the watercourse would be dammed at either side of the onshore cable route using sandbags or straw bales and ditching clay with water flow pumped/piped across the dammed section re-entering the watercourse downstream. As such water flow would be maintained during construction. The cable trenches would then be excavated within the dammed section and ducts installed to a suitable level below the drainage depth (e.g. 2m of cover below the bed level). Reinstatement of the trench would be conducted to the pre-construction depth of the watercourse and the dams removed.

1224. As water flow would be maintained, and given the distance of these sites from Booton Common, effects from trenching works at these locations upon the Blackwater Drain will be minimal.

1225. During consultation with Norfolk Wildlife Trust (NWT) as part of the EPP, NWT has indicated that they do not have any concerns about effects arising from development of the Norfolk Vanguard project in relation to Booton Common (J Hiskett 2018, pers. comm., 23 January).

1226. The Annex I habitats Alkaline fens and Northern Atlantic wet heaths with *Erica tetralix* are both sensitive to changes in nitrogen deposition arising from construction projects. An air quality impact assessment in line with IAQM guidance (IAQM, 2014) has been conducted for Norfolk Vanguard to understand the potential effects of dust and fine particle emissions. For this assessment, ecological receptors within 50m of the onshore project area or within 50m of the route(s) used by construction vehicles on the public highway, up to 500m from the site entrance(s), are also identified at this stage. Booton Common is located approximately 1.4km south of the nearest access route for construction vehicles for the proposed project, and is located 600m from the onshore project area. As such, following IAQM guidance, it is considered to be outside the potential ZOI of the project in terms of air quality emissions.

1227. As the qualifying features are located outside of the ZOI for potential air quality impacts for the project, and no likely significant effects are anticipated to the Blackwater Drain which adjoins Booton Common, there is **no potential adverse effect on the integrity of the Norfolk Valley Fens SAC in relation to the conservation objectives for the site.**

9.3.3.3. Potential effects of Norfolk Vanguard in-combination with other plans and projects

1228. The in-combination assessment for the onshore elements of this HRA has adopted the principles outlined in section 9.3.1.4. The assessment for the potential for adverse effect upon site integrity arising from the development of Norfolk Vanguard alone did not identify any potential adverse effect upon site integrity upon the qualifying habitats and species of the Norfolk Valley Fens SAC. As such, there is **no potential adverse effect on the integrity of the Norfolk Valley Fens SAC in relation to the conservation objectives for the site.**

9.3.3.4. Summary of potential for adverse effect on site integrity

1229. Table 9.14 below summarises the potential effects arising from the construction phase of the proposed Norfolk vanguard project.

Table 9.14 Summary of the potential effects of Norfolk Vanguard in relation to the Norfolk Valley Fens SAC

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?	Potential for adverse effect upon site integrity in-combination?
Alkaline fens	Indirect effects on Alkaline fens present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×
Alluvial forests with Alnus glutinosa and Fraxinus excelsior	Indirect effects on Alluvial forests with Alnus glutinosa and Fraxinus excelsior present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×
Calcareous fens with	Indirect effects on Calcareous fens with Cladium mariscus and species of the Caricion davallianae	×	×

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?	Potential for adverse effect upon site integrity in-combination?
Cladium mariscus and species of the Caricion davallianae	present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects		
European dry heaths	Indirect effects on European dry heaths present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×
Molinia meadows on calcareous, peaty or clayey-silt-laden soils	Indirect effects on Molinia meadows on calcareous, peaty or clayey-silt-laden soils present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×
Northern Atlantic wet heaths with *Erica tetralix*	Indirect effects on Northern Atlantic wet heaths with *Erica tetralix* present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×

× = no potential for any adverse effect on the integrity of the site in relation to the conservation objectives;

9.3.4. The Broads SAC

9.3.4.1. Potential effects of Norfolk Vanguard

1230. The potential effects during the construction, operation and decommissioning of the proposed Norfolk Vanguard project that will be assessed as part of the HRA process for The Broads SAC have been agreed in consultation with Natural England during consultation on a draft version of this document (23rd April 2018).

1231. The potential effects during construction of the proposed Norfolk Vanguard project that have the potential for adverse effect upon site integrity are:

- Direct effects upon ex-situ habitats which may support the qualifying feature otter, due to suitable ex-situ habitats for this feature being present;
- Indirect effects upon habitats and species within the SAC boundary arising from changes in local groundwater / hydrology conditions; and
- Indirect effects upon ex-situ habitats which may support the qualifying feature otter, arising from changes in groundwater / hydrology conditions.

1232. No potential effects during operation or decommissioning were screened in to the assessment.

9.3.4.2. Otter

9.3.4.2.1. Direct and indirect effects upon ex-situ habitats which may support the qualifying feature otter, due to suitable ex-situ habitats for this feature being present.

1233. The onshore project area crosses two watercourses upstream of The Broads SAC: the North Walsham and Dilham Canal, crossed approximately 9.9km upstream (or 7.7km in a straight line) from The Broads SAC, and Hundred Stream, crossed approximately 5.3km upstream (or 4.6km in a straight line) from The Broads SAC. The location of these watercourses in relation to the onshore project area and The Broads SAC are shown on Figure 9.8.

1234. Otters are known to have large home ranges, which can extend up to 50km in some instances (Chanin, 2003). In light of this, it is possible that that otters associated within The Broads SAC may also use these two watercourses within the onshore project area.

1235. A review of the desk-based records obtained from Norfolk Biodiversity Information Service (NBIS) in July 2016 indicates that there are no records of otter on the Hundred Stream. There is one record of an otter spraint on the North Walsham and Dilham Canal, recorded in 2015 and located at TG28863183. This is located approximately 700m upstream of the onshore project area.

The absence of records of otter on the Hundred Stream is not conclusive proof of the absence of this species from the watercourse. The Hundred Stream was visited during February 2018. As shown in Plate 9-1, at the point at which the onshore project area crosses the Easton Rushton Stream, the watercourse is narrow (<2m wide) and shallow (approximately 10-20cm deep in winter). These depths are likely to be too shallow to form part of an otter's home range, especially given the superior habitat available downstream on other parts of the river network connected to The Broads SAC. In light of this it is considered unlikely that otter are present within the reaches of the Hundred Stream in which the onshore project area is located.

Plate 9-1 Hundred Stream at point at which it is crossed by the onshore project area. L: Looking upstream; R: Looking downstream. (NGR: TG 34457 30503) [Photo taken in February 2018]

1236. North Walsham and Dilham Canal within the onshore project area and 50m up and downstream of the onshore project area was surveyed for field signs of otter during the 2017 Extended Phase 1 Habitat Survey and the 2017 Water Vole Survey (Appendix 22.3 of the Norfolk Vanguard ES), in February 2017 and May-June 2017 respectively. No field signs of otter were found during either survey. Therefore, it is considered that otters may be commuting along the North Walsham and Dilham Canal within the onshore project area, but that they are not resting or making other use of bankside habitat in these locations.

1237. As part of the project's embedded mitigation, the North Walsham and Dilham Canal will be crossed using a trenchless crossing technique (e.g. HDD), to minimise impacts to the watercourse at this location. This means that the North Walsham and Dilham Canal and its immediate bankside habitat will be avoided, and no works will take place within these habitats. As a consequence, the commuting route for otters along the North Walsham and Dilham Canal at this location will be maintained.

1238. As the qualifying feature, otter, is either unlikely to be present within a watercourse crossed by the project (Hundred Stream), or present as a commuter in a watercourse which will be avoided through the use of trenchless techniques (North Walsham and

Dilham Canal), there is **no potential adverse effect on the integrity of The Broads SAC in relation to the conservation objectives for otter.**

1239. Although no potential adverse effect is predicted, there is a low risk that commuting otters may move into terrestrial bankside habitats at North Walsham and Dilham Canal. As a precaution, while works are taking place within 100m of North Walsham and Dilham Canal, all excavations will be either covered overnight of left with escape ramps to allow otters to escape if they enter, and all vehicles wheels / tracks will be checked in morning for the presence of sleeping otter.

9.3.4.3. Annex I habitats and Annex II species dependant on upstream hydrological conditions

9.3.4.3.1. Indirect effects upon habitats and species within the SAC boundary arising from changes in local groundwater / hydrology conditions

1240. As outlined in the preceding section of this report, the onshore project area crosses two watercourses upstream of The Broads SAC: North Walsham and Dilham Canal and Hundred Stream. The onshore project area is also located within the Broadland Rivers Chalk & Crag groundwater body.

1241. As part of the project's embedded mitigation, the North Walsham and Dilham Canal will be crossed using a trenchless crossing technique (e.g. HDD). This means that the North Walsham and Dilham Canal will be avoided, and no works will take place within this watercourse. As a consequence, no potential effects upon this watercourse are anticipated.

1242. The East Ruston Stream is proposed to be crossed using a trenching methodology. Trenching will be undertaken at depths of 2m below bed level. The potential exists for the accidental release of lubricants, fuels, oils and drilling fluid from construction machinery working in and adjacent to the groundwater, through spillage, leakage and in-wash from vehicle storage areas after rainfall / sediment runoff due the proposed works in these locations. Given the localised nature of the works significant distance between the onshore works at Hundred Stream and The Broads SAC (4.6km in a straight line), the risk of groundwater pollution effects at The Broads SAC is low. However good practice pollution prevention measures set out in Section 9.3.1 will be employed.

1243. In order to minimise the potential effects of using a trenching methodology on surface water courses, a number of construction options have been developed. For watercourses which are shallower than 1.5m, temporary damming and diverting of the watercourse may be employed during trenching works. The suitability of this method would be advised at detailed design following consent from the relevant land owners as part of the agricultural design process. The watercourse would be dammed at either side of the onshore cable route using sandbags or straw bales and ditching clay with water flow pumped, piped or diverted around the dammed section. The cable trenches can be excavated within the dammed section and ducts installed to a suitable level below the drainage depth, e.g. 2m of cover below the bed level for IDB drains (sufficient to account for climate-related changes in fluvial erosion). Reinstatement of the trench would be conducted to the pre-construction depth of the watercourse and the dams removed. Soil storage and re-instatement of the trench would be conducted in line with the main onshore cable route installation.

1244. In order to ensure that there are no adverse impacts resulting from the installation of temporary dams, the following measures would be employed:

- Restricting the amount of time that temporary dams are in place, e.g. typically no more than one week;
- Fish rescue should be undertaken in the area between the temporary dams prior to dewatering;
- Ensuring that any pumps, flumes (pipes) or diversion channels are appropriately sized to maintain flows downstream of the obstruction whilst minimising upstream impoundment;
- Where appropriate, selecting a technique that can allow fish passage to be maintained in watercourses which support migratory fish species such as brown trout; and
- Where diversion channels are used, geotextiles or similar techniques will be used to line the channel and prevent sediment entering the watercourse.

1245. Culverting may also be required temporarily for a width of 6m to allow the running track to cross watercourses during duct installation works (up to 2 years dependant on location along the route section being worked) and for 'inaccessible' sections of the running track relating to the cable pulling works period (approximately 3 months per location). This is unlikely to be required at the Hundred Stream, given the prevalence of access roads nearby, but this will not be determined until detailed design stage post-consent. In addition to the general measures to mitigate the impacts of culverts noted above, the following would also be applied to temporary culverts:

- Restricting the width of the running track to 3m to minimise the length of each culvert; and
- At the most sensitive locations (e.g. where culvert installation is likely to have an impact on channel morphology and ecology), alternative techniques such as temporary bridges will be adopted.

1246. Where trenching is required, the trench would be reinstated to at least the previous standard (if not an improved standard; for example, re-sectioned banks to be replaced with a more natural profile), and the dams removed. Cable ducts would typically be installed 1.5m below the bed of the watercourse, although this would be dependent upon local geology and associated risks.

1247. A diagram of how temporary damming and diverting would operate is shown in Figure 9.9 and Figure 9.10 below.

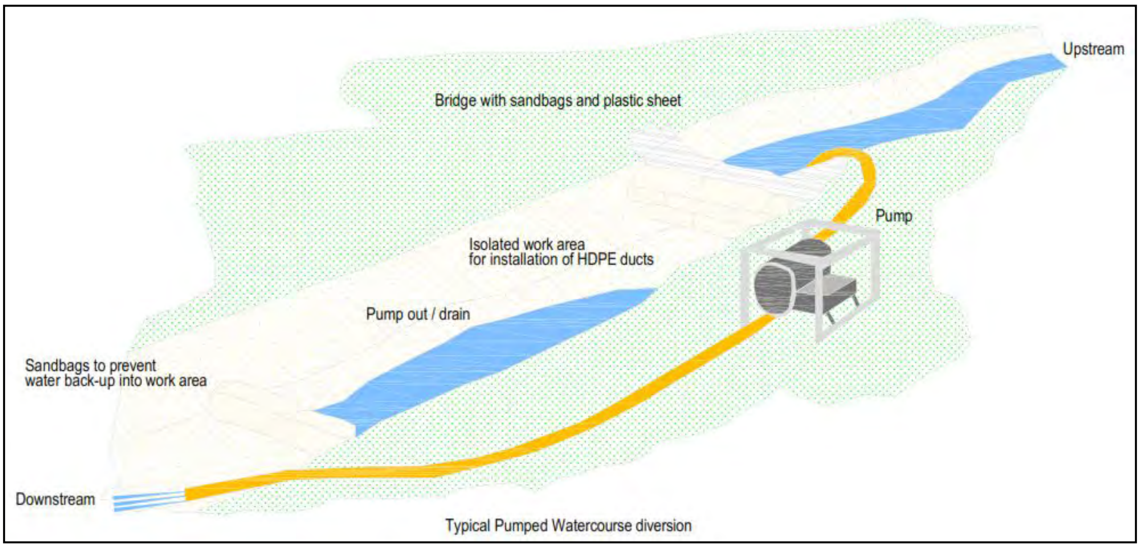

Figure 9.9 Indicative Temporary Dam and Divert (Construction Isometric View)

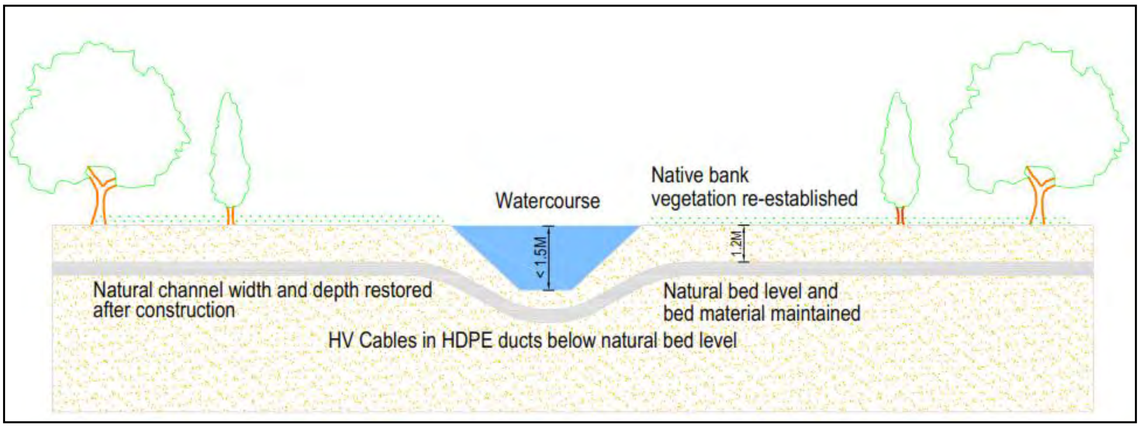

Figure 9.10 Indicative Temporary Dam and Divert (Post-Installation Cross-Sectional View)

1248. Further information on the assessment of impacts of the project upon surface water resources is provided within Chapter 20 Water Resources and Flood Risk of the Norfolk Vanguard ES.

1249. Use of temporary damming and diverting the watercourse will ensure that water flow is maintained during construction, and that any changes in water flow last for one week only. The potential need for a 3m long culvert to be in place for up to two years at this location will have a negligible effect on water flow within the channel, given the small length of the culvert and the distance of the culvert from the nearest point of The Broads SAC (5.3km). In light of these factors, there is **no potential adverse effect on the integrity of The Broads SAC in relation to the conservation objectives for all Annex I habitats and Annex II species of The Broads SAC.**

9.3.4.4. *Potential effects of Norfolk Vanguard in-combination with other plans and projects*

1250. The in-combination assessment for the onshore elements of this HRA has adopted the principles outlined in section 9.3.1.4. The assessment for the potential for an adverse effect upon site integrity from the development of Norfolk Vanguard alone did not identify any potential for adverse effect upon site integrity of The Broads SAC in relation to the conservation objectives for qualifying features of the site. As such, there is **no potential adverse effect on the integrity of The Broads SAC in relation to the conservation objectives for the site.**

9.3.4.5. Summary of potential for adverse effect on site integrity

1251. Table 9.15 below summarises the potential effects arising from the construction phase of the proposed Norfolk Vanguard project.

Table 9.15 Summary of the potential effects of Norfolk Vanguard in relation to The Broads SAC

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?	Potential for adverse effect upon site integrity in-combination?
Otter	Direct effects upon ex-situ habitats which may support the qualifying feature otter, due to suitable ex-situ habitats for this feature being present	×	×
	Indirect effects upon ex-situ habitats which may support the qualifying feature otter, arising from changes in groundwater / hydrology conditions	×	×
All Annex I habitats and Annex II species of the Broads SAC	Indirect effects upon habitats and species within the SAC boundary arising from changes in local groundwater / hydrology conditions	×	×

× = no potential for any adverse effect on the integrity of the site in relation to the conservation objectives

9.3.5. Mitigation and Management

1252. This section summarises the mitigation measures which have been set out in the preceding sections. Mitigation has been outlined above in relation to the following potential effects of Norfolk Vanguard:

- Potential direct effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation and Desmoulin's whorl snail present within the River Wensum SAC boundary arising from geology / contamination and groundwater / hydrology effects;
- Direct effects on barbastelle present in ex-situ habitats of the Paston Great Barn SAC (hedgerows / watercourses);
- Potential indirect effects on barbastelle present within ex-situ habitats of the Paston Great Barn SAC (hedgerows / watercourses) arising from light effects;
- Potential direct effects upon ex-situ habitats which may support the qualifying feature otter of The Broads SAC.

9.3.5.1. Potential direct effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation and Desmoulin's whorl snail present within the River Wensum SAC boundary arising from geology / contamination and groundwater / hydrology effects

- A pre-construction survey of the left-hand (northern) bank of the River Wensum to search for springs and seepages, and a pre-construction invertebrate survey of one ditch on the left-hand (northern) bank of the River Wensum to search for presence of the Desmoulin's whorl snail.
- Best practice topsoil management practices will be followed. All topsoil will be reinstated and measures will be put in place to reinstate any damage to ground conditions caused by vehicle tracking. All sediment management measures used (e.g. sediment traps) will be removed and disposed of following construction. The practices to be followed will be detailed in a CoCP, the details and content of which will be agreed with stakeholders (including the Environment Agency and Natural England) in advance of construction.
- A pre-construction drainage plan will also be developed and implemented to minimise water within the cable trench and ensure ongoing drainage of surrounding land. Where water enters the trenches during installation, this would be pumped via settling tanks or ponds to remove sediment, before being discharged into local ditches or drains via temporary interceptor drains in order to prevent increases in fine sediment supply to the watercourses.
- Existing tracks and roadways would be utilised for access where possible. Where temporary accesses are needed, topsoil and surface water management

measures would be employed as defined in the Drainage Plan and CoCP (document reference 8.1).

- Geotextile, or other suitable material, will be used, where required, to allow the safe storage and movement of vehicles within the area, maintain required drainage, and prevent soil erosion and increased surface runoff.
- The working methodology would follow construction industry good practice guidance, as detailed in the Environment Agency's Pollution Prevention Guidance (PPG) notes (including PPG01, PPG05, PPG08 and PPG21), and CIRIA's '*Control of water pollution from construction sites – A guide to good practice*' (2001), such as having spill kits on site at all times, checking equipment regularly to ensure leakages do not occur, and limiting refuelling of construction plant to designated impermeable areas.
- The project is aiming for a construction scenario whereby construction works within the River Wensum floodplain (i.e. land north of Penny Spot Beck) are not required, and the trenchless crossing at the River Wensum would run beneath this area. However, in advance more detailed assessment of ground conditions, this possibility cannot be ruled out at this stage. If land north of Penny Spot Beck within the River Wensum floodplain is used during construction, then works will take place outside of the winter period (October – February inclusive).

9.3.5.2. Potential direct effects on barbastelle present in ex-situ habitats of the Paston Great Barn SAC (hedgerows / watercourses)

- Hedgerow removal will be programmed for winter where possible, to give bats time to adjust to the change prior to maternity period. Hedgerows will be removed as close to the onset of works as possible, and works will not commence after nights of poor weather (in case of bad weather roosts being used).
- Replanting will follow in the first winter after construction of all except the 6m gap required for the running track (BCT, 2012). Replanting will follow guidance within the Norfolk hedgerow BAP and will include appropriate species for north-east Norfolk (NBP, 2009), including ground flora planting designed to encourage insect biomass (BCT, 2012). Future hedgerow management to include allowing standard trees to develop.
- Subject to landowner permissions, the six hedgerows that are important for foraging and commuting bats would be left to become overgrown either side of the section to be removed prior to construction. Hedgerows would be allowed to become overgrown within the onshore cable route width, therefore at each hedgerow a total of up to 25m will be left to become overgrown in this manner. This would be undertaken to improve the quality of the surrounding hedgerow as a resource for commuting and foraging bats (Bates, 2010).

- The replanting measures described above will be captured in the OLEMS (document reference 8.7).
- Pre-construction activity surveys at the hedgerow along North Walsham Road from Edingthorpe Green to Edingthorpe Heath and at two hedgerows between Witton and North Walsham Road will be undertaken to provide full baseline data for these features.

9.3.5.3. Potential indirect effects on barbastelle present within ex-situ habitats of the Paston Great Barn SAC (hedgerows / watercourses) arising from light effects

- Construction phase lighting for cable duct installation will be used between 7am-7pm, only if required (i.e. in low light conditions). Lighting will not be used overnight, except at trenchless crossing locations. In these instances, lighting may be needed for eight weeks at Dilham Canal and land east of Dilham Canal. Any lighting used will be directional i.e. angled downwards and a cowl provided for the light to minimise light spill.

9.3.5.4. Potential direct effects upon ex-situ habitats which may support the qualifying feature otter of The Broads SAC

- As a precaution, while works are taking place within 100m of North Walsham and Dilham Canal, all excavations will be either covered overnight or left with escape ramps to allow otters to escape if they enter, and all vehicles wheels / tracks will be checked in morning for the presence of sleeping otter.

9.3.6. Summary of Potential Effects

1253. Table 9.16 below summarises the potential effects arising from the construction phase of the proposed Norfolk vanguard project.

Table 9.16 Summary of the potential effects of Norfolk Vanguard

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?	Potential for adverse effect upon site integrity in-combination?
River Wensum SAC (construction phase only)			
Ranunculion fluitantis and *Callitricho-Batrachion* vegetation	Direct effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation present within ex-situ habitats of the SAC	×	×
	Indirect effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation present within the SAC boundary arising from geology / contamination and groundwater / hydrology effects	×	×
	Indirect effects on *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation present within ex-situ	×	×

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?	Potential for adverse effect upon site integrity in-combination?
	habitats of the SAC arising from geology / contamination and groundwater / hydrology effects		
Desmoulin's whorl snail	Direct effects on Desmoulin's whorl snail present within ex-situ habitats of the SAC	×	×
	Indirect effects on Desmoulin's whorl snail present within the SAC boundary arising from geology / contamination and groundwater / hydrology effects	×	×
	Indirect effects on Desmoulin's whorl snail present within ex-situ habitats of the SAC arising from geology / contamination and groundwater / hydrology effects	×	×
Paston Great Barn SAC (construction operation and decommissioning phases)			
Barbastelle bat	Direct effects on barbastelle present in ex-situ habitats of the SAC (hedgerows / watercourses)	×	×
	Indirect effects on barbastelle present within ex-situ habitats of the SAC (hedgerows / watercourses) arising from light and groundwater / hydrology effects	×	×
Norfolk Valley Fens SAC (construction phase only)			
Alkaline fens	Indirect effects on Alkaline fens present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×
Alluvial forests with Alnus glutinosa and Fraxinus excelsior	Indirect effects on Alluvial forests with Alnus glutinosa and Fraxinus excelsior present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×
Calcareous fens with Cladium mariscus and species of the Caricion davallianae	Indirect effects on Calcareous fens with Cladium mariscus and species of the Caricion davallianae present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×
European dry heaths	Indirect effects on European dry heaths present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×
Molinia meadows on calcareous, peaty or	Indirect effects on Molinia meadows on calcareous, peaty or clayey-silt-laden soils present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?	Potential for adverse effect upon site integrity in-combination?
clayey-silt-laden soils			
Northern Atlantic wet heaths with *Erica tetralix*	Indirect effects on Northern Atlantic wet heaths with *Erica tetralix* present within ex-situ habitats of the SAC arising from air quality and groundwater / hydrology effects	×	×
The Broads SAC (construction phase only)			
Otter	Direct effects upon ex-situ habitats which may support the qualifying feature otter, due to suitable ex-situ habitats for this feature being present	×	×
	Indirect effects upon ex-situ habitats which may support the qualifying feature otter, arising from changes in groundwater / hydrology conditions	×	×
All Annex I habitats and Annex II species of the Broads SAC	Indirect effects upon habitats and species within the SAC boundary arising from changes in local groundwater / hydrology conditions	×	×

× = no potential for any adverse effect on the integrity of the site in relation to the conservation objectives.

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Norfolk Vanguard Offshore Wind Farm

Appendix 5.1
Habitats Regulations Assessment Offshore Screening

Applicant: Norfolk Vanguard Limited
Document Reference: 5.3.5.1
Pursuant to: APFP Regulation 5(2)(q)

Date: June 2018
Revision: Version 1
Author: Royal HaskoningDHV

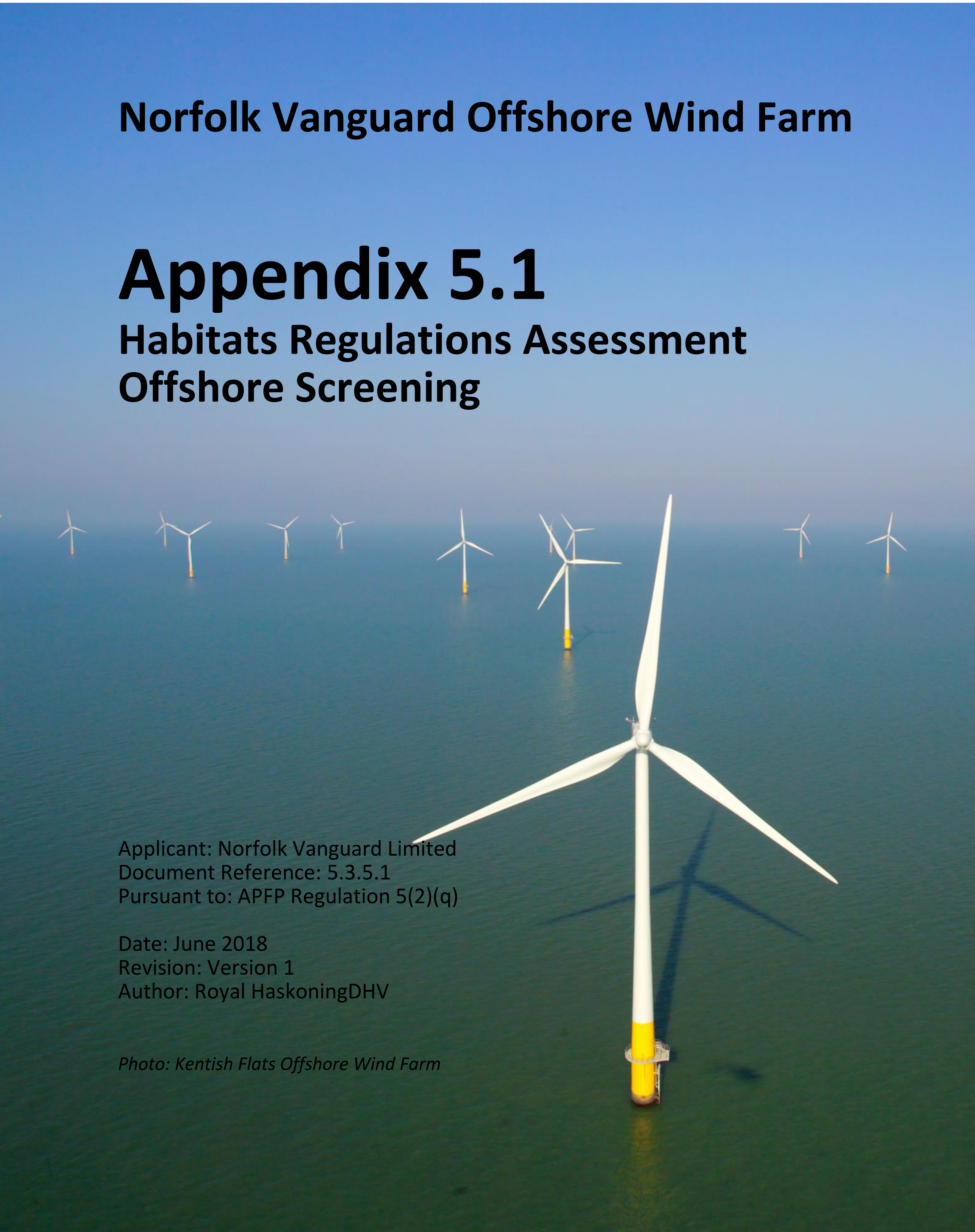

Photo: Kentish Flats Offshore Wind Farm

Document Reference 5.3.5.1

June 2018

For and on behalf of Norfolk Vanguard Limited

Approved by: Ruari Lean and Rebecca Sherwood

Signed: [redacted] [redacted]

Date: 8th June 2018

For and on behalf of Royal HaskoningDHV

Drafted by: Gemma Keenan

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Signed: [redacted]

Date: 30th May 2018

Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
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23/06/17	01F	Final for submission	GK	AD	AD

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Glossary of acronyms

HRA	Habitats Regulations Assessment
LSE	Likely Significant Effect
PEIR	Preliminary Environmental Information Report
DCO	Development Consent Order
SPA	Special Protection Areas
SAC	Special Area of Conservation
pSAC	Possible SACs
cSAC	Candidate SAC
SCI	Sites of Community Importance
EAOW	East Anglia Offshore Wind
ZDA	Zone Development Agreement
VWPL	Vattenfall Wind Power Ltd
SPR	ScottishPower Renewables (UK) Limited
AfL	Agreement for Lease
OWF	offshore wind farm
NV West	Norfolk Vanguard West
NV East	Norfolk Vanguard East
DCLG	Department for Communities and Local Government
ODPM	Office of the Deputy Prime Minister
Defra	Department for Environment, Food and Rural Affairs
SNCB	Statutory Nature Conservation Bodies
HRGN	Habitats Regulations Guidance Note
NSER	No Significant Effects Report
IROPI	Imperative Reasons of Overriding Public Interest
MU	Management Unit
IAMMWG	Inter-Agency Marine Mammal Working Group
SMRU	Sea Mammal Research Unit
IMARES	Institute of Marine Engineering, Science and Technology

Glossary of Terminology

Natura 2000 site	A network of nature protection areas in the territory of the European Union. It is made up of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) designated under the Habitats Directive and Birds Directive, respectively
Ramsar sites	A Ramsar Site is a wetland site of international importance under the Convention on Wetlands, known as the Ramsar Convention
the OWF sites	Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West)
The offshore project area	Norfolk Vanguard East and Norfolk Vanguard West and the offshore cable corridor

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1 INTRODUCTION

1.1 Purpose of this document

1. This document provides the offshore screening of Natura 2000 sites for Habitats Regulations Assessment (HRA) in relation to the Norfolk Vanguard offshore wind farm. This document covers designated sites for marine mammals, benthic habitats, fish and birds. The document provides the information that was used in stakeholder consultation as part of the Evidence Plan Process, to seek agreement on the designated sites which should be considered further. This also forms stage 1 of the HRA Process (discussed further in Section 1.4). Any updates since screening in Q3/4 of 2017 are discussed in the main Information to Support HRA report. Impacts of the onshore project infrastructure on Natura 2000 sites are screened separately in Appendix 5.2.

2. Designated sites are proposed to be “screened out” where no Likely Significant Effect (LSE) from Norfolk Vanguard is predicted. Where LSE cannot be ruled out at this stage the designated sites will be “screened in” and assessed further. Information to support HRA (both offshore and onshore) will be provided with the Preliminary Environmental Information Report (PEIR) and the Development Consent Order (DCO) application.

3. Note that Natura 2000 sites included in this document include sites in other EU Member States.

4. The classes of Natura 2000 designations considered within this HRA Screening are:

- Special Protection Areas (SPAs) (some of which are also Ramsar sites)
- Potential SPA (pSPA)
    - SPAs that are approved by the UK Government but are still in the process of being classified
- Special Areas of Conservation (SACs)
- Possible SACs (pSACs)
    - A site which has been identified and approved to go out to formal consultation.
- Candidate SACs (cSACs)
    - Following consultation on the pSAC, the site is submitted to the European Commission (EC) for designation and it this stage it is called a cSAC.
- Sites of Community Importance (SCI)

- Once the EC approves the site it becomes a SCI, before the national government then designates it as a SAC.

5. Consideration is also given to impacts on Ramsar sites. Ramsar sites protect wetland areas and extend only to “areas of marine water the depth of which at low tide does not exceed six metres”.

6. Screening of SPAs and SACs affected by the onshore project elements will be provided separately.

1.2 Project Background

7. In December 2009, as part of the UK Offshore Wind Round 3 tender process, The Crown Estate awarded the joint venture company, East Anglia Offshore Wind (EAOW) Ltd, the rights to develop Zone 5 (later called the ‘East Anglia zone’). These rights were granted through a Zone Development Agreement (ZDA). EAOW Ltd. is a 50:50 joint venture owned by Vattenfall Wind Power Ltd (VWPL) and ScottishPower Renewables (UK) Limited (SPR).

8. Under the ZDA, the joint venture consented East Anglia ONE, and commenced the EIAs for East Anglia THREE (prior to the project being taken forward to submission by SPR) and East Anglia FOUR (up to submission of a request for Scoping Opinion in 2012).

9. In December 2014, a decision was taken to split the zone, with VWPL having development rights within the north of the former East Anglia Zone, and SPR continuing to develop the southern part. In agreement with The Crown Estate, the ZDA was effectively dissolved in 2016. New Agreement for Lease (AfL) areas have been awarded by The Crown Estate within the former Zone, separately to VWPL and its affiliate companies, and SPR and its affiliates.

10. Norfolk Vanguard Ltd (an affiliate company of VWPL) is now undertaking the EIA for Norfolk Vanguard and a Scoping Report was submitted to the Planning Inspectorate in October 2016 (Royal HaskoningDHV, 2016).

11. The offshore wind farm (OWF) comprises two distinct areas, Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) (‘the OWF sites’), and will be connected to the shore by offshore export cables installed within the offshore cable corridor (Figure 1.1).

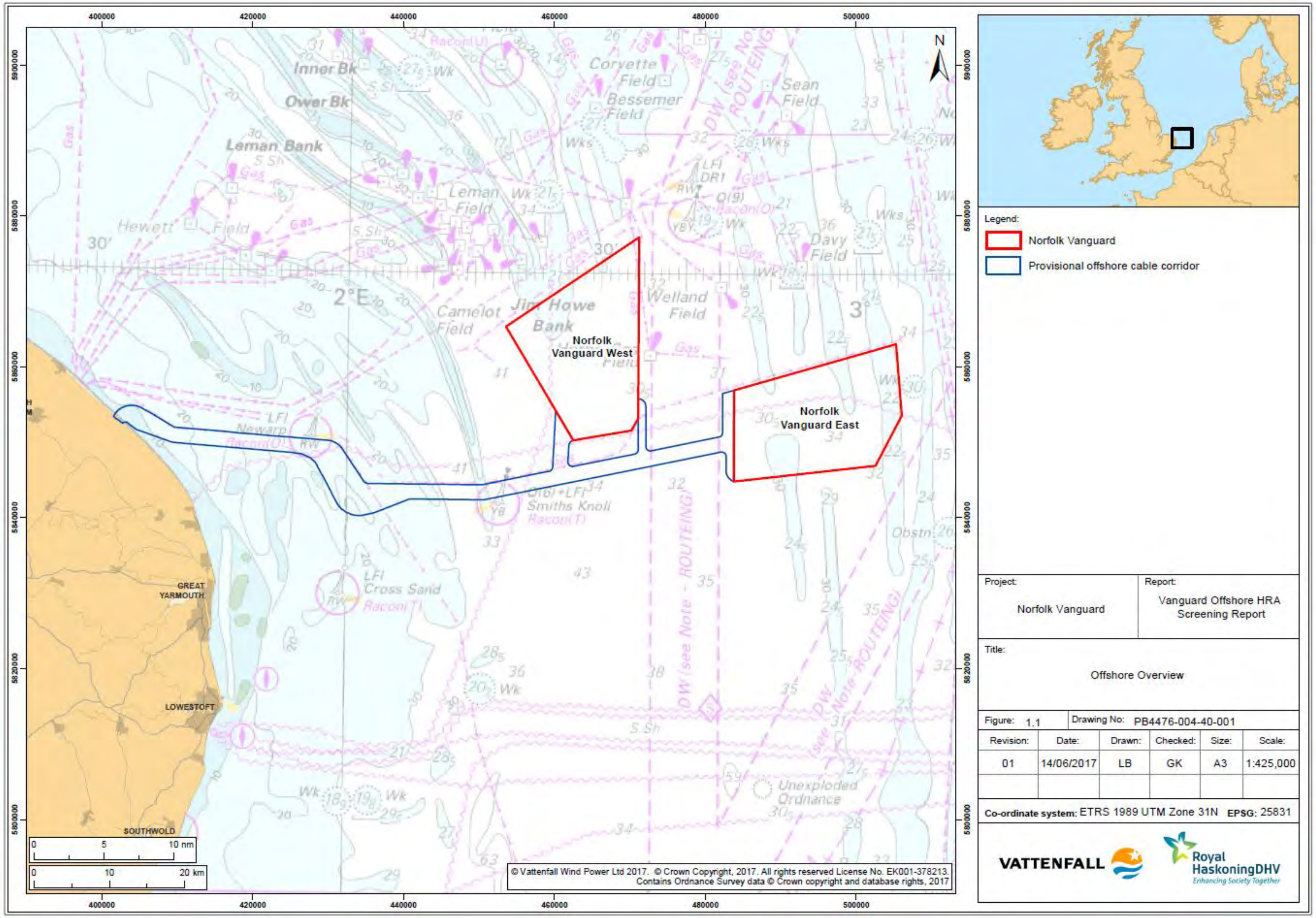

Figure 1.1 Norfolk Vanguard offshore project area

12. The development of the Norfolk Vanguard offshore project area has followed a careful site selection process in order to minimise the impacts on designated sites and where possible sites have been avoided. It has not been possible to avoid the Southern North Sea cSAC which overlaps with the whole of the former East Anglia zone. The requirement to route through the Haisborough, Hammond and Winterton SCI/cSAC followed a detailed site selection exercise and resulted from the need to avoid existing infrastructure and operations, specifically oil and gas pipelines and aggregate dredging areas (see further information in the Norfolk Vanguard Scoping Report, Royal HaskoningDHV, 2016).

1.3 HRA Legislation, Policy and Guidance

1.3.1 Legislation

13. The HRA process derives from the requirements of specific European Directives and the Regulations that implement their requirements in national law.

14. The UK has triggered article 50 of the Treaty on European Union (TEU) and is in a two year process of negotiating a withdrawal agreement for the UK to leave the EU. Following withdrawal from the EU, the UK government plans to enact the Great Repeal Bill. In its white Paper the UK Government has confirmed that it plans to transpose all current European environmental regulation into UK law after Brexit.

1.3.1.1 The Birds Directive

15. The EU Directive on the Conservation of Wild Birds (2009/147/EC) (hereafter called the Birds Directive) provides a framework for the conservation and management of wild birds in Europe. The relevant provisions of the Directive are the identification and classification of SPAs for rare or vulnerable species listed in Annex I of the Directive and for all regularly occurring migratory species (required by Article 4). The Directive requires national Governments to establish SPAs and to have in place mechanisms to protect and manage them. The SPA protection procedures originally set out in Article 4 of the Birds Directive have been replaced by the Article 6 provisions of the Habitats Directive.

1.3.1.2 The Habitats Directive

16. The EU Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (hereafter called the Habitats Directive) provides a framework for the conservation and management of natural habitats, wild fauna (except birds) and flora in Europe. Its aim is to maintain or restore natural habitats and wild species at a favourable conservation status. The relevant provisions of the Directive are the identification and classification of Special Areas of Conservation (SAC) (Article 4) and procedures for the protection of SACs and SPAs (Article 6). SACs are identified based

on the presence of natural habitat types listed in Annex I and populations of the species listed in Annex II. The Directive requires national Governments to establish SACs and to have in place mechanisms to protect and manage them.

1.3.1.3 The Conservation of Habitats and Species Regulations 2010

17. The Conservation of Habitats and Species Regulations 2010, (hereafter called the 'Habitats Regulations') transpose the Birds Directive and the Habitats Directive into UK law. The Habitats Regulations place an obligation on 'competent authorities' to carry out an appropriate assessment of any proposal likely to affect a SAC or SPA, to seek advice from Natural England and not to approve an application that would have an adverse effect on a SAC or SPA except under very tightly constrained conditions that involve decisions by the Secretary of State. The competent authority in the case of Norfolk Vanguard is the Secretary of State for Business, Energy and Industrial Strategy.

1.3.1.4 The Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007

18. The Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 (as amended), (referred to here as the 'Offshore Regulations') transposes the Birds Directive and the Habitats Directive into national law in the offshore environment (from territorial waters to the continental shelf). The Offshore Regulations place an obligation on 'competent authorities' to carry out an appropriate assessment of any proposal likely to affect a SAC or SPA, to seek advice from Natural England and / or the joint Nature Conservation Committee (JNCC) and not to approve an application that would have an adverse effect on a SAC or SPA except under very tightly constrained conditions that involve decisions by the Secretary of State. The competent authority in the case of Norfolk Vanguard is the Secretary of State for Business, Energy and Industrial Strategy.

1.3.1.5 Application of the legislation to designated sites

19. As discussed in Section 1.1 the HRA process also applies as a matter of law or policy to the following sites:

- SCI and cSAC: HRA process applied as a result of Article 4(5) and Article 6(2)(4) of the Habitats Directive.
- pSPAs: HRA process applied as a result of UK Government policy - paragraph 118 of the National Planning Policy Framework (DCLG, 2012).
- pSACs: HRA process applied as a result of UK Government policy - paragraph 118 of the National Planning Policy Framework (DCLG, 2012).
- Listed and proposed Ramsar sites (internationally important wetlands designated under the Ramsar Convention 1971): HRA process applied as a result of UK Government policy (ODPM & Defra, 2005; DCLG, 2012).

1.3.2 Guidance on the HRA Process

20. In preparing this report, consideration has been given to the relevant guidance issued by a number of Governmental, statutory and industry bodies.

21. In relation to guidance from Government bodies this includes:

- European Commission: Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites.
- European Commission: EU Guidance on wind energy development in accordance with EU nature directives.
- Department of Communities and Local Government: Guidance on 'Planning for the Protection of European Sites: Appropriate Assessment'.
- The Planning Inspectorate Advice Note Nine: Rochdale Envelope.
- The Planning Inspectorate Advice Note Ten: Habitat Regulations Assessment relevant to nationally significant infrastructure projects.

22. In relation to guidance from the Statutory Nature Conservation Bodies (SNCBs) this includes:

- English Nature: Habitats Regulations Guidance Note (HRGN 1): The Appropriate Assessment (Regulation 48) The Conservation (Natural Habitats &c) Regulations, 1994.
- English Nature: Habitats Regulations Guidance Note (HRGN 3): The Determination of Likely Significant Effect under the Conservation (Natural Habitats &c) Regulations, 1994.
- English Nature: Habitats Regulations Guidance Note (HRGN 4): Alone or in combination.
- Natural England and JNCC: Interim advice on HRA screening for seabirds in the non-breeding season.
- Natural England and JNCC: Advice on HRA screening for seabirds in the breeding season.
- Natural England and JNCC: Interim Advice Note – Presenting information to inform assessment of the potential magnitude and consequences of displacement of seabirds in relation to Offshore Wind farm Developments.

1.4 The HRA Process

23. The HRA process is carried out in a sequential manner and the stages of that sequence are described as follows in Planning Inspectorate Advice Note 10 (Planning Inspectorate, 2016):

- Stage 1 –Screening (This report);

   - European and Ramsar sites are screened for LSE, both effects from the project alone and in combination with other projects. The Planning Inspectorate advises that for those projects where no LSE is predicted then that should reported in the form of a No Significant Effects Report (NSER) and the Stage 2 assessment is not carried out (the Planning Inspectorate, 2016).

- Stage 2 - Appropriate Assessment;
   - For those sites where LSE on a European or Ramsar site cannot be excluded in Stage 1 then further information to inform the assessment will be prepared and the test applied to determine whether the project alone or in-combination could adversely affect the integrity of the site in view of its conservation objectives. This assessment stage will be reported in the form of a HRA Report and the results of the assessment summarised in the form of a series of matrices.

24. In those cases where the conclusion of the HRA Report is that an adverse effect on the integrity of a European or Ramsar site has been identified then the assessment proceeds to two further stages:

- Stage 3 - Assessment of Alternatives; and
   - The alternatives that have been considered will be assessed. The Planning Inspectorate advises that alternative solutions can include a proposal of a different scale, a different location and an option of not having the scheme at all – the 'do nothing' approach.
- Stage 4 – Assessment of Imperative Reasons of Overriding Public Interest (IROPI).
   - If it is demonstrated that there are no alternative solutions to the proposal that would have a lesser effect or avoid an adverse effect on the integrity of the site(s), then a justified case will be prepared that the scheme must be carried out for IROPI.

25. If the conclusion of Stages 3 and 4 is that there is no alternative and that the project has demonstrated IROPI then the project may proceed with a requirement that appropriate compensatory measures are delivered.

1.4.1 In-combination Assessment

26. The Habitats Regulations and the Offshore Regulations require the consideration of the potential effects of a project on European sites and Ramsar sites both alone and in-combination with other plans or projects.

27. The identification of plans and projects to include in the in-combination assessment will be based on:

- Approved plans;
- Constructed projects;
- Approved but as yet unconstructed projects; and
- Projects for which an application has been made, are currently under consideration and will be consented before the Norfolk Vanguard consent decision.

28. The classes of projects that could potentially be considered for the in-combination assessment include:

- Offshore wind farms;
- Marine renewables (wave and tidal);
- Harbour and port developments
- Marine aggregate extraction and dredging;
- Licensed disposal sites;
- Oil and gas exploration and extraction;
- Subsea cables and pipelines;
- Commercial marine fishing activity;
- Recreational marine fishing activity; and
- Onshore major residential, commercial and industrial development.

29. The assessment will present relevant in-combination impacts of projects in the following tiered approach (Table 1.1) as advised by Natural England (JNCC and Natural England, 2013a).

Table 1.1 Suggested tiers for undertaking a staged cumulative impact assessment (JNCC and Natural England, 2013a)

Tier Description	Consenting or Construction Phase	Data Availability
Tier 1	Built and operational projects should be included within the cumulative assessment where they have not been included within the environmental characterisation survey, i.e. they were not operational when baseline surveys were undertaken, and/or any residual impact may not have yet fed through to and been captured in estimates of “baseline” conditions e.g. “background” distribution or mortality rate for birds.	Pre-construction (and possibly post-construction) survey data from the built project(s) and environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project).
Tier 2	Tier 1 + projects under construction	As Tier 1 but not including post-construction survey data
Tier 3	Tier 2 + projects that have been consented	Environmental characterisation survey data from proposed project (including

Tier Description	Consenting or Construction Phase	Data Availability
	(but construction has not yet commenced)	data analysis and interpretation within the ES for the project) and possibly pre-construction
Tier 4	Tier 3 + projects that have an application submitted to the appropriate regulatory body that have not yet been determined	Environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project)
Tier 5	Tier 4 + projects that the regulatory body are expecting an application to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects)	Possibly environmental characterisation survey data (but strong likelihood that this data will not be publicly available at this stage).
Tier 6	Tier 5 + projects that have been identified in relevant strategic plans or programmes (e.g. projects identified in Round 3 wind farm zone appraisal and planning (ZAP) documents)	Historic survey data collected for other purposes/by other projects or industries or at a strategic level.

30. Projects will be included in the quantitative assessment where there is sufficient certainty and data confidence that they make a meaningful contribution to the assessment process.

1.5 Process for the Identification of European and Ramsar Sites and Features Potentially Affected by the Project

31. The initial identification of European and Ramsar sites for inclusion in the Stage 1 HRA Screening is primarily based on the location of the site relative to Norfolk Vanguard. The approach for each site interest feature (i.e. marine mammals, benthic habitat, fish and birds) is outlined in Sections 2.1, 3.1, 4.1 and 5.1 as each receptor has different range and therefore different potential for connectivity.

1.6 HRA Stage 1 Screening Process

32. Screening has been based on a conceptual 'source-pathway-receptor' approach. The approach identifies likely environmental impacts resulting from the proposed construction, operation and maintenance (O&M) and decommissioning of the wind farm and its supporting transmission infrastructure. The parameters are defined as follows:

- Source – the origin of a potential impact (noting that one source may have several pathways and receptors).
    - Example: Re-suspension of sediments due to cable laying activity.

- Pathway – the means by which the effect of the activity could impact a receptor.
    - Example: Settlement of re-suspended sediments causing smothering of seabed.
- Receptor – the element of the receiving environment that is impacted.
    - Example: Smothering has a direct effect on a seabed organism that forms an important part of the food chain for a site interest feature.

33. Where there is no pathway or the pathway is so long that the effect from the source has dissipated to a negligible level before reaching the receptor, there is justification for the screening out of that particular receptor.

34. It only requires one category of site interest feature to be identified in the process below for the European and / or Ramsar site to be screened in, along with all its associated interest features.

35. The approach to screening for each receptor is outlined in Sections 2.2, 3.2, 4.2, and 5.2 based on the known distribution, ecology and sensitivities of each receptor and therefore the potential for being affected by Norfolk Vanguard.

36. Where there is insufficient information available at this stage to screen out a site, it is screened in for further consideration.

2 SCREENING MARINE MAMMAL SAC SITES AND FEATURES

2.1 Identification of Marine Mammal Sites and Features

37. Based on data collected during Norfolk Vanguard aerial surveys and a review of existing data sources, the Annex II species likely to occur in Norfolk Vanguard and therefore considered in the HRA screening are:

- Harbour porpoise *Phocoena phocoena*;
- Grey seal *Halichoerus grypus*; and
- Harbour seal *Phoca vitulina*.

38. Bottlenose dolphin *Tursiops truncatus* has not been identified during Norfolk Vanguard aerial surveys and no bottlenose dolphin were positively sighted during the aerial surveys of the adjacent East Anglia THREE site (EATL, 2015). During SCANS III surveys in summer 2016, no bottlenose dolphin were recorded in or around the area of Norfolk Vanguard (Hammond *et al*., 2016). During the SCANS II surveys, only two bottlenose dolphin groups were sighted within the survey block which encompasses the East Anglia Zone; resulting in an estimated density of 0.0032 (CV 0.74) individuals per km^2 (Hammond *et al*., 2013). There are currently seven Management Units (MU) for bottlenose dolphin in UK waters; Norfolk Vanguard is located in the Greater North Sea (GNS) MU, which has an estimated population size of zero (IAMMWG, 2015). Taking into account the very low occurrence of sightings in and around Norfolk Vanguard and the assessment of the GNS MU population size by the IAMMWG, this species will not be considered further.

39. The following sections (2.1.1 – 2.1.3) describe the process used to define the list of sites for which there is theoretical connectivity and therefore potential for a source – pathway – receptor relationship for harbour porpoise, grey seal and harbour seal.

2.1.1 Harbour porpoise

40. For harbour porpoise, connectivity is considered potentially possible between Norfolk Vanguard and any Natura 2000 site within the North Sea Management Unit (MU) (Inter-Agency Marine Mammal Working Group (IAMMWG, 2015) (see Figure 2.1). The extent of the North Sea MU has been agreed during consultation with the Marine Mammals Expert Topic Group[1] (February 2017), as the most appropriate population which any harbour porpoise occurring within Norfolk Vanguard may be part of.

[1] Natural England, Whale and Dolphin Conservation (WDC), Wildlife Trust and Cefas.

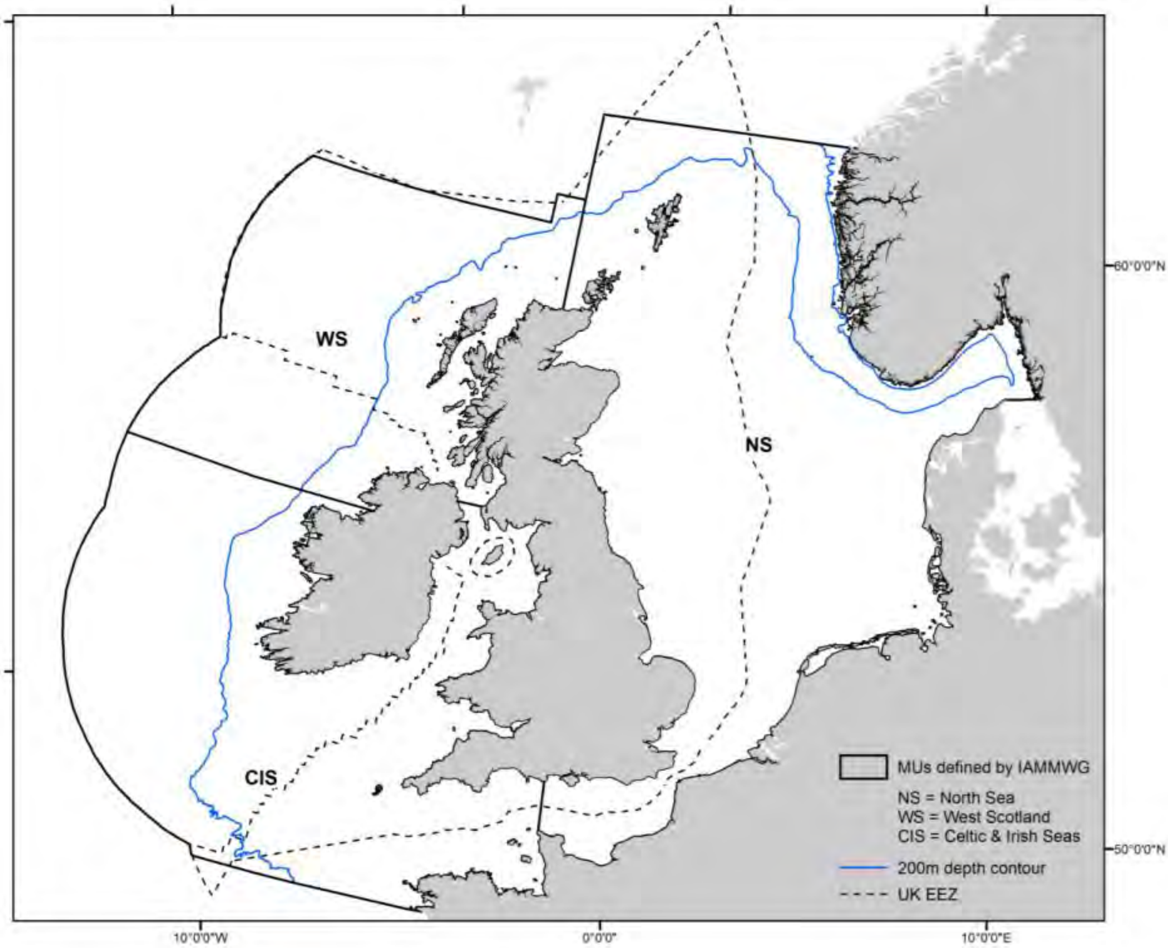

Figure 2.1 Harbour porpoise management units (IAMMWG, 2015)

41. This HRA screening considers any Natura 2000 site within the harbour porpoise North Sea MU, where the species is considered as a grade A, B or C feature. Grade D indicates a non-significant population (JNCC, 2009). All Natura 2000 sites outwith the harbour porpoise North Sea MU area have been screened out from further consideration.

42. Table 2.3 provides the list of sites with harbour porpoise interest features considered for screening.

2.1.2 Grey seal

43. For grey seal, the screening process includes any Natura 2000 site where the species is a grade A, B or C feature. There is potential connectivity with sites that are within 1,000km of Norfolk Vanguard based on studies of regular foraging and dispersal between winter breeding sites, and summer foraging and haul out sites (e.g. McConnell *et al*., 1992).

44. Table 2.3 provides the list of sites with grey seal interest features considered for screening.

2.1.3 Harbour seal

45. For harbour seal, the screening process considers Natura 2000 sites where the species is a grade A, B or C feature and the site was within 300km of Norfolk Vanguard.

46. The distance of 300km is used as harbour seal exhibit relative short foraging trips from their haul out sites. The range of these trips does vary depending on the surrounding marine habitat (e.g. 25km on the west of Scotland (Cunningham *et al*., 2009); 30km-45km in the Moray Firth (Tollit *et al*., 1998; Thompson and Miller, 1990). However, data from The Wash (from 2003- 2005) suggest that harbour seal travel further, and repeatedly forage between 75km and 120km offshore (with one seal travelling 220km; Sharples *et al*., 2008). Data from the Thames Estuary (from 2006) indicate most animals in this region undertaking short range trips (up to 40km), but one individual did have a range of 660km from the southernmost to the northern most extent of its movements (Sharples *et al*., 2008). Although occasional longer trips do occur, these are often associated with young animals dispersing from sites, and are therefore not considered to indicate likely repeated connectivity between Natura 2000 sites and Norfolk Vanguard. Telemetry studies of harbour seal have also been completed in German and Danish waters and in the German Bight area of the North Sea (e.g. Tougard *et al*., 2008). These data support the screening out of sites beyond 300km from Norfolk Vanguard, as telemetry data suggest a lack of dispersal between German Bight and Danish waters, and seals using Dutch areas of the Wadden Sea, and locations around the Dutch / German border. As such, 300km was chosen as a suitable screening distance for connectivity.

47. Table 2.3 provides the list of sites with harbour seal interest features considered for screening.

2.2 Approach to screening

2.2.1 Potential Effects (Source)

48. The following potential effects during construction, O&M and decommissioning are considered in the HRA process:

- Indirect impacts through effects on prey species;
- Underwater noise; and
- Vessel interactions.

2.2.2 Proximity of source to feature (i.e. SAC) (pathway and receptor)

49. For marine mammals, the approach to HRA screening primarily focuses on the potential for connectivity between individual marine mammals from designated populations and the proposed Norfolk Vanguard project (i.e. demonstration of a

clear source-pathway-receptor relationship). This is based on the distance of Norfolk Vanguard from the designated site, the range of each effect and the potential for animals from a site to be within range of an effect.

50. Therefore sites are screened on the basis of the following:

- The distance between the potential impact range of the proposed project and a site with a marine mammal interest feature is within the range for which there could be an interaction e.g. the pathway is not too long for significant noise propagation.
- The distance between the proposed project and resources on which the interest feature depends (i.e. an indirect effect acting though prey or access to habitat) is within the range for which there could be an interaction i.e. the pathway is not too long.
- The likelihood that a foraging area or a migratory route occurs within the zone of interaction of the proposed project (applies to mobile interest features when outside the SAC).

2.3 Screening

2.3.1 Harbour porpoise

2.3.1.1 Indirect impacts through effects on prey species

51. For indirect effects on prey, results from underwater modelling suggests that noise impacts upon fish will be limited to <50km, for the widest ranging behavioural effects (based on Popper *et al.* (2014) TTS criteria of 186dB SEL). Therefore all sites with the exception of the Southern North Sea cSAC are screened out with regard to indirect effects due to the distance between the potential impact range and other designated sites (see Table 2.3).

52. As there is no discrete population of harbour porpoise associated with designated sites due to their wide ranging nature within the North Sea, it is assumed that at any one time, harbour porpoise foraging in this area are associated with the Southern North Sea cSAC (as they cannot simultaneously be part of the population of multiple designated sites, although all are part of the larger MU population). Therefore connectivity with animals from other designated sites foraging within the impact range of indirect changes to prey resource as a result of Norfolk Vanguard is screened out and the Southern North Sea cSAC is screened in.

2.3.1.2 Underwater noise

53. With regard to underwater noise impacts upon designated sites themselves (or individual animals within them), it is considered that for piling (which is the greatest of the potential noise sources) the potential range of disturbance impact is up to

26km from the source of noise. Based on the effective deterrent radius (EDR) for a single monopile of 26km (Tougaard *et al*, 2013), as suggested in the JNCC discussion paper ‘a potential approach to assessing the significance of disturbance against conservation objectives of the harbour porpoise cSAC for the harbour porpoise SACs stakeholder workshop, February 2017. Therefore all sites with the exception of the Southern North Sea cSAC are screened out with regard to noise impacting upon the sites themselves due to being at a greater distance than this impact range.

54. Animals affected by underwater noise from Norfolk Vanguard would be within or in close proximity to the Southern North Sea cSAC. As discussed above, it is considered that during this time, harbour porpoise in this area are associated with the Southern North Sea cSAC and therefore all sites, with the exception of the Southern North Sea cSAC, are screened out with regard to impacts from underwater noise.

2.3.1.3 Vessel interactions

55. For vessel interactions, condensed vessel activity will occur in the vicinity of the Norfolk Vanguard offshore project area and routes to local ports (beyond this, vessel activity will be dispersed and becomes part of the background vessel traffic, using already established vessel routes). Thus, all animals affected would be within or in close proximity to the Southern North Sea cSAC. As discussed above, it is considered that during this time, harbour porpoise in the area are associated with the Southern North Sea cSAC and therefore all sites, with the exception of the Southern North Sea cSAC, are screened out with regard to vessel interactions.

2.3.2 Grey seal

56. A telemetry study by the Sea Mammal Research Unit (SMRU) tagged grey seal at the Berwickshire and North Northumberland Coast (Farnes Island haul out and breeding colony), the Humber Estuary (Donna Nook haul out and breeding colony), the Isle of May (haul out and breeding colony) and within the Firth of Tay and Eden Estuary SAC (Abertay haul out region). Tracks for grey seal pups (Figure 2.2) and adults (Figure 2.3) were assessed for the East Anglia FOUR site (EATL, 2014), which is now NV East. The data indicate that potential use of Norfolk Vanguard, and therefore connectivity with SAC sites in the UK, is low.

57. The track of only one grey seal pup tagged at the Isle of May in 2002 overlapped with the East Anglia FOUR 20km buffer (Figure 2.2) and the edge of NV West. However the extent of overlap is very low with less than 0.3% of locations within the buffer. The track of one adult grey seal also overlaps with NV West.

58. Mixing between the North Sea and West coast of Scotland and Irish Sea sub-populations is not observed; therefore Natura 2000 sites in these locations have been screened out. In addition telemetry data from grey seals in French (Vincent *et*

al., 2002) and Irish (e.g. http://sealtrack.ucc.ie/) waters suggest that there is very limited connectivity between haul out sites on the Isles of Scilly or Irish Sea and individuals foraging in the Southern North Sea. As such, Natura 2000 sites in these locations have also been screened out.

59. None of the grey seal tagged in the UK entered Natura 2000 sites in other member states. However, telemetry from Dutch waters (Figure 2.4 and Figure 2.5) supports potential connectivity between grey seal at the Humber Estuary SAC, Isle of May SAC, and the Berwickshire and North Northumberland Coast SAC and shows movement across the southern North Sea and use of NV East by seals which have also used Natura 2000 sites along the Dutch, French and Belgian coasts.

60. Grey seal have been shown to move from the Thames Estuary area to haul out sites in the English Channel and on the French coast as far as Brest (Matthiopoulos *et al*., 2004).

61. A few grey seal have been tagged in the mouth of the Baltic and Kattegat and Skaggerak but these data (e.g. Dietz *et al*., 2003) do not provide certainty as to where the boundary lies between the Baltic population and the Northeast Atlantic population. Numbers of grey seals in this region are low (Härkönen *et al*., 2007). Tagged pups from in the Kattegat-Skagerrak have been shown to originate from the Danish North Sea coast, but the timing of breeding indicated that animals may come from both the Atlantic and Baltic stocks. As such, Natura 2000 sites in the mouth of the Baltic and Kattegat and Skaggerak have been screened out.

62. Grey seal telemetry data show no evidence of connectivity between the German and Danish Natura 2000 sites along the German Bight with movement limited to the Dutch Waddensea and Delta areas, and not extending into the German Waddensea and Helgoland.

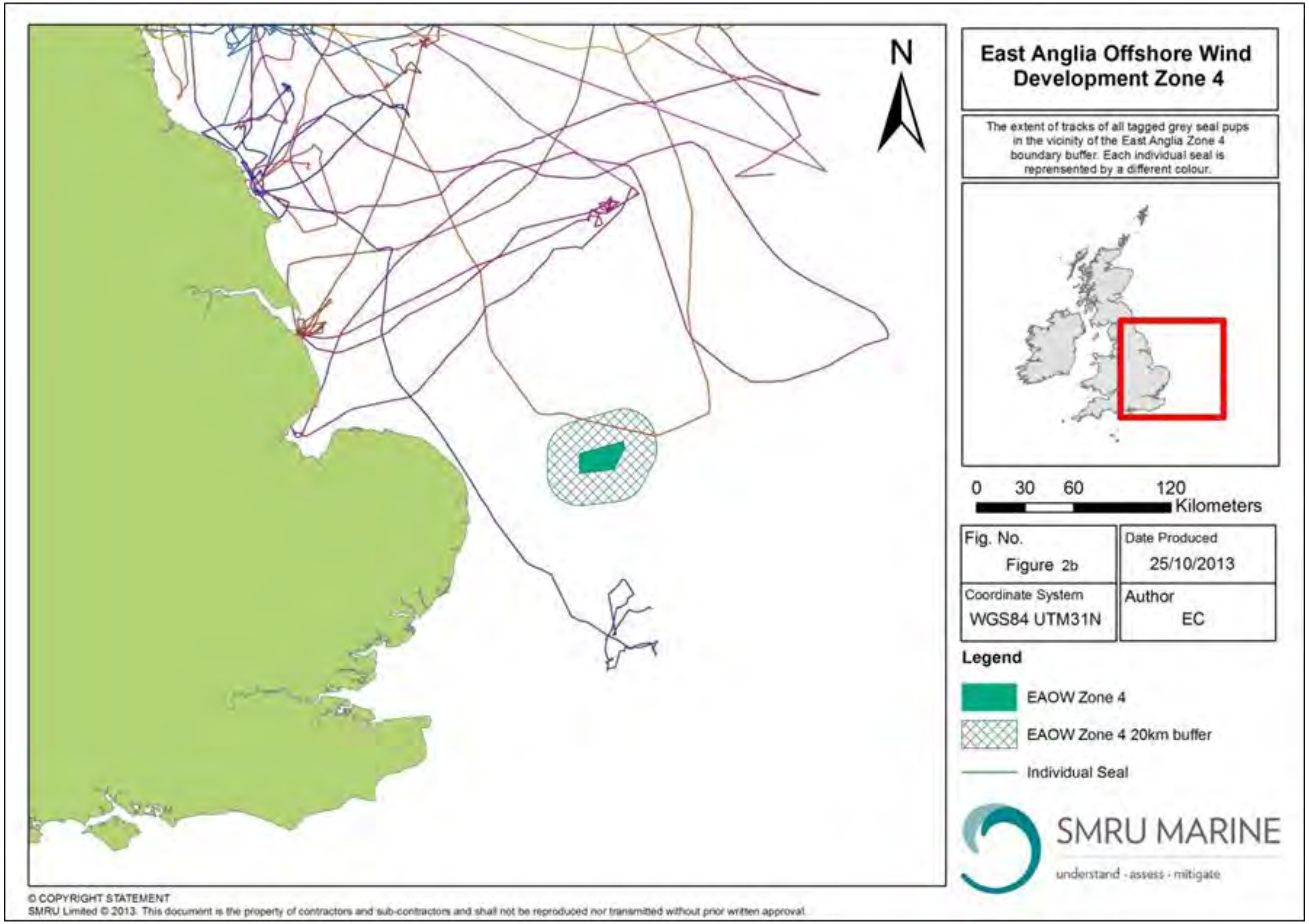

Figure 2.2: Tracks of grey seal pups in the vicinity of the former East Anglia FOUR (now Norfolk Vanguard East) plus buffer from telemetry deployment in the UK

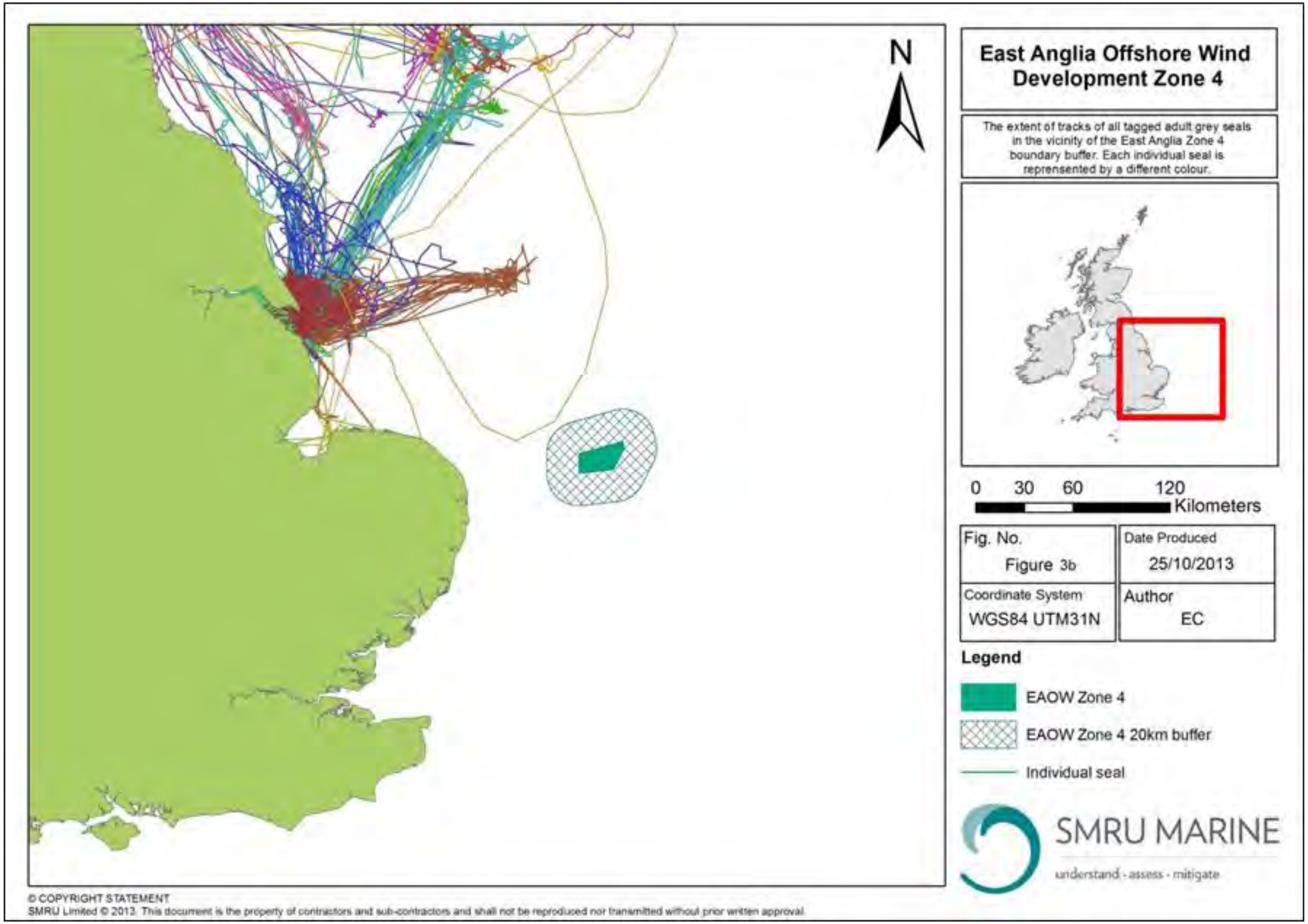

Figure 2.3: Tracks of adult grey seal in the vicinity of the former East Anglia FOUR (now Norfolk Vanguard East) plus buffer from telemetry deployment in the UK

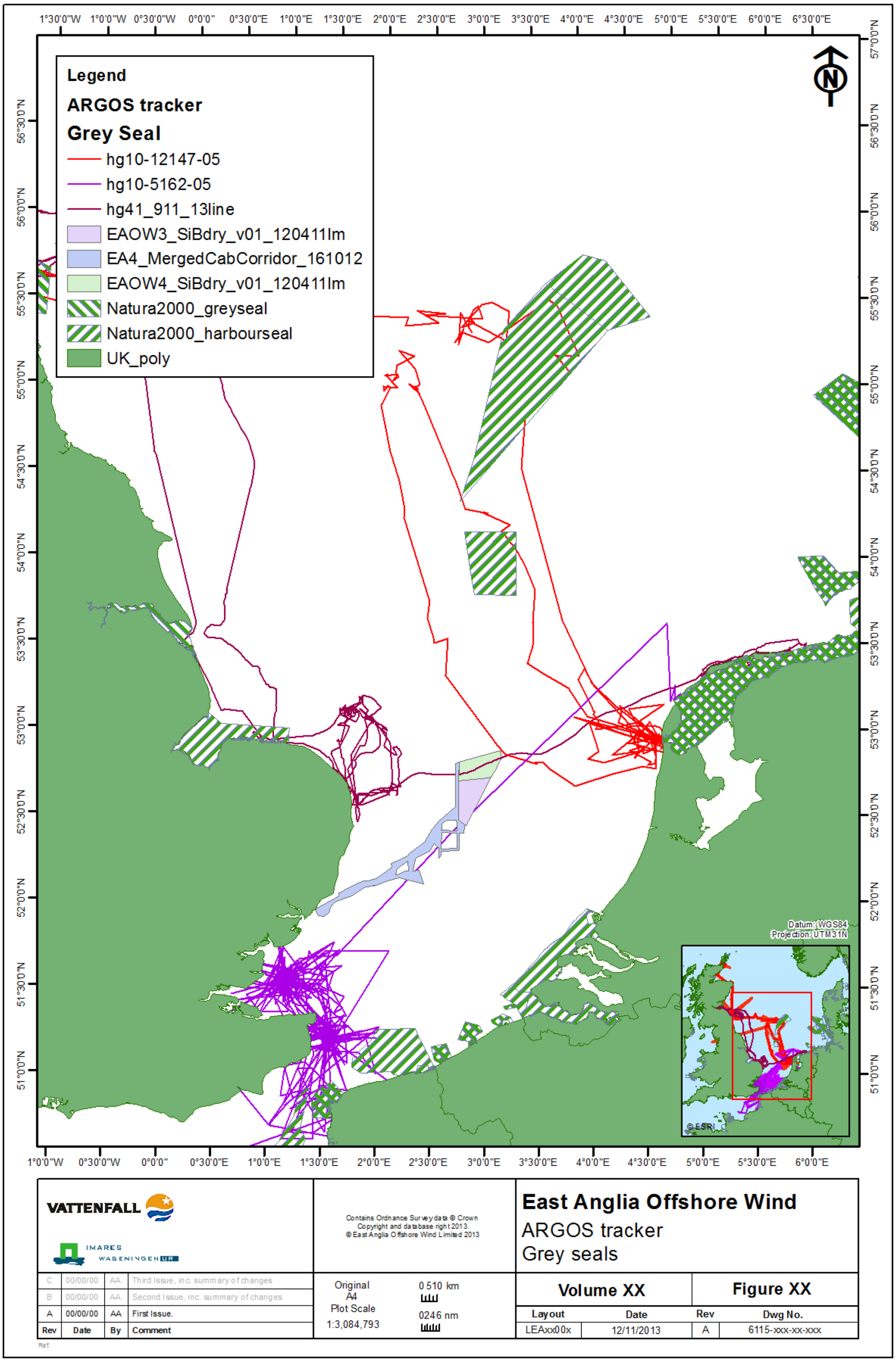

Figure 2.4: Tracks of grey seals tagged in Dutch waters using the Argos location system

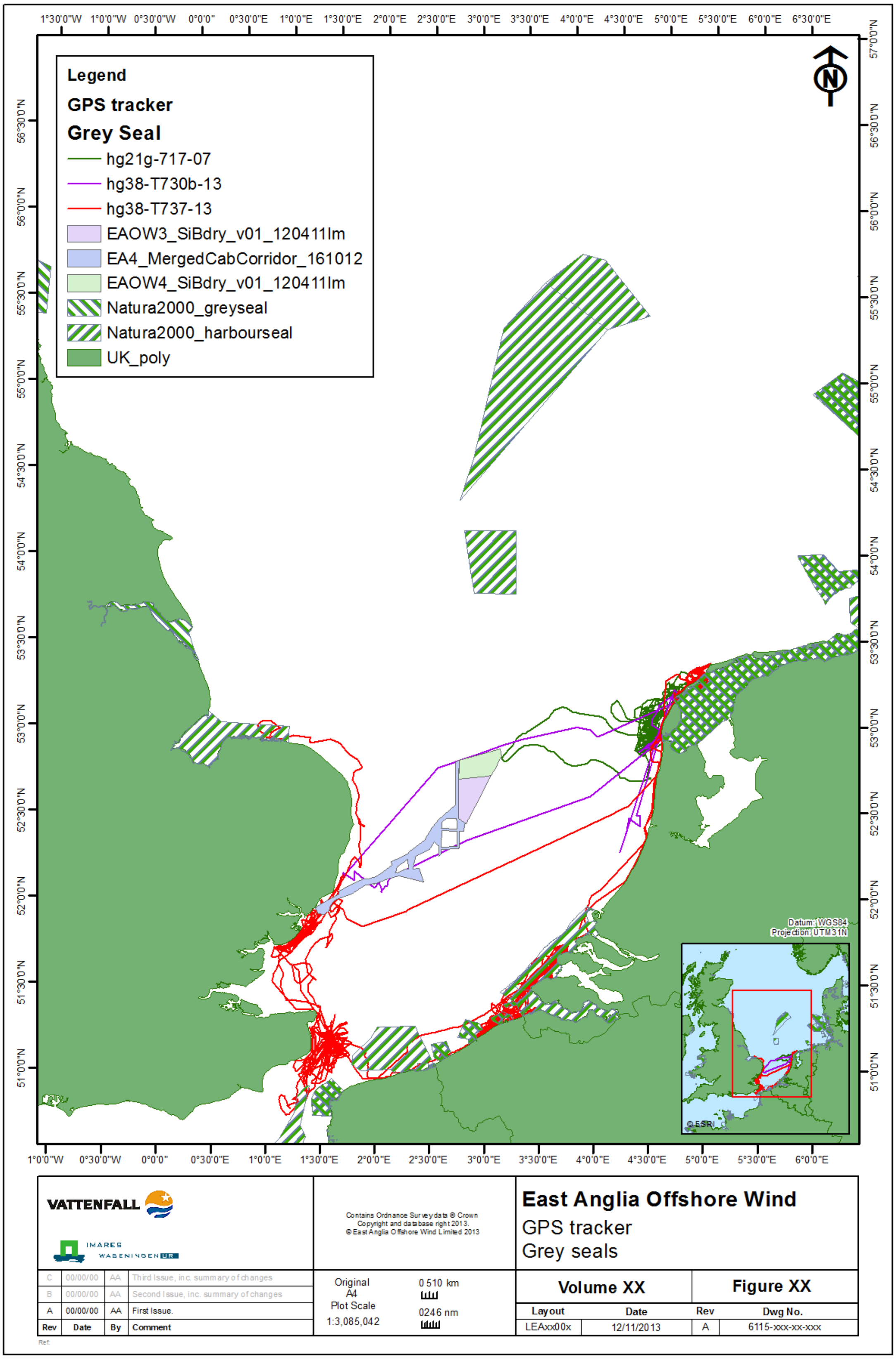

Figure 2.5: Tracks of grey seals tagged in Dutch waters using the GPS-GSM location system

63. Table 2.3 shows the sites considered to have theoretical connectivity to Norfolk Vanguard (i.e. those within 1,000km as discussed in Section 2.1.2). Using the information above, this list has been refined to screen out sites where there is no evidence of potential connectivity. This refined list was then further screened, in relation to the potential effects discussed below.

2.3.2.1 Indirect impacts through effects on prey species

64. For indirect effects on prey, results from underwater modelling suggests that noise impacts upon fish will be limited to <50km, for the widest ranging behavioural effects (based on Popper *et al.* (2014) TTS criteria of 186dB SEL). Therefore all sites are screened out with regard to indirect effects due to the distance between the potential impact range and other designated sites (see Table 2.3). Potential connectivity, and therefore potential for grey seals from designated sites to be foraging in and around Norfolk Vanguard is discussed above.

2.3.2.2 Underwater noise

65. With regard to direct underwater noise impacts upon designated sites (or individual animals within them), it is considered that for piling (which is the greatest of the potential noise sources) the maximum predicted potential range of impact would be up to 5.4km for Temporary Threshold Shift (TTS) and fleeing response based on Southall *et al.,* (2007) criteria of 171db SEL. Therefore all sites are screened out with regard to direct noise impacting upon the designated sites and individual animals located within them.

66. Individuals could come from any of the sites considered to have potential connectivity, given that grey seal are highly mobile and as a result these may be affected within the potential TTS impact range of up to 5km.

67. The number of animals that could be exposed to any potential direct impacts from underwater noise can be estimated based on their density in the potential impact area. In lieu of site specific data for density of grey seal (as sightings data was too low within the Norfolk Vanguard offshore project area) it is proposed that the density used should be the SMRU seals at-sea density data (Jones *et al.* 2016) as agreed for the EIA during the Evidence Plan Process (meeting 15th February 2017). Table 2.1 shows the density estimates for Norfolk Vanguard which have been calculated from the 5 x 5km cells (provided in Jones *et al.,* 2016) based on the area of overlap with Norfolk Vanguard.

Table 2.1 Grey seal density estimates (Jones *et al.* 2016)

	Individuals per km^2				
Density Estimate	Norfolk Vanguard Offshore Cable	Norfolk Vanguard West	Norfolk Vanguard East	Norfolk Vanguard OWF sites	Norfolk Vanguard Offshore Project Area
Lower at-sea	0.0006	0.0005	0.0004	0.0004	0.0005
Mean at-sea	0.001	0.0008	0.0007	0.0008	0.0009
Upper at-sea	0.002	0.001	0.001	0.001	0.001

68. Table 2.1 shows an upper at sea density estimate of 0.001 per km^2 in the OWF sites. For noise impacts, making the conservative assumption of an impact range for TTS of up to 5.4km, the affected area for a single piling event would be approximately 22.9km^2 and 45.8km^2 for concurrent piling at two locations (assuming a worst case scenario of no overlap). Therefore using the conservative upper at-sea density a total of 0.05 individuals would be affected during concurrent piling. At this magnitude of effect it is not considered that there is potential for LSE on any site to which the individual could be attributed. Therefore all sites are screened out with regard to noise impacts.

2.3.2.3 Vessel interactions

69. As discussed in Section 2.3.1.3, condensed vessel activity will occur in the vicinity of the Norfolk Vanguard offshore project area and routes to local ports (beyond this, vessel activity will be dispersed and becomes part of the background vessel traffic).

70. Within the offshore wind farm sites (592km^2) the upper at-sea density of grey seal is estimated to be 0.001/km^2) and therefore the potential number of individuals which could interact with vessels in this area is 0.6.

71. Within the offshore cable corridor area (237km^2) the upper at-sea density of grey seal is estimated to be 0.002/km^2) and therefore the potential number of individuals which could interact with vessels in this area is 0.5.

72. The total number of seals that could interact with vessels associated with the project is therefore estimated to be one.

73. Latest grey seal counts from the north east England and south east England in August 2015 were 6,942 and 5637, respectively (SCOS, 2016). One seal therefore represents 0.01% of the north east count and 0.02% of the south east count. At this magnitude of effect it is not considered that there is potential for LSE on grey seals from designated sites within this MU.

74. There is little information on collision rates or avoidance behaviour in seals, however it should be noted that the majority of vessels within the offshore project area will be slow moving or stationary. It is also highly unlikely that every grey seal in the offshore project area will be at risk of vessel collision.

75. Given the low numbers of affected individuals even on an unrealistic and highly precautionary worst case, at this magnitude of effect it is not considered that there is potential for LSE on any site to which the individual could be attributed. Therefore all sites are screened out with regard to any LSE from vessel interactions.

76. The port location is not confirmed at this stage, however if a port to the north (e.g. Hull) is selected there is potential for impact on the Humber Estuary SAC due to the proximity of this site to Hull port. If a port to the south is used (e.g. Great Yarmouth or Lowestoft) there will be no impact on grey seal SACs due to the distance of this site and the route vessels would be required to take from designated sites.

2.3.3 Harbour seal

77. A telemetry study by the SMRU tagged harbour seal at the Wash and North Norfolk SAC, the Firth of Tay and Eden Estuary SAC and the Thames Estuary. No harbour seal tagged in these locations entered NV East (former East Anglia FOUR) (Figure 2.6), although the site is within the potential foraging range of seals using the Wash and North Norfolk SAC. The location of NV West (shown in Figure 1.1) is on the edge the tracks of one individual from the SAC.

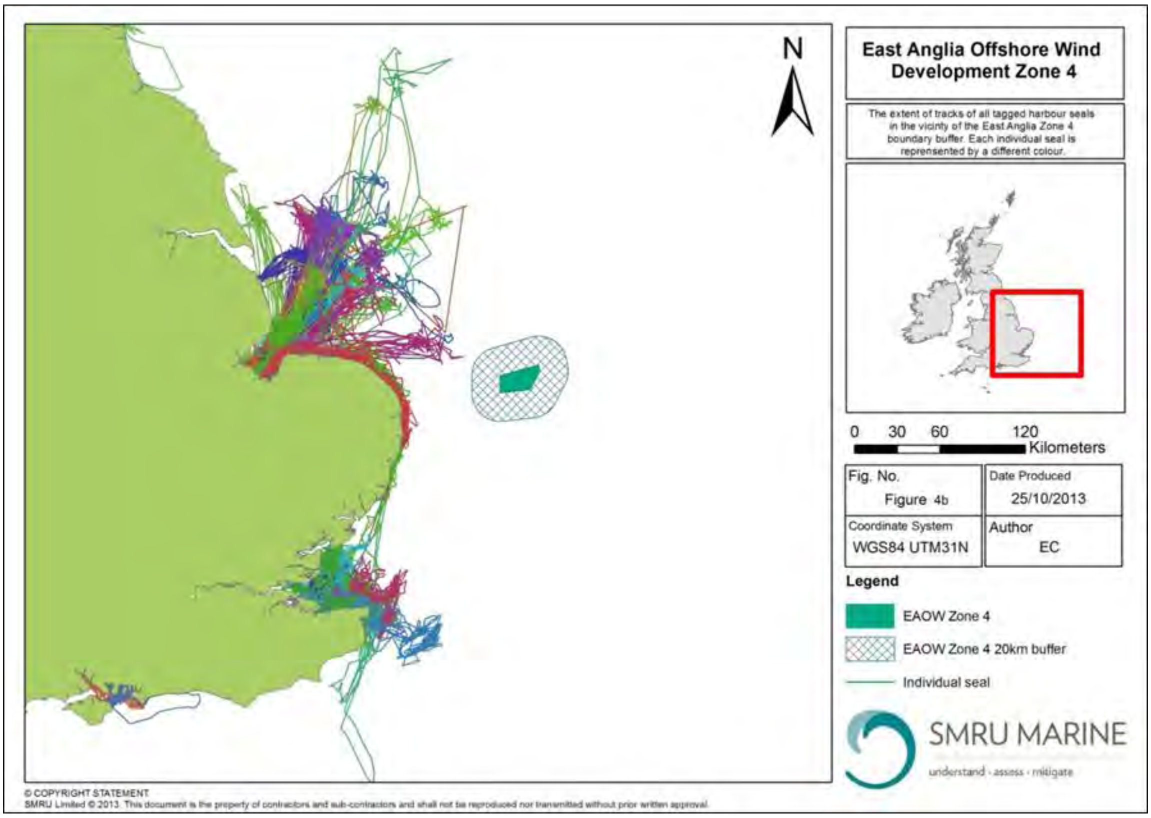

Figure 2.6: Tracks of adult harbour seal in the vicinity of the former East Anglia Zone 4 plus buffer (now Norfolk Vanguard East) from telemetry deployment in the UK

78. Figure 2.7 and Figure 2.8 show tracks from seals tagged in Dutch waters. These indicate that seals in the vicinity of Norfolk Vanguard have used the Wash and North Norfolk SAC, as well as haul-out sites and at-sea areas near Dutch and Belgian designated sites.

79. Data from seals tagged in UK and Dutch waters suggest very limited dispersal or mixing between seals within the southern North Sea and seals using the English Channel. Tagging studies in French waters in 2006 and 2007 (Vincent *et al*., 2010) also suggest that no seals ranged from the waters of the English Channel beyond the Straits of Dover. Although this lack of movement by tagged animals between the southern North Sea and England Channel does not completely exclude mixing between these subpopulations, it does support the conclusion that there is little or no potential for connectivity between harbour seal using Norfolk Vanguard, and any Natura 2000 sites along the south of the English Channel and along the French coast, and therefore no potential for LSE.

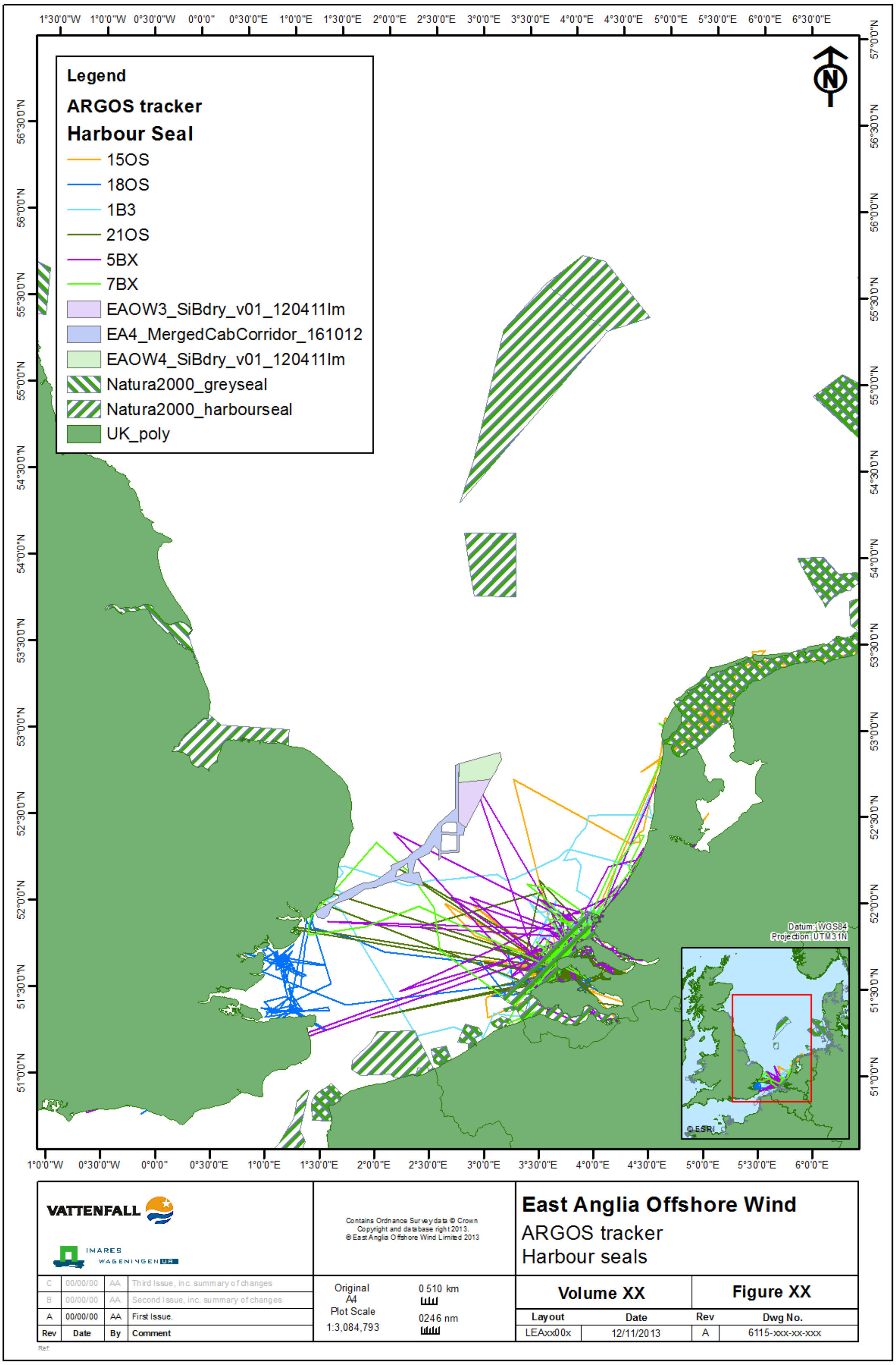

Figure 2.7: Tracks of harbour seals tagged in Dutch waters using the Argos location system

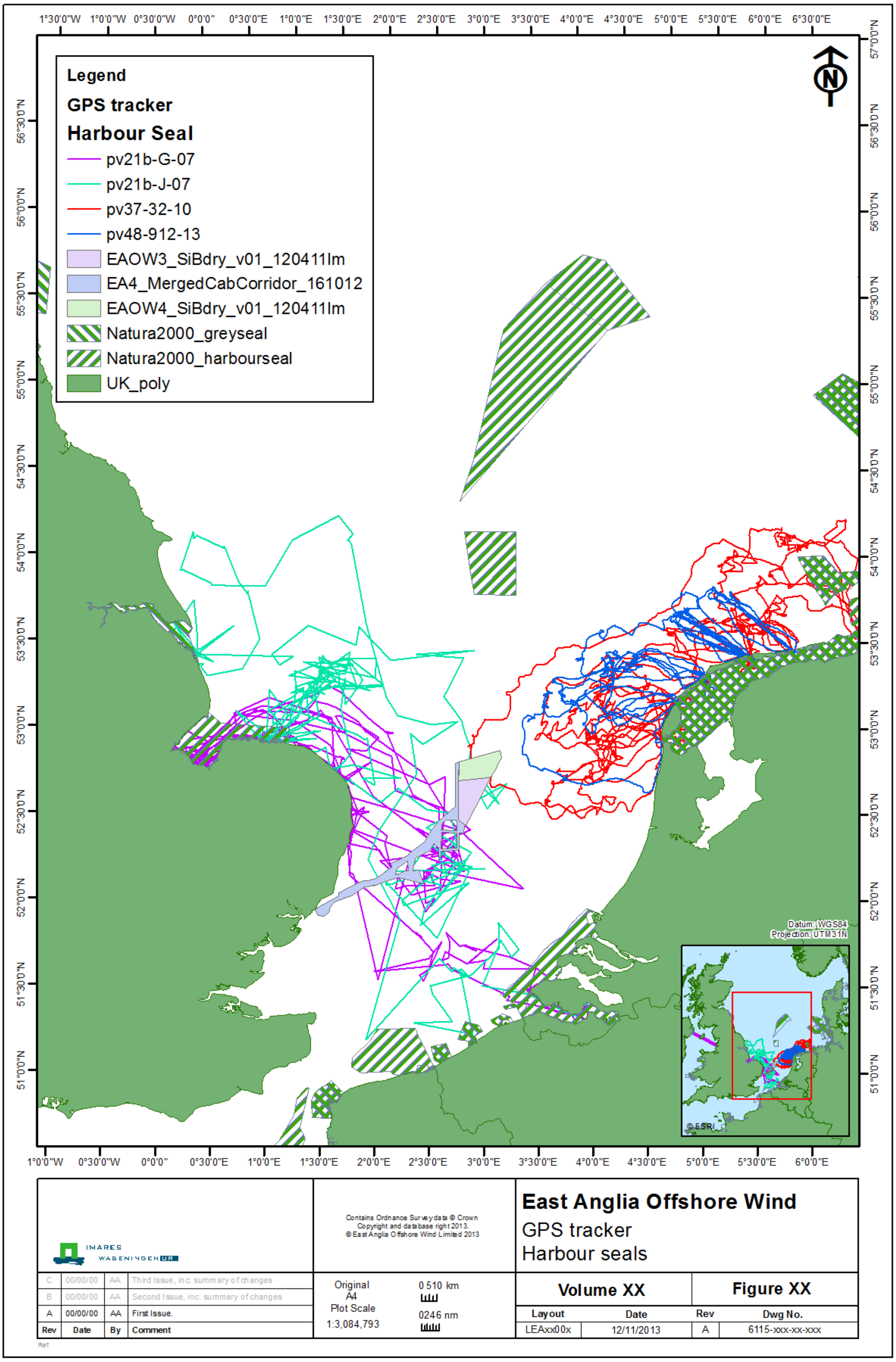

Figure 2.8: Tracks of harbour seals tagged in Dutch waters using the GPS-GSM location system

80. Table 2.3shows the sites considered to have theoretical connectivity to Norfolk Vanguard (i.e. those within 300km as discussed in Section 2.1.3). Using the information above, this list has been refined to screen out sites where there is no evidence of potential connectivity. This refined list was then further screened, in relation to the potential effects discussed below.

2.3.3.1 Indirect impacts through effects on prey species

81. As previously discussed, results from underwater modelling suggests that noise impacts upon fish will be limited to <50km, for the widest ranging behavioural effects (based on Popper *et al.* (2014) TTS criteria of 186dB SEL). Therefore all sites are screened out with regard to indirect effects due to the distance between the potential impact range and other designated sites (see Table 2.3). Potential connectivity, and therefore potential for animals from designated sites to be foraging in and around Norfolk Vanguard is discussed above.

2.3.3.2 Underwater noise

82. With regard to direct underwater noise impacts upon designated sites (or individual animals within them), it is considered that for piling (which is the greatest of the potential noise sources) the maximum predicted potential range of impact would be up to 5.4km for TTS and fleeing response based on Southall *et al.,* (2007) criteria of 171db SEL. Therefore all sites are screened out with regard to direct noise impacting upon the designated sites and individual animals located within them. Individuals could come from any of the sites considered to have potential connectivity given that harbour seal are mobile and as a result these may be affected within the potential TTS impact range of up to 5.4km.

83. The number of animals that could be exposed to any potential direct the impacts from underwater noise can be estimated based on their density in the potential impact area. In lieu of site specific data for density of harbour seal (as sightings data was too low within the Norfolk Vanguard offshore project area) it is proposed that the density used should be the SMRU seals at-sea density data (Jones *et al.* 2016; shown in Table 2.2) for harbour seal as agreed for the EIA during the Evidence Plan Process (meeting 15th February 2017). Table 2.2 shows the density estimates for Norfolk Vanguard which have been calculated from the 5 x 5km cells (provided in Jones *et al.,* 2016) based on the area of overlap with Norfolk Vanguard.

Table 2.2 Harbour seal density estimates (Jones *et al.* 2016)

Density Estimate	Individuals per km^2				
	Norfolk Vanguard Offshore Cable	Norfolk Vanguard West	Norfolk Vanguard East	Norfolk Vanguard OWF sites	Norfolk Vanguard Offshore Project Area
Lower at-sea	0.0001	$4x10^{-7}$	$2x10^{-7}$	$3x10^{-7}$	$5x10^{-5}$
Mean at-sea	0.004	$7x10^{-6}$	$4x10^{-6}$	$5x10^{-6}$	0.001
Upper at-sea	0.008	$1.4x10^{-6}$	$7x10^{-6}$	$1x10^{-5}$	0.002

84. Table 2.2 shows an upper at sea density estimate of $1x10^{-5}$ per km^2 in the OWF sites. For noise impacts, making the conservative assumption of an impact range for TTS of up to 5.4km, the affected area for a single piling event would be approximately 22.9km^2 and 45.8km^2 for concurrent piling at two locations (assuming a worst case scenario of no overlap). Therefore using the conservative upper at-sea density a total of 0.0005 individuals would be affected during concurrent piling. At this magnitude of effect it is not considered that there is potential for LSE on any site to which the individual could be attributed. Therefore all sites are screened out with regard to noise impacts.

2.3.3.3 Vessel interactions

85. As discussed previously, condensed vessel activity will occur in the vicinity of the Norfolk Vanguard offshore project area and routes to local ports (beyond this, vessel activity will be dispersed and becomes part of the background vessel traffic within established vessel routes).

86. Within the offshore wind farm sites (592km^2) the upper at-sea density of harbour seal is estimated to be $1x10^{-5}$km^2) and therefore the potential number of individuals which could interact with vessels in this area is 0.006.

87. Within the offshore cable corridor area (237km^2) the upper at-sea density of harbour seal is estimated to be 0.008/km^2) and therefore the potential number of individuals which could interact with vessels in this area is 1.9.

88. The total number of seals that could interact with vessels associated with the project is therefore estimated to be 2. The mean harbour seal count for the Wash in 2015 was 3336 (SCOS, 2016), therefore 2 seals would represent 0.06% of the 2015 count. This represents the most conservative population to assess the effect against. The south east England harbour seal count (based on surveys from 2008 to 2015) is 4740 (SCOS, 2016). At this magnitude of effect it is not considered that there is potential for LSE on the Wash and North Norfolk SAC if all individuals with potential vessel interactions were from this SAC.

89. There is little information on collision rates or avoidance behaviour in seals, however as previously discussed, the majority of vessels within the offshore project area will be slow moving or stationary. It is also highly unlikely that every harbour seal potentially in the offshore project area will be at risk of vessel collision.

90. Given the low numbers of individuals even on an unrealistic and highly precautionary worst case, at this magnitude of effect it is not considered that there is potential for LSE on any site to which the individual could be attributed. Therefore all sites are screened out with regard to vessel interactions.

91. The port location is not confirmed at this stage, however if a port to the north (e.g. Hull) is selected there is potential for impact on the Wash and North Norfolk Coast SAC. If a port to the south is used (e.g. Great Yarmouth or Lowestoft) there will be no impact on harbour seal SACs.

2.3.4 Screening summary

92. Table 2.3 provides a list of sites for which there is theoretical connectivity to Norfolk Vanguard for harbour porpoise, grey seal and harbour seal, as outlined in Sections 2.1.1, 2.1.2 and 2.1.3, respectively.

93. In summary, a total of 41 sites were initially considered in the screening process for harbour porpoise and these sites were then assessed for the potential effects listed in Section 2.3.1. Shaded rows have been screened out from further consideration in the HRA and the Southern North Sea cSAC site will be assessed further.

94. A total of 42 sites were initially considered in relation to grey seal. Based on the potential impacts outlined in Section 2.3.2, all sites for grey seal, with the exception of the Humber Estuary SAC, have been screened out from further consideration in the HRA.

95. A total of 40 sites were initially considered in the screening for harbour seal. Based on the potential impacts outline in Section 2.3.3, all sites for harbour seal, with the exception of the Wash and North Norfolk Coast SAC, have been screened out from further consideration in the HRA.

Table 2.3 Screening list of SACs and SCIs for harbour porpoise, grey seal and harbour seal (screened out sites are shown in grey).

Site code	Country	Site name	Interest Feature	Designation	Distance (km)*	Potential connectivity	Screening decision	Reason for screening decision
BEMNZ0001	Belgium	Vlaamse Banken	Harbour porpoise	SAC	138	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
			Harbour seal			No		
BEMNZ0002	Belgium	SBZ 1 / ZPS 1	Harbour porpoise	SPA	170	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
			Grey seal			Yes		
			Harbour seal			No		
BEMNZ0003	Belgium	SBZ 2 / ZPS 2	Harbour porpoise	SPA	156	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
			Grey seal			Yes		
			Harbour seal			No		
BEMNZ0004	Belgium	SBZ 3 / ZPS 3	Harbour porpoise	SPA	153	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
			Grey Seal			Yes		
			Harbour seal			No		
BEMNZ0005	Belgium	Vlakte van de Raan	Harbour porpoise	SCI	147	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
			Grey seal			Yes		
			Harbour seal			No		
DK00FX112	Denmark	Skagens Gren og Skagerrak	Harbour porpoise	SAC	680	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DK00VA347	Denmark	Sydlige Nordsø	Harbour porpoise	SAC	367	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
			Grey seal			No		

Site code	Country	Site name	Interest Feature	Designation	Distance (km)*	Potential connectivity	Screening decision	Reason for screening decision
DK00VA259	Denmark	Gule Rev	Harbour porpoise	SCI	571	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DK00VA258	Denmark	Store Rev	Harbour porpoise	SCI	654	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DK00AY176	Denmark	Vadehavet med Ribe Å, Tved Å og Varde Å vest for Varde	Harbour porpoise	SAC	418	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
			Grey seal			No		
dk00va302	Denmark	Knudegrund	Harbour porpoise	SAC	675	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
dk00va301	Denmark	Lønstrup Rødgrund	Harbour porpoise	SAC	648	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
dk00va340	Denmark	Sandbanker ud for Thyboron	Harbour porpoise	SAC	523	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
dk00va348	Denmark	Thyboron Stenvolde	Harbour porpoise	SCI	506	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
dk00va341	Denmark	Sandbanker ud for Thorsminde	Harbour porpoise	SAC	492	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE1003301	Denmark	Doggerbank	Harbour seal	SCI	281	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE1209301	Denmark	Sylter Aussenriff	Harbour seal	SCI	311	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects

Site code	Country	Site name	Interest Feature	Designation	Distance (km)*	Potential connectivity	Screening decision	Reason for screening decision
DE1011401	Denmark	SPA Ostliche Deutsche Bucht	Harbour seal	SPA	345	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE0916391	Denmark	NTP S-H Wattenmeer und angrenzende Kustengebiete	Harbour seal	SAC	365	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE1813391	Denmark	Helgoland mit Helgolander Felssockel	Harbour seal	SAC	343	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE1714391	Denmark	Steingrund	Harbour seal	SAC	353	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2016301	Denmark	Hamburgisches Wattenmeer	Harbour seal	SCI	361	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2323392	Denmark	Schleswig-Holsteinisches Elbastuar und angrenzende Flachen	Harbour seal	SAC	388	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2018331	Denmark	Unterelbe	Harbour seal	SCI	388	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2424302	Denmark	Muhlenberger Loch/Nesssand	Harbour seal	SCI	448	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2507331	Denmark	Unterems und Aussenems	Harbour seal	SCI	263	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2507301	Denmark	Hund und Paapsand	Harbour seal	SCI	261	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects

Site code	Country	Site name	Interest Feature	Designation	Distance (km)*	Potential connectivity	Screening decision	Reason for screening decision
DE2306301	Denmark	Nationalpark Niedersachsisches Wattenmeer	Harbour seal	SAC	246	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2104301	Denmark	Borkum-Riffgrund	Harbour seal	SCI	234	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
FR2200346	France	Estuaires et littoral picards (baies de Somme et d'Authie)	Harbour porpoise	SAC	275	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
			Harbour seal			No		
FR2300121	France	Estuaire de la Seine	Harbour porpoise	SCI	394	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
FR2300139	France	Littoral Cauchois	Harbour porpoise	SAC	314	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
FR2502020	France	Baie de Seine occidentale	Harbour porpoise	SAC	429	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
FR2502021	France	Baie de Seine orientale	Harbour porpoise	SAC	408	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
FR3100478	France	Falaises du Cran aux Oeufs et du Cap Gris-Nez, Dunes du Chatelet, Marais de Tardinghen et Dunes de Wissant	Harbour porpoise	SAC	217	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
			Grey seal			Yes		The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
			Harbour seal			No		No potential connectivity based on information in Annexes 1 and 2

Site code	Country	Site name	Interest Feature	Designation	Distance (km)*	Potential connectivity	Screening decision	Reason for screening decision
FR3102002	France	Bancs des Flandres	Harbour porpoise Grey seal Harbour seal	SAC	162	No Yes No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
FR3102003	France	Recifs Gris-Nez Blanc-Nez	Harbour porpoise Grey seal Harbour seal	SAC	209	No Yes No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
FR3102004	France	Ridens et dunes hydrauliques du detroit du Pas-de-Calais	Harbour porpoise Harbour seal	SAC	217	No No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
FR3102005	France	Baie de Canche et couloir des trois estuaires	Harbour porpoise Grey seal Harbour seal	SAC	254	No Yes No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
FR5300017	France	Abers - Côtes Des Legendes	Grey seal	SAC	667	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
FR5300023	France	Archipel Des Glenan	Grey seal	SAC	713	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
FR5300015	France	Baie De Morlaix	Grey seal	SAC	622	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.

Site code	Country	Site name	Interest Feature	Designation	Distance (km)*	Potential connectivity	Screening decision	Reason for screening decision
FR5300020	France	Cap Sizun	Grey seal	SAC	711	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
FR2500079	France	Chausey	Grey seal	SAC	509	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
FR5300009	France	Cote De Granit Rose-Sept-Iles	Grey seal	SAC	583	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
FR5300018	France	Ouessant-Molene	Grey seal	SAC	698	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
FR7200811	France	Panache De La Gironde Et Plateau Rocheux De Cordouan (Système Pertuis Gironde)	Grey seal	SAC	837	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
FR5400469	France	Pertuis Charentais	Grey seal	SAC	767	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
FR5300019	France	Presqu'ile De Crozon	Grey seal	SAC	700	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
FR5300010	France	Tregor Goëlo	Grey seal	SAC	571	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.

Site code	Country	Site name	Interest Feature	Designation	Distance (km)*	Potential connectivity	Screening decision	Reason for screening decision
FR3100474	France	Dunes De La Plaine Maritime Flamande	Harbour seal	SAC	185	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
FR3100480	France	Estuaire De La Canche, Dunes Picardes Plaquees Sur L'ancienne Falaise, Foret D'hardelot Et Falaise D'equihen	Harbour seal	SAC	241	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE0916391	Germany	NTP S-H Wattenmeer und angrenzende Küstengebiete	Harbour porpoise	SAC	365	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
			Grey seal			No		
DE1011401	Germany	SPA Östliche Deutsche Bucht	Harbour porpoise	SPA	345	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
			Grey seal			No		
DE1209301	Germany	Sylter Außenriff	Harbour porpoise	SCI	311	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
			Grey seal			No		
DE1003301	Germany	Doggerbank	Harbour porpoise	SCI	281	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2104301	Germany	Borkum-Riffgrund	Harbour porpoise	SCI	234	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
			Grey seal			Yes		
			Harbour seal			No		
DE1813391	Germany	Helgoland mit Helgoländer Felssockel	Harbour porpoise	SAC	343	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
			Grey seal			No		

Site code	Country	Site name	Interest Feature	Designation	Distance (km)*	Potential connectivity	Screening decision	Reason for screening decision
DE1714391	Germany	Steingrund	Harbour porpoise	SAC	353	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
			Grey seal			No		
DE2016301	Germany	Hamburgisches Wattenmeer	Harbour porpoise	SCI	361	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result in no potential for LSE
			Grey seal			Yes		
DE2018331	Germany	Unterelbe	Harbour porpoise	SCI	388	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2306301	Germany	Nationalpark Niedersächsisched Wattenmeer	Harbour porpoise	SAC	246	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result in no potential for LSE.
			Grey seal			Yes		
			Harbour seal			No		
DE1115391	Germany	Dünenlandschaft Süd-Sylt	Grey seal	SAC	399	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE1315391	Germany	Küsten- und Dünenlandschaften Amrums	Grey seal	SAC	395	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2507301	Germany	Hund und Paapsand	Harbour seal	SCI	261	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
DE2507331	Germany	Unterems und Außenems	Harbour seal	SCI	263	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
NL2008001	Netherlands	Doggersbank	Harbour porpoise	SAC	149	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result in no potential for LSE.
			Grey seal			Yes		
			Harbour seal			No		

Site code	Country	Site name	Interest Feature	Designation	Distance (km)*	Potential connectivity	Screening decision	Reason for screening decision
NL2008002	Netherlands	Klaverbank	Harbour porpoise	SAC	93	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result in no potential for LSE.
			Grey seal			Yes		
			Harbour seal			No		
NL9802001	Netherlands	Noordzeekustzone	Harbour porpoise	SAC	98	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result in no potential for LSE.
			Grey seal			Yes		
			Harbour seal			No		
NL2008003	Netherlands	Vlakte van de Raan	Harbour porpoise	SAC	135	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
			Grey seal			Yes		
			Harbour seal			No		
NL4000017	Netherlands	Voordelta	Grey seal	SAC and SPA	106	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
			Harbour seal			No		
NL1000001	Netherlands	Waddenzee	Grey seal	SAC	111	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
			Harbour seal			No		
BEMNZ0001	Netherlands	Vlaamse Banken	Grey seal	SAC	138	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result in no potential for LSE.
NL9803061	Netherlands	Westerschelde & Saeftinghe	Harbour seal	SAC	141	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.

Site code	Country	Site name	Interest Feature	Designation	Distance (km)*	Potential connectivity	Screening decision	Reason for screening decision
NL3009016	Netherlands	Oosterschelde	Harbour seal	SAC	130	No	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
SE0520170	Sweden	Kosterfjorden-Väderöfjorden	Harbour porpoise	SAC	800	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
	UK	Southern North Sea	Harbour porpoise	cSAC	0	Yes	In	Norfolk Vanguard is within the cSAC. Assumed that all harbour porpoise in this area are associated with this cSAC.
UK0017072	UK	Berwickshire and North Northumberland Coast	Grey seal	SAC	368	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result are negligible and would result in no potential for LSE.
UK0017096	UK	Faray and Holm of Faray	Grey seal	SAC	762	No	Out	The distance between the potential impact range of the proposed project and the site is beyond that of potential for direct or indirect effects
UK0030170	UK	Humber Estuary	Grey seal	SAC	149	Yes	In	Potential for vessel interactions if a port to the north of Norfolk Vanguard is selected.
UK0030172	UK	Isle of May	Grey seal	SAC	478	Yes	Out	The distance between the potential impact range of the proposed project and the extent of any impact on individuals from this site result in no potential for LSE.
UK0017075	UK	The Wash and North Norfolk Coast	Harbour seal	SAC	80	Yes	In	Potential for vessel interactions if a port to the north of Norfolk Vanguard is selected.

*Distance measured from the closest point of Norfolk Vanguard (i.e. the wind turbine array) to the closest point of the SAC/cSAC/SCI rounded to the nearest kilometre

3 SCREENING BENTHIC ECOLOGY SAC SITES AND FEATURES

3.1 Identification of Benthic Sites and Features

96. Natura 2000 sites in the southern North Sea, which have benthic habitats (Habitats Directive Annex I) as an interest feature, have been considered for HRA Screening. Table 3.1 provides the list of sites considered for screening.

3.2 Approach to Screening

97. The sites which could potentially be affected by the proposed project have been screened in to the HRA on the basis of the following:

- A component of the proposed project directly overlaps a site whose interest features includes a particular habitat.
- The distance between the proposed project and the offshore habitat interest feature is within the range for which there could be an interaction e.g. the pathway is not too long for sediment deposition.

3.2.1 Potential effects (Source)

98. The conservation objectives for offshore Annex I habitats are to "maintain or restore the habitat in Favourable Condition".

99. The formal advice associated with the Haisborough, Hammond and Winterton cSAC (JNCC and Natural England, 2013) identifies six pressure categories which may cause deterioration of natural habitats within SACs, either alone or in combination (and thus affect Favourable Condition), have been identified as:

- Physical loss;
- Physical damage;
- Non-physical disturbance;
- Toxic contamination;
- Non-toxic contamination[2]; and
- Biological disturbance[3]

100. The potential effects on offshore habitats from Norfolk Vanguard have been identified as follows based on the Norfolk Vanguard scoping report (Royal HaskoningDHV, 2016) and scoping opinion (the Planning Inspectorate, 2016b):

- Construction
    - Permanent habitat loss[4];

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[2] For some sites this includes changes in nutrient and / or organic enrichment and / or in salinity.
[3] For some sites this includes the introduction of non-native species and / or the selective extraction of species.

    - Temporary physical disturbance;
    - Smothering due to increased suspended sediment;
    - Re-mobilisation of contaminated sediments; and
    - Underwater noise and vibration.

- Operation

    - Permanent habitat loss;
    - Physical disturbance through maintenance activities;
    - Smothering through increased suspended sediment; and
    - Introduction of new substrate.

- Decommissioning

    - Temporary physical disturbance;
    - Smothering due to increased suspended sediment;
    - Re-mobilisation of contaminated sediments; and
    - Underwater noise and vibration.

101. Within the Norfolk Vanguard offshore project area (the offshore wind farm (OWF) sites and offshore cable corridor), construction activities such as the installation of foundations, cables and ancillary structures and the placement of jack-up vessel legs, will cause physical disturbance and indirect disturbance.

102. Operation of Norfolk Vanguard would create more permanent impacts (i.e. for the 25 year predicted lifespan of the proposed project) through the loss of existing habitat and introduction of new substrate.

103. Other temporary impacts identified during operation will be caused by maintenance activities such as the use of jack up vessels and the replacement and repair of any cables or through potential scour associated with the installed infrastructure.

104. Decommissioning impacts will be primarily caused by the removal of structures from the seabed. Decommissioning would cause similar impacts to that identified during construction.

3.2.2 Proximity of source to feature (i.e. SAC) (pathway and receptor)

105. The significance of such impacts would be dependent on the characteristics of the habitats and communities (receptors) present within the footprint of the impact and, in particular, the capacity of the affected communities to recover from those impacts identified.

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[4] The installation of turbine foundations will result in a permanent loss of habitat. As the loss of habitat is an on-going impact this is considered under operation rather than construction to avoid double counting.

106. Impacts to offshore habitats will be small scale when put in the context of the wider environment, being localised to Norfolk Vanguard and in many cases to individual elements of the proposed project.

107. Some benthic species may react to episodic noise such as that from pile driving (Lovell *et al*, 2005, Heinisch and Weise, 1987) however any impact is likely to be localised and temporary (i.e. occurring only during piling). Annex 1 habitats, for which Natura 2000 sites are designated, are not known to have any noise sensitivity. These include:

- Sandbanks which are slightly covered by sea water all the time;
- Estuaries;
- Mudflats and sandflats not covered by seawater at low tide;
- Coastal lagoons;
- Reefs;
- Large shallow inlets and bays;
- Submarine structures made by leaking gases; and
- Submerged or partially submerged sea caves.

3.3 Screening

108. Table 3.1 provides the list of 30 sites within the southern North Sea which have benthic features as a primary or secondary reason for designation. In summary, all sites have been screened out with the exception of the Haisborough, Hammond and Winterton SCI.

109. The Haisborough, Hammond and Winterton SCI overlaps with the cable corridor, and therefore there is potential for its designated features, Sandbanks which are slightly covered by sea water all the time and Reefs to be impacted during construction, O&M or decommissioning of Norfolk Vanguard. The following impacts will be considered further during the HRA:

- Temporary physical disturbance;
- Increased suspended sediment and smothering;
- Permanent habitat loss; and
- Introduction of new substrate.

110. Based on the draft Marine Physical Process impact assessment the majority of suspended sediments are predicted to be deposited locally to the area of disturbance, with only a very small proportion of mud becoming more widely dispersed before settling on the seabed. Based on comparable plume modelling studies for East Anglia ONE (ABPmer, 2012), the range of indirect effects associated with the deposition of suspended sediments is predicted to extend to approximately

50km within a band of a few hundred metres in the direction of the tidal flow (north to south). This deposited sediment is likely to become rapidly incorporated into the existing mobile seabed sediment layer. The North Norfolk Sandbanks and Saturn Reef SCI and Inner Dowsing, Race Bank and North Ridge SCI lie outside the area of direct impact but within the area of suspended sediment deposition. Within the predicted deposition area, the deposited sediment layer is predicted to be generally less than 0.2mm with a maximum of 2mm in some locations. No LSE on the sandbank or *Sabellaria* features of the North Norfolk Sandbanks and Saturn Reef SCI is predicted in relation to a potential for up to 2mm of deposited sediment.

111. All other sites are beyond the range of any potential direct or indirect effects from Norfolk Vanguard.

Table 3.1: List of SACs in the southern North Sea with their respective categories of Annex 1 habitat interest feature and screening decisions (screened out sites are shown in grey).

Site Code	Country	SAC name	Category of interest feature	Distance* (km)	Screening decision	Reason for screening decision
BEMNZ0001	Belgium	Vlaamse Banken SAC	H1170 Reefs H1110 Sandbanks which are slightly covered by sea water all the time	138	Out	Beyond the range of potential impact
BEMNZ0005	Belgium	Vlakte Van de Raan SAC	H1110 Sandbanks which are slightly covered by sea water all the time	147	Out	Beyond the range of potential impact
FR3102002	France	Bancs Des Flandres SAC	H1110 Sandbanks which are slightly covered by sea water all the time	162	Out	Beyond the range of potential impact
FR3100474	France	Dunes De La Plaine Maritime Flamande SAC	H1110 Sandbanks which are slightly covered by sea water all the time H1140 Mudflats and sandflats not covered by seawater at low tide	185	Out	Beyond the range of potential impact
FR3100478	France	Falaises Du Cran Aux Oeufs et du Cap Gris-Nez, Dunes du Chatelet, Marais de Tardinghen et Dunes de Wissant SAC	H1110 Sandbanks which are slightly covered by sea water all the time H1140 Mudflats and sandflats not covered by seawater at low tide H1170 Reefs	217	Out	Beyond the range of potential impact
FR3100479	France	Falaises et Dunes de Wimereux, Estuaire de la Slack, Garennes et Communaux d'Ambleteuse-Audresselles SAC	H1130 Estuaries H1140 Mudflats and sandflats not covered by seawater at low tide H1170 Reefs	228	Out	Beyond the range of potential impact
FR3100477	France	Falaises et Pelouses du Cap Blanc Nez, du Mont d'Hubert, des Noires Mottes, du Fond de la Forge et du Mont de couple SAC	H1140 Mudflats and sandflats not covered by seawater at low tide H1170 Reefs	212	Out	Beyond the range of potential impact

Site Code	Country	SAC name	Category of interest feature	Distance* (km)	Screening decision	Reason for screening decision
FR3102003	France	Récifs Gris-Nez Blanc-Nez SAC	H1110 Sandbanks which are slightly covered by sea water all the time H1170 Reefs	209	Out	Beyond the range of potential impact
FR3102004	France	Ridens Et Dunes Hydrauliques Du Detroit Du Pas-De-Calais SAC	H1110 Sandbanks which are slightly covered by sea water all the time	217	Out	Beyond the range of potential impact
FR3102004	France	Ridens Et Dunes Hydrauliques Du Detroit Du Pas-De-Calais SAC	H1170 Reefs	217	Out	Beyond the range of potential impact
NL2008003	Netherlands	Vlakte Van de Raan SAC	H1110 Sandbanks which are slightly covered by sea water all the time	135	Out	Beyond the range of potential impact
NL1000001	Netherlands	Waddenzee SAC	H1110 Sandbanks which are slightly covered by sea water all the time H1130 Estuaries 1140 Mudflats and sandflats not covered by seawater at low tide	111	Out	Beyond the range of potential impact
NL9802001	Netherlands	Noordzeekustzone SAC	H1110 Sandbanks which are slightly covered by sea water all the time H1140 Mudflats and sandflats not covered by seawater at low tide	98	Out	Beyond the range of potential impact
NL2008001	Netherlands	Doggersbank SAC	H1110 Sandbanks which are slightly covered by sea water all the time	149	Out	Beyond the range of potential impact
NL4000017	Netherlands	Voordelta SAC	H1110 Sandbanks which are slightly covered by sea water all the time 1140 Mudflats and sandflats not covered by seawater at low tide	106	Out	Beyond the range of potential impact
UK0030076	UK	Alde, Ore and Butley Estuaries SAC	H1130 Estuaries H1140 Mudflats and sandflats not covered by seawater at low tide	68	Out	Beyond the range of potential impact
UK0030368	UK	Bassurelle Sandbank SAC	H1110 Sandbanks which are slightly covered	235	Out	Beyond the range of

Site Code	Country	SAC name	Category of interest feature	Distance* (km)	Screening decision	Reason for screening decision
			by sea water all the time			potential impact
UK0017072	UK	Berwickshire and North Northumberland Coast SAC	H1150 Coastal lagoons H8330 Submerged or partially submerged sea caves	341	Out	Beyond the range of potential impact
UK0030357	UK	Braemar Pockmarks SAC	H1180 Submarine structures made by leaking gases	663	Out	Beyond the range of potential impact
UK0013690	UK	Essex Estuaries SAC	H1130 Estuaries H1140 Mudflats and sandflats not covered by seawater at low tide	114	Out	Beyond the range of potential impact
UK0013036	UK	Flamborough Head SAC	H8330 Submerged or partially submerged sea caves	199	Out	Beyond the range of potential impact
UK0013107	UK	Thanet Coast SAC	H1110 Sandbanks which are slightly covered by sea water all the time 1140 Mudflats and sandflats not covered by seawater at low tide H1170 Reefs	170	Out	Beyond the range of potential impact
UK0030369	UK	Haisborough, Hammond and Winterton SCI	H1110 Sandbanks which are slightly covered by sea water all the time H1170 Reefs	0	In	Overlaps with the offshore cable corridor
UK0030170	UK	Humber Estuary SAC	H1130 Estuaries H1140 Mudflats and sandflats not covered by seawater at low tide H1110 Sandbanks which are slightly covered by sea water all the time H1150 Coastal lagoons	104	Out	Beyond the range of potential impact
UK0030370	UK	Inner Dowsing, Race Bank and North Ridge SCI	H1110 Sandbanks which are slightly covered by sea water all the time H1170 Reefs	44	Out	The magnitude of any impact on the features of this site result is negligible and would result in no

Site Code	Country	SAC name	Category of interest feature	Distance* (km)	Screening decision	Reason for screening decision
						potential for LSE.
UK0030371	UK	Margate and Long Sands SCI	H1110 Sandbanks which are slightly covered by sea water all the time	99	Out	Beyond the range of potential impact
UK0030358	UK	North Norfolk Sandbanks and Saturn Reef SCI	H1110 Sandbanks which are slightly covered by sea water all the time H1170 Reefs	2	Out	The magnitude of any impact on the features of this site result is negligible and would result in no potential for LSE.
UK0014780	UK	Orfordness - Shingle Street SAC	H1150 Coastal lagoons	70	Out	Beyond the range of potential impact
UK0030354	UK	Scanner Pockmark SAC	H1180 Submarine structures made by leaking gases	591	Out	Beyond the range of potential impact
UK0017075	UK	The Wash and North Norfolk Coast SAC	H1110 Sandbanks which are slightly covered by sea water all the time H1140 Mudflats and sandflats not covered by seawater at low tide H1160 Large shallow inlets and bays	26	Out	Beyond the range of potential impact

* Distance measured from the closest point of Norfolk Vanguard offshore project area to the closest point of the SAC site rounded to the nearest kilometre

4 SCREENING FISH SAC SITES AND FEATURES

4.1 Identification of Fish Sites and Features

112. Natura 2000 sites in the southern North Sea, which have migratory fish species as an interest feature, are considered for HRA Screening. Table 4.1 provides the list of sites considered for screening.

4.2 Approach to Screening

113. The sites which could potentially be affected by the proposed project will be screened in to the HRA on the basis of the following:

- A component of the proposed project directly overlaps a site whose interest features includes a species of fish.
- The distance between the proposed project and a site with a fish interest feature is within the range for which there could be an interaction e.g. the pathway is not too long for sediment deposition.
- The distance between the proposed project and resources on which the interest feature depends (i.e. an indirect effect acting though prey or access to habitat) is within the range for which there could be an interaction i.e. the pathway is not too long.
- The likelihood that a foraging area or a migratory route occurs within the zone of interaction of the proposed project.

114. The key factors that will be applied during the HRA screening process are:

- Potential effects (source); and
- Proximity of source to feature (distance between the proposed development and SACs, migration routes) (pathway and receptor).

4.2.1 Potential effects (source)

115. Example conservation objectives for sites with migratory fish are listed below based on the Humber Estuary SAC (Natural England undated):

- Avoid the deterioration of the qualifying natural habitats and the habitats of qualifying species, and the significant disturbance of those qualifying species, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving Favourable Conservation Status of each of the qualifying features.
- Subject to natural change, to maintain or restore:
    - The extent and distribution of qualifying natural habitats and habitats of qualifying species;

- The structure and function (including typical species) of qualifying natural habitats and habitats of qualifying species;
- The supporting processes on which qualifying natural habitats and habitats of qualifying species rely;
- The populations of qualifying species; and
- The distribution of qualifying species within the site.

116. The key effects of development on migratory fish comprise the following:

- Construction
  - Temporary physical disturbance;
  - Smothering due to increased suspended sediment;
  - Re-mobilisation of contaminated sediments; and
  - Underwater noise and vibration.
- Operation
  - Permanent habitat loss;
  - Physical disturbance through maintenance activities;
  - Smothering through increased suspended sediment;
  - Introduction of new substrate/ fish aggregation;
  - Underwater noise and vibration; and
  - Electromagnetic fields (EMF).
- Decommissioning
  - Temporary physical disturbance;
  - Smothering due to increased suspended sediment; and
  - Underwater noise and vibration.

4.2.2 Proximity of source to feature (pathway)

117. Direct impacts associated with Norfolk Vanguard (e.g. from loss of habitat, physical disturbance and potential smothering) will be localised to Norfolk Vanguard. As discussed in Section 3.2.2, based on the draft Marine Physical Process impact assessment, there is a potential for 0.2 to 2mm of deposited sediment to a distance of approximately 50km within a band of a few hundred metres in the direction of the tidal flow (north to south).

118. Based on underwater noise modelling of potential fish disturbance impact ranges associated with pile driving, all sites greater than 50km from Norfolk Vanguard are proposed to be screened out of the HRA.

119. Consideration is also given to the potential for migratory fish associated with SACs and Ramsar sites to be present in the waters in and around Norfolk Vanguard.

4.2.3 Annex 2 fish species (receptor)

120. Atlantic salmon, allis shad, twaite shad, and sea lamprey migrate through or spend time in the North Sea at particular stages through their lifecycle. Subject to the location and distance from Norfolk Vanguard, these species could potentially be indirectly affected by the effects identified above, during the construction, operation, or decommissioning of the proposed project. Brook lamprey are fully estuarine or freshwater species and do not undertake migration through marine waters and therefore no pathway exists for impact upon designated populations of this species.

121. The nearest SAC/SCI designated for Annex II fish features (Noordzeekustzone SAC in The Netherlands) is located 98km from Norfolk Vanguard. Given the distance of the sites listed in Table 4.1, from Norfolk Vanguard and the potential impact ranges discussed in Section4.2.2, it is considered that there will be no pathway for impacts upon the supporting habitats and processes of any sites designated for migratory fish.

122. There is potential for migratory fish to be present in the waters in and around the proposed project to be affected by the effects listed above. However, given the distances to designated sites and to the coast from Norfolk Vanguard, it is considered that there would be no significant barrier effects to migratory fish reaching the designated sites and therefore no potential LSE.

4.3 Screening

123. Table 4.1 provides a list of 13 sites for which there is theoretical connectivity to Norfolk Vanguard for fish receptors, as outlined in Section 4.1. Based on the approach outlined in Section 4.2, it was concluded that there is no potential for LSE from Norfolk Vanguard for any of the sites considered and therefore it is proposed that these will not be considered further in the HRA.

Table 4.1 List of SACs in the southern North Sea with their respective Annex 2 migratory fish species interest feature and screening decisions (screened out sites are shown in grey).

Site Code	Country	SAC name	Category of interest feature	Distance* (km)	Screening decision	Reason for screening decision
BEMNZ0001	Belgium	Vlaamse Benken SAC	1095 Sea Lamprey 1103 Twaite Shad*	138	Out	The distance between the proposed project and the site is beyond that of potential impacts on the fish features or the supporting habitat and processes and no barrier impacts are predicted.
BEMNZ0005	Belgium	Vlakte Van der Raan SCI	1095 Sea Lamprey 1099 River lamprey* 1103 Twaite Shad*	147	Out	
FR3102005	France	Baie De Canche et Couloir Des Trois Estuaires SAC	1106 Salmon 1095 Sea Lamprey 1099 River lamprey 1102 Allis Shads	254	Out	
FR2200346	France	Estuaires et littoral Picards SAC	1099 River lamprey	275	Out	
FR3100479	France	Falaises et Dunes de Wimereux, Estuaire de la Slack, Garennes et Communaux d'Ambleteuse-Audresselles SAC	1099 River lamprey	228	Out	
DE2104301	Germany	Borkum-Riffgrund (Borkum Reef Ground) SCI	1103 Twaite Shad	234	Out	
DE1209301	Germany	Sylter Außenriff (Sylt Outer Reef) SAC	1099 River lamprey* 1103 Twaite Shad	311	Out	
NL9802001	Netherlands	Noordzeekustzone SAC	1095 Sea Lamprey 1102 Allis Shad 1103 Twaite Shad	98	Out	
NL2008003	Netherlands	Vlakte Van der Raan SAC	1103 Twaite Shad*	135	Out	
NL4000017	Netherlands	Voordelta SAC	1095 Sea Lamprey 1099 River lamprey 1102 Allis Shad 1103 Twaite Shad	106	Out	
NL9803061	Netherlands	Westerschelde SAC	1099 River lamprey* 1103 Twaite Shad*	141	Out	

Site Code	Country	SAC name	Category of interest feature	Distance* (km)	Screening decision	Reason for screening decision
UK0030170	UK	Humber Estuary SAC	1095 Sea Lamprey** 1099 River lamprey**	104	Out	
UK0030253	UK	River Derwent SAC	1099 River lamprey*	234	Out	

* Distance measured from the closest point of Norfolk Vanguard OWF sites to the closest point of the SAC site rounded to the nearest kilometre

5 SCREENING SPA SITES AND FEATURES

5.1 Identification of Ornithology Sites and Features

124. SPA and Ramsar sites around the North Sea basin, in the northern North Sea and around the coast of the British Isles for which there is the potential for connectivity are considered for HRA Screening (see Table 5.1).

5.2 Approach to Screening

125. Following the same principles as used in assessments for previous developments such as East Anglia ONE and East Anglia THREE (APEM 2012, EAOL 2013, Planning Inspectorate 2013, DECC 2014), SPAs and Ramsar sites will be screened related to birds potentially affected by the offshore components of the proposed project as follows:

- A component of the proposed project directly overlaps a site whose interest features includes a species of bird (applies to SPAs and Ramsar sites).
- The distance between the proposed project and a site with a bird interest feature is within the range for which there could be an interaction. For seabirds in the breeding season this element of the screening process will be informed by published information on maximum foraging range (especially the data presented in Thaxter *et al*., 2012a).
- Assessment of species-specific risk which informs the extent to which populations of particular species may be vulnerable to collision mortality, displacement or barrier effects (Garthe & Hüppop 2004, Cook *et al*. 2012, Furness *et al*. 2013, Bradbury *et al*. 2014).
- The distance between the proposed project and resources on which the interest feature depends (i.e. an indirect effect acting though prey or access to habitat) is within the range for which there could be an interaction i.e. the pathway is not too long (applies to SPAs and Ramsar sites).
- Evidence that a migratory route passes through the proposed project wind turbine array for bird species migrating to and / or from protected sites (applies to SPAs and Ramsar sites). This will be informed by published information on migration routes, principally Wright *et al*. (2012), but also Wernham *et al*. (2002), Brown and Grice (2005) and Furness (2015).

5.2.1 Potential effects (source)

126. The following potential effects, related to specific stages of the offshore components of the Project, will be considered in the HRA process.

- Construction

- Disturbance / displacement; and
- Indirect impacts through effects on habitats and prey species.

- Operation
  - Disturbance / displacement (e.g. see Schwemmer *et al.* 2011, Dierschke *et al.* 2016);
  - Indirect impacts through effects on habitats and prey species (e.g. see Carter *et al.* 2017);
  - Collision risk (e.g. Band 2000, 2012); and
  - Barrier effect (e.g. see Carter *et al.* 2017).

- Decommissioning
  - Disturbance / displacement; and
  - Indirect impacts through effects on habitats and prey species.

5.2.2 Proximity of source to receptors/ pathway for effect

5.2.2.1 Migratory birds and transboundary considerations

127. Many SPA sites within the UK and in neighbouring Member States can be screened out of HRA because there is no connectivity between the SPA site and the proposed project area in terms of populations of birds that are features of the SPAs. Therefore, LSE can be ruled out. This applies to most SPAs that are distant from the proposed project. However, some bird species are highly mobile and may interact with projects because they range over considerable distances. This applies especially to seabirds.

128. Migratory birds may move into areas where there are projects and so may interact during their migration. From an initial consideration of all SPAs in the UK and in neighbouring Member States that were listed in APEM and Royal HaskoningDHV (2014), we have scoped out those for which connectivity with the proposed East Anglia THREE project can be ruled out or assessed as negligible. This applies to most of the SPAs in those territories, including all SPAs in Member States on the European mainland designated for coastal birds / waterbirds / seabirds (Table 5.1).

129. Birds of some species that are SPA features, such as shorebirds, may migrate from the mainland of Europe to eastern England (for example from SPAs in Netherlands to the Wash or Thames estuaries) so these birds need to be considered. Migrating shorebirds and other coastal birds tend to fly high when weather conditions are favourable for migration, and normally set off on a migratory flight under such weather conditions, and so are rarely recorded to be collision victims at offshore wind farms, where passerines are the group most at risk of collision (Hüppop *et al.* 2006). Indeed, Hüppop *et al.* (2006) reported that only six out of 442 collision carcasses in their study were non-passerine birds. Assessments of collision risk of

migrating coastal birds at offshore wind farms in UK waters also indicate that risk is low and for most species does not represent a hazard that would require HRA assessment (Wright *et al*. 2012; WWT 2013).

130. The Netherlands Ministry of Infrastructure and the Environment stated in a letter of 7 July 2014 that they had a concern that the proposed projects in the East Anglia zone could have an effect on the seabirds of Bruine Bank pSPA. The non-breeding seabirds that are the interest feature of the Bruine Bank (Brown Ridge) pSPA are primarily auks. An assessment of potential impacts on auks has been conducted as part of the East Anglia THREE EIA (MacArthur Green 2015, sections 13.7.1.1 and 13.7.2.1) in relation to construction and operational disturbance and displacement. In all cases impacts were found to be minor or negligible (based on BDMPS populations in UK North Sea waters, Furness 2015). Assessment of impacts over the whole North Sea (i.e. including non UK waters) would greatly increase the estimated seabird population sizes and only slightly increase cumulative impacts (because most offshore wind farms are in UK waters). Accordingly a likely significant effect on the Bruine Bank (Brown Ridge) pSPA can be screened out.

131. The Netherlands Ministry of Infrastructure and the Environment also stated in their letter of 7 July 2014 ‘on-shore bird colonies in the Netherlands are all situated more than 100km from the Dutch-UK border, so no effects are to be expected there’. We agree with that interpretation (with one exception discussed below), particularly since the seabirds that breed in the Netherlands are predominantly species with coastal and relatively short foraging ranges, such as terns, cormorants and gulls, and there is no evidence that breeding birds from those populations cross into the UK while they are breeding. However, lesser black-backed gulls breed in large numbers in The Netherlands. Between 32,000 and 57,000 pairs were estimated to breed in The Netherlands in 1992-97 (Mitchell *et al*. 2004) and the numbers subsequently increased to a peak of over 90,000 pairs in 2005 (Camphuysen 2013). With a maximum foraging range of 181km from breeding colonies (Thaxter *et al*. 2012a), there is theoretical potential for connectivity between some colonies in The Netherlands and Norfolk Vanguard. However, extensive colour ringing and tracking of breeding lesser black-backed gulls from multiple colonies in The Netherlands has found no evidence for connectivity during the breeding season between birds breeding in those colonies and the UK, and also that there is remarkably little migration of birds from the colonies in The Netherlands through UK waters outside the breeding season (Camphuysen 2013). Not only do breeding adult lesser black-backed gulls from colonies in The Netherlands normally remain on the continental side of the North Sea while breeding, but 95% of their foraging trips are less than 135km from those colonies (Camphuysen 1995, 2013), so would be very unlikely to

reach Norfolk Vanguard. These studies therefore rule out any transboundary impacts of Norfolk Vanguard on any of these breeding lesser black-backed gull populations.

132. Similarly, impacts on seabird breeding populations in Germany, Belgium and France can be screened out due to the distance of colonies in those countries from the proposed project (Table 5.1), which, with two exceptions discussed in the next paragraph, exceeds maximum foraging ranges of breeding seabirds (Thaxter *et al.* 2012a).

133. There are breeding gannets at colonies where Norfolk Vanguard lies within the reported maximum foraging range of breeding gannets (590km, Thaxter *et al.* 2012a). These colonies are at Seevogelschutzgebiet Helgoland SPA (Germany) and Littoral Seino-Marin SPA (France). However, tracking studies of breeding adults at each of these colonies show that birds from those colonies do not travel into Norfolk Vanguard but forage relatively close to their breeding colonies (Stefan Garthe, pers. comm., Wakefield *et al.* 2013).

134. Therefore, no trans-boundary issues are screened in to this assessment.

5.2.3 Receptors

135. Based on the data collected from site specific surveys for Norfolk Vanguard and a review of existing data sources, the bird species likely to occur in Norfolk Vanguard can be grouped into a series of categories for this high level screening process. This categorisation is based on biological relationships related to breeding biology, feeding, habitat use and migratory pathways. The categories are:

- Breeding seabirds;
- Breeding waterbirds;
- Non-breeding seabirds
- Passage waterbirds; and
- Wintering waterbirds.

5.3 Screening

136. Table 5.1 provides a list of SPAs and Ramsar sites in the North Sea and around the British Isles, along with whether they are proposed to be screened in or out based on whether LSE is deemed to be possible (summarised in Table 5.1 and discussed where relevant in greater detail in paragraphs 137 to 140).

Table 5.1: List of SPA and Ramsar sites with their respective categories of bird interest feature and screening decisions (screened out sites are shown in grey)

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
#N/A	Netherlands	Bruine Bank (Brown Ridge) pSPA	Non-breeding seabirds	c. 20 (estimate as no detailed maps available)	Out	Migrations of birds from this SPA are likely to result in negligible numbers passing through Norfolk Vanguard during migration relative to the size of BDMPS regional populations.
UK9020309	UK	Outer Thames Estuary SPA and pSPA extension	Wintering marine birds and breeding terns	21	Out	SPA is beyond maximum foraging range of designated breeding seabird species (terns) and tern foraging tends to be coastal so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are likely to be small as these species are thought to remain close to shore during much of their migration through UK waters. Migrations of non-breeding seabirds from this pSPA are likely to result in only very small numbers passing through the site during migration, as the migration of divers and sea ducks from SE England tends to be to German Bight and northeastwards to breeding areas, and not therefore in the direction of Norfolk Vanguard.
	UK	Greater Wash pSPA	Non-breeding seabirds and breeding terns	c. 35 (estimate as no detailed maps available)	IN	SPA is beyond maximum foraging range of designated seabird species (terns) and tern foraging tends to be coastal so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are likely to be small as these species are thought to remain close to shore during much of their migration through UK waters. Migrations of non-breeding seabirds from this pSPA are likely to result in small numbers passing through the site during migration, but given the proximity of the site to this pSPA further more detailed assessment of that is appropriate.
UK9009271	UK	Great Yarmouth and North Denes SPA	Breeding seabirds	49	Out	SPA is beyond maximum foraging range of designated seabird species (little tern) and little tern foraging tends to be coastal so has no breeding season connectivity. Proportions of this populations migrating through Norfolk Vanguard are likely to be small as the species is thought to remain close to shore during much of its migration through UK waters.

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
UK9009181	UK	Breydon Water SPA and Ramsar	Wintering and passage waterbirds	53	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009253	UK	Broadland SPA and Ramsar	Wintering and passage waterbirds	53	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009101	UK	Minsmere - Walberswick SPA and Ramsar	Breeding, wintering and passage waterbirds	75	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009031	UK	North Norfolk Coast SPA and Ramsar	Wintering and passage waterbirds	80	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009112	UK	Alde-Ore Estuary SPA and Ramsar	Breeding seabirds and breeding, wintering and passage waterbirds	92	IN	Lesser black-backed gull and herring gull populations may have connectivity with Norfolk Vanguard. This SPA holds the closest large colony of these species to Norfolk Vanguard, and some birds from that SPA may pass through Norfolk Vanguard during migration.
#N/A	Netherlands	Frisian Front pSPA	Non-breeding seabirds	c. 100	Out	Migrations of birds from this SPA are likely to result in negligible numbers passing through Norfolk Vanguard during migration relative to the size of BDMPS regional populations.
NL4000017	NL	Voordelta SPA	Wintering and passage waterbirds	106	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009261	UK	Deben Estuary SPA and Ramsar	Wintering and passage waterbirds	107	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
NL9801001	NL	Waddenzee (Wadden Sea) SPA	Wintering and passage waterbirds	111	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
UK9009121	UK	Stour & Orwell Estuaries SPA and Ramsar	Wintering and passage waterbirds	119	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9008021	UK	The Wash SPA and Ramsar	Wintering and passage waterbirds	120	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009131	UK	Hamford Water SPA and Ramsar	Wintering and passage waterbirds	127	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9008022	UK	Gibraltar Point SPA and Ramsar	Wintering and passage waterbirds	133	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009243	UK	Colne Estuary SPA and Ramsar	Wintering and passage waterbirds	144	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK0030170	UK	Humber Estuary SPA and Ramsar	Wintering and passage waterbirds	149	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009141	UK	Abberton Reservoir SPA and Ramsar	Wintering and passage waterbirds	150	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009245	UK	Blackwater Estuary SPA and Ramsar	Wintering and passage waterbirds	152	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
BEMNZ0004	Belgium	SBZ 3 / ZPS 3[GK9] (off Molenhoek)	Non-breeding seabirds	153	Out	Migrations of birds from this SPA are likely to result in negligible numbers passing through Norfolk Vanguard during migration relative to the size of BDMPS regional populations.
UK9009242	UK	Dengie SPA and Ramsar	Wintering and passage waterbirds	155	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
BEMNZ0003	Belgium	SBZ 2 / ZPS 2 (off Ostend)	Non-breeding seabirds	156	Out	Migrations of birds from this SPA are likely to result in negligible numbers passing through Norfolk Vanguard during migration relative to the size of BDMPS regional populations.

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
UK9009246	UK	Foulness SPA and Ramsar	Wintering and passage waterbirds	158	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009244	UK	Crouch & Roach Estuaries SPA and Ramsar	Wintering and passage waterbirds	167	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
BEMNZ0002	Belgium	SBZ 1 / ZPS 1 (off Nieuwpoort)	Non-breeding seabirds	170	Out	Migrations of birds from this SPA are likely to result in negligible numbers passing through Norfolk Vanguard during migration relative to the size of BDMPS regional populations.
UK9012071	UK	Thanet Coast and Sandwich Bay SPA and Ramsar	Wintering and passage waterbirds	171	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9009171	UK	Benfleet & Southend Marshes SPA and Ramsar	Wintering and passage waterbirds	182	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9012011	UK	The Swale SPA	Wintering and passage waterbirds	187	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9012021	UK	Thames Estuary and Marshes SPA and Ramsar	Wintering and passage waterbirds	188	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9012031	UK	Medway Estuary & Marshes SPA and Ramsar	Wintering and passage waterbirds	190	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9006171	UK	Hornsea Mere SPA	Wintering and passage waterbirds	197	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
	UK	Flamborough and Filey Coast pSPA	Breeding seabirds	c. 200	IN	Uncertain proportions of the kittiwake, gannet, common guillemot, razorbill and puffin populations most likely migrate through Norfolk Vanguard. Only gannet has potential for connectivity during the breeding season based on maximum foraging range but tracking data indicate no connectivity of breeding gannets.
DE2104301	Germany	Borkum-Riffgrund SPA	Non-breeding seabirds	234	Out	Migrations of birds from this SPA are likely to result in negligible numbers passing through Norfolk Vanguard during migration relative to the size of Biologically Defined Minimum Population Scale (BDMPS) regional populations.
UK9006061	UK	Teesmouth and Cleveland Coast SPA and Ramsar	Wintering and passage waterbirds	289	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9006131	UK	Northumbria Coast SPA and Ramsar	Wintering and passage waterbirds	308	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
DE1209301	Germany	Sylter Auβenriff SPA	Non-breeding seabirds	311	Out	Migrations of birds from this SPA are likely to result in negligible numbers passing through Norfolk Vanguard during migration relative to the size of BDMPS regional populations.
UK9011011	UK	Chichester & Langstone Harbours SPA	Migratory waterbirds	313	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
FR2310045	France	Littoral Seino-Marin SPA	Breeding seabirds	315	Out	Norfolk Vanguard is within the theoretical maximum foraging range of breeding gannets from this SPA, but tracking data show that breeding gannets from the SPA do not reach Norfolk Vanguard. The SPA is far beyond maximum foraging range of other designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are likely to be extremely small relative to BDMPS.
UK9011051	UK	Portsmouth Harbour SPA	Migratory waterbirds	326	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
UK9011061	UK	Solent & Southampton Water SPA	Migratory waterbirds	331	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
DE1813491	Germany	Seevogelschutzgebiet Helgoland SPA	Breeding seabirds	343	Out	Tracking data from gannets breeding on Helgoland show these birds do not travel in the direction of or as far as Norfolk Vanguard despite this site being within theoretical maximum foraging range of gannet. The site is beyond the maximum foraging range of other seabird species at Helgoland. Proportions of these populations migrating through Norfolk Vanguard are likely to be very small relative to BDMPS regional populations.
DE1011401	Germany	Östliche Deutsche Bucht SPA	Non-breeding seabirds	345	Out	Migrations of birds from this SPA are likely to result in negligible numbers passing through Norfolk Vanguard during migration relative to the size of BDMPS regional populations.
DE0916491	Germany	Ramsar-Gebiet S-H Wattenmeer und angrenzende Küstengebiete SPA	Breeding, wintering and passage waterbirds	365	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9006031	UK	Coquet Island SPA	Breeding seabirds	366	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9006021	UK	Farne Islands SPA	Breeding seabirds	393	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9006011	UK	Lindisfarne SPA and Ramsar	Wintering and passage waterbirds	398	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9010091	UK	Chesil Beach & The Fleet SPA	Migratory waterbirds	420	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
FR2502020	France	Baie de Seine Occidentale SPA	Breeding, wintering and passage waterbirds	429	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK0030281	UK	St Abbbs Head to Fast Castle SPA	Breeding seabirds	438	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
FR2510099	France	Falaise du Bessin Occidental SPA	Breeding seabirds	445	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9004411	UK	Firth of Forth SPA	Wintering and passage waterbirds	463	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9010081	UK	Exe Estuary SPA	Migratory waterbirds	470	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9004171	UK	Forth Islands SPA	Breeding seabirds	471	Out	Tracking data show breeding gannets from Bass Rock do not commute to Norfolk Vanguard although the site is just within maximum foraging range. Except for gannet, SPA is far beyond maximum foraging range of other designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9004451	UK	Imperial Dock Lock, Leith SPA	Breeding seabirds	491	Out	SPA is far beyond maximum foraging range of designated seabird species (common tern) so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9004121	UK	Firth of Tay & Eden Estuary SPA	Wintering and passage waterbirds	503	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9004031	UK	Montrose Basin SPA	Wintering and passage waterbirds	520	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
UK9002271	UK	Fowlsheugh SPA	Breeding seabirds	525	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002491	UK	Buchan Ness to Collieston Coast SPA	Breeding seabirds	556	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002221	UK	Ythan Estuary, Sands of Forvie and Meikle Loch SPA	Wintering and passage waterbirds	556	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9002211	UK	Loch of Strathbeg SPA	Wintering and passage waterbirds	581	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9002471	UK	Troup, Pennan and Lion`s Heads SPA	Breeding seabirds	597	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9001625	UK	Moray and Nairn Coast SPA	Wintering and passage waterbirds	624	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9001624	UK	Inner Moray Firth SPA	Wintering and passage waterbirds	652	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9001623	UK	Cromarty Firth SPA	Wintering and passage waterbirds	664	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.
UK9001622	UK	Dornoch Firth and Loch Fleet SPA	Wintering and passage waterbirds	669	Out	Survey data show little or no evidence of SPA features occurring in Norfolk Vanguard and migrations of birds from this SPA are likely to result in negligible numbers passing through the site during migration.

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
UK9001182	UK	East Caithness Cliffs SPA	Breeding seabirds	685	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9001181	UK	North Caithness Cliffs SPA	Breeding seabirds	708	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9001131	UK	Pentland Firth Islands SPA	Breeding seabirds	716	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002151	UK	Copinsay SPA	Breeding seabirds	725	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002141	UK	Hoy SPA	Breeding seabirds	733	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002431	UK	Calf of Eday SPA	Breeding seabirds	760	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002091	UK	Fair Isle SPA	Breeding seabirds	762	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002371	UK	Rousay SPA	Breeding seabirds	763	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
UK9002121	UK	Marwick Head SPA	Breeding seabirds	767	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002101	UK	West Westray SPA	Breeding seabirds	773	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002111	UK	Papa Westray (North Hill and Holm) SPA	Breeding seabirds	778	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002511	UK	Sumburgh Head SPA	Breeding seabirds	791	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002361	UK	Mousa SPA	Breeding seabirds	807	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002081	UK	Noss SPA	Breeding seabirds	816	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002061	UK	Foula SPA	Breeding seabirds	833	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002051	UK	Papa Stour SPA	Breeding seabirds	851	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.

Site code	Country	SPA/ Ramsar site name	Category of interest feature	Distance (km)*	Screening decision	Reason for screening decision
UK9002031	UK	Fetlar SPA	Breeding seabirds	859	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002041	UK	Ronas Hill - North Roe and Tingon SPA	Breeding seabirds	866	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.
UK9002011	UK	Hermaness, Saxa Vord and Valla Field SPA	Breeding seabirds	881	Out	SPA is far beyond maximum foraging range of designated seabird species so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are small relative to BDMPS.

*Distance measured from the closest point of Norfolk Vanguard OWF sites (i.e. the wind turbine array) to the closest point of the SPA site rounded to the nearest kilometre

137. Many protected sites can be scoped out as having negligible connectivity with Norfolk Vanguard. Three sites were scoped in for further detailed assessment: Alde-Ore Estuary SPA, Flamborough & Filey pSPA and Greater Wash pSPA.

138. Thaxter *et al*. (2012a) report a maximum foraging range of 181km for lesser black-backed gull, a mean maximum across studies of 141km and a mean foraging range of 71.9km. The Alde-Ore Estuary SPA is a minimum of 92km from Norfolk Vanguard, so is beyond the mean foraging range but well within the maximum foraging range of this species, so some breeding birds from the Alde-Ore Estuary SPA may forage within Norfolk Vanguard. Thaxter *et al.* (2012a) report a maximum foraging range of 92km for herring gull, a mean maximum across studies of 61.1km and a mean foraging range of 10.5km. Therefore, it is unlikely that any herring gulls breeding at the Alde-Ore Estuary SPA forage within Norfolk Vanguard during the breeding season. Further consideration therefore needs to focus on evidence regarding the foraging of lesser black-backed gulls from the Alde-Ore Estuary SPA, especially in relation to tracking work (Thaxter *et al.* 2012b, 2015), and the extent to which connectivity with Norfolk Vanguard may occur.

139. The Flamborough and Filey Coast pSPA is a minimum of 200km from Norfolk Vanguard. Thaxter *et al.* (2012a) report a maximum foraging range of breeding gannets as 590km, puffins as 200km, common guillemots as 135km, kittiwakes as 120km, and razorbills as 95km. RSPB tracking data from gannets breeding at Flamborough and Filey Coast pSPA suggest low connectivity with Norfolk Vanguard (RSPB 2012). However, Carroll *et al*. (2017) present tracking data from breeding kittiwakes at Flamborough and Filey Coast pSPA showing that these birds may travel particularly far out into the Dogger Bank area to forage while breeding. Therefore, Flamborough and Filey Coast pSPA is potentially within the maximum foraging range of gannet from that pSPA. Some of the birds from that colony are also likely to pass through Norfolk Vanguard during migrations. Assessed impacts on these populations need also to consider the conservation status of the designated populations (e.g. increases in gannet numbers (Trinder 2012, WWT 2012, Murray *et al.* 2015) but declines in kittiwake and many other seabird breeding numbers, and other factors driving population change, such as breeding success (Coulson 2017), and the influences on this of changes in fish stocks and fisheries (ICES 2013, Carroll *et al.* 2017), and winter distributions of birds (Frederiksen *et al*. 2012).

140. The Greater Wash pSPA is approximately 35km from Norfolk Vanguard. Although this is less than the mean max foraging range of Sandwich tern, the breeding colonies themselves (already designated as North Norfolk Coast SPA) are beyond foraging range of Norfolk Vanguard. This means that there will be little or no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are likely to be small as these species are thought to remain close

to shore during much of their migration through UK waters. Migrations of non-breeding seabirds (red-throated divers, little gulls and common scoters; Lawson *et al*. 2016) from this pSPA are likely to result in small numbers passing through the site during migration, but given the proximity of the site to this pSPA further more detailed assessment of that is appropriate.

6 OVERALL SUMMARY

141. Following the screening process, seven sites will be considered further within the HRA to determine any LSE.

142. Three sites will be considered for marine mammals:

- Southern North Sea cSAC will be further assessed for harbour porpoise, as Norfolk Vanguard lies within the footprint of the cSAC;
- Humber Estuary SAC will be further assessed for grey seal as there is potential for vessel interactions if a port to the north of Norfolk Vanguard is selected; and
- Wash and North Norfolk Coast SAC will be further assessed for harbour seal, as there is potential for vessel interactions if a port to the north of Norfolk Vanguard is selected.

143. One site will be considered for benthic:

- Haisborough, Hammond and Winterton SCI will be further assessed for Sandbanks which are slightly covered by sea water all the time and Reefs, as it overlaps with the cable corridor.

144. Three sites will be considered further for birds:

- Greater Wash pSPA will be further assessed for non breeding seabirds and breeding terns. The SPA is beyond maximum foraging range of designated seabird species (terns) and tern foraging tends to be coastal so has no breeding season connectivity. Proportions of these populations migrating through Norfolk Vanguard are likely to be small as these species are thought to remain close to shore during much of their migration through UK waters. Migrations of non-breeding seabirds from this pSPA are likely to result in small numbers passing through the site during migration, but given the proximity of the site to this pSPA further more detailed assessment of that is appropriate;
- Alde-Ore Estuary SPA and Ramsar will be further assessed for Breeding seabirds and breeding, wintering and passage waterbirds. Lesser black-backed gull and herring gull populations may have connectivity with Norfolk Vanguard. This SPA holds the closest large colony of these species to Norfolk Vanguard, and some birds from that SPA may pass through Norfolk Vanguard during migration; and
- Flamborough and Filey Coast pSPA will be further assessed for breeding seabirds. Uncertain proportions of the kittiwake, gannet, common guillemot, razorbill and

puffin populations most likely migrate through Norfolk Vanguard. Only gannet has potential for connectivity during the breeding season based on maximum foraging range but tracking data indicate no connectivity of breeding gannets.

145. No sites will be considered further for impacts to designated fish features as there will be no connectivity.

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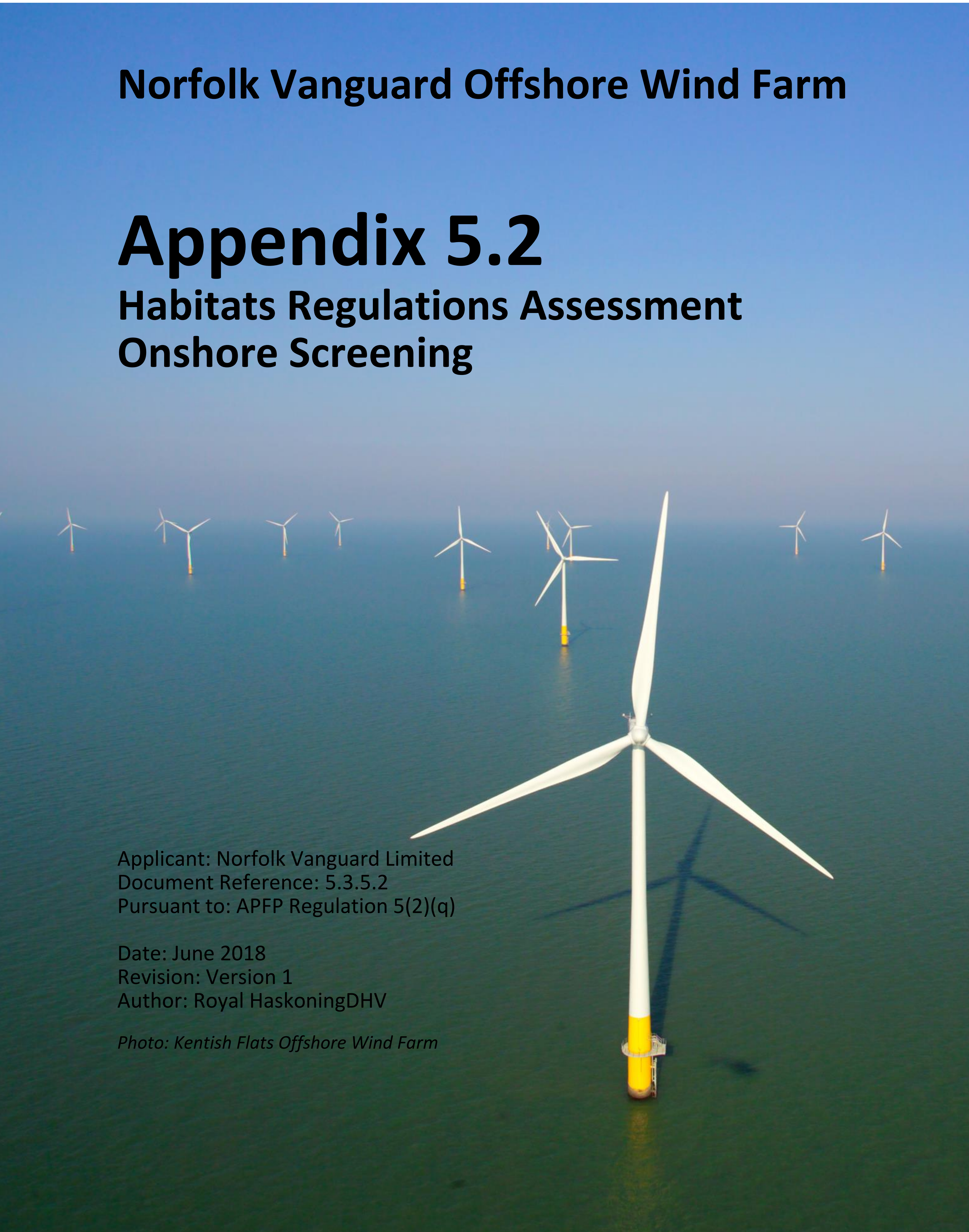
Norfolk Vanguard Offshore Wind Farm

Appendix 5.2

Habitats Regulations Assessment Onshore Screening



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Document Reference 5.3.5.2

June 2018

For and on behalf of Norfolk Vanguard Limited

Approved by: Ruari Lean and Rebecca Sherwood

Signed: [redacted]

Date: 8th June 2018

For and on behalf of Royal HaskoningDHV

Drafted by: Gordon Campbell

Approved by: Alistair Davison

Signed: [redacted]

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23/10/17	02F	Final version for submission	GC	ST/RH	AD

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Figures

Glossary

HRA	Habitats Regulations Assessment
AA	Appropriate Assessment
AfL	Agreement for Lease
BCT	Bat Conservation Trust
cSAC	Candidate SAC
DCLG	Department for Communities and Local Government
DCO	Development Consent Order
Defra	Department for Environment, Food and Rural Affairs
EAOW	East Anglia Offshore Wind Limited
EC	European Commission
EEC	European Economic Community
EIA	Environmental Impact Assessment
ES	Environmental Statement
EU	European Union
HDD	Horizontal Directional Drilling
HRA	Habitats Regulations Assessment
HRGN	Habitats Regulations Guidance Note
IROPI	Imperative Reasons of Overriding Public Interest
JNCC	Joint Nature Conservation Committee
LSE	Likely Significant Effect
NBIS	Norfolk Biodiversity Information Service
NBSG	Norfolk Barbastelle Study Group
NSER	No Significant Effects Report
NV east	Norfolk Vanguard East
NVC	National Vegetation Classification
O&M	Operational and Maintenance
ODPM	Office of the Deputy Prime Minister
OWF	Offshore wind farm
PEIR	Preliminary Environmental Information Report
pSAC	Possible SACs
pSPA	Possible SPA
SAC	Special Area of Conservation
SCI	Sites of Community Importance
SNCB	Statutory Nature Conservation Bodies
SPA	Special Protection Area
SPR	Scottish Power Renewables (UK) Limited
SSSI	Site of Special Scientific Interest
TEU	Treaty of the European Union
VWPL	Vattenfall Wind Power Ltd
ZAP	Zone Appraisal and Planning
ZDA	Zone Development Agreement
ZOI	Zone of Influence

Glossary of Terminology

Cable Relay Station	A CRS would be required for a HVAC connection arrangement only and would not be included in a HVDC connection solution. The CRS would accommodate reactive compensation equipment required to absorb the capacitive currents generated by long HVAC power cables.
Landfall	Where the offshore cables come ashore.
Link boxes	Underground chambers or above ground cabinets next to the cable trench housing low voltage electrical earthing links.
Mobilisation zone	Area within which mobilisation areas, required for facilitating the duct installation, would be located.
National Grid substation extension	The proposed location for the National Grid substation extension.
Natura 2000 site / European site	A network of nature protection areas in the territory of the European Union. It is made up of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) designated under the Habitats Directive and Birds Directive, respectively.
Necton National Grid substation	The grid connection location (Onshore Interface Point) for Norfolk Vanguard.
Onshore cables	The cables which transmit electricity from landfall to the onshore project substation.
Onshore cable corridor	200m wide onshore corridor within which the onshore cable route would be located.
Onshore infrastructure	The combined name for all onshore infrastructure associated with the project from landfall to grid connection.
Onshore project area	All onshore electrical infrastructure.
Onshore project substation	A compound containing electrical equipment to enable connection to the National Grid. In an HVAC solution the substation steps up the exported power from 220kV (export cable voltage) to 400kV (grid voltage). In an HVDC system the substation would convert the exported power from HVDC to HVAC, with a step up to 400kV (grid voltage). For both options this also contains equipment to help maintain stable grid voltage.
Overhead line modification zone	Area within which the work would be undertaken to complete the necessary modification to the existing 400kV overhead lines.
The project	Norfolk Vanguard Offshore Wind Farm, including the onshore and offshore infrastructure.
Ramsar sites	A Ramsar Site is a wetland site of international importance under the Convention on Wetlands, known as the Ramsar Convention.

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1 INTRODUCTION

1.1 Purpose of this document

1. This document provides the findings of the onshore screening of Natura 2000 sites for Habitats Regulations Assessment (HRA) in relation to the Norfolk Vanguard Offshore Wind Farm (herein 'the project'). This document covers those Natura 2000 sites designated for the terrestrial and freshwater habitats and species they support, as well as those Natura 2000 sites designated for bird species which utilise terrestrial habitats. The document provides the information that was used in stakeholder consultation as part of the Evidence Plan Process, to seek agreement on the designated sites which should be considered further. This document also forms Stage 1 of the HRA Process (discussed further in section 1.4). Any updates since screening in Q4 of 2017 are discussed in the main Information to Support HRA report. Impacts of the offshore project infrastructure on Natura 2000 sites are screened separately in Appendix 5.1.

2. Designated sites are proposed to be 'screened out' where no Likely Significant Effect (LSE) from the project is predicted. Where LSE cannot be ruled out at this stage the designated sites will be 'screened in' and assessed further. Information to support the HRA (both offshore and onshore) is provided in the Preliminary Environmental Information Report (PEIR) and the Development Consent Order (DCO) application documents.

3. The classes of Natura 2000 designations considered within this HRA Screening are:

- Special Protection Areas (SPAs) (some of which are also Ramsar sites);
- Potential SPA (pSPA);
    - SPAs that are approved by the UK Government but are still in the process of being classified.
- Special Areas of Conservation (SACs);
    - Sites that have been adopted by the European Commission and formally designated by the government of each country in whose territory the site lies.
- Possible SACs (pSACs);
    - A site which has been identified and approved to go out to formal consultation.
- Candidate SACs (cSACs); and

  - Following formal consultation on the pSAC, the site is then submitted to the European Commission (EC) for approval (referred to as adoption). At this stage the site it is called a cSAC.
- Sites of Community Importance (SCI).
  - Once adopted by the EC, the site it becomes a SCI, before the national government then designates it as a SAC.

4. Consideration is also given to impacts on Ramsar sites. Ramsar sites protect wetland areas and extend only to 'areas of marine water the depth of which at low tide does not exceed six metres'.

5. Screening of SPAs and SACs affected by the offshore project elements will be provided separately (see Norfolk Vanguard Offshore Wind Farm Habitats Regulations Assessment Offshore Screening Document Reference: PB4476-004-040).

1.2 Project Background

1.2.1 Background

6. In December 2009, as part of the UK Offshore Wind Round 3 tender process, The Crown Estate awarded the joint venture company, East Anglia Offshore Wind (EAOW) Ltd, the rights to develop Zone 5 (later called the 'East Anglia zone'). These rights were granted through a Zone Development Agreement (ZDA). EAOW Ltd. is a 50:50 joint venture owned by Vattenfall Wind Power Ltd (VWPL) and ScottishPower Renewables (UK) Limited (SPR).

7. In December 2014, a decision was taken to split the zone, with VWPL having development rights within the north of the former East Anglia Zone, and SPR continuing to develop the southern part. In agreement with The Crown Estate, the ZDA was effectively dissolved in 2016. New Agreement for Lease (AfL) areas have been awarded by The Crown Estate within the former Zone, separately to VWPL and its affiliate companies, and SPR and its affiliates.

8. Norfolk Vanguard Ltd (an affiliate company of VWPL) is now undertaking the EIA for Norfolk Vanguard and a Scoping Report was submitted to the Planning Inspectorate in October 2016 (Royal HaskoningDHV, 2016).

9. The offshore project area comprises two distinct offshore wind farm (OWF) areas, Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) ('the OWF sites'), and will be connected to the shore by offshore export cables installed within the offshore cable corridor.

1.2.2 Project description

10. The onshore project area consists of the following key elements:

- Landfall;
- Cable relay station (if required);
- Onshore cable corridor;
- Onshore project substation; and
- Extension to the existing Necton National Grid substation and overhead line modifications.

11. The location of the onshore project area is shown on Figure 22.1.

12. During the development of the project, the onshore Scoping Area that was initially defined has been refined, to identify three landfall options, associated cable relay station search zones, as well as an onshore project substation search zone in proximity to the Necton National Grid substation. A 200m wide onshore cable corridor has been identified, within which the cable will be located, and Horizontal Directional Drilling (HDD) zones and mobilisation zones have been identified along the onshore cable corridor. As the project design is further refined, these search zones will decrease in size, and the final options for the siting of infrastructure (i.e. one cable relay station, one landfall, one onshore substation) will be taken forward in the Norfolk Vanguard DCO application.

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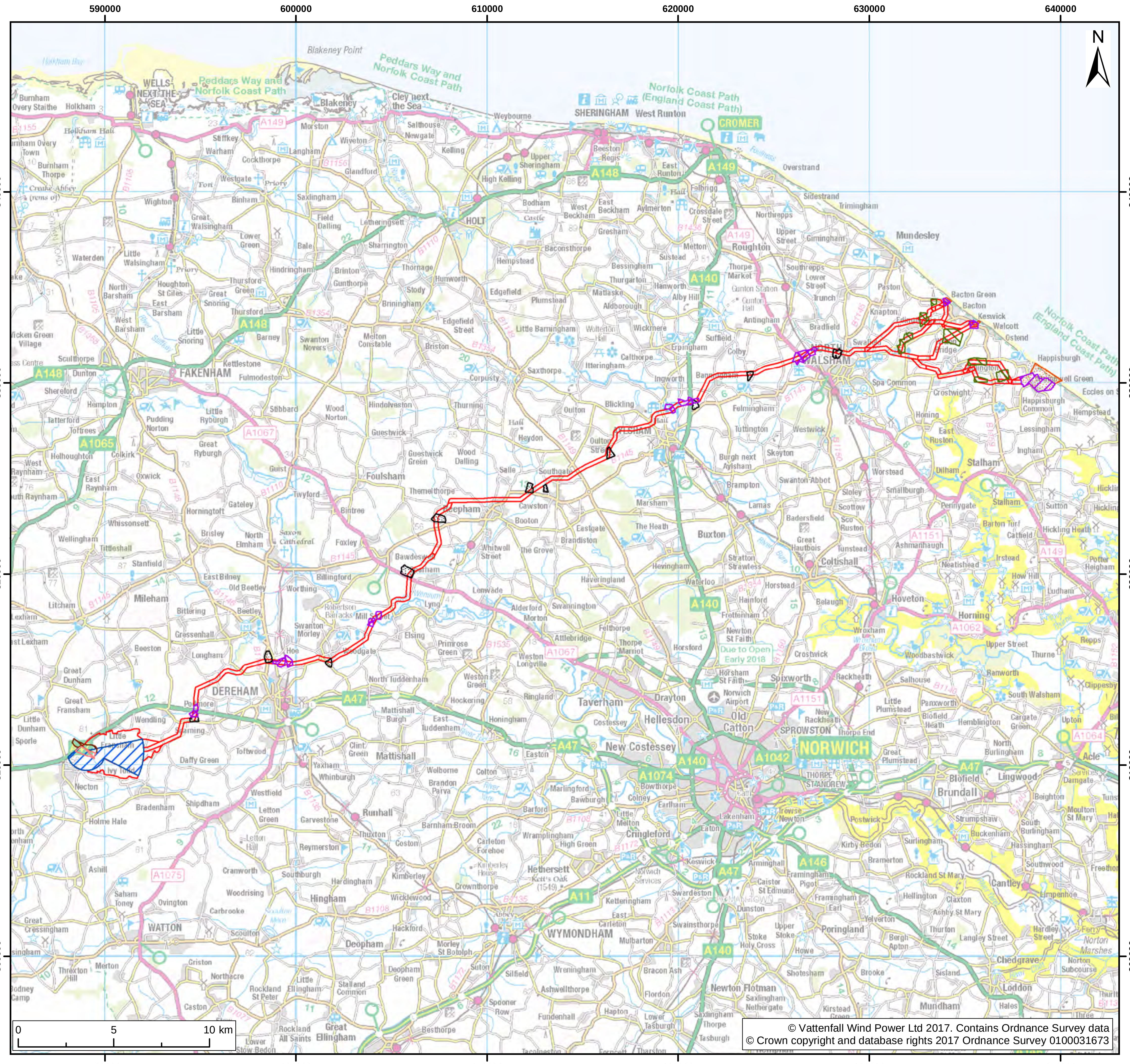

Legend:

Norfolk Vanguard Onshore Infrastructure

- Landfall Zone
- Cable Relay Station Search Zone
- Onshore Cable Corridor
- Horizontal Directional Drilling (HDD) Zone
- Mobilisation Zone
- Project Substation Search Zone
- National Grid Substation Extension Zone
- Overhead Line Modification Zone

Project:	Report:
Norfolk Vanguard	Preliminary Environmental Information Report

Title:

Norfolk Vanguard onshore infrastructure

Figure: 22.1 Drawing No: PB4476-004-02206_001

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Co-ordinate system: British National Grid **EPSG:** 27700

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Enhancing Society Together

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1.2.3 Onshore project area site selection process

13. The project has undergone an extensive site selection process which has involved incorporating ecological constraints into the identification of the onshore project area. A constraints mapping exercise was undertaken prior to the publication of the Norfolk Vanguard EIA Scoping Report (Royal HaskoningDHV, 2016) in order to determine the route options for the onshore project area. This constraints mapping exercise identified international designated sites for nature conservation (SAC, SPA, Ramsar sites) to ensure that, where possible, these sites were avoided.

14. Where it was not possible to avoid the location of an internationally designated site, for example in the case of linear designated sites such as the River Wensum SAC, it is intended to use trenchless techniques (i.e. HDD) these locations in order to ensure that no above ground works occur within these designations. The River Wensum SAC is the only example where an internationally designated site needs to be crossed in this way.

15. Further details on the site selection process are set out in Chapter 4 Site Selection and Consideration of Alternatives in the PEIR.

1.3 HRA Legislation, Policy and Guidance

1.3.1 Legislation

16. The HRA process derives from the requirements of specific European Directives and the Regulations that implement their requirements into UK and devolved national law.

17. The UK has triggered article 50 of the Treaty on European Union (TEU) and is in a two year process of negotiating a withdrawal agreement for the UK to leave the EU. Following withdrawal from the EU, the UK government plans to enact the Great Repeal Bill. In its White Paper, the UK Government has confirmed that it plans to transpose all current European environmental regulation (e.g. the Habitats Directive and Birds Directive) into UK law after leaving the European Union.

1.3.1.1 The Birds Directive

18. The EU Directive on the Conservation of Wild Birds (2009/147/EC) (hereafter called the Birds Directive) provides a framework for the conservation and management of wild birds in Europe. The relevant provisions of the Directive are the identification and classification of SPAs for rare or vulnerable species listed in Annex I of the Directive and for all regularly occurring migratory species (required by Article 4). The Directive requires national Governments to establish SPAs and to have in place mechanisms to protect and manage them. The SPA protection procedures originally

set out in Article 4 of the Birds Directive have been replaced by the Article 6 provisions of the Habitats Directive.

1.3.1.2 The Habitats Directive

19. The EU Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (hereafter called the Habitats Directive) provides a framework for the conservation and management of natural habitats, wild fauna (except birds) and flora in Europe. Its aim is to maintain or restore natural habitats and wild species at a favourable conservation status. The relevant provisions of the Directive are the identification and classification of Special Areas of Conservation (SAC) (Article 4) and procedures for the protection of SACs and SPAs (Article 6). SACs are identified based on the presence of natural habitat types listed in Annex I and populations of the species listed in Annex II. The Directive requires national Governments to establish SACs and to have in place mechanisms to protect and manage them.

1.3.1.3 The Conservation of Habitats and Species Regulations 2010

20. The Conservation of Habitats and Species Regulations 2010, (hereafter called the 'Habitats Regulations') transpose the Birds Directive and the Habitats Directive into UK law. The Habitats Regulations place an obligation on 'competent authorities' to carry out an appropriate assessment of any proposal likely to affect a SAC or SPA, to seek advice from Natural England and not to approve an application that would have an adverse effect on a SAC or SPA except under very tightly constrained conditions that involve decisions by the Secretary of State. The competent authority in the case of Norfolk Vanguard is the Secretary of State for Business, Energy and Industrial Strategy.

1.3.1.4 Application of the legislation to designated sites

21. As discussed in section 1.1 the HRA process also applies as a matter of law or policy to the following sites:

- SCI and cSAC: HRA process applied as a result of Article 4(5) and Article 6(2)(4) of the Habitats Directive.
- pSPAs: HRA process applied as a result of UK Government policy - paragraph 118 of the National Planning Policy Framework (DCLG, 2012).
- pSACs: HRA process applied as a result of UK Government policy - paragraph 118 of the National Planning Policy Framework (DCLG, 2012).
- Listed and proposed Ramsar sites (internationally important wetlands designated under the Ramsar Convention 1971): HRA process applied as a result of UK Government policy (ODPM & Defra, 2005; DCLG, 2012).

1.3.2 Guidance on the HRA Process

22. In preparing this report, consideration has been given to the relevant guidance issued by a number of governmental, statutory and industry bodies.

23. In relation to guidance from government bodies this includes:

- European Commission: Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites;
- European Commission: EU Guidance on wind energy development in accordance with EU nature directives;
- Department of Communities and Local Government: Guidance on 'Planning for the Protection of European Sites: Appropriate Assessment';
- The Planning Inspectorate Advice Note Nine: Rochdale Envelope; and
- The Planning Inspectorate Advice Note Ten: Habitat Regulations Assessment relevant to nationally significant infrastructure projects.

24. In relation to guidance from the Statutory Nature Conservation Bodies (SNCBs) this includes:

- English Nature: Habitats Regulations Guidance Note (HRGN 1): The Appropriate Assessment (Regulation 48) The Conservation (Natural Habitats &c) Regulations, 1994.
- English Nature: Habitats Regulations Guidance Note (HRGN 3): The Determination of Likely Significant Effect under the Conservation (Natural Habitats &c) Regulations, 1994.
- English Nature: Habitats Regulations Guidance Note (HRGN 4): Alone or in combination.

1.4 The HRA Process

25. The HRA process is carried out in a sequential manner and the stages of that sequence are described as follows in Planning Inspectorate Advice Note 10 (Planning Inspectorate, 2016):

- Stage 1 –Screening (This report) for LSE;
    - European and Ramsar sites are screened for LSE, both effects from the project alone and in combination with other projects. The Planning Inspectorate advises that for those projects where no LSE is predicted then that should reported in the form of a No Significant Effects Report (NSER) and the Stage 2 assessment is not carried out (the Planning Inspectorate, 2016).
- Stage 2 - Appropriate Assessment (AA);

- For those sites where LSE on a European or Ramsar site cannot be excluded at Stage 1, then further information to inform the assessment will be prepared and the test applied to determine whether the project alone or in-combination could adversely affect the integrity of the site in view of its conservation objectives. This assessment stage will be reported in the form of a HRA AA Report and the results of the assessment summarised in the form of a series of matrices.

26. In those cases where the conclusion of the HRA AA Report is that an adverse effect on the integrity of a European or Ramsar site has been identified then the assessment proceeds to two further stages:

- Stage 3 - Assessment of Alternatives; and
    - The alternatives that have been considered will be assessed. The Planning Inspectorate advises that alternative solutions can include a proposal of a different scale, a different location and an option of not having the scheme at all – the 'do nothing' approach.
- Stage 4 – Assessment of Imperative Reasons of Overriding Public Interest (IROPI).
    - If it is demonstrated that there are no alternative solutions to the proposal that would have a lesser effect or avoid an adverse effect on the integrity of the site(s), then a justified case will be prepared that the scheme must be carried out for IROPI.

27. If the conclusion of Stages 3 and 4 is that there is no alternative and that the project has demonstrated clear Imperative Reasons of Overriding Public Interest (IROPI) then the project may proceed with a requirement that appropriate compensatory measures are delivered.

1.4.1 In-combination Assessment

28. The Habitats Regulations require the consideration of the potential effects of a project on European sites and Ramsar sites both alone and in-combination with other plans or projects.

29. The identification of plans and projects to include the in-combination assessment will be based on:

- Approved plans;
- Constructed projects;
- Approved but as yet unconstructed projects; and

- Projects for which an application has been made, those which are currently under consideration and those which will be consented before the project's consent decision.

30. The classes of projects that could potentially be considered for the in-combination assessment include:

- Construction or improvement of highways or roads;
- Cycle tracks and other ancillary works;
- Other major transport works;
- Generating station development;
- Above ground electrical line installation;
- Pipeline development;
- Water operations (abstraction or impounding); and
- Major residential or commercial development.

31. The assessment will present relevant in-combination impacts of projects in the following tiered approach (Table 1.1) as advised by Natural England (Joint Nature Conservation Committee (JNCC) and Natural England, 2013a).

Table 1.1 Suggested tiers for undertaking a staged cumulative impact assessment (JNCC and Natural England, 2013a)

Tier description	Consenting or construction phase	Data availability
Tier 1	Built and operational projects should be included within the cumulative assessment where they have not been included within the environmental characterisation survey, i.e. they were not operational when baseline surveys were undertaken, and/or any residual impact may not have yet fed through to and been captured in estimates of 'baseline' conditions e.g. 'background' distribution or mortality rate for birds.	Pre-construction (and possibly post-construction) survey data from the built project(s) and environmental characterisation survey data from proposed project (including data analysis and interpretation within the Environmental Statement (ES) for the project).
Tier 2	Tier 1 + projects under construction.	As Tier 1 but not including post-construction survey data.
Tier 3	Tier 2 + projects that have been consented (but construction has not yet commenced).	Environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project) and possibly pre-construction.
Tier 4	Tier 3 + projects that have an application submitted to the appropriate regulatory body that have not yet been determined.	Environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project).
Tier 5	Tier 4 + projects that the regulatory body are	Possibly environmental characterisation

Tier description	Consenting or construction phase	Data availability
	expecting an application to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects).	survey data (but strong likelihood that this data will not be publicly available at this stage).
Tier 6	Tier 5 + projects that have been identified in relevant strategic plans or programmes (e.g. projects identified in Round 3 wind farm zone appraisal and planning (ZAP) documents).	Historic survey data collected for other purposes/by other projects or industries or at a strategic level.

32. Projects will be included in the quantitative assessment where there is sufficient certainty and data confidence that they make a meaningful contribution to the assessment process.

1.5 Process for the Identification of European and Ramsar Sites and Features Potentially Affected by the Project

33. In order to identify relevant European and Ramsar sites that have the potential to be affected by the project, a 5km buffer zone around the onshore infrastructure has been applied (see Figure 22.2).

34. The 5km buffer was used to capture all of the designated sites that are considered to have the potential to be affected by the project.

1.6 HRA Stage 1 Screening Process

35. Screening has been based on a conceptual 'source-pathway-receptor' approach. The approach identifies likely environmental impacts resulting from the proposed construction, operation and maintenance (O&M) and decommissioning of the wind farm and its supporting transmission infrastructure. The parameters are defined as follows:

- Source – the origin of a potential impact (noting that one source may have several pathways and receptors).
    - Example: Site clearance works required for cable trenching.
- Pathway – the means by which the effect of the activity could impact a receptor.
    - Example: Loss of vegetation leading to severance of ecological networks.
- Receptor – the element of the receiving environment that is impacted.
    - Example: Commuting / foraging routes for a bat species for which a site is designated are severed by vegetation removal.

36. Where there is no pathway or the pathway is so long that the effect from the source has dissipated to a negligible level before reaching the receptor, there is justification for the screening out of that particular receptor.

37. It only requires one category of site interest feature to be identified in the process below for the European and / or Ramsar site to be screened in, along with all its associated interest features.

38. Where there is insufficient information available at this stage to screen out a site, it is screened in for further consideration.

39. The assessment of LSE in the context of these sites comprised expert assessment of the likely effects of the project during both the construction, operational and decommissioning phases. This includes the analysis of the maximum distance over which potential impacts could occur (known as the 'zone of influence' (ZOI)) for specific environmental parameters associated with the construction and operational phases of the project. This screening exercise considers whether the project ZOIs overlap with either of the following footprints:

- The European and Ramsar site boundaries; and
- Ex-situ habitats of the qualifying features of European and Ramsar sites.

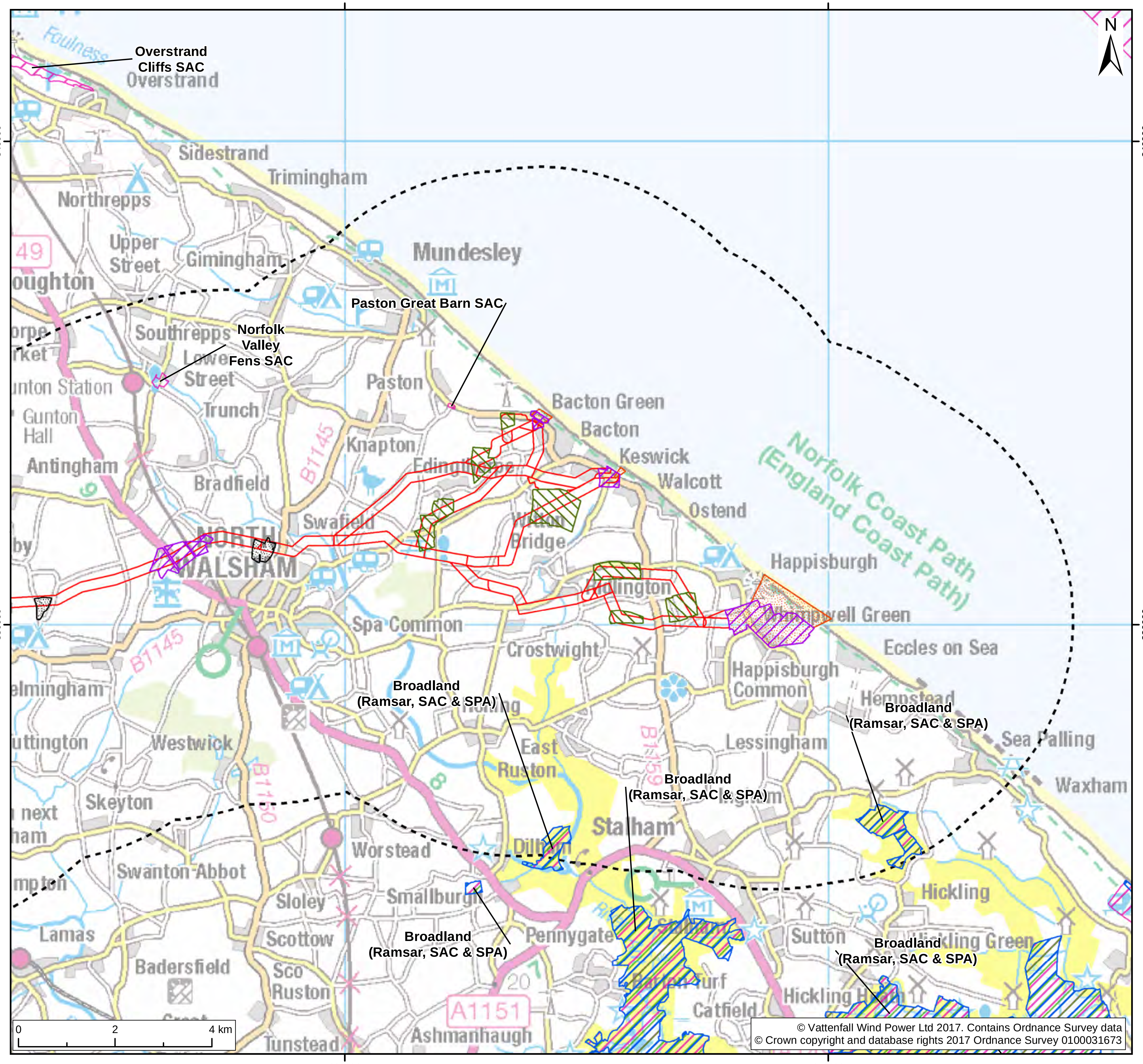
40. Ex-situ habitats are those which support qualifying features of the European or Ramsar site but are located outside of the designated site boundary.

41. The ZOI for different environmental parameters is summarised Table 1.2. The environmental parameters and also ex-situ habitats relevant for the qualifying features of specific designated sites are set out within section 4 below. These ZOIs have been determined using expert judgement. An explanation of how each ZOI is derived is set out in Table 1.2.

Table 1.2 The ZOI of potential effects for relevant environmental parameters

Environmental parameter	Zone of Influence (ZoI) of potential effect	Explanation
Noise	1km from the **onshore project area**.	**A precautionary buffer based** on the sensitivity of ornithological receptors to noise disturbance (Whitfield, Ruddock & Bullman, 2008).
Air quality	50m from the **onshore project area** for construction dust. 1km from the **onshore project area** for project emissions.	**Precautionary buffers based on the anticipated** dispersion distances of emissions generated by the project (IAQM guidance considers receptors within 500m of a pollution source (IAQM, 2014)).
Light	50m from the **onshore project area**, the zone of potential (controlled) light spill.	Buffer based on the potentially effects of light upon sensitivity ecological features (e.g. bat commuting / foraging routes).
Visual	500m from the **onshore project area**.	A precautionary buffer based on the

Environmental parameter	Zone of Influence (ZoI) of potential effect	Explanation
disturbance		sensitivity of ornithological receptors to noise disturbance (Whitfield, Ruddock & Bullman, 2008).
Geology and land contamination	500m from the **onshore project area**.	A precautionary buffer based on the assumed maximum extent of release of contaminated material caused by the project.
Groundwater and Hydrology	**Generally taken to be 1km from the** onshore project area**, although this could be larger where a groundwater connection exists.**	A precautionary buffer based on the maximum extent of groundwater bodies' functional connectivity with a designated site.



Legend:

Norfolk Vanguard Onshore Infrastructure

- Landfall Zone
- Cable Relay Station Search Zone
- Onshore Cable Corridor
- Horizontal Directional Drilling (HDD) Zone
- Mobilisation Zone
- 5km buffer zone
- SPA[1]
- Ramsar[2]
- SAC[3]

[1] Defra, 2017
[2] Natural England, 2017
[3] Natural England, 2017

Project:	Report:
Norfolk Vanguard	Preliminary Environmental Information Report

Title:

European and Ramsar sites potentially affected by the project
Map 1 of 5

Figure: 22.2 Drawing No: PB4476-004-02206-002

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Co-ordinate system: British National Grid **EPSG:** 27700

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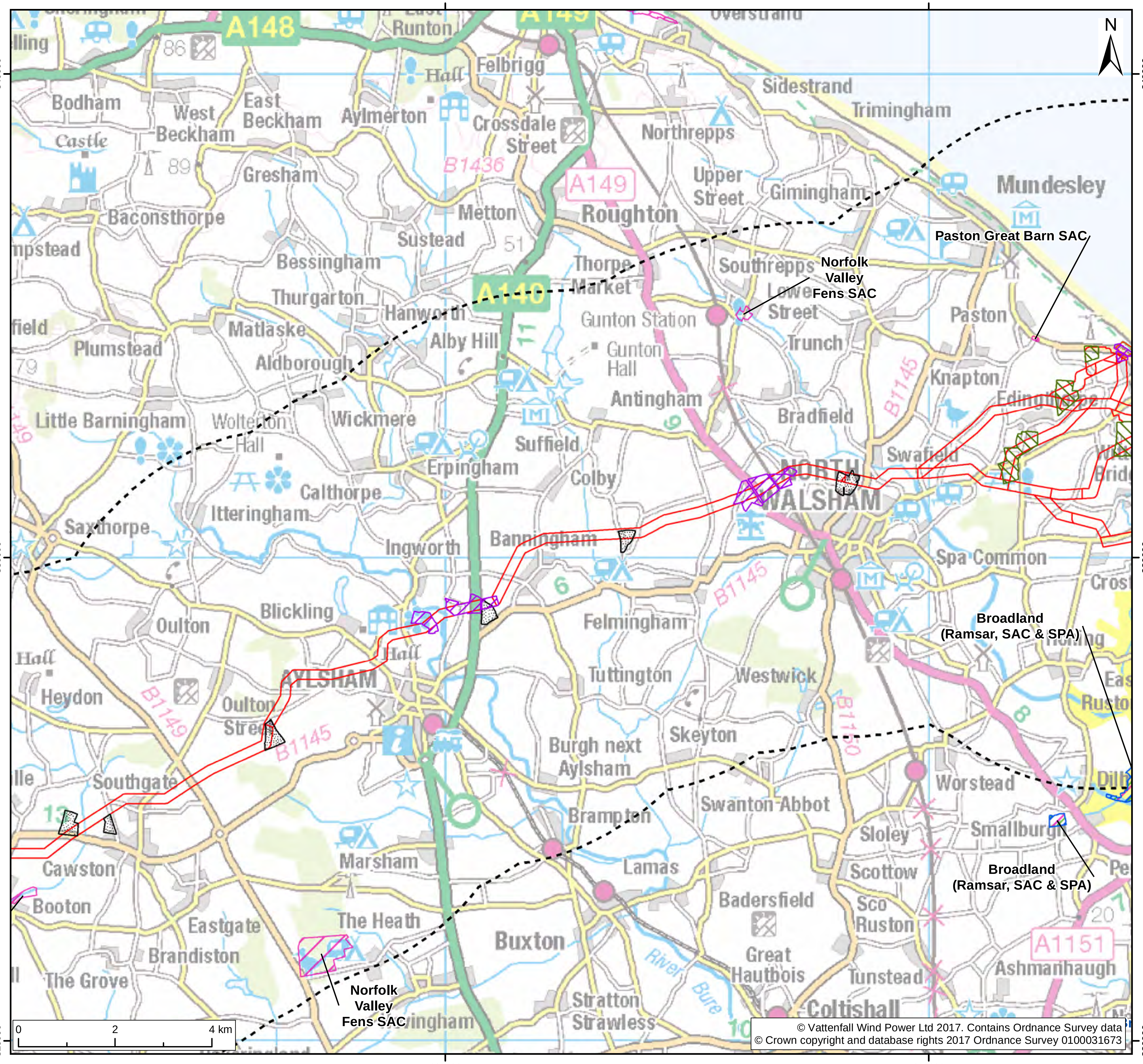

Legend:

Norfolk Vanguard Onshore Infrastructure

- Landfall Zone
- Cable Relay Station Search Zone
- Onshore Cable Corridor
- Horizontal Directional Drilling (HDD) Zone
- Mobilisation Zone
- 5km buffer zone
- SPA[1]
- Ramsar[2]
- SAC[3]

[1] Defra, 2017
[2] Natural England, 2017
[3] Natural England, 2017

Project:	Report:
Norfolk Vanguard	Preliminary Environmental Information Report

Title:

European and Ramsar sites potentially affected by the project
Map 2 of 5

Figure: 22.2 Drawing No: PB4476-004-02206-002

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	14/09/2017	NJ	GC	A3	1:80,000
02	19/09/2017	NJ	GC	A3	1:80,000

Co-ordinate system: British National Grid **EPSG:** 27700

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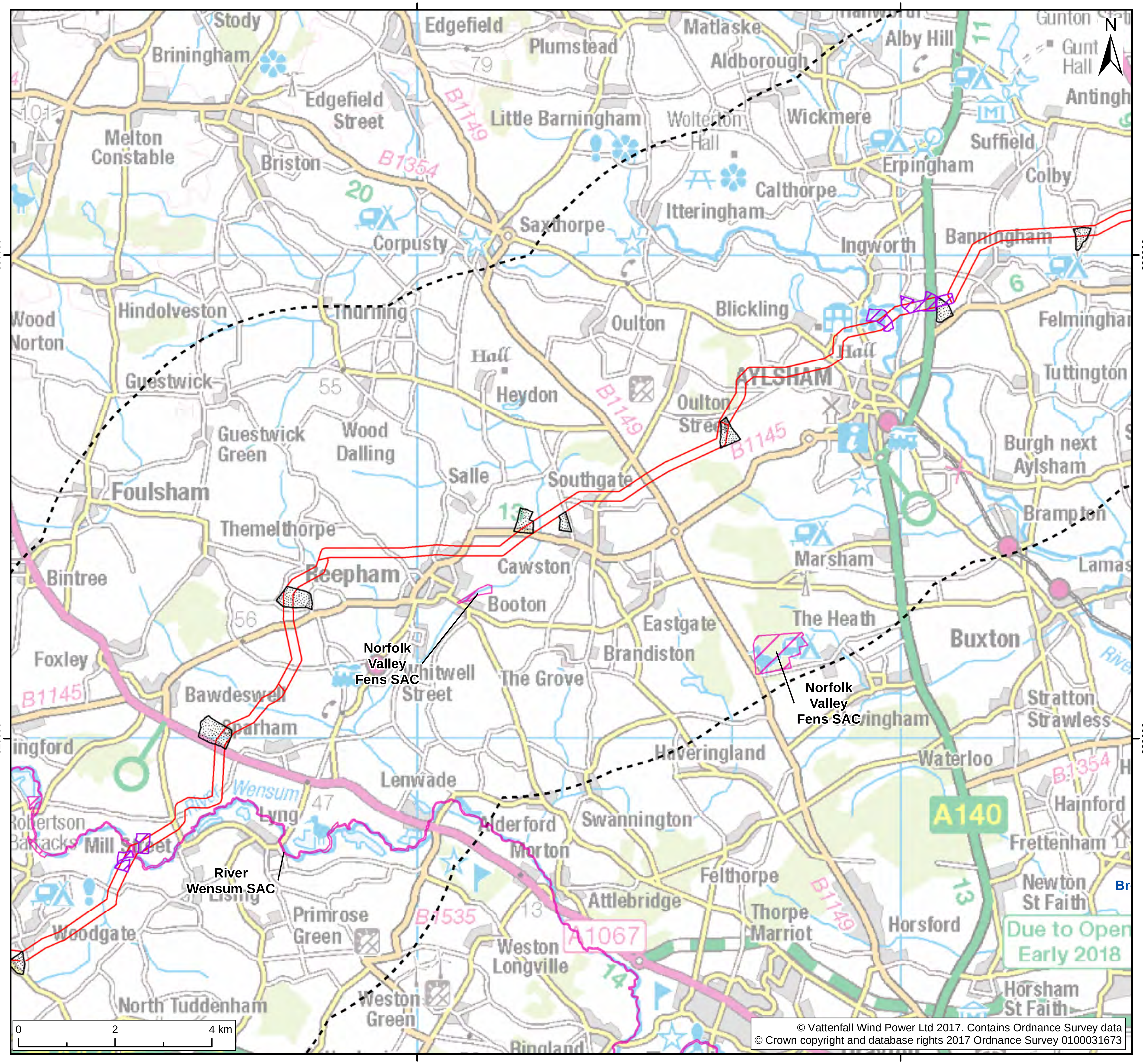

Legend:

Norfolk Vanguard Onshore Infrastructure

- Onshore Cable Corridor
- Horizontal Directional Drilling (HDD) Zone
- Mobilisation Zone
- 5km buffer zone
- SAC[3]

[1] Defra, 2017
[2] Natural England, 2017
[3] Natural England, 2017

Project:	Report:
Norfolk Vanguard	Preliminary Environmental Information Report

Title:

European and Ramsar sites potentially affected by the project
Map 3 of 5

Figure: 22.2 Drawing No: PB4476-004-02206-002

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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02	19/09/2017	NJ	GC	A3	1:80,000

Co-ordinate system: British National Grid **EPSG:** 27700

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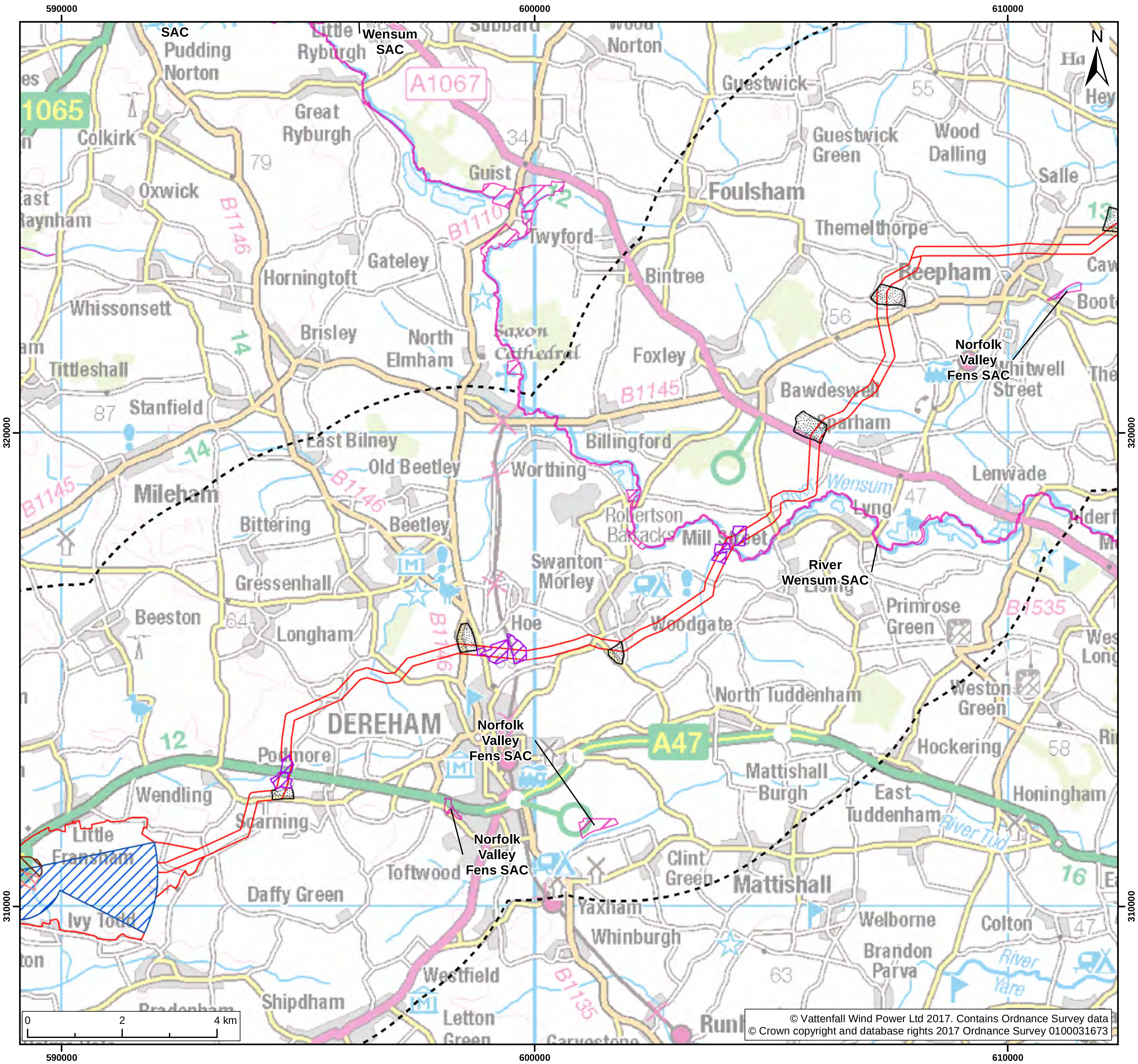

Legend:

Norfolk Vanguard Onshore Infrastructure

- Onshore Cable Corridor
- Horizontal Directional Drilling (HDD) Zone
- Mobilisation Zone
- Project Substation Search Zone
- National Grid Substation Extension Zone
- Overhead Line Modification Zone
- 5km buffer zone
- SAC[3]

[1] Defra, 2017
[2] Natural England, 2017
[3] Natural England, 2017

Project: Norfolk Vanguard

Report: Preliminary Environmental Information Report

Title: European and Ramsar sites potentially affected by the project Map 4 of 5

Figure: 22.2 | Drawing No: PB4476-004-02206-002

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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02	19/09/2017	NJ	GC	A3	1:80,000

Co-ordinate system: British National Grid **EPSG:** 27700

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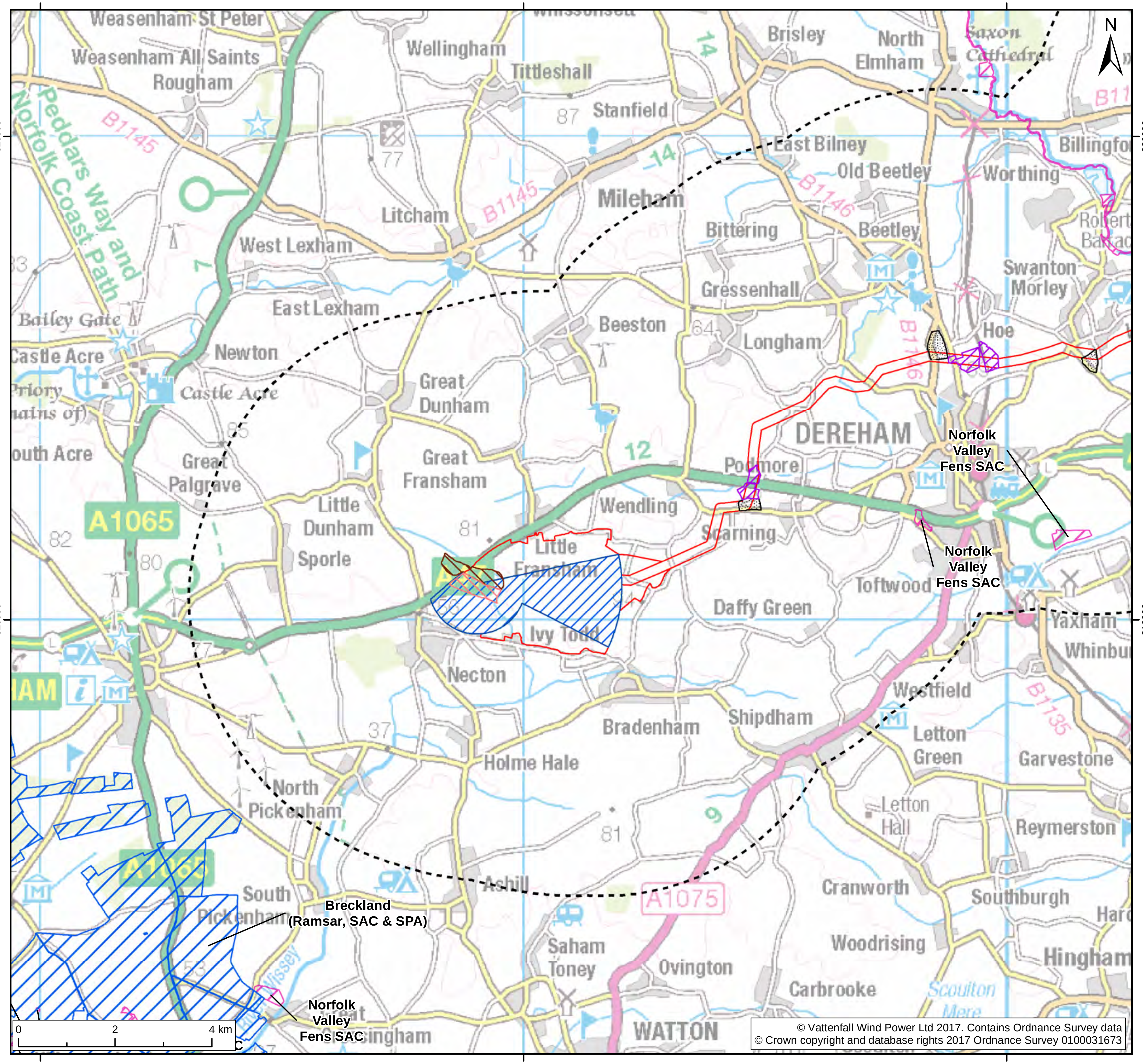

Legend:

Norfolk Vanguard Onshore Infrastructure

- Onshore Cable Corridor
- Horizontal Directional Drilling (HDD) Zone
- Mobilisation Zone
- Project Substation Search Zone
- National Grid Substation Extension Zone
- Overhead Line Modification Zone
- 5km buffer zone
- SPA[1]
- SAC[3]

[1] Defra, 2017
[2] Natural England, 2017
[3] Natural England, 2017

Project:	Report:
Norfolk Vanguard	Preliminary Environmental Information Report

Title:
European and Ramsar sites potentially affected by the project
Map 5 of 5

Figure: 22.2 Drawing No: PB4476-004-02206-002

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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2 DESIGNATED SITES POTENTIALLY AFFECTED BY THE PROJECT

2.1 European and Ramsar sites included in the Screening Assessment

42. There are four European sites and one Ramsar site within 5km of the onshore infrastructure. These are:

- River Wensum SAC;
- Paston Great Barn SAC;
- Norfolk Valley Fens SAC; and
- Broadland SPA and Ramsar site.

43. The distances between the designated sites and the onshore infrastructure are shown in Table 2.1. Details of each designated site are provided below. The location of these sites is shown on Figure 22.2.

Table 2.1 European and Ramsar sites within 5km of the onshore infrastructure

European / Ramsar site	Closest point to the onshore infrastructure
River Wensum SAC	**Lies within the onshore project area**
Paston Great Barn SAC	**2.9km (located north-east of the** onshore project area**)**
Norfolk Valley Fens SAC	**570m (located south of the** onshore project area**)**
Broadland SPA and Ramsar site	3.6km (located south of the onshore project area)

2.1.1 River Wensum SAC

44. The River Wensum SAC[1] covers approximately 307ha and includes the river and certain adjacent floodplain habitats from its source near Fakenham to its confluence with the River Tud at Norwich. The river is a naturally enriched, calcareous lowland river. The upper reaches are fed by springs that rise from the chalk and by run-off from calcareous soils rich in plant nutrients. This gives rise to beds of submerged and emergent vegetation characteristic of a chalk stream. Lower down, the chalk is overlain with boulder clay and river gravels, resulting in aquatic plant communities more typical of a slow-flowing river on mixed substrate. Much of the adjacent land is managed for hay crops and by grazing, and the resulting mosaic of meadow and marsh habitats, provides niches for a wide variety of specialised plants and animals.

45. The qualifying features of the River Wensum SAC are summarised in Table 2.2.

[1] http://jncc.defra.gov.uk/ProtectedSites/SACselection/n2kforms/UK0012647.pdf

Table 2.2 River Wensum SAC qualifying features

Qualifying features/reasons for notification
Annex I habitats that are a primary reason for selection of this site: • Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation. Annex II species that are a primary reason for selection of this site: • White-clawed (or Atlantic stream) crayfish *Austropotamobius pallipes.* Annex II species present as a qualifying feature, but not a primary reason for selection of this site: • Desmoulin's whorl snail *Vertigo moulinsiana* • Brook lamprey *Lampetra planeri* • Bullhead *Cottus gobio*

46. The River Wensum SAC conservation objectives are as follows:

47. Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring:

- The extent and distribution of qualifying natural habitats and habitats of qualifying species;
- The structure and function (including typical species) of qualifying natural habitats;
- The structure and function of the habitats of qualifying species;
- The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;
- The populations of qualifying species; and
- The distribution of qualifying species within the site.

2.1.2 Paston Great Barn SAC

48. Paston Great Barn SAC[2] covers approximately 1ha and the only known example of a maternity roost of barbastelle bats *Barbastella barbastellus* in a building. The Barn is a 16th century thatched barn with associated outbuildings. A maternity colony of barbastelles utilises a range of cracks and crevices in the roof timbers for roosting.

49. The qualifying features of the Paston Great Barn SAC are summarised in Table 2.3.

[2] http://jncc.defra.gov.uk/ProtectedSites/SACselection/n2kforms/UK0030235.pdf

Table 2.3 Paston Great Barn SAC qualifying features

Qualifying features/reasons for notification
Annex II species that are a primary reason for selection of this site • Barbastelle

50. Paston Great Barn SAC's conservation objectives are as follows:

51. Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring:

- The extent and distribution of the habitats of qualifying species;
- The structure and function of the habitats qualifying species;
- The supporting processes on which the habitats of the qualifying species rely;
- The populations of qualifying species; and
- The distribution of qualifying species within the site.

2.1.3 Norfolk Valley Fens SAC

52. Norfolk Valley Fens SAC[3] comprises a series of valley-head spring-fed flush fens located throughout Norfolk. The fens collectively represent 616ha of fen habitat at 17 separate sites within the county. Such spring-fed flush fens are very rare in the lowlands. The spring-heads are dominated by the small sedge fen type, mainly referable to black-bog-rush – blunt-flowered rush (*Schoenus nigricans – Juncus subnodulosus*) mire, but there are transitions to reedswamp and other fen and wet grassland types. The individual fens vary in their structure according to intensity of management and provide a wide range of variation. There is a rich flora associated with these fens, including species such as grass-of-Parnassus *Parnassia palustris*, common butterwort *Pinguicula vulgaris*, marsh helleborine *Epipactis palustris* and narrow-leaved marsh-orchid *Dactylorhiza traunsteineri*.

53. The qualifying features of the Norfolk Valley Fens SAC are summarised in Table 2.4.

Table 2.4 Norfolk Valley Fens SAC qualifying features

Qualifying features/reasons for notification
Annex I habitats that are a primary reason for selection of this site: • Alkaline fens Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site: • Northern Atlantic wet heaths with *Erica tetralix* • European dry heaths • Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (*

[3] http://jncc.defra.gov.uk/ProtectedSites/SACselection/n2kforms/UK0012892.pdf

Qualifying features/reasons for notification
important orchid sites) • Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) • Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* (Priority feature) • Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)(priority feature) Annex II species that are a primary reason for selection of this site: • Narrow-mouthed whorl snail *Vertigo angustior* • Desmoulin`s whorl snail *Vertigo moulinsiana*

54. Norfolk Valley Fens SAC's conservation objectives are as follows:

55. Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring:

- The extent and distribution of qualifying natural habitats and habitats of qualifying species;
- The structure and function (including typical species) of qualifying natural habitats;
- The structure and function of the habitats of qualifying species;
- The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;
- The populations of qualifying species; and
- The distribution of qualifying species within the site.

2.1.4 Broadland SPA

56. The Broadland SPA[4] covers approximately 5508ha. Table 2.5 summarises the qualifying features of the Broadland SPA.

Table 2.5 Qualifying features of the Broadland SPA (*population counts are derived from the SPA citation*)

This site qualifies under Article 4.1 of the Directive (79/409/EEC) by supporting populations of European importance of the following species listed on Annex I of the Directive:
Over winter; Bewick's Swan Cygnus *columbianus bewickii*, 495 individuals representing up to 7.1% of the wintering population in Great Britain (5 year peak mean 1987/8-1991/2) Bittern *Botaurus stellaris*, 2-3 individuals representing up to 10-15% of the wintering population in Great Britain (5 year peak mean 1987/8-1991/2) Hen Harrier *Circus cyaneus*, 22 individuals representing up to 3% of the wintering population in Great Britain (5 year peak mean 1987/8-1991/2)

[4] http://jncc.defra.gov.uk/pdf/SPA/UK9009253.pdf

This site qualifies under Article 4.1 of the Directive (79/409/EEC) by supporting populations of European importance of the following species listed on Annex I of the Directive:
Ruff *Philomachus pugnax*, 96 individuals representing up to 6.4% of the wintering population in Great Britain (5 yr peak mean 1987/8-1991/2) Whooper Swan *Cygnus cygnus*, 121 individuals representing up to 2% of the wintering population in Great Britain (5 yr peak mean 1987/8-1991/2) Marsh Harrier *Circus aeruginosus*, 16 individuals representing up to 16% of the wintering population in Great Britain (5 year peak mean 1987/8-1991/2)
This site also qualifies under Article 4.2 of the Directive (79/409/EEC) by supporting populations of European importance of the following migratory species:
Over winter; Gadwall *Anas strepera*, 486 individuals representing up to 4.0% of the wintering Northwestern Europe population (5 yr peak mean 1987/8-1991/2) Shoveler *Anas clypeata*, 675 individuals representing up to 1.7% of the wintering Northwestern Europe population (5 yr peak mean 1987/8-1991/2) Widgeon *Anas penelope*, 8,966 individuals representing up to 1.2% of the wintering Northwestern Europe population (5 yr peak mean 1987/8-1991/2) The following species was also included under the SPA Review (Stroud et al. 2001): Pink-footed Goose *Anser brachyrhynchus*, 3,290 individuals representing up to 1.5% of the wintering Eastern Greenland/Iceland/UK population (5 yr peak mean 1994/5-1998/9)
Under the SPA Review (Stroud et al. 2001), the area also qualifies under Article 4.2 of the Directive (79/409/EEC) by regularly supporting at least 20,000 waterfowl
Over winter, the area regularly supports 22,603 individual waterfowl (RSPB, Count 99/00) including: Cormorant *Phalacrocorax carbo*, Bewick's Swan Cygnus *columbianus bewickii*, Whooper Swan *Cygnus cygnus*, Ruff *Philomachus pugnax*, Pink-footed Goose *Anser brachyrhynchus*, Gadwall *Anas strepera*, Bittern *Botaurus stellaris*, Great Crested Grebe *Podiceps cristatus*, Coot *Fulica atra*, Bean Goose *Anser fabalis*, White-fronted Goose *Anser albifrons albifrons*, Wigeon *Anas penelope*, Teal *Anas crecca*, Pochard *Aythya ferina*, Tufted Duck *Aythya fuligula*, Shoveler *Anas clypeata*.

57. Following consultation with Natural England undertaken in September 2016, Natural England has supplied draft maps of functionally-linked (i.e. supporting) land for pink-footed goose outside of the Broadland SPA boundary (Natural England, pers. comm. 9th September 2016). This information provides additional baseline data on the key areas for this Broadland SPA qualifying species within the scoping area. A copy of these draft maps are provided in Appendix 1.

58. The maps indicate that, based on the 2008/9-2012/3 distribution, the key feeding areas for pink-footed geese within the study area are located in a triangle between the villages of Happisburgh, Bacton and Witton Bridge, towards the east of the study area.

2.1.5 Broadland Ramsar Site

59. The Broadland Ramsar site shares a boundary with the Broadland SPA site and its reasons for designated are provided in Table 2.6.

Table 2.6 Qualifying features of the Broadland Ramsar site (*population counts are derived from the Ramsar Information Sheet*)

Ramsar criterion 6 – species/populations occurring at levels of international importance. Qualifying Species/populations (as identified at designation):
Species with peak counts in winter: Tundra swan, NW Europe 196 individuals, representing an average of 2.4% of the GB population (5 year peak mean 1998/9- 2002/3) Eurasian wigeon, NW Europe 6769 individuals, representing an average of 1.6% of the GB population (5 year peak mean 1998/9-2002/3) Gadwall, NW Europe 545 individuals, representing an average of 3.1% of the GB population (5 year peak mean 1998/9- 2002/3) Northern shoveler, NW & C Europe 247 individuals, representing an average of 1.6% of the GB population (5 year peak mean 1998/9- 2002/3)
Species/populations identified subsequent to designation for possible future consideration under criterion 6.
Species with peak counts in winter: Pink-footed goose, Greenland, Iceland/UK 4263 individuals, representing an average of 1.7% of the population (5 year peak mean 1998/9-2002/3) Greylag goose, *Anser anser anser*, Iceland/UK, Ireland 1007 individuals, representing an average of 1.1% of the population (Source period not collated)

3 BASELINE ENVIRONMENT

3.1 Data sources

60. Desk-based and field survey data has been collected from July 2016 onwards and will be continued to be collected through 2017 in order to inform the EIA process which is being undertaken for the project. The ecological baseline which is generated from this data collection programme will be used to inform the HRA process. The data sources used to inform this HRA screening are summarised in Table 3.1.

61. As field surveys are ongoing, full ecological survey data with respect to the qualifying features of the European and Ramsar sites within 5km of the onshore infrastructure are not available at this time. Where data have already been collected, they are presented in the remainder of this section.

62. All data sources upon which the ecological baseline is based are considered to be compliant with the relevant survey guidance and to provide robust evidence of the ecological receptors present with the study area.

Table 3.1 Data sources

Data source	Date	Data contents	Coverage	Status
Desk study data				
JNCC	July 2016	European designated sites (SPA, SAC, Ramsar sites)	Onshore infrastructure plus a 5km buffer	Data obtained
Norfolk Biodiversity Information Service (NBIS)	July 2016	Protected and notable species records including: • The Conservation of Habitats & Species Regulations 2010 Schedules 2 & 5; • Habitats Directive Annex I, IV & V;	Onshore infrastructure plus a 2km buffer (5km for bats)	Data obtained
NBIS	March 2017	Norfolk 'Living Map' remote sensing habitat mapping data	Onshore infrastructure plus a 50m buffer	Data obtained
Norfolk Barbastelle Study Group (NBSG)	June 2017	Barbastelle *Barbastella barbastellus*: • Radio tracking data for maternity colonies, to show roost locations and home ranges; • Barbastelle roosts (summer and winter), commuting routes (at hedgerow level as far as possible), core foraging areas; • Additional acoustic data for later summer/autumn.	Radiotracking data and other species roost data: Onshore infrastructure plus a 5km buffer	Data obtained
Natural England	August 2016	Sensitivity maps for the following Broadland SPA species from 1986/87 to 2012/13: • Bewick's Swan; • Whooper swan; and • Pink-footed goose	Up to 5km from the Broadland SPA (*NB: records from up to 20km from the Broadland SPA also provided*)	Data obtained
Field survey data				
Extended Phase 1 Habitat Survey	February 2017	An Extended Phase 1 Habitat Survey following 'Extended Phase 1' methodology as set out in *Guidelines for Baseline Ecological Assessment* (Institute of Environmental Assessment, 1995). Habitats were classified and mapped following JNCC's *Handbook for Phase 1 habitat survey: A technique for environmental audit* (2010). Included a search for:	Great crested newts: Onshore infrastructure plus 250m buffer (temporary works) and 500m buffer (permanent works)	Full survey results available

Data source	Date	Data contents	Coverage	Status
		• Assessment of roost suitable of trees and structures for bats; • Assessment of commuting / foraging suitability of all linear features for bats; • Assessment of suitability of habitats to notable invertebrates.	All other habitats and species: Onshore infrastructure plus a 50m buffer) Coverage of approx. 50% of survey area.	
Bat Emergence / Re-entry Surveys	April - October 2017 (in progress)	Bat emergence / re-entry surveys of all trees and structures identified during the Extended Phase 1 Habitat Survey as providing moderate or high suitability to support roosting bats.	Onshore infrastructure plus a 50m buffer	Survey ongoing. No results available yet.
Bat Activity Surveys	May - August 2017 (in progress)	Bat activity surveys of all linear features (hedgerows, watercourses scrub patches and woodland edges, coastline) identified during the Extended Phase 1 Habitat Survey as providing moderate or high suitability to support commuting or foraging bats.	Onshore infrastructure plus a 50m buffer	Survey ongoing. No results available yet.
Aquatic Invertebrate Survey	July 2017 (in progress)	A survey for the Desmoulin's whorl snail within floodplain habitats adjacent to the River Wensum.	Floodplain habitats of the River Wensum	Survey ongoing. No results available yet.
Botanical National Vegetation Classification (NVC) Survey	July 2017 (in progress)	A NVC survey searching for the qualifying flora species (Stream water-crowfoot *R. penicillatus ssp. Pseudofluitans*, thread-leaved water-crowfoot *R. trichophyllus* and fan-leaved water-crowfoot *R. circinatus*) of the River Wensum SAC.	Floodplain habitats of the River Wensum	Survey ongoing. No results available yet.
Wintering bird surveys	June 2017	A survey of ex situ habitats of the Broadland SPA, and of those SSSI within 1km of the cable route which support wintering bird interest features. This includes surveys of the following areas: • Agricultural fields in North Walsham District; • Dereham Rush Meadows SSSI;	Habitats within 300m of the onshore infrastructure and 5km of the Broadland SPA; SSSI within 300m of the	Full survey results available

Data source	Date	Data contents	Coverage	Status
		• Hundred Stream; and • North Norfolk Coast between Eccles-on-Sea and Paston.	onshore infrastructure.	

3.2 Desk study data

3.2.1 Barbastelle

63. Approximately 4km of the onshore cable corridor is within the known home ranges of the Paston Great Barn barbastelle home ranges, based on NSBG radio-tracking data. Within this 4km, the following areas have been identified by NSBG as core foraging areas:

- Dilham Canal;
- Hedgerows along North Walsham Road from Edingthorpe Green to Edingthorpe Heath;
- Witton Hall Plantation along Old Hall Road;
- Road from Bacton Wood to Witton;
- Two hedgerows between Witton and North Walsham Road; and
- Drains and hedgerows at Ridlington Street.

64. The location of these core foraging areas are shown in Appendix 2.

3.2.2 Bewick's Swan, whooper swan and pink-footed goose sensitivity maps

65. Natural England has supplied draft maps of functionally-linked (i.e. supporting) land for pink-footed goose outside of the Broadland SPA boundary (up to 5km from the site boundary) (Natural England, pers. comm. 9th September 2016). This information provides additional baseline data on the key areas for this Broadland SPA qualifying species within the onshore infrastructure area. These maps are provided in Appendix 1.

66. The maps indicate that, based on the 2008/9-2012/3 distribution, the key feeding areas for pink-footed geese within the study area are located in a triangle between the villages of Happisburgh, Bacton and Witton Bridge, towards the east of the study area.

3.2.3 White-clawed crayfish, bullhead, brook lamprey

67. NBIS holds no records for white-clawed crayfish, bullhead, brook lamprey within 2km of the study area. Advice received from the Environment Agency indicated that white-clawed crayfish are not known to be present in any reaches located within the study area (Environment Agency, pers. comm. 24th March 2017).

3.3 Field survey data

3.3.1 Wintering / passage bird surveys

68. A desk-based scoping exercise was undertaken in August 2016 to identify those habitats which may support wintering / passage bird species associated with statutory designated sites for nature conservation (Onshore Winter / Passage Bird Survey Scoping Report. Document Reference: PB4476-003-024 (Royal HaskoningDHV 2016b)). This assessment identified both in situ and ex situ habitats that have the potential to support the ornithological interest features of all internationally designated sites within 5km of the project scoping area. As such a suite of wintering birds surveys focussing on these habitats and areas, in order to describe the nature of the ornithological resource at these habitats, were recommended, the scope and methodology of which was agreed with Norfolk County Council and Natural England in August 2016 and February 2017 (Natural England, pers. comm. 9th September 2016; Natural England, pers. comm. 5th September 2016; Natural England, pers. comm. 21st February 2017). The results of these surveys are summarised here, are presented in full in Appendix 23.2 of Chapter 23 Onshore Ornithology.

69. Following the ongoing site selection process for the project, the scoping area was revised into an onshore infrastructure area in December 2016. Following this, the scope of the planned wintering bird surveys were revised to only include those habitats with the potential to support the ornithological interest features of the internationally designated sites within 5km of the revised onshore infrastructure area. Therefore data for the full survey period, October – March, was collected for the following habitats:

- Agricultural land within 5km of the Broadland SPA and Ramsar site, and also within – or within a precautionary 1km disturbance buffer of – the onshore infrastructure;
- Coastal habitats within 5km of the Broadland SPA and Ramsar site, and also within – or within a precautionary 1km disturbance buffer of – the onshore infrastructure; and
- Lowland fen, rivers and lakes and lowland heathland habitats of the Hundred Stream within 5km of the Broadland SPA and Ramsar site, and also within – or within a precautionary 1km disturbance buffer of – the onshore infrastructure.

70. The findings of the wintering bird surveys of these habitats is summarised in the following section.

3.3.1.1 Agricultural fields in North Walsham District

71. All agricultural habitats (i.e. pasture and arable) within 5km of the Broadland SPA and Ramsar site were surveyed for their potential to support wintering populations of qualifying features of the Broadland SPA. These habitat areas were identified by the Onshore Wintering / Passage Bird Survey Scoping Report, and are shown on Figure 22.3.

Table 3.2 Agricultural fields in North Walsham District: Peak count of waterbird species across six visits (*peak counts in yellow*)

Importance	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6
Golden plover	-	-	-	-	-	120
Lapwing	-	-	-	-	-	197
Black-headed gull	-	-	-	-	28	192
Common gull	-	-	-	-	23	74

72. The recorded waterbird counts are considered to not be of a scale of national or greater importance or to be a significant component of the Broadland SPA.

73. Flocks of pink-footed geese were observed in flight during the surveys, but no evidence to confirm their roosting, foraging or loafing was noted within the study area. The peak size of these mobile flocks was approximately 2,000 individuals.

3.3.1.2 Hundred Stream

74. Reedbed, Lowland fen, Rivers and Lakes and Lowland heathland within 5km of the Broadland SPA and Ramsar site were surveyed for their potential to support wintering populations of qualifying features of the Broadland SPA. These habitat areas were identified along the Hundred Stream by the Onshore Wintering / Passage Bird Survey Scoping Report, and are shown on Figure 22.4.

Table 3.3 Habitats along the Hundred Stream: peak count of waterbird species across six visits

Species	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6
Pink-footed Goose	-	-	75	-	-	-
Mallard	-	2	-	4	-	3
Black-headed Gull	-	-	47	1	4	2

75. Flocks of pink-footed geese were observed in flight during the surveys, but no evidence of them roosting, foraging or loafing was noted.

76. The recorded waterbird counts are considered to not be of a scale of national or greater importance or to be a significant component of the Broadland SPA.

North Norfolk Coast between Eccles-on-Sea and Paston

77. Coastal habitats within 5km of the Broadland SPA and Ramsar site were surveyed for their potential to support wintering populations of qualifying features of the Broadland SPA. These habitats areas were identified along the coast between Eccles-on-Sea and Paston by the Onshore Wintering / Passage Bird Survey Scoping Report, and are shown on Figure 22.4.

Table 3.4 North Norfolk Coast between Eccles-on-Sea and Paston: peak count of waterbird species across six visits

Species	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6
Red-throated Diver	5	11	3	16	14	17
Black-throated Diver	-	-	1	1	2	-
Great Northern Diver	-	-	-	1	-	-
Great Crested Grebe	-	1	-	-	-	-
Cormorant	15	-	-	-	-	6
Gannet	2	1	-	2	7	70
Dark-bellied Brent Goose	4	-	1	-	-	-
Wigeon	-	-	11	-	-	-
Teal	14	-	-	-	-	-
Mallard	-	2	4	-	-	-
Shoveler	-	-	1	-	-	-
Eider	-	11	-	-	-	-
Common Scoter	14	53	-	3	15	-
Goldeneye	4	-	-	-	-	-
Red-breasted Merganser	-	4	-	-	-	-
Kestrel	-	1	-	-	-	-
Oystercatcher	-	-	-	2	-	3
Ringed Plover	-	8	12	1	5	3
Sanderling	-	7	2	3	2	-
Dunlin	-	2	-	-	-	-
Purple Sandpiper	-	1	-	-	-	-
Turnstone	30	38	26	26	29	49
Mediterranean Gull	1	2	2	1	2	2
Little Gull	-	-	-	1	-	-
Black-headed Gull	1,479	1,269	3,530	189	143	664
Common Gull	256	500	1,106	26	54	207
Lesser Black-backed Gull	4	7	1	1	2	3
Herring Gull	150	355	172	125	110	218
Great Black-backed Gull	110	568	79	41	16	47
Glaucous Gull	-	-	-	-	2	-
Kittiwake	-	-	-	-	-	8
Guillemot	10	7	16	20	10	1
Razorbill	-	2	2	2	2	-
Puffin	-	-	-	1	-	-
Auk sp.	1	-	-	1	-	-
Great Skua	1	2	-	-	-	1

Species	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6
Kingfisher	-	2	-	-	-	-
Carrion Crow	13	3	11	8	8	8
Jackdaw	8	-	1	-	-	-
Pied Wagtail	1	2	8	5	2	11
Meadow Pipit	-	2	3	-	-	3
Rock Pipit	-	-	-	-	-	2
Wren	-	-	1	-	-	-
Stonechat	-	1	-	-	-	-
Black Redstart	1	-	-	-	-	-
Starling	-	42	8	16	27	48
Snow Bunting	1	7	-	-	-	-
House Sparrow	-	-	1	-	-	1

78. The recorded waterbird counts are considered not to be of a scale of national or greater importance or to be a significant component of the Broadland.

3.3.2 Extended Phase 1 Habitats Survey

79. The Extended Phase 1 Habitat Survey conducted in February 2017 identified habitats and protected species potential within the onshore infrastructure. The full results of the Extended Phase 1 Habitat Survey are presented in Appendix 22.5 of Chapter 22 Onshore Ecology.

80. Figure 22.5 shows those habitats recorded within 5km of the designated sites which have been screened in for further assessment.

3.3.2.1 Bats

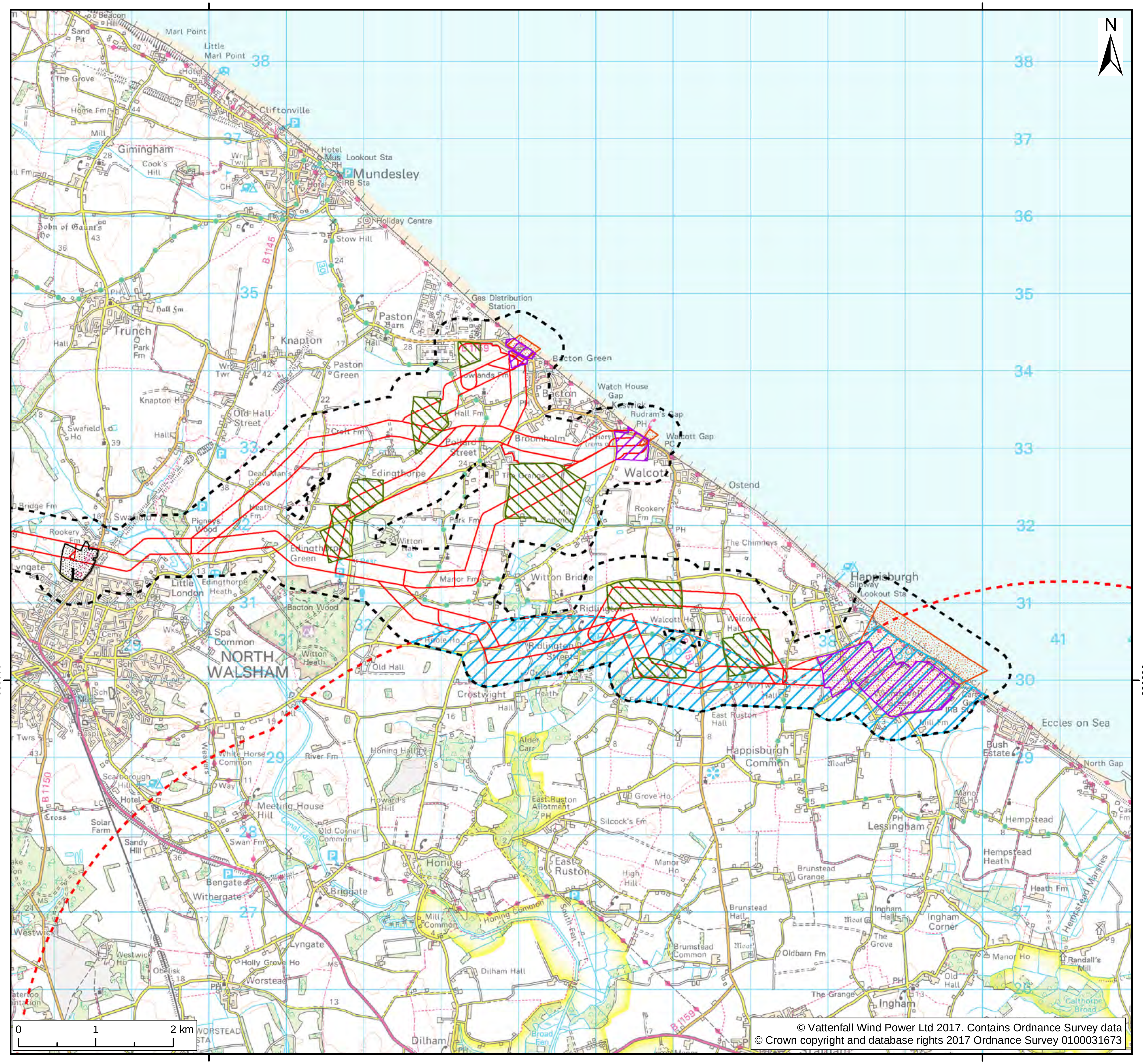
81. All trees and structures (a total of 358 features) noted during the Extended Phase 1 Habitat Survey were assessed from the ground using binoculars (following the Bat Conservation Trust's (BCT) guidance (2016)) for their suitability to support roosting bats. Of these 358 features, 300 were assessed as providing low suitability for roosting bats, 52 as having moderate suitability and 1 as having high suitability. The locations of these commuting and foraging features are shown on Figure 22.5. As emergence / re-entry surveys are not yet completed, more detailed information regarding the roosting bat resource is not yet known.

82. In addition to trees and structures, all linear features (e.g. watercourses, hedgerows) were categorised in terms of their suitability to support commuting or foraging bats following BCT guidance (2016). This categorisation was based on the habitat type and their connection to the surrounding habitat. The categorisation used was:

- Defunct hedgerows and field drains typically provided low suitability for commuting and foraging bats;

- Intact species-rich hedgerows, areas of scrub and small watercourses typically provided moderate suitability for commuting and foraging bats; and
- Species-rich hedgerows with trees and large watercourses well connected to the wider landscape typically provided moderate suitability for commuting and foraging bats.

83. In total, 266 linear features were assessed for their suitability to support commuting or foraging bats. Of these, 99 were assessed as providing low suitability to support commuting or foraging bats, 78 as providing moderate suitability and 89 as providing high suitability. The locations of these commuting and foraging features are shown on Figure 22.5.



Legend:

Norfolk Vanguard Onshore Infrastructure

- Landfall Zone
- Cable Relay Station Search Zone
- Onshore Cable Corridor
- Horizontal Directional Drilling (HDD) Zone
- Mobilisation Zone
- Study area
- Broadland SPA 5km Study Area
- Land subject to road transect survey

Project:	Report:
Norfolk Vanguard	Preliminary Environmental Information Report

Title:

Agricultural habitats within 5km of the Broadland SPA and Ramsar site

Figure: 22.3 Drawing No: PB4476-004-02206-003

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	15/09/2017	NJ	GC	A3	1:50,000
02	19/09/2017	NJ	GC	A3	1:50,000

Co-ordinate system: British National Grid **EPSG:** 27700

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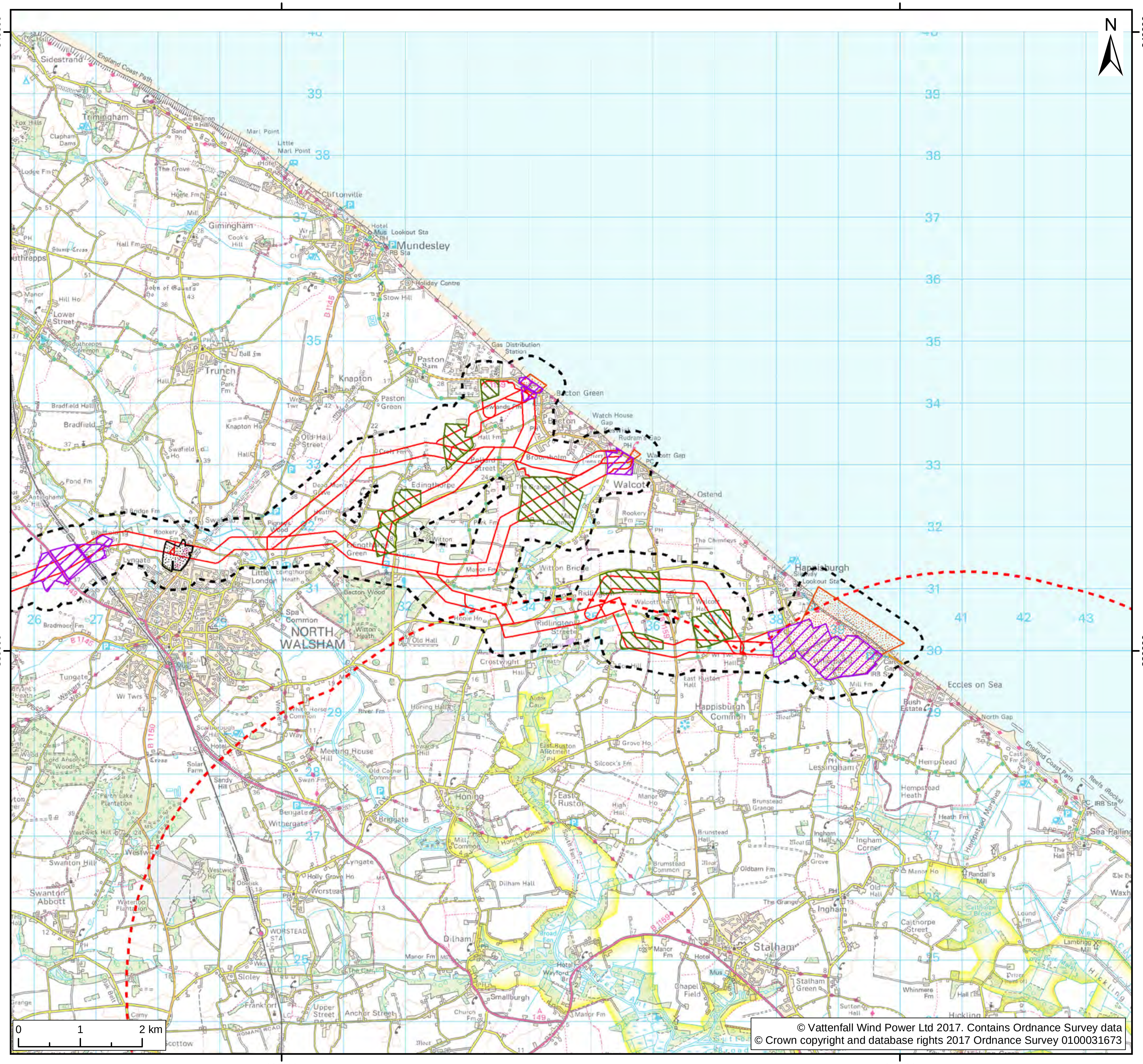

Legend:

Norfolk Vanguard Onshore Infrastructure

- Landfall Zone
- Cable Relay Station Search Zone
- Onshore Cable Corridor
- Horizontal Directional Drilling (HDD) Zone
- Mobilisation Zone
- Study area
- Broadland SPA 5km Study Area

UK Habitats of Principal Importance[1]

- Coastal sand dunes
- Lowland heathland

[1] Natural England, 2016.

Project:	Report:
Norfolk Vanguard	Preliminary Environmental Information Report

Title:

Coastal and Wetland habitats within 5km of the Broadland SPA and Ramsar site

Figure: 22.4 | Drawing No: PB4476-004-02206-004

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	15/09/2017	NJ	GC	A3	1:62,500
02	19/09/2017	NJ	GC	A3	1:62,500

Co-ordinate system: British National Grid **EPSG:** 27700

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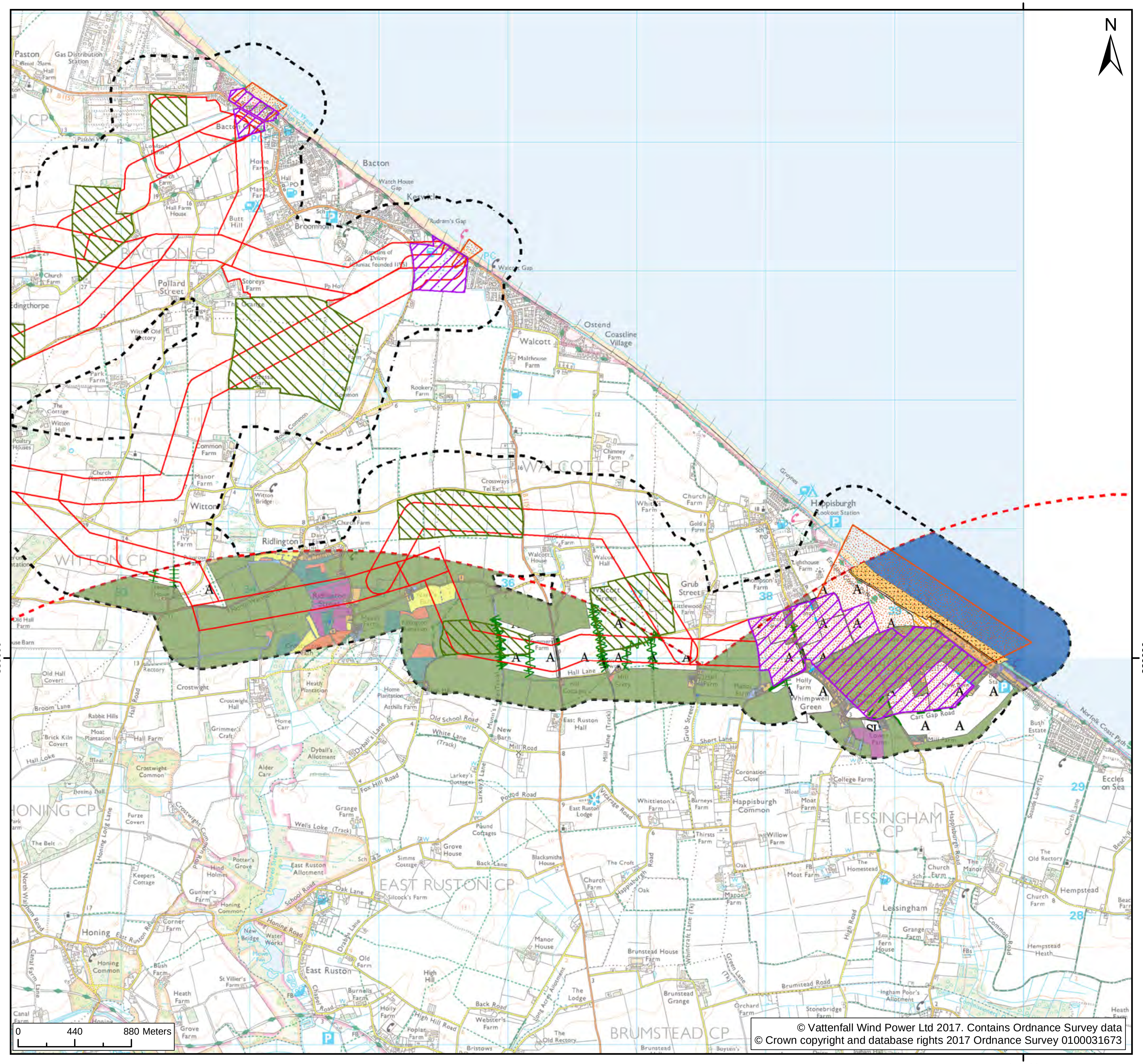

Legend:

Norfolk Vanguard Onshore Infrastructure
- Landfall Zone
- Cable Relay Station Search Zone
- Onshore Cable Corridor
- Horizontal Directional Drilling (HDD) Zone
- Study area
- Broadland SPA 5km Study Area

Norfolk Living Map[1]
- Arable
- Beach
- Coastal Sand Dunes
- Coastal Sediment
- Dune Grassland
- Gardens
- Hedgerow or Field Margin
- Improved Grassland
- Lowland Mixed Deciduous Woodland
- Maritime Cliff and Slopes
- Scrub
- Semi-improved (poor condition)
- Semi-improved grassland
- Urban
- Waterbodies

Phase 1 Habitat Classification
- Scrub - dense/continuous
- Scrub - scattered
- Improved grassland
- Poor semi-improved grassland
- Intertidal - mud/sand
- Dune grassland
- Coastal grassland
- Cultivated/disturbed land - arable
- Cultivated/disturbed land - amenity grassland
- Buildings
- Bare ground
- Intact hedge - Native species-rich
- Intact hedge - Species-poor
- Defunct hedge - Native species-rich
- Defunct hedge - Species-poor
- Hedge with trees - Native species-rich
- Hedge with trees - Species-poor
- Fence
- Dry ditch

[1] Natural England, 2016.

Project: Norfolk Vanguard

Report: Preliminary Environmental Information Report

Title: Habitats within 5km of the Broadland SPA and Ramsar site

Figure: 22.5 Drawing No: PB4476-004-02206-005

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	18/09/2017	NJ	GC	A3	1:30,000
02	19/09/2017	NJ	GC	A3	1:30,000

Co-ordinate system: British National Grid **EPSG:** 27700

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4 SCREENING ASSESSMENT

4.1 Introduction

84. This section presents the screening for LSE (Stage 1 of the HRA process). The qualifying features of each European or Ramsar site is considered against the ZOI of the different environmental parameters to determine whether an LSE may occur. Where the ZOI overlaps with either (i) the European or Ramsar site boundary or (ii) the ex-situ habitats associated with the European or Ramsar site, it will be noted that a LSE may occur and further assessment at the AA stage of the HRA process (Stage 2) will be required for that qualifying feature. Where no pathway to LSE is identified, it will be recommended that potential LSE upon that qualifying feature will not be considered further. If there is any uncertainty as to whether or not a LSE could arise, the precautionary principle has been applied and LSE concluded to ensure that the potential implications for the site are assessed further at the AA stage.

85. Potential effects upon each European or Ramsar site have been considered in the following four categories:

- **Direct effects within the site boundary** (i.e. onshore infrastructure located within the site boundary);
- **Direct effects on ex-situ habitats of site** (i.e. onshore infrastructure located within habitats located outside the site boundary but which have the potential to support its interest features);
- **Indirect effects within the site boundary** (i.e. the site boundary falls within the ZOI of an environmental parameter associated with the onshore infrastructure); and
- **Indirect effects on ex-situ habitats of site** (i.e. habitats located outside the site boundary but which have the potential to support its interest features falls within the ZOI of an environmental parameter associated with the onshore infrastructure).

4.2 River Wensum SAC

86. The River Wensum supports the following qualifying features:

- Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation;
- White-clawed (or Atlantic stream) crayfish;
- Desmoulin’s whorl snail;
- Brook lamprey; and
- Bullhead.

87. In the absence of more detailed information being available as to the location of these features, it has been assumed that they are present throughout the River Wensum SAC.

4.2.1 Direct effects within SAC boundary

88. The River Wensum is located within the onshore project area. The onshore cable corridor crosses the River Wensum at Elsing. As part of the embedded mitigation for the project, a trenchless technique (e.g. HDD) will be used when crossing the River Wensum. This technique will ensure that there are no direct effects upon any of the qualifying features of the SAC within the site boundary, and therefore potential direct effects upon the SAC boundary are **screened out** from any further assessment.

4.2.2 Direct effects upon ex-situ habitats

89. The following interest features of the River Wensum may also be present in habitats functionally connected to the River Wensum, including coastal floodplain and grazing marsh habitat:

- *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation; and
- Desmoulin's whorl snail.

90. The HDD activities required for the project will involve activities located within coastal floodplain grazing marsh adjacent to the River Wensum at Elsing. In light of this, there is the potential for direct effects upon these qualifying features to occur, and therefore these potential effects been **screened in** for further assessment.

91. The ditches present within the coastal and floodplain grazing marsh habitats were assessed during the Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017) as being sub-optimal habitat for white-clawed crayfish and freshwater fish species. These ditches are separated from the River Wensum by water control structures and are static water bodies with silty beds, and do not possess suitable gravel beds for spawning. Consequently these habitats do not provide a suitable habitat for the remaining qualifying features of the River Wensum SAC, specifically:

- White-clawed (or Atlantic stream) crayfish;
- Brook lamprey; and
- Bullhead.

92. As such, potential effects upon these qualifying features have been **screened out** of further assessment.

4.2.3 Indirect effects within SAC boundary

93. Table 4.1 summarises the potential indirect effects upon the qualifying features of the River Wensum SAC.

Table 4.1 The ZOI of potential indirect effects on the River Wensum SAC boundary

Environmental parameter	Zone of influence of potential effect
Noise	The qualifying features of the River Wensum SAC are not sensitive to noise, visual, air quality or light disturbance, so indirect effects upon these qualifying features will not occur and these effects have been **screened out** of further assessment.
Air quality	
Light	
Visual disturbance	
Geology and land contamination	The HDD activities will involve construction activities within 500m of the River Wensum SAC. This will include HDD beneath the River Wensum SAC, excavation at HDD receptor sites and cable trenching within the River Wensum floodplain. As a consequence, potential indirect effects arising as a result of land contamination encountered during construction have been **screened in** for further assessment.
Groundwater and Hydrology	HDD activities will involve construction activities within 1km of the River Wensum SAC. This will include HDD beneath the River Wensum SAC, excavation at HDD receptor sites and cable trenching within the River Wensum floodplain. As a consequence, potential indirect effects arising as a result of changes to the groundwater / hydrology regime have been **screened in** for further assessment.

4.2.4 Indirect effects on ex-situ habitats

94. Table 4.2 summarises the potential indirect effects upon the qualifying features of the River Wensum SAC.

Table 4.2 The ZOI of potential indirect effects on the River Wensum SAC ex-situ habitats

Environmental parameter	Zone of influence of potential effect
Noise	The qualifying features of the River Wensum SAC are not sensitive to noise, visual, air quality or light disturbance, so indirect effects upon these qualifying features will not occur and these effects have been **screened out** of further assessment.
Air quality	
Light	
Visual disturbance	
Geology and land contamination	HDD activities will involve construction activities within 500m of the coastal floodplain grazing marsh ex-situ habitats of the River Wensum SAC. This will include excavation at HDD receptor sites and cable trenching within 500m of the River Wensum floodplain. As a consequence, potential indirect effects arising as a result of land contamination encountered during construction have been **screened in** for further assessment.
Groundwater and Hydrology	HDD activities will involve construction activities within 1km of the coastal floodplain grazing marsh ex-situ habitats of the River Wensum SAC. This will include excavation at HDD receptor sites and cable trenching within 500m of the River Wensum floodplain. As a consequence, potential indirect effects arising as a result of changes to the groundwater / hydrology regime have been **screened in** for

Environmental parameter	Zone of influence of potential effect
	further assessment.

4.3 Paston Great Barn SAC

95. Paston Great Barn supports a colony of Barbastelle bats.

4.3.1 Direct effects within the SAC boundary

96. Paston Great Barn is located 2.9km from on onshore infrastructure. Therefore direct effects upon the boundary are **screened out** from further assessment.

4.3.2 Direct effects on ex-situ habitats

97. Six areas within the onshore infrastructure are known to be core foraging areas for the barbastelle colony at Paston Great Barn. As these habitats will be directly affected by the project construction and operation phases, potential impacts on ex situ habitats have been **screened in** for further assessment.

4.3.3 Indirect effects within the SAC boundary

98. Paston Great Barn is located 2.9km from on onshore infrastructure. This is outside of the ZOI of any of the environmental parameters associated with the construction and operation of the project. Therefore direct effects upon the boundary are **screened out** from further assessment.

4.3.4 Indirect effects on ex-situ habitats

99. Table 4.3 summarises the potential indirect effects upon the qualifying features of the Paston Great Barn SAC.

Table 4.3 The ZOI of potential indirect effects on the Paston Great Barn SAC boundary

Environmental parameter	Zone of influence of potential effect
Noise	The qualifying features of the Paston Great Barn SAC are not sensitive to noise, visual or air quality disturbance, so indirect effects upon these qualifying features will not occur and these effects have been **screened out** of further assessment.
Air quality	
Visual disturbance	
Light	There are hedgerows which are identified barbastelle core foraging areas located within the ZOI of the onshore infrastructure, therefore lighting has been **screened in** for further assessment.
Geology and land contamination	Barbastelle bats are associated with hedgerow, scrub, woodland and watercourse habitats which will not be affected by changes to the geology or land contamination regime. Therefore these effects have been **screened out** of further assessment.
Groundwater and	Watercourses identified as core foraging areas for the Paston Great Barn barbastelle colony (i.e. drains at Ridlington Street) will be subject to trenching works during the

Environmental parameter	Zone of influence of potential effect
Hydrology	project construction phase, and as such there may be effects upon this ex-situ habitat. These effects have been **screened in** for further assessment.

4.4 Norfolk Valley Fens SAC

100. The Norfolk Valley Fens support the following qualifying features:

- Alkaline fens;
- Northern Atlantic wet heaths with *Erica tetralix;*
- European dry heaths;
- Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*);
- Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*);
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae;*
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*);
- Narrow-mouthed whorl snail; and
- Desmoulin`s whorl snail.

101. The Norfolk Valley Fens are comprised of a 17 separate sites, spread across more than 70km of the county. The qualifying features of the SAC have not been recorded at every site.

102. Five of the 17 sites of the Norfolk Valley Fens falls within 5km of the onshore infrastructure, but only one of these is located within 1km, the maximum extent of the ZOIs identified in section 1.6. This is site is Booton Common, also a Site of Special Scientific Interest (SSSI). Following a review of the SSSI citation and accompanying condition assessment, the qualifying features that are present at this site include:

- Alkaline fens;
- Northern Atlantic wet heaths with *Erica tetralix;* and
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*.

103. The screening assessment in this section will consider possible effects on these qualifying features only.

4.4.1 Direct effects within the SAC boundary

104. All sites which comprise Norfolk Valley Fens are located 570m or more from on onshore infrastructure. Therefore direct effects upon the boundary are **screened out** from further assessment.

4.4.2 Direct effects on ex-situ habitats

105. The relevant qualifying features of the Norfolk Valley Fens SAC are all habitats and not mobile species. As such, ex-situ habitats have not been identified for this site. Direct effects upon ex-situ habitats are **screened out** from further assessment.

4.4.3 Indirect effects within the SAC boundary

106. Table 4.4 summarises the potential indirect effects upon the qualifying features of the Norfolk Valley Fens SAC.

Table 4.4 The ZOI of potential indirect effects on the Norfolk Valley Fens SAC boundary

Environmental parameter	Zone of influence of potential effect
Noise	The qualifying features of the Norfolk Valley Fens SAC are not sensitive to noise, visual, or light disturbance, so indirect effects upon these qualifying features will not occur and these effects have been **screened out** of further assessment.
Light	
Visual disturbance	
Air quality	Potential nitrogen and acid sensitive habitats (Alkaline fens, Northern Atlantic wet heaths with *Erica tetralix*, Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*) are located within 1km of the onshore infrastructure. Therefore potential effects upon these sensitive habitats have been **screened in** for further assessment.
Geology and land contamination	The onshore infrastructure is located outside of 500m from the SAC boundary and outside the ZOI for geology and land contamination effects. As such effects from these environmental parameters have been **screened out** of further assessment.
Groundwater and Hydrology	Cable trenching will take place within 1km of the Norfolk Valley Fens SAC. As a consequence, potential indirect effects arising as a result of changes to the groundwater / hydrology regime have been **screened in** for further assessment.

4.4.4 Indirect effects on ex-situ habitats

107. The relevant qualifying features of the Norfolk Valley Fens SAC are all habitat types and not mobile species. As such, ex-situ habitats have not been identified for this site. Indirect effects upon ex-situ habitats are **screened out** from further assessment.

4.5 Broadland SPA

108. The Broadland SPA support the following qualifying features over winter:

- Bewick's Swan;
- Bittern;
- Hen Harrier;
- Ruff;
- Whooper Swan;
- Gadwall;

- Shoveler;
- Widgeon;
- Pink-footed Goose; and
- A waterfowl assemblage, including:
    - Cormorant, Bewick's Swan, Whooper Swan, Ruff, Pink-footed Goose, Gadwall, Bittern, Great Crested Grebe, Coot, Bean Goose, White-fronted Goose, Wigeon, Teal, Pochard, Tufted Duck.

4.5.1 Direct effects within the SPA boundary

109. All sites which comprise the Broadland SPA are located 3.6km or more from on onshore infrastructure. Therefore direct effects upon the boundary are **screened out** from further assessment.

4.5.2 Direct effects on ex-situ habitats

110. The wintering qualifying features of the Broadland SPA are likely to utilise a range of supporting habitats outside the boundary of the SPA over the winter months. Hen Harrier are likely to utilise a range of habitats, including lowland farmland, heathland, coastal marshes, fenland and river, whereas bittern are associated solely with lowland fen during winter. The various qualifying species of wildfowl use predominantly reedbeds and rivers and lakes, although the qualifying geese species also rely on winter crop waste associated with arable agriculture. Cormorants and grebes are more firmly associated with coastal habitats or sizeable inland waterbodies over winter.

111. In summary, the qualifying species are likely to use the following supporting habitats:

- Reedbed;
- Lowland fen;
- Rivers and Lakes;
- Lowland heathland;
- Coastal habitats; and
- Farmland (pasture and arable).

112. The locations of these habitats within 5km of the Broadland SPA are shown in Figure 22.3 and Figure 22.4. It should be noted that in particular the geese and swan species may travel up to 10km to forage over winter, however the main focus of foraging is likely to be at distances closer to the SPA. Therefore 5km is considered a reasonable study area. This study area was agreed with Natural England in September 2016 (Natural England pers. comm. 9th September 2016).

113. Wintering bird surveys of these ex-situ habitats were undertaken over six months between October 2016 and March 2017, as set out in section 3 and presented in full in Appendix 23.2 of Chapter 23 Onshore Ornithology. These surveys recorded waterbird counts that are considered to not be of a scale of national or greater importance or to be a significant component of the Broadland SPA. As a consequence, these ex-situ habitats are not considered to be important habitats for the qualifying features of the Broadland SPA, and potential effects upon these habitats are **screened out** from further assessment.

4.5.3 Indirect effects within the SPA boundary

114. The Broadland SPA is located 3.6km from on onshore infrastructure. This is outside of the ZOI of any of the environmental parameters associated with the construction and operation of the project. Therefore direct effects upon the boundary are **screened out** from further assessment.

4.5.4 Indirect effects on ex-situ habitats

115. As set out in section 4.5.2 above, qualifying features of the Broadland SPA have not been recorded within ex-situ habitats within 5km of the Broadland SPA and as such potential effects upon these habitats are **screened out** from further assessment.

4.6 Broadland Ramsar site

116. The Broadland Ramsar site supports the following qualifying features over winter:

- Tundra swan;
- Eurasian wigeon;
- Gadwall;
- Northern shoveler;
- Pink-footed goose; and
- Greylag goose.

4.6.1 Direct effects within the Ramsar site boundary

117. All sites which comprise the Broadland Ramsar site are located 3.6km or more from on onshore infrastructure. Therefore direct effects upon the boundary are **screened out** from further assessment.

4.6.2 Direct effects on ex-situ habitats

118. The wintering qualifying features of the Broadland Ramsar site are likely to utilise a range of supporting habitats outside the boundary of the Ramsar site over the winter. The various qualifying species use predominantly reedbeds and rivers and

lakes, although the qualifying geese species also rely on winter crop waste associated with arable agriculture.

119. In summary, the qualifying species are likely to use the following supporting habitats:

- Reedbed;
- Lowland fen;
- Rivers and Lakes; and
- Farmland (pasture and arable).

120. The locations of these habitats within 5km of the Broadland Ramsar site are shown in Figure 22.3 and Figure 22.4.

121. Wintering bird surveys of these ex-situ habitats were undertaken over six months between October 2016 and March 2017, as set out in section 3 and presented in full in Appendix 23.2 of Chapter 23 Onshore Ornithology. These surveys recorded waterbird counts that are considered to not be of a scale of national or greater importance or to be a significant component of the Broadland Ramsar site. As a consequence, these ex-situ habitats are not considered to be important habitats for the qualifying features of the Broadland Ramsar site, and potential effects upon these habitats are **screened out** from further assessment.

4.6.3 Indirect effects within the Ramsar site boundary

122. The Broadland Ramsar site is located 3.6km from on onshore infrastructure. This is outside of the ZOI of any of the environmental parameters associated with the construction and operation of the project. Therefore direct effects upon the boundary are **screened out** from further assessment.

4.6.4 Indirect effects on ex-situ habitats

123. As set out in section 4.5.2 above, qualifying features of the Broadland Ramsar site have not been recorded within ex-situ habitats within 5km of the Broadland Ramsar site and as such potential effects upon these habitats are **screened out** from further assessment.

5 SUMMARY

124. Following the initial screening process, three sites will be considered further at Stage 2 within the HRA process to determine whether any LSE may occur. These are:

- River Wensum SAC;
- Norfolk Valley Fens SAC; and
- Paston Great Barn SAC.

125. The Broadland SPA and Ramsar site has been screened out from further assessment.

126. Table 5.1 provides a summary of the HRA screening assessment that has been presented in section 4. Those potential effects which have been screened in for further assessment, and those which have been screened out, are summarised and the list of sites screened in for further assessment is also presented.

Table 5.1 Screening summary

Site name	Potential effects screened in	Potential effects screened out	Site screened in for further assessment?
River Wensum SAC	• Direct effects on ex-situ habitats for *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation and Desmoulin's whorl snail qualifying features due to suitable ex-situ habitats for these features being present. • Indirect effects within SAC boundary arising from geology / contamination and groundwater / hydrology effects due to lying within the ZOI for these parameters. • Indirect effects upon ex-situ habitats arising from geology / contamination and groundwater / hydrology effects due to lying within the ZOI for these parameters.	• Direct effects within SAC boundary due to distance from onshore infrastructure. • Direct effects on ex-situ habitats for white-clawed (or Atlantic stream) crayfish, brook lamprey and bullhead qualifying features due to no suitable ex-situ habitats for these features being present. • Indirect effects within SAC boundary arising from noise, air quality, visual or light effects due to no pathway being present. • Indirect effects upon ex-situ habitats arising from noise, air quality, visual or light effects due to no pathway being present.	Yes
Paston Great Barn SAC	• Direct effects upon ex-situ habitats due to known ex-situ habitats of barbastelle (hedgerows / watercourses) being present within the onshore infrastructure. • Indirect effects upon ex-situ habitats arising from light and groundwater/hydrology effects due to lying within the ZOI for these parameters.	• Direct effects within SAC boundary due to distance from onshore infrastructure. • Indirect effects within SAC boundary due to lying outside the ZOI or due to no pathway being present. • Indirect effects upon ex-situ habitats arising from noise, air quality, visual, or geology / contamination effects due to lying outside the ZOI or due to no pathway being present.	Yes
Norfolk Valley Fens SAC	• Indirect effects within SAC boundary arising from air quality and groundwater/hydrology due to lying within the ZOI for these parameters. [Effects on Alkaline fens, Northern Atlantic wet heaths with *Erica tetralix* and Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* only screened in]	• Direct effects within SAC boundary due to distance from onshore infrastructure. • Direct effects upon ex-situ habitats due to no mobile qualifying features present. • Indirect effects within SAC boundary arising from noise, light, visual, or geology / contamination effects due to lying outside the ZOI or due to no pathway being present. • Indirect effects upon ex-situ habitats due to no	Yes

Site name	Potential effects screened in	Potential effects screened out	Site screened in for further assessment?
		mobile qualifying features present.	
Broadland SPA	None	• Direct effects within SPA boundary due to distance from onshore infrastructure • Direct effects upon ex-situ habitats due to survey evidence indicating that qualifying features are not present in significant numbers within the ex-situ habitats. • Indirect effects within SPA boundary due to distance from onshore infrastructure (outside of ZOIs) • Indirect effects upon ex-situ habitats due to survey evidence indicating that qualifying features are not present in significant numbers within the ex-situ habitats.	No
Broadland Ramsar site	None	• Direct effects within Ramsar site boundary due to distance from onshore infrastructure • Direct effects upon ex-situ habitats due to survey evidence indicating that qualifying features are not present in significant numbers within the ex-situ habitats. • Indirect effects within Ramsar site boundary due to distance from onshore infrastructure (outside of ZOIs) • Indirect effects upon ex-situ habitats due to survey evidence indicating that qualifying features are not present in significant numbers within the ex-situ habitats.	No

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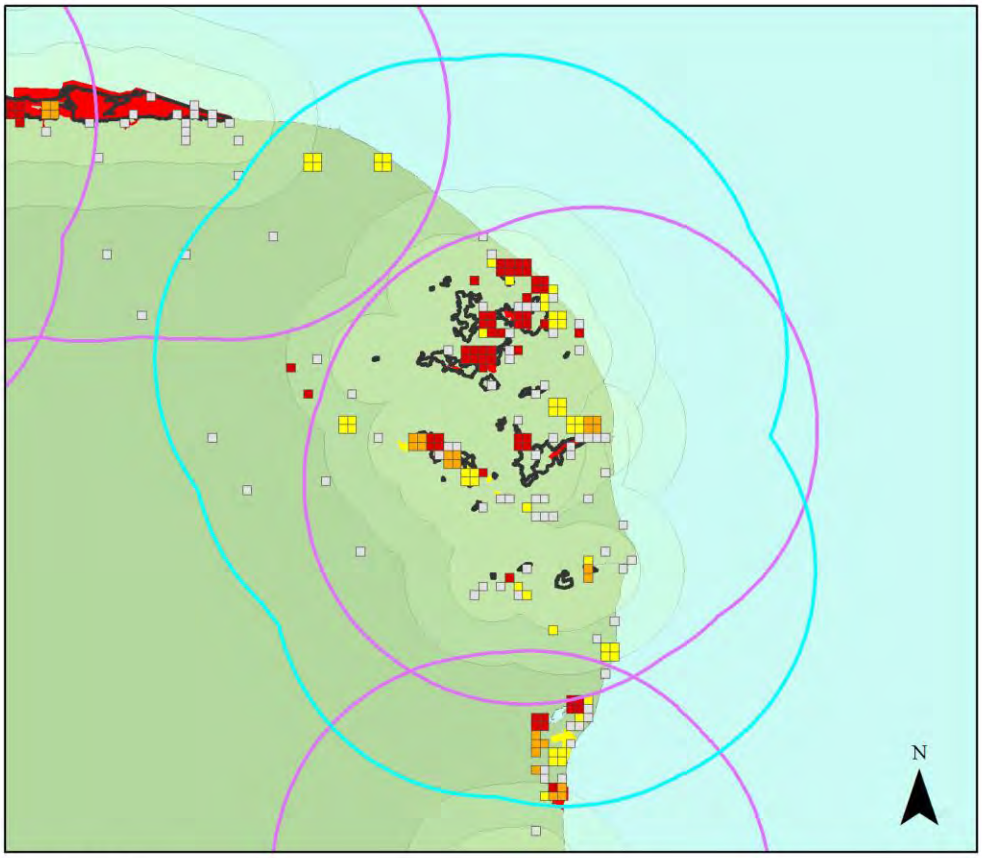
Annex 1 Swan and Goose Sensitivity Maps

Bewick's Swan - Broadland



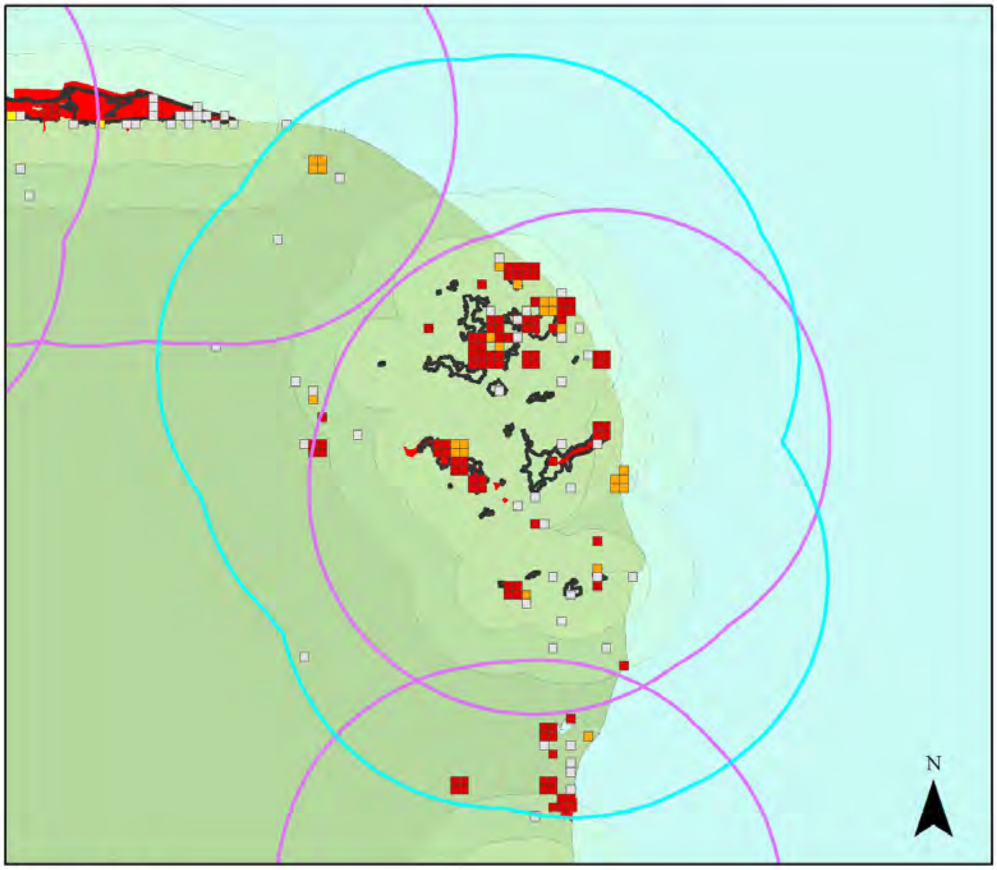
Legend

Sensitivity of 1-km square (or WeBS site)

- HIGH
- MEDIUM
- LOW
- VERY LOW

- Other BirdTrack records (location of birds may be imprecise)

Whooper Swan - Broadland



Legend

Sensitivity of 1-km square (or WeBS site)

- HIGH
- MEDIUM
- LOW
- VERY LOW

- Other BirdTrack records (location of birds may be imprecise)

Appendix 3. Sensitivity maps.

For each SPA for which the site is designated and selected important roost sites, two maps are presented; one showing the distribution of all feeding records (from the period 1986/87 to 2012/13) and one showing the distribution of feeding records from the most recent five years (2008/09 to 2012/13).

Key:

For Figures 7 to 26, the following symbols were used:

1) Sensitivity Index represented by four graduated dark blue symbols (dots) (see 2.3.4 above).

2) 1km squares for which no quantitative data exists but geese were known to be present (see 2.3.1 above) represented by small red symbols (dots).

3) The SPA boundary (thick red line).

4) Important roosts either within the SPA boundary (if known) or other nearby waterbodies (see 2.5 and appendix 2) represented by green symbols (dots).

5) 20km line surrounding the SPA boundary (black line).

Interpreting the maps

The maps show the distribution of feeding geese based on available data. There are fewer records from the most recent period (from 2008/09 to 2012/13) partly due to the shorter time period (five years) and partly due to the reduction in the number of geese being ringed in recent years and a subsequent reduction in the number of sightings.

However, at some sites, a reduction in feeding records may also represent an absence, or reduction in number of geese. The maps should therefore be interpreted in conjunction with results from any available local surveys, recent roost count data, annual IGC reports (e.g. Mitchell 2011), a review of goose use of SPAs (Mitchell & Hall 2012) and the Waterbird Review Series reports for Pink-footed Goose (Mitchell & Hearn 2004).

1) Broadland (UK9009253):

Roost locations and feeding distribution

The two main Pink-footed Goose roosts within Broadland are Horsey Mere and Berney Marshes (Figure 7). Birds from there generally remain close to the roost sites when feeding, moving mainly along the coast rather than inland. The main concentration is around Horsey Mere, though some move as far south as north Suffolk.

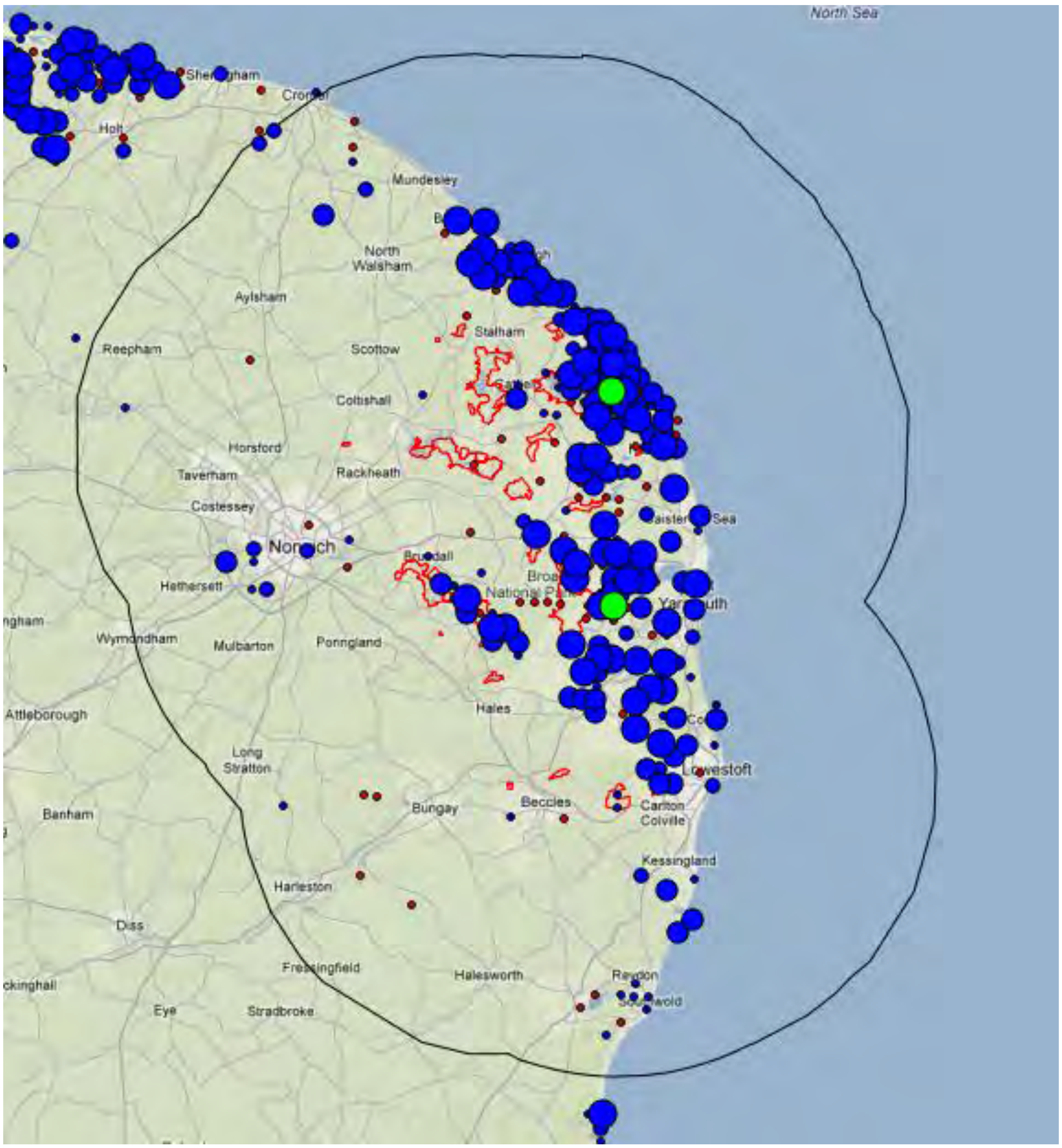


Figure 7. Feeding distribution (1986/87 to 2012/13 - all records) of Pink-footed Geese in relation to the Broadland SPA. For key see page 25.

The data for the most recent five years (Figure 8) show that during this period little change has taken place in the main feeding areas of birds roosting within Broadland.

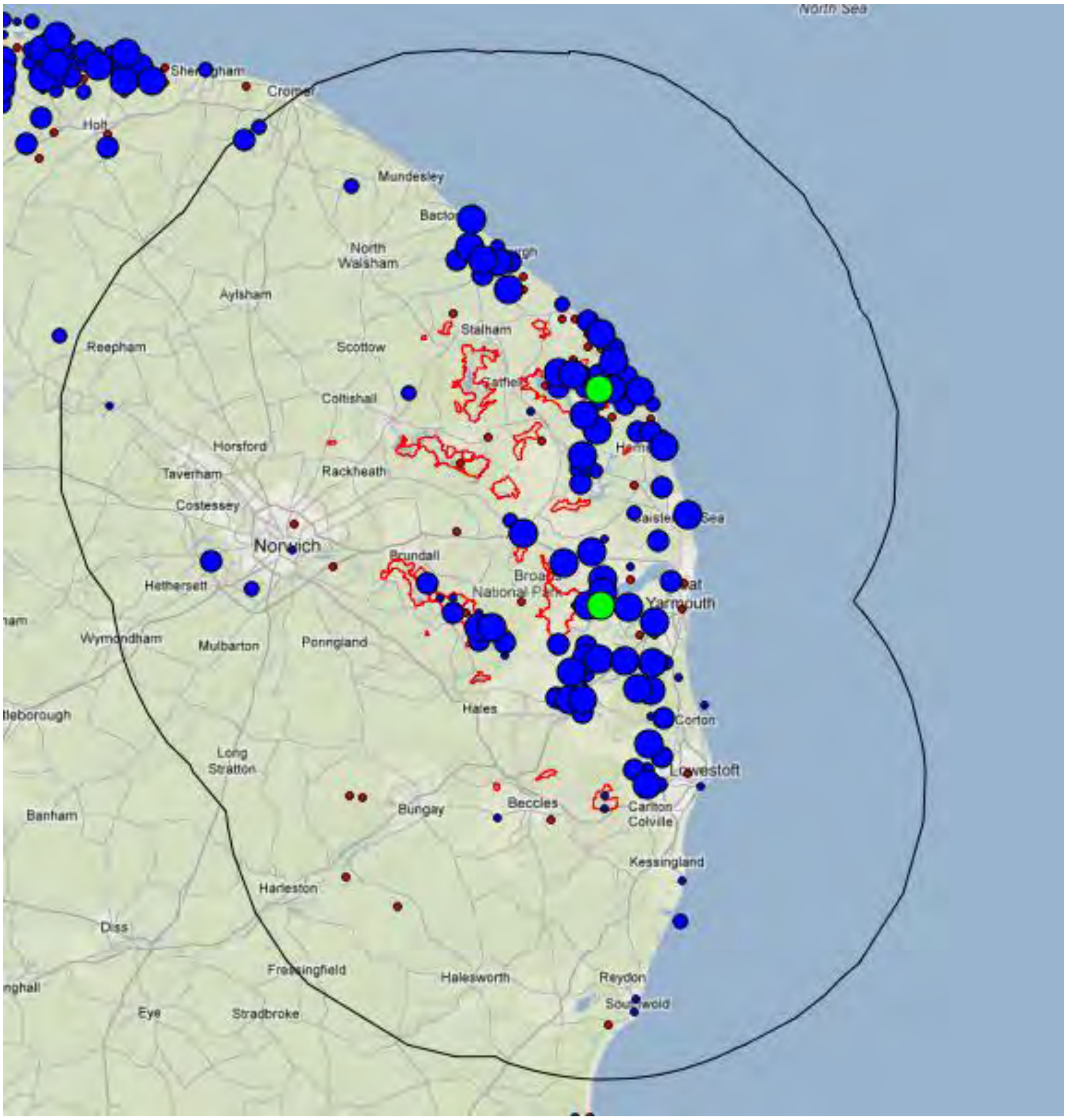


Figure 8. Feeding distribution (2008/09 to 2012/13 - new records) of Pink-footed Geese in relation to the Broadland SPA. For key see page 25.

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Annex 2: Paston Great Barn SAC barbastelle core foraging areas

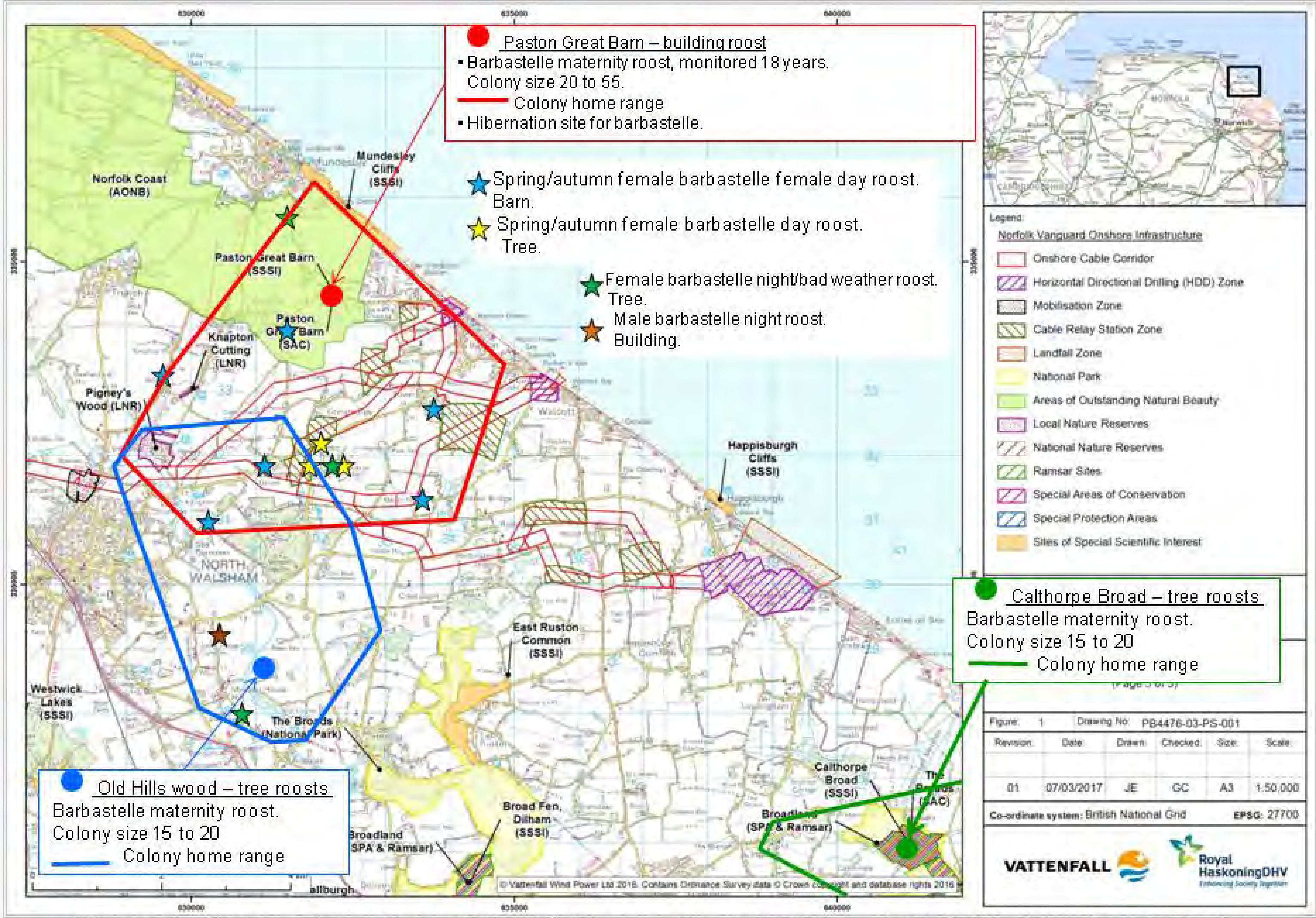


Figure 3. Paston Great Barn NNR, Calthorpe Broad NNR and Old Hills (Honing estate) – barbastelle maternity colonies

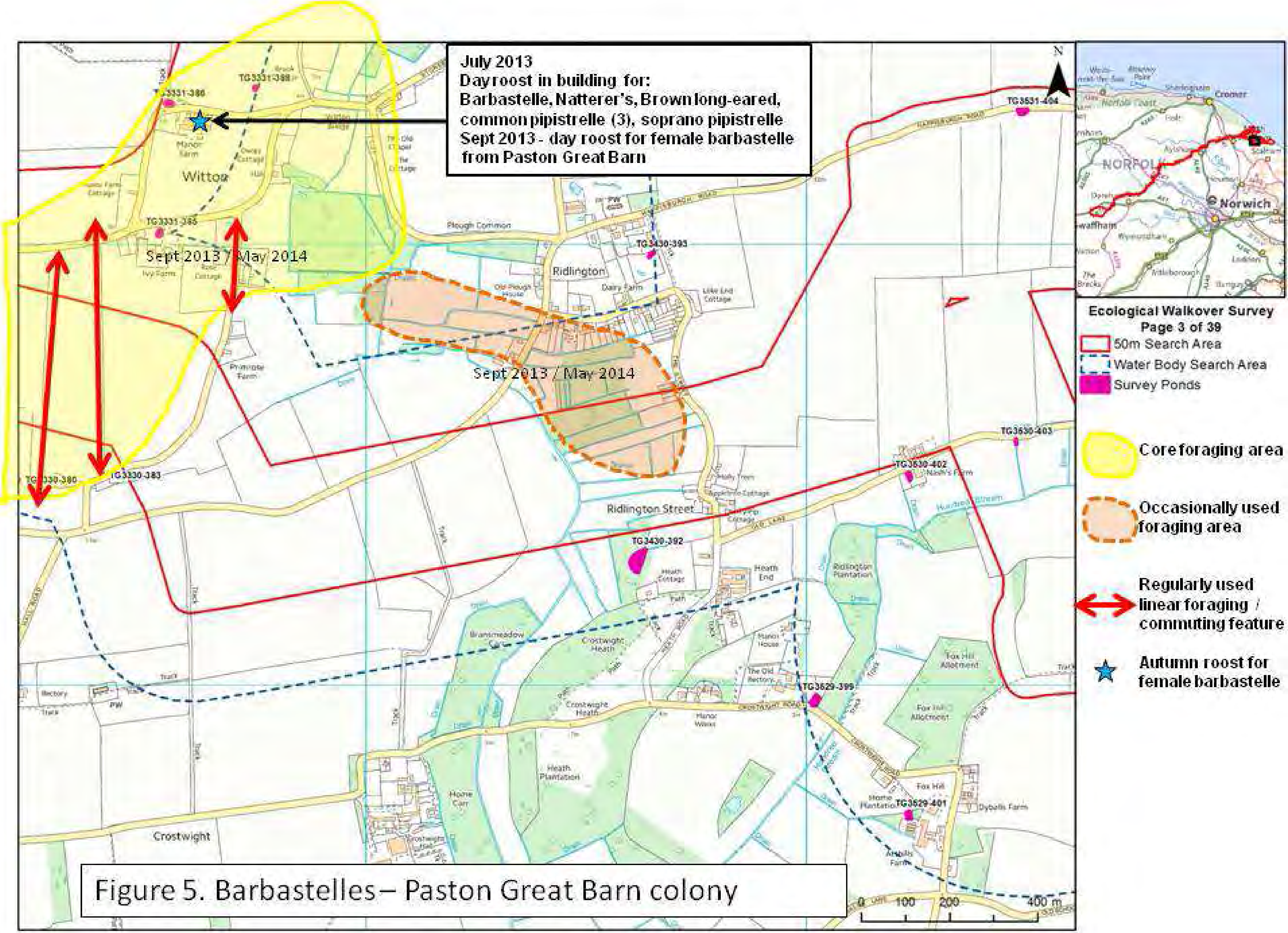


Figure 5. Barbastelles – Paston Great Barn colony

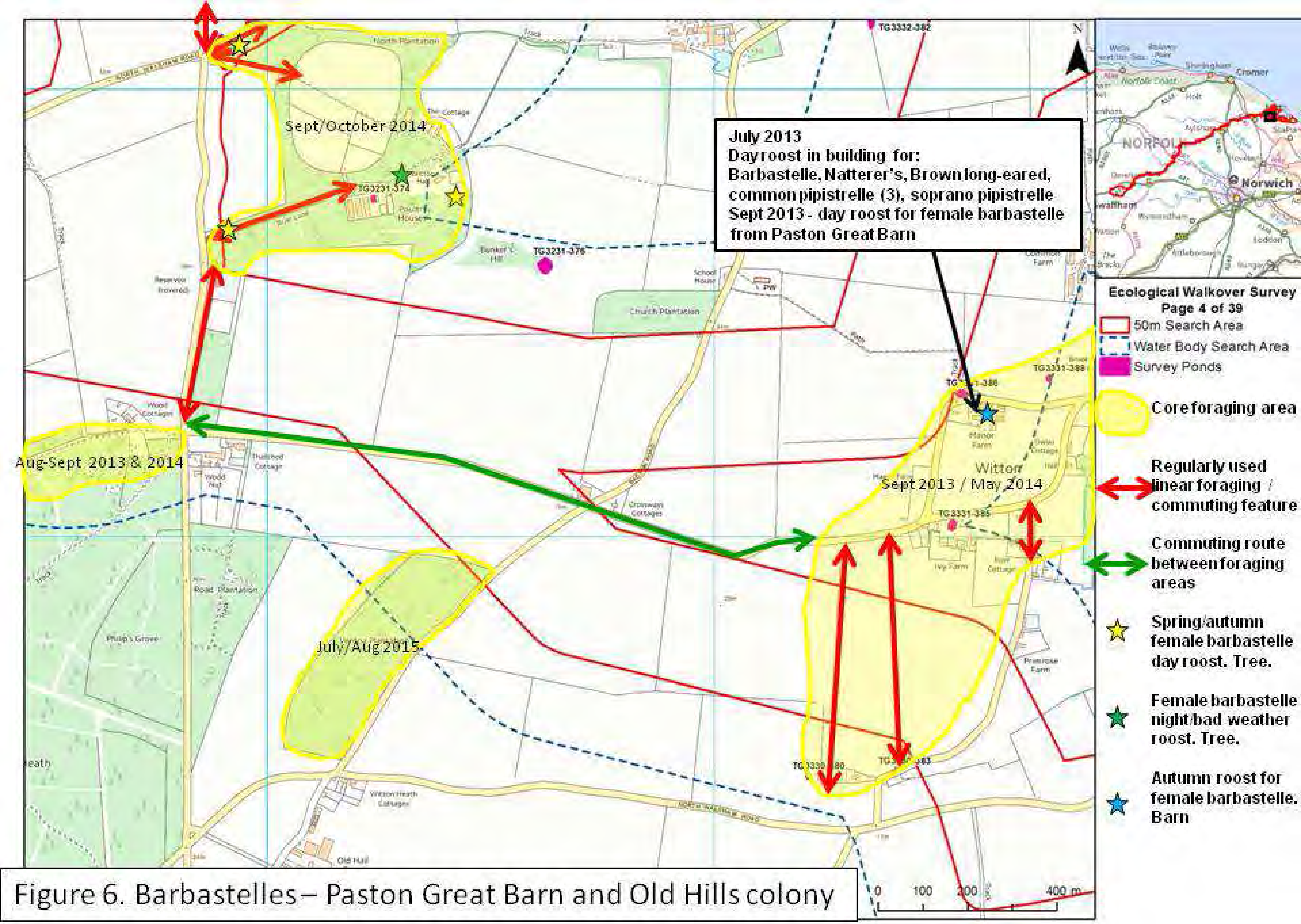


Figure 6. Barbastelles – Paston Great Barn and Old Hills colony

Figure 7. Barbastelles – Paston Great Barn colony

Figure 8. Barbastelles – Paston Great Barn colony

Figure 9. Barbastelles – Paston Great Barn colony

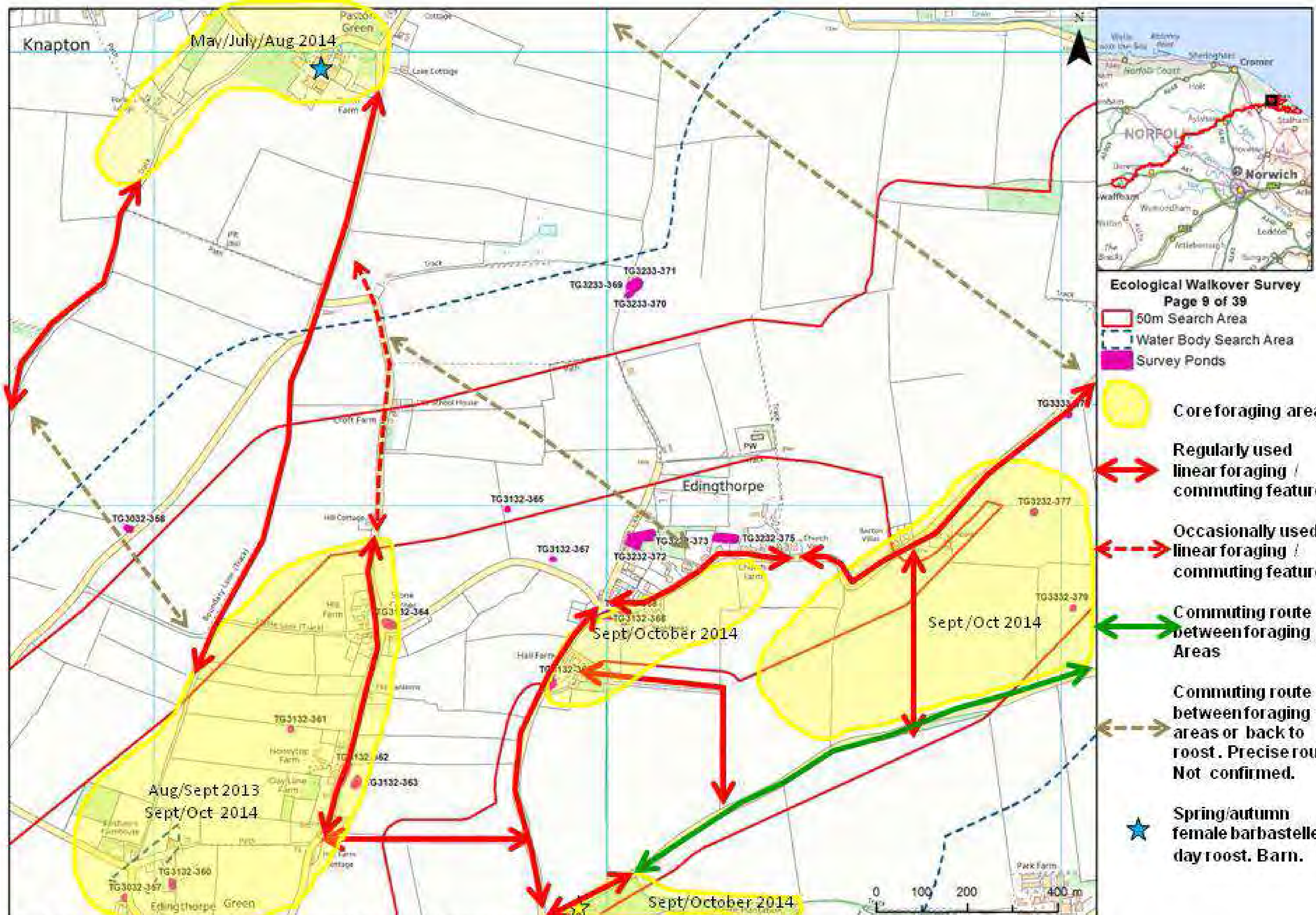


Figure 10. Barbastelles – Paston Great Barn colony

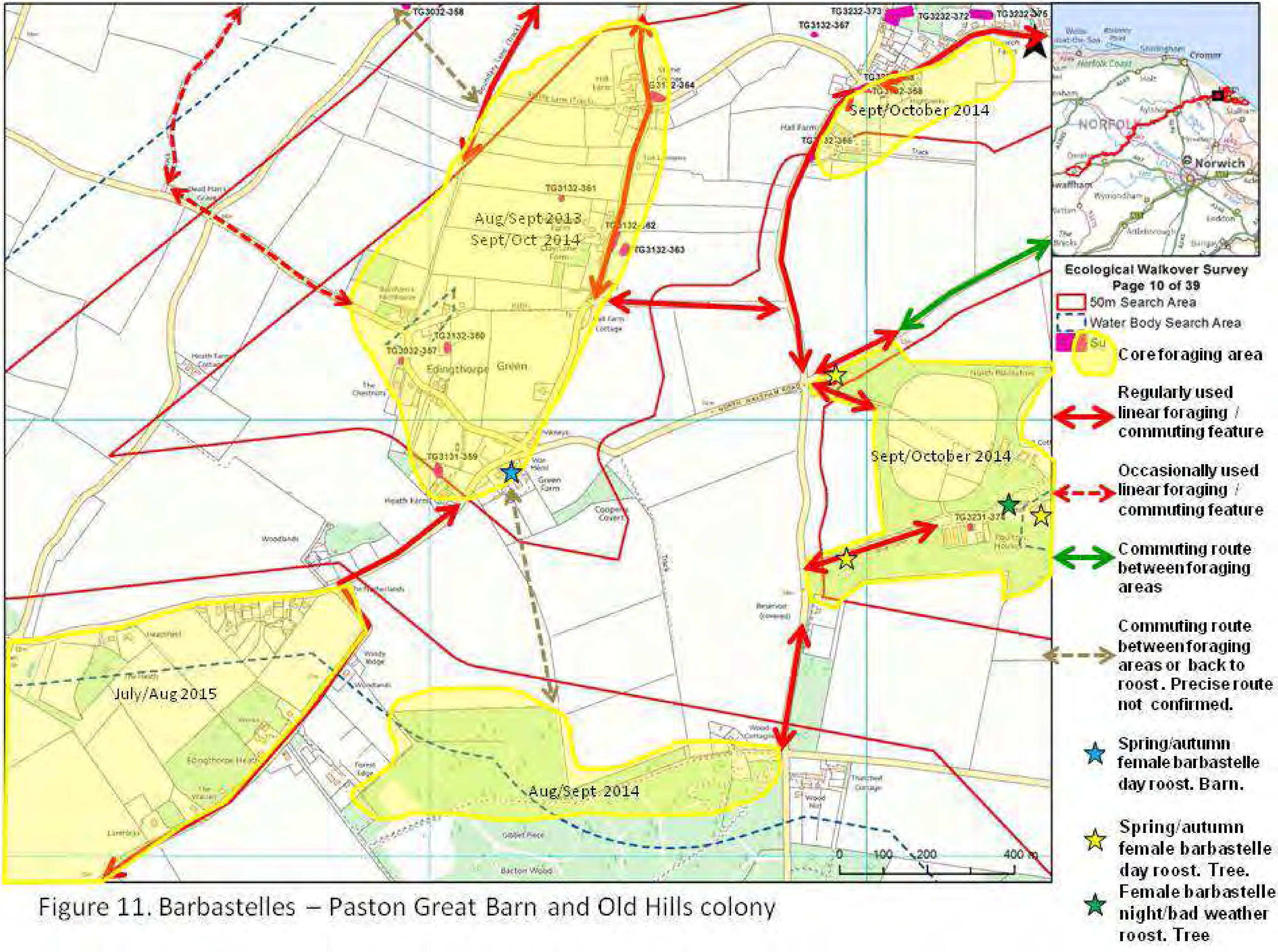


Figure 11. Barbastelles – Paston Great Barn and Old Hills colony

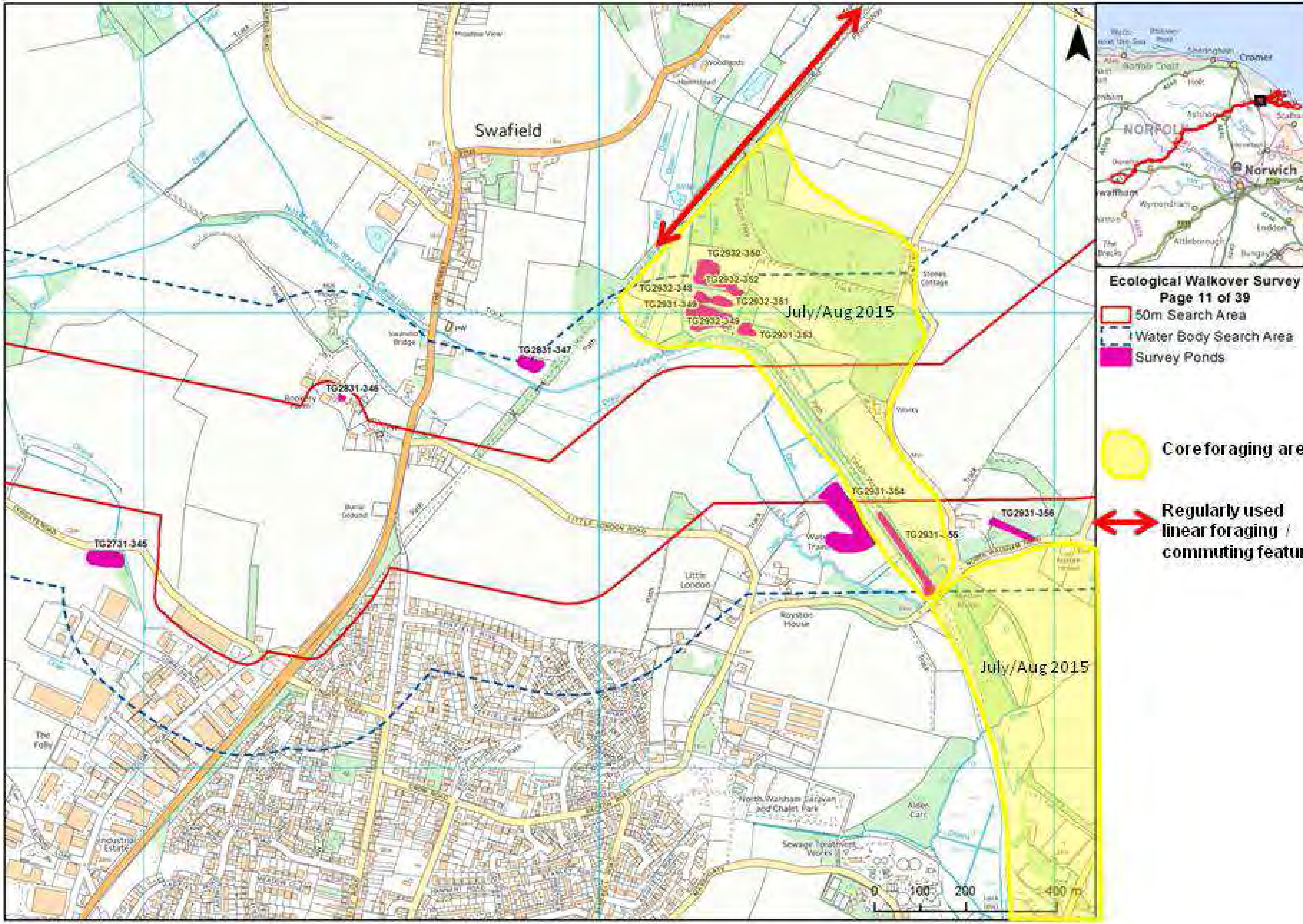
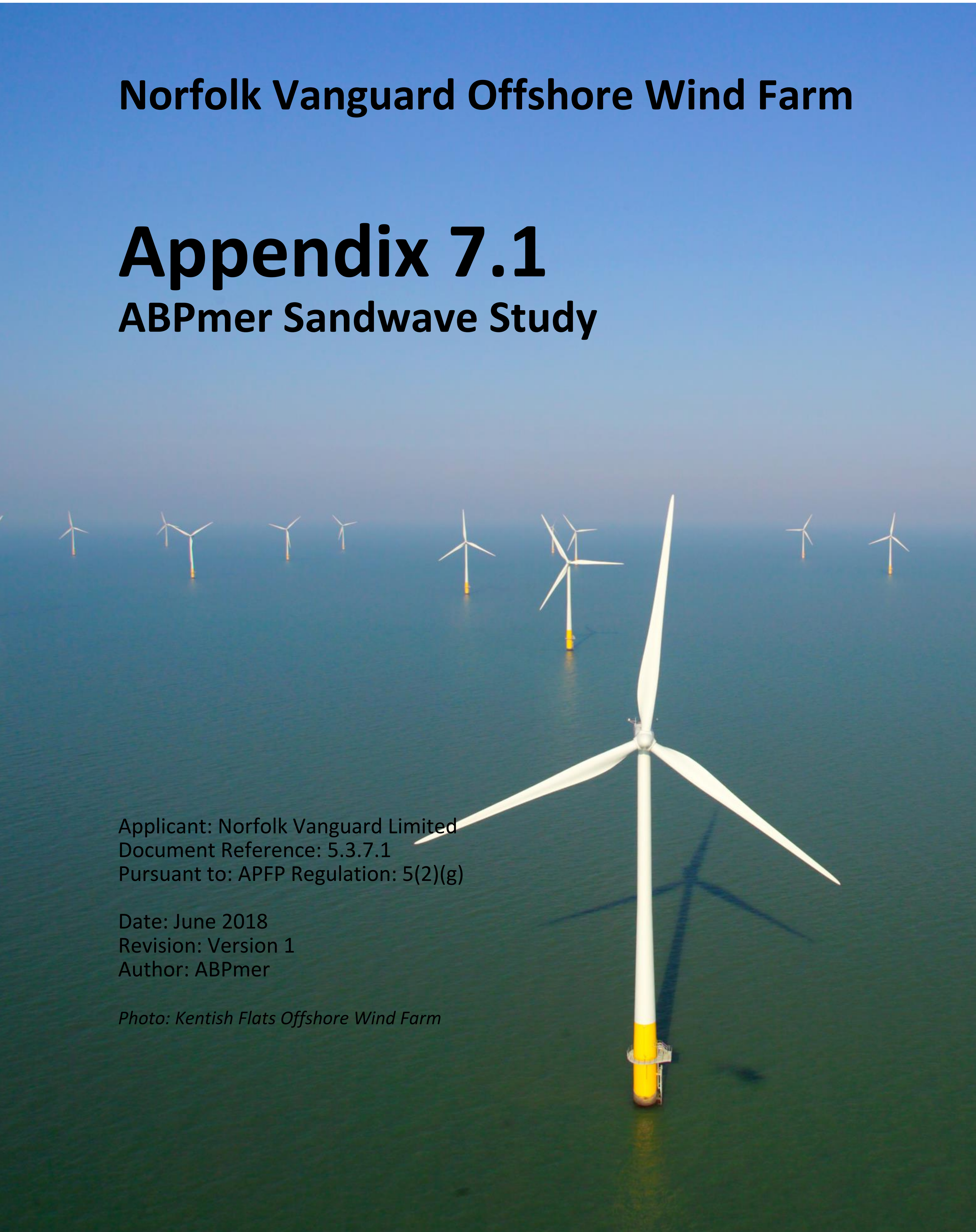


Figure 12. Barbastelles – Paston Great Barn and Old Hills colony



Norfolk Vanguard Offshore Wind Farm

Appendix 7.1
ABPmer Sandwave Study

Applicant: Norfolk Vanguard Limited
Document Reference: 5.3.7.1
Pursuant to: APFP Regulation: 5(2)(g)

Date: June 2018
Revision: Version 1
Author: ABPmer

Photo: Kentish Flats Offshore Wind Farm

Information for the Habitats Regulations Assessment

Document Reference: 5.3.7.1

June 2018

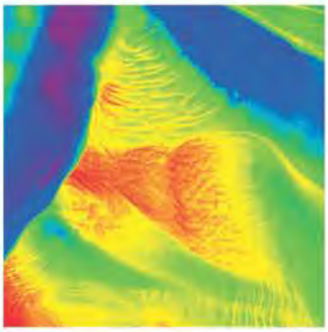
For and on behalf of Norfolk Vanguard Limited Approved by: Ruari Lean and Rebecca Sherwood Signed: [redacted] Date: 8th June 2018

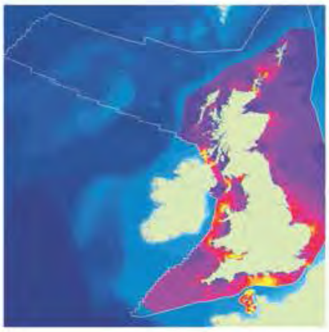
Royal HaskoningDHV

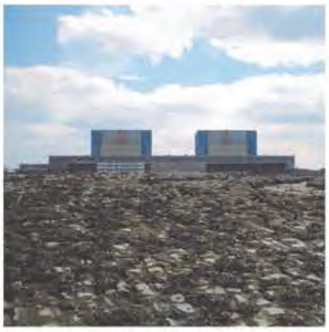
Norfolk Vanguard and Norfolk Boreas Export Cable Route

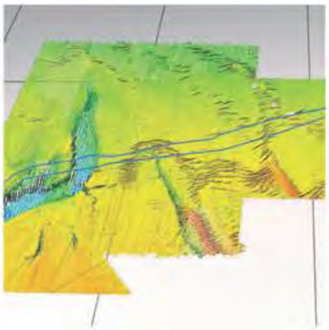
Sandwave bed levelling

April 2018









Innovative Thinking - Sustainable Solutions

ABP mer

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Norfolk Vanguard and Norfolk Boreas Export Cable Route

Sandwave bed levelling

April 2018

Document Information

Document History and Authorisation		
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	Sandwave bed levelling	
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Issue date	April 2018	
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Project no	R/4579/1	
Date	**Version**	**Revision Details**
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11.01.2018	2	Issued for client use
	V2	
29.03.2018	1	Issued for client review
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Prepared (PM)	Approved (QM)	Authorised (PD)
Anna Chaffey	David Lambkin	Heidi Roberts

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Acknowledgements

Cooper Marine Advisors for external advice and review

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Summary

Vattenfall proposes to undertake cable installation activities in the offshore cable corridor for the Norfolk Vanguard and Norfolk Boreas Offshore Wind Farms and these works may entail seabed levelling through a number of sandwaves. Natural England has raised concerns about the proposed bed levelling works and is seeking reassurance that any future operations will not adversely affect the sandbank systems within the Haisborough, Hammond and Winterton Special Area of Conservation (SAC).

In order to address the concerns raised, ABPmer has completed a study assessing the potential for any impacts on the seabed and sandwave morphology within the study area and any onward effects on the form and function of the systems within the Haisborough, Hammond and Winterton SAC (hereafter referred to as the Haisborough SAC). This included investigating the sandwave properties (height, wavelength, asymmetry, mobility and migration characteristics) and the sediment transport potential present within the study area.

Results highlight the study area is in an active and highly dynamic environment, governed by flow speeds, water depth and sediment supply; conditions conducive for the development and ongoing maintenance of sandwave bedforms. Assessed sandwave migration rates varied between 5 and 30 m/year, with both northerly and southerly migrating sandwaves present along the cable corridor. The different migration directions relate to localised sediment re-circulation patterns around sandbanks or the influence of the bedload parting zone that crosses this part of the study area and Southern North Sea.

The estimated time for the cable trenches and the seabed levelling to be naturally infilled (and sandwave recovery) in relation to the transport regime is in the order of a few days to a year. This is based on the representative forcing conditions at a single water depth, with storm effects having the potential to accelerate the process to days or weeks. Due to the sandwave migration characteristics and prevalent sediment transport, it is likely that any affected sandwaves would have migrated away from the levelled area before being reformed.

The governing sediment transport processes within the Haisborough, Hammond and Winterton SAC study area, occurs at a much larger scale than the proposed bed levelling works. Therefore, these processes will not be disrupted by the localised bed levelling. In addition, the volume and area being affected is small in comparison to the volume of material within the local sandbank systems (i.e. Newarp Banks system) and the Haisborough SAC, as a whole.

Finally, the proposed sandwave levelling methodology is to dispose of sediment locally so there is no net loss of sediment to the SAC. It is therefore likely that neither the form nor function of the sandbank systems locally or within the wider Haisborough SAC will be disrupted as a result of the proposed levelling through the sandwave crest or sediment disposal within the indicative spoil zone.

The following can also be concluded from the study:

- Due to the ongoing migration characteristics of the sandwaves, in the time it takes the levelled area to reform, the sandwave, including the originally levelled area, would have moved and reshaped. Therefore, the levelled sandwaves are unlikely to fully return to their original shape, but this will not disrupt the onward migration of the sandwaves or the form and function of the sandwave field;
- The absolute width, length, shape and thickness of sediment deposition as a result of disposal cannot be predicted with certainty and is likely to vary due to the nature of the dredged

material, the local water depth and the ambient environmental conditions during disposal. However, there is not expected to be any significant difference in the thickness or extent of spoil deposits associated with either a surface release or disposal at the seabed via a downpipe. Following disposal, the material will most likely remain within the Haisborough SAC on the same time frame it would take surficial sediment to move through the Haisborough SAC as currently occurs; and

- The cable installation scenario would be the phased levelling at adjacent locations, with a short separation distance, aligned in an approximately south-north direction, with the works progressing in the same direction as sandwave migration (from south to north). In this scenario the adjacent or nearby areas of a sandwave could be repeatedly levelled up to four times. However, the area and volume of sandwave to clear per phase would be proportionally reduced. The likelihood of this altering the form and function of the sandwave field and the wider sandbank system is considered to be minimal. This is because all evidence suggests the study area is in a dynamic environment conducive to the development and maintenance of sandwaves. Sandwave bedforms are continually being modified, converging and bifurcating, also with new bedforms being created and migrating through the cable corridor.

Contents

Appendix

Tables

Figures

1 Introduction

Vattenfall proposes to undertake bed levelling activities through a number of sandwaves as part of cable installation activities in the export cable route for the Norfolk Vanguard and Norfolk Boreas Offshore Wind Farms. Part of the proposed bed levelling works is to occur on the sandwaves within the Haisborough, Hammond and Winterton Special Area of Conservation (SAC), referenced as the Haisborough SAC in the remainder of the report. The Haisborough SAC is designated as an Annex I habitat, on the basis of the sandbanks and biogenic reefs that occur within the area. This study mainly assesses the effects of works on the sandwave bedforms which are the smaller features that overly the more static and larger sandbank bedforms. Therefore in relation to the designated features, this study only focusses on the sandbank characteristics, for which the area is designated on the basis of the following descriptive criteria:

> *Sand banks which are slightly covered by sea water all the time. These features consist of sandy sediments that are permanently covered by shallow sea water, typically at depths of less than 20 m below chart datum (but sometimes including channels or other areas greater than 20 m deep (JNCC, 2010; 2017)).*

Natural England has raised concerns about the proposed bed levelling works, which are described further in Section 1.2. It is seeking reassurance that any future operations will not adversely affect the sandbank systems within the Haisborough SAC and therefore pose a risk to the conservation objectives of the site. The conservation objectives (JNCC and Natural England, 2013; JNCC, 2016; Natural England, 2017) are to ensure that subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring:

- The extent and distribution of qualifying natural habitats and habitats of the qualifying species;
- The structure and function (including typical species) of qualifying natural habitats;
- The structure and function of the habitats of the qualifying species;
- The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;
- The populations of qualifying species; and
- The distribution of qualifying species within the site.

ABPmer has been commissioned to undertake an assessment of the potential nature, magnitude, extent and duration of effects of the proposed bed levelling activities on the physical environment. This is in relation to the structure and function of the qualifying natural habitat, which are the sandbanks (and overlying sandwaves, although not explicitly mentioned within the designation documents (JNCC and Natural England, 2013; JNCC, 2016)). No assessment has been undertaken for the qualifying species within the site, which is considered in a separate study (i.e. Envision Sabellaria reef mapping, Appendix 7.2 of the Norfolk Vanguard Information to support HRA report (Vattenfall, unpublished). This study assesses the effect of the proposed bed levelling with regards to:

- Potential effects on the local sandwave morphology and evolution;
- Potential effects on the seabed morphology and sediment transport regime; and
- Potential effects or onward effects on the structure and function of the sandwaves and sandbanks within the Haisborough SAC, in relation to the conservation objectives.

This study provides a summary of the relevant baseline environmental conditions and an estimated rate of recovery (including recovery of sediment volume and shape) for the sedimentary features which may be affected by the proposed bed levelling activities. In addition to understanding the general effects of bed levelling the following questions are considered in the concluding section:

- Will sandwaves within the Haisborough SAC reform following dredging of the crest?
- If the sediment is disposed of within an adjacent disposal site where will that sediment be transported to?
- Are there any onward effects on the form and functioning of the sandwaves and sandbanks within the Haisborough SAC?

Following an Evidence Plan Process meeting with the benthic ecology expert topic group[1] on 31 January 2018, a number of points for clarification were raised by Natural England which are also included in the report, namely:

- Further consideration of the sandwave recovery potential, providing evidence from existing examples or case studies where available;
- Assess the impacts of sediment disposal, including the deposition extent and thickness, also considering where the dredged and disposed sediment will go, and if will it remain within the Haisborough SAC. What are the different impacts with the sediment disposed at the sea surface or close to the seabed? and
- Reassess the effects on the local sandwave morphology and evolution, seabed morphology, sediment transport and onward effects on the form and function of the Haisborough SAC in relation to a phased cable installation methodology and redefined indicative spoil zone.

1.1 Study area

The study covers the area of the Haisborough SAC, focussing on the Newarp Banks sandbank system and cable corridor that transects the Haisborough SAC. The other sandbank systems present within the Haisborough SAC (i.e. further north of the cable corridor) are also discussed, as applicable, as is consideration of the larger region covered by the Southern North Sea.

The study area is located in an active and dynamic sediment environment that is conducive to the development and ongoing maintenance of sandwave bedforms. This is in relation to the governing tidal processes, seabed depths and abundant sediment availability. Depths within the study area generally range between -13 and -50 m Lowest Astronomical Tide (mLAT), with depths of between -23 to -28 mLAT typifying it. The study area along with the sandbanks which occur within the Haisborough SAC are illustrated in Figure 1.

Within the Haisborough SAC are a number of distinct sandbank systems. The Haisborough Sand sandbank system comprises of Haisborough Sand, Haisborough Tail, Hammond Knoll, Winterton Ridge and Hearty Knoll. These sandbanks in addition to Hewett Ridges, Smiths Knoll, Newarp Banks and Cross Sands make up the Haisborough, Hammond and Winterton SAC (Figure 1), which is classified for their Annex I habitat "Sandbanks slightly covered by sea water all the time".

The Haisborough Sand system is composed of alternating ridge headland associated sandbanks (Haisborough Sand) and open shelf sinusoidal sandbanks which have evolved over the last 5,000 years. The sandbanks would have originally been associated with the coastal alignment at the time the Holocene marine transgression occurred (Dyer and Huntley, 1999; Cooper *et al*., 2008; JNCC, 2016).

[1] MMO, Cefas, Natural England and Eastern Inshore Fisheries and Conservation Authority (EIFCA).

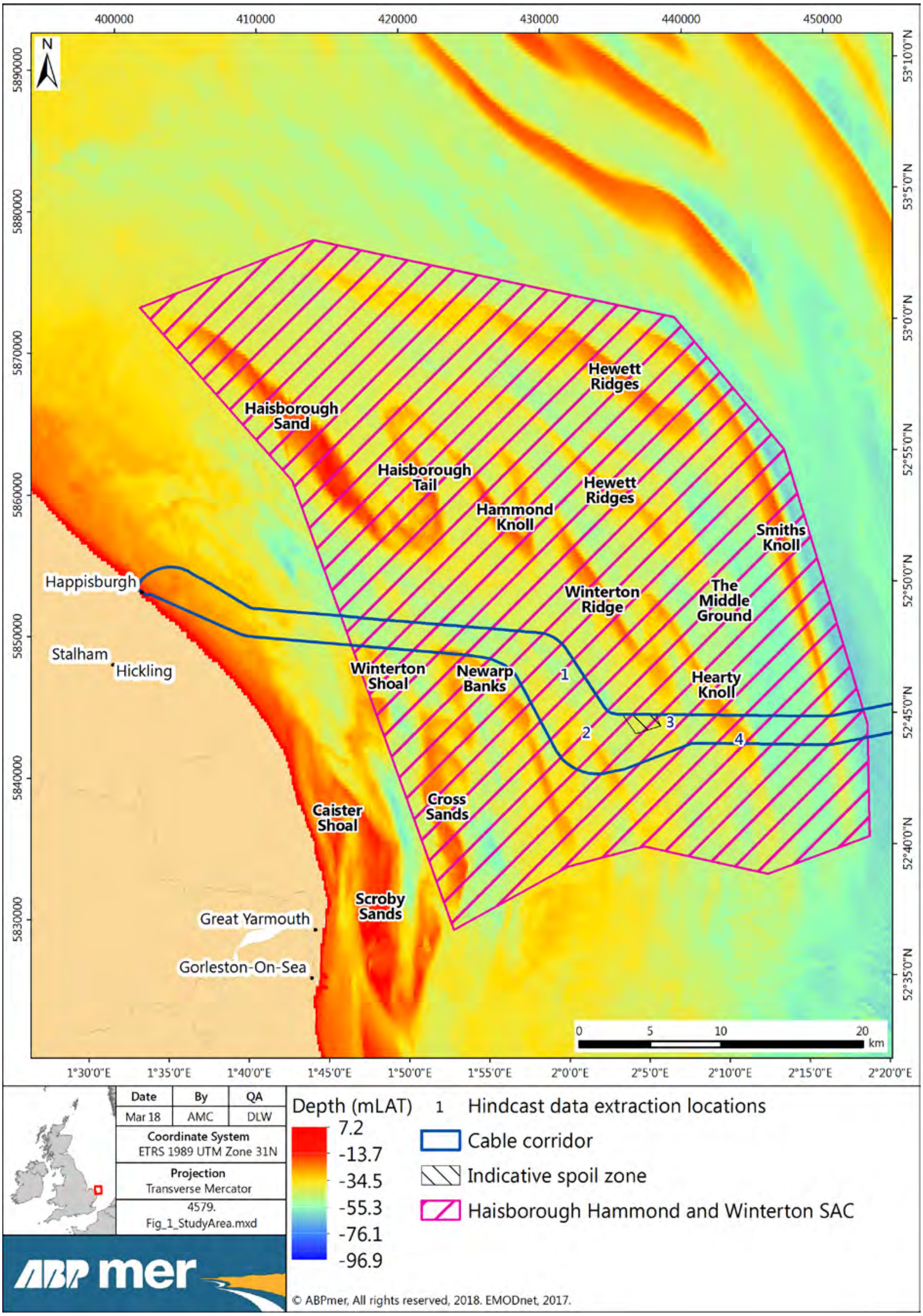

Figure 1. **Study area**

A recent study suggests this system comprises of one complex sinusoidal feature, with ongoing sediment linkages between the sandbanks from Haisborough Sand through to Hearty Knoll (Burningham and French, 2016).

Further offshore of the Haisborough system are Hewett Ridge and Smiths Knoll, which form an older sequence of sandbanks located along the outer boundary of the Haisborough SAC (Figure 1). The origin of these sandbanks is considered to be similar to the Haisborough sandbank system, which would have initially formed as alternating ridge headland associated sandbanks, but are geologically older (JNCC, 2016). These features are still actively evolving most likely due to the relatively shallow depths of their crests, which are likely to experience wave influence. Bed level differences estimated by Burningham and French (2016) provide evidence for migration of the sandbanks over the last 150 years, with the rate of change slowing more recently.

Inshore and to the southeast of the Haisborough system are Winterton Shoal, Newarp Banks and North and Middle Cross Sands (Figure 1). The origin of the inshore features is considered to be geologically recent (JNCC, 2016) and again originated as alternating ridge headland associated sandbanks. This sandbank system is of most interest to this study as the cable corridor passes through it.

1.2 Proposed bed levelling works

1.2.1 Introduction

Information on the proposed bed levelling is taken from the "Norfolk Vanguard Offshore Windfarm - Export Cable Installation Study (221_NVOWF_Installation_Study_002)" (CWind, 2017).

The export cable route and corridor cross a number of sandwaves and sandbanks. Were cables to be installed in the present day superficial sediments in the mobile parts of these features, they would be at risk of exposure, requiring regular monitoring and likely reburial. Localised bed levelling to remove the crests of mobile sandwaves and burying the cable into the underlying immobile seabed is therefore a proposed option. The majority of the sandwaves requiring levelling occur along the cable route within the Haisborough SAC.

Two methods are considered for carrying out the bed levelling work in CWind (2017), namely, a trailer suction hopper dredger (TSHD) or a mass flow excavator (MFE). Both of these techniques will displace sediment material to create a corridor through the sand wave crest in which the cable burial tool can then be used.

1.2.2 Assessment scenario

The cable installation scenario assessed in this report is the phased installation and associated bed levelling events across the Haisborough SAC, with a hiatus between phases. The following realistic worst case scenario for phasing of the export cable installation is as follows:

i. Bed levelling associated with the installation of Norfolk Vanguard cable pair 1;
ii. Gap of 6 to 24 months;
iii. Bed levelling associated with the installation of Norfolk Vanguard cable pair 2;
iv. Gap of 6 to 24 months;
v. Bed levelling associated with the installation of Norfolk Boreas cable pair 1;
vi. Gap of 6 to 24 months; and
vii. Bed levelling associated with the installation of Norfolk Boreas cable pair 2.

For the locations that require levelling, a dredge corridor for each cable with a nominal width of 7 m, allowing for 1:3 side slopes is applied. Based on the information presented in CWind (2017) and the associated supporting spatial data for the High Voltage Direct Current (HVDC) cables, the following applies:

- There will be two cable pairs for each offshore wind farm project and within each project there will be:
  - A 75 m separation between the cables pairs for each project, with around 68 m between the dredge corridor margins; and
  - Each cable pair will be laid in the same trench.
- There will be 250 m separation between the cables for each project.

1.2.3 Volumes for assessment

Initial estimations by CWind (2017) indicate that most sandwaves would be levelled by 0.5 to 4 m below the seabed surface, with isolated locations being levelled by as much as 6 m (associated with the crests of steep sandwaves generally in depths greater than -20 mLAT).

Vattenfall estimate a worst case dredge volume of 250,000 m^3 per cable pair (which also relates to per phase of installation). This results in a total volume of 500,000 m^3 per wind farm and a cumulative total of 1,000,000 m^3 for the Norfolk Vanguard and Norfolk Boreas Offshore Wind Farms within the SAC.

Based on the above phasing information and bed levelling volumes, an assessment of the impacts on sandwave recovery from the cable installation for Norfolk Vanguard and Norfolk Boreas individually and the cumulative impacts on sandwave recovery from both together is provided in Section 4.2.

Vattenfall aims to keep all the dredged sediment within the Haisborough SAC's boundaries during bed levelling activities. This is in order to keep the dredged sediment volume within the sandbank system, also enabling the material to be re-worked by natural processes and encouraging the re-establishment of bedform features (CWind, 2017). The exact disposal location and extent is still to be finalised, it is however, anticipated that material will be deposited within a suitable spoil disposal zone such as that shown indicatively in Figure 1. At present, based on the regional net sediment transport direction, the indicative spoil zone is located down-drift of where the proposed levelling is to occur, although there are likely to be spatial and temporal variations in the sediment transport characteristics (see Section 2.6.2.

2 Baseline Environmental Conditions

2.1 Previous studies

The study first completes a literature review from previous studies, summarising the baseline environmental conditions within the Haisborough SAC and the Southern North Sea where applicable. The following studies and data sources have been reviewed in order to inform the relevant environmental characteristics:

- Zonal Environmental Assessment (ZEA) Physical Processes Baseline (East Anglia Offshore Wind (EAOW), 2012 and the references therein);
- A synthesis of current knowledge on the genesis of the Great Yarmouth and Norfolk Bank Systems' (ABPmer, 2007; Cooper *et al.*, 2008);
- Southern North Sea Sediment Transport Study Phase II (SNSSTS) (HR Wallingford *et al.*, 2002);
- Sandbanks, sand transport and offshore wind farms (Kenyon and Cooper, 2005);
- Strategic Environmental Assessments Area 2– SEA 2 (Balson *et al.*, 2001);
- SAC Selection Assessment Haisborough, Hammond and Winterton (JNCC, 2010);
- Historical morphodynamics of the Haisborough Sand bank system (Burningham and French, 2016);
- ABPmer SEASTATES Wave Hindcast Database (ABPmer, 2013); and
- ABPmer SEASTATES Tide and Surge Hindcast Database (ABPmer, 2017).

The ZEA physical processes baseline document (EAOW, 2012) is particularly useful due to the close proximity of the study area and the nature of the primary data collected to inform it.

2.2 Seabed depths

All depths specified within this report are referenced to depths below Lowest Astronomical Tide (LAT). Water depths within the Haisborough SAC approximately range between -2 and -55 mLAT. A number of the sandbanks within the SAC have fairly steep slopes with the sandbanks generally having heights of over 10 m above the surrounding seabed. The seabed between the sandbanks has depths of around -30 mLAT, with the deeper troughs between sandbanks being up to -50 mLAT in depth. These features fall within the JNCC description for the Annex I habitats defined in Section 1.

In the local vicinity of the cable corridor the seabed is characterised by relatively shallow water depths, with sandbank and sandwave bedforms present. In this area, water depths approximately range between -13 and -50 mLAT. The depths on the sandbank crests are at about -13 to -18 mLAT. Away from the crests and along the sandbank flanks, depths are typically between -23 and -28 mLAT, increasing to depths of up to -50 mLAT in the sandbank troughs. The shallowest areas (less than -15 mLAT) occur over the northern extent of the Newarp Bank and on the sinuous banks east of the main sandbank body, which are still classed as part of the Newarp Banks (Figure 1). The deepest areas occur at the eastern margin of the study area in a trough between Hearty Knoll and Smiths Knoll, and another trough running parallel to the eastern flank of Smiths Knoll. Figure 1 illustrates the depths within the study area and to the wider morphology within the Haisborough SAC, where similar depths occur.

A representative seabed depth of -28 mLAT is applied in the analyses completed as part of this study as it is the median depth that occurs locally in relation to the cable corridor and is considered a characteristic depth around the sandbank flanks.

2.3 Seabed morphology

The sandbanks which are present within the study area have developed and evolved during the Holocene period (Caston, 1972; Belderson *et al*., 1982; Dyer and Huntley, 1999; Balson; 1999; HR Wallingford *et al*., 2002.; Cooper *et al*., 2008). These extend from 8 to 40 km offshore of the Norfolk coast and are subject to a range of current flow speeds, which are strongest around the inshore banks and reduce offshore (JNCC, 2010). Present understanding of the formation and morphology of the sandbanks can be summarised as follows:

- The sandbanks are formed on a relatively flat seabed comprising Pleistocene sediments (Cooper *et al,* 2008; Stride, 1988; Caston, 1972; Houbolt, 1968), with no underlying bedrock control (Burningham and French, 2016);
- The sandbanks have a northwest to southeast orientation and are asymmetric with a steeper flank facing the northeast (Stride, 1988; Caston, 1972; Houbolt, 1968);
- The summits of the sandbanks are in water shallower than -20 mLAT and the flanks of the banks extend into waters that are up to -40 mLAT deep;
- The internal structure of the sandbanks comprise layered sands interspersed by clay layers; this has been interpreted as sand laid down by tidal currents overlain by sand deposited after storm events with a higher content of fines (Stride, 1988); and
- The internal structure of the sandbanks indicates that they are migrating in a north-westerly direction at a rate of 1 to 16 m/year (Stride, 1988; Caston, 1972; Houbolt, 1968).

BGS maps and regional studies within the Southern North Sea identify that sandwaves are abundant across the study area and the wider region (BGS, 1984; 1988; Cameron *et al*., 1992; McCave, 1971). Sandwaves commonly occur on the flanks of the large tidal sandbanks, but also occur on areas of seabed where sandbanks are absent but there is a sufficient supply of sand (Belderson, *et al*., 1982; HR Wallingford *et al*., 2002; Cooper *et al*., 2008). Sandwaves within the Southern North Sea mainly occur in water depths between 18 and 60 m; their absence in depths shallower than 18 m is attributed to the effects of storm waves (Cameron *et al.,* 1992; Limpenny *et al*., 2011).

Superimposed on the sandbanks in proximity to the cable corridor and along the flanks are a number of tidally aligned sandwaves, which also partially extend into the troughs between the larger sandbank bedforms. The overlying sandwaves range between from 50 to 200 m in wavelength and 3 to 7 m in height. The presence of these sandwaves generally coincides with locations where the superficial sediments are greater than 1 m in thickness.

The current speeds assessed for the site are also of sufficient strength to form sandwaves (Belderson *et al*., 1982), which are still actively evolving. Across the cable corridor there is up to a ±9 m change in seabed level in the period between 2014 and 2016, with the largest change occurring in relation the migrating sandwave crests. The largest range, also associated with the larger migration distance is mostly observed for the sandwave bedforms overlying Newarp Banks which are at the shallowest water depths of about -13 mLAT. Away from the Newarp Banks sandwaves, the variation in seabed levels are much lower at about ±2 m for even larger sandwave bedforms.

Migration direction based on the sandwave asymmetry showed a circulation pattern around individual sandbanks within the Southern North Sea (McCave and Langhorne; 1982; HR Wallingford *et al*., 2002; Collins, *et al.,* 1995). In this study, closer examination of the sandwaves in proximity to the cable corridor showed both southerly and northerly sandwave movement at different locations. This was also confirmed by asymmetry estimates for several sandwaves across the same area. A northerly migration was observed on the sandwaves in the eastern part, whereas a southerly movement was observed on the sandwaves on the western flank of the Newarp Banks. The behaviour is likely to be even more complex as there as also instances that along a single transect there is movement towards the sandbank crest from either direction. Migration properties of the sandwaves along the cable corridor are assessed and discussed further in Section 3.3.4 and 4.2.

Stride (1963) deduced a migration direction for the sandwaves from their asymmetry within the Southern North Sea and related this with the direction of the strongest tidal current. In these instances, the asymmetry followed the net bed load sediment transport direction, which was towards the north. Sandwave migration rates of approximately 15 m/year and above are not uncommon in parts of the Southern North Sea (McCave, 1971; Belderson *et al*., 1982; HR Wallingford *et al*., 2002). However, along the cable corridor, a comparison of the limited available historical data, showing the position of individual sandwave crests at different times, suggests that net migration rates for the sandwave features vary across this area and the sandbank system.

The general understanding on the migration direction of bedforms in this part of the Southern North Sea is that although there is a dominant northerly migration of bedforms (both sandwave and sandbanks) (Belderson *et al*., 1982; HR Wallingford *et al*., 2002; Cooper *et al*., 2008), there are also instances of localised re-circulation around the sandbanks which modify the dominant pattern (HR Wallingford *et al*., 2002; Collins, *et al.,* 1995). Such re-circulations were identified for the sandbanks within the Haisborough Sand sandbank system, north of the study are but still within the Haisborough SAC (McCave & Langhorne, 1982; JNCC, 2010). There is therefore the potential for similar patterns on the sandbanks that intersect the cable corridor, particularly the Newarp Banks.

2.4 Water levels and currents

2.4.1 Tidal water levels

Water levels vary due to semi-diurnal tidal influences by up to 3 m over the water depth described in Section 2.1, based on the difference between the highest and lowest astronomical tides. The mean spring and neap tidal range is approximately 2 and 1 m respectively. The regional tidal regime is influenced by the position and interaction of two tidal amphidromes in the Southern North Sea (positions of near-zero tidal range, about which the tidal wave rotates). The tidal range therefore tends to increase from east to west through the through the Haisborough SAC.

Over the cable operational lifetime, there may be some small influence of sea level rise on total water levels. Data extracted from UK Climate Projections (UKCP09; Lowe *et al*., 2009), for locations along the adjacent UK coastline, indicate that over the operational lifetime of the export cable route, mean sea level (MSL) is likely to increase by between 0.03 and 0.1 m (and based on a range of uncertainties for a high emission greenhouse gas scenario). The scale of any change in mean sea level is very small in proportion to the total water depth and natural variability in local water level (e.g. due to tides, surges and waves) and so is unlikely to have any effect on the conclusions of this study.

2.4.2 Tidal currents

Currents within the Southern North Sea are mainly tidal in nature, especially in areas of deeper water. The tidal currents in the region are broadly to the south on the flood tide and to the north on the ebb tide. Tidal current direction through the study area is rectilinear (with minimal variance of direction during the periods of flood and ebb tide). The orientation of the tidal axis is relatively uniform through the study area, with slight localised variations due to flow around the sandbank bedforms (McCave and Langhorne, 1982; Dyer and Huntley, 1999 HR Wallingford *et al*., 2002; Burningham & French, 2016).

A broad indication of the regional current speeds within the study area, as provided by the Atlas of UK Marine Renewable Energy Resources (ABPmer *et al*., 2008), is around 1.3 and 0.7 m/s for the peak mean spring and neap tides, respectively. Information from the ZEA confirms peak mean spring and neap current speeds of approximately 1.29 and 0.72 m/s, respectively (EAOW, 2012, based on a United Kingdom Hydrographic Office (UKHO) tidal diamond within the study area). This is again consistent with metocean observations of around 1.34 m/s further east of the study area. Therefore, due to its proximity, current speeds from the tidal diamond within the study area are used as the representative tidal conditions. Relatively faster current speeds were typically observed to occur during the ebb tide across the ZEA and this is thought to also occur within the study area (EAOW, 2012).

2.4.3 Storm surges

Total water levels and currents within the study area are a combination of a predictable "astronomical" tidal component (described in the preceding sections), and an episodic "residual" (surge) component. Surges are formed by rapid changes in atmospheric pressure, with low atmospheric pressure raising the water surface (positive surge) and high atmospheric pressure depressing the water surface (negative surge). Regional scale patterns of stronger winds also contribute to storm surge effects. Larger surges are typically associated with larger storms and so are more likely to occur in winter months.

When they occur, surges will modify the normal tidal current speed (i.e. a greater or lesser than expected speed for the expected tidal range depending on the relative orientation of the tidal and surge current contributions) and the surge effect might persist for more than one normal tidal cycle. When a surge is in phase with the tidal flow, its effects can be considered to be additive, but when it is opposite, its effects are reduced.

The magnitude, direction and duration of surge events are variable, however the SNSSTS considered the surge tide to be of major relevance to sediment transport in the region (HR Wallingford *et al*., 2002). Representative surge water levels (above the normal astronomical levels) for 1-year and 50-year return period surge events are 1.6 m and 2.3 m, respectively (EAOW, 2012). A maximum surge current of 0.4 m/s (potentially in addition to the expected tidal value) is predicted to be associated with an (approximately 50-year return period) surge event of 2.5 m (EAOW, 2012).

2.4.4 Other non-tidal currents

Within the study area, (in addition to surges, described above) additional currents can be generated as a result of wind stress over the sea surface and by waves. The depth to which wind and wave driven currents act is relatively limited but could still influence the seabed in relatively shallow water, e.g. over larger seabed bedforms in shallow water within the study area.

Local wind driven surface currents are typically confined to the upper part of the water column and do not contribute to near bed current speeds. Maximum wind driven current speeds (up to 3% of the wind speed) occur at the water surface and decrease rapidly with depth. Wind driven currents are orientated in approximately the same direction as the local wind.

Near-bed wave induced orbital currents are more likely to occur with a greater frequency and magnitude in relation to larger waves, with a longer period, in relatively shallower water depths. The ZEA (EAOW, 2012) estimated that peak orbital current speeds may exceed 0.8 m/s during a 1-year return period wave event, increasing to over to 1.1 m/s during a 50-year return period wave event. These are estimated at a water depth of around -23 mLAT. In shallower water, it is likely that the effects would be greater and the reverse for deeper water depths. The wave characteristics associated with these speeds are discussed in Section 2.5.

2.5 Waves

The local wave regime comprises both locally generated wind waves (smaller height, shorter period and length waves), and swell (longer waves generated by distant storm events). The longest fetches (distances of open water) for wave development to the study area are to the north and northeast (>600 km). Across much of the proposed cable route, water depths are likely to be sufficiently deep to limit the effect of wave stirring on local seabed sediments, apart from over shallower seabed areas and during events when wave periods are at their maximum.

A broad indication of the regional scale spatial variation of annual mean significant wave height is provided by the Atlas of UK Marine Renewable Energy Resources (ABPmer *et al*., 2008). Within the study area, the annual mean significant wave height reported by the Atlas is approximately 1.5 m, associated with a wave period of approximately 5 s.

Wave observations are also available from field surveys and secondary information collected for the ZEA (EAOW, 2012), with a wave buoy deployed towards the eastern boundary of the study area, between January and July 2011. The key wave characteristics in proximity to the study area include:

- Significant wave height (Hs) is most frequently in the range 0.5 to 1.0 m, accounting for approximately 34% of all records;
- Wave period is most frequently in the range 3.5 s to 4 seconds, accounting for approximately 25% of all records;
- The dominant wave directions are from the south-southwest and north-northeast, with very similar occurrence percentages. These approach directions each account for 17% of all records, as there is no clear geographical trends in relation to the relative dominance; and
- The largest waves are over 4 m in height and come from directions between north and northeast.

The annual mean significant wave height generally increases with distance offshore. Estimates of the annual representative significant wave height for the period between 2010 and 2016 from the SEASTATES wave hindcast database for a location at -28 mLAT is 1.7 m. Similar representative value of the peak wave period is 7 s, these values are used as the representative annual averages in ongoing analyses.

Results of extreme wave analysis completed by Noble Denton (2010) estimated the significant wave height and associated wave period to be 5.2 m and 8 s for the 1-year return period wave event, and 6.2 m and 8.8 s for the 50-year return period wave event, respectively. The largest waves originate from the north, which is associated with the largest fetch distance. There is however a reasonable level of uncertainty associated with these values mainly in relation assumptions applied and measurement errors in the input data.

2.6 Seabed sediment and sediment transport

2.6.1 Seabed sediments

The seabed within the Haisborough SAC is broadly characterised as coarse Holocene sediments, predominantly sand, with pockets of slightly gravelly sand and gravelly sand (BGS, 1984; 1988; 2002; Cameron *et al*., 1992).

Locally, along the cable corridor, benthic grab samples indicate the sediment mainly consists of slightly gravelly sand (Fugro, 2017); with localised areas of more gravelly sand, gravelly sandy mud and sandy gravel (Figure 2).

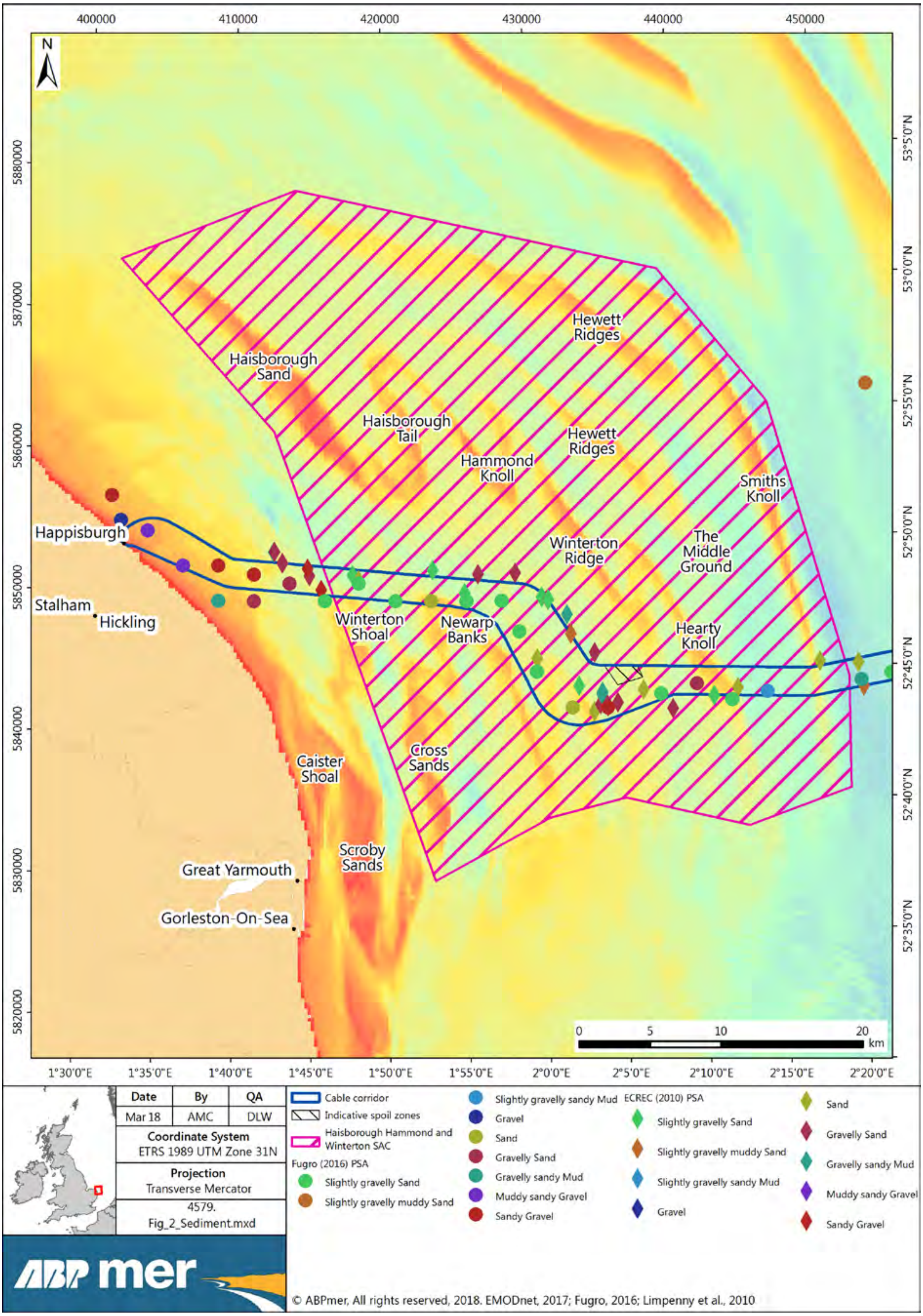

Figure 2. Seabed sediment across the study area

The available sediment samples are characterised as predominantly well-sorted, with limited occurrences of poorly sorted sediment (Fugro, 2017). Typically, up to 90% (by mass) of the sediment is sand, with a median grain size in the range 250 to 500 µm, corresponding to medium sand. Benthic grab samples along the cable route outside of the Haisborough SAC (Fugro, 2017) and the ZEA (MESL, 2011 in EAOW, 2012), indicate there are localised areas of very fine to coarse gravel sized material; however, these are less common along the cable corridor.

2.6.2 Sediment transport

Sediment transport is driven by the combined action of tidal currents, surge, swell and wind-wave currents, the dominance of which are geographically variable across the Southern North Sea (Kenyon, 1970; Chang and Evans, 1992; Barne *et al.*, 1995; 1998; Kenyon and Cooper, 2005). Studies of sediment transport potential and analyses of bedform indicators demonstrate that tidal currents, in particular the residual current magnitude and direction are the dominant process controlling net sand transport in the Southern North Sea (Terwidnt, 1971; Kenyon *et al.*, 1981; McCave and Langhorne, 1982; Stride, 1988; HR Wallingford *et al.*, 2002; Kenyon and Cooper, 2005; Limpenny *et al.*, 2011). Waves may also have an influence on sediment transport in shallower water depths. The relative magnitude of wave effects on local sediment transport is dependent on the combination of local water depth and wave climate.

A conceptual understanding of the sediment transport pathways through the study area are illustrated in Figure 3. These are based on information from modelling studies and identification of transport characteristics from bedform features (HR Wallingford *et al.*, 2002; Kenyon and Cooper, 2005; Cooper *et al.*, 2008). These studies suggest the net sediment transport direction through the study area is towards the north to north-northwest, which is consistent with the migration direction for the sandbank bedforms present (HR Wallingford *et al.*, 2002; Kenyon and Cooper, 2005; Cooper *et al.*, 2008). In addition, the studies also highlight the presence of a bedload parting zone which crosses the study area (Figure 3). The presence of the bedload parting means there is a dominant southerly sediment transport direction to the west and closer to the coast, whereas on the eastern side there is a northerly transport trend. Further influences on the transport regime are from the sandbank bedforms, as these are considered to introduce localised variations and re-circulation patterns (McCave and Langhorne, 1982; HR Wallingford *et al.*, 2002; Collins, *et al.*, 1995). Therefore, the general picture for the study area is of a complex sediment transport regime, determined and influenced by a number of large scale and regional processes. Over longer time scales, it is these properties and the resulting net sediment transport characteristics that controls the morphological evolution of sedimentary features present.

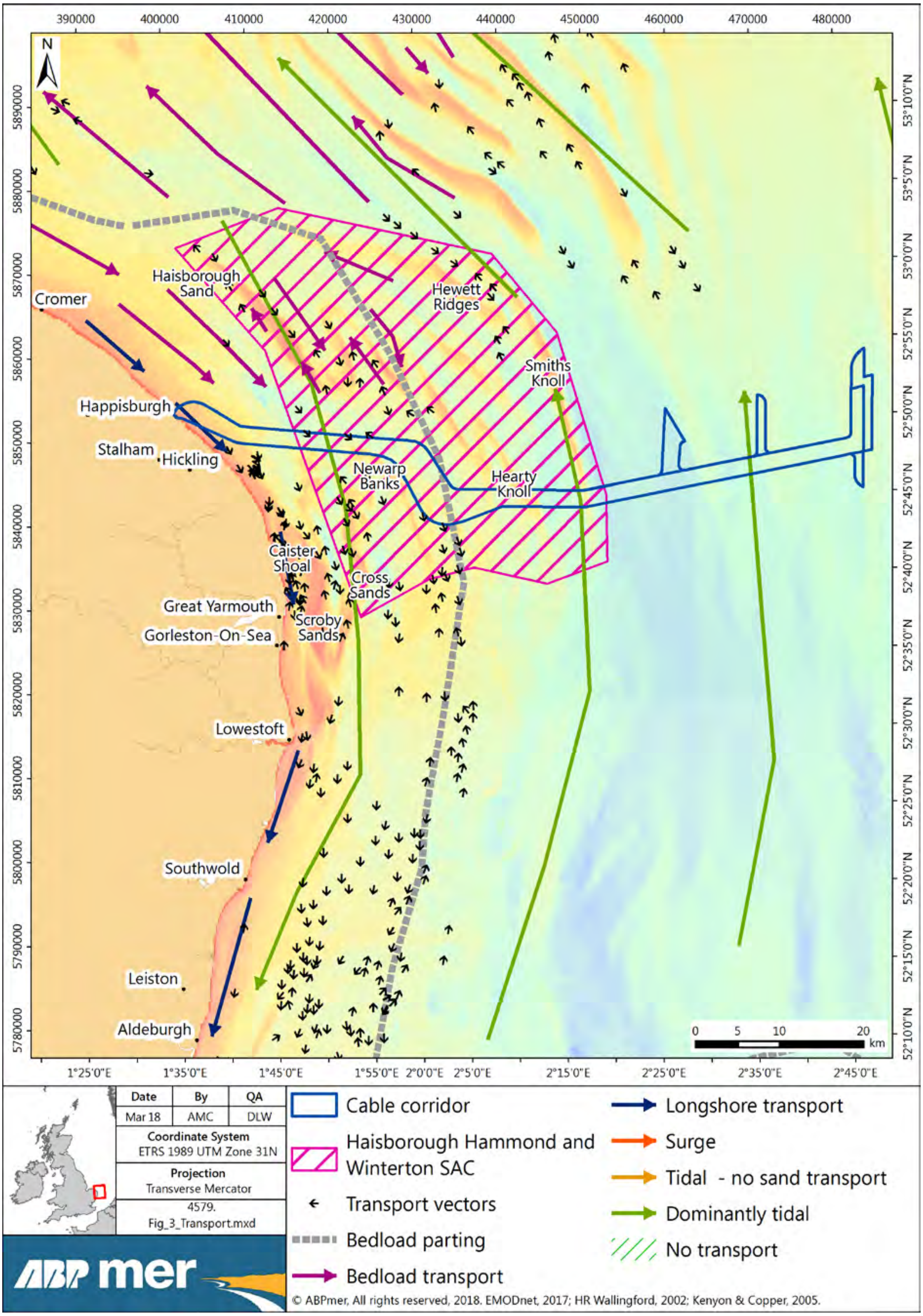

Figure 3. Conceptual sediment transport regime

3 Methodology

3.1 Data sources

In addition to the more general environmental baseline information and data sources described Section 2.1; the following key datasets are used to inform the assessment on potential environmental changes from the proposed bed levelling works:

- High-resolution multibeam bathymetry along the cable route (Fugro, 2016);
- High-resolution multibeam bathymetry (HI1428) from the UKHO obtained from the Inspire bathymetry data centre;
- High-resolution multibeam bathymetry from the East Coast Regional Environmental Characterisation (ECREC) survey in 2010;
- Geotechnical data collected by the East Anglia ZEA (EAOW, 2012);
- Particle Size Analysis (PSA) data from benthic grabs along the cable route (Fugro, 2016) and East Anglia ZEA (EAOW, 2012); and
- BODC observational flow data collected as part of the East Anglia ZEA (EAOW, 2012).

Also, the following regional-scale process investigations are used:

- East Coast Regional Environmental Characterisations (Limpenny *et al*., 2011)
- 'A synthesis of current knowledge on the genesis of the Great Yarmouth and Norfolk Bank Systems' (Cooper *et al*., 2008); and
- Southern North Sea Sediment Transport Study (http://www.sns2.org/index.html)

The methods of analysis applied in this study aim to improve the understanding of the localised seabed and bedform mobility, particularly through:

- Investigation of seabed mobility, bedform evolution and migration properties; and
- Consideration of the potential sediment transport regime throughout the area.

Assessing the potential impacts of the bed levelling activities on the morphology considers the total area and volume of sediment disturbance in relation to the proposed levelling works. Information on the total area and volume of disturbance are summarised in Section 1.2.3. The applied methods of analysis are described in further detail below. They are principally completed for sandwaves that intersect the export cable route. Where necessary, consideration is also given to the sandbanks adjacent to but not directly intersected by the routes.

3.2 Previous monitoring of levelled sandwave recovery at Race Bank Wind Farm

Monitoring data is available on the sandwave recovery pre and post bed levelling from ten locations along the Race Bank export cable route (DONG Energy, 2017). The bathymetric images have been interpreted by ABPmer to provide information on the potential for recovery of dredged sandwaves for cable installation. The interpretations of the bathymetry images are summarised as follows:

- The images illustrate evidence of partial sandwave recovery in the 5-months after levelling, whereby the levelling was mostly transverse to the sandwave alignment.

- At most of the sites, the images indicate the sandwaves were reforming *in situ*. Although the crest height were not at the same point prior to levelling within the 5-month period, the shape and form of the sandwaves were reforming within the levelled area without any significant migration or decay of the adjacent unaffected crest areas.
- The images also suggest movement of smaller bedform features (i.e. interpreted to be ripples and mega-ripples) and potential sediment mobility, but do not demonstrate any sandwave migration. However this may simply relate to the time frame of the monitoring data and the potential migrations characteristics of the sandwaves (i.e. episodic rather than continuous).
- The observed partial recovery is interpreted to relate to the natural infill of the levelled area, potentially through a combination of the contribution from the sediment transport regime and from smaller ripple and mega-ripple bedforms.
- However, at two of the sites, the levelled sandwaves did not appear to have reformed as described above, but instead had developed into separate distinct features, with indications of potential convergence in the future.

ABPmer interpretation of the bathymetry monitoring images indicates sandwave recovery which is consistent with the Race Bank site being in an active and dynamic environment that is conducive to the development and maintenance of sandwave bedforms.

3.3 Analysis methods

A set of analysis methods are applied in order to assess the potential effects of the bed levelling works on the local sandwave and seabed morphology, the sediment transport regime and any potential onward effects on the form and function of the bedforms in the Haisborough SAC. The purpose of each method and its application within this study is described in the sections below.

3.3.1 Analysis of sediment transport potential and seabed mobility

Mobilisation of sediments occurs when the shear stress imposed by the forcing exceeds a critical threshold, which leads to the erosion and transportation of sediments. The bed shear stress required to initiate sediment transport can be estimated using standard approaches and relationships (e.g. as described in Soulsby, 1997). A summary of the sediment types within the cable corridor, along with the respective grain size description and critical bed shear stress for the initiation of sediment transport, are provided in Table 1. Typically, up to 90% (by mass) of the sediment within the cable corridor is sand, with a median grain size in the range 250 to 650 µm, corresponding to medium sand (EAOW, 2012). Therefore, a representative sediment size of 350 µm is used for the analyses of sediment transport potential and direction. Further descriptions of the sediment properties within the study area are in Section 1.

Table 1. Sediment characteristics and the associated bed shear stress threshold

Representative Size (µm)	Size Class (Wentworth)	Bed Shear Stress Threshold (N/m^2)
250	Fine Sand	0.19
350	Medium Sand	0.21
650	Coarse Sand	0.31
2,000	Coarse Sand	1.15
2,500	Very Fine Gravel	1.58
7,000	Fine Gravel	5.89
25,000	Coarse Gravel	21.82

The sediment transport potential, which is an estimate of the amount of material available for transport is used to assess the rate of movement of material across the cable corridor and the Haisborough SAC and therefore the amount of sediment available for reworking. This includes assessing if the dredged or disposal areas pose a potential impact on the sediment transport and resulting seabed morphology within the cable corridor and across the Haisborough SAC. The transport direction is used as a basis to inform where sediment would likely move to and the extent of movement. It is important to note that the analysed transport direction is a representation, with high degrees of variability in relation to the temporally and spatially varying hydrodynamic forcing conditions.

The sediment transport potential across the study area was calculated in response to typical and peak flow speeds under mean spring and neap tidal current conditions, determined from UKHO tidal diamonds in the study area (Section 2.4.2). Consideration was also given to the enhancement of the sediment transport potential by both typical and more extreme wave action that is likely to occur over the operational lifetime of the export cable route, as defined for the nearby ZEA (EAOW, 2012) and described in Sections 2.4.4 and 2.5. The relationships used to estimate the resulting sediment transport rates are the total load transport equations as a result of combined currents and waves, as described in Soulsby (1997).

To further explore the transport potential over a longer time frame, a time series of current and wave characteristics were obtained from the SEASTATES hindcast databases (ABPmer. 2013; 2017) for the period between 01/01/2006 and 31/12/2016 (i.e. 11-year period). The associated bed shear stress was calculated for the current and wave only instances, in addition to the combined case, to account for varying forcing mechanisms. The results were used to assess the transport potential over the time frame and the proportion of time the characteristic site seabed sediment (350 µm) would be mobile. Other sediment sizes, including fine sand and very fine gravel (Table 1) were also assessed at different depths to inform how the transport potential varied. The current speeds and wave parameters used to assess transport potential are described for the study area in Section 2.4 and 2.5.

The sediment transport direction was calculated using the time series of current and wave properties for four locations within the proposed cable corridor (Figure 1). This was carried out for the period between 2006 and 2016 (11 years, inclusive), using data obtained from the SEASTATES hindcast database. To inform this, a progressive vector analysis method was applied to demonstrate the relative sediment transport magnitude and direction across the locations. A description of the method is provided further below.

Transport potential due to tidal currents

Within the study area, the behaviour of the sediment regime is primarily determined by the response of sediments to the applied hydrodynamic forces. Tidal currents are the most frequently occurring and persistent process controlling sediment transport through the study area. However, there can also be contributions from storm events, which can result in short but sharp influences on the transport, after which the tides then control the transport again.

The bed shear stress and sediment mobility potential for the study area are estimated in Table 2. These use relationships contained in Soulsby (1997) and described in Appendix A, for the peak mean spring and neap current speeds of approximately 1.29 and 0.72 m/s (Section 2.4.2) and assuming a representative water depth of -28 mLAT, based on site properties described in Section 2.2.

For the purpose of providing a representative 'everyday' condition, a nominal typical current speed of 0.5 m/s is also considered, as this current speed will be met or exceeded on almost every tide (i.e. several times every day). The estimated bed shear stress and resulting sediment transport rate is sensitive to the 'roughness' of the seabed, with a coarse grained and/or undulating seabed inducing greater flow turbulence and bed shear stress than otherwise encountered with a smooth, flat seabed. For these calculations, the seabed is assumed to consist of medium sand with a D_{50} value of 350 µm. The bed shear stress as a result of the forcing (Table 2) is compared against the mobility threshold for different sediment sizes (Table 1) to infer which material would be moved because of the forcing (Table 2).

Table 2. Summary of sediment mobility due to tidal currents

Tidal Condition	Peak Current Speed (m/s)	Resultant Bed Shear Stress (N/m²)	Mobility Statement (Based on Thresholds in Table 1)
Typical	0.50	0.21	Mobility up to medium sand (~350 µm)
Peak mean spring	1.29	1.39	Mobility up to coarse sand (~650 µm)
Peak mean neap	0.72	0.43	Mobility up to coarse sand (~650 µm)

As shown in Table 2, coarse sand size and smaller material are potentially mobile during peak flow conditions on both mean spring and neap tides. Based on the mobility thresholds for different grain sizes (Table 1), the mean neap tidal currents with a shear stress of 0.43 N/m² are only sufficient to mobilise coarse sands up to 650 µm (i.e. threshold of 0.31 N/m²). Spring currents with a shear stress of up to 1.39 N/m² would mobilise coarse sands up to 2000 µm (i.e. threshold of 1.15 N/m²).

Higher peak current speeds tend to occur during the ebb tide (EAOW, 2012), which will generally promote the north-north-westerly transport of material. This transport direction is consistent with the available historical studies in terms of the directions of both net sediment transport (medium sand) and bedform migration in the area.

Transport potential due to waves

Waves in relatively shallow water produce an oscillatory movement of water at the seabed which can help to mobilise sediments. The magnitude of the wave induced flow is a function of the wavelength (related to the wave period), the wave height and the water depth. Relatively longer wavelengths associated with swell conditions influence the movement of water to a greater depth and so can contribute to sediment mobility in relatively deeper water. The wave induced motion is largely symmetrical in deeper water (relative to the wave length) and so actual net transport of sediment as a result of wave action alone is expected to be typically limited in the study area.

The bed shear stress and sediment mobility potential in the study area are estimated in Table 3. These use relationships contained in Soulsby (1997) and described in Appendix A, for wave properties (in the absence of currents) summarised in Section 2.5 and assuming a representative water depth of -28 mLAT, based on site properties described in Section 2.2.

The wavelengths and periods of waves required to initiate sediment transport within the study area will vary with depth. In this way, material in shallower water will become mobile under relatively smaller wave conditions, whilst in deeper water, larger wave events would be required to mobilise an equivalent class of sediment.

Table 3 shows that annual average wave conditions (alone) would be insufficient to mobilise the characteristic sediment types in the study area (such as medium sand at 350 µm). Less frequently, the 1-year extreme return period wave event has the potential to mobilise up to coarse sand, while a 50-year wave event has the potential to mobilise up to very fine gravel (~2,500 µm). Although wave events can theoretically mobilise larger sediment sizes, this occurs infrequently and only for a very short period of time.

Table 3. Extreme and typical wave conditions and resulting sediment mobility

Wave Event	Significant Wave Height (m)	Wave Peak Period (s)	Resultant Bed Shear Stress (N/m²)	Comment
Representative annual average	1.7	6.7	0.14	Not sufficient to mobilise sand
Representative 1-year	5.2	8.0	1.52	Mobility up to coarse sand (~650 μm)
Representative 10-year	5.8	8.5	2.08	Mobility up to very fine gravel (~2,500 μm)
Representative 50-year	6.2	8.8	2.47	Mobility up to very fine gravel (~2,500 μm)

Transport potential due to combined tidal currents and waves

The bed shear stress and sediment mobility potential in the study area are estimated in Table 4. These use relationships contained in Soulsby (1997) and described in Appendix A, for a combination of current and wave forcing summarised in Sections 2.4.2 and 2.5 and assuming a representative water depth of -28 mLAT, based on site properties described in Section 2.2.

Table 4. Summary of sediment mobility due to combined tidal currents and waves

Wave Event	Significant Wave Height (m)	Wave Peak Period (s)	Current Speed (m/s)	Resultant Peak Bed Shear Stress (N/m²)	Comment
Representative annual average	1.7	6.7	Typical: 0.5	0.34	Mobility up to coarse sand (~650 μm)
			Spring: 1.29	1.90	Mobility up to very fine gravel (~2,500 μm)
			Neap: 0.72	0.65	Mobility up to coarse sand (~650 μm)
Representative 1-year	5.2	8.0	Typical: 0.5	0.63	Mobility up to coarse sand (~650 μm)
			Spring: 1.29	2.76	Mobility up to very fine gravel (~2,500 μm)
			Neap: 0.72	1.10	Mobility up to coarse sand (~650 μm)
Representative 10-year	5.8	8.5	Typical: 0.5	0.72	Mobility up to coarse sand (~650 μm)
			Spring: 1.29	3.00	Mobility up to very fine gravel (~2,250 μm)
			Neap: 0.72	1.22	Mobility up to coarse sand (~2,000 μm)
Representative 50-year	6.2	8.8	Typical: 0.5	0.77	Mobility up to coarse sand (~650 μm)
			Spring: 1.29	3.15	Mobility up to very fine gravel (~2,500 μm)
			Neap: 0.72	1.31	Mobility up to coarse sand (~2,000 μm)

A nominal typical current speed of 0.5 m/s is again used as a representative 'everyday' condition. Under more 'typical' wave conditions (annual average), there is potential for the mobility of gravel and coarse sand under peak spring and neap tidal conditions, respectively, which would mean the transport of medium sand (350 µm) characteristics to the cable corridor. With suitable water depths and sediment availability, sandwaves begin to develop with flow speeds of 0.5 m/s and above (Belderson *et al.*, 1982), as typically experienced within the study area. When larger extreme wave events are coupled with peak spring and neap tidal currents, sediments up to very fine gravel (~2,500 µm) size can theoretically be mobilised. However, it is noted that this higher level of mobility will only take place for a limited time during peak flow conditions and under infrequent extreme events.

A comparison of the bed shear stresses generated by tidal currents (Table 2) and waves alone (Table 3) would indicate that under 'typical' wave conditions (i.e. annual average), tidal currents predominantly control the potential for sediment mobility as waves are insufficient to mobilise sediment. However, the combined influence of tides and waves would increase the mobility potential over that from tides alone and the occurrence of extreme events has the potential to increase sediment mobility.

The potential volumetric sediment transport rate (i.e. the rate that would occur with an unlimited supply of sediment present for transport) for the range of sand grain sizes found in the study area are estimated in Table 5. These use relationships contained in Soulsby (1997) and described in Appendix A, for a combination of current and wave forcing summarised in Sections 2.4.2 and 2.5. They assume a representative water depth of -28 mLAT based on site properties described in Section 2.2. The estimates are representative of the typical and higher rates at which sands might be transported over the seabed to contribute to the processes considered in this study, such as bedform migration, including dispersion of dredged sediment and infill of the levelled sandwave crests.

Table 5. Summary of potential sediment transport rates for sand in the study area due to combined tidal currents and waves

Wave Event	Current Speed (m/s)	Potential Sediment Transport Rate for Fine Sand at 250 µm (m^3/m/hour)	Potential Sediment Transport Rate for Medium Sand at 350 µm (m^3/m/hour)	Potential Sediment Transport Rate for Coarse Sand at 500 µm (m^3/m/hour)
Representative annual average waves	Typical: 0.5	0.02	0.02	0.01
	Spring: 1.29	3.35	2.71	2.04
	Neap: 0.72	0.18	0.17	0.11
Representative 1-year storm	Typical: 0.5	2.98	2.36	2.29
	Spring: 1.29	15.47	11.30	10.34
	Neap: 0.72	5.89	3.87	3.62
Representative 10-year storm	Typical: 0.5	7.28	4.80	3.96
	Spring: 1.29	27.68	12.21	14.04
	Neap: 0.72	11.88	8.30	5.39
Representative 50-year storm	Typical: 0.5	10.70	7.94	4.94
	Spring: 1.29	34.54	27.70	18.11
	Neap: 0.72	13.93	12.39	8.02

It is noted that these estimates of sediment transport potential are empirical in nature (i.e. based on a limited range of observed conditions) and the absolute rates are therefore subject to uncertainty (a discussion is provided in Soulsby, 1997). However, by using a consistent approach (as used in the present study), greater confidence can be placed in any relative comparisons of predicted rates than placing reliance on a single value.

Sediment transport direction

Initial investigations presented the sediment transport magnitude and described this in relation to the recognised sediment transport pathways across the study area. A request for further information was raised by Natural England regarding the direction of sediment transport, particularly in relation to sediment disposal. To inform the answer, progressive vector analysis (PVA) has been applied to investigate the relative net magnitude and direction of potential sand transport in four areas of the study area within the cable corridor (Figure 1). Due to the varying depths that occur across the study area, three depths are assessed using PVA. These are carried out at -16 mLAT as a representation of the depths over the sandbanks, at -31 mLAT, which is the representative depth within the indicative spoil zone and at -50 mLAT, which relates to the deepest depths within the cable corridor.

The long-term net sediment transport pathways within the study area and the wider Southern North Sea occur mainly as a result of the tidal asymmetry (HR Wallingford *et al*., 2002), with the potential for local variations and re-circulation in relation to the larger scale bedforms which are present (Section 2.6.2). PVA is carried out to investigate the effect of the tidal asymmetry and the contribution of occasional storm surge and wave events, more locally within the study area on the net sediment transport. Tide and surge water levels, currents, wave heights and wave period time series data from the ABPmer SEASTATES hindcast database (ABPmer, 2017) have been used to support the PVA.

When using PVA results the following should be taken into consideration:

- PVA provides an estimate of the long term (net) magnitude and direction of potential sediment transport relative to a fixed location (i.e. a Eularian analysis). It therefore provides an indication of the general magnitude and direction of residual sediment displacement through that location over the assessed period of time. Due to inherent uncertainties in the accuracy of the estimates of sediment transport at any given point in time, only relative differences in the magnitude and direction of the PVA results should be compared between the different locations.
- PVA for an individual site or area alone does not provide a reliable description of the long-term path taken by sediment in transport through it (i.e. a Lagrangian analysis). This is because, as the sediment is transported away from the location being assessed, it will be subject to different water depths, flow and wave conditions, etc. However, spatial patterns in the magnitude and direction of PVA results for multiple locations can provide a more reliable basis for the estimation of likely net sediment transport paths through a region.
- When considering the long-term transport direction of a particular grain or body of sediment it is also likely that, in practice, sediment grains will only be transported short distances before becoming buried at a lower level in or even below the active part of the seabed surface, or incorporated into larger bedforms, and may not be transported further until exposed again at some point in the future.

3.3.2 Analysis of sediment deposition extent and thickness

Analysis of the potential deposition extent and resulting sediment thickness or change in bed levels that could arise as a result of the disposal of dredged material was undertaken in order to address the request for further details from Natural England.

The study has used a worst case disposal scenario. This scenario assumes all of the dredged material is deposited within a single indicative spoil zone within the export cable corridor (Figure 1), where water depths range between -26 and -37 mLAT. The analysis completed for the sediment deposition extent and thickness is based on the disposal scenarios only (i.e. released at the surface or at the seabed) into the single indicative spoil zone (Figure 1). It does not include material overspill during the dredging, although this would be minor in proportion.

Sediment released into the water column during disposal of the dredged material will settle downwards at a rate depending upon its grain size. On initial release from the hopper, it is assumed around 90% of the material released will fall directly to the seabed as a single mass in the 'dynamic phase'. The remaining 10% of material would then be shed from the dynamic phase during its descent to the seabed and enters suspension, termed the 'passive phase' of the plume. In the passive phase, the sediment plume will be advected away from the point of release by any currents that are present and will also be dispersed laterally by turbulent diffusion. The horizontal advection distance will be related to the flow speed and the physical properties of the sediment. The resulting sediment thickness will be a combination of the deposition during the dynamic and passive phases.

Once deposited to the seabed, the previously dredged sediment will be of a similar type and similarly mobile to the surrounding seabed material. Any subsequent transport of the deposited or surrounding sediment will be generally at the same rate and in the same direction as would happen naturally, irrespective of the dredging and disposal activity.

To assess the potential impact from disposal, two disposal sediment release mechanisms are considered for their deposition extent and thickness, namely the release of dredged material from the hopper at the sea surface and discharged through a downpipe at approximately 5 m above the seabed.

The exact pattern of sediment deposition at the seabed will depend on the disposal method (i.e. at the surface using a split bottom barge or at the seabed via a downpipe), sediment type and the ambient environmental conditions at the time of the event, which may all be variable. However, given the total volume of sediment, a range of potential alternative combinations of extent, thickness and shape can be calculated. For example, for a given sediment volume, a smaller area of extent will correspond to a greater thickness of accumulation, and *vice versa*. A steeper sided cone shape deposit will have a greater thickness and a smaller area of change than a less steep sided cone or flat deposit shape. For the proposed disposal, a range of deposition scenarios are assessed, which include:

- The maximum possible thickness, associated with the smallest footprint or extent of impact;
- The different thicknesses and footprints associated with varying spoil deposition 'cones';
- The maximum thickness from a single disposal from the hopper compared with the cumulative thickness associated with multiple disposal events; and
- The most extensive accumulation over the entire indicative spoil zone and the resulting thickness.

More concentrated and localised deposits of coarse sediments are assumed to deposit naturally into a cone shape where the maximum thickness is in the centre of the deposit and thickness decreases gradually from the centre towards the edges. Operationally, very thick deposits in shallow water may affect safe navigation or other engineering considerations and so would not be planned or allowed to occur. The greatest possible thickness (at the central point of the cone, also corresponding to the smallest possible area) is associated with a cone that has the steepest possible slope angle (i.e. the angle of repose for such loose sediments = 32°). The height of cones with two and three times the diameter of the steepest cone is provided for comparison. The largest possible areas impacted by uniformly distributed thicknesses of 0.5, 0.25 and 0.05 m are also provided (making no assumptions regarding the shape of the area) along with the deposition thickness associated with a uniform disposal within the indicative spoil zone (Figure 1).

The above methods are used to consider the main mass of spoil in the active phase (90% of the material volume in the hopper), which will descend rapidly to the seabed as a single unit irrespective of the detail of sediment properties. The remaining sediment volume (10%) in the passive phase will settle according to the properties of the individual sediment grains. Coarser grained (e.g. sand/ gravel) sediments, will settle out of suspension quickly (e.g. in the order of seconds to minutes) over a smaller area. Finer grained (e.g. silt/ clay) sediments would remain in suspension for a longer period of time (in the order of hours to days), potentially affecting a larger area, but at a progressively reducing concentration due to ongoing advection and dispersion.

To estimate the potentially greater extent but limited thickness of deposit associated with settlement of the passive phase, the representative water depth and current speed are used to determine the horizontal plume footprint at the seabed (accounting for horizontal advection and dispersion during settling). The maximum average deposition thickness is then estimated as the total volume of sediment in the passive phase, divided by the deposition footprint area on the seabed. The likelihood of a combined effect on seabed levels through overlap of the active and passive phases is greater when the passive phase contains mainly coarser material.

The above methods are used to estimate the dimensions of spoil mounds resulting from individual disposal events, however, multiple dredging cycles will be required.

To analyse the potential changes to the bed levels and deposition extent based on the total proposed disposal volumes, a number of spreadsheet based numerical models have been developed. Such models are used regularly to inform the EIA for both dredging and disposal activities and apply the following information, assumptions and principles:

- A hopper volume of 14,000 m^3 is used as the representative maximum sediment volume to be disposed during any one event. The hopper capacity is less than the proposed dredge volumes, as a result, several dredge and disposal events will be needed;
- A representative current speed of 0.5 m/s is used as an indication of the typical everyday condition for the site (Section 3.3.1), in order to inform the deposition extent. Assuming a higher value will increase dispersion of the passive phase as it descends through the water column and reduce the thickness of subsequent deposits and *vice versa*; and
- For the purpose is estimating the settling rate and deposition extent, it is assumed that the sediments released will comprise of medium sands with a representative grain size of 350 μm and settling rate of 0.5 m/s. Also, the material would be released into the indicative spoil zone with a representative mean depth of 31 m.

Results of this analysis are presented and discussed further in Section 4.3.

3.3.3 Analysis of sandwave orientation, wavelength and asymmetry

To inform the sandwave properties, bathymetry transects were extracted from a subset of representative sandwave features within the cable corridor, using the Fugro (2016) bathymetric survey data. The bathymetry transects were orientated perpendicular to the dominant crest alignment (crests are aligned approximately east to west) (Figure 4). The key dimensions (height, wavelength, slope steepness and asymmetry) of individual sandwave features were characterised (Figure 4).

Using the transect data the sandwave height was determined as the elevation of the crest relative to the level of the adjacent troughs. The wavelength was determined as the distance between sandwave crests. The steepness of the bedform slopes was calculated based on the local bed level gradients. The sandwave asymmetry (an indicator of the sandwave migration direction) was calculated as the ratio of the length of the slopes (measured from crest to trough) either side of the crest.

3.3.4 Analysis of sandwave migration rate

The sandwave migration rate was calculated to investigate the rate at which the bedforms are moving and the likelihood of a new morphology baseline forming, from which future change occurs. To estimate the migration rate, directly comparable bathymetry transects were extracted from the site specific Fugro (2016), UKHO (2014) and ECREC (2010) bathymetries. Both the UKHO and ECREC bathymetries had previously been corrected to the same spatial and vertical datums (i.e. ETRS89 31N and LAT respectively) as the Fugro bathymetry. The position and character of key bathymetric features (e.g. the position and elevation of individual sandwave crests) were noted and compared. The movement of the sandwave crests along a transect chainage between the surveys was used to indicate the direction and rate of bedform migration (Figure 4).

The migration rates varied within each bedform field and more broadly across the study area. An average rate of about 16 m/year was calculated with an associated standard deviation of ±10 m/year, for the period between 2014 and 2016 for the assessed sandwaves across the analysis transects. The minimum and maximum rates within the same period were 4 and 34 m/year respectively. Faster rates generally occurred in relation to the sandwaves located on Newarp Banks (Transects 1 and 2, Figure 4, while slower rates occurred with the sandwave field east of Newarp Banks (Transect 3, Figure 4).

3.3.5 Analysis of sandwave sediment volumes

The approximate volume of material associated with the sandwave bedform field was calculated as a proxy estimate of the sediment volume available for transport by natural processes. Three sandwave fields, as illustrated in Figure 5 were assessed for their potential sediment volumes. The estimation of available volume was based on a plane depth at the base of the sandwaves, on the main body of the sandbank, rather than the base of the sandbanks or Holocene sediment unit. The volume was calculated as the total volume of the three-dimensional shape formed between the applied plane depth and the seabed surface. In doing so, it is the case that part of the main body of the underlying sandbank was also included in the volume and smaller sandwaves on the flanks of the sandbank were potentially under-represented. Calculations were made using the ESRI ArcGIS spatial analysis software based on the UKHO (2014) bathymetry due to it wider coverage over the bedforms. The estimated sediment volumes in relation to each sandwave field is summarised in Table 6 below.

Table 6. Estimated sediment volume from sandwave fields

Location	Estimated Sediment Volume (million m^3)
Main body of Newarp Bank	76
Newarp Bank "Tail"	40
Sandwave field east of Newarp Bank	112

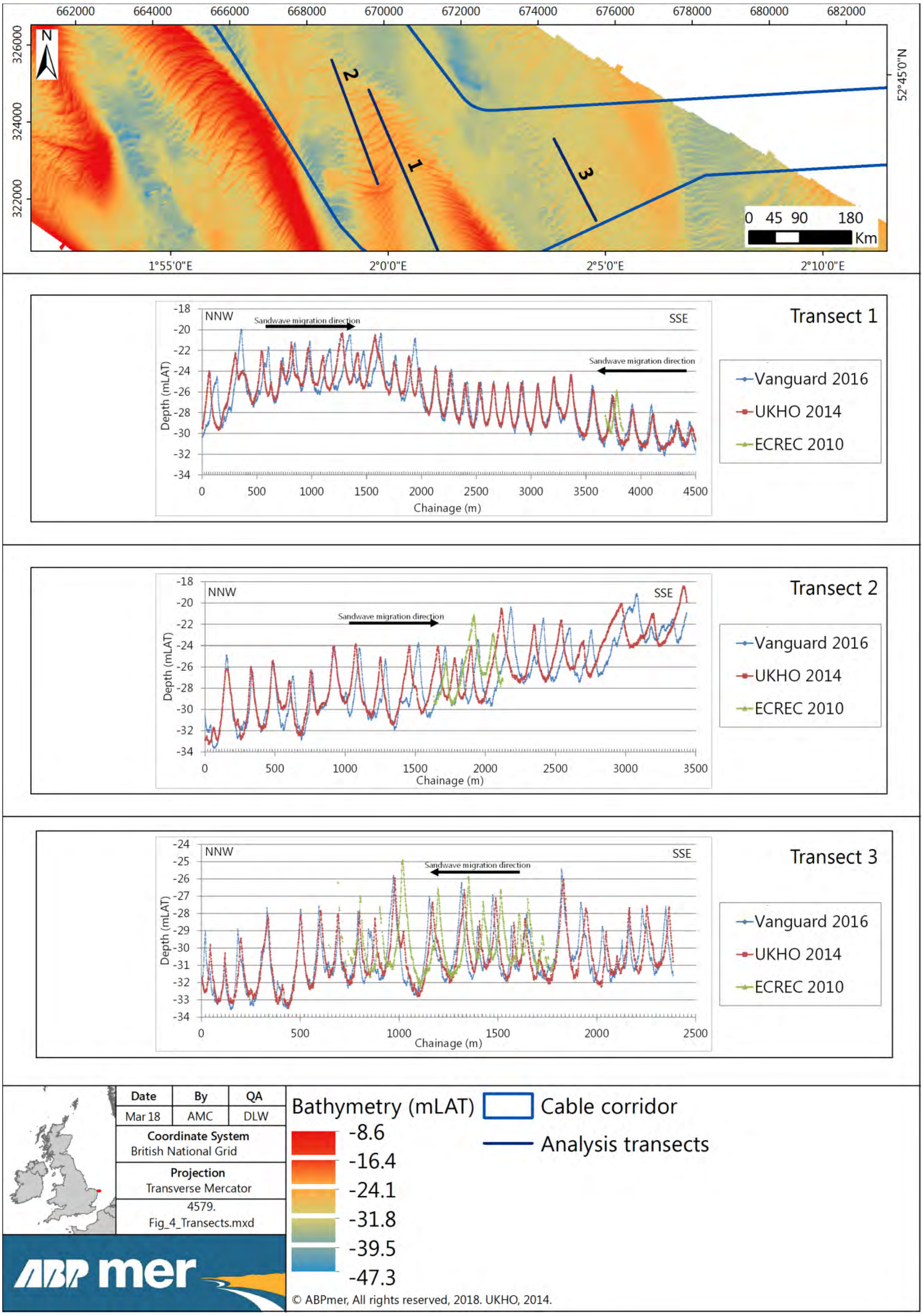

Figure 4. Analysis transects and assessed migration directions

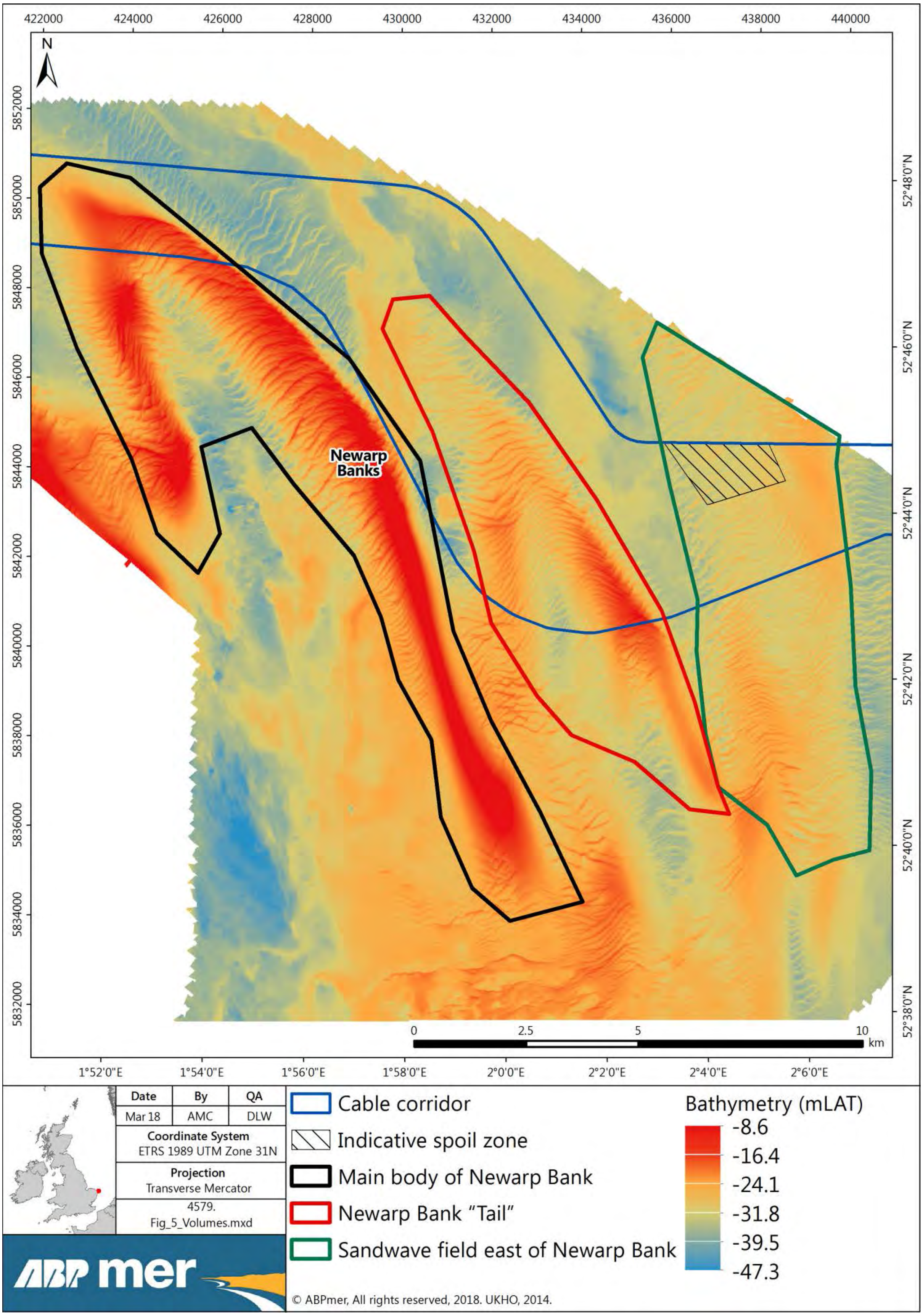

Figure 5. Assessed sandwave fields

4 Assessment

4.1 Potential effects on seabed morphology

Sediment re-circulation patterns were identified around the sandbanks within the Haisborough SAC (Section 2.3). The potential for such re-circulations have also been identified more locally on the Newarp Banks along the cable corridor, with both northerly and southerly movement at different locations, which may also relate to the presences of a bedload parting zone. Therefore, any potential changes to sediment thickness caused by dredging and disposal of material will in the short term only affecting very local areas to the south-southeast or north-northwest. Due to the presence of the parting zone, these patterns could potentially continue in the long term, so that to the east of the zone, areas to the north-northwest would potentially be affected over greater distances. To the west of the zone, areas to the south-southeast would then be affected. Any deposited material can be considered to move in the same net directions.

The analysis of potential sediment transport results for a time series of tide and wave conditions for the period between 01/012006 and 31/12/2016 (i.e. 11-years), obtained from the SEASTATES hindcast database (ABPmer, 2013; 2017) is included in (Table 7). This information was used to assess the proportion of time different sediment is above the threshold for transport at different depths within the study area. The results highlight the dynamic properties of the study area and the contribution from the sediment transport processes into the seabed morphology across the Haisborough SAC.

Table 7. Proportion of time sediment is mobile, based on SEASTATES data for 2006-2016

Scenarios	Tidal Currents Only	Waves Only	Combined Tides and Waves
Fine sand, sandbank and sandwave crests	75%	55%	92%
Fine sand, sandbank and sandwave flanks	71%	5%	87%
Fine sand, sandbank and sandwave troughs	69%	<1%	86%
Medium sand, sandbank and sandwave crests	74%	52%	91%
Medium sand, sandbank and sandwave flanks	71%	5%	86%
Medium sand, sandbank and sandwave troughs	69%	<1%	85%
Very fine gravel, sandbank and sandwave crests	35%	20%	67%
Very fine gravel, sandbank and sandwave flanks	25%	<1%	55%
Very fine gravel, sandbank and sandwave troughs	20%	<1%	51%
Fine sand is 250 µm; Medium sand is 350 µm; Very fine gravel is 2500 µm. Sandwave crests at -13 mLAT; flanks at -28 mLAT and troughs at -40 mLAT.			

The SEASTATES time series data for the study area, suggests the mobility of material under the combined influence of tides and waves is a more realistic estimate of the conditions that can be expected within the Haisborough SAC. On the occasions when the seabed is mobilised, sand and to a lesser degree gravel, will be locally redistributed, at the instantaneous transport rate, to infill dredge trenches or level out deposition mounds. Any transported sediment would move in the broad directions described above.

For the bed levelled areas, it may be that the dredged trenches act as localised and temporary sediment sinks for a period of time, however, the wider sediment transport processes will still continue uninterrupted. The maximum rate of sediment accumulation will be at the ambient rate of transport although the net rate of infill may be lower due to simultaneous transport out of the area. An assessment of effect of seabed lowering from aggregate dredging indicates that dredge pockets can result in small decreases in flow speeds within the dredge pocket and its immediate area (ABPmer, 2014). However, the effect on the flow speeds from the proposed levelled area will be much smaller. This is mainly due to the difference in scales between the aggregate dredge pocket and the bed levelling trenches. The proposed bed levelling approach states that the levelling area will have a nominal width of 7 m (plus side slopes) for each cable (CWind, 2017 unpublished). This is small compared with the aggregate dredge pocket with widths of several kilometres (ABPmer, 2014). Therefore, any effect from the trenches on the flow will be minimal and localised to the levelled area. Due to the localised variations in flow speeds and the re-circulations present, it is most likely that any changes in the flow properties as a result of the levelled area will be undiscernible from the background variations.

Similar variations are observed in the wave regime for the aggregate sites, for the same reasons as described for the flow properties. Therefore, the proposed levelling area is again likely to have no effect on the wave regime. As the proposed levelling area will not disrupt the wave regime across this part of the Southern North Sea, any contributions to the sediment transport from waves should then continue undisrupted across the study area.

Results of the PVA provide an illustration of the long term general direction and magnitude of the residual sediment movement through the assessed locations (Figure 6). This is based on a representative grain size of 350 µm) over the 11 year period. The results highlight dominant northerly transport direction, although there is a slight variation (towards the north-northeast) with increasing depth. The exception to the above is Location 3, whereby the trend is more to the northeast, which is due to variances in the flow and wave fields represented within the SEASTATES data. The described variations are considered to relate to difference in the flow field as represented within the hindcast datasets. Also represented within the graphs are infrequent but significant changes to the sediment transport direction (Figure 6). During these events, the transport is more towards the west and northwest and is represented at all four locations. The events occur a number of times within the assessed time period (i.e. 2006 to 2016) (Figure 6) and relate to larger storm events, with sustained significant wave heights of over 3 m.

In terms of the transport magnitude, the progressive vector results illustrate the largest magnitudes occur at the shallower assessed depth (i.e. -16 mLAT which occurs on the sandbank crests), with cumulative transport rates of up to 12,000 m^3/m over the 11-year period. Based on the tide and wave properties at the same location, but for deeper depths, the cumulative rates are less than half. This would mean that within the study area, shallower areas would have larger transport rates, more than double that would occur at deeper locations. In relation to the proposed works, these are likely to occur at varying depths as the cable routes transect the sandbank features, which are the bedforms that contribute to the largest depth changes. Therefore, varying transport magnitudes can be expected at the different locations where levelling and disposal are to occur.

Natural England questioned whether any of the disturbed sediment (through dredging and subsequent disposal) would be lost from within the SAC. The likelihood of any disturbed material being lost from the Haisborough SAC is considered to be minimal. Previous studies (HR Wallingford *et al.*, 2002; Kenyon and Cooper, 2005; Cooper *et al.*, 2008), as well as the PVA results, demonstrate a distinctive northerly net transport pathway and the boundary in this direction is many kilometres away. Also, when considering the long-term transport direction of a body of sediment, sediment grains will only be transported short distances before becoming buried at a lower level in or even below the active part of the seabed surface, or incorporated into larger bedforms, and may not be transported further until exposed again at some point in the future.

The Haisborough SAC is not a closed system and it presently has sediment both entering and leaving it around the boundaries. The proposed works are some distance from the boundaries (over 6 km from the southern boundary) and are unlikely to bring about any disruption to the transport regime discussed above. Therefore, the movement in and out of the Haisborough SAC as occurs at present will continue, irrespective of the proposed dredging or disposal activities.

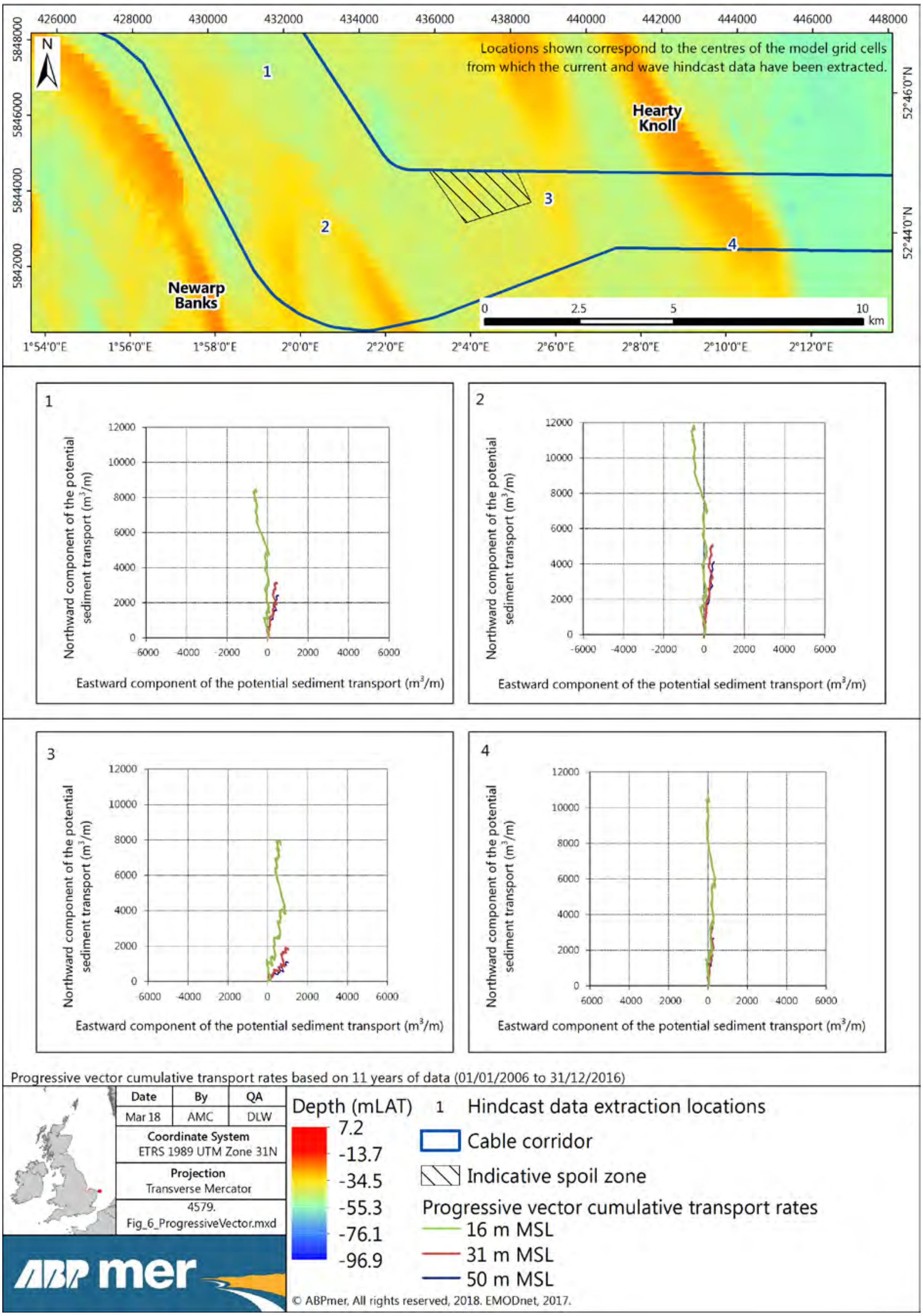

Figure 6. Progressive vector analysis

4.2 Potential effects on sandwave morphology

4.2.1 Introduction

The present study area is also an active and dynamic sediment environment that is conducive to the development and maintenance of sandwave bedforms. This is in relation to the flow speeds, water depths and sediment availability. Evidence of sandwave migration, along with bifurcating and converging sandwaves means the sandwaves are continually evolving with the formation of new bedforms. The availability of sand to form the bedforms as a result of the sediment transport processes and its continuation means there is ongoing potential for new bedforms to be established within the study area, a process which will not be disrupted by the proposed bed levelling works.

The cable orientation in relation to the sandwaves requiring levelling within the study area is mostly transverse to the bedform alignment and migration direction. This is particularly the case for the sandwaves overlying the Newarp Banks. In these instances, only a section of each sandwave is being levelled.

There can be varying asymmetry and migration properties along the length of a single sandwave, which does not necessarily disrupt the overall functioning of that particular sandwave or the system as a whole. The same can be implied for the proposed levelling works, in that the works affect a limited area of each sandwave, but the sandwave can continue to evolve and migrate along the remainder of its length. This is because, the processes that determine or influence the sandwave properties are not affected by the bed levelling works, therefore the form and function of the system (inclusive of the sandwaves and sandbanks) should continue unaffected. This is a process that is also evident from the sandwave response at the assessed sites along the Race Bank export cable route (DONG Energy, 2017).

In the sandwave field east of the Newarp Banks, the cable corridor is orientated roughly parallel to the bedform alignment, in these instances broader sections of the sandwave would be levelled. This has the potential to affect a number of sandwaves, potentially levelling a larger proportion of each sandwave than elsewhere along the corridor. In these cases, the area and volume of material being affected would be large in respect to each sandwave. It would however be minimal in the context of the sandwave field and sandbank as a whole which comprises of a large number of sandwaves. Furthermore, the current speeds, sediment availability and water depth are all conducive to the formation of new sandwaves. Therefore, despite the levelling of the sandwaves that intersect the cable corridor, the overall form and function of this sandwave field will remain undisturbed, with potentially new sandwaves being formed in time. Furthermore, the effects are limited to the overlying sandwaves, the form and function of the sandbanks within the Haisborough SAC would not be disrupted.

The sediment transport regime through the study area is governed by tidal processes, with notable influence from storm events, which can alter the transport direction and magnitude (Section 4.1 and Figure 6). Both of these processes occur at a larger scale to the proposed bed levelling works. As the works are not considered to disrupt these characteristics, the sediment transport is also not likely to be disrupted. The sediment transport potential based on predicted tide and wave conditions that occur within the study area is summarised in Table 5 and Table 7.

4.2.2 Norfolk Vanguard cable route

Section 1.2 summarises the proposed phased cable installation approach, whereby there is a gap of 6 to 24 months between the installation of each of the two cable pairs, for each windfarm. The proposed cable routes cross a number of sandwaves, for which a nominal volume of 35 m^3 per metre width was estimated as a representative sandwave cross section area requiring dredging. The potential dredge volumes from individual sandwaves (35 m^3/m) divided by the prevailing sediment transport rates (m^3/m/hr) described in Table 5 suggests that a volume of sediment equivalent to the dredged volume could be naturally transported back into each dredged area within the order of few months to years, depending on the frequency and magnitude of larger storms. This is due to the prevailing transport rates (Table 5) and sediment will be simultaneously moving into, through, and out of the dredged area.

In addition, due to the (mostly) northerly sandwave migration, with rates of 4 to over 30 m/year, it is again likely that in the time it takes the levelled area to reform (as a result of sediment infill, re-emergence of bedforms or up drift sandwaves migrating through), the sandwave, including the originally levelled area, would have moved and have been reshaped due to mobility, migration properties and the environment they are located. This means that the sandwaves are unlikely to return to their original shape and position, but their onward migration would continue uninterrupted. At the same time, as established sandwaves migrate out of an area, new sandwaves would continue to be naturally formed and migrate through. It is also possible that in the time it takes the levelled area to reform, or for the sandwaves to migrate onwards, the governing processes will act to bifurcate or converge the sandwave features.

The described sandwave response post-dredge would expect to start immediately after bed levelling. The length of time between each phase will then determine how much migration or reshaping the levelled sandwave will undergo. In terms of both HVDC cable pairs, there is an expected separation of 75 m. Based on the assessed migration rate for the sandwaves, there is the potential that any levelled sandwaves could undergo reshaping and migrate into the location of the next planned sandwave clearance area within the interval between phases of installation. This is most likely to occur with the fastest moving sandwaves (i.e. over 30 m/year) with the longest construction hiatus (i.e. 24 months).

In these instances, it is possible that the form of the affected sandwaves could be altered to a greater extent locally, affecting the timescale and nature of the recovery for that sandwave section. It is also possible, however, that a partially recovered section of sandwave that migrates closer to another location requiring levelling at a later date could then present a smaller local cross-section or volume requiring levelling. This could reduce the overall area and volume of levelling/dredging required and could even reduce the overall timescale for recovery as the effect is limited to a single smaller area. With the implementation of a shorter time gap between each phase (e.g. 6 to 12 months), there will not be enough time for the affected sandwaves to migrate into the area to level for the next cable pair.

It is not considered that spatially closer or overlapping levelling activities would be any more likely to alter the overall form and function of the sandwave field (and sandbank system) as very similar behaviour is evident in the natural environment, e.g. bifurcation of sandwaves. The largest impacts would occur for the sandwaves that are orientated parallel to the cable routes, while the least impacts would occur for the sandwaves orientated perpendicular, of which the majority are. Although the sandwaves are also unlikely to return to their original shape with a phased approach, their onward migration would continue in relation to the governing processes. At the same time, as established sandwaves migrate out of an area, new sandwaves would continue to be naturally formed and migrate through.

The bathymetry monitoring images from (DONG Energy, 2017) would suggest that the sandwave migration rate along the Race Bank export cable route is slower than what has been assessed within the present study area, which is more likely due to the different environmental conditions and sandwave migration characteristics (Section 3.2). The images also suggest that the levelled sandwaves are undergoing partial recovery mainly through natural infill, rather than from the migration of the sandwave bedforms (DONG Energy, 2017 and see Section 3.2). Due to the environmental conditions and assessed migration properties within the study area, recovery of the levelled sandwaves is more likely to occur in relation to both the natural infill of the levelled area and through migration of the sandwave features within the time frames discussed above (i.e. months to years).

In addition, there is evidence of bifurcating and converging sandwaves on and between the existing sandbanks within the study area, indicating this process is active within the Newarp Banks sandbank system. Therefore, localised changes on the seabed may result in the ongoing development of new bedforms within the study area, thereby also contributing the sandwave recovery. The Race Bank images illustrate this process, with indications of converging bedforms approximately 5-months after levelling (DONG Energy, 2017). This further supports the potential for such recovery of the sandwaves within the study area as these processes are presently active and are known to occur after levelling, as indicated at Race Bank.

Overall, the partial recovery and the associated recovery rate of the sandwaves along the Race Bank export cable route provides some support and justification for similar responses within the study area. Active bedform development requires the conditions which prevail across the Haisborough SAC and which contribute to the maintenance of the features present. The conditions include the flow speeds, water depth and supply of sediment (Belderson, *et al*., 1982). These conditions will continue after the bed levelling and are expected to lead to the recovery of the sandwaves. There is, also, the potential that further bedforms may be established, which would be consistent with the dynamic properties of the system. In this case, the form and function of the sandbank system will not be disrupted. The bedforms outside the levelled area and within the wider bedform field and sandbank system would continue to migrate and evolve with respect to the natural governing processes, as will the affected bedforms. This interpretation is supported by the evidence from the assessed Race Bank bed levelling sites, which demonstrates that the governing processes, which are not disrupted, do have an over-arching influence on the dynamics of the sandwaves.

4.2.3 Norfolk Boreas cable route

The phased installation of the Norfolk Boreas cable route will follow the same format as described for the Norfolk Vanguard cable route (Section 1.2.2). This includes installation of a cable pair with a 6 to 24 month hiatus, followed by the installation of the second cable pair. The cable route for the Norfolk Boreas would be within the same cable corridor set out for Norfolk Vanguard and provided for this study. Based on the above assumptions, the same level of impact identified for the Norfolk Vanguard cable route (Section 4.2.2) can be expected for the Norfolk Boreas cable route if completed in isolation.

4.2.4 Cumulative effects from both cable routes

This section discusses the worst case cumulative effects of the installation of the Norfolk Vanguard OWF completed in isolation, followed by the installation of Norfolk Boreas OWF cable pairings 6 to 24 months later (refer to section 1.2.2).

Based on the planned 250 m separation between the cables from each OWF and the assessed migration rate for the sandwaves, there will not be enough time for sandwaves levelled for the Norfolk Vanguard OWF to migrate into the area to level for the Norfolk Boreas OWF. Therefore, there should be no additional impact on the sandwaves in implementing the phased approach at the specified schedule. The overall result would be a series of sandwaves that have been levelled and would naturally reshape and migrate on in the same form or converge or bifurcate in relation to governing processes.
The potential for repeated impacts on the sandwaves, (on their form, migration and partial recovery post dredge) is dependent on the separation between the cables for each wind farm and the length of the hiatus. As a large separation is being applied between the OWF cables with respect to the sandwave migration rates, there is very limited potential for such cumulative effects within the study area, based on the phased approach for both OWF. Instead any effects would be restricted to that described for

each OWF independently (Section 4.2.2 and 4.2.3). Due to the very limited potential for cumulative effects, the likelihood of altering the form and function of the sandwave field and the wider sandbank system is considered to be minimal and will not be beyond that described for each OWF. This is because all evidence suggests the study area is in a dynamic environment conducive to the development and maintenance of sandwaves. Sandwave bedforms are continually being modified, converging and bifurcating, also with new bedforms being created and migrating through the cable corridor. Also the evidence from the Race Bank export cable route would support the potential for this process within the study area.

4.3 Potential effects from sediment disposal

4.3.1 Disposal location

The indicative disposal zone is presently located down-drift of the proposed levelling with respect to the regional net transport direction, although there are likely to be spatial and temporal variations in the sediment transport characteristics (see Section 2.6.2). To ensure the ongoing maintenance and form and function of the sandwaves and sandbank system, the dredged material should be disposed nearby and back into the sandbank system where the bulk of material is removed. Ideally this would be close to and up drift from the proposed levelling works. The regional sediment transport pathways are generally in a northerly direction (Figure 3 and Figure 6). However on a more local scale there may be both northerly and southerly direction transport in relation to re-circulations around the sandbanks. It would therefore be relatively more beneficial to dispose of material up drift of the cable route relative to the more localised sediment transport characteristics. Based on the transect analysis carried out (Figure 4), this would mainly be south of the cable route. However, further analysis of local sediment transport processes would be required.

The dredged material would have very similar properties as the receiving environment, and therefore have the same response to the environmental conditions as the surrounding sediment, with no adverse effects on the sediment transport regime. As the proposal is also to dispose of material within the Haisborough SAC, no material will be removed and would therefore be available for transport in relation to the local and regional sediment transport characteristics.

4.3.2 Deposition extent and thickness

Introduction

This section sets out the discussion of potential effects from disposal of sediment based on a volume of 250,000 m^3 per cable pair, 500,000 m^3 per offshore wind farm (i.e. two cable pairs) and a total of 1,000,000 m^3 for both offshore wind farms (i.e. four cable pairs). The assessment is based on the single indicative disposal zone, which has an approximate total area of 2,400,000 m^2 and is located down-drift of net regional sediment transport pathway (noting the likelihood of local re-circulations). It also assumes a dredge hopper volume of 14,000 m^3, which relates to the volume that would be released with each disposal event, for which approximately 18 disposal events would be needed per cable pair (i.e. volume of 250,000 m^3). It sets out the potential resulting extent and thickness of the disposed material and any differences that may occur as a result of the disposal method, i.e. using a surface release or disposal at the seabed via a downpipe.

Table 8 sets out the estimated deposition extent and thickness in relation to the varying deposition scenarios. The quantitative outputs from these spreadsheet models are validated for consistency with ABPmer's internal evidence base of sediment disposal for similar dredging activities in relation to offshore wind farm development.

The completed assessments set out values of potential (conservative) deposition thickness in relation to the varying scenarios. They provide an important basis from which to interpret bed level change. In the context of natural variation in the physical processes involved, results should be interpreted according to the order of magnitude (e.g. tens of centimetres thickness, etc.).

Table 8. Estimated deposition thickness and extent based on varying deposition scenarios

Deposition Scenario		Thickness of Deposit (m)[1*, 3*]	Single Disposal Event (14,000 m^3 Hopper Capacity)		18 Disposal Events (250,000 m^3 per Cable Pair)	
			Nominal Radius of Influence (m)[3*]	Deposition Area (m^2)[3*]	Total Deposition Area (m^2)	Percentage of Disposal Site Area (%)[4*]
Cone	2 x radius of steepest cone[2*]	4.20	54	9,028	162,499	7
	3 x radius of steepest cone[2*]	1.90	80	20,312	365,623	15
Uniform thickness		1.00	63	12,600	226,800	9
		0.75	73	16,800	302,400	13
		0.50	90	25,200	453,600	19
		0.25	127	50,400	907,200	39
		0.05	283	252,000	4,536,000	188

1* Height of peak for cones and average uniform thickness. The dimensions of the steepest cone are not provided in this table as it is not realistically expected that cone deposits of greater thicknesses (e.g. >5 to 10 m) will be allowed to accumulate in practice. The assessment is based on a uniform sediment size, i.e. medium sand at 350 µm.

2* The "steepest cone" relates to the greatest possible thickness and smallest deposition area, associated with a cone that has the steepest possible slope angle (i.e. the angle of repose for such loose sediments = 32° (Section 3.3.2).

3* The deposition area and thickness are based on the 90% hopper volume which equates to the dynamic phase (Section 3.3.2).

4* The available area within the indicative spoil zone is 2,407,681 m^2.

N.B. All value pairs are part of a continuous scale of possible outcomes. Therefore the results should be interpreted according to the corresponding order of magnitude (e.g. tens of centimetres thickness, etc.).

Although the extent, thickness and shape of sediment deposited on the seabed can be highly variable, a range of potential alternative combinations can be calculated based on a disposal volume. Therefore, for a given sediment volume, a deposition area/extent will correspond to a greater thickness of accumulation, and vice versa. In addition, a steeper sided cone shape deposit will have a greater thickness and a smaller area than a less steep sided cone or flat and uniform deposit shape. A range of possible value combinations based on the proposed dredge volumes are set out in Table 8 for a single sediment size (i.e. medium sand at 350 µm). The table demonstrates the changing spatial scale of the impact between the maximum possible thickness (associated with the smallest footprint) and the largest deposition extent (associated with the smallest thickness of 0.05 m). However, it is noted that, in practice, very thick deposits in shallow water would not be planned or allowed to occur as these may affect safe navigation and/or other engineering considerations. Consideration of potential deposition extents and thicknesses are provided in the following sections.

Uniform deposition across disposal site

If the total volume of sediment per cable pair (250,000 m^3) is returned to the seabed with an average uniform thickness of 0.5 m, an area of about 450,000 m^2 would be covered, which is equal to approximately 20 % of the indicative spoil zone area (Section 1.2.3). With the disposal associated with all four cable pairs related to both the Norfolk Vanguard and Norfolk Boreas OWF (to a uniform thickness again), approximately 80% of the site would be covered.

Minimum area of deposition

The smallest deposition area that could be impacted is related to the dimensions of a single steepest sided cone, where the maximum thickness is in the centre of the deposit and thickness decreases gradually from the centre towards the edges. Such a cone could potentially form if the dredge spoil is all released instantaneously with no lateral displacement and there is minimal redistribution of that sediment by natural processes. The thickness associated with the steepest cone and associated smallest deposition area is a cone height of 16.7 m, with a nominal radius of 27 m and deposition area of around 2,300 m^2 per disposal event. Such a cone would result in an unrealistic thickness that would not be allowed to occur, therefore, the cone associated with the second steepest is discussed here. From a single disposal event, the second steepest cone would have a nominal radius of 54 m and approximate base area of 9,000 m^2, with an associated maximum thickness of 4.2 m at its centre. With 18 disposal events and multiple non-coincident cones associated with a cable pair, the total deposition area would approximately be 161,000 m^2, at 7% of the indicative spoil zone and up to 28% for all cable pairs at the same thickness (Table 8). If depositional cones were to occur, the area and thickness would vary due to variations in the environmental conditions during each disposal event and is therefore best considered as a range between the estimates set out in Table 8.

Discussion

In reality, the absolute width, length, shape and thickness of sediment deposition as a result of individual and all (combined) disposal events cannot be predicted with certainty. Instead it is more likely to vary due to the nature of the dredged material, the local water depth, the ambient environmental conditions during disposal, the disposal method (surface or through a down-pipe) and the vessel speed. Therefore, the most likely occurrence for a single disposal event is within a range of possible combinations of shape, area and thickness of sediment deposition as illustrated in Table 8. Irrespective of the deposition scenario, it is noted that the sandwaves within the indicative spoil zone typically have amplitudes of over 3 m and wavelengths of about 100 m. Therefore, there is already some variation in seabed depths within the indicative spoil zone and depending on the deposition characteristics (i.e. location, thickness and extent); the result would potentially be within the range already encountered within the indicative spoil zone.

4.3.3 Disposal method

Natural England has questioned the effects of the different disposal methods, i.e. is there the potential for varying deposition thickness and extent depending on the disposal method between a surface release or disposal at the bed via a downpipe.

Theoretically there is very little difference in the potential deposition thickness associated with either disposal method. The deposition thickness and extent will mainly be determined by the nature and final shape of the active phase of the dredge disposal plume (containing approximately 90% of the sediment volume). A range of possible realistic outcomes are provided in Table 8. The main difference between a surface release or disposal at the bed via a downpipe instead arises in relation to the passive phase (sediment plume), which may be subject to a greater degree of advection and dispersion before settling to the seabed (Section 3.3.2).

The deposition thickness associated with each disposal event (as a result of the passive sediment plume) is less than 0.02 m (and up to 0.3 m per cable pair). This is based on a surface release into a water depth of 31 m (i.e. representative depth within the indicative spoil zone), a current speed of 0.5 m/s, 350 µm grain size and 0.05 m/s settling rate. For each disposal event, the deposition extent would be over an approximate area of 86,000 m^2. Theoretically, the deposition area would vary with each disposal event due to variations in the tidal states and hydrodynamic conditions, meaning the overlap from each disposal plume would vary so the actual thickness per cable pair, (i.e. 18 disposal events) would be less than 0.3 m. Also, although the deposition extents may be larger per disposal event, the actual resulting thickness is far smaller (closer to. 0.02 m) and would largely be indiscernible on the seabed, due to the sandwave amplitudes present.

With the deposition of the sediment at the seabed, the surface exposed material would immediately become part of the northerly sediment transport regime (Figure 3). The results from the progressive vector analysis also illustrate a northerly pattern across much of the cable corridor (Figure 6). The estimated transport rates for sand across the study area range between 0.01 and 3.4 m^3/m/hr for the assessed tidal conditions associated with annual waves (Table 5), with lower estimates for tides only. The assessed rates are within the range modelled for the wider region within the Southern North Sea sediment transport study (HR Wallingford *et al.*, 2002), whereby spring net transport rates on the order of 1,000 to 10,000 kg/m/tide (approximately 0.34 to 3.78 m^3/m/tide) were determined for medium sand. Any deposited sediment would be transported based on these existing rates. In addition, if any mounds were formed during disposal, these would have relatively low heights per release. The mounds would be quickly winnowed down to levels that can be expected to resemble nearby bedforms, which have heights in the order of metres.

As stated in Section 4.1, the potential for material to be lost from the Haisborough SAC as a result of disposal is again minimal, as the net transport pathway is typically to the north and the associated boundary is many kilometres away. Any loss would therefore be within the existing sediment transport processes.

4.4 Potential effects on the form and function of the Haisborough SAC

Estimated sediment volumes for three sandwave fields, which interact with the cable corridor are summarised in Table 6, using the approach described in Section 3.3.5. The estimates illustrate the volumes that may be available for transport, based on their migrating properties. The volume of sediment present within each bedform field is in the order of tens to hundred millions of cubic metres (Table 6). These three sandwave fields are in themselves a small component of the volumes within the wider Haisborough SAC with estimates of several billions of cubic metres (based on Annex I sandbank habitat coverage of at least 66,900 ha, with depths ranging from less than 10 m to 50 m (JNCC, 2010; JNCC, 2017).

Although the proposed bed levelling area and volumes within the Haisborough SAC are not insignificant amounts, they are very much smaller than the volume present within the wider sandbank system. The total volume of material within the local sandwaves (i.e. on and around Newarp Banks) and the whole Haisborough SAC is one to several orders of magnitude larger than the proposed bed levelling area and volume (Section 1.2.3). This means the proposed levelling only comprises a very small percentage of the total volume of sediment within the Haisborough SAC.

Sediment will generally not be removed from the local sandbank system, as the proposed method is to dispose of material on or around the Newarp Banks system. Therefore, the dredged sediment volume will only be displaced by a short distance from individual bedforms, presenting minimal impacts to local sediment availability and budget. The nature of the sediments being dredged (mineralogy and grain size) is and will remain similar to the receiving environment. In order to ensure the ongoing form and function of the sandwaves and sandbank system the dredged material would ideally be disposed of nearby and up-drift (i.e. to the south) from the proposed levelling works. This would effectively keep the displaced sediment volume within the local area of the affected sandwave, with the highest chance of it being naturally returned to the dredged area over time. Also, no sediment volume is being removed or made more likely to leave the associated sandbank system. Once redeposited to the seabed, the disturbed sediment will immediately re-join the local and regional sedimentary system, presenting minimal potential to affect to the form and function of the sandbank system as a whole.

In the event that material is removed from sandbanks not local to the disposal location, sediment will still be maintained within the Haisborough SAC and there would be no net sediment loss. In addition to the northerly and southerly transport pathways, studies also indicate there is an offshore sediment transfer mechanism through the sandbanks, which occurs over a long time frame (Burningham and French, 2016; Cooper, *et al.*, 2008; Collins, *et al.*, 1995). The mechanism is such that sediment moves from the sandbanks located in the nearshore to the more offshore bedforms, through the sinusoidal characteristics of the sandbanks. Therefore, any material deposited within the indicative disposal zones would be distributed across the wider SAC, including the sandbanks located further offshore. It is also noteworthy that the volume of material being dredged from any individual sandbank is minimal compared to the total sediment volume contained within the sandbank and for these reasons, the form and function of the sandbank systems within the Haisborough SAC would not be disrupted by the proposed bed levelling works.

The large coverage of the Haisborough SAC means it is exposed to range of environmental conditions from the coast to its offshore extent. The tides, waves, sediment supply and transport regime occur at the scale of the Southern North Sea, which is significantly larger than the Haisborough SAC itself and which will also continue unaffected.

The study results indicate that the proposed levelling will have little to no long term impact on the sandwave or seabed morphology, as the overarching governing processes are not disrupted (Section 4.1 and 4.2). In addition, the environment and processes within and around the Haisborough SAC are conducive to the development of new bedforms including sandwaves, which could form within or migrate into the Haisborough SAC. In fact, the environmental processes along with the sediment supply and water depths are the principal factors that influence the sandwaves and directly contribute to maintaining the form and function of the Haisborough SAC. Therefore, as the proposed works do not alter these factors across the Haisborough SAC, there is no reason why the form and function of the Haisborough SAC should be altered. The ongoing sediment supply, onward migration of the features in response to the tide and potential for new sandwave bedforms, will mean the form and function of the sandbank systems within the Haisborough SAC should be maintained. Information from the monitored sites along the Race Bank export cable route would also support this conclusion as there is evidence of sandwaves reforming and the ongoing evolution of these bedforms post levelling (DONG Energy, 2017). With respect to the seabed, the resulting levelled area or marginally raised seabed as a result of disposal are not considered to create a barrier to sediment movement across the sandbank systems and through the Haisborough SAC (Section 4.1). Therefore, the form and function within the Haisborough SAC will again be maintained.

5 Conclusions

An assessment has been made of the potential nature, magnitude, extent and duration of effects on the physical environment within the Haisborough, Hammond and Winterton SAC as a result of proposed bed levelling works and cable installation for the Norfolk Vanguard and Norfolk Boreas Offshore Wind Farms. This includes assessing the potential for any impacts on the seabed and sandwave morphology within the study area and any onward effects on the conservation objectives and designated features of the Haisborough SAC. The assessment is based on the existing baseline understanding of the present nature of sediments and morphology in the area, the processes controlling the morphology, and consideration of the potential for the proposed bed levelling activities to cause an impact.

A summary of the study conclusions are provided below.

5.1 Sediment transport and sandwave migration

- The varying bedform sizes, migration characteristics, bifurcating and converging sandwaves all observed within the study area are strong indicators of a very dynamic and active environment. In addition, they highlight the presence of governing processes that occur at a scale that is much larger than the proposed levelling. The factors which particularly influence the bedform properties are the water depth, tidal flow speeds and sediment availability, which are also conducive for the development of new sandwaves and maintenance of existing features.

- Calculated migration rates varied between 5 to over 30 m/year across the different bedform fields along the cable corridor. Between 2014 and 2016, the assessed sandwave properties demonstrate both northerly and southerly migration trends across different bedform fields. A northerly trend occurred on the sandwaves to the east of Newarp Banks, while a southerly trend was observed on the western flank of the Newarp Bank. The variation in migration characteristics potentially relate to the presence of a bedload parting zone and local re-circulations through the study area.

- The representative sediment size across the section of the offshore cable corridor within the SAC is medium sand, at about 350 µm. This sediment size, at average depths across the study area, is mobile for over 70% of the time (i.e. over the assessed 11-year period), but increased to over 85% with the combined influence of waves.

5.2 Effects on sandwaves

- There is the potential for partial recovery of the levelled sandwaves within the Haisborough SAC, although they are unlikely to reform to their original state following the dredging of the crest. This is due to the ongoing migration properties of the sandwave field. It, whereby is likely the sandwaves will continue to migrate in their new form, moving away from the levelled area, during which time also the crests would partially recover to a naturally stable shape.

- As the levelled sandwaves move away from the levelled area, new sandwaves would also form and migrate into the area, as the sandwave migration properties are unimpeded by the proposed bed levelling works.

- The worst case scenario would be phased levelling at adjacent locations, with a short separation distance between the cables, aligned in an approximately north-south direction, with the works progressing in the same direction as sandwave migration (from south to north) and relative to the migration rate.). In this worst case scenario, the adjacent or nearby areas of a sandwave could be repeatedly levelled up to four times. This would also mean that, as the sandwave is reshaped (or partially reforms) it could be modified up to four times, which would repeatedly alter the form of the sandwave. However, the total area and volume of sandwave to clear, and the overall area of sandwaves affected could also be proportionally reduced.

- The likelihood of this altering the form and function of the sandwave field and the wider sandbank system is considered to be minimal. This is because all evidence suggests the study area is in a dynamic environment conducive to the development and maintenance of sandwaves. Sandwave bedforms are continually being modified, converging and bifurcating, also with new bedforms being created and migrating through the cable corridor.

- The conclusions with respect to recovery of the levelled sandwaves within the study area (including both recovery through sediment volume replenishment and shape through migration of the sandwave feature) is supported by evidence from the levelled sandwaves along the Race Bank export cable route. The monitoring images showed evidence of partial recovery and reformation *in situ* over a 5-month period, without migrating away (DONG Energy, 2017). This is in part likely to be due to sediment volume replenishment, either through transport or contribution from smaller mega-ripple bedforms within the same area.

- The study area is an active and dynamic sediment environment with converging and bifurcating sandwaves evident in the available bathymetry data. The sandwave behaviour and responses are determined by the governing processes (tidal forcing, water depth and sediment supply) that occur at a much larger and regional scale than the proposed works. As these will not be disrupted by the proposed works, all available indicators point towards the form and function of the sandwaves, sandbanks and the Haisborough SAC being maintained.

5.3 Effects of disposal

- The absolute width, length, shape and thickness of sediment deposition as a result of disposal cannot be predicted with certainty and is likely to vary due to the nature of the dredged material, the local water depth and the ambient environmental conditions during disposal. A range of realistically possible combinations of shape, area and thickness of sediment deposition are provided in Table 8.

- There is not expected to be any significant difference in the thickness or extent of spoil deposits associated with either a surface release or disposal at the seabed via a downpipe.

- Following disposal, the material will most likely remain within the Haisborough SAC on the same time frame as currently occurring. This accounts for the fact that the Haisborough SAC is not a closed system but has sediment moving in from the south and out at its northern boundary. Different validation methods confirm a dominant northerly net sediment transport direction

- In the short term, sediment transport will be directed to the north-northwest and south-southeast of the indicative spoil zones in line with the prevalent sediment transport pathways. In the long term, the transport direction will be determined by the location of the spoil zone with respect to the regional scale bedload parting zone and local re-circulation patterns. Material deposited to the east of the bedload parting would more likely move to the north-northwest in the long term and sediment deposited to the west of the parting would more likely move to the south-southeast in the long term.

- It is noted that the SAC boundary to the north is many tens of kilometres away in this direction, and that individual sediment grains or bodies of sediment will not be transported independently of the other sediment which is present.

5.4 Effects on the Haisborough SAC

- The Haisborough SAC is not a closed system and it presently has sediment both entering and leaving it around the boundaries. The proposed works are some distance from the boundaries (at over 6 km from the southern boundary) and are unlikely to bring about any disruption to the transport regime. Therefore, the movement in and out of the Haisborough SAC as occurs at present will continue, irrespective of the proposed dredging or disposal activities.

- The area and volume of sediment to be dredged from the sandwaves as part of the proposed bed levelling works is very small in proportion to the area and volume of the Newarp Banks sandbank system. It is even smaller when considered in relation to the sandbank systems within the Haisborough SAC.

- Any sediment dredged from the sandwaves is to be returned to the seabed within the Newarp Banks sandbank system. There should be limited or no net removal of sediment from the system. Also, as sediment is only being locally displaced, the nature (texture) of surficial sediments, regional patterns of tidal currents and waves affecting the area will remain largely unchanged. Any deposited material will re-join the local sedimentary environment. Therefore, the form and function of the local Newarp Banks sandbank system and wider systems within the Haisborough SAC are not likely to be affected.

- The proposed bed levelling works are not considered likely to disrupt the form and function of the sandwaves locally or at the sandbank systems scale within the SAC. These are governed by processes that occur at a much larger scale than the proposed works. The sandwaves are expected to continue to evolve in response to the natural regional scale processes, which will continue unaffected.

- The same is considered likely for the seabed morphology, as the tides and sediment supply and transport regime are the governing forcing. The proposed works will not alter these; therefore the sediment transport properties are not likely to be disrupted.

- The disposal will also not affect the form and function of the Haisborough SAC. The transport direction will be determined by the location of the spoil zone with respect to the regional scale bedload parting zone and local re-circulation patterns. The SAC boundary to the north is many tens of kilometres away in this direction, and individual sediment grains or bodies of sediment will not be transported independently of the larger scale sediment transport processes.

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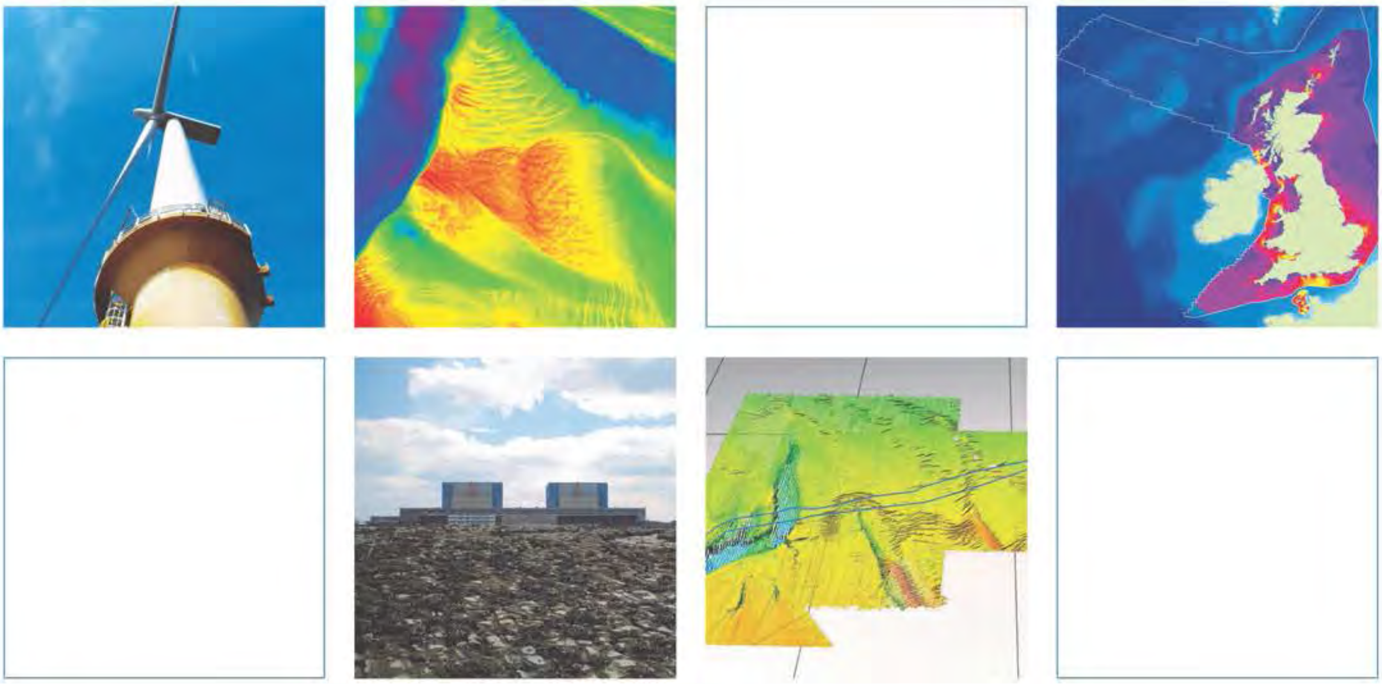
7 Abbreviations/Acronyms

BGS	British Geological Survey
BODC	British Oceanographic Data Centre
Cefas	Centre for Environment, Fisheries and Aquaculture Science
D_{50}	Median grain diameter
EAOW	East Anglia Offshore Wind Ltd
ECREC	East Coast Regional Environmental Characterisation
EIFCA	Eastern Inshore Fisheries and Conservation Authority
ETRS89	European Terrestrial Reference System 1989
GIS	Geographic Information System
HRA	Habitat Regulations Assessment
Hs	Significant wave height
HVDC	High Voltage Direct Current
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
MESL	Marine Ecological Surveys Ltd
MFE	Mass Flow Excavator
mLAT	metres below Lowest Astronomical Tide
MMO	Marine Management Organisation
MSL	Mean Seal Level
OWF	Offshore Wind Farm
PSA	Particle Size Analysis
PVA	Progressive Vector Analysis
SAC	Special Area of Conservation
SCI	Site of Community Importance
SEA 2	Strategic Environmental Assessments Area 2
SNSSTS	Southern North Sea Sediment Transport Study Phase II
TSHD	Trailer Suction Hopper Dredger
UK	United Kingdom
UKCP09	United Kingdom Climate Projections (2009)
UKHO	United Kingdom Hydrographic Office
ZEA	Zonal Environmental Assessment

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

Appendix



Innovative Thinking - Sustainable Solutions

A Bed Shear Stress and Sediment Mobility Calculation

A.1 Method

Estimates of sediment mobility and rates of sediment transport are made using equations and relationships summarised in Soulsby (1997) 'Dynamics of Marine Sands'. This reference is a standard text for such information and is often used for this purpose. More than 50 equations and tables of coefficients are used in the full spreadsheet of calculations and these are not all repeated here. The following is a summary of the approaches used. The equation reference in Soulsby (1997) is provided for key values. Full details of each equation, in some cases including a discussion of relative accuracy and limitations, may be found in Soulsby (1997).

The user specifies:

- Sediment grain size (250, 350 and 500 µm are considered in the present study).
- Sediment mineral density (representative 2650 kg/m^3).
- The density of seawater (representative 1027 kg/m^3).
- Water depth including any tidal variation (representative -28 mLAT for most examples, 16, -31 and -50 mLAT are also considered in relation to the progressive vector analysis (PVA)).
- Current speed (various values, m/s).
- Wave height (various values, m).
- Wave period (various values, s).

The water depth of -28 mLAT used for most examples in the report is representative of the general depth of the sea bed in the wider study area. Shallower water depths are present in some limited areas, mainly the crests of the sandbanks and individual sandwave features. In such shallower areas, the resulting bed shear stress estimates will be higher, hence sediment will be more mobile and with a higher transport rate. The greater depth used therefore provides a conservatively low estimate of the minimum level of mobility and transport rates in the wider area including between sandwave crests and between sandbank features. A range of water depths (-16, -31 and -50 mLAT) are used to illustrate this variability in the PVA.

Various representative values of current speed, wave height and wave period are used for most examples in the report to summarise the level of mobility (maximum grains size mobile) under characteristic every day and annually significant storm conditions, which are most likely to contribute to regional sediment transport and bedform migration. The sediment transport rate and direction estimates informing the PVA use a continuous hourly hindcast time series of coincident total current speeds, directions and water levels (including tide and surge components), and wave height, period and direction.

The following equations are used in the further analysis of the user specified input:

- Wave length is estimated from wave period and water depth following (Example 4.1). Near bed orbital velocity amplitude (Eq54) and orbital excursion (Eq77) are also estimated to be used as inputs for other relationships below.
- The critical bed shear stress for initial mobilisation of the sediment is estimated using the Shields Criterion (Eq77).

- The bed shear stress as a result of currents alone is estimated using a quadratic stress relationship with drag coefficient (Eq37 and 30) assuming a bed roughness coefficient of z0=0.006, representative of rippled sands.
- The maximum (peak) bed shear stress as a result of waves alone is estimated using a quadratic stress relationship (Eq57) and an appropriate choice of smooth (Eq62a) or rough (Eq63) bed friction factor depending on the particular user inputs.
- The mean bed shear stress under waves and currents combined is estimated using the current and wave alone shear stress values (Eq69), and the maximum (peak) value is estimated using the mean combined shear stress and wave alone shear stress values (Eq70). These calculations follow (Example 5.1) and use the GM79 (Grant, W.D., Madsen, O.S., 1979) coefficients.
- Sediment mobility (whether the specified sediment type is likely to be mobile or not) is tested by comparing the estimated bed shear stress for given water depth, current and/or wave conditions, and the critical (threshold) shear stress value.
- Sediment (total load) transport rates for currents and waves combined are estimated using an empirical relationship fitted to a range of field observations (Eq136).

A.2 References

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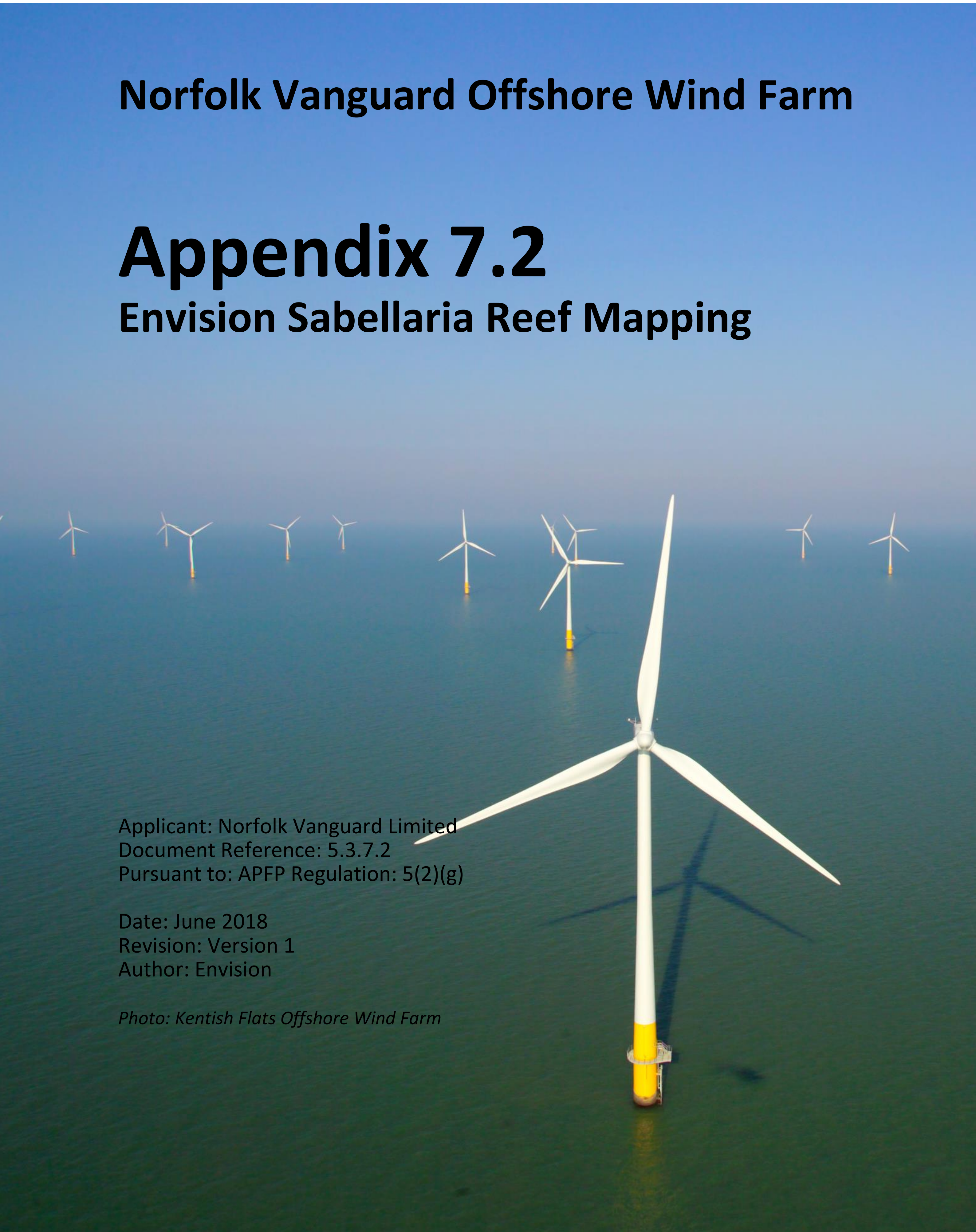
Norfolk Vanguard Offshore Wind Farm

Appendix 7.2

Envision Sabellaria Reef Mapping



Applicant: Norfolk Vanguard Limited
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Revision: Version 1
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Photo: Kentish Flats Offshore Wind Farm

Information for the Habitats Regulations Assessment

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June 2018

For and on behalf of Norfolk Vanguard Limited
Approved by: Ruari Lean and Rebecca Sherwood
Signed: [redacted] [redacted]
Date: 8th June 2018

Norfolk Vanguard & Norfolk Boreas Sabellaria Review

May / 2018

Review and interpretation of survey data

Site

Norfolk Vanguard and Norfolk Boreas Offshore Wind Farms

Prepared for

Royal HaskoningDHV & Vattenfall

Prepared by

Envision Mapping Ltd.

Author(s)

Ian Sotheran

PREPARED FOR	Royal HaskoningDHV & Vattenfall
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3	Ian Sotheran	20/12/2017	Draft	KW,DT, JL	20/12/2017
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NOTES

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Envision Mapping's environmental policy involves the use of renewable electricity and recycled paper that is manufactured using wind-generated electricity

CONTENTS

FIGURES

1. Introduction

Norfolk Vanguard Limited and Norfolk Boreas Limited (affiliate companies of Vattenfall Wind Power Ltd (VWPL)) are seeking Development Consent Orders for Norfolk Vanguard and Norfolk Boreas, two offshore wind farms (OWF)s in the southern North Sea. The two wind farms have a shared offshore cable corridor within which export cables will be installed connecting the wind farms with the landfall area at Happisburgh South.

The offshore export cable corridor passes through the Haisborough, Hammond and Winterton (HHW) Special Area of Conservation (SAC) (Figure 1). The SAC contains a series of sandbanks which meet the Annex I habitat description for "Sandbanks slightly covered by sea water all the time". The biogenic reefs of the worm *Sabellaria. spinulosa* are also a protected feature of the SAC.

A site characterisation survey of the Norfolk Vanguard and Norfolk Boreas offshore cable corridor (Fugro, 2016) identified potential presence of the biotope '*Sabellaria spinulosa* on stable circalittoral mixed sediment' (SS.SBR.PoR.SspiMx).

SS.SBR.PoR.SspiMx is a component part of *S. spinulosa* reefs, however Annex I reefs are not always present where the biotope occurs. This report provides a review of all available data pertaining to the likelihood, presence, distribution, and nature of *S. spinulosa* biotopes and reefs within the Norfolk Boreas and Vanguard offshore cable corridor and Norfolk Vanguard West OWF area has been undertaken with the specific aims of;

i. Identifying the presence and extent of any *S. spinulosa* reef within the Norfolk Boreas and Vanguard offshore cable corridors which fall within the Haisborough, Hammond and Winterton SAC, and

ii. If found, to assess any areas in context with the protected features within the SAC.

A draft 'Norfolk Vanguard & Norfolk Boreas Sabellaria Review' was provided to Natural England in January 2018 for consultation. The datasets which have been reviewed and utilised within the present updated review are outlined below, and include information provided by Natural England on the 15th March 2018:

- Geophysical data (sidescan sonar and multibeam bathymetry) from the project survey undertaken by Fugro, 2016.
- Video and grab samples collected as part of the same Fugro 2016, survey campaign
- Benthic sample data from East Anglia Zone Environmental Appraisal (MESL, 2012).
- Regional and other datasets were sourced from the Regional Seabed Monitoring Plan (RSMP) baseline assessment dataset (Cooper & Barry, 2017).

- Sample records and habitat extents from the East Coast Regional Environmental Characterisation study (MALSF, 2011)

- Draft sample records and notes were reviewed from data from the CEFAS cruise (code CEND 11/16) (McIlwaine *et al*, 2017) but following advice from the Marine Management Organisation these data were not incorporated into habitat extent mapping.

- Frojan, 2013 Benthic Survey of Inner Dowsing, Race Bank and North Ridge cSAC and of Haisborough, Hammond and Winterton cSAC

- Gardline 2010 Bacton to Baird pipeline route and environmental survey.

In addition, Norfolk Vanguard Limited were recently advised By JNCC and Natural England of areas which the SNCBs intend to manage as Annex I *S. spinulosa* reefs (JNCC & NE, 2018). Some of the area to be managed as reef intersect with Norfolk Vanguard West and the cable corridor (Figure 1).

From reviewing the site specific geophysical and sample data (Fugro 2016) and augmenting this with other available data, the areas mapped as potential Sabellaria biotope have been refined to more precise and spatially constrained areas which are supported by sample data. These areas and samples have been further reviewed to identify where *S. spinulosa* reef may occur and the characteristics/ 'reefiness' of these areas have been assessed in accordance with Gubbay et al, (2007) and Foster-Smith & Hendrick (2006).

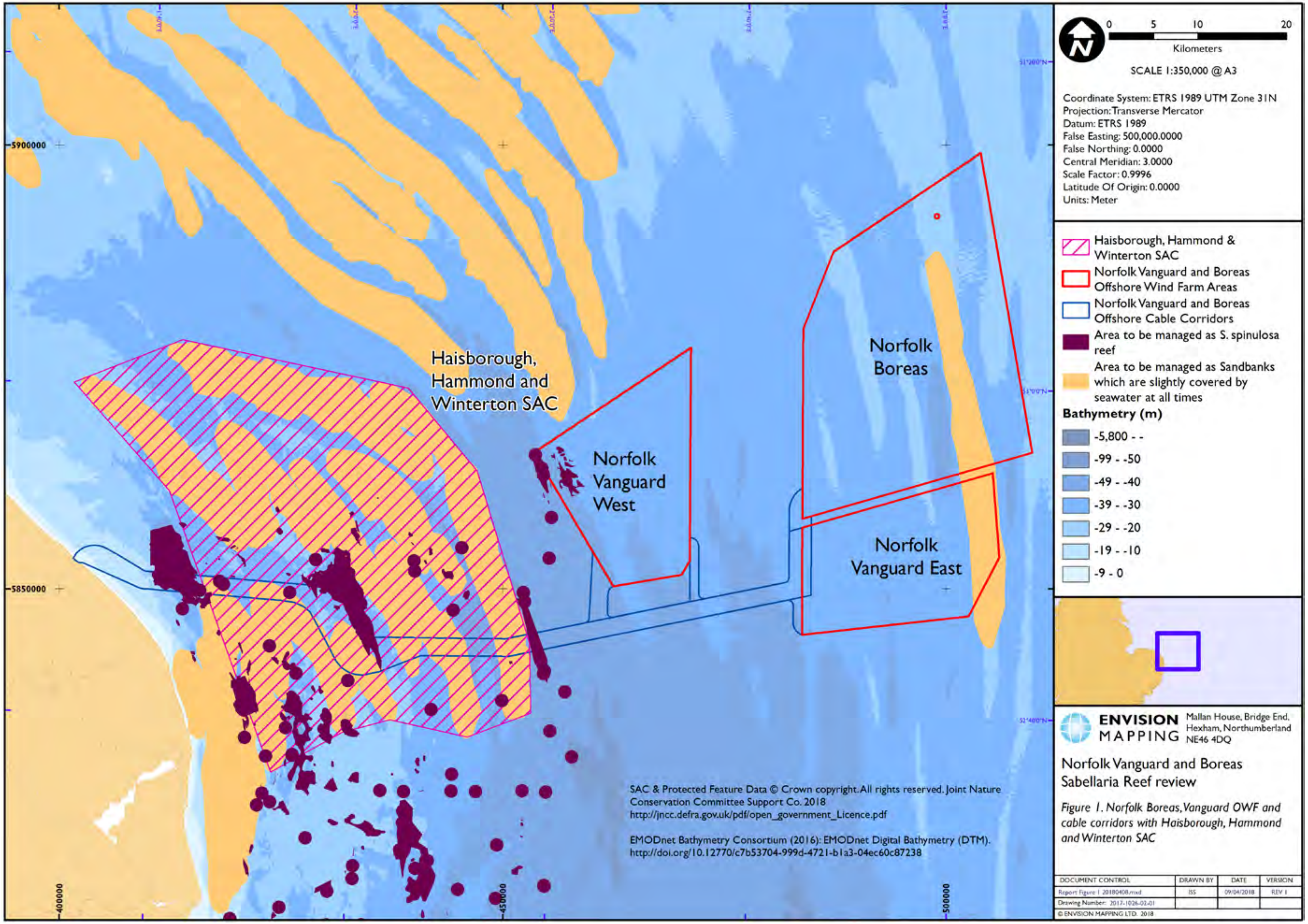

Figure 1.
Norfolk Boreas, Vanguard OWF, and cable corridors with Haisborough, Hammond and Winterton SAC shown

2. Methods for analysis

The overarching strategy for the interpretation of the available data is to combine information from the geophysical data with the benthic sample data using image processing and spatial statistical analysis. This process uses the sample data to 'ground truth' the geophysical data, a strategy which is described in the Mapping European Seabed Habitats (MESH) documentation from which Figure 2 is taken (MESH, 2008). The existing geophysical data require processing and interpolation prior to integration so that the data are in a suitable format for the mathematical analyses. The main outputs are descriptions of habitats and distribution maps.

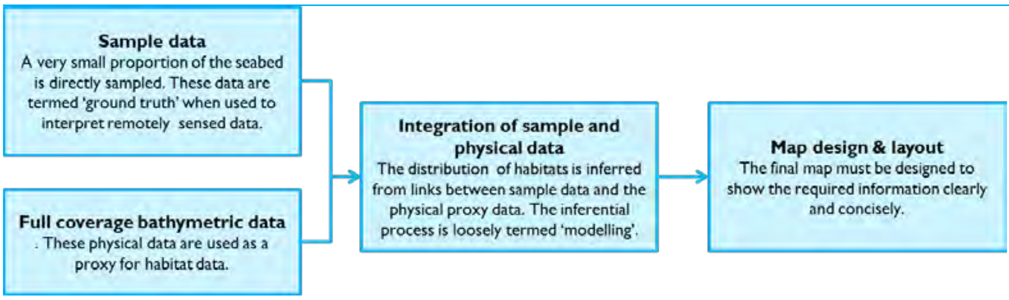

Figure 2.
A flow chart of the main stages in making a habitat map by integrating sample data and full coverage physical data

Several approaches have been used to map the cable corridor and OWF area, and the resultant maps from each combined to produce an ensemble map incorporating confidence.

2.1. Geophysical data

Site characterisation geophysical data collected in 2016 by Fugro (Fugro, 2016), for the Norfolk Vanguard and Norfolk Boreas cable corridor area and Norfolk Vanguard West site have been analysed within this report. Of the data available, the most suitable for habitat mapping and detection of *S. spinulosa* reefs are bathymetry and sidescan sonar supported by rugosity information which is a derivative of the bathymetric data (Figures 3 to 5).

Bathymetry was used as gridded data at a resolution of 1m. In addition to detailing the depth of the seafloor, bathymetry can be used to derive other parameters such as an index of rugosity which can highlight where the seabed is variable in nature. Bathymetry data were processed, and the final analysis used a 5m resolution to match other derivatives and datasets.

Seabed terrain heterogeneity can indicate the complexity of a habitat and is known to be correlated to distribution of benthic fauna (Tappin *et al.*, 2010), associated with areas of *S. spinulosa* reefs and has been used to detect reefs around the UK (McIlwaine, 2017 & MESL, 2012). Rugosity was calculated using a terrain ruggedness index which produces gridded data suitable for analysis. Other derivates from bathymetry such as slope of aspect were excluded from analysis as they are too closely correlated to rugosity.

The sidescan data were used as gridded mosaics for the cable and OWF areas.

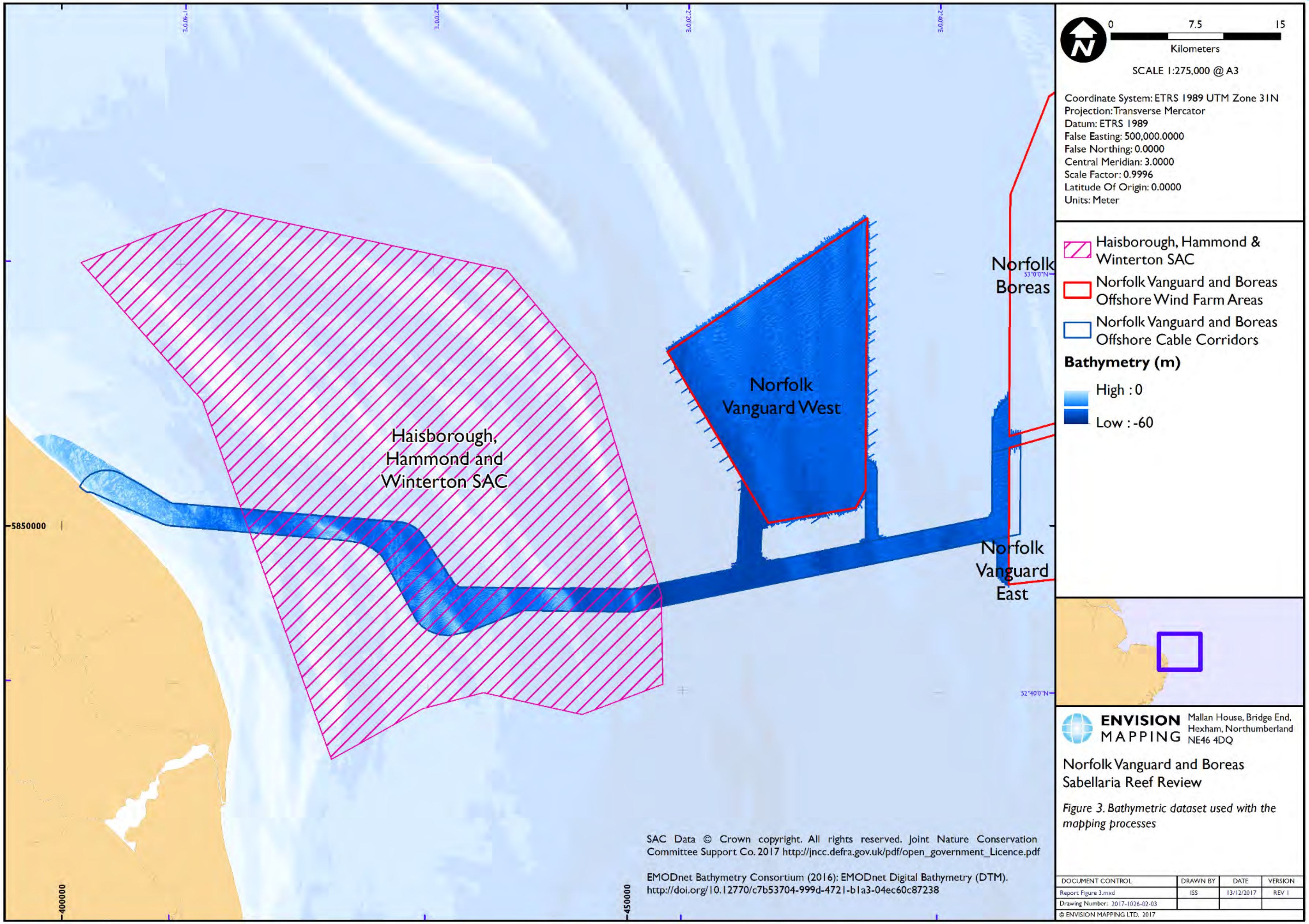

Figure 3. *Bathymetric dataset used with the mapping processes*

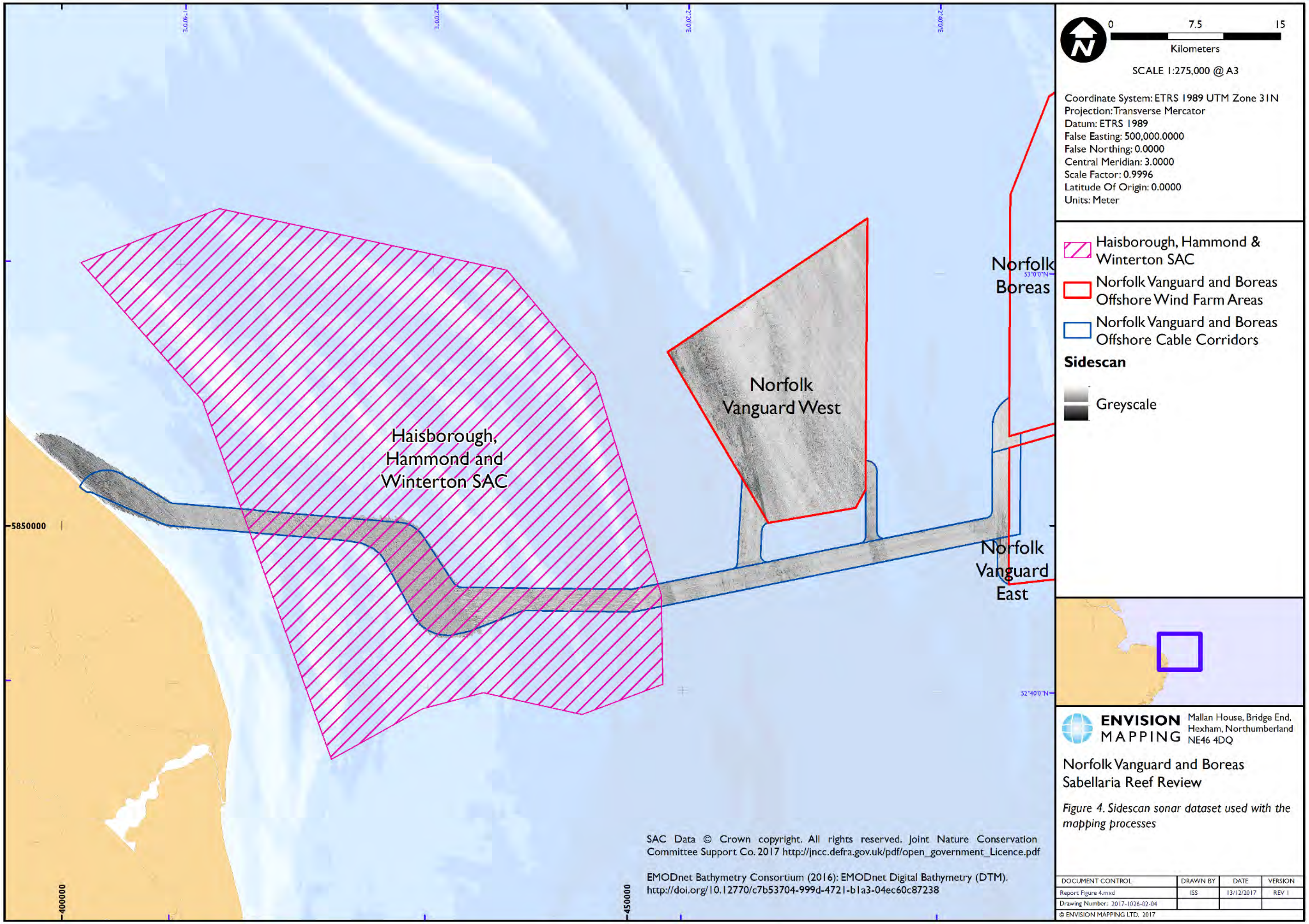

Figure 4. *Sidescan dataset used with the mapping processes*

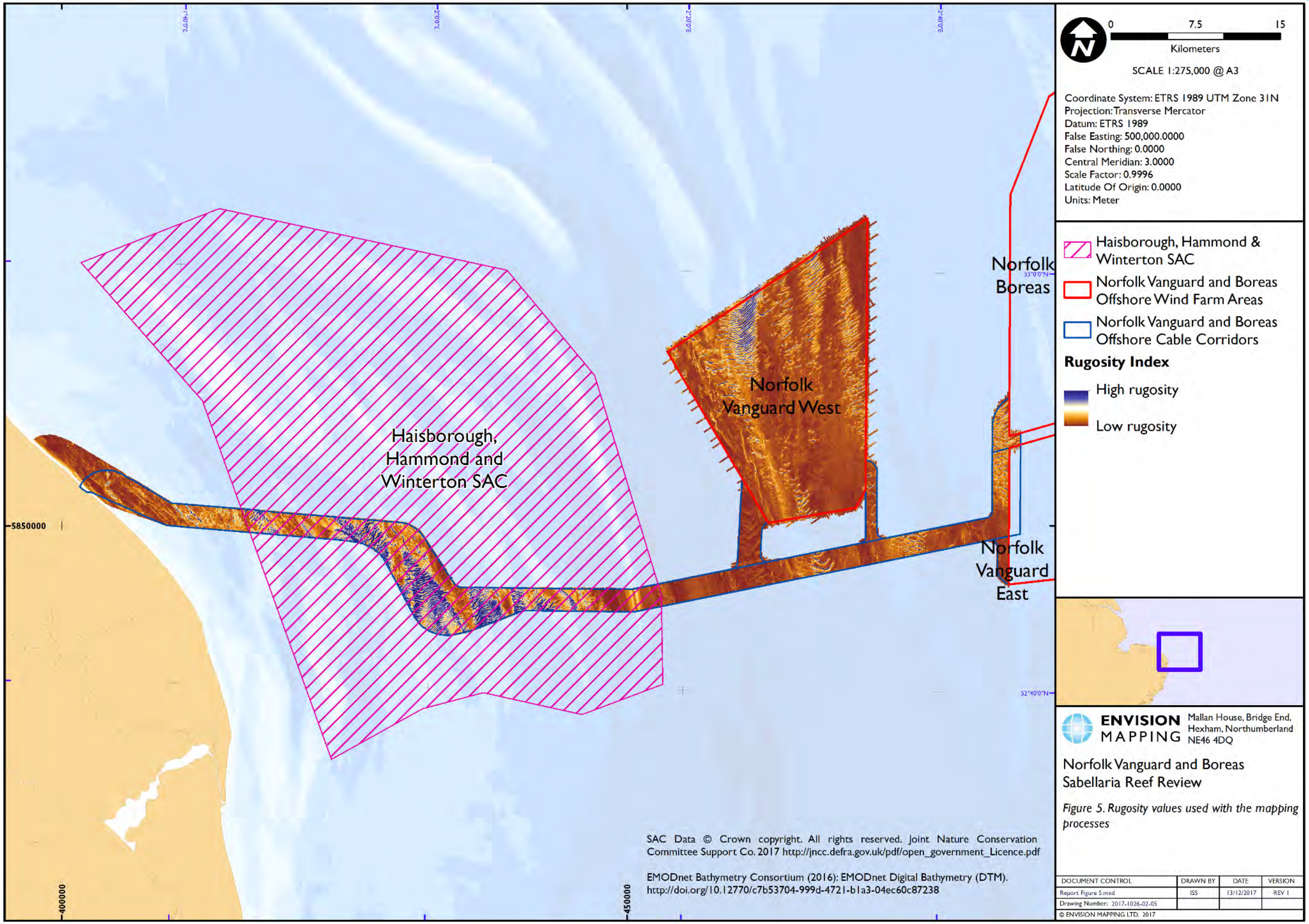

Figure 5. *Rugosity index data used with the mapping processes*

2.2. Sample data

Sample data from stations within the Norfolk Vanguard and Norfolk Boreas cable corridor area and Norfolk Vanguard West OWF site included samples collected as part of the Norfolk Vanguard Benthic characterisation surveys (Fugro, 2016) and part of the East Anglia Zone Environmental Appraisal (MESL, 2012). Full particle size analysis (PSA) data, benthic infauna from grabs and images and descriptions from video footage were available for these samples.

Regional and other datasets were sourced from the Regional Seabed Monitoring Plan (RSMP) baseline assessment dataset[1] (Cooper & Barry, 2017). These data incorporate a range of surveys from a variety of sources with accompanying infaunal and PSA data. Of particular relevance is data collected by Cefas for the Inner Dowsing, Race Bank and North Ridge along with Haisborough, Hammond and Winterton survey data from 2013 for which updated reef assessment data is available.

The EC REC, (MALSF, 2011) collected ground truthing data to which a 'reefiness' assessment has been applied (Gubbay et al, 2007, Foster-Smith & Hendrick, 2006), these data have been used to determine the extent of reefs within the cable corridor and OWF areas.

Sample records and notes were reviewed from data from the CEFAS cruise (code CEND 11/16) (McIlwaine *et al*, 2017) and records where *S. spinulosa* reef was observed were noted but as these are currently preliminary or draft they were not used within the current models. Once these data are finalised it may be possible to incorporate them within the mapping process.

The majority of the grab samples had not been attributed to a UK or European Nature Information System (EUNIS) marine habitat category therefore the physical parameters (such as PSA) were used to attribute each sample with a EUNIS/Marine Nature Conservation Review (MNCR) category based upon the varying percentages of gravels, sands, and muds (after Long, 2006). Samples from the Norfolk Vanguard Benthic characterisation surveys (Fugro, 2016) had been attributed to a habitat/biotope category and these have been used to inform the study. Where habitat categories included a biological element, which is unlikely to be distinguished or detected from acoustic data then these samples were pooled to a high level within the classification (e.g. SS.SCS.CCS.MedLumVen and SS.SCS.CCS.Pkef were pooled to SS.SCS.CCS) for mapping purposes, but original category retained for sample mapping.

[1] *https://www.cefas.co.uk/cefas-data-hub/dois/rsmp-baseline-dataset/ [accessed October 2017]*

The marine habitat categories used within the mapping process are shown in Table 1 below:

Table 1.
Marine habitat categories used with the mapping processes

MNCR Habitat/Biotope	Name	Composite of biotopes
SS.SSa.CFiSa	Circalittoral fine sand	SS.SSa, SS.SSa.CMuSa, SS.SSa.CFiSa, SS.SSA.CFiSa.EpusOborApr
SS.SMx.CMx	Circalittoral mixed sediment	SS.SMx, SS.SMx.CMx
SS.SMu.CMuSa	Circalittoral sandy mud	SS.SMu, SS.SMu.CMuSa
SS.SCS.CCS	Circalittoral coarse sediment	SS.SCS, SS.SCS.CCS, SS.SCS.CCS.MedLumVen, SS.SCS.CCS.Pkef
SS.SBR.PoR.SspiMx	*Sabellaria spinulosa* on stable circalittoral mixed sediment	SS.SBR.PoR.SspiMx

Video data and grab sample data have been reviewed and assessed for the presence of *S. spinulosa* and were used to assess the likelihood of reef habitat occurring in the vicinity of each sample.

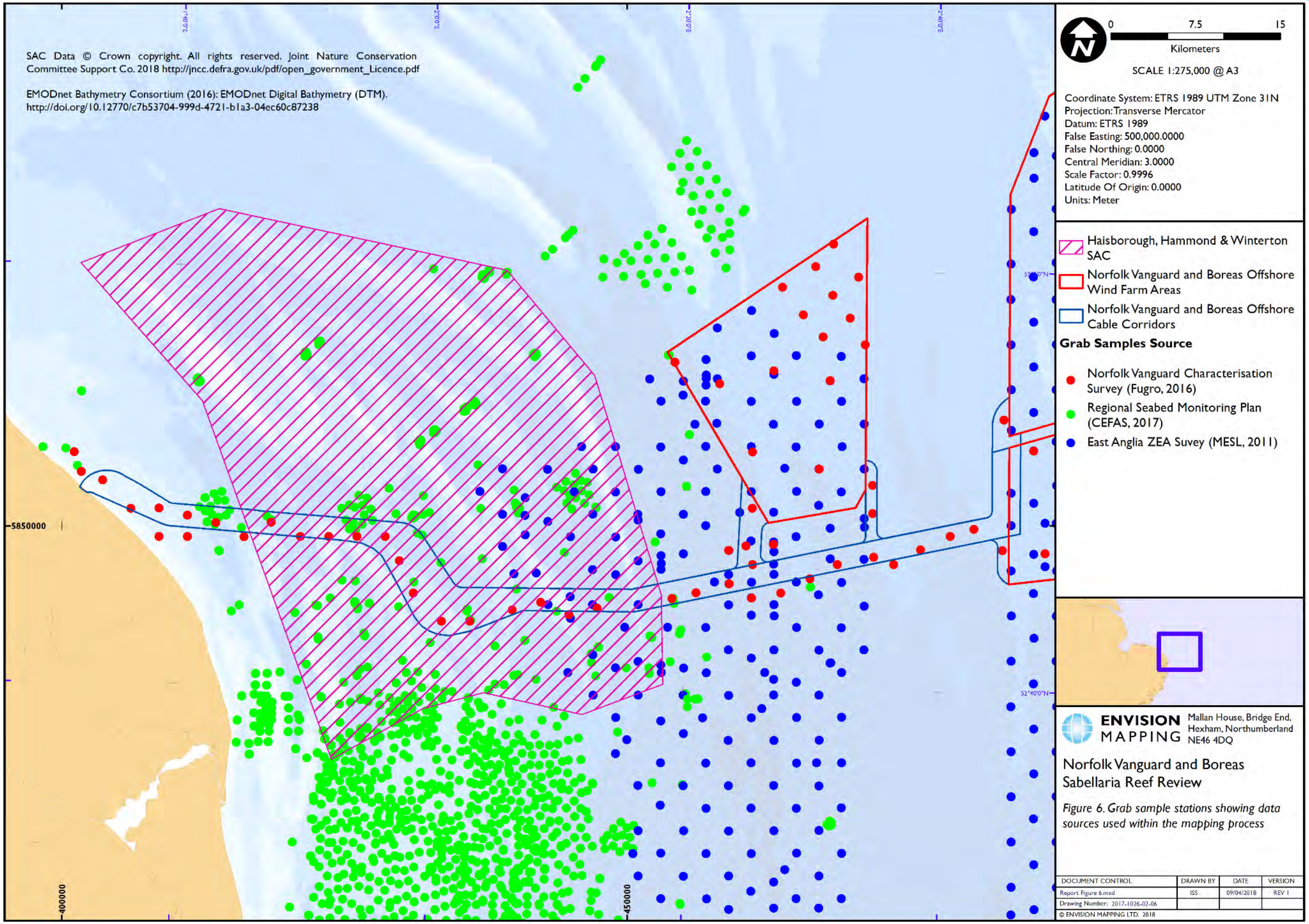

Figure 6. *Grab sample stations showing data sources used within the mapping process*

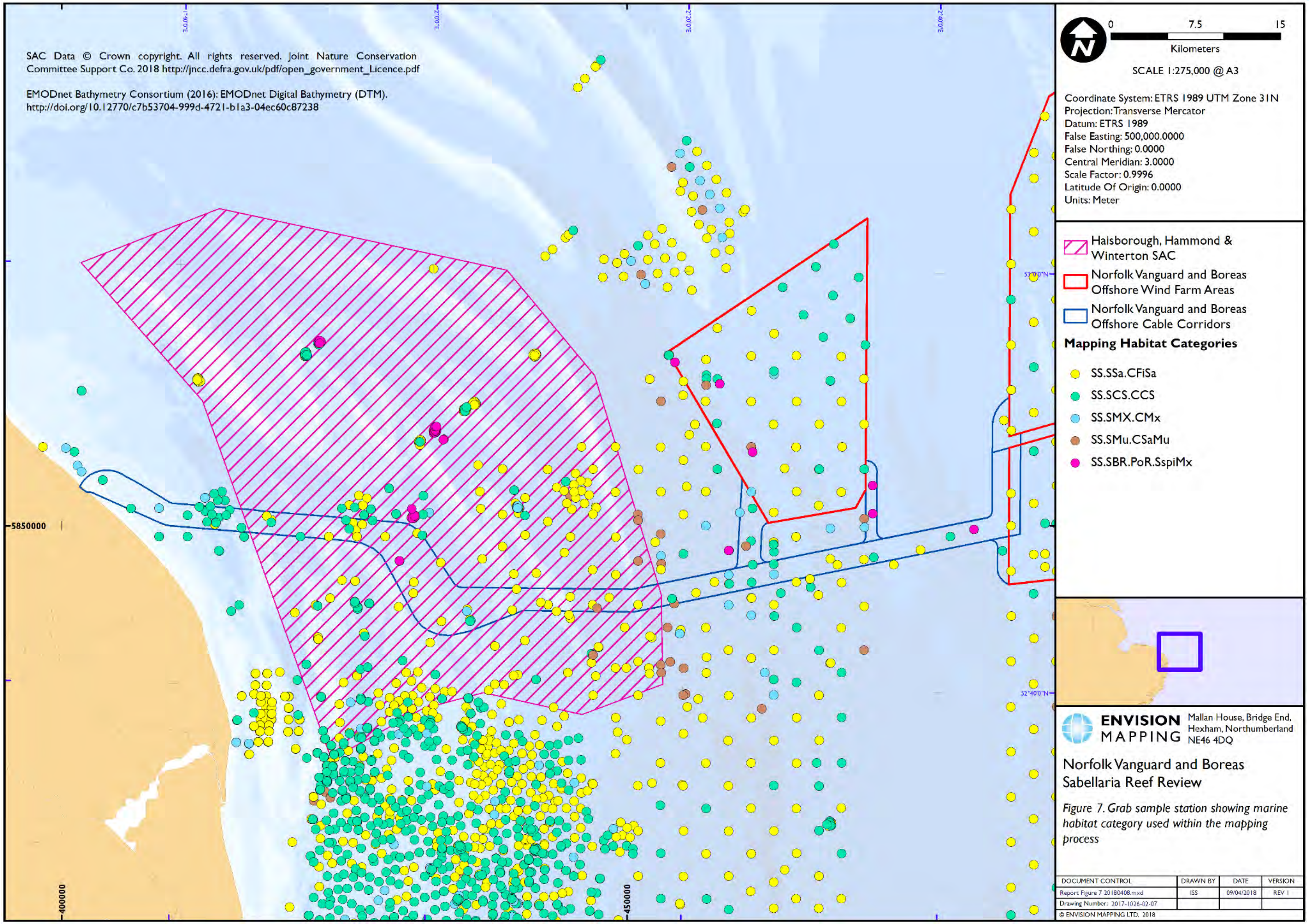

Figure 7.
Grab sample station showing marine habitat category used within the mapping process.

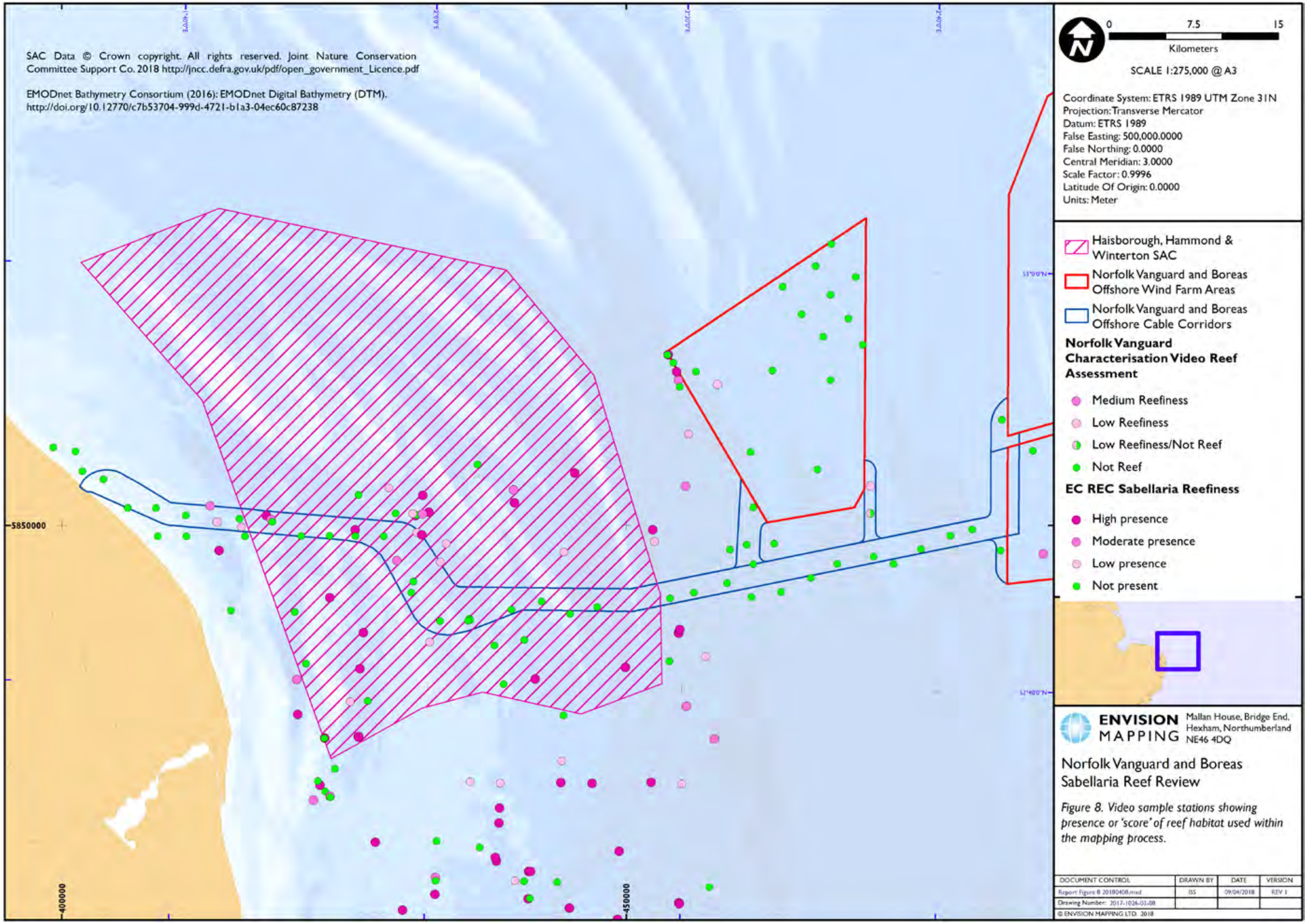

Figure 8. *Video sample stations showing presence or 'score' of reef habitat used within the mapping process.*

2.3. *Sabellaria spinulosa* review

Sabellaria spinulosa is a ubiquitous species found in varying abundances throughout the North Sea present as solitary individuals, thin crusts, or reef systems; the biotope SS.SBR.PoR.SspiMx is commonly attributed to samples with elevated numbers of individuals. Therefore, in order to distinguish whether aggregations of this species should be considered as reef, the methodology for determining 'reefiness' (Gubbay 2007) has been used with this review. The main focus of the study was to assess the likelihood, presence, distribution, and nature of *S. spinulosa* reef existing within the Norfolk Vanguard and Norfolk Boreas cable corridor area and Norfolk Vanguard West OWF site. Therefore, an assessment was made of the currently mapped distribution of the biotope SS.SBR.PoR.SspiMx along with the samples which contributed to the mapping of these extents. Samples from other datasets which may inform the distribution of the biotope and whether reef habitat is present have also been reviewed and incorporated into the analyses.

For each area mapped as potential SS.SBR.PoR.SspiMx by Fugro (2016), a scoring assessment was made to gauge the confidence of the mapped area as part of the current study. This assessment considered how the feature was mapped and the supporting evidence. A positive score was given to all areas initially as these have been identified by expert interpretation and judged to be areas of seabed which potentially support SS.SBR.PoR.SspiMx. If the area was substantiated by a sample station which supported this assignment, then the confidence was increased as the likelihood the area supported SS.SBR.PoR.SspiMx is increased. Conversely if samples from the same location, collected at different times, were found to contain data which does not consistently support SS.SBR.Por.SspiMx, then the likelihood that the area supports SS.SBR.PoR.SspiMx is diminished and the confidence is reduced. Both video and grab sample data were used where possible.

Figure 9 shows the areas identified by Fugro (2016) as potential SS.SBR.PoR.SspiMx, coloured to show level of confidence for each area. It can be seen that Figure 9 shows some areas mapped with high confidence, but others mapped as the potential SS.SBR.PoR.SspiMx biotope without supporting sample data from current or historic records have lower confidence.

Further review of sample data and supporting evidence has therefore been undertaken and the habitat maps refined.

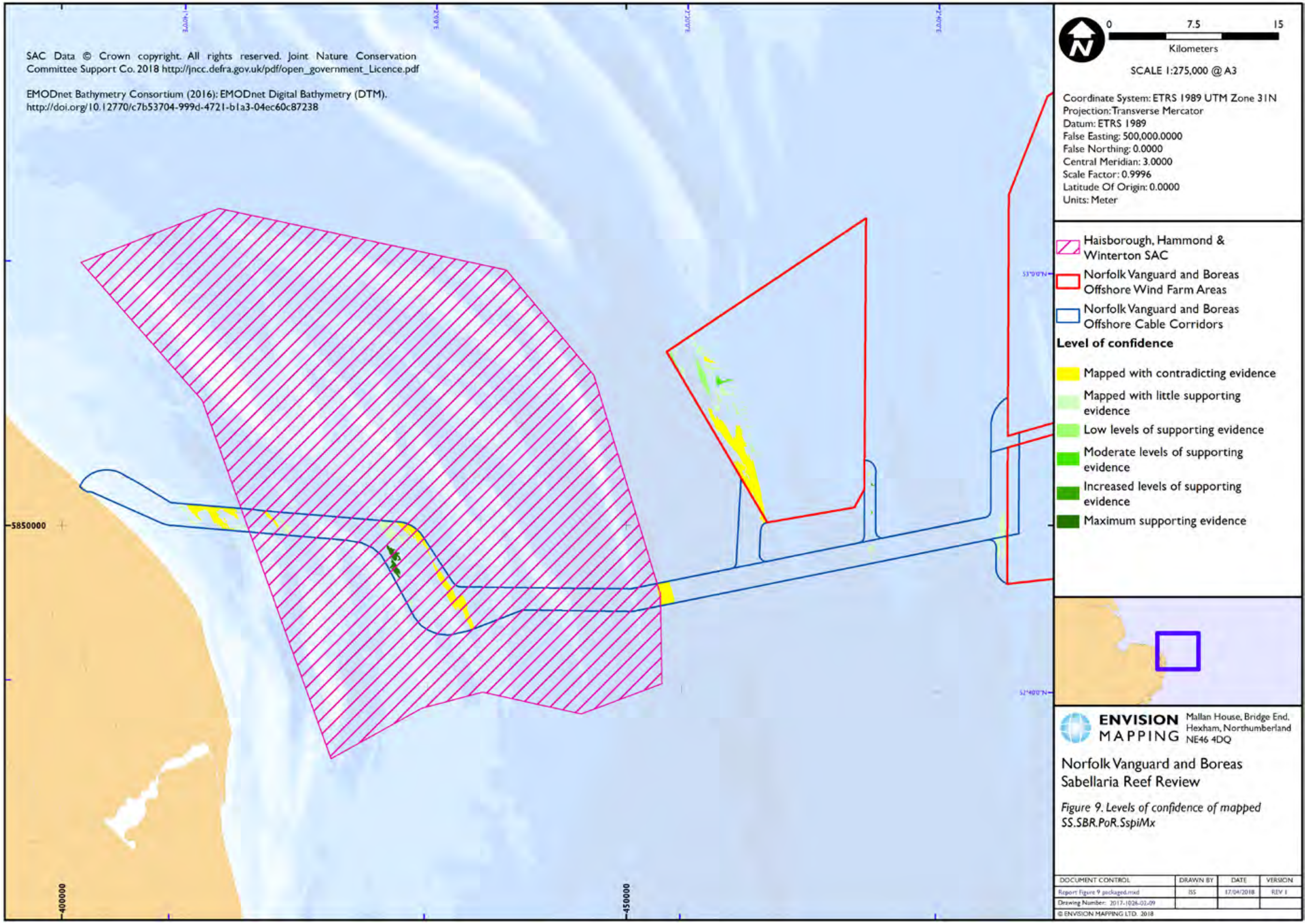

Figure 9.

Levels of confidence of mapped potential SS.SBR.PoR.SspiMx

2.3.1. Reef assessment of samples

At several locations along the shared cable corridor and within the Norfolk Vanguard West site, Fugro (2016) analysis has attributed samples with the biotope SS.SBR.PoR.SspiMx and indicated the possibility of reef. This process of attributing samples to the *S. spinulosa* biotope and reef habitat appear to have taken a precautionary approach. An assessment of 'reefiness' was undertaken as part of the original analysis, with no samples having high 'reefiness' scores and only 2 having a medium level of reefiness and the biotope SS.SBR.PoR.SspiMx being attributed to samples regardless of 'reefiness'.

The data and imagery from these samples has subsequently been reviewed and where it was found Sabellaria abundance and 'reefiness' score were both low then samples were attributed with the habitat based upon the physical properties from the grab sample (PSA) following methods developed by Long, 2006 and used within UKSeaMap (McBreen & Askew, 2011)

Within the Norfolk Vanguard benthic characterisation report (Fugro, 2016) 8 grab and 6 video samples were attributed with the biotope SS.SBR.PoR.SspiMx, or as having low to medium 'reefiness'. Table 2 shows these samples along with comments from the current review process.

Table 2

Sample	Biotope (from grab sample)	Reefiness (from video sample)	Review	Mapped Habitat
01MS	SS.SBR.PoR.SspiMx	Low	Reefiness from video is low, and description is of clumps and sand inundation with moribund tubes. With 757 individuals within the grab this was not thought to constitute reef and was mapped according to the sediment properties	SS.SSa.CFiSa
02MS	SS.SBR.PoR.SspiMx	Unassessed	Grab sample contained only 40 individuals and with no supporting video this was not thought to constitute reef and was mapped according to the sediment properties	SS.SMu.CSaMu
03MS	SS.SBR.PoR.SspiMx	Not reef	Grab sample contained only 117 individuals and with video assessed as not reef this station was mapped according to the sediment properties	SS.SCS.CCS
19MS	SS.SSa.CFiSa	Low/Medium	With low numbers of individuals (64) and poor-quality video suggesting low relief and moribund tubes the habitat mapped was as attributed in the original analysis.	SS.SSa.CFiSa

Sample	Biotope (from grab sample)	Reefiness (from video sample)	Review	Mapped Habitat
25CR	SS.SCS.CCS.MedLumVen	Low	Grab sample contained only 145 individuals and attributed to the 'MedLumVen' biotope. Video assessment indicates low reefiness with only clumps and crusts the habitat mapped was as attributed in the original analysis.	SS.SCS.CCS
40CR	SS.SBR.PoR.SspiMx	Medium	Grab sample contains very high numbers of individuals (3773) and video supports medium reef in places therefore mapped as SS.SBR.PoR.SspiMx and considered as Sabellaria reef	SS.SBR.PoR.SspiMx
62CR	SS.SBR.PoR.SspiMx	Not reef	Grab sample contained relatively low numbers (294) of individuals and with video assessed as 'not reef' this station was mapped according to the sediment properties	SS.SMx.CMx
64CR	SS.SBR.PoR.SspiMx	Not reef/Low	With video and grab (1255 individuals) both suggesting the possibility of low 'reefiness' this sample was attributed with the biotope allocated in the original analysis and considered as low reefiness	SS.SBR.PoR.SspiMx
65CR	SS.SBR.PoR.SspiMx	Low	With video and grab (2464 individuals) both suggesting the possibility of low 'reefiness' this sample was attributed with the biotope allocated in the original analysis and considered as low reefiness	SS.SBR.PoR.SspiMx
67CR	SS.SBR.PoR.SspiMx	Not reef	This sample station has 1180 recorded from the characterisation survey and lower numbers from the zone wide survey (2). The video sample was inconclusive but suggested reef habitat therefore precaution was used and the sample attributed with the SS.SBR.PoR.SspiMx biotope.	SS.SBR.PoR.SspiMx

Ground truthing data (video, grab and trawl) from Inner Dowsing, Race Bank and North Ridge along with Haisborough, Hammond and Winterton survey data had been assessed for 'reefiness' using an assessment based on recommendations made by Foster-Smith and Hendrick (2006) and Gubbay (2007), Data from the Vanguard Characterisation Report (Fugro, 2016) had been assessed using the same recommendations (Figure 8). Additionally, preliminary data collected as part of a CEFAS Survey (code CEND 11/16) (McIlwaine *et al*, 2017) has been assessed and investigated to determine the status of reefs in the surrounding area but advice from MMO suggests these preliminary data are removed from reef prediction model and therefore these data have not been included in this further assessment. Once data have been finalised it is possible these could be incorporated in the process to better determine the likely extents of *S. spinulosa* reef.

Sample data collated as part of Cooper & Barry, 2016 and from East Anglia Zone Environmental Appraisal (MESL, 2012) were reviewed by assessing the numbers of Sabellaria individuals recorded within samples.

All samples were used to assess the confidence in any area mapped as the biotope SS.SBR.PoR.SspiMx in the original analysis (Fugro, 2016). Where elevated numbers of Sabellaria were found or samples were identified as reef by the original authors these added confidence to any mapped areas.

In addition to reviewing the current mapped habitat extents, all available sample data, and ensemble mapping techniques (see section 2.5) were used to build habitat distribution maps of the area. This method uses multiple mapping processes, with the aim of improving map performance and outputs by combining the results of several mapping techniques to produce a refined 'ensemble map'.

The resulting maps are compared and where there is consensus, this builds confidence in the mapped areas and enables a final, refined map to be produced which is supported by available datasets providing a greater level underlying confidence. This map incorporates appropriate levels of precaution in terms of how the sample data are assessed and used within the mapping processes. Any ambiguous or uncertain areas were also mapped using the original (Fugro, 2016) precautionary approach.

2.4. Integration of sample and physical data for mapping

The ground truth point data were buffered to create a training area of 25m radius around each point and these areas associated with the appropriate habitat category.

The integration analysis was performed in the GIS and image processing software *Idrisi Taiga*. The training areas were used to extract values from each of the geophysical layers that could be associated with the biological habitat classes. These values were used to create a statistical 'signature' for each class.

These signatures were then applied to the whole geophysical data set. One method of classifying images is to use a maximum likelihood classifier, whereby each grid cell/area is assigned to the class to which the grid cell has the highest probability of membership. This works well where the data in the images provide sufficient discrimination. The initial outputs indicated a lack of discriminatory power that resulted in a high level of confusion between classes or classes attributed to incorrect locations; so, to increase the power of discrimination, probability mapping was introduced to better define the areas where habitats could occur.

The point sample data were used to derive *probability images* which reflect the spatial trends of the occurrence of habitats across the cable corridor and OWF area. These images express the likelihood of finding a particular habitat or biotope in an area based on prior knowledge of their distribution from the ground truth data.

Incorporating these probability images into a maximum likelihood model enables the spatial trends and knowledge from the sample data influence the mapping processes and does not rely on the interpretation of the geophysical data alone. This improves the mapping process as there can be confusion between habitats identified purely from the properties of geophysical data alone. A schematic diagram illustrating the main stages in the analytical process is shown in Figure 10.

Two datasets were used to introduce the probability of a habitat occurring in a certain location. Primarily, the dataset collected as part of Norfolk Vanguard Benthic characterisation were used, these data were collected as part of the same survey campaign as the geophysical datasets that are contemporary both spatially and temporally. Secondly, the data from other surveys were introduced which enables samples which are not coincident with the geophysical datasets to influence the mapping process, as habitat probabilities from sample stations close to the cable corridor and OWF can 'bleed' in the area.

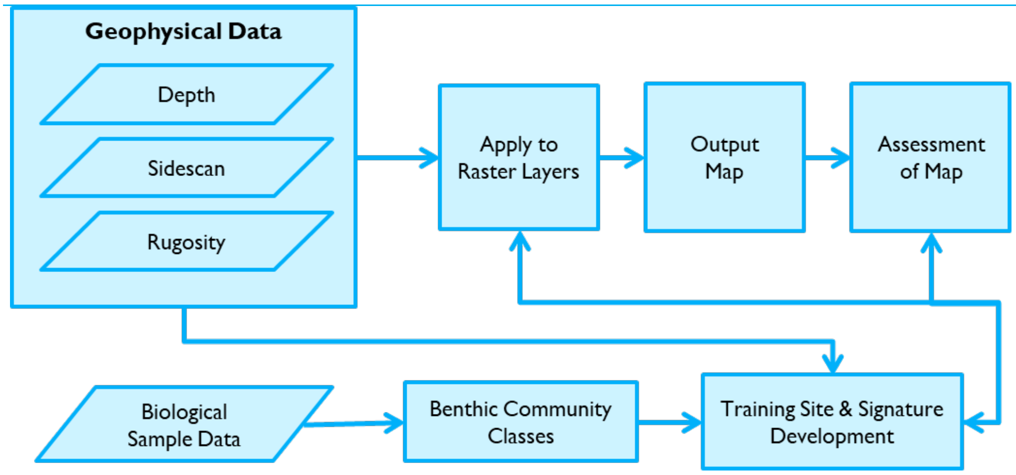

Figure 10.
Schematic diagram outlining the main stages in the modelling of the distribution of biotas classes

2.5. Existing distribution maps

In addition to the distribution of 'potential SS.SBR.PoR.SspiMx' identified within the Vanguard Characterisation Report (Fugro, 2016) information from the EC REC have been provided by Natural England and are incorporated within this current assessment.

The EC REC data provides two versions of reef extent, the first is the likely extent as determined by acoustic records using methods after Limpenny *et al.* (2010), the second being 'bottom-up" modelling which identifies areas of 'dense Sabellaria' which are described as '*forming extensive reefs*' and 'moderately dense Sabellaria' described as '*areas with crusts and patches rather than extensive reef*' but are considered by Natural England to have the potential to support reef due to the high presence of *S. spinulosa* individuals.

2.6. Ensemble Mapping

A range of mapping processes have been applied which employ the principles shown in Figure 10. these range from image processing classification systems to topographic analysis classification, and rule-based modelling. Current opinion (Lillis *et al.*, 2016, Diesing & Stephens, 2015) is that there is no best process to use, with each having merits and downsides. To accommodate this and also to provide an additional level of confidence in the mapping processes a system of 'ensemble mapping' has been employed.

Ensemble mapping involves the creation of several iterations of benthic habitats and sediment maps each using a different mapping process. Whilst each of these iterations may have lower or higher confidences, or be more appropriate for specific habitats or datasets, they are combined and compared to produce benthic habitat and ecological characterisation of the area using the best current evidence base and as such be in line with regulatory guidelines. This process is summarised in Figure 11.

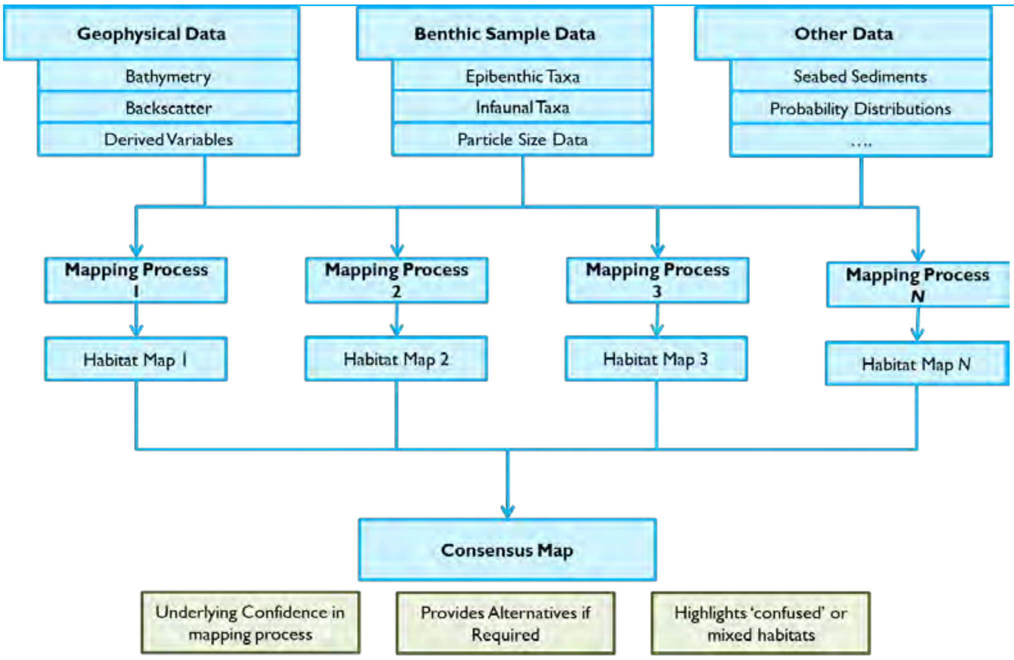

Figure 11. *Summary of data flow and outputs from the ensemble mapping process*

Five resultant maps were incorporated in to the ensemble mapping process:

1. The existing habitat map from Norfolk Vanguard Benthic characterisation
2. A newly derived habitat map using Norfolk Vanguard Benthic characterisation datasets
3. A newly derived map incorporating Norfolk Vanguard Benthic geophysical data with sample data from all other available datasets
4. The extent of *S. spinulosa* reef from EC REC derived from acoustic data interpretation
5. The extent of *S. spinulosa* reef from EC REC derived from 'bottom-up' modelling

The existing habitat map from Norfolk Vanguard Benthic characterisation was reclassified to represent the contemporary suite of habitats (Table 1) used within the process. Two classes, 'outcropping' areas and 'Nearshore pitted seafloor' were incorporated into the surrounding habitat SS.SMx.CMx or assessed as 'null' records respectively as these were not present in other mapping process or sample data and are not recognised habitat classes.

Once the five habitat maps were combined a consensus map was derived which shows the habitat category which is represented in the majority of maps. Where there is an equal probability of several habitat classes (i.e. five maps showing five different habitat categories), this was noted and the category from the habitat map produced from the Norfolk Vanguard Benthic characterisation datasets used.

2.7. Confidence Assessment

Confidence in the extents mapped by ensemble mapping process has been assessed using a scoring system, where all maps are in agreement then the area is give a high (5) value and when 4 maps are in agreement and one is contrary then a value of 4 is attributed to the mapped area etc. until where only one map suggests *S. spinulosa* reef then the lowest confidence score of 1 is given.

This confidence score does not consider the underlying confidence or accuracies for each of the maps used but is a measure of agreement indicating concordance between a variety of mapping techniques and processes. Where all mapping methods agree, this can be considered a high confidence area and where the mapping method results contradict each other these areas can be considered as lower confidence areas.

The implication of this could be that areas of high confidence should be avoided within any development plans and areas of low to moderate confidence could be targeted for additional investigation prior to any development.

2.8. Assumptions

Several assumptions have been made within this review which should be considered when utilising any data or outputs. Habitat classes attributed to samples were considered to be accurate and whilst the process of how they were assigned has been reviewed the underlying dataset have not been queried extensively. Likewise, the results from video footage analysis have been relied upon, a review of still images and descriptions and analyses has been undertaken as part of this study but original video interpretation (Fugro, 2016) has been used. The original characterisation habitat map has been used as supplied and the method of how this was produced has been reviewed but not critically assessed. Within the mapping processes there are underlying statistical processes and parameters which have inherent assumptions and caveats, and these have been accepted and incorporated within any outputs.

3. Results

The main outputs of this review are a series of maps showing the distribution of habitats from the various mapping methods, with a consensus map showing the distribution of marine habitats from the current understanding of the area in question.

Figure 12 shows the distribution of marine habitats from the original characterisation study (Fugro, 2016) with the habitats standardised to a common level. This map has been produced by expert interpretation from geophysical data along with grab and video data. The map has been reviewed by using sample data to assess the certainty in the mapped areas (Section 2.3). As the underlying levels of confidence in the map are relatively low, data has been reworked and assessed to produce refined maps.

Figure 13 is derived from the same sample and geophysical data as Figure 12 but also incorporates the level of probability of each habitat being located throughout the mapped area. This map shows patterns in habitat distribution similar to that found in the original habitat map but with a reduced area of *S. spinulosa* habitat and introduces the habitat of circalittoral muds and sandy muds which is supported by the PSA data from grab samples. There are also some variations in the distribution of sands and coarse sediments which appear to be associated with sand wave features.

Figure 14 shows a habitat distribution map derived using a large set of sample data which have been allocated to habitat type based on the properties of the sediment within the samples, alongside the site specific data used to generate the preceding habitat maps (Figure 12 & Figure 13). Introducing these additional data does alter the distribution of habitats within the Vanguard West OWF area, in that the seabed is mapped as a sandy habitat (SS.SSa.CFiSa) where other maps have been predominantly coarse sediment-based habits (SS.SCS.CCS and lower hierarch levels). This change is explained by the use of the PSA data to classify the samples with a habitat category (as described in Long, 2006). This, along with the increased number of samples, overrides coarse habitats and biotopes which have been allocated based upon the biological communities which occur within the samples which is in line with current advice for using the marine habitats classification. (Lillis *et al.*, 2016). The effect on the mapping process is discussed below.

Figure 15 shows the distribution of habitats which best represents the current datasets. The map is derived from the ensemble mapping process and combines the outputs of the previous three maps (Figure 12, Figure 13 and Figure 14). The map shows the Norfolk Vanguard West OWF area to be dominated by coarse sediment communities (SS.SCS.CCS and lower hierarchy levels) with sandier (SS.SSa.CFiSa and lower hierarchy levels) within sand wave systems. The western edge of the OWF area appears to be influenced by the silt content found within the seabed, and sandy mud habitats are predicted based upon the silt content of the grab samples found in this area. There are some areas which are mapped as SS.SBR.PoR.SspiMx biotope, which are found on the edges of large sand waves and are supported by the presence of large numbers (>750) of *S. spinulosa* in the grab sample and the video footage information which suggests reef but with a low 'reefiness' score. It may be that these are patches of *S. spinulosa* which grow to elevated levels above the seabed but, due to the migration of sand waves in the area (ABPmer, 2017, Appendix 7.1 of the Information to Support HRA report (Document 5.3)), are subject to inundation by sediment and do not form extensive or elevated reef systems.

The export cable corridor which leads from the eastern boundary of the Norfolk Vanguard West OWF area also has SS.SBR.PoR.SspiMx biotope predicted in several locations and these predictions are supported by samples with very high numbers (1000-2400 individual per sample) of *S. spinulosa*. Here the video data show low levels of 'reefiness' as the structures are not highly elevated and are patchy in structure.

These areas should therefore be considered as *S. spinulosa* reef but with low levels of 'reefiness'.

The export cable corridor has coarse sediment and sandy habitat throughout its length which are occasionally interspersed with softer sediments. Towards landfall the seabed is of mixed substrate with patches of coarse sediments. *S. spinulosa* reefs are found to occur within the 'dog-leg' section of the shared Norfolk Vanguard and Norfolk Boreas cable corridor. An oval shaped reef is predicted with medium to high certainty and is supported by grab samples with over 3700 individuals within a sample and video evidence supporting a medium 'reefiness'. To the east of this area there are elongated sections of SS.SBR.PoR.SspiMx biotope which are supported by elevated numbers of *S. spinulosa* within samples but are poorly supported by video evidence. The abundance of *S. spinulosa* are high (2000-3000 per sample) but the data are from records collected in 2009. With this in mind these areas should be considered as potential reef habitat as *S. spinulosa* reefs are known to be ephemeral and not permanent structures.

Figure 16 is a map which represents the underlying confidence in the ensemble map which has been produced. This confidence is based upon the number of times each of the maps are in agreement. Habitat areas which are consistently mapped the same having the highest confidence and those which are confused throughout the maps having the lowest confidence. The attributed level of confidence should be considered when using the distribution of habitats within any decision-making processes.

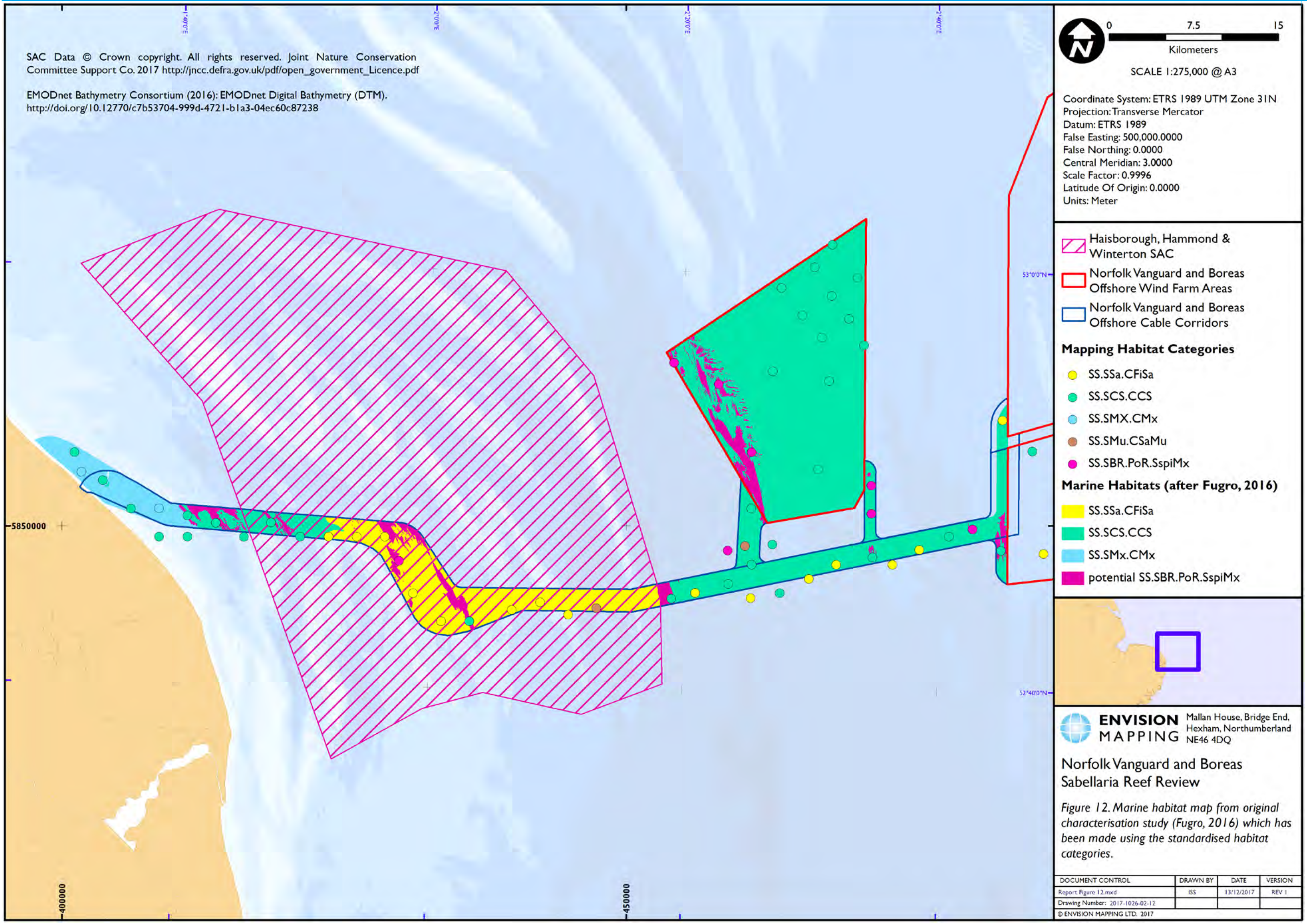

Figure 12.
Marine habitat map from original characterisation study (Fugro, 2016) which has been made using the standardised habitat categories.

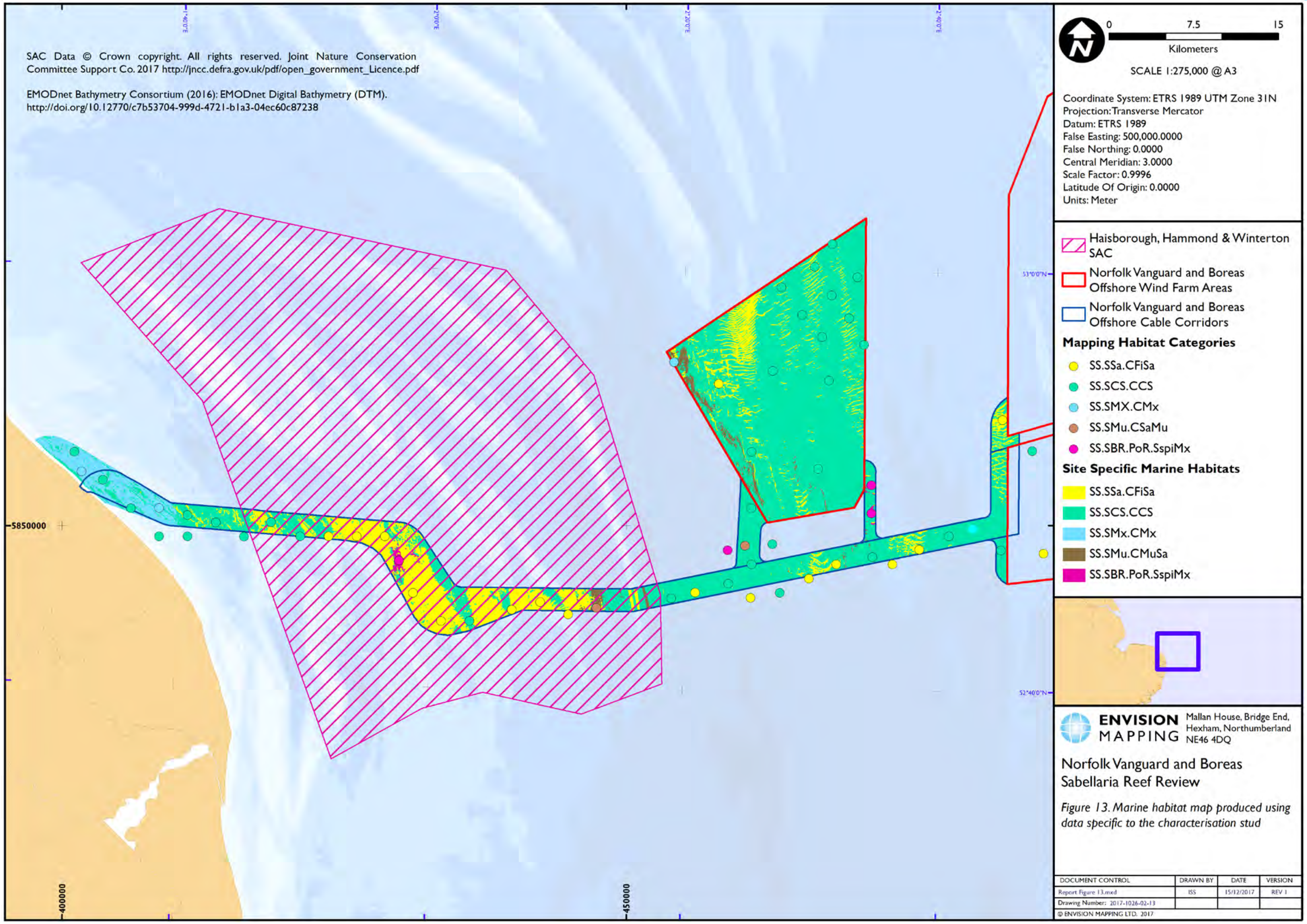

Figure 13.
Marine habitat map produce using data specific to the characterisation study

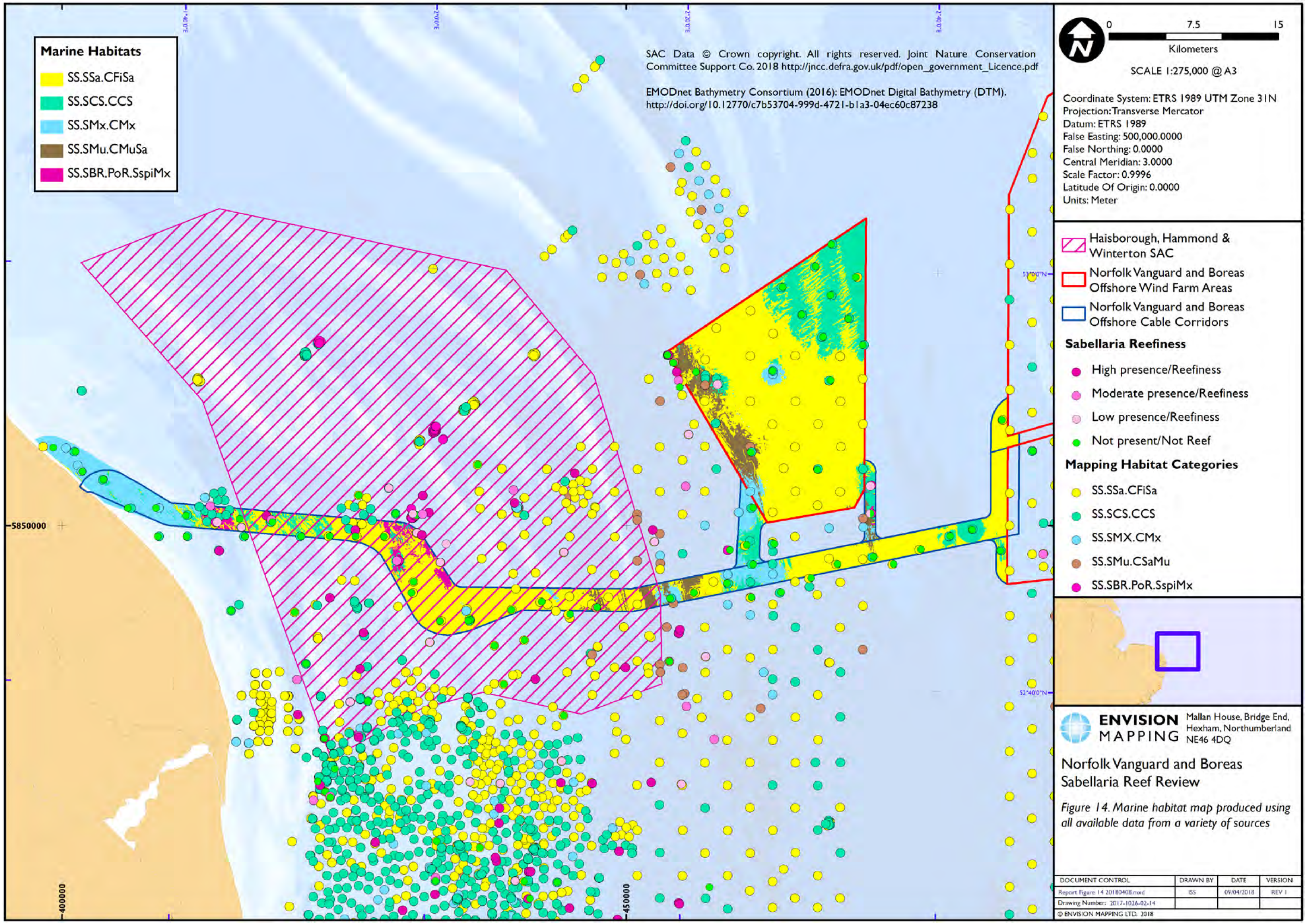

Figure 14.

Marine habitat map produced using all available data from a variety of sources

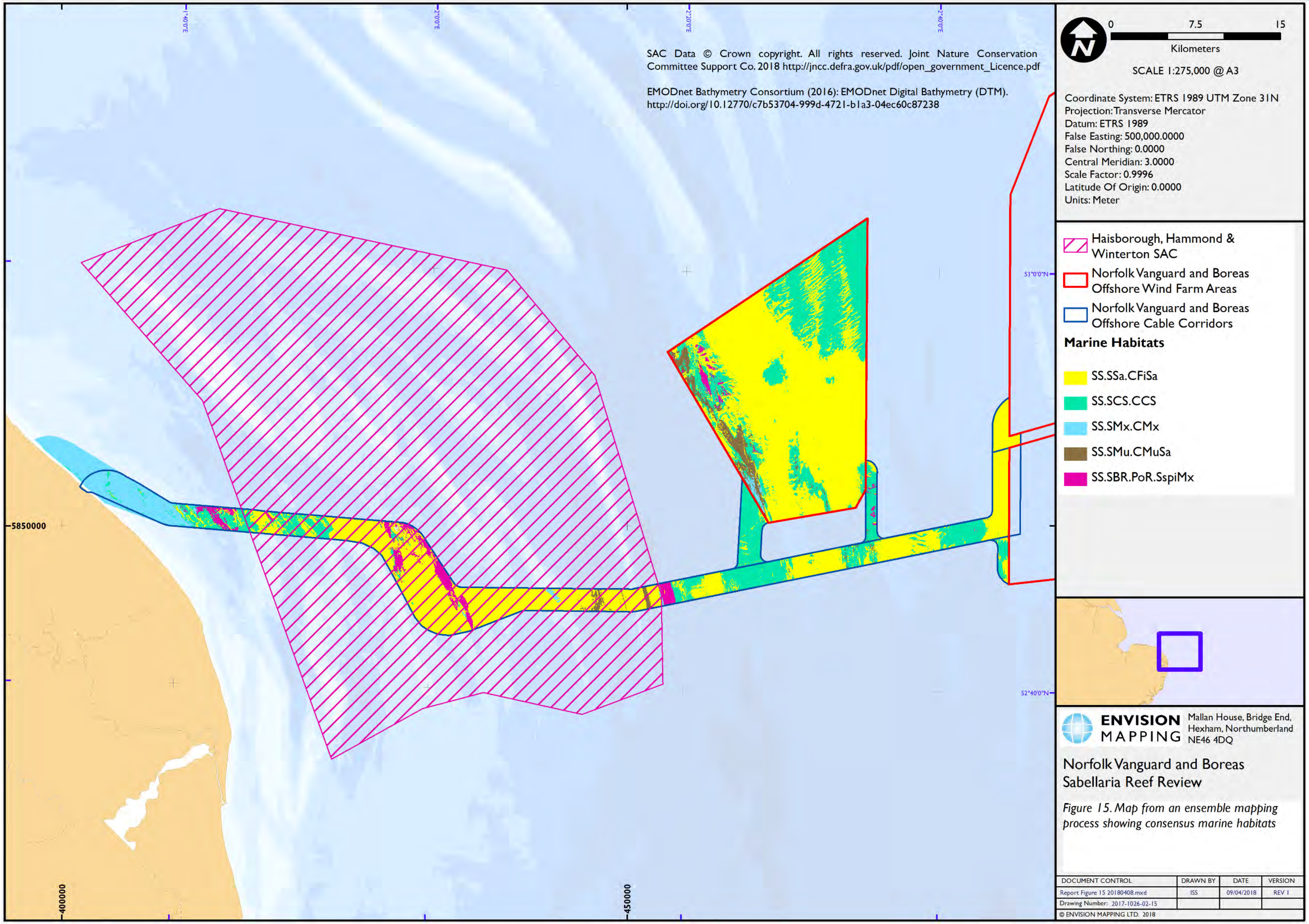

Figure 15.
Map from an ensemble mapping process showing consensus marine habitats

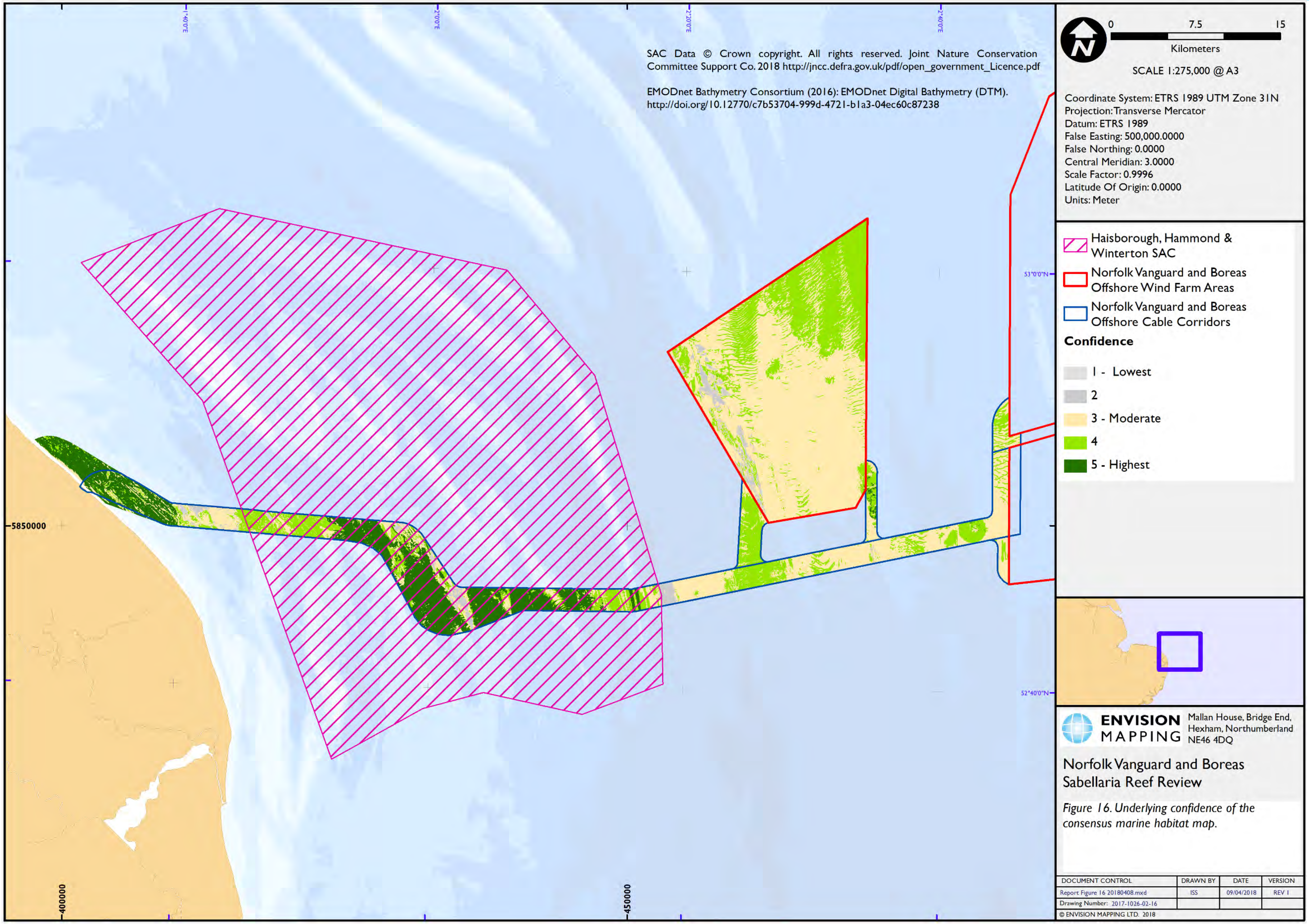

Figure 16.
Underlying confidence of the consensus marine habitat map.

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3.1. Current distribution of *Sabellaria spinulosa* reefs

The aim of the review was to focus on the distribution of the SS.SBR.PoR.SspiMx biotope and *S. spinulosa* reef. Therefore, the likely distribution of SS.SBR.PoR.SspiMx biotope has been mapped separately with supporting data shown (Figure 17).

In order to map the distribution of *S. spinulosa* reef the underlying confidence levels for the areas mapped as SS.SBR.PoR.SspiMx biotope were used. The areas of SS.SBR.PoR.SspiMx biotope and the confidence associated with them have been mapped separately (Figure 18 to Figure 22. Supporting sample data for these areas have also been considered and the 'reefiness' associated with them included when assessing whether an area is considered to be *S. spinulosa* reef. These maps indicate *S. spinulosa* reefs to occur in several locations throughout the cable corridor and Vanguard West OWF area.

Within the eastern entrance to the Vanguard West OWF Figure 18 shows *S. spinulosa* reef in two discrete areas with supporting sample data giving this area a low 'reefiness' score which should be considered within management or mitigation processes. The grab samples contained elevated number of individuals (>1000) but video sample data showed aggregations of *S. spinulosa* tubes had low relief and patchy distribution.

Within the 'dog leg' section of the shared Norfolk Vanguard and Norfolk Boreas cable corridor, Figure 19 shows *S. spinulosa* reef to occur and this is supported by grab sample data which contained the highest number of individuals (3773) within the shared Norfolk Vanguard and Norfolk Boreas cable corridors or Norfolk Vanguard OWF area and video data which indicated the area to have patchy 'reefiness', with areas of medium 'reefiness' containing aggregations of *S. spinulosa* tubes raised 5-10cm from the seabed and forming continuous aggregated structures in places. Other low reefiness areas are also encompassed in this area with consolidated clumps of *S. spinulosa* tubes raising up to 10cm from the seabed. An area identified as reef extends to the southern boundary of the cable corridor which has low/moderate confidence, within this area 5 samples, collected between 1998 – 2015, all have low abundance of *S. spinulosa* individuals (2 – 5 per sample) with no samples being classified as potential reef at any time. It would appear this area is unlikely to support *S. spinulosa* reef.

To the eastern boundary of the HHW SAC (Figure 20) a 'band' of *S. spinulosa* reef is predicated with relatively low confidence (Confidence score 2). This area appears to be predicted from interpretation of acoustic data and sample points to the North and South of the area have been identified as supporting reef yet several coincident sample points over a period from 2007, 2010 and 2015 do not suggest reef occurs in this area.

As the cable corridor passes through the western boundary of the HHW SAC there are several areas (Figure 21) of potential *S. spinulosa* reef identified. One area is within the SAC boundary, which is supported by samples from 2009 (EC REC), has been scored having moderate to high presence of Sabellaria with a medium level of confidence.

West of the HHW SAC (Figure 21) there are areas of seabed which have been classified as *S. spinulosa* reef or 'moderately dense Sabellaria' which represents areas with crust and patches of Sabellaria rather than extensive reef. These areas have a moderate (3) confidence score with sample data for the area showing one sample within the cable corridor (collected 2015) classified as low reefiness and a moderate reefiness sample from 2009 on the northern boundary of the cable corridor. *S .spinulosa* abundances are very variable (1 -145 per sample) and it is noted the area is subject to sand inundation (Fugro, 2016) suggesting this area may be ephemeral or patchy in nature.

Within Vanguard West OWF area (Figure 22) there are some areas which are mapped as SS.SBR.PoR.SspiMx biotope, which have relatively low confidence (Confidence score 2). These areas have been identified only by interpretation of acoustic data. However, the sample data for these do not show elevated numbers of Sabellaria. Sample data along the south-western edge of the OWF area do suggest *S. spinulosa* reef is likely to occur in this vicinity but the extent may be restricted. This area does appear to be a dynamic sand wave system (ABPmer, 2017) and it may be that due to the migration of sand waves clumps or crusts of Sabellaria are inundated by sediment and do not form extensive or elevated reef systems.

The ephemeral nature of *S. spinulosa* reefs and the variation in the forms it can take over time does mean that precise boundaries and 'reefiness' of any of the areas identified could change. Sample data supports this variation as samples collected from the same location two years apart can have vast changes in *S. spinulosa* numbers.

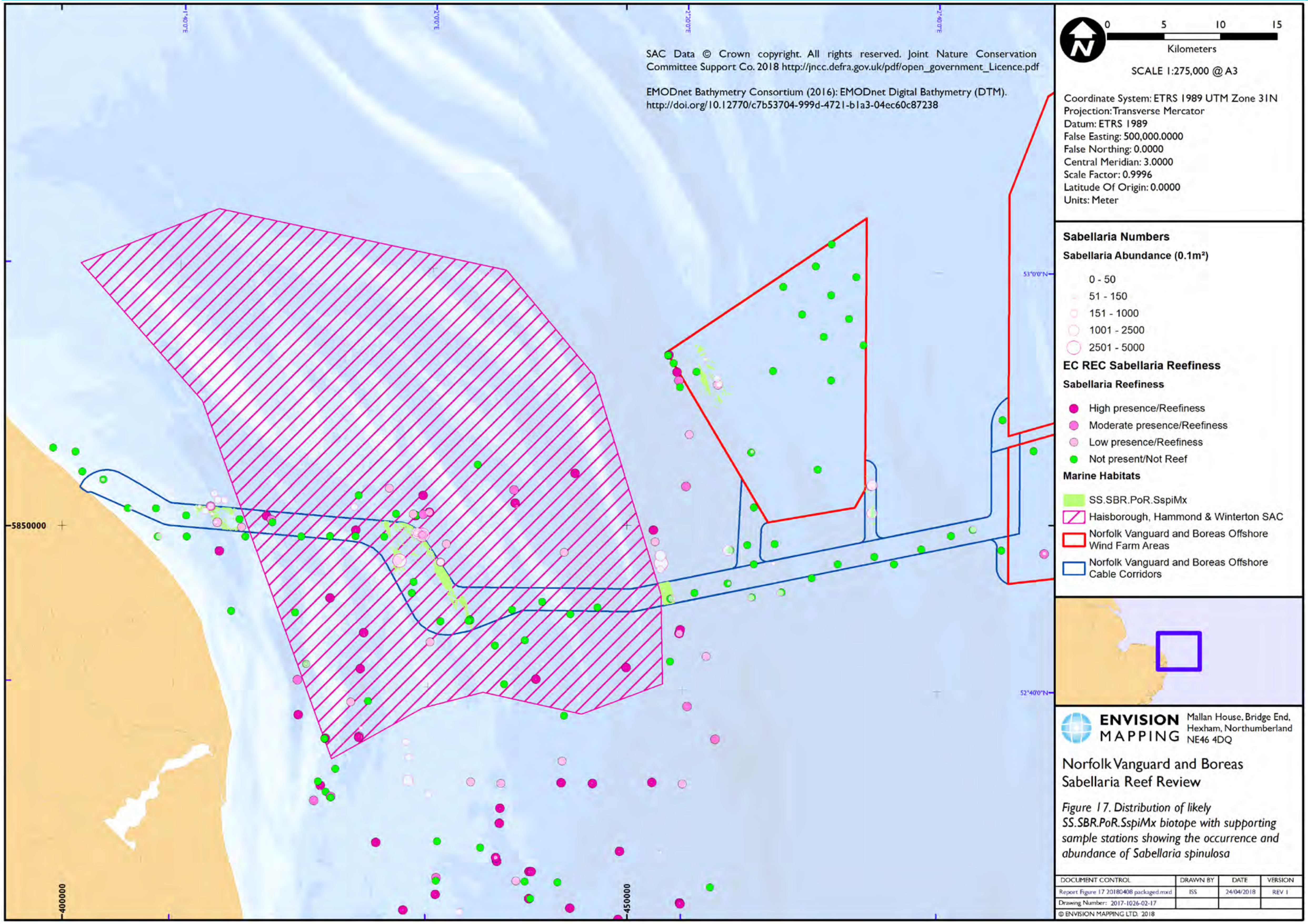

Figure 17.
Distribution of likely SS.SBR.PoR.SspiMx biotope with supporting sample stations showing the occurrence and abundance of Sabellaria spinulosa.

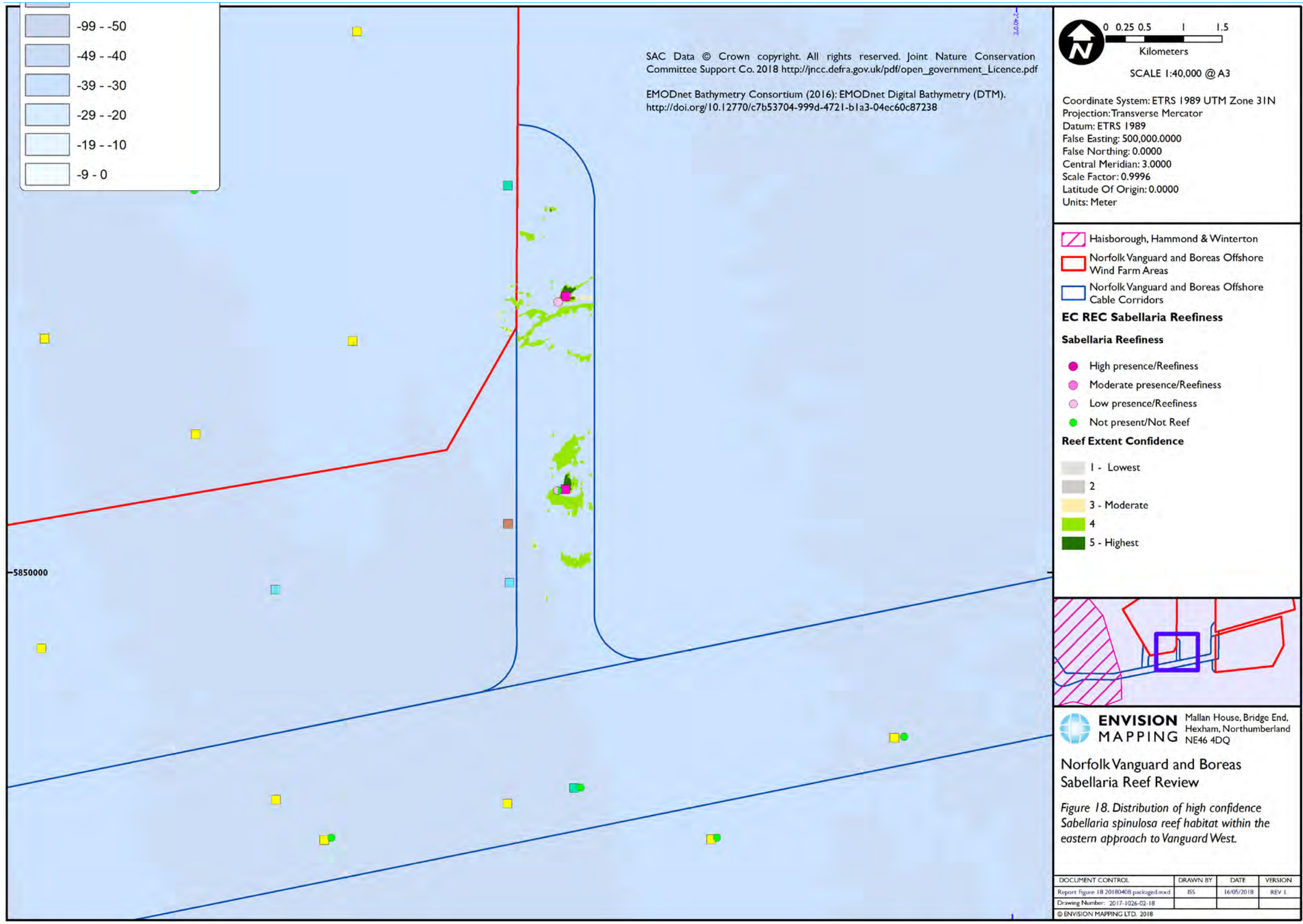

Figure 18.
Distribution of high confidence Sabellaria spinulosa reef habitat within the eastern approach to Vanguard West which are supported by low 'reefiness' video footage and elevated numbers of individual Sabellaria worms within grab samples.

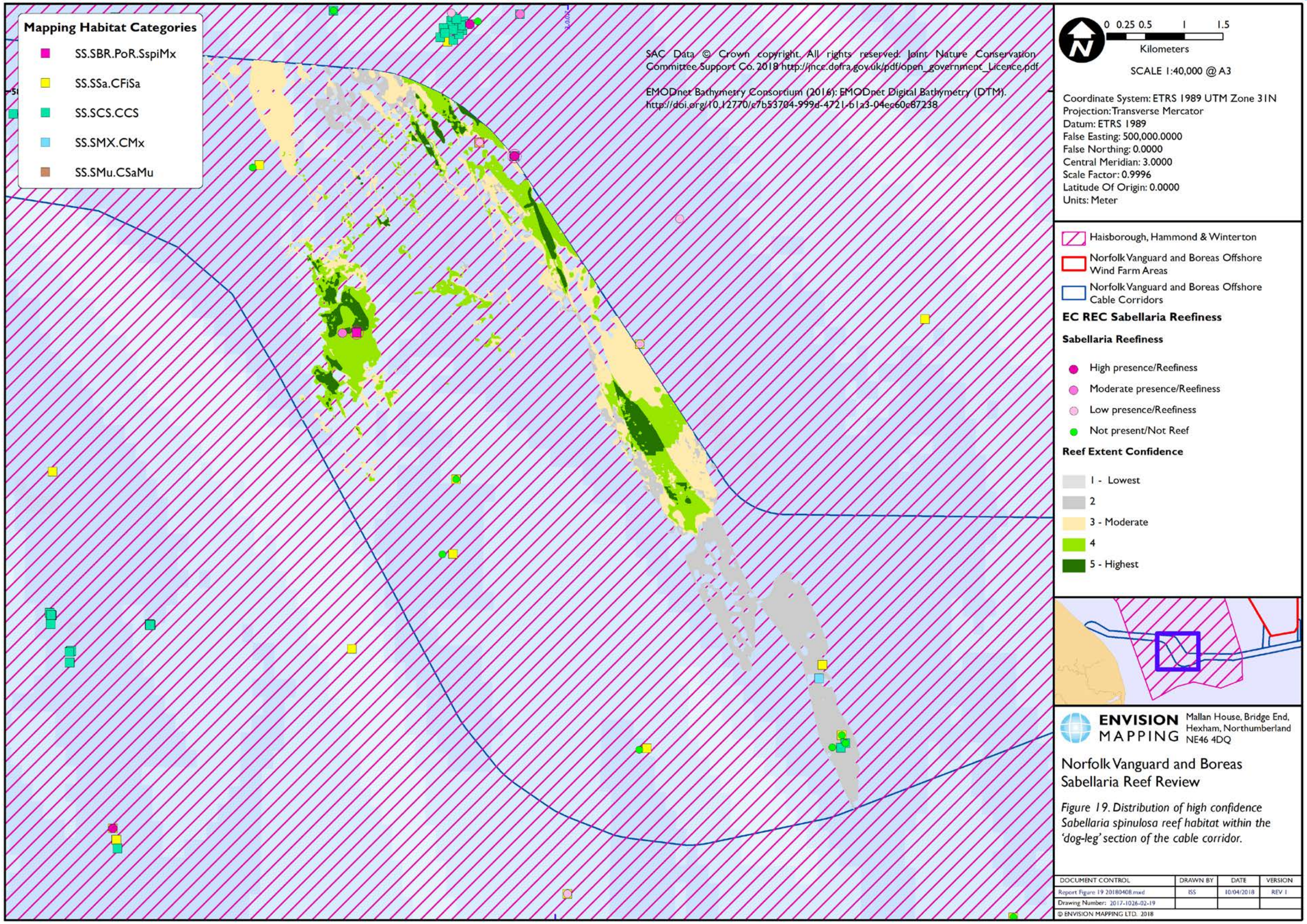

Figure 19.

Distribution of high confidence Sabellaria spinulosa reef habitat within the 'dog-leg' section of the cable corridor.

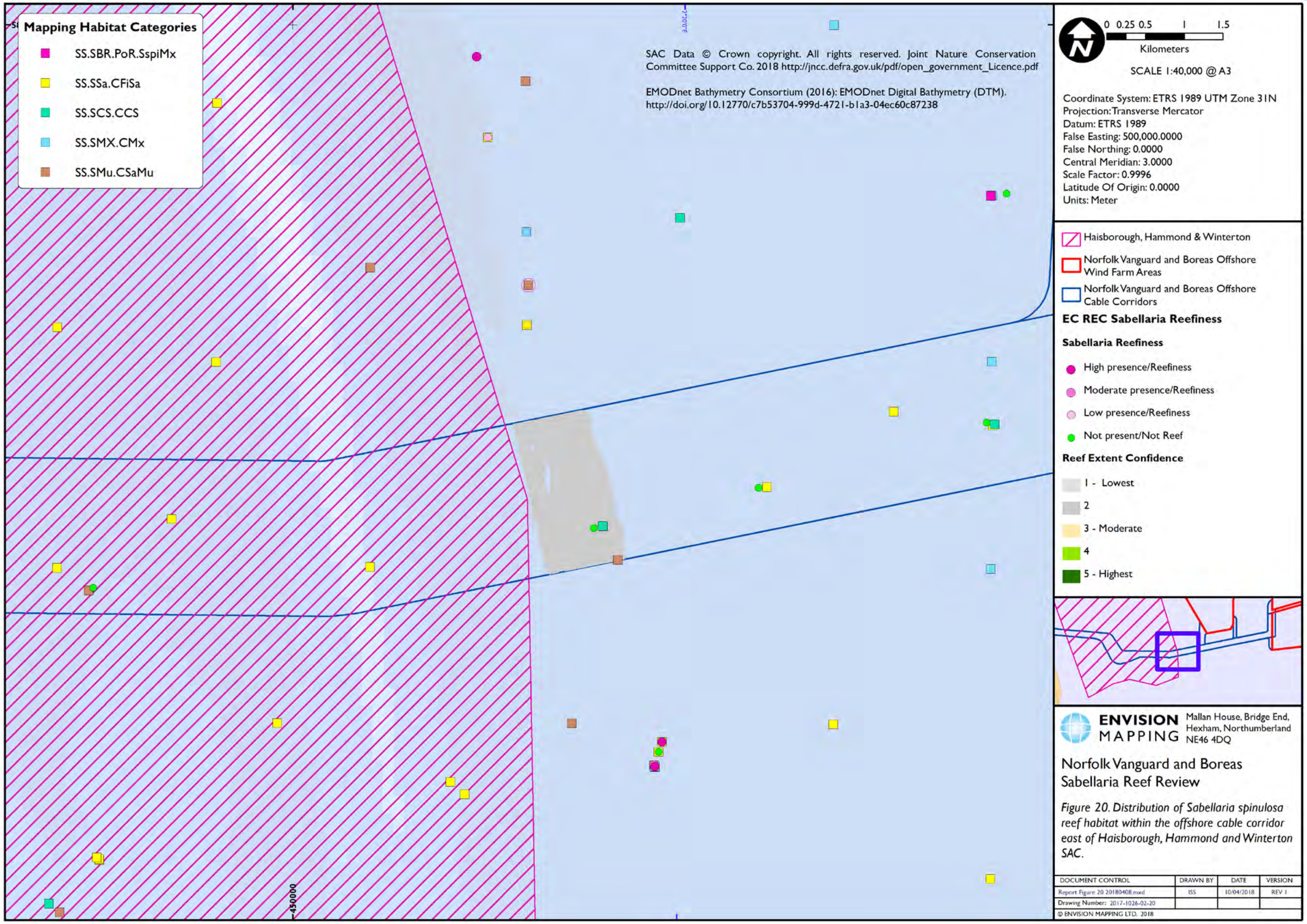

Figure 20.
Distribution of Sabellaria spinulosa reef habitat within the offshore cable corridor east of Haisborough, Hammond and Winterton SAC

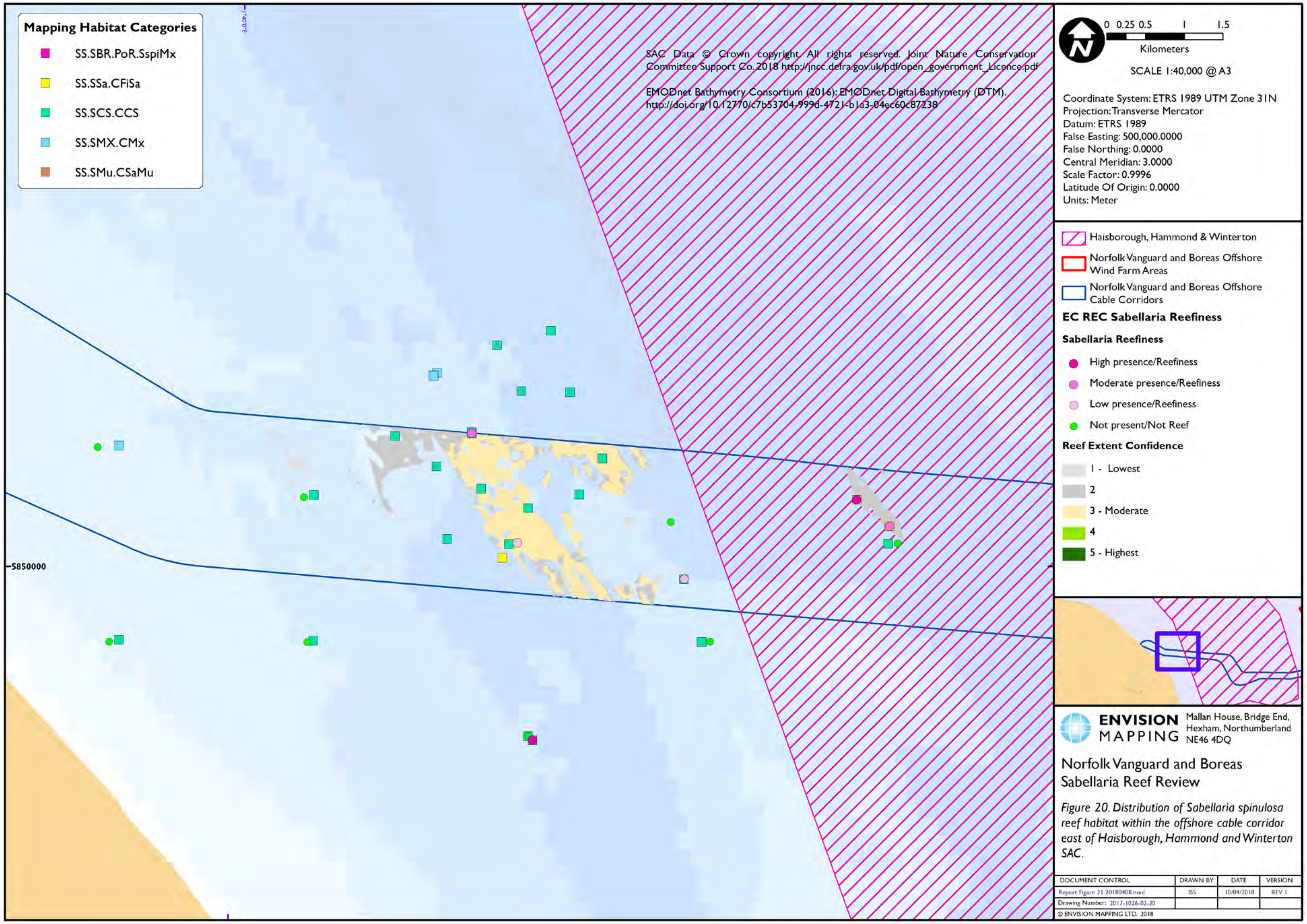

Figure 21.
Distribution of Sabellaria spinulosa reef habitat within the offshore cable corridor west of and within Haisborough, Hammond and Winterton SAC

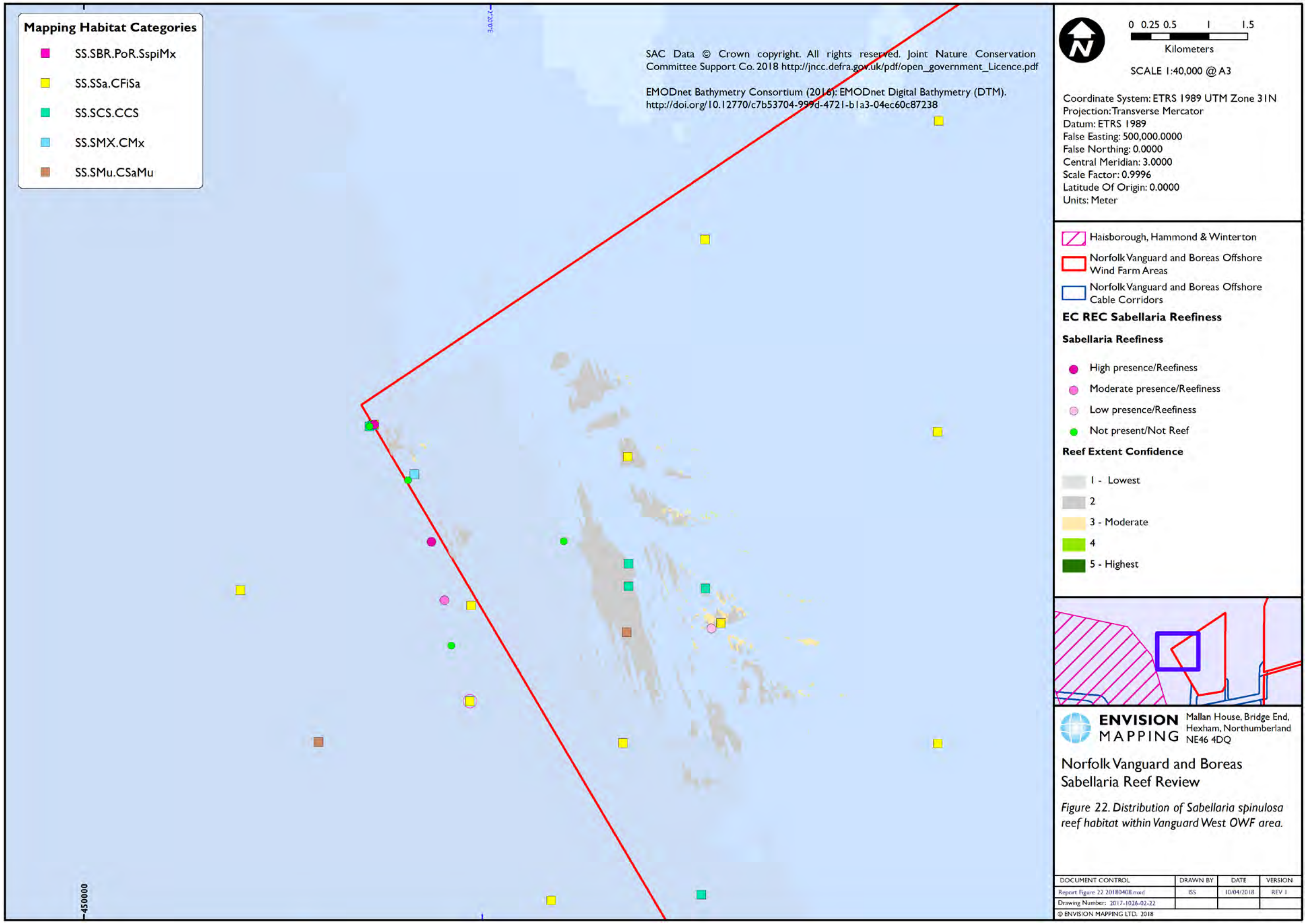

Figure 22.
Distribution of Sabellaria spinulosa reef habitat within Vanguard West OWF area.

4. Summary

The initial biotope mapping within the cable corridors and Norfolk Vanguard OWF (Fugro, 2016) showed extensive areas of potential Sabellaria biotope (SS.SBR.PoR.SspiMx). From reviewing the data collected by Fugro, 2016 and augmenting this with other available data, the areas mapped as potential Sabellaria biotope have been refined to more precise and spatially constrained areas which are supported by sample data. These areas and samples have also been reviewed to identify where *S. spinulosa* reef may occur and the characteristics or 'reefiness' of these areas have been assessed.

Using ensemble mapping and incorporating regional sample data allows for a probabilistic approach to mapping to be incorporated along with the attribution of confidence to habitat areas which have been mapped. The ensemble mapping process does not dismiss any original findings or historic data but enables them to be used to build a better understanding of the marine habitats and their distribution. The use of this system will also allow for any future data to be incorporated and the habitat maps updated with any new data and information as it becomes available.

In general, the marine habitat distribution mapped currently shows very similar distribution to the habitats found within the Norfolk Vanguard characterisation study (Fugro, 2016), with some variations in sedimentary habitat types throughout the cable corridor and OWF area. Such variation can be expected in areas which are dynamic in terms of sediment movement.

The distribution of the biotope SS.SBR.PoR.SspiMx and *S. spinulosa* reef has been refined and now show areas which are considered low to medium in 'reefiness' and also highlights areas which are mapped with varying levels of confidence.

This definition of these areas within the Norfolk Boreas and Vanguard offshore cable corridor enables any future development within this area to consider this location and minimise any impacts and allow them to be mitigated appropriately.

Within the Haisborough, Hammond and Winterton SAC there are areas which have been identified by Natural England and JNCC to be managed as Annex I *S. spinulosa* reef (Natural England & JNCC 2018). Figure 1 shows the location of these areas in conjunction with the Norfolk Boreas and Vanguard offshore cable corridor.

S. spinulosa reefs are known to be unstable and ephemeral. They can form and reform rapidly, therefore, areas mapped as reef habitat should be considered alongside the confidence in the underlying mapping processes and in context with direct sample data which can provide supporting or contrary evidence for the likelihood of Sabellaria reef habitat being present.

5. References

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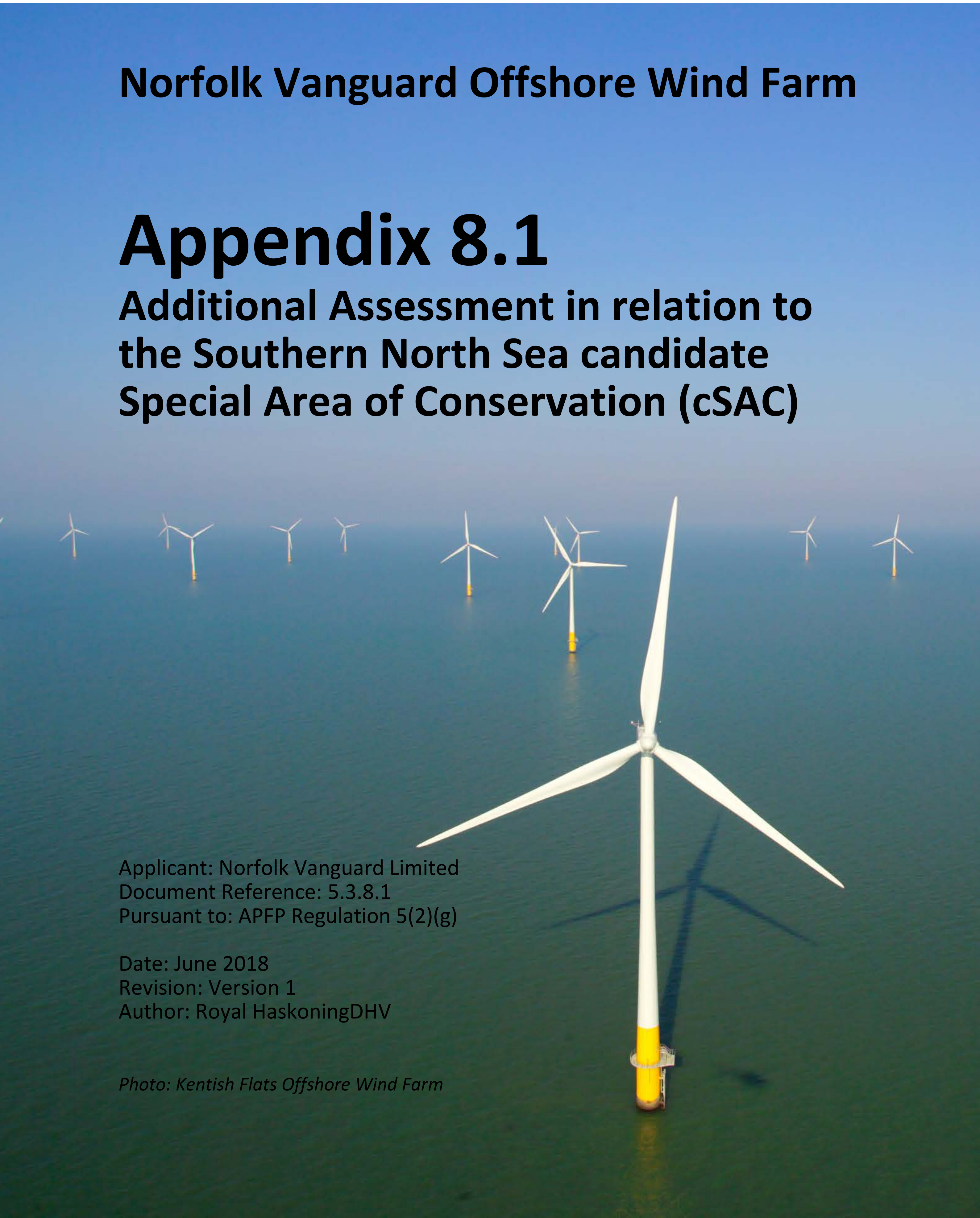
Norfolk Vanguard Offshore Wind Farm

Appendix 8.1

Additional Assessment in relation to the Southern North Sea candidate Special Area of Conservation (cSAC)



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For and on behalf of Royal HaskoningDHV Drafted by: Jennifer Learmonth Approved by: Alistair Davison Signed: [redacted] Date: 16th June 2018

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02/05/18	00	First draft for Norfolk Vanguard Limited review	JL	GK	AD
13/06/18	01	Final for DCO submission	JL	GK	AD

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Tables

Glossary

ADD	Acoustic Deterrent Device
CI	Confidence Interval
cSAC	Candidate Special Area of Conservation
CV	Confidence Variation
dB	Decibels
EPP	Evidence Plan Process
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Group
HP	Harbour porpoise
HRA	Habitats Regulations Assessment
JNCC	Joint Nature and Conservation Committee
kJ	Kilojoules
km	Kilometre
km^2	Kilometre squared
MMMP	Marine Mammal Mitigation Protocol
MU	Management Unit
NMFS	National Marine Fisheries Services
NOAA	National Oceanic and Atmospheric Administration
NS	North Sea
NV East	Norfolk Vanguard East
NV West	Norfolk Vanguard West
O&M	Operation and Maintenance
OWF	Offshore Wind Farm
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SEL	Sound Exposure Level
SCANS	Small Cetaceans in the European Atlantic and North Sea
SIP	Site Integrity Plan
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Body
SNS	Southern North Sea
SPL	Sound Pressure Level
TTS	Temporary Threshold Shift
UK	United Kingdom
UXO	Unexploded Ordnance

Terminology

Array cables	Cables which link the wind turbines and the offshore electrical platform.
Interconnector cables	Buried offshore cables which link the offshore electrical platforms
Landfall	Where the offshore cables come ashore at Happisburgh South
Offshore accommodation platform	A fixed structure (if required) providing accommodation for offshore personnel. An accommodation vessel may be used instead
Offshore cable corridor	The corridor of seabed from the Norfolk Vanguard OWF sites to the landfall site within which the offshore export cables would be located.
Offshore electrical platform	A fixed structure located within the wind farm area, containing electrical equipment to aggregate the power from the wind turbines and convert it into a more suitable form for export to shore.
Offshore export cables	The cables which bring electricity from the offshore electrical platform to the landfall.
Offshore project area	The overall area of Norfolk Vanguard East, Norfolk Vanguard West and the offshore cable corridor.
Safety zone	A marine zone outlined for the purposes of safety around a possibly hazardous installation or works / construction area under the Energy Act 2004.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.
The Applicant	Norfolk Vanguard Limited.
The OWF sites	The two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West.
The project	Norfolk Vanguard Offshore Wind Farm, including the onshore and offshore infrastructure.

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1. INTRODUCTION

1.1. Purpose of this Document

1. The Southern North Sea (SNS) candidate Special Area of Conservation (cSAC) has been recognised as an area with persistent high densities of harbour porpoise (JNCC, 2017a). The cSAC has a surface area of 36,951km^2 and covers both winter and summer habitats of importance to harbour porpoise, with approximately 66% of the candidate site being important in the summer and the remaining 33% of the site being important in the winter period (JNCC, 2017a).

2. Both NV East and NV West lie wholly within the SNS cSAC (see Figure 5.3 of the Information for the Habitats Regulations Assessment). NV East is located wholly within the summer area. The majority of NV West is located within the summer area, with a small segment of the southern edge of the site being located within the winter area.

3. The SNS cSAC Site Selection Report (JNCC, 2017a) identifies that the SNS cSAC site supports approximately 18,500 individuals (95% CI = 11,864 - 28,889) for at least part of the year (JNCC, 2017a). However, JNCC (2017a) states that because this estimate is from a one-month survey in a single year (the SCANS-II survey in July 2005) it cannot be considered as an estimated population for the site. It is therefore not appropriate to use site population estimates in any assessments of effects of plans or projects, as these need to take into consideration population estimates at the Management Unit (MU) level, to account for daily and seasonal movements of the animals (JNCC, 2017a).

4. The North Sea MU population of 345,373 (CV = 0.18; 95% CI = 246,526-495,752; Hammond *et al*., 2017) based on the SCANS-III data, has been used as the reference population throughout the Information for the Habitats Regulations Assessment. However it was agreed with the marine mammal Expert Topic Group (ETG) at the meeting on 15th February 2017 that the estimate that the SNS cSAC could support 17.5% of the UK North Sea reference population would be assessed in a separate appendix for information.

5. Therefore, for information purposes, this Appendix presents an assessment on the estimated number of harbour porpoise that the SNS cSAC site could support of 29,384 harbour porpoise. This estimate is based on the UK North Sea MU area (322,897km^2), the overall harbour porpoise density estimate of 0.52/km^2 (CV = 0.18) for the North Sea MU area from the SCANS-III survey (Hammond *et al*., 2017) and the estimated UK North Sea MU population of 167,906 harbour porpoise, with 17.5% of the population within the UK part of the North Sea MU of approximately **29,384 harbour porpoise**.

2. POTENTIAL EFFECTS DURING CONSTRUCTION

2.1. Underwater noise during UXO clearance

2.1.1. Permanent auditory injury

6. Caution should also be raised over the longer range SPL_{peak} values. Peak noise levels are difficult to predict accurately in a shallow water environment (von Benda Beckmann, 2015) and would tend to be significantly over-estimated over ranges of the order of 3,000m compared to real data. Therefore, the use of SEL is considered preferential at long range (Chapter 5 Project Description, Appendix 5.4). However, as a precautionary approach and based on the current Natural England advice (20180209 NE position on NOAA UXOs and EPS) the assessment has been based on the worst-case scenarios for the unweighted SPL_{peak} predicted PTS impact ranges and weighted SEL predicted TTS impact ranges.

7. A MMMP for UXO clearance will be produced post-consent in consultation with the MMO and relevant SNCBs and will be based on the latest scientific understanding and guidance, pre-construction UXO surveys at the Norfolk Vanguard offshore project area, and detailed project design. The MMMP for UXO clearance will detail the proposed mitigation measures to reduce the risk of any lethal injury, physical injury or permanent auditory injury (PTS) to harbour porpoise during any underwater detonations.

Table 1: Potential effect of permanent auditory injury (PTS) on harbour porpoise during UXO clearance without mitigation

Potential Effect	TNT Equivalent / Charge weights	55kg	120kg	150kg	250kg	261kg	525kg	770kg
	SOURCE LEVEL, SPL_{PEAK}	287.4 dB	290.0 dB	290.7 dB	292.4 dB	292.5 dB	294.8 dB	296.1 dB
PTS SPL_{peak} Unweighted (NMFS, 2016)	202 dB re 1 µPa	5.4km	6.8km	7.3km	8.4km	8.5km	10.4km	11.5km
PTS SEL Weighted (NMFS, 2016)	155 dB re 1 µPa^{2}s	1.2km	1.7km	1.9km	2.4km	2.4km	3.3km	3.9km
Number of harbour porpoise and % of reference population based on maximum impact range (11.5km) for unweighted SPL_{peak} (NMFS, 2016)		Maximum impact area* based on unweighted SPL_{peak} = 415.5km^2 368.5 harbour porpoise (0.1% of NS MU; 1.25% SNS cSAC) based on SCANS-III survey density (0.888/km^2). 523.5 harbour porpoise (0.15% of NS MU; 1.8% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East$^+$						

*Maximum area based on area of circle with maximum impact range for radius;
$^+$Worst-case scenario based on greatest density estimate for the NV West and NV East sites.

2.1.2. Disturbance

8. The SNCBs currently recommend that a potential disturbance range of 26km (approximate area of 2,124km^2) around UXO detonations is used to assess the area that harbour porpoise may be disturbed in the Southern North Sea (SNS) cSAC.

9. The estimated number of harbour porpoise that could be disturbed during UXO clearance at Norfolk Vanguard is presented in Table 2. Only one UXO would be detonated at a time during UXO clearance operation at Norfolk Vanguard, there would be no concurrent UXO detonations.

Table 2: Estimated number of harbour porpoise potentially disturbed during UXO clearance

Potential Effect	Estimated number in area	% of reference population
Area of disturbance (2,124km^2) during underwater UXO clearance	1,886 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,676 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 1,678 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.55% of NS MU (6.4% SNS cSAC) based on SCANS-III density. 0.8% of NS MU (9.1% SNS cSAC) based on the site specific survey density at NV East. 0.5% of NS MU (5.7% SNS cSAC) based on the site specific survey density at NV West.

10. The assessment indicates that less than 1% of the North Sea MU reference population (approximately 9.1% of the number of harbour porpoise that the SNS cSAC could potentially support) could be temporarily displaced during UXO clearance at Norfolk Vanguard (alone), based on the worst-case scenario.

2.2. Underwater noise during piling

2.2.1. Disturbance during proposed mitigation

11. The number of harbour porpoise that could potentially be disturbed as a result of the proposed mitigation would be up to 52 individuals (0.015% of the NS MU reference population; 0.18% SNS cSAC), based on the site specific density for NV East (1.26 harbour porpoise per km^2) as a worst-case scenario.

12. It should be noted that the disturbance of harbour porpoise as a result of the proposed mitigation prior to piling would be part of the 26km disturbance range for piling and is therefore not an additive effect to the overall area of potential disturbance. However, the duration of the proposed mitigation prior to piling has been taken into account, as a worst-case scenario, in the assessment of the duration of potential disturbance.

2.2.2. Disturbance during single pile installation

13. The estimated number of harbour porpoise that could be disturbed during single pile installation at Norfolk Vanguard is presented in Table 3.

Table 3: Estimated number of harbour porpoise potentially disturbed during piling based on 26km range from a single piling location at Norfolk Vanguard

Potential Effect	Estimated number in area[1]	% of reference population[1]
Area of disturbance (2,124km^2) from underwater noise during single pile installation	1,886 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,676 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 1,678 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.55% of NS MU (6.4% SNS cSAC) based on SCANS-III density. 0.8% of NS MU (9.1% SNS cSAC) based on the site specific survey density at NV East. 0.5% of NS MU (5.7% SNS cSAC) based on the site specific survey density at NV West.

14. The assessment indicates that less than 1% of the North Sea MU reference population (approximately 9.1% of the number of harbour porpoise that the SNS cSAC could potentially support) could be temporarily displaced during any single pile installation at Norfolk Vanguard (alone), based on the worst-case scenario.

2.2.3. Disturbance during concurrent piling

15. The estimated number of harbour porpoise that could be disturbed during concurrent pile installation at Norfolk Vanguard is presented in Table 4 based on the maximum disturbance areas.

Table 4: Estimated number of harbour porpoise potentially disturbed during concurrent piling based on 26km range from each piling location

Potential Effect	Estimated number in area[1]	% of reference population[1]
Two concurrent piling events in NV West (3,520km^2)	3,126 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,781 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.9% of NS MU (10.6% SNS cSAC) based on SCANS-III density. 0.8% of NS MU (9.5% SNS cSAC) based on site specific survey density at NV West.
Two concurrent piling events in NV East (3,508km^2)	3,115 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 4,420 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.9% of NS MU (10.6% SNS cSAC) based on SCANS-III density. 1.3% of NS MU (15% SNS cSAC) based on site specific survey density at NV East.
Two concurrent piling events	3,772 harbour porpoise based on SCANS-III	1.1% of NS MU (13% SNS cSAC)

Potential Effect	Estimated number in area[1]	% of reference population[1]
based on one worst-case location in NV East and one worst-case location NV West (4,248km^2)	survey block O density (0.888/km^2). 4,354 harbour porpoise based on site specific survey density at NV East and NV West.	based on SCANS-III density. 1.3% of NS MU (15% SNS cSAC) based on site specific survey density at NV East & NV West.

16. The assessment indicates that up to a maximum of 1.3% of the North Sea MU reference population (approximately 15% of the number of harbour porpoise that the SNS cSAC could potentially support) could be temporarily disturbed during concurrent piling at Norfolk Vanguard (alone), based on the worst-case scenario.

2.3. Underwater noise during other construction activities

17. As a precautionary worse-case scenario, the number of harbour porpoise that could be disturbed as a result of underwater noise during construction from activities other than piling and vessel movements has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor.

18. This is very precautionary, as it is highly unlikely that construction activities, other than piling activity, could result in disturbance of all harbour porpoise from the entire wind farm area and the offshore cable corridor. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

19. Based on a more realistic, but precautionary approach that up to 50% of all individuals could potentially be disturbed from the wind farm sites and offshore cable corridor area, approximately 453 harbour porpoise (0.1% of the North Sea MU reference population; 1.5% SNS cSAC) could be temporarily displaced.

Table 5 Estimated number of harbour porpoise (and % of reference population; % SNS cSAC) that could be present in the Norfolk Vanguard offshore area (wind farm sites and cable corridor)

Potential Area	Estimated number in area	% of reference population (% SNS cSAC)
NV East area (297km^2)	264 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 374 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.08% of NS MU (0.9% SNS cSAC) based on SCANS-III density. 0.1% of NS MU (1% SNS cSAC) based on site specific survey density at NV East.
NV West area (295km^2)	262 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 233 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.08% of NS MU (0.9% SNS cSAC) based on SCANS-III density. 0.07% of NS MU (0.8% SNS cSAC) based on site specific survey density at NV West.
Offshore cable corridor (237km^2)	210.5 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 299 harbour porpoise based on site	0.06% of NS MU (0.7% SNS cSAC) based on SCANS-III density. 0.09% of NS MU (1% SNS cSAC) based on site

Potential Area	Estimated number in area	% of reference population (% SNS cSAC)
	specific survey density (1.26/km^2) at NV East.	specific survey density at NV East.
Total offshore project area (829km^2)	736.5 harbour porpoise based on SCANS-III survey block O density. 906harbour porpoise based on site specific survey densities for NV East and NV West.	0.2% of NS MU (2.5% SNS cSAC) based on SCANS-III density. 0.3% of NS MU (3% SNS cSAC) based on site specific survey density.

2.4. Underwater noise and disturbance from vessels

20. Maximum number of vessels on site at any one time during construction is estimated to be 57 vessels.

21. Underwater noise generated by vessels would not be sufficient to cause PTS or other injury to harbour porpoise. The potential for TTS is only likely if the animal remains in very close proximity to a vessel for a prolonged period of time, which is highly unlikely. Disturbance is therefore the only potential underwater noise effect associated with vessels.

22. Modelling by Heinänen and Skov (2015) indicates that the number of ships represents a relatively important factor determining the density of harbour porpoise in the North Sea MU during both seasons, with markedly lower densities with increasing levels of traffic. A threshold level in terms of effects seems to be approximately 20,000 ships per year (approximately 80 vessels per day within a 5km^2 area).

23. Chapter 15 Shipping and Navigation of the ES provides a description of the baseline conditions and anticipated additional ship movements arising from the construction and operation of the proposed project.

24. Throughout the summer period of the marine traffic survey, there was on average 69 unique vessels per day recorded within NV East, 46 unique vessels per day recorded within the NV West and on average 96 unique vessels per day recorded within the offshore cable corridor. Throughout the winter period of the marine traffic survey, there was on average 63 unique vessels per day recorded within the NV East, 39 unique vessels per day recorded within the NV West and on average 92 unique vessels per day recorded within the offshore cable corridor. The majority of vessels recorded were cargo vessels and tankers, with most of these vessels utilising the IMO Routeing Measures in the area; however other main routes were identified outwith the Deep Water Routes (DWR), including routes which intersected the OWF sites.

25. There would be some re-routing of existing vessels around the Norfolk Vanguard site, with a minimum passing distance of 500m from areas where construction is underway. This is likely to re-route existing large and fast moving vessels (predominantly general cargo ships).

26. The maximum number of vessels on site at any one time during construction is estimated to be 57 vessels. This could therefore represent up to a 27% increase in the number of vessels during the summer period and 29% increase in the number of vessels during the winter periods, compared to current baseline vessel numbers.

27. The maximum number of 57 vessels at any one time in the offshore project area (829km^2) during construction would be significantly less than the Heinänen and Skov (2015) threshold of 80 vessels per day within an area of 5km^2. Based on the precautionary worst-case scenario, including existing vessel movements in around the Norfolk Vanguard area, but taking into account that other vessels would be restricted from entering the immediate construction site (with a 500m safety zone around construction vessels and partially installed foundations), the number of vessels would be unlikely to exceed the Heinänen and Skov (2015) threshold level of 80 vessels per day in a 5km^2 area. Therefore, there unlikely to be is the potential for significant disturbance to harbour porpoise as a result of the increased number of vessels during construction.

28. As a precautionary worse-case scenario approach the number of harbour porpoise that could be disturbed as a result of underwater noise from vessels has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 5). This is very precautionary, as it is highly unlikely that underwater noise from vessels could result in disturbance from the entire wind farm area and the offshore cable corridor at any one time. Any disturbance is likely to be limited to the immediate vicinity around the actual vessel.

29. Underwater noise and disturbance from additional vessels during construction are likely to be localised in comparison to existing shipping noise. The disturbance of harbour porpoise from the presence and underwater noise of vessels would be temporary as the vessels move in and out of the site and move between different locations within the site, harbour porpoise would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

30. Based on a more realistic, but precautionary approach that up to 50% of all individuals could potentially be disturbed from the wind farm sites and offshore cable corridor area, approximately 453 harbour porpoise (0.1% of the North Sea MU reference population; 1.5% SNS cSAC) could be temporarily displaced.

2.5. Vessel collision risk

31. During the construction of Norfolk Vanguard there will be an increase in vessel traffic. Vessels will follow established shipping routes utilising the shipping lane between NV East and NV West and routes to the relevant ports in order to minimise vessel traffic in the wider area.

32. For Norfolk Vanguard West and Norfolk Vanguard East, alone or for the two sites combined, the overall worst-case scenario for vessel movements during construction would be:

- 1,180 two-way vessel movements based on a Single Phase approach; or
- 1,180 (590 x2) two-way vessel movements for a Two Phased approach.

33. The construction port to be used for Norfolk Vanguard is not yet known and could be located on the south east coast of England. Indicative daily vessel movements (return trips to a local port) during construction of Norfolk Vanguard are estimated to be an average of two per day.

34. As a precautionary worse-case scenario, the number of harbour porpoise that could be at increased collision with vessels during construction has been assessed based on the number of animals that could be present in the wind farm areas and the offshore cable corridor and the number that could potentially be at increased collision risk based on 90-95% avoidance rates (Table 6).

35. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the Norfolk Vanguard area would be at increased collision risk with vessels during construction, especially taking into account the relatively small increase in number of vessel movements compared to existing vessel movements in the area.

36. Vessel movements, where possible, will be incorporated into recognised vessel routes and hence to areas where harbour porpoise are accustomed to vessels, in order to reduce any increased collision risk. All vessel movements will be kept to the minimum number that is required to reduce any potential collision risk. Additionally, vessel operators will use good practice to reduce any risk of collisions with harbour porpoise.

37. In addition, based on the assumption that harbour porpoise would be disturbed from a 26km radius during piling and disturbed from the Norfolk Vanguard offshore wind farm site and cable corridor as a result of underwater noise from construction activities and vessels, there should be no potential for increased collision risk with vessels at Norfolk Vanguard during the construction period.

Table 6 Estimated number of harbour porpoise that could be present in the Norfolk Vanguard offshore area (wind farm sites and cable corridor) at potential increased collision risk based on 95-90% avoidance

Potential Area	Estimated number at potential increased collision risk based on 95-90% avoidance	% of reference population (% SNS cSAC)
Total offshore project area (829km^2)	37-74 harbour porpoise based on SCANS-III survey block O density. 45-91 harbour porpoise based on site specific survey densities for NV East and NV West.	0.01-0.02% of NS MU (0.1-0.2% SNS cSAC) based on SCANS-III density. 0.01-0.03% of NS MU (0.15-0.3% SNS cSAC) based on site specific survey density.

2.6. Changes to prey resource

38. As a precautionary worse-case scenario, the number of harbour porpoise that could be affected as a result of changes to prey resources during construction has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 8). This is very precautionary, as it is highly unlikely that any changes in prey resources could occur over the entire wind farm area and the offshore cable corridor. It is more likely that effects would be restricted to an area around the working sites.

39. Based on a more realistic, but precautionary approach that any changes in prey resource could occur affect up to 50% of harbour porpoise that could potentially be present in the wind farm sites and offshore cable corridor area, this would result in up to approximately 453 harbour porpoise (0.1% of the North Sea MU reference population; 1.5% SNS cSAC) could be temporarily displaced.

40. In addition, there would be no additional displacement of harbour porpoise as a result of any changes in prey resources during construction, as harbour porpoise would be potentially disturbed from the wind farm sites or cable corridor as a result of underwater noise during piling, other construction activities or vessels, as the potential area of effect would be less or the same as those assessed for piling, other construction activities or vessels.

3. POTENTIAL EFFECTS DURING OPERATION

41. All offshore infrastructure including wind turbines, foundations, cables and offshore substations would be monitored and maintained during this period in order to maximise efficiency.

3.1. Underwater noise from operational turbines

42. Currently available data indicates that there is no lasting disturbance or exclusion of harbour porpoise around wind farm sites during operation (Diederichs *et al*., 2008; Lindeboom *et al*., 2011; Marine Scotland, 2012; Scheidat *et al*., 2011; Tougaard *et al*., 2005, 2009a, 2009b). Data collected suggests that any behavioural responses for harbour porpoise may only occur up to a few hundred metres away (Touggard *et al*., 2009a).

43. As a precautionary worse-case scenario, the number of harbour porpoise that could be disturbed as a result of underwater noise from operational turbines has been assessed based on the number of animals that could be present in the wind farm area (Table 7). This is very precautionary, as it is highly unlikely that underwater noise from operational wind turbines could result in disturbance from the entire wind farm area.

44. Therefore values have been presented for three scenarios; 0% disturbance, as there is currently no evidence of any significant disturbance of harbour porpoise or seals from operational wind farm sites; a precautionary 50% disturbance; and a very worst-case of a 100% disturbance from the offshore wind farm areas as a result of underwater noise from operational turbines (Table 7).

Table 7 Estimated number of harbour porpoise (and % of reference population and % SNS cSAC) that could be disturbed from the Norfolk Vanguard offshore wind farm area during operation based on 100%, 50% and 0% disturbance as a result of operational turbine noise

Potential Area	Receptor	Estimated number in potential area			% of reference population (% SNS cSAC)		
		100%	50%	0%	100%	50%	0%
Total offshore wind farm area (592km^2)	Harbour porpoise	526 based on SCANS-III density (0.888/km^2). 607 based on densities at each site.	263 based on SCANS-III density (0.888/km^2). 303.5 based on densities at each site.	0	0.2% of NS MU (1.8% SNS cSAC) based on SCANS-III density. 0.2% of NS MU (2% SNS cSAC) based on densities at each site.	0.08% of NS MU (0.9% SNS cSAC) based on SCANS-III density. 0.09% of NS MU (1% SNS cSAC) based on densities at each site.	0

3.2. Underwater noise from maintenance activities

45. The requirements for any potential maintenance work, such as additional rock dumping or cable re-burial, are currently unknown, however the work required and associated effects would be less than those during construction.

46. As a precautionary worse-case scenario approach the number of harbour porpoise that could be disturbed as a result of underwater noise from maintenance activities has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 5).

47. This is very precautionary, as it is highly unlikely that maintenance activities could result in disturbance from the entire wind farm area and the offshore cable corridor. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

3.3. Vessel underwater noise and disturbance during operation and maintenance

48. Taking into account the existing vessel movements in around the Norfolk Vanguard area and the potential 1-2 vessel movement per day during operation and maintenance, the number of vessels would not exceed the Heinänen and Skov (2015) threshold level of approximately 80 vessels per day. Therefore, there is no increase in the potential for disturbance to harbour porpoise as a result of the increased number of vessels during operation and maintenance at Norfolk Vanguard.

49. As a precautionary worse-case scenario approach the number of harbour porpoise that could be disturbed as a result of underwater noise from vessels during

operation and maintenance has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 5).

50. The potential effects as a result of underwater noise and disturbance from additional vessels during operation and maintenance from vessels would be short-term and temporary in nature. Disturbance responses are likely to be limited to the area in the immediate vicinity of the vessel. Harbour porpoise would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

3.4. Vessel collision risk

51. Based on the worst-case scenario of an average of two vessel movements per day, the increase in vessels movement per day at the Norfolk Vanguard site (up to approximately 480 round trips per year) during operation and maintenance is relatively small compared to existing vessel traffic.

52. As a precautionary worst-case scenario approach the number of harbour porpoise that could be at increased collision with vessels during operation and maintenance has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor and the number that could potentially be at increased collision risk based on 90-95% avoidance rates (Table 6).

53. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the Norfolk Vanguard area would be at increased collision risk with vessels during operation and maintenance, especially taking into account the relatively small increase in number of vessel movements compared to existing vessel movements in the area.

3.5. Changes to prey resource during operation and maintenance

54. As a precautionary worst-case scenario approach the number of harbour porpoise that could be affected as a result of changes to prey resources during operation and maintenance has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 5). This is very precautionary, as it is highly unlikely that any changes in prey resources could occur over the entire wind farm area and the offshore cable corridor during operation and maintenance.

4. POTENTIAL EFFECTS DURING DECOMMISSIONING

55. Possible effects on harbour porpoise associated with the decommissioning stage(s) have been assessed; however a further assessment will be carried out ahead of any decommissioning works to be undertaken taking account of known information at that time, including relevant guidelines and requirements.

4.1. Underwater noise from foundation removal

56. A detailed decommissioning plan will be provided prior to decommissioning that will give details of the techniques to be employed and any relevant mitigation measures.

57. For this assessment it is assumed that the potential effects from underwater noise during decommissioning would be less than those assessed for piling and comparable to those assessed for other construction activities.

4.2. Vessel underwater noise and disturbance from vessels

58. For this assessment it is assumed that the potential effects would be the same as for construction.

4.3. Vessel collision risk

59. For this assessment it is assumed that the potential effects would be the same as for construction.

4.4. Changes to prey resource

60. For this assessment it is assumed that the potential effects would be the same as for construction.

5. IN-COMBINATION EFFECTS

5.1. Approach

61. The approach to this in-combination assessment differs from that taken in the ES chapter in terms of geographic range. If this assessment is based upon the number of harbour porpoise that the SNS cSAC could potentially support than it follows that the effects must be limited to those occurring within the SNS cSAC boundary, if the effects outside the boundary are included (as per the ES) then the population used for the assessment must reflect that (i.e. the NS MU population as per the ES).

5.2. Underwater noise effects during construction from OWF piling

62. Auditory injury (PTS) could occur as a result of pile driving during offshore wind farm installation, pile driving during oil and gas platform installation, underwater explosives (used occasionally during the removal of underwater structures and UXO clearance) and seismic surveys (JNCC, 2010a, 2010b, 2017b). However, if there is the potential for any auditory injury (PTS) suitable mitigation would be put in place to reduce any risk to harbour porpoise. Other activities such as dredging, drilling, rock dumping and disposal, vessel activity, operational wind farms, oil and gas installations or wave and tidal sites will emit broadband noise in lower frequencies and auditory injury (PTS) from these activities is very unlikely. Therefore the potential risk of any auditory injury (PTS) in harbour porpoise is not included in the CIA.

63. Following the current advice from the SNCBs, the CIA has been based on the following parameters:

- A distance of 26km from an individual percussive piling location has been used to assess the area that harbour porpoise could potentially be disturbed during piling, for both single and concurrent piling operations.
- A distance of 10km around seismic operations has been used to assess the area that harbour porpoise could potentially be disturbed.
- A distance of 26km around UXO clearance has been used to assess the area that harbour porpoise could potentially be disturbed.

64. The potential disturbance from underwater noise has been assessed for the relevant plans and projects screened in to the CIA, based on these standard disturbance areas for piling, seismic surveys and UXO clearance.

65. The potential disturbance from OWFs during construction activities other than pile driving noise sources, including vessels, seabed preparation, rock dumping and cable installation, has been based on the area of the OWF sites, this is a precautionary approach, as it is highly unlikely that construction activities, other than piling activity

and other noisy activities including the operation of large vessels, rock dumping or cable burial would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

66. The potential disturbance from operational OWFs and maintenance activities, including vessels, any rock dumping or cable re-burial, has been based on the area of the OWF sites, this is again a precautionary approach, as it is highly unlikely that operational OWFs and maintenance activities, including vessels, would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

67. Where a quantitative assessment has been possible, the potential magnitude of disturbance in the CIA has been based on the number of harbour porpoise in the potential area using the latest SCANS-III density estimates (Hammond *et al*., 2017) for the area of the projects.

68. The conservative potential worst-case scenario for OWFs that could be piling at the same time as Norfolk Vanguard in the SNS cSAC includes four other UK OWFs:

- Creyke Beck B
- Sofia
- Hornsea Project 3
- East Anglia TWO

69. In this potential worst-case scenario, for concurrent piling the estimated maximum area of potential disturbance is 21,240km^2, without any overlap in the potential areas of disturbance at each wind farm or between wind farms.

70. Based on a single pile installation at each of the five OWFs, the estimated maximum area of potential disturbance is 10,620km^2, without any overlap in the potential areas of disturbance at each wind farm or between wind farms.

71. In this assessment (different from the ES and HRA) the number of harbour porpoise that could be disturbed has been estimated based on the potential area of overlap with the SNS cSAC (Table 8). The number of harbour porpoise has been estimated using the SCANS-III density estimate for survey block O of 0.888 harbour porpoise per km^2 as a worst-case scenario (as there are currently no available density estimates for the winter and summer SNS cSACs areas that are suitable to use, as the data Heinänen and Skov (2015) covers the wider area).

Table 8 Estimated maximum, minimum and average overlap with SNS cSAC winter and summer areas and number of harbour porpoise (% of reference population and % SNS cSAC) for potential worst-case scenarios (Sofia, Dogger Bank Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for single and concurrent piling and the number of harbour porpoise that could be disturbed from these areas in the SNS cSAC

In-combination assessment scenario	Maximum area overlap with SNS cSAC	Minimum area overlap with SNS cSAC	Average area overlap with SNS cSAC
Potential worst-case scenario (5 OWFs) – single piling	Maximum overlap with summer SNS cSAC area = 5,458km^2 [4,847 harbour porpoise (1.4% NS MU; 16.5% SNS CSAC)] Maximum overlap with winter SNS cSAC area = 3,056km^2 [2,714 harbour porpoise (0.8% NS MU; 9% SNS cSAC)] Total maximum overlap with SNS cSAC = 8,514km^2 [7,561 harbour porpoise (2% NS MU; 26% SNS cSAC)]	Minimum overlap with summer SNS cSAC area = 3,078km^2 [2,733 harbour porpoise (0.8% NS MU; 9% SNS cSAC)] Minimum overlap with winter SNS cSAC area = 2,130km^2 [1,891 harbour porpoise (0.6% NS MU; 6% SNS cSAC)] Total minimum overlap with SNS cSAC = 5,208km^2 [4,624 harbour porpoise (1% NS MU; 16% SNS cSAC)]	Average overlap with summer SNS cSAC area = 4,268km^2 [3,790 harbour porpoise (1% NS MU; 13% SNS cSAC)] Average overlap with winter SNS cSAC area = 2,593km^2 [2,303 harbour porpoise (0.7% NS MU; 8% SNS cSAC)] Total average overlap with SNS cSAC = 6,861km^2 [6,093 harbour porpoise (2% NS MU; 21% SNS cSAC)]
Potential worst-case scenario (5 OWFs) – concurrent piling	Maximum overlap with summer SNS cSAC area = 7,332km^2 [6,511 harbour porpoise (2% NS MU; 22% SNS cSAC)] Maximum overlap with winter SNS cSAC area = 4,834km^2 [4,293 harbour porpoise (1% NS MU; 15% SNS cSAC)] Total maximum overlap with SNS cSAC = 12,166km^2 [10,804 harbour porpoise (3% NS MU; 37% SNS cSAC)]	Minimum overlap with summer SNS cSAC area = 3,150km^2 [2,797 harbour porpoise (0.8% NS MU; 9.5% SNS cSAC)] Minimum overlap with winter SNS cSAC area = 2,214km^2 [1,966 harbour porpoise (0.6% NS MU; 7% SNS cSAC)] Total minimum overlap with SNS cSAC = 8,514km^2 [4,763 harbour porpoise (1% NS MU; 16% SNS cSAC)]	Average overlap with summer SNS cSAC area = 5,241km^2 [4,654 harbour porpoise (1% NS MU; 18% SNS cSAC)] Average overlap with winter SNS cSAC area = 3,525km^2 [3,130 harbour porpoise (0.9% NS MU; 11% SNS cSAC)] Total average overlap with SNS cSAC = 8,766km^2 [7,784 harbour porpoise (2% NS MU; 26.5% SNS cSAC)]

5.3. Underwater noise effects from all other noise sources

5.3.1. UXO clearance

72. The commitment to the MMMP for UXO clearance would result in no potential effects for lethal injury, physical injury and permanent auditory injury (PTS). As such, the proposed Norfolk Vanguard project would not contribute to any in-combination effects for lethal injury, physical injury and permanent auditory injury (PTS), therefore the CIA only considers potential disturbance effects.

73. It is currently not possible to estimate the number of potential UXO clearance operations that could be undertaken in the harbour porpoise NS MU during the construction and potential piling activity at Norfolk Vanguard.

74. It is therefore been assumed as a worst-case scenario that there could potentially be up to two UXO detonations at any one time:

i) both are in the summer cSAC area;

ii) both are in the winter cSAC area; or

iii) one is in the summer cSAC area and one is in the winter cSAC area.

75. Following the current SNCB advice, the CIA has been based on the following parameter:

- A distance of 26km around UXO clearance has been used to assess the area that harbour porpoise could potentially be disturbed.

76. If two UXO detonations were undertaken at the same time the potential area of disturbance could be 4,248km^2, which is approximately 16% of summer cSAC area and 32% of the winter cSAC area.

77. If one UXO detonation was undertaken, the potential area of disturbance could be (2,124km^2) which would be approximately 8% of summer cSAC area and 16% of the winter cSAC area.

78. The number of harbour porpoise has been estimated using the SCANS-III density estimate for survey block O of 0.888 harbour porpoise per km^2 as a worst-case scenario (Hammond *et al.*, 2017).

79. However, it is highly unlikely that two UXO clearance operations would actually be undertaken at the same time in either the summer or winter area of the SNS cSAC.

Table 9 Quantified CIA for the potential disturbance of harbour porpoise (and % of reference population and % SNS cSAC) during up to two UXO clearance operations in the SNS cSAC

UXO clearance	SCANS-III density estimate (No/km^2)	Area of potential disturbance	Potential number of harbour porpoise
One UXO clearance operation	0.888	2,124km^2	1,886 (0.6% NS MU; 6% SNS cSAC)
Two UXO clearance operations	0.888	4,248km^2	3,772 (1% NS MU: 13% SNS cSAC)

5.3.2. Seismic surveys

80. It is currently not possible to estimate the number of potential seismic surveys that could be undertaken in the harbour porpoise NS MU during the construction and potential piling activity at Norfolk Vanguard.

81. It is therefore been assumed as a worst-case scenario that there could potentially be up to two seismic surveys at any one time:

i) both are in the summer cSAC area;

ii) both are in the winter cSAC area; or

iii) one is in the summer cSAC area and one is in the winter cSAC area.

82. Following the current SNCB advice, the CIA has been based on the following parameter:

- A distance of 10km around seismic surveys has been used to assess the area that harbour porpoise could potentially be disturbed (314km^2).

83. It should be noted that this assessment is based on the potential effects for seismic surveys required by the oil and gas industry. Geophysical surveys conducted for offshore wind farms generally use multi-beam surveys in shallow waters. Therefore, the higher frequencies typically used fall outside the hearing frequencies of cetaceans and the sounds produced are likely to attenuate more quickly than the lower frequencies used in deeper waters (JNCC, 2017b). JNCC (2071b) do not, therefore, advise mitigation is required for multi-beam surveys in shallow waters as there is no risk to EPS in relation to deliberate injury or disturbance offences.

84. Therefore for the maximum of up to two seismic surveys being undertaken at the same time the potential disturbance area would be 628km^2.

85. The number of harbour porpoise has been estimated using the SCANS-III density estimate for survey block O of 0.888 harbour porpoise per km^2 as a worst-case scenario (Hammond *et al.*, 2017).

86. However, it is highly unlikely that up to two seismic surveys would be undertaken at the same time in either the summer or winter area of the SNS cSAC.

Table 10 Quantified CIA for the potential disturbance of harbour porpoise during up to two seismic surveys in the SNS cSAC

UXO clearance	SCANS-III density estimate (No/km^2)	Area of potential disturbance	Potential number of harbour porpoise
One seismic survey	0.888	314	279 (0.08% NS MU; 0.95% SNS cSAC)
Two seismic surveys	0.888	628	558 (0.2% NS MU; 2% SNS cSAC)

5.3.3. OWF construction

87. During the construction of Norfolk Vanguard there is the potential overlap with effects from the construction activities, other than piling, of offshore wind farms.

88. There would be no additional in-combination effects of underwater noise from other construction activities for those projects which also have overlapping piling with Norfolk Vanguard as the ranges for piling would be significantly greater than those from other construction noise sources.

89. The potential impact ranges of these noise sources during OWF construction will be localised and significantly less than the ranges predicted for piling. There could be potential in-combination effects from construction of OWFs in and around the area of Norfolk Vanguard.

90. The CIA includes OWFs in the SNS cSAC which could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period.

91. This highly conservative approach for OWFs that could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period includes six OWFs:

- Creyke Beck A
- Teesside A
- East Anglia THREE
- East Anglia ONE North
- Thanet Extension
- Norfolk Boreas

92. The potential temporary disturbance during OWF construction activities, other than pile driving noise sources, has been based on the area of the OWF sites. This is a precautionary approach, as it is highly unlikely that construction activities, other than piling activity would result in disturbance from the entire wind farm area. Any

disturbance is likely to be limited to the area in and around where the activity is actually taking place.

93. In addition, it is likely, as outlined for the in-combination assessment for piling, that developers of more than one site will develop one site at a time, as it is more efficient and cost effective to develop one site and have it operational prior to constructing the next site.

94. For each project, the number of harbour porpoise in the area of each OWF site has been estimated using the latest SCANS-III density estimates (Hammond *et al.*, 2017) for the relevant survey block that the project is located within.

95. Based on this highly conservative approach for the six UK OWFs that could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period.

96. The assessment indicates that if all six of these OWFs in the southern North Sea were conducting construction activities, other than piling, at the same time, the estimated maximum in-combination area of disturbance in the summer SNC cSAC area is 1,567km^2 and 482km^2 in the winter area.

Table 11 Quantified in-combination assessment for the potential disturbance of harbour porpoise during construction activities (other than piling) at OWFs in the SNS cSAC during construction at Norfolk Vanguard

Name of Project	Area of OWF site (km^2)*	Area in summer cSAC area (km^2)	Area in winter cSAC area (km^2)
Creyke Beck A	515	515	0
Teesside A		0	0
East Anglia THREE	301	301	203
Norfolk Boreas	727	704	0
Thanet Extension	73	0	73
East Anglia ONE North	206	47	206
Total area	**1,822km^2**	**1,567km^2**	**482km^2**
Number of harbour porpoise (100% disturbance; based on SCANS-III density estimate of 0.888/km^2)		**1,392**	**428**
% of North Sea MU reference population (345,373 harbour porpoise)		**0.4%**	**0.1%**
% SNS cSAC (29,384 harbour porpoise)		**4.7%**	**1.5%**

5.3.4. OWF operation and maintenance

97. For operational OWFs within (wholly or partly) the SNS cSAC that could have potential in-combination effects during the Norfolk Vanguard construction period, the area of the OWF that overlaps the cSAC winter and summer areas has been estimated. Based on this 'potential worst-case' scenario, six OWFs located in the SNS cSAC could potentially have disturbance from operational OWFs and maintenance activities that overlap with construction of Norfolk Vanguard.

98. The in-combination assessment indicates that, the estimated maximum in-combination area of disturbance is 915km^2 (Table 15).

99. One of these OWFs is located in the summer cSAC area and the estimated maximum area of disturbance for the summer cSAC area is 52km^2, which represents approximately 0.2% of the summer cSAC area (Table 12).

100. Five of these OWFs are located in the winter cSAC area and the estimated maximum in-combination area of disturbance for the winter cSAC area is 482km^2, which represents approximately 4% of the winter cSAC area (Table 12).

Table 12 Quantified CIA for the potential disturbance of harbour porpoise (and % of reference population and % SNS cSAC) during operation and maintenance activities at OWFs in the SNS cSAC during construction at Norfolk Vanguard

Name of Project	Area of OWF site (km^2)*	SCANS-III density estimate (No/km^2)	Area in summer cSAC area (km^2)	Area in winter cSAC area (km^2)	Potential number of harbour porpoise disturbed
Greater Gabbard	146	0.607	0	146	89
Scroby Sands	9	0.607	0	9	6
Thanet	35	0.607	0	9	6
Galloper	113	0.607	0	113	69
Hornsea Project One	407	0.888	52	0	46
East Anglia ONE	205	0.607	0	205	124
Total	**915**		**52**	**482**	**340**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.1%**
% SNS cSAC (29,384 harbour porpoise)					**1%**

*Source: http://www.4coffshore.com/

5.4. Overall in-combination underwater noise effects for Norfolk Vanguard alone

101. This section considers the overall in-combination effects of underwater noise associated with piling and all other noise sources. There would be no additional in-combination effects of noise from other construction activities for those projects which also have overlapping piling with Norfolk Vanguard as the impact ranges for

piling would be significantly greater than those from other construction noise sources.

102. The worst-case assessment (Table 13) is based on highly conservative assumptions (e.g. displacement of all harbour porpoise from the boundary of each offshore wind farm and the assumption that there is no overlap from the disturbance effects listed).

Table 13 Quantified CIA for the potential disturbance of all harbour porpoise in the North Sea MU and SNS cSAC summer and winter areas (and % of reference population and %SNS cSAC) from all possible noise sources during construction at Norfolk Vanguard based on worst-case scenario

Potential noise sources during piling at Norfolk Vanguard	Area in summer cSAC area (km^2)	Area in winter cSAC area (km^2)
Piling at OWF projects, based on potential worst-case scenario of OWF projects that could be piling at the same time (Sofia, Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for single pile installation at each site and average overlap with cSAC seasonal areas	4,268km^2	2,593km^2
OWF construction activities, based on OWFs that are not piling but potential for other construction activities during piling at Norfolk Vanguard and 100% disturbance	1,567km^2	482km^2
OWF operation and maintenance, based on constructed OWFs that could have O&M activities during piling at Norfolk Vanguard and 100% disturbance	52km^2	482km^2
Sub-total (without UXO clearance and seismic surveys)	***5,887km^2***	***3,557km^2***
Number of harbour porpoise (based on SCANS-III density estimate of 0.888/km^2)	***5,228***	***3,159***
% of North Sea MU reference population (345,373 harbour porpoise)	***1.5%***	***0.9%***
% SNS cSAC (29,384 harbour porpoise)	***18%***	***11%***
UXO clearance, based on up two locations, one in each cSAC seasonal area	2,124km^2	2,124km^2
Seismic surveys, based on up two locations, one in each cSAC seasonal area	324km^2	324km^2
Total	**8,335km^2**	**6,005km^2**
Number of harbour porpoise (based on SCANS-III density estimate of 0.888/km^2)	**7,402**	**5,332**
% of North Sea MU reference population (345,373 harbour porpoise)	**2%**	**1.5%**
% SNS cSAC (29,384 harbour porpoise)	**25%**	**18%**

5.5. Changes in prey availability

103. The in-combination assessment for potential changes to prey availability has assumed that any potential effects on harbour porpoise prey species from underwater noise, including piling, would be the same or less than those for harbour porpoise. Therefore there would be no additional effects other than those assessed for harbour porpoise, i.e. if prey are disturbed from an area as a result of underwater noise, harbour porpoise will be disturbed from the same or greater area, therefore any changes to prey availability would not affect harbour porpoise as they would already be disturbed from the same area.

104. Any effects on prey species are likely to be intermittent, temporary and highly localised, with potential for recovery following cessation of the disturbance activity. Any permanent loss or changes of prey habitat will typically represent a small percentage of the potential habitat in the surrounding area.

5.6. Increased collision risk

105. The potential increased collision risk with vessels during the construction of OWFs has used a precautionary approach. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore the increased risk for any vessel interaction is within the wind farm site. Therefore, the number of harbour porpoise that could be at increased collision risk with vessels has been assessed based on the number of animals that could be present in the wind farm areas taking into account 95% avoidance rates. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the wind farm areas would be at increased collision risk with vessels.

106. The number of harbour porpoise in the potential area has been determined using the latest SCANS-III density estimates (Hammond *et al*., 2017) for the area of the projects, taking into account 95% avoidance rates.

Table 14 Quantified CIA for the potential increased collision risk with vessels for harbour porpoise during OWF construction

Name of Project	Tier	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site*	Potential number of harbour porpoise based on 95% avoidance
Norfolk Vanguard	5	0	O[1]	0.888	592	26
Creyke Beck A	3	163	O	0.888	515	23
Creyke Beck B	3	193	O	0.888	599	27
Teesside A	3	180	N	0.837	562	24
Sofia	3	175	O[2]	0.888	593	26
East Anglia THREE	3	0	L	0.607	301	9
Norfolk Boreas	5	30	O[3]	0.888	727	32
Hornsea Project 3	5	80	O	0.888	695	31
Thanet Extension	5	165	L	0.607	73	2
East Anglia ONE North	5	30	L	0.607	206	6
East Anglia TWO	5	45	L	0.607	255	8
Total						**214**
% of North Sea MU reference population (345,373 harbour porpoise)						**0.06%**
% SNS cSAC (29,384 harbour porpoise)						**0.7%**

[1]NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O; therefore higher density estimate from survey block O is used.
[2]Dogger Bank Zone Teesside B overlaps SCANS-III survey block O & N, but majority of site is in block O.
[3]Norfolk Boreas overlaps SCANS-III survey block O & L; therefore higher density estimate from survey block O is used.
*Source: http://www.4coffshore.com/

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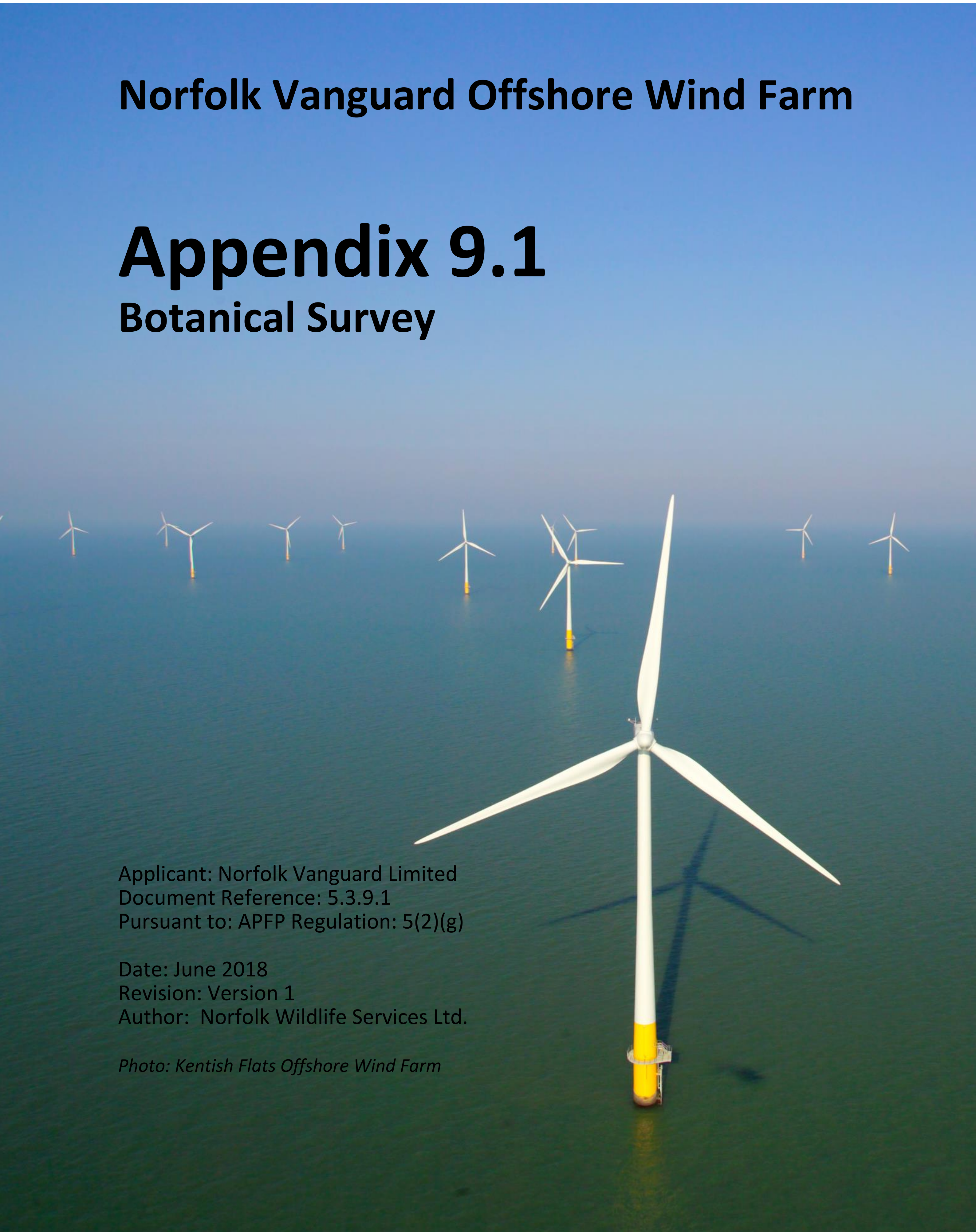

Norfolk Vanguard Offshore Wind Farm

Appendix 9.1
Botanical Survey

Applicant: Norfolk Vanguard Limited
Document Reference: 5.3.9.1
Pursuant to: APFP Regulation: 5(2)(g)

Date: June 2018
Revision: Version 1
Author: Norfolk Wildlife Services Ltd.

Photo: Kentish Flats Offshore Wind Farm

Information for the Habitats Regulations Assessment

Document Reference: 5.3.9.1

June 2018

For and on behalf of Norfolk Vanguard Limited
Approved by: Ruari Lean and Rebecca Sherwood
Signed: [redacted] [redacted]
Date: 8th June 2018

Norfolk Vanguard
Botanical survey

Report prepared by Norfolk Wildlife Services Ltd.
on behalf of Royal HaskoningDHV, October 2017

Reference: 2016/131/7

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1. Document details

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1	22/09/17	All All Creation of first draft for client review	All	First draft for client	SM
2	20/10/17	All	All	Second draft for client – changes made to first draft based on clients comments	SM
3	01/12/17	All	All	report update for client – based on changes to the structure	SM
4	04/12/17	All	All	Final report for client – based on changes to the structure	SM

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2. Executive Summary

2.1. Following consultation on The Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a), a detailed survey of the River Wensum and its floodplain were recommended to be carried out to understand any potential effects of horizontal directional drilling on the designated and notifiable features of River Wensum Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI).

2.2. The survey had four aims:

1. To identify the National Vegetation Classification (NVC) communities within the River Wensum SAC and SSSI.
2. To note if the following plants are growing within the River Wensum or grazing marsh ditches:
    - pond water-crowfoot *Ranunculus peltatus;*
    - stream water-crowfoot *Ranunculus penicillatus ssp. pseudofluitans;*
    - river water-crowfoot *Ranunculus fluitans.*
3. To identify the NVC communities within the semi-improved grassland found adjacent to the River Wensum.
4. To look for presence of calcareous groundwater springs/seepage within the semi-improved grassland.

2.3. Methodologies were developed using guidance documents from Rodwell (2006) and Doarks and Leach (1990).

2.4. The semi-improved grassland adjacent to the River Wensum consisted of two main NVC communities, which were often transitional to each other:

- MG6 – *Lolium perenne-Cynosusus cristatus* grassland
- MG10 – *Holco-Juncetum effusi* rush pasture

2.5. The River Wensum consisted of two main NVC communities:

- A8a - *Nuphar lutea* community, "species-poor" sub community (aquatic zone)
- S5 - *Glycerietum maximae* swamp, *Alisma plantago-aquatica-Sparganium erectum* sub community (marginal edge)

2.6. Communities associated with the ditches varied depending on location and land management. They were classified according to Doarks and Leach (1990) as being:

- Aquatic End Group A5b – *Lemna minor-Lemna trisulca*-filamentous algae
- Aquatic End Group A6 - *Callitriche stagnalis/platycarpa*
- Aquatic End Group A7b - *Potamogenton pectinatus-Myriophyllum spicatum*
- Emergent End Group E1 – *Carex riparia/acutiformis-Phragmities australis*
- Emergent End Group E2 – *Glyceria Maxima-Berula erecta*
- Emergent End Group E3 - *Juncus effusus*

2.7. None of the following species, associated with the River Wensum SAC habitat were recorded during the botanical survey within the River Wensum or its floodplain: *R. peltatus, R. penicillatus ssp. pseudofluitans or R. fluitans*

2.8. There was no evidence of calcareous ground water spring or seepage activity with the study area.

3. Introduction

3.1. Project background

3.1.1. Norfolk Vanguard is a proposed offshore wind farm being developed by Vattenfall Wind Power Limited (or an affiliate company), with a capacity of 1800MW, enough to power 1.3 million UK households. The offshore wind farm comprises two distinct areas, Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) and will be connected to the shore by offshore export cables installed within the provisional offshore cable corridor. The project will also require onshore infrastructure in order to connect the offshore wind farm to the National Grid at the existing National Grid substation at Necton, which in summary will comprise the following:

- Landfall;
- Cable relay station (if required);
- Underground cables;
- Onshore substation; and
- Extension to the existing Necton National Grid substation.

3.1.2. The location of the onshore electrical infrastructure is shown on Figure 1, Appendix A: of the Extended Phase 1 Habitat Survey Report (Royal HaskoningDHV, 2017a). Collectively the onshore electrical infrastructure is herein referred to as the 'onshore project area'.

3.1.3. During the development of the project, the onshore Scoping Area that was initially defined has been refined, to include three landfall options, associated cable relay search zones, as well as an onshore substation search zone in proximity to the Necton National Grid substation. A 200m wide cable corridor has been identified within which the buried cable will be located, and Horizontal Directional Drilling (HDD) zones and mobilisation zones have been identified along the cable corridor.

3.1.4. The surveys described within this report were designed and based on the onshore project area which was in use when the project Extended Phase 1 Habitat Survey was undertaken (February 2017). As the project design is further refined, these search zones will decrease in size, and the final options for the siting of infrastructure (i.e. one cable relay station, one landfall, one onshore substation) will be taken forward for the final Development Consent Order (DCO) application in June 2018.

3.2. Aim of report

3.2.1. As Norfolk Vanguard is a Nationally Significant Infrastructure Project (NSIP) an Environmental Impact Assessment (EIA) is required as part of a DCO application under the Planning Act 2008.

3.2.2. Norfolk Wildlife Services were appointed in late April 2017 to undertake additional ecological surveys to support this application as set out within the Survey Scope (Royal HaskoningDHV, 2017b).

3.2.3. The Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a) identified the potential for legally protected species located within the project area plus a 50m buffer surrounding the project area, and provided recommendations for further surveys required to characterise the ecological baseline for the project area.

3.3. Survey objective

3.3.1. The botanical survey had four objectives:

1. To identify the NVC communities within the River Wensum SAC and SSSI;

2. To note if the following plants are growing within the River Wensum or grazing marsh ditches:
   - pond water-crowfoot *R. peltatus;*
   - stream water-crowfoot *R. penicillatus ssp. pseudofluitans;*
   - river water-crowfoot *R. fluitans.*
3. To identify the NVC communities within the semi-improved grassland found adjacent to the River Wensum.
4. To look for presence of calcareous groundwater springs/seepage within the semi-improved grassland.

3.4. Survey scope

3.4.1. Development of survey scope

3.4.1.1. A Scoping Report for the EIA (Royal HaskoningDHV, 2016) was submitted to the Secretary of State on 3 October 2016 and the response in the form of a Scoping Opinion (PINS, 2016) published on 11 November 2016. That Scoping Opinion included the consultation responses of Natural England and Norfolk County Council.

3.4.1.2. An Extended Phase 1 Habitat Survey of the onshore project area was undertaken during February 2017 (Royal HaskoningDHV, 2017a). The Extended Phase 1 Habitat Survey identified the potential for legally protected species located within the project area plus a 50m buffer surrounding the project area, and provided recommendations for further surveys required to characterise the ecological baseline for the project area. These recommendations were issued to stakeholders on 17 March 2017 for comment, as part of the project Evidence Plan Process. Feedback was received from Norfolk County Council and Natural England on the 23 March 2017 and 3 April 2017 respectively that the methodologies were appropriate and acceptable.

3.4.1.3. A Survey Scope detailing the surveys required in order to deliver the Extended Phase 1 Habitat Survey Report recommendations (Royal HaskoningDHV, 2017b) was produced in March 2017. The Survey Scope (set out in Section 3.4.2) was used to tender for delivery of ecological surveys required for the project. Norfolk Wildlife Services based the methodology on this Survey Scope in consultation with the client.

3.4.2. Survey Scope

Survey area

3.4.2.1. Following consultation with Natural England conducted as part of the Evidence Plan Process, the need for a detailed assessment of the habitat associated with the River Wensum was recommended to ensure that the potential effects of proposed horizontal directional drilling under the River Wensum upon the quantifying features of the River Wensum SAC and the notified features of the River Wensum SSSI were fully understood. As a consequence a botanical survey will be undertaken to characterise the habitats of the semi-improved grassland found adjacent to the River Wensum during the field survey. This botanical survey will also involve a systematic search of the site in order to check the wet grassland habitats for the presence of springs and seepages, in order to characterise the water environment within the River Wensum floodplain.

3.4.2.2. The locations of the habitats scoped into the botanical survey are shown on Figure 1 (Appendix 1 of this report).

Methodology

3.4.2.3. The botanical survey will follow the methodology set out in *National Vegetation Classification: Users' handbook* (Rodwell, 2006). The survey will cover all semi- improved and wet grassland areas adjacent to the River Wensum within the survey area (as shown on Figure 1). Quadrat sampling will be used within delineated sub-communities, and those species found within each quadrat identified. An NVC communities map will be drawn up following the results of the survey, and the precise location of all notable species recorded.

The following aquatic plant species, for which the habitat is given its SAC status, will be given particular attention:

- pond water-crowfoot *Ranunculus peltatus*
- stream water-crowfoot *R. penicillatus ssp. pseudofluitans*
- river water-crowfoot *R. fluitans*.

3.4.2.4. The optimal surveying window for the botanical survey is between April and June.

3.4.2.5. The survey should be undertaken by experienced NVC surveyors, preferably members of the CIEEM. No species licences are required for this survey.

3.5. Scoping of survey locations

3.5.1. Natural England recommended the need for a detailed assessment of the habitat associated with the River Wensum to ensure that the potential effects of proposed horizontal directional drilling under the River Wensum upon the qualifying features of the River Wensum SAC and the notified features of the River Wensum SSSI were fully understood.

3.6. Conservation Status of the River Wensum SAC

3.6.1. The whole length of the River Wensum is a designated Site of Special Scientific Interest (1993) and Special Area of Conservation (2005). The site is listed under Annex I for habitat 3260 "Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation".

3.6.2. The River Wensum represents sub-type 1 in lowland eastern England. Although the river is extensively regulated by weirs, *Ranunculus* vegetation occurs sporadically throughout much of the river's length. Stream water-crowfoot *R. penicillatus*ssp. *pseudofluitans* is the dominant *Ranunculus* species but thread-leaved water-crowfoot *R. trichophyllus* and fan-leaved water-crowfoot *R. circinatus* also occur.

3.7. Presence of springs and seepages

3.7.1. Soligenous water movement through the soil discharging from rocks can be at a point (spring) or over a wide area (seepage). A pre-requisite for this type of groundwater discharge is an underlying or adjacent aquifer, such as the Cretaceaous chalk aquifer underlying the soils of the River Wensum.

3.7.2. Evidence of spring activity is usually characterised by surface wetness and/or a change in vegetation community within a site.

4. Methodology

4.1. Section 4.1 sets out the proposed survey protocol as agreed between Royal HaskoningDHV and Norfolk Wildlife Services prior to any field work commencing, and Section 4.2 sets out how the surveys were delivered in relation to the protocol and identifies any deviations or modifications that took place during the delivery phase.

4.1. Survey protocol

4.1.1. This Section details the proposed survey protocol as agreed between Royal HaskoningDHV and Norfolk Wildlife Services prior to any field work commencing.

Relevant guidance

4.1.2. The following guidance documents were used to inform development of the survey methodology:

- Rodwell, J.S. (2006) National Vegetation Classification: Users' handbook. JNCC
- Doarks, C., & Leach, S. J. (1990). A classification of grazing marsh dyke vegetation in Broadland. Nature Conservancy Council.

Methodology

4.1.3. Three different methodologies will be undertaken for different aspects of the Norfolk Vanguard botanical survey.

- An NVC survey of grassland within the wider floodplain (Rodwell 2006) including identification of any springs and seepages.
- For the Norfolk Vanguard River Wensum SAC/SSSI Survey, an adapted NVC river survey on a point-sampling basis, supplemented by visual examination.
- A vegetation survey of the ditches using the methodology of Doarks and Leach (1990).

4.1.4. The three methodologies are described below.

Grassland NVC survey

4.1.5. Sampling of the site will be undertaken in accordance with the approach set out in Rodwell (2006). An initial walkover will be conducted to identify the broad vegetation communities present within the site. Following this, sampling quadrats will be randomly selected within each broad vegetation community. A full species list will be noted for each quadrat, with species abundances quantified in accordance with the Domin scale and vegetation height will be recorded.

Table 1 : Domin cover values

Domin	Cover (%)
10	91-100
9	76-90
8	54-75
7	34-50
6	26-33
5	11-25
4	4-10
3	<4% (many individuals)
2	<4% (several individuals)

1	<4% (few individuals)

4.1.6. Any potential calcareous groundwater seepage/spring activity within the site will be noted.

4.1.7. A NVC community type will be attributed to the sampling locations. A map showing the NVC communities will be drawn up following the results of the survey, and the precise location of all notable species recorded.

4.1.8. Quadrat sampling will be used within delineated sub-communities, and those species found within each quadrat identified.

Analysis to NVC Communities

4.1.9. The NVC community type for each sampling location will be on Rodwell (2006) and surveyor experience from comparable sites with those identified communities. Floristic tables will be generated for each community type that summarises the abundance and constancy values of constituent species among the samples. Constancy values will be allocated as per the following table:

Table 2 : Constancy tables as defined in Rodwell (2006)

Constancy	Frequency (5%)	Description
I	1-20 (i.e. 1 stand in 5)	scarce
II	21-40	occasional
III	41-60	frequent
IV	61-80	constant
V	81-100	constant

4.1.10. Keys of British Plant Communities Volume 3: Grasslands and Montane Communities, British Plant Communities Volume 4: Aquatic communities, swamps and tall herb fen and British Plant Communities Volume 1: Woodlands and scrub will be used to assign NVC community types.

River Wensum SAC/SSSI Survey

4.1.11. The total length of the River Wensum survey reach (a distance of 360m) will be split into 10 equal parts, so sampling will occur approximately every 35m.

4.1.12. A canoe will be anchored in the approximate centre of the river at the identified sampling locations (Figure 2). Photographs will be taken and grid references noted at each sampling location.

4.1.13. A rope with a 3 headed grapnel will be thrown 5m south west and north east of each anchored sampling location. The grapnel will be allowed to sink to the river bed before being slowly pulled along the river bed and into the canoe.

4.1.14. At each sampling location any plants collected on the grapnel will be noted by the field surveyor and scored according to a percentage scale (0-100%).

4.1.15. A bathascope will be used at and between sampling locations to look through the water column at vegetation towards the river bed. A visual assessment will be made through the water column regarding species, abundances and vegetation height. Shallower vegetation will be incorporated within the sampling regime.

4.1.16. Particular attention will be paid to identify those species listed within the specification document.

4.1.17. The following aquatic plant species, associated with the River Wensum SAC habitat, will be given particular attention:

- pond water-crowfoot *R. peltatus .*
- stream water-crowfoot *R. penicillatus ssp. pseudofluitans .*
- river water-crowfoot *R. fluitans*.

4.1.18. An NVC community will be attributed to each of the sampling locations, based on a combination of the grapnel sampling and bathascope assessment.

4.1.19. An NVC community will be attributed to the marginal vegetation.

Ditch Survey

4.1.20. Four distinct ditch systems were identified within the River Wensum floodplain survey area and were labelled Ditch 1-4 (see Figure 3).

4.1.21. Within each ditch system, 20m sections will be chosen per ditch that appears to contain homogenous or representative vegetation for both aquatic and emergent communities. Photographs will be taken and grid references noted at each sampling location.

4.1.22. All species within the aquatic zone will be noted with abundances (quantified within DAFOR) and general notes about the ditch recorded. Local cover values will also be noted, where relevant. Emergent species are defined as those within the aquatic zone, which for most of the summer have the majority of their biomass above the water surface.

Table 3 : DAFOR and local cover values

DAFOR	Cover (%)	Local cover vales
Dominant (D)	70-100	A-LD
Abundant (A)	30-70	F-LD, FLA
Frequent (F)	10-30	O-LD, OLA
Occasional (O)	3-10	R-LD, R-LA, O-LF
Rare (R)	<3	R-LF, R-LO

4.1.23. The following aquatic plant species, associated with The River Wensum SAC habitat, will be given particular attention:

- pond water-crowfoot *R. peltatus*
- stream water-crowfoot *R. penicillatus ssp. pseudofluitans*
- river water-crowfoot *R. fluitans*

Analysis to Endgroups

4.1.24. Aquatic and emergent species for each sampling location will be attributed an End Group. Species and abundances will be hand sorted through the key in Doarks and Leach (1990) to identify an aquatic and emergent End Group for each sampling location. These groups are set out in the Tables below.

Table 4 : Aquatic vegetation communities, as defined in Doarks and Leach (1990)

Community	Binomial Names	Common names
A1	*Scirpus fluitans-Potamogeton natans*	Floating club rush-broad leaved pondweed

A2	*Potamogeton natans-Hottonia palustris-Myriophyllum verticillatum*	Broad leaved pondweed-Water violet-Whorled water milfoil
A3a	*Potamogeton natans*	Broad leaved pondweed
A3b	*Stratiotes aloides-Hydrocharis morsus-ranae*	Water soldier-Frogbit
A4 A5a	*Ceratophyllum demersum* *Elodea Canadensis-Ceratophyllum demersum*	Rigid hornwort Canadian pondweed-Rigid hornwort
A5b A6	*Lemna minor-Lemna trisulca*-Filamentous algae *Callitriche stagnalis/platycarpa*	Common duckweed-Ivy leaved duckweed-Filamentous algae Common/Various leaved water starwort
A7a A7b	Filamentous algae-*Enteromorpha* Potamogeton pectinatus – Myriophyllum spicatum	Filamentous algae-Gutweed Fennel pondweed-Spiked water milfoil

Table 5 : Emergent vegetation communities, as defined in Doarks and Leach (1990)

Community	Binomial Names	Common names
E1	*Carex riparia/acutiformis-Phragmities australis*	Greater/Lesser pond sedge-Common reed
E2	*Glyceria maxima-Berula erecta*	Reed canary grass/Lesser water parsnip
E3	*Juncus effusus*	Soft rush
E4 E5	*Phragmities australis* *Scirpus maritimus-Scirpus lacustris subsp, tabernaemontani-Eleocharis uniglumis*	Common reed Saltmarsh bulrush-Common club rush-Slender spike rush
E6	*Scirpus maritimus-Juncus gerardii*	Saltmarsh bulrush-Saltmarsh rush

Personnel

4.1.25. All surveys will be undertaken by suitably experienced NVC surveyors, who are either members of CIEEM or act according to its code of conduct.

Survey timing, equipment and weather conditions

4.1.26. Although the optimal surveying window for the botanical survey was identified by the ITT as being between April and June, given the survey required identification of sedges and rushes the optimal period is May to late July / early August.

Additional information

4.1.27. A permit to survey within The River Wensum SAC will be required from Natural England.

4.1.28. Any locally scarce species will be noted with reference to A Flora of Norfolk (Beckett and Bull, 1999).

4.1.29. Any nationally scarce species will be noted with reference to The Vascular Plant Red Data List for Great Britain (Cheffings and Farrell (Eds), 2005).

4.2. Survey delivery

4.2.1. This Section details how the surveys were delivered in relation to the agreed protocol, identifies any deviations or modifications that took place during the delivery phase and highlights survey limitations.

4.2.1. Survey methodology as delivered

Access to survey sites

4.2.1.1. Access permission to the northern half of the River Wensum was not granted.

4.2.1.2. There were no other access restrictions.

Survey effort

4.2.1.3. There appeared to be two distinct grassland NVC community types identified during the walkover of the site. 14 quadrats of 2m x 2m, specified in accordance with Rodwell (2006) for short herbaceous vegetation, were randomly selected within these two areas (Figure 1).

4.2.1.4. Due to the depth of the river being too deep to wade in, and too wide to sample from the southern bank, the survey of the River Wensum was undertaken by canoe.

4.2.1.5. Due to the dangers of sampling the marginal vegetation of the River Wensum from the bank next to deep water and silt or from a canoe, the marginal vegetation was attributed a NVC community based on visual impression of the species present.

Dates of surveys

Table 6 : Dates, personnel and weather for vegetation surveys

Location	Visit Date	Time	Weather	Personnel
NVC Grassland	05/07/2017	10:00-17:00	2/8 cloud cover, BWS 1, dry, hot 27°C	Sally McColl Chris Smith
NVC Grassland	24/08/2017	08:00-15:00	2/8 cloud cover, BWS 1, dry with sunny spells, hot 24°C	Sally McColl Carolyn Smith
NVC River Wensum	28/07/2017	08:30-14:00	7/8 cloud cover, BWS 3, dry, cool with sunny spells	Sally McColl James Allitt
NVC Ditches	23/08/2017	08:00-15:00	2/8 cloud cover, BWS 1, dry, with sunny spells, hot 22°	Sally McColl Ben Moore
NVC Ditches	24/08/2017	08:00-15:00	2/8 cloud cover, BWS 1, dry with sunny spells, hot 24°C	Sally McColl Carolyn Smith

Personnel

4.2.1.6. All surveys were undertaken by suitably experienced NVC surveyors, who are listed in the table below. Other personnel mentioned in Table 6 were safety workers.

Table 7 : Personnel and relevant experience

Team Member	Experience
Chris Smith	20 years' experience within ecological consultancy and 25 years' experience of ecological surveying including NVC plant surveys.
Sally McColl	10 years' experience of ecological surveying, including aquatic plant surveys, condition monitoring and NVC plant surveys.
Carolyn Smith	4 years' experience of ecological surveying including NVC plant surveys.

Consent

4.2.1.7. A permit to survey within the SAC was received from Natural England on 24th July 2017 (Appendix 3).

4.2.2. Limitations

4.2.2.1. The NVC approach was not felt applicable to ditch vegetation within the site, due to the limitations of that classification for artificial dykes (Mountford, 2006). However the alternative use of Doarks and Leach (1990) is felt to be more robust and applicable in this instance and gives no significant limitations.

4.2.2.2. Limitations for each survey type are outlined in the Table below.

Table 8: Limitations and suggested impacts

Survey Type	**Limitation**	**Impact of Limitation**
Grassland Survey	No limitations	N/A
River Survey	Access to the northern half of the river was not given by the landowner, so the survey was carried out on the southern half; The marginal edge was too dangerous to sample from the bank or by canoe.	Not significant – the emergent vegetation was visible from the southern half of the river, and the aquatic vegetation was fairly uniform. Not significant – the marginal edge consisted of a single species swamp community and was easily assessed by eye.
Ditch Survey	No limitations	N/A

5. Results

5.1. Maps showing sampling locations are shown in Appendix 1 (Figures 1-3).

5.2. Photographs taken at sampling locations are included in Appendix 2 (Figures 4-38).

5.3. Raw data tables and endgroup descriptions (Doarks and Leach, 1990) are attached as separate documents.

5.4. A map showing field names is attached in Appendix 6 and NVC map is attached in Appendix 7.

5.1. Grassland NVC survey

Overview

5.1.1. The site consists of a relatively flat floodplain, which nevertheless contains some variation in levels and drainage patterns. Areas closest to the river appear to have the highest water tables, and include areas with peaty soils (Fields 4, 7, 8 and 9) whereas the more southerly and westerly sections are drier and loamy (Fields 6 and 1). The site is roughly grazed throughout to varying degrees by cattle.

5.1.2. The site slopes down from the upland in the north easterly direction although the majority of the fields are undulating, with some lower wetter patches having impeded drainage. Penny Spot Beck and the River Wensum were embanked, whilst all other ditches graded into the surrounding grassland.

5.1.3. On the back of the floodbank, Field 9, there was a distinct patch of wetter vegetation. This is thought to be caused by seepage of water through the floodbank due to proximity to the river rather than soligenous water flow. Another distinct wetter area was on the edge of the survey area in Field 7, which is likely caused by natural undulation of the field. The remaining fields, although showing undulation with lower areas, appeared much drier.

5.1.4. The aquatic and marginal communities of the ditches are a prominent feature, but are dealt with in the subsequent sections.

5.1.5. The grassland appears to consist of the following vegetation communities:

- MG6 – *Lolium perenne-Cynosusus cristatus* grassland
- MG10 – *Holco-Juncetum effusi* rush pasture

5.1.6. MG6 is present throughout the southern and easterly parts of the site, whilst MG10 is confined to a small area at the back of the floodbank and the north western and north eastern (part of) marshes. These habitats are intrinsically linked with ground conditions, with MG6 located on free draining soil and on areas of higher ground, and MG10 being located on impeded soils and in lower areas.

5.1.7. There are overgrown hedgerows and scattered scrub throughout the site with species such as hawthorn *Crataegus monogyna* (which is classified as W21 – *Crataegus monogyna-Helix hedera* scrub (Target notes 1 and 3)), and sallow *Salix cinerea* with a bramble *Rubus fruticosus* understorey (which is classified as W2a *Salix cinerea-Betula pubescens-Phragmities australis, Alnus glutinosa-Filipendula ulmaria* sub community).

5.1.8. A line of oaks *Quercus robur* (Target note 4) and poplars *Populus spp.* (Target note 2) were recorded.

5.1.9. Field 10 was excluded from classification under NVC as it appeared to be in a cropping regime, and not grassland.

MG6 Lolium perenne-Cynosuretum cristati grassland

Description

5.1.10. The sampling locations were grass-dominant with species such as *Agrostis stolonifera*, *Holcus lanatus* and *L. perenne* having the highest constancy values as well as *Ranunculus repens*, which typically persists in grazed areas.

5.1.11. Herbs present with the highest constancy values are small creeping species such as *Potentilla repens*, *Trifolium repens*, and *Trifolium pratense* with taller herbs present at some sampling locations.

5.1.12. The MG6 grassland sampling locations were labelled as D1-D6.

5.1.13. On average between 10 and 20 species were recorded per sampling location, with over half of those recorded being grasses.

5.1.14. No nationally or locally scarce species were noted at any of the sampling locations.

Variation within community

5.1.15. There is variation between the fields within the site, as shown by the sample data.

5.1.16. At the south-east of the site, there was a lush, tussocky sward which had approximately four coarse grass species of equal abundance including *A. stolonifera* and *Festuca arundinacea* and appeared to have been grazed earlier in the season (Field 5).

5.1.17. At the back of the floodbank adjacent to the wetter MG10 community (Field 9), the vegetation here was less species rich and had coarse grasses such as *A. stolonifera*, *H. lanatus* and *F. arundinacea* in higher abundances.

5.1.18. Throughout the site, but especially on the eastern side the community was often transitional to the MG10 community and examples of samples within these areas had higher occurrence of *J. effusus*, *H.lanatus* and *R. repens* (Field 8).

5.1.19. As the ground rose towards the west the sward became drier (Field 6), and became a more closely grazed sward with more fine grasses evident. A lot of ruderal species such as *Circium arvense* and *Rumex obtusifolius* were evident.

5.1.20. At the south-west (Field 1) the sward was lusher, and lightly grazed with a higher proportion of herbs and *Juncus inflexus* present. However, the southern and eastern areas of this field appeared higher and drier. This location is very clearly transitional in places towards the *J. inflexus* variation of MG10 (Target note 5).

5.1.21. Fields 2, 3 and 4 were ungrazed at the time of survey and vegetation was very tall and had Arrhenatherum *elatioris* evident.

5.1.22. The back of the floodbank (Field 9) and Field 5 had a much more tussocky sward, consistent with a lighter grazing regime.

Goodness of fit to community

5.1.23. MG6 is described as “a short, tight sward which is grass-dominated. *Lolium Perenne* is usually the most abundant grass with varying amounts of *Cynosurus cristatus*. *Festuca Rubra* and *Agrostis capillaris* are frequent throughout and, in long-established pasture, they may be abundant. *Holcus lanatus and Dactylis glomerata* are also frequent but of somewhat patchy distribution. They may become more prominent as coarse tussocks if pasture is under-grazed and *H. lanatus* is often abundant and vigorous around cattle dung which the animals avoid.” (Rodwell,1992).

5.1.24. It is not an exact fit with MG6, as *C. cristatus* is only present at one of the quadrats, and *T. repens* is in a lower value. However this may be because many of the areas are transitional to MG10 and are located within damper areas which are less favourable for *C. cristatus*.

5.1.25. MG6 is typical of grazed lowland pasture in Britain on moist freely draining soils, which is consistent with the site.

5.1.26. Ungrazed Fields 2 and 5 could potentially fit better with MG1-*A. elatioris* as it grades to the arable upland (Target notes 6 and 7)), where under grazing has allowed this grass to appear more dominant, or it could just be that a lighter grazing regime has led to this appearance of change.

Constancy table

5.1.27. The constancy table is shown below.

Table 9: Constancy table for MG6 Lolium perenne-Cynosuretum cristati

Species	Average for stand (DOMIN)	Constancy
Agrostis stolonifera (creeping bent)	4	V
Holcus lanatus (Yorkshire fog)	5	V
Lolium perenne (perennial ryegrass)	2	V
Ranunculus repens (creeping buttercup)	3	V
Taraxacum agg. (dandelion)	2	V
Festuca rubra (red fescue)	2	IV
Phleum pratensis (timothy)	3	IV
Arrhenatherum elatius (false oat grass)	2	III
Cerastium fontanum (common mouse ear)	1	III
Poa trivialis (rough meadow grass)	1	III
Bromus mollis (soft brome)	1	II
Carex hirta (hairy sedge)	1	II
Dactylis glomerata (cocks foot)	1	II
Festuca arundinacea (tall fescue)	2	II
Juncus inflexus (hard rush)	2	II
Plantago lanceolata (ribwort plantain)	1	II
Poa pratensis (smooth stalked meadow grass)	1	II
Potentilla repens (creeping cinquefoil)	1	II
Trifolium pratense (red clover)	1	II
Trifolium repens (white clover)	1	II
Agrostis capillaris (common bent)	1	I
Alopecurus geniculatus (marsh foxtail)	1	I
Brachythecium rutabulum (rough stalked feather moss)	0	I
Cynosurus cristatus (crested dogs tail)	0	I
Deschampsia cespitosa (tufted hair grass)	1	I
Glechoma hederacea (ground ivy)	0	I
Juncus effusus (soft rush)	1	I
Lathyrus pratensis (meadow vetchling)	1	I
Lotus corniculatus (bird's foot trefoil)	1	I
Potentilla anserina (silverweed)	1	I
Pulicaria dysenterica (common fleabane)	1	I
Rumex crispus (curled dock)	<1	I
Rumex obtusifolius (broad leaved dock)	1	I
Senecio jacobaea (ragwort)	<1	I
Urtica dioica (nettle)	<1	I
Vicia cracca (tufted vetch)	<1	I

MG10 – Holco-Juncetum effusi rush pasture

Description

5.1.28. These wetter grasslands were on peaty soils, located within the lowest areas within the site and are numbered W1-W7.

5.1.29. The species with highest constancy values are *J. effusus, A. stolonifera,* and *H. lanatus* with *R. repens* a constant but at a low abundance.

5.1.30. Sampling locations W1, W2, W6-W8 were taken along the back of the river bank to north/north-east of the site.

5.1.31. Sampling locations W3-W5 were taken in the northern marsh, although this habitat continued slightly to the south (Field 8).

5.1.32. No nationally or locally scarce species were noted at any of the sampling locations.

Variation within community

5.1.33. W5 (Field 7) was distinctly wetter and *Persicaria amphibia* was evident within the *J. effusus.*

5.1.34. W7 (Field 9) had *Glyceria maxima* present instead of *J. effusus*. These sampling locations were generally lightly or not grazed, although the grass sward between the tussocks were well grazed.

Goodness of fit to community

5.1.35. MG10 *Holco-Juncetum effusi* – "a sward with prominent tussocks of *Juncus effusus* up to 80cm tall in a generally species poor and shorter grassy ground. *Holcus lanatus* and *Juncus effusus* are the only constant grasses and each or both may be abundant" (Rodwell, 1992).

5.1.36. This community is characteristic of permanently moist sites, which is widely distributed in pastures and are usually grazed.

5.1.37. It is a good fit with this community type as *A. stolonifera*, *H.lanatus* and *J. effusus* are present at high constancies, although *R. repens* is at a lower occurrence.

Constancy table

5.1.38. The constancy table is below.

Table 10: Constancy table for MG10

Species	Average for stand (DOMIN)	Constancy
Agrostis stolonifera (creeping bent)	4	V
Holcus lanatus (Yorkshire fog)	5	V
Juncus effusus (soft rush)	5	V
Alopecurus pratensis (meadow foxtail)	2	IV
Arrhenatherum elatius (false oat grass)	2	IV
Festuca arundinacea (tall fescue)	2	IV
Filipendula ulmaria (meadow sweet)	2	IV
Stellaria graminea (lesser stitchwort)	1	IV
Potentilla anserina (silverweed)	2	III
Ranunculus repens (creeping buttercup)	1	III
Rumex acetosa (common sorrel)	1	III
Cerastium fontanum (common mouse ear)	1	III
Juncus articulatus (jointed rush)	1	II

Lathyrus pratensis (meadow vetchling)	1	II
Lotus pedunculatus (greater bird's-foot-trefoil)	1	II
Poa trivialis (rough meadow grass)	1	II
Taraxacum agg. (dandelion)	1	II
Carex acutiformis (lesser pond sedge)	1	II
Dactylis glomerata (cock's-foot)	1	II
Glechoma hederacea (ground ivy)	1	II
Glyceria maxima (reed sweet-grass)	1	II
Carex riparia (greater pond sedge)	1	II
Trifolium pratense (red clover)	<1	II
Carex hirta (hairy sedge)	<1	I
Circium arvense (creeping thistle)	<1	I
Lolium perenne (perennial ryegrass)	<1	I
Myosotis secunda (creeping forget me not)	<1	I
Persicaria amphibia (amphibious bistort)	1	I
Phalaris arundinacea (reed canary grass)	1	I
Urtica dioica (common nettle)	<1	I
Circium dissectum (meadow thistle)	<1	I
Equisetum palustre (marsh horsetail)	<1	I
Quercus spp. (oak sapling)	<1	I
Rumex conglomeratus (clustered dock)	<1	I
Rumex obtusifolius (broad leaved dock)	<1	I
Senecio aquaticus (marsh ragwort)	<1	I
Senecio jacobea (common ragwort)	<1	I
Trifolium repens (white clover)	<1	I

5.1.39. Full data tables are provided as an excel table in Appendix 4.

5.2. River Wensum SAC/SSSI survey

Description

5.2.1. The river was approximately 2m deep and 20m wide, with good marginal vegetation, often in floating and inaccessible mats.

5.2.2. There were no trees along the river banks of the southern stretch of the survey area. There were a few white willows *Salix alba*, along the southern banks between sampling locations 6 and 8, and some oaks *Quercus robur*, and alders *Alnus glutinosa* along the northern bank.

5.2.3. Two main vegetation communities were identified:

- A8a-*Nuphar lutea* community, species-poor sub community.
- S5-*Glycerietum maximae* swamp, *Alisma plantago-aquatica-Sparganium erectum* sub community.

S5-Glycerietum maximae swamp

5.2.4. There was a good marginal vegetation dominated by *G. maxima* with large mats of *Apium nodiflorum* stretching out into the river, narrowing the open water by up to 10m in certain areas. There were some floating mats of *P. arundinacea* and *Veronica catenata* throughout the sampled area. *Sparganium erectum* with some *Myosotis scorpioides* was present at sampling location 10. This emergent community was assessed as NVC S5-*Glycerietum maximae* swamp, *Alisma plantago-aquatica-Sparganium erectum* sub community.

A8a-Nuphar lutea community, species-poor sub community

5.2.5. The majority of the open water was generally covered by *N. lutea*, which persisted throughout the water column. The amount to which the *N. lutea* persisted through the water column varied along the length. It was estimated that *N. lutea* was present over 25% of the water column growing from the bed to 50cm below the surface at sampling locations 4 and 5, whereas at most other sampling locations *N. lutea* was evident on the water surface and was estimated to occupy an average of 25%-50% of the water column.

5.2.6. *N. lutea*, dominated the water column, with occasional species such as *Callitriche spp.*, and *Elodea nuttalli* being recorded. The occasional strand of *M. spicatum* was noted floating on the water surface, but not picked up during the survey. Beds of this plant were noted upstream from the survey area.

5.2.7. The NVC community assigned to the aquatic communities is A8a-*Nuphar lutea* community, species-poor sub community.

Variation within community

5.2.8. This stretch of river was fairly uniform in terms of aquatic macrophyte diversity.

5.2.9. None of the following species listed within the Norfolk Vanguard Phase 2 Ecological Surveys Scope associated with the River Wensum SAC habitat were noted:

- pond water-crowfoot *R. peltatus*
- stream water-crowfoot *R. penicillatus ssp. pseudofluitans*
- river water-crowfoot *R. fluitans*

5.2.10. No locally or nationally scarce species were noted during the survey.

Goodness of fit to community

5.2.11. A8 is described in Rodwell (1995) "…Much of the vegetation is species poor, consisting of little else apart from *N. lutea*…"

5.2.12. The species-poor sub community is described in Rodwell (1995) as "*N. lutea* is sometimes the only plant here, with just very occasional *L. minor* on the surface, *Elodea canadensis*, *Callitrice stagnalis*, *Zannichellia* or *Ceratophyllum demersum* beneath and a few shoots or clumps of *Sagittaria*, *Apium*, *V. beccabunga* or *Mentha aquatica*."

5.2.13. The sampling locations fit well with the description of this community type.

Results table

5.2.14. Species and abundances of aquatic plants noted at each sampling location are listed in Table 10 below.

Table 11 : Species and abundances of aquatic plants at river sampling locations

Point	**Sampling direction**	**Species**			
		Nuphar lutea **% cover**	***Callitriche spp.*** **% cover**	***Elodea nuttalli*** **% cover**	***Myosotis scorpioides*** **% cover**
1	NE	25	-	5	-
1	SW	25	-	-	-
2	NE	10	5	25	-
2	SW	-	5	20	-
3	NE	10	-	5	-
3	SW	50	-	-	-
4	NE	30	-	1	-
4	SW	10	-	15	-
5	NE	25	-	-	-
5	SW	10	-	5	-
6	NE	25	-	-	-
6	SW	30	-	-	-
7	NE	15	-	-	-
7	SW	20	-	-	-
8	NE	5	-	-	-
8	SW	-	-	-	-
9	NE	30	-	-	-
9	SW	30	-	-	-
10	NE	75	-	-	1
10	SW	75	-	-	-

5.3. Ditch survey

Ditch 1

Description

5.3.1. This was an agricultural field drain of approximately 2.5m wide and was fairly uniform along its length, with water being very shallow (10-30cm) and abundant vegetation cover.

Aquatic vegetation

5.3.2. *Polygonum amphibium* was locally dominant, at three of the sampling locations (1A, 1B, 1D) with *Potamogeton berchtoldii* being abundant at 1C.

5.3.3. The species recorded along this ditch length key out to three different End Groups. Species recorded at sampling locations 1A correspond to the End Group A6-*Callitriche stagnalis*/*platycarpa* which is a good fit with this group with both *C. spp.* and *L. minor* being present.

5.3.4. Species recorded at sampling location 1B key out to the End Group A7b-*Potamogenton pectinatus-Myriophyllum spicatum*, which doesn't fit well as none of the constant species for this group were recorded, and only keyed to this group due to the presence of *L. minor*.

5.3.5. Species recorded at sampling locations 1C and 1D key out to End Group A5b-*Lemna minor/Lemna trisulca*/filamentous algae. Despite two of the constant species not being recorded with only *L. minor* being present, it is a good fit to this group as it represents ditches with low species diversity with some *C. spp*. and *P. pusilus/berchtoldii* present. End Group A5b is the best fit with sampling locations 1B-1D.

Table 12 : Ditch 1 – Species and abundances of aquatic vegetation

Species	Sampling Location			
	1A	1B	1C	1D
Polygonum amphibium	A - LD	F	-	F - LD
Potamogeton bertoldii	O	A	A	R
Callitriche spp.	O - LD	-	R	-
Lemna minor	R	R	R	O
Aquatic End Group	**A6**	**A7b**	**A5b**	**A5b**

Emergent vegetation

5.3.6. Emergent vegetation was in general low growing with species such as *B. erecta*, frequently occurring. Other species such as *Mentha aquatica* were of rare occurrence. There were no dominant species at any of the points except at 1A where pendulous sedge *Carex pendula*, was locally dominant.

5.3.7. The emergent vegetation does not fill well with the End Groups due to the lack of dominant species resulting from shading.

Table 13: Ditch 1 – Species and abundances of emergent vegetation

Species	Sampling Location			
	1A	1B	1C	1D
Agrostis stolonifera	R	O	R	
Alisma aquatica			R	
Berula erecta		F	R	

Species	**Sampling Location**			
Cardamine pratensis		R	R	
Carex pendula	LD			
Carex spp.			O	
Epilobium hirsutum	R	R	R	
Equisetum palustris	R			
Juncus articulatus			O	
Juncus inflexus	R	R	A	
Mentha aquatica	O	O	F	R
Polygonum amphibium		F		
Ranunculus repens	R	R	R	
Salix cinerea		O	O	O
Solanum dulcamara	R			
Tussilago farfara			R	
Typha latifolia	O	O	O	
Emergent End Group	**E2**	**E3**	**E3**	**E2**

Summary

5.3.8. End Group A6-*Callitriche stagnalis*/*platycarpa* is typically found in ditches that border between the uplands and grazing marsh, which can dry out for periods in the summer. Land to the north of the ditch does slope downwards, and due to the woodland fringe on the south side it is thought likely that the ditch does dry out at times in the shallower areas. This group is most closely associated with emergent End Group E2-*Glyceria maxima-Berula erecta*.

5.3.9. End Group A5b-*Lemna minor/Lemna trisulca*/filamentous algae is species poor, typically found in water depths of <20cm, and is associated with moderately eutrophic conditions.

5.3.10. None of the following species listed within the Norfolk Vanguard Phase 2 Ecological Surveys Scope associated with the River Wensum SAC habitat were noted:

- pond water-crowfoot *R. peltatus*
- stream water-crowfoot *R. penicillatus ssp. pseudofluitans*
- river water-crowfoot *R. fluitans*

Ditch 2

Description

5.3.11. This was an agricultural field drain of approximately 2.5m wide, 5-30cm water depth and was variable along its length in terms of vegetation cover.

Aquatic vegetation

5.3.12. Sampling locations 2C to 2E keyed out to End Group A5b – *Lemna minor*-*Lemna trisulca*-filamentous algae where species such as *C. spp*. and *P. berchtoldii* are often typical.

5.3.13. Sampling locations 2A and 2B could not be assigned aquatic End Groups due to the lack of water plants. These points were heavily overshadowed by dense hedgerow to the west and tall ruderal vegetation to the east. The water level was very low at these points, with the sandy substrate at the bottom of the ditch evident. However, the ditch is quite uniform along its length, and the End Groups are thought likely to follow the same community, if shading was reduced.

Table 14: Ditch 2 - Species and abundances of aquatic vegetation

Species	Sampling Locations				
	2A	2B	2C	2D	2E
Lemna triscula	-	-	R	A	-
Lemna minor	R	-	R	O	R
Calltitriche spp.	-	-	O-LD	R	R
Filamentous algae	-	-	F-LD	O	O
Hottonia palustre	-	-	F	O	-
Potamogeton bertoldii	-	-	F-LD	-	-
Elodea nuttalli	-	-	-	R	-
Aquatic End Group	**A5b**	**A5b**	**A5b**	**A5b**	**A5b**

Emergent vegetation

5.3.14. Emergent vegetation was generally low growing with species such as *B. erecta*, and *M. aquatica*, occurring with the highest scores at each sampling location. *P. arundinacea*, and *G. maxima* were locally dominant at sampling locations 2C and 2D.

5.3.15. Sampling location 2A was closest to emergent End Group E3-*Juncus effusus*, due to the presence of *Juncus effusus*, however this was only at rare occurrence and therefore sampling location 2A fits better with E2-*Glyceria maxima*-*Berula erecta* to which sampling locations 2B-2E also key out. However, only sampling location 2E has *G.maxima* present, whist sampling locations 2A and 2D have *B. erecta* present as abundant to dominant and sampling locations 2B and 2C have it occurring occasionally.

Table 15: Ditch 2 – Species and abundances of emergent vegetation

Species	Point				
	2A	2B	2C	2D	2E
Agrostis stolonifera	R	R			
Apium nodiflorum					R
Berula erecta	D	O	O	A	
Cardamine pratensis	R				R
Cerstium fontanum					R
Epilobium hirsutum	R	R			

Equisetum palustris					O
Eupatorium cannabinum	R				
Filipendula ulmaria				R	
Galium palustre					R
Glyceria maxima					A/LD
Holcus lanatus				R	
Iris pseudoacorus					O
Juncus effusus	R				
Juncus inflexus		R			
Mentha aquatica	F	F		F	R
Myosotis scorpidium			O	O	O
Phalaris arundinacea	O		A/LD	O	
Ranunculus repens	O			R	
Ranunculus scleratus					R
Salix cinerea	O				
Scrophularia auriculatum					R
Solanum dulcamara		R	R	R	R
Urtica dioica	R	O			
Valeriana officinalis	R	R			
Emergent End Group	**E3**	**E2**	**E2**	**E2**	**E2**

Summary

5.3.16. Ditch 2 was consistently classified as this End Group A5b-*Lemna minor/Lemna trisulca*/filamentous algae along its length.

5.3.17. End Group A5b-*Lemna minor/Lemna trisulca*/filamentous algae is a species poor community typically found in water depths of <20cm, and is associated with eutrophic conditions.

5.3.18. This aquatic community is often associated with the emergent vegetation End Group E2-*Glyceria maxima*-*Berula erecta* which is typical of eutrophic freshwater conditions with a high base status.

5.3.19. None of the following species listed within the Norfolk Vanguard Phase 2 Ecological Surveys Scope associated with the River Wensum SAC habitat were noted:

- pond water-crowfoot *R. peltatus*
- stream water-crowfoot *R. penicillatus ssp. pseudofluitans*
- river water-crowfoot *R. fluitans*

Ditch 3

5.3.20. This was an Internal Drainage Board (IDB) drain running along the back of the floodbank, which looked to have been cleared out within the last few years. This ditch was 2.5m wide and approximately 45-60cm deep.

Aquatic vegetation

5.3.21. Beds of *C. spp.*, dominated under the water surface with *Lemna minuta* dominating at the water surface. *E. nuttalli* was also recorded at all 5 sampling locations. This was the most diverse of the four ditches sampled, with an average of 5-6 species per sampling location.

5.3.22. The End Group assigned to the aquatic vegetation in this ditch is A5b – *Lemna minor-Lemna trisulca*-filamentous algae.

Table 16: Ditch 3 – Species and abundances of aquatic vegetation

Species	Sampling Locations				
	3A	3B	3C	3D	3E
Lemna minuta	A	A	A	F	O
Calltitriche spp.	A	A	F	O	O
Filamentous algae	F	F	F	O	-
Certophyllum demursum	-	-	O	R	-
Elodea nuttalli	R	R	F	O	O
Hottonia palustre	-	F	O	R	-
Hydrodictyon algae	-	-	R	-	-
Polygonum amphibium	-	R	R	-	-
Potamogeton pusillus	R	R	-	-	-
Aquatic End Group A6	**A5b**	**A5b**	**A5b**	**A5b**	**A5b**

Emergent vegetation

5.3.23. Emergent vegetation had a good mix of species with *Sparganium erectum*, and *G. maxima* occurring abundantly within the sampling locations. Other typical swamp species such as *Filipendula ulmaria*, and *Galium palustre* were recorded at low abundances.

5.3.24. The End Group assigned to the emergent vegetation in this ditch is E2 – *Glyceria Maxima-Berula erecta*. It is a good fit with E2, as *G. maxima* was present at four of the sampling locations, and *A. stononifera* and *A. nodiflorum*/*B.erecta* were present at the majority of sampling locations.

Table 17: Ditch 3 – Species and abundances of emergent vegetation

Species	Sampling Locations				
	3A	3B	3C	3D	3E
Agrostis stolonifera	R		R		
Apium nodiflorum	R	R	F	R	R
Berula erecta			R		R
Carex riparia		R			
Cerstium fontanum			R	R	
Equisetum palustris			R		
Filamentous algae			F		
Filipendula ulmaria		R	R	R	R

Species	Sampling Locations				
Galium palustre			O	R	R
Glyceria maxima	O	F		O	
Hippuris vulgaris			F		
Holcus lanatus		R			R
Juncus articulatus		R			
Juncus effusus		R	R	R	
Mentha aquatica	R		O		
Phalaris arundinacea	R	R	R		O
Polygonum amphibium		R			
Ranunculus repens	R	R	R	R	R
Rumex conglemeratus			R		
Salix cinerea		O	O	R	
Scrophularia auriculatum		R			R
Solanum dulcamara					O
Sparganium emerusm	F				
Sparganium erectum	F	O		O	F
Stachys palustris	R		O		
Urtica dioica	R		R	R	R
Veronica beccabunga			O		
Emergent End Group	**E2**	**E2**	**E2**	**E2**	**E2**

Summary

5.3.25. Ditch 3 was consistently classified along its length as aquatic End Group A5b – *Lemna minor*-*Lemna trisulca*-filamentous algae. It is associated with the emergent End Group is E2 – *Glyceria Maxima-Berula erecta*, typical of high nutrient conditions.

5.3.26. None of the following species listed within the Norfolk Vanguard Phase 2 Ecological Surveys Scope associated with the River Wensum SAC habitat were noted:

- pond water-crowfoot *R. peltatus*
- stream water-crowfoot *R. penicillatus ssp. pseudofluitans*
- river water-crowfoot *R. fluitans*

Ditch 4 (Penny Spot Beck)

5.3.27. Penny Spot Beck meanders through the site where it flows out into the River Wensum. The ditch has steeply sloping sides, well vegetated with emergent vegetation, which encroach into the ditch significantly along the majority of its length causing significant shading. It is different from the other ditches sampled by having a slow flow, whereas other ditches were static.

Aquatic vegetation

5.3.28. This ditch had no aquatic plants at any of the sampling locations, except for filamentous algae at one point. The ditch had macrophytes present during the July grassland visit (pers. obs. Chris Smith 05/07/17).

5.3.29. At sampling location 4C, the ditch is approximately 5cm deep and is adjacent to a cattle drinking point. The substrate is gravelly and flowing with water with the odd piece of filamentous algae, caught on the stone. At sampling location 4B the ditch deepens to 30cm, the stony bottom is replaced by silt and there is encroachment from marginal vegetation. At sampling location 4C, the water is deeper to 45cm and becomes more turbid.

5.3.30. It is not clear why there were no plants growing within the ditch in the sample area, where the ditch is more open and not subject to significant shading. There was no sign of the ditch being recently cleared out, or any treatment by herbicides. It is unlikely that the cattle are the issue, as there is significant poaching by cattle on the other ditches surveyed. It is thought possible run-off from the arable land to the north may be responsible, although there were no blooms of algae present which are consistent with nutrient enrichment.

5.3.31. It is though likely that if aquatic vegetation was present, it would be consistent with a species poor community A5b – *Lemna minor*-*Lemna trisulca*-filamentous algae as environmental conditions within Penny Spot Beck appear similar to that of neighbouring ditches within the site. The A5b End Group was most frequently associated with E2 (Doarks and Leach, 1990), and were most frequently recorded together across the survey area.

Table 18: Ditch 4 - Species and abundances of aquatic vegetation

Species	Sampling Locations		
	4A	4B	4C
Filamentous algae	R	-	-
Aquatic End Group A6	**A5b**	**A5b**	**A5b**

Emergent vegetation

5.3.32. Emergent vegetation was dominated by single-species stands of reeds and grasses with limited associated species recorded at each point. *G. maxima*, *P. arundinacea*, and *C. riparia* were recorded as the most abundant species.

5.3.33. Sampling locations D2 and D3 keyed out to emergent End Group E2, whilst D1 keyed out to group E1 – *Carex riparia/acutiformis-Phragmities australis* due to the presence of *C. riparia* at the water line. Although all sampling locations seem more consistent with E2 it is however a poor fit as two of the constant species, *B. erecta* and *A. stolonifera* were not present.

Table 19: Ditch 4 – Species and abundances of emergent vegetation

Species	Sampling Locations		
	4A	4B	4C
Agrostis stolonifera			

Species	**Sampling Locations**		
Apium nodiflorum			R
Berula erecta			
Carex riparia	O		
Cerstium fontanum			
Equisetum palustris			
Filamentous algae			
Filipendula ulmaria			
Galium palustre			
Glyceria maxima	F	A	
Hippuris vulgaris			
Holcus lanatus			
Juncus articulatus			
Juncus effusus			
Mentha aquatica			
Phalaris arundinacea	O	O	F
Polygonum amphibium			
Ranunculus repens		R	R
Rumex conglemeratus			
Salix cinerea			
Scrophularia auriculatum			
Sparganium emerusm			
Sparganium erectum			
Stachys palustris			
Urtica dioica			
Veronica catenata			R
Emergent End Group	**E1**	**E2**	**E2**

Summary

5.3.34. No aquatic species were evident along the beck within the survey area. The majority of the beck is very narrow, with steep banks and very tall emergent vegetation which is shading the ditch. It is thought likely that if vegetation were to be present it would be consistent with A5b – *Lemna minor*-*Lemna trisulca*-filamentous algae. The majority of emergent vegetation along the beck is classified as emergent End Group E2 – *Glyceria maxima*-*Berula erecta* which is consistent with the lack of grazing along this ditch length.

5.3.35. None of the following species listed within the Norfolk Vanguard Phase 2 Ecological Surveys Scope associated with the River Wensum SAC habitat were noted:

- pond water-crowfoot *R. peltatus*
- stream water-crowfoot *R. penicillatus ssp. pseudofluitans*
- river water-crowfoot *R. fluitans*

5.4. Incidental observations

5.4.1. A number of signal crayfish *Pacifastacus leniusculus*, were seen whilst carrying out the survey of the River Wensum.

6. Conclusions

Grassland NVC Survey

6.1. The semi-improved grassland found adjacent to the River Wensum consisted of two main NVC communities, which were often transitional to each other:

- MG6 – *Lolium perenne-Cynosusus cristatus* grassland
- MG10 – *Holco-Juncetum effusi* rush pasture

6.2. MG10 is a species poor community and characteristic of permanently moist sites, which are widely distributed in grazed pastures. It is a good fit with this community type.

6.3. MG6 is typical of short, tight grass-dominated swards found on free draining soil within grazed lowland pastures, which is consistent with the study area. It is not an exact fit with MG6 because many of the areas are transitional to MG10 and are located within damper areas, and some ungrazed areas could fit better with MG1.

River Wensum SAC/SSSI Survey

6.4. The section of the River Wensum within the study area is dominated by beds of *N. lutea* and is classified as NVC community A8a-*Nuphar lutea* community, "species-poor" sub community. Marginal vegetation consists of NVC community S5-*Glycerietum maximae* swamp, *Alisma plantago-aquatica-Sparganium erectum* sub community.

Ditch Survey

6.5. The ditches varied depending on location and land management. They were classified according to Doarks and Leach (1990) as being:

- Aquatic End Group A5b – *Lemna minor-Lemna trisulca*-filamentous algae
- Aquatic End Group A6 - *Callitriche stagnalis/platycarpa*
- Aquatic End Group A7b - *Potamogenton pectinatus-Myriophyllum spicatum*
- Emergent End Group E1 – *Carex riparia/acutiformis-Phragmities australis*
- Emergent End Group E2 – *Glyceria Maxima-Berula erecta*
- Emergent End Group E3 - *Juncus effusus*

6.6. Some ditches were very shaded or for other reasons lacked aquatic vegetation.

6.7. Despite the variation in appearance of vegetation communities the best fit End Groups across the study area appeared to be species poor End Groups A5b – *Lemna minor-Lemna trisulca*-filamentous algae and E2 – *Glyceria Maxima-Berula erecta* associated with eutrophic conditions.

Ranunculecae floating beds

6.8. None of the following species, associated with the River Wensum SAC habitat were recorded during the botanical survey within the River Wensum or its floodplain:

- pond water-crowfoot *R. peltatus*
- stream water-crowfoot *R. penicillatus ssp. pseudofluitans*
- river water-crowfoot *R. fluitans*

Presence of springs and seepage

6.9. There was no evidence of calcareous ground water spring or seepage activity with the study area. The MG10 community at the back of the flood bank is likely to be a result of river water seepage through the flood bank, as this area is isolated, not extensive and is in close proximity to the river. Other wetter communities on the site, such as MG10, and dyke vegetation such as A5b are more consistent with lateral water flows or impeded drainage rather than soligenous water movement.

7. References

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Royal HaskoningDHV (2017). *Norfolk Vanguard Offshore Wind Farm Extended Phase 1 Habitat Survey Report* (Document ref: PB4476-003-040). Royal HaskoningDHV, Edinburgh.

8. Appendix 1 – Map of sampling points

Figure 1: Grassland sampling point map

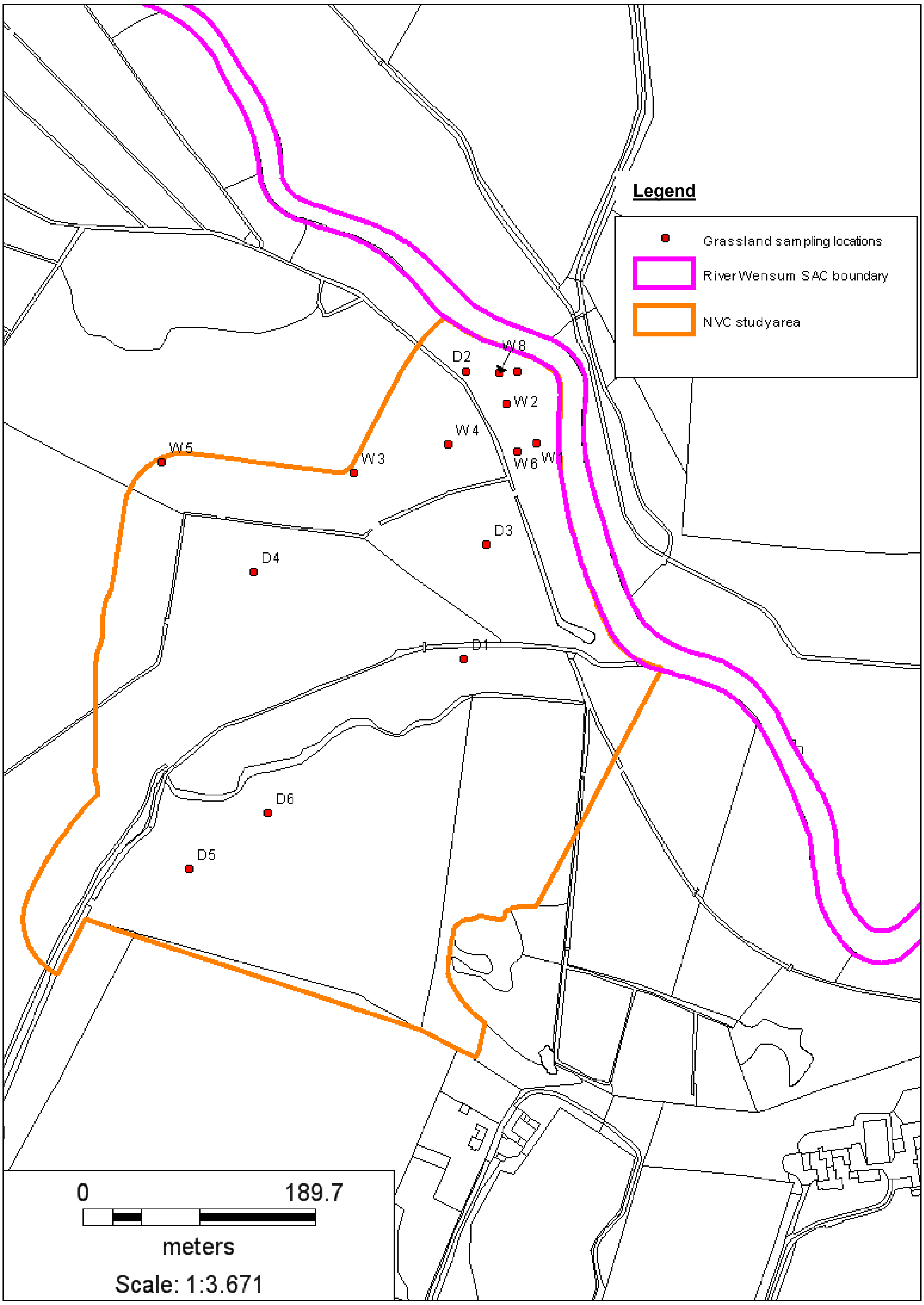


Figure 2: River survey sampling point map

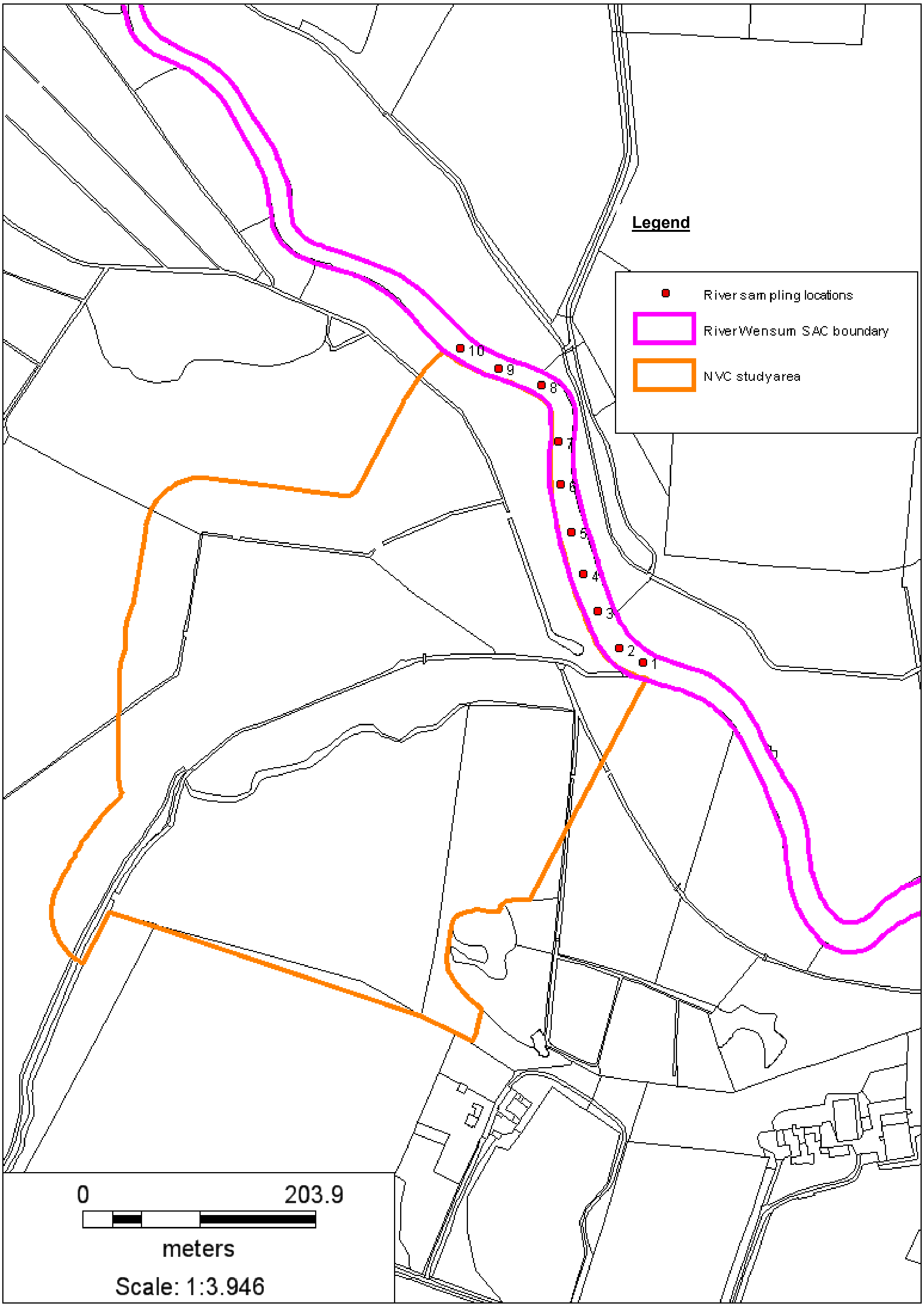
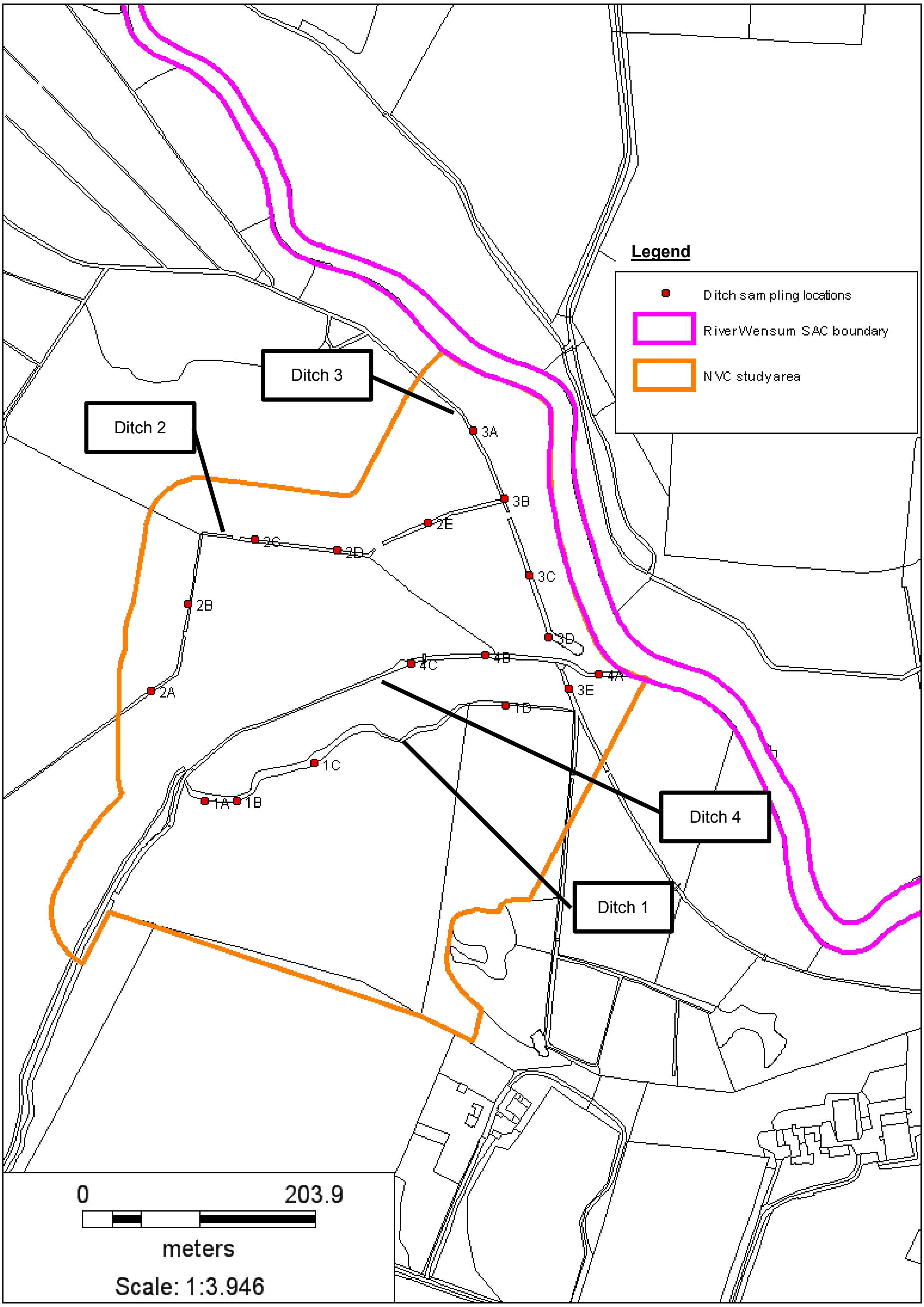


Figure 3: Ditch survey sampling point map



9. Appendix 2 – Photographs

Figure 4 : Grassland survey sampling point W1 – MG10

Figure 5 : Grassland survey sampling point W2 – MG10

Figure 6 : Grassland survey sampling point W3 – MG10

Figure 7 : Grassland survey sampling point W4 – MG10

Figure 8 : Grassland survey sampling point W5 – MG10

Figure 8 : Grassland survey sampling point W7 – MG10

Figure 10 : Grassland survey sampling point W8 – MG10

Figure 11 : Grassland survey sampling point D1-MG6

Figure 12 : Grassland survey sampling point D2 - MG6

Figure 13 : Grassland survey sampling point D3 - MG6

Figure 14 : Grassland survey sampling point D4 - MG6 on driest part of site with many ruderals

Figure 15 : Grassland survey sampling point D5 - MG6

Figure 16 : Grassland survey sampling point D6 - MG6

Figure 17 : Ditch survey sampling point 1A – A6 / E2

Figure 18 : Ditch survey sampling point 1B – A7b / E3

Figure 19 : Ditch survey sampling point 1C – A5b / E3

Figure 20 : Ditch survey sampling point 1D – A5b / E2

Figure 21 : Ditch survey sampling point 2A – A5b / E3

Figure 22 : Ditch survey sampling point 2C – A5b / E2

Figure 23 : Ditch survey sampling point 2D – A5b / E2

Figure 24 : Ditch survey sampling point 3A – A5b / E2

Figure 25 : Ditch survey sampling point 3B – A5b / E2

Figure 26 : Ditch survey sampling point 3C – A5b / E2

Figure 27 : Ditch survey sampling point 3D – A5b / E2

Figure 28 : Ditch survey sampling point 3E – A5b / E2

Figure 29 : Ditch survey sampling point 4A – E1

Figure 30 : Ditch survey sampling point 4B – E1

Figure 31 : River survey sampling point 2 – A8a

Figure 32 : River survey sampling point 3 – A8a

Figure 33 : River survey sampling point 4 – A8a

Figure 34 : River survey sampling point 5 – A8a

Figure 35 : River survey sampling point 6 – A8a

Figure 36 : River survey sampling point 8 – A8a

Figure 37 : River survey sampling point 9 – A8a

Figure 38 : River survey sampling point 10 – A8a

10. Appendix 3 – Consent

River Wensum Site of Special Scientific Interest Norfolk ("the SSSI")
River Wensum Special Area of Conservation (SAC)

CONSENT OF NATURAL ENGLAND

Section 28E(3)(a) of the Wildlife and Countryside Act 1981 (as amended and inserted by section 75 and Schedule 9 of the Countryside and Rights of Way Act 2000)
Regulation 21 of the Conservation of Habitats and Species Regulations 2010

To:

Mr Carrick

Of:

Castle Farm, Swanton Morley, Dereham, NR20 4JT

You have Natural England's consent to carry out, cause or permit to be carried out the operations specified below, on the land specified below.

This consent covers the period to 31st August 2017.

The specified operations:

Aquatic plant and Desmoulin whorl snail surveys

Timing of the operations:

24th July 2017 to 31st August 2017

Land on which the operations are to be carried out:

The River Wensum and adjacent land and ditches as shown on the attached maps.

Signed for Natural England:

Date: **24/07/2017**

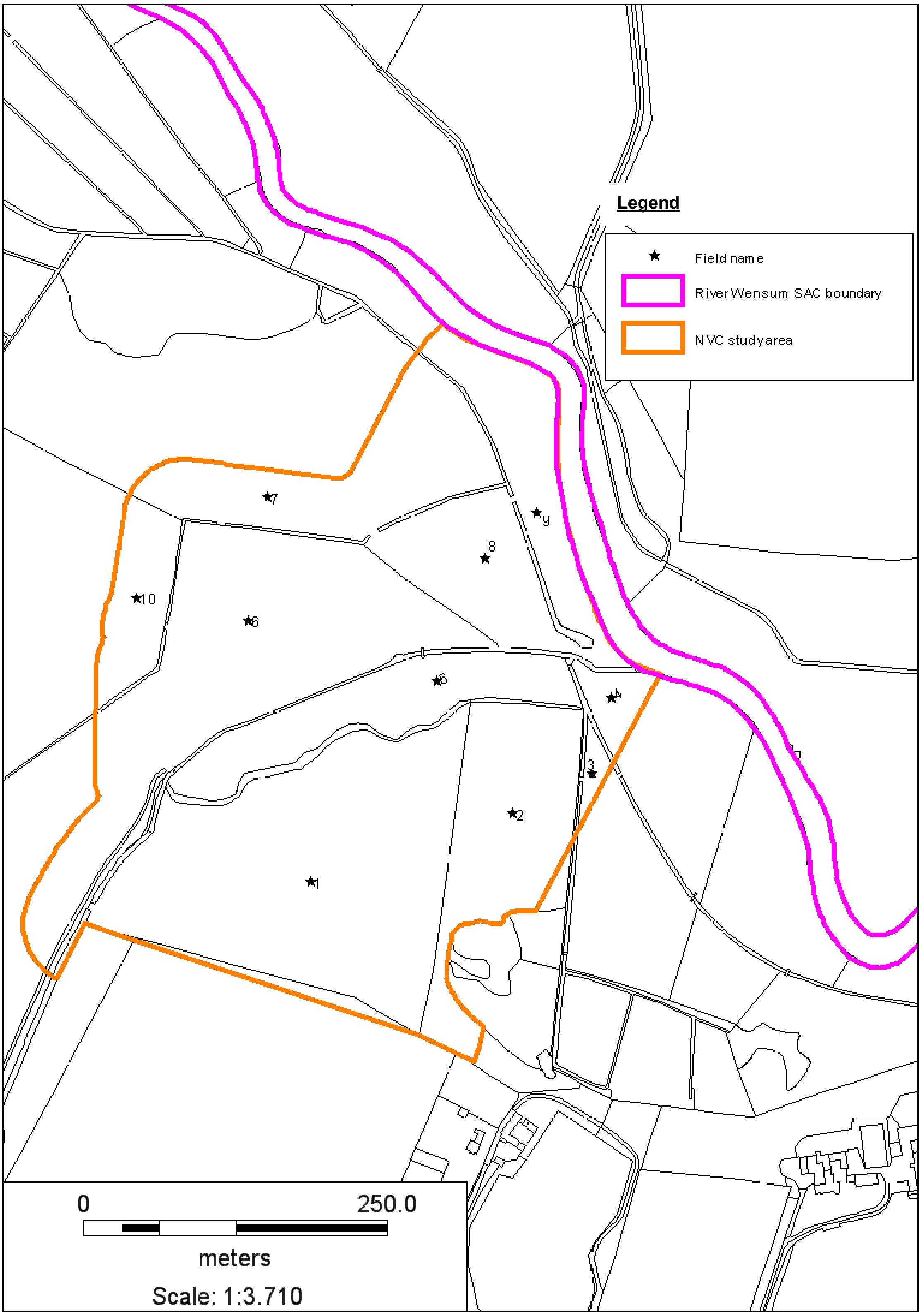
11. Appendix 4 – Raw data tables

Attached as excel files

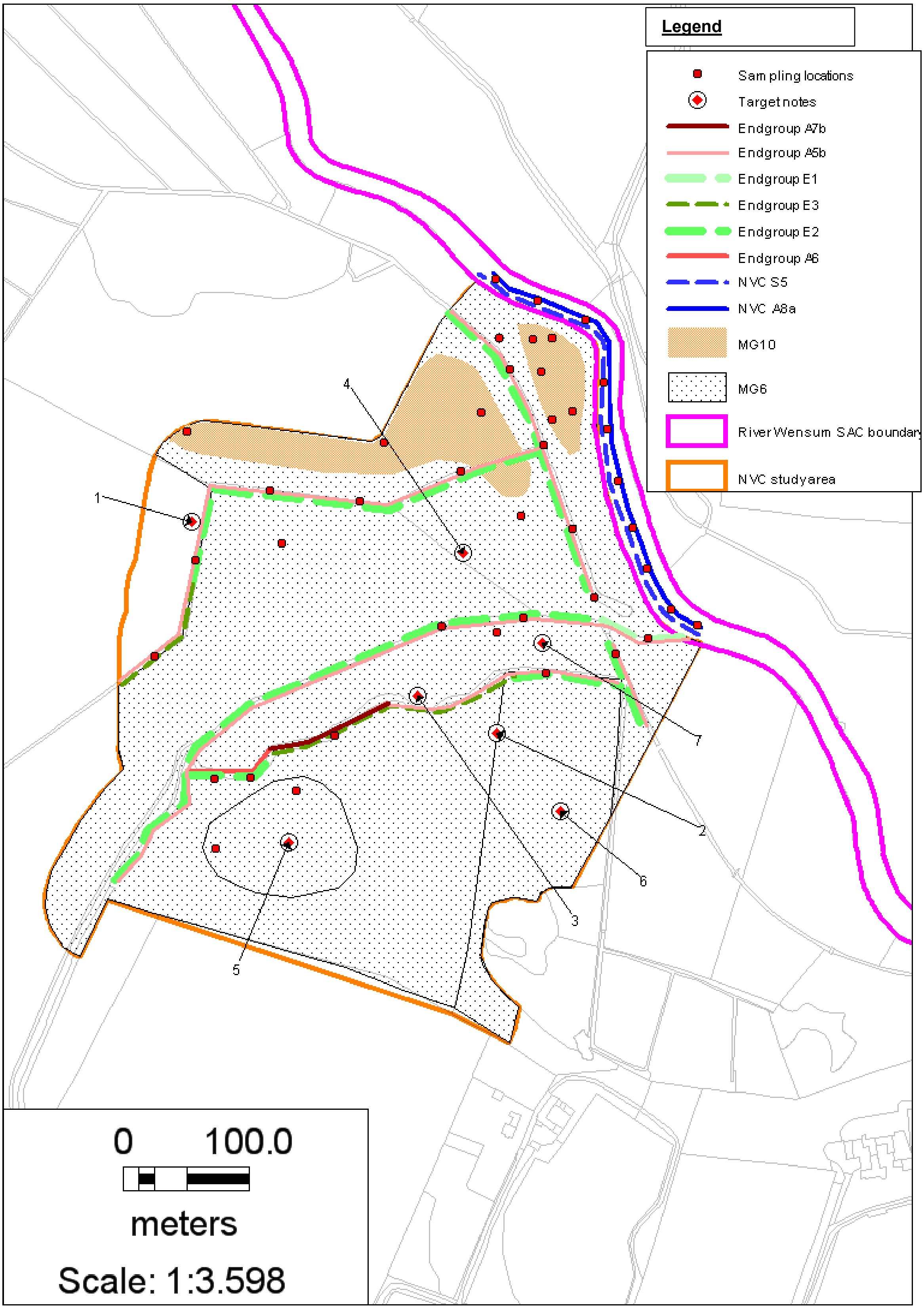
12. Appendix 5 – Endgroup descriptions

Attached as pdf files

13. Appendix 6 – Field Name Map



14. Appendix 7 – NVC/End Group Map



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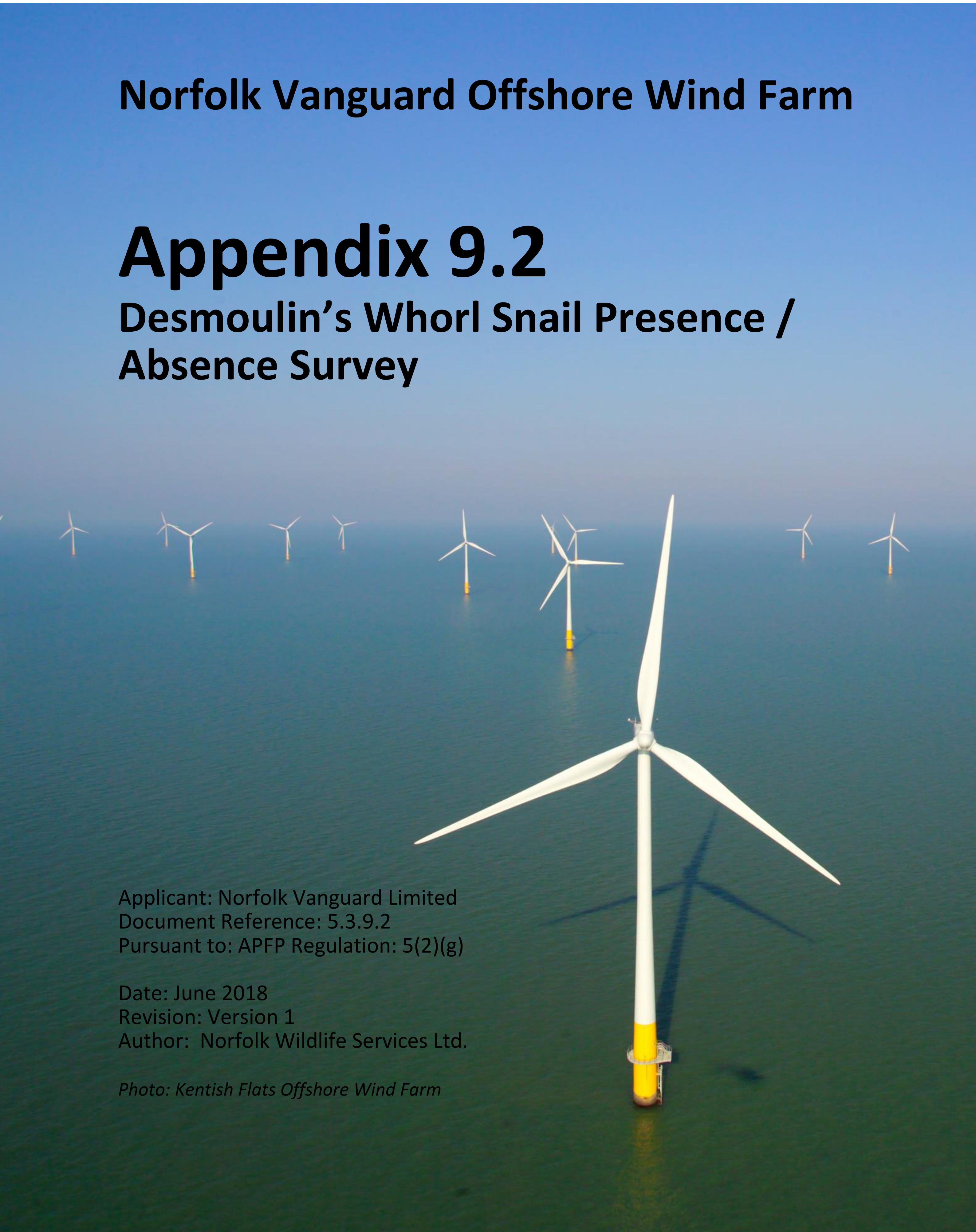

Norfolk Vanguard Offshore Wind Farm

Appendix 9.2

Desmoulin's Whorl Snail Presence / Absence Survey

Applicant: Norfolk Vanguard Limited
Document Reference: 5.3.9.2
Pursuant to: APFP Regulation: 5(2)(g)

Date: June 2018
Revision: Version 1
Author: Norfolk Wildlife Services Ltd.

Photo: Kentish Flats Offshore Wind Farm

Information for the Habitats Regulations Assessment

Document Reference: 5.3.9.2

June 2018

For and on behalf of Norfolk Vanguard Limited

Approved by: Ruari Lean and Rebecca Sherwood

Signed: [redacted] [redacted]

Date: 8th June 2018

Norfolk Vanguard
Desmoulin's whorl snail presence / absence survey

Report prepared by Norfolk Wildlife Services Ltd.
on behalf of Royal HaskoningDHV

Reference: 2016/131.6

Table of contents

1. Document details

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Version Number	Date	Section(s)	Page(s)	Summary of Changes	Approved by
1.3	25/09/17	All	All	First draft for client	CS
2	17/10/17	All	All	Second draft for client - Project background update - Change of structure - Minor wording changes - Addition of GIS map	CS
3	13/11/17	All	All	Changes to structure	CS
4	01/12/17	All	All	Update as per comments and final changes to structure	CS

2. Executive Summary

2.1. Following consultation with Natural England, a presence/absence survey of Desmoulin's whorl snail *Vertigo moulinsiana* was identified as being required within wet grassland and field drain habitats associated with the margins of the River Wensum and the adjacent floodplain (Royal HaskoningDHV 2017b).

2.2. The purpose of the survey was to ascertain whether *V. moulinsiana* is present within these habitat areas.

2.3. Eight survey locations were identified (referenced as AQ01 – 08) within the Norfolk Vanguard Phase 2 Ecological Survey Scope (Royal HaskoningDHV 2017b). These survey locations were sampled 3 times during August 2017 following methods set out by Killeen and Moorkens (2003) to determine the presence or absence of *V. moulinsiana*.

2.4. Observed limitations to the survey included a bull preventing access to part of the AQ07 survey location during the first visit, and only the southern bank of the River Wensum was sampled.

2.5. *V. moulinsiana* was not found during any of the sample visits and is considered absent from the survey locations.

2.6. It is recommended to create an additional survey location on the northern bank of the River Wensum and survey for *V. moulinsiana* following the methodology set out in this report due to the presence of the snail in other reaches of the River Wensum.

2.7. Further survey of location points AQ04, AQ05, AQ07 and AQ08 (as the most suitable locations) is recommended if works take place over three years from the survey date due to the potential for *V. moulinsiana* to become established within the survey area.

3. Introduction

3.1. Project background

3.1.1. Norfolk Vanguard is a proposed offshore wind farm being developed by Vattenfall Wind Power Limited (or an affiliate company), with a capacity of 1800MW, enough to power 1.3 million UK households. The offshore wind farm comprises two distinct areas, Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) and will be connected to the shore by offshore export cables installed within the provisional offshore cable corridor. The project will also require onshore infrastructure in order to connect the offshore wind farm to the National Grid at the existing National Grid substation at Necton, which in summary will comprise the following:

- Landfall;
- Cable relay station (if required);
- Underground cables;
- Onshore substation; and
- Extension to the existing Necton National Grid substation.

3.1.2. The location of the onshore electrical infrastructure is shown on Figure 1, Appendix A of the Extended Phase 1 Habitat Survey Report (Royal HaskoningDHV, 2017a). Collectively the onshore electrical infrastructure is herein referred to as the ‘onshore project area’.

3.1.3. During the development of the project, the onshore Scoping Area that was initially defined has been refined to include three landfall options, associated cable relay search zones, as well as an onshore substation search zone in proximity to the Necton National Grid substation. A 200m wide cable corridor has been identified within which the buried cable will be located, and Horizontal Directional Drilling (HDD) zones and mobilisation zones have been identified along the cable corridor.

3.1.4. The surveys described within this report were designed and based on the onshore project area which was in use when the project Extended Phase 1 Habitat Survey was undertaken (February 2017). As the project design is further refined, these search zones will decrease in size, and the final options for the siting of infrastructure (i.e. one cable relay station, one landfall, one onshore substation) will be taken forward for the final Development Consent Order (DCO) application in June 2018.

3.2. Aim of report

3.2.1. As Norfolk Vanguard is a Nationally Significant Infrastructure Project (NSIP) an Environmental Impact Assessment (EIA) is required as part of a DCO application under the Planning Act 2008.

3.2.2. Norfolk Wildlife Services were appointed in late April 2017 to undertake additional ecological surveys to support this application as set out within the Survey Scope (Royal HaskoningDHV, 2017b).

3.2.3. The Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a) identified the potential for legally protected species located within the project area plus a 50m buffer surrounding the project area, and provided recommendations for further surveys required to characterise the ecological baseline for the project area.

3.3. Survey objective

3.3.1. To provide baseline information on the presence or absence of *V. moulinsiana* within the wet grassland and field drain habitats associated with the River Wensum SAC survey area (Norfolk Vanguard Phase 2 Ecological Survey Scope, Royal HaskoningDHV, 2017b).

3.4. Survey scope

3.4.1. Development of survey scope

3.4.1.1. A Scoping Report for the EIA (Royal HaskoningDHV, 2016) was submitted to the Secretary of State on 3 October 2016 and the response in the form of a Scoping Opinion (PINS, 2016) published on 11 November 2016. That Scoping Opinion included the consultation responses of Natural England and Norfolk County Council.

3.4.1.2. An Extended Phase 1 Habitat Survey of the onshore project area was undertaken during February 2017 (Royal HaskoningDHV, 2017a). The Extended Phase 1 Habitat Survey identified the potential for legally protected species located within the project area plus a 50m buffer surrounding the project area, and provided recommendations for further surveys required to characterise the ecological baseline for the project area. These recommendations were issued to stakeholders on 17 March 2017 for comment, as part of the project Evidence Plan Process. Feedback was received from Norfolk County Council and Natural England on the 23 March 2017 and 3 April 2017 respectively that the methodologies were appropriate and acceptable.

3.4.1.3. A Survey Scope detailing the surveys required in order to deliver the Extended Phase 1 Habitat Survey Report recommendations (Royal HaskoningDHV, 2017b) was produced in March 2017. The Survey Scope (set out in Section 3.4.2, Royal HaskoningDHV 2017b) was used to tender for delivery of ecological surveys required for the project. Norfolk Wildlife Services used the methodology set out in the Survey Scope.

3.4.1.4. The whole length of the River Wensum is a designated Site of Special Scientific Interest (1993) and Special Area of Conservation (2005). The site is listed under Annex I for habitats and Annex II for species, including *V. moulinsiana*.

3.4.1.5. *V. moulinsiana* is listed under Annex II of the European Union Habitats and Species Directive. It is a priority species in the UK Biodiversity Action Plan (HMSO 1996) and is listed in the British Red Data Book (Bratton 1991) as an RDB3 (Rare) species.

3.4.2. Survey Scope

Survey area

3.4.2.1. Following consultation with Natural England conducted as part of the Evidence Plan Process, the need for a terrestrial invertebrate survey is required in relation to the wet grassland and field drain habitats associated with River Wensum. The survey was recommended by Natural England in order to determine presence / absence of *V. moulinsiana*, an Annex II species present as a qualifying feature, but not a primary reason for site selection for the River Wensum SAC.

3.4.2.2. The survey area is shown in Appendix 1 of this report, with the exact survey locations shown in Appendix 2.

Methodology

3.4.2.3. This invertebrate survey will follow the protocol set out in the Buglife's *A manual for the survey and evaluation of the aquatic plant and invertebrate assemblages of grazing marsh ditch systems* (Version 6) (2013). All of the ditches functionally connected to the River Wensum within the survey area, plus both banks of the River Wensum within the survey area, will be sampled, as shown on Figure 1. This should include 7 samples in total. Each sample will be taken by netting on three occasions for 1-3 minutes at a selected location. Then each netted sample will then be sorted and species identified, and species abundance recorded. Those species which cannot be identified in the field will be taken back to the laboratory for identification.

3.4.2.4. The invertebrate survey should start in the last week in April and ideally be completed by early June (although useful results can be obtained up to mid-October).

3.4.2.5. All surveys should be undertaken by ecologists with experience in aquatic invertebrates surveys, preferably members of the CIEEM. No species licences are required for these surveys.

3.5. Scoping of survey locations

3.5.1. The survey locations identified by the Survey Scope (Royal HaskoningDHV, 2017b) based upon the Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a) consist of 8 separate survey locations (AQ01 – AQ08).

4. Methodology

4.1. This section sets out the protocol for the survey at the point prior to any field work commencing.

4.1. Survey protocol

Relevant guidance

4.1.1. The following guidance document was used to inform development of the survey methodology: "Killeen IJ and Moorkens E.A. (2003) A Monitoring Protocol for Desmoulin's Whorl Snail, Vertigo moulinsiana. Conserving Natura 2000 Rivers Monitoring Series No. 6. English Nature, Peterborough".

Survey locations

4.1.2. Eight survey locations were sampled, referenced as AQ01 – 08 (Appendix 2) as per the specified survey locations from the Norfolk Vanguard Phase 2 Ecological Survey Scope (Royal HaskoningDHV 2017b).

Survey methodology

4.1.3. The survey period and broad methodology outlined in the Survey Scope (Royal HaskoningDHV 2017b)was considered to be unsuitable for *V. moulinsiana*. Between April and June, the snails are lower on the vegetation and often present in very low numbers. The snails are most active and found with the highest numbers of adults high on vegetation during August.

4.1.4. The survey methodology is adapted from Killeen and Moorkens (2003), which is specific to *V. moulinsiana* and is described below.

4.1.5. For each of the eight identified survey locations, 3 survey samples will be spread out on approximately 1 week apart during August to gain maximum coverage during the peak survey season for adults of *V. moulinsiana*.

4.1.6. At each survey location, a photograph and GPS co-ordinates will be taken.

4.1.7. Within 20m either side of the survey locations, 5 sub-samples will be taken within suitable vegetation and combined to form a survey sample.

4.1.8. A sub-sample will consist of 1 minute of vegetation beating over a white tray. The survey sample will be sorted in the field, and presence / absence of *V. moulinsiana* recorded. Voucher specimens of any terrestrial gastropod molluscs (Pupilloidea) will be taken back to the laboratory for confirmation of identification.

4.1.9. Environmental variables as per Killeen and Moorkens (2003) shown in Table 1 will be recorded for each survey location including: ground moisture level, vegetation class and average sward height. The optimum ground moisture is between level 2 and 4, and optimum vegetation is considered to be Class 1 and 2 at an average sward height of 0.7m.

Table 1 : Environmental variables adapted from Killeen and Moorkens (2003). Highlighted rows show optimal variables.

Ground moisture			Vegetation classes	
1	Dry	No visible moisture	**Class 1**	*Glyceria, Carex, Cladium*
2	Damp	Ground visibly damp, but does not rise	**Class 2**	*Phalaris, Phragmites, Sparganium, Filipendula, Urtica*
3	Wet	Water rises under light pressure	**Class 3**	*Mentha, Epilobium, Persicaria*
4	Very wet	Pools of standing water, less than 5cm deep	**Class 4**	All other species
5	Under water	Entire site in standing or flowing water		

4.1.10. There are no specific time constraints. However, the snails shelter low down amongst vegetation overnight, surveys should therefore avoid early mornings and evenings.

4.1.11. Surveys will not be undertaken during wet and windy conditions, or early mornings with dew.

4.1.12. Specialist equipment was used to carry out the field surveys, which included:

- A 2m ruler calibrated at 10cm intervals to measure vegetation height,
- A white plastic tray (50x40cm, 5cm deep),
- A 1m long beating stick,
- A 20x magnification hand lens for field identification,
- Sample tubes for collection of voucher specimens pre-labelled for each survey location,
- A hand-held GPS receiver (Garmin eTrex).

4.1.13. A National Vegetation Classification survey, undertaken in 2017 by Norfolk Wildlife Services, identified NVC communities at sampling locations within the River Wensum survey area. The nearest NVC sampling locations (Norfolk Wildlife Services, 2017) to the eight survey locations (AQ01 – 08) will be referenced (Section 5.2).

4.1.14. No species licences are required for these surveys however; a permit to survey within the SAC will be required from Natural England.

4.1.15. All surveys will be undertaken by suitably experienced invertebrate surveyors, who will either be members of CIEEM or act according to its code of conduct.

4.2. Survey delivery

4.2.1. This Section details how the surveys were delivered in relation to the survey protocol, identifies any deviations or modifications that took place during the delivery of the survey and highlights survey limitations.

4.2.1. Survey methodology as delivered

Access to survey sites

4.2.1.1. A bull prevented access to part of the AQ07 survey location during visit 1 on 8th August 2017.

Survey effort

4.2.1.2. At all survey locations sampled, 3 repeat samples consisting of 5 sub-samples were carried out.

Timing and weather conditions

4.2.1.3. Survey visits were carried out on all survey locations on the 8th, 14th and 22nd August 2017.

4.2.1.4. Weather conditions as given previously were all suitable for the survey protocol.

Table 2 : Dates, time and weather for field visits

Survey visit	Date	Survey times (BST)	Surveyor	Safety worker	Beaufort Windscale	Precipitation	Presence of dew
Visit 1	08/08/2017	09:00 – 12:00	Ben Christie	Jennifer Christie	1	None	Absent
Visit 2	14/08/2017	08:30 – 11:30	Ben Christie	Carolyn Smith	2	None	Absent

Visit 3	22/08/2017	08:30 – 11:30	Ben Christie	Carolyn Smith	1	None	Absent

Personnel

4.2.1.5. All survey visits were carried out by Ben Christie GradCIEEM. Ben has over 6 years' experience in surveying invertebrates, across terrestrial and aquatic habitats. Other personnel mentioned in Table 2 were safety workers.

Consent

4.2.1.6. Consent for the survey of *V. moulinsiana* within the identified survey area during August 2017 was provided by Natural England on 24th July 2017 (Appendix 4).

4.2.2. Limitations

4.2.2.1. A bull prevented access to part of the AQ07 survey location during visit 1 however; this was not considered to be a significant limitation due to five sub-samples taken within the remaining accessible area and additional 2 repeated sample visits.

4.2.2.2. Only the southern bank of the River Wensum was sampled at one survey location (AQ08). The northern bank of the River Wensum was not included within the Survey Scope (Royal HaskoningDHV 2017b) due to lack of landowner access for this area. Since the northern bank of the River Wensum was not surveyed, there is potential that *V. moulinsiana* is present in this location.

5. Results

5.1. Presence / absence

5.1.1. The results of the field surveys are shown in Table 3 below. Photographs for each survey location are provided in Appendix 3.

5.1.2. *V. moulinsiana* was found to be absent from the survey locations.

5.1.3. Two common and widespread species of terrestrial gastropod molluscs were recorded throughout the survey locations: silky snail *Ashfordia granulata* and large amber snail *Succinea putris*.

Table 3 : Results of the presence / absence surveys for V. Moulinsiana *during the 2017 survey visits*

Survey Location	GPS co-ordinates	Visit 1 Presence 08/08/2017	Visit 2 Presence 14/08/2017	Visit 3 Presence 22/08/2017
AQ01	TG 03792 17399	Absent	Absent	Absent
AQ02	TG 03775 17515	Absent	Absent	Absent
AQ03	TG 03814 17615	Absent	Absent	Absent
AQ04	TG 03906 17451	Absent	Absent	Absent
AQ05	TG 03920 17521	Absent	Absent	Absent
AQ06	TG 03890 17652	Absent	Absent	Absent
AQ07	TG 03987 17648	Absent	Absent	Absent
AQ08	TG 04130 17662	Absent	Absent	Absent

5.2. *Environmental variables*

5.2.1. The environmental variables at five survey locations were suitable for *V. moulinsiana*, the exceptions were AQ02, AQ03 and AQ06 which were not solely dominated by suitable vegetation.

5.2.2. The nearest NVC sampling locations (Norfolk Wildlife Services, 2017) to the eight survey locations (AQ01 – 08) have been referenced in the vegetation description column in Table 4.

Table 4 : Environmental variables during the 2017 survey visits. Highlighted rows show sub-optimal environmental variables. Nearest NVC sampling locations have been included as per the NVC report (Norfolk Wildlife Services, 2017).

Survey Location	**Ground moisture**	**Dominant vegetation class**	**Average vegetation height (m)**	**Brief vegetation description (nearest NVC sampling location)**
AQ01	2	2	0.7	Consisting mostly of *Epilobium hirsutum* with some *Phalaris arundinacea* (1A)
AQ02	3	2/3	0.5	Consisting mostly of *Urtica dioica* with some *Epilobium hirsutum*. In-channel vegetation was dominated by *Berula eretca* with frequent *Mentha aquatica* (2A)
AQ03	2	2/3	1	Consisting mostly of *U. dioica* on the east bank. In-channel vegetation had frequent *M. aquatica* and occasional *B. erecta* and *U. dioica* (2B)
AQ04	4	1	1.2	Consisting mostly of *Carex sp.* with *Juncus inflexus* and *M. aquatica* (1C – 1D)
AQ05	3/4	1	1	Consisting mostly of *Carex sp.* with some *Sparganium erectum* (4C)
AQ06	2	2	1	Consisting mostly of *U. dioica* with some *P. arundinacea* and *Fillipendula ulmaria*. In-channel vegetation with frequent *M. aquatica* and *B. erecta* (2C – 2D)
AQ07	3	1	1.5	Consisting mostly of *Glyceria maxima* with some *Iris pseudacoris* and *S. erectum* (2E)
AQ08	2/3	1/2	1	Dominated by *G. maxima* with some *P. arundinacea* (River Wensum)

6. Conclusions

6.1. *V. moulinsiana* is absent from the survey locations.

6.2. Given the presence of *V. moulinsiana* in other reaches of the River Wensum and the suitable habitats present in the survey area, it is possible that a population could become established within the survey area in the future.

6.3. Further survey of location points AQ04, AQ05, AQ07 and AQ08 (as the most suitable locations) are recommended if works take place over three years from the survey date.

6.4. It is recommended to create an additional survey location on the northern bank of the River Wensum and survey for *V. moulinsiana* following the methodology set out in this report.

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Royal HaskoningDHV (2017b) PB4476.003.041 Environmental Impact Assessment Phase 2 Ecological Surveys Scope April 2017 (Document ref. PB4476.003.041)

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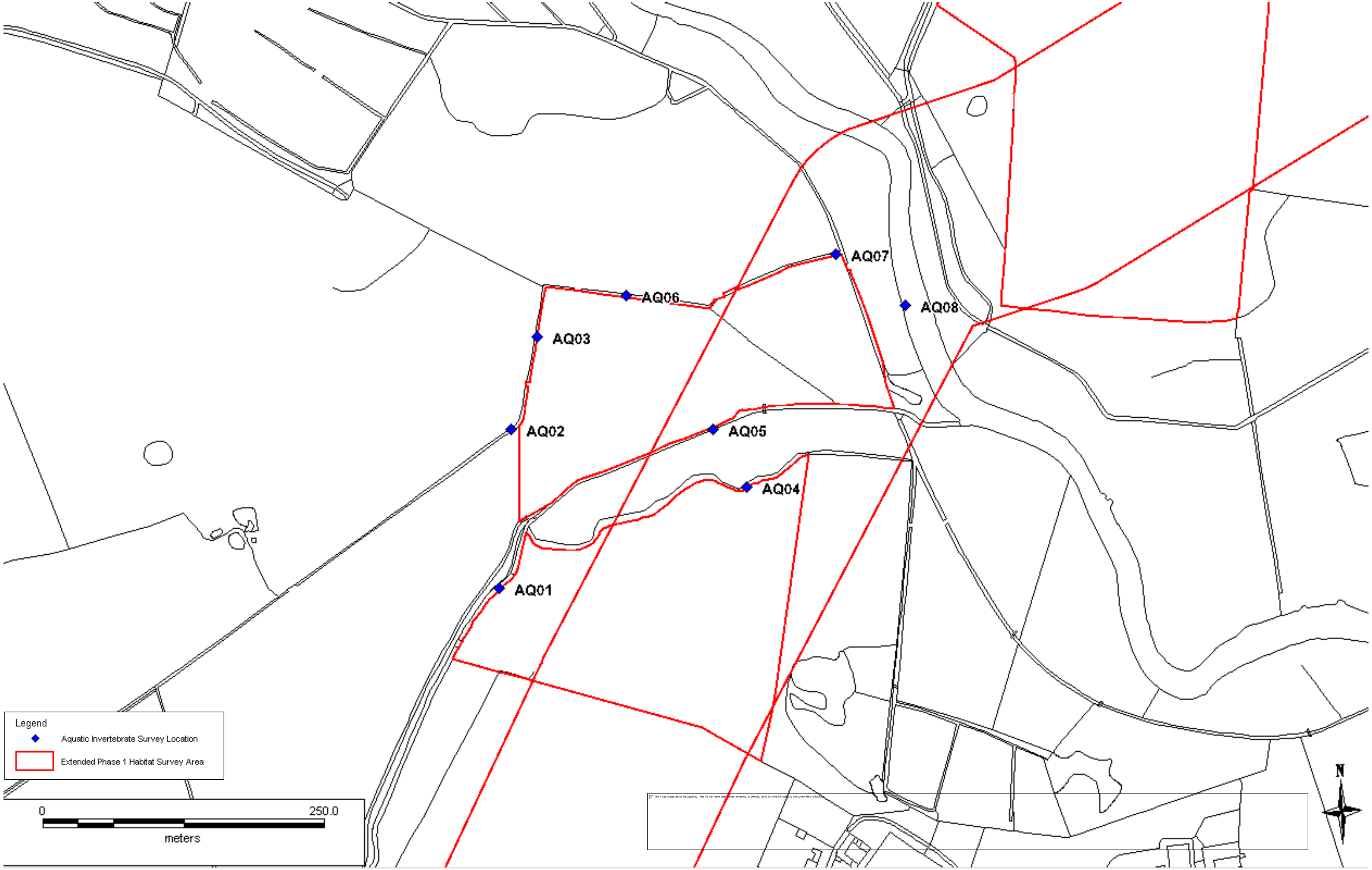
Appendix 1: Survey area

Appendix 2: Survey locations



Appendix 3: Photographs

Figure 1 : AQ01, facing northeast

Figure 2 : AQ02, facing northeast

Figure 3 : AQ03, facing north

Figure 4 : AQ04, facing west

Figure 5 : AQ05, facing southwest

Figure 6 : AQ06, facing east

Figure 7 : AQ07, facing northeast

Figure 8 : AQ08, facing north

Appendix 4: Natural England consent for survey

NATURAL ENGLAND

River Wensum Site of Special Scientific Interest Norfolk ("the SSSI")
River Wensum Special Area of Conservation (SAC)

CONSENT OF NATURAL ENGLAND

Section 28E(3)(a) of the Wildlife and Countryside Act 1981 (as amended and inserted by section 75 and Schedule 9 of the Countryside and Rights of Way Act 2000)
Regulation 21 of the Conservation of Habitats and Species Regulations 2010

To:

Mr Carrick ……………………………………………………

Of:

Castle Farm, Swanton Morley, Dereham, NR20 4JT ……………………………………………………

You have Natural England's consent to carry out, cause or permit to be carried out the operations specified below, on the land specified below.

This consent covers the period to 31st August 2017.

The specified operations:

Aquatic plant and Desmoulin whorl snail surveys ……………………………………………………
…………………………………

Timing of the operations:

24th July 2017 to 31st August 2017 ……………………………………………………

Land on which the operations are to be carried out:

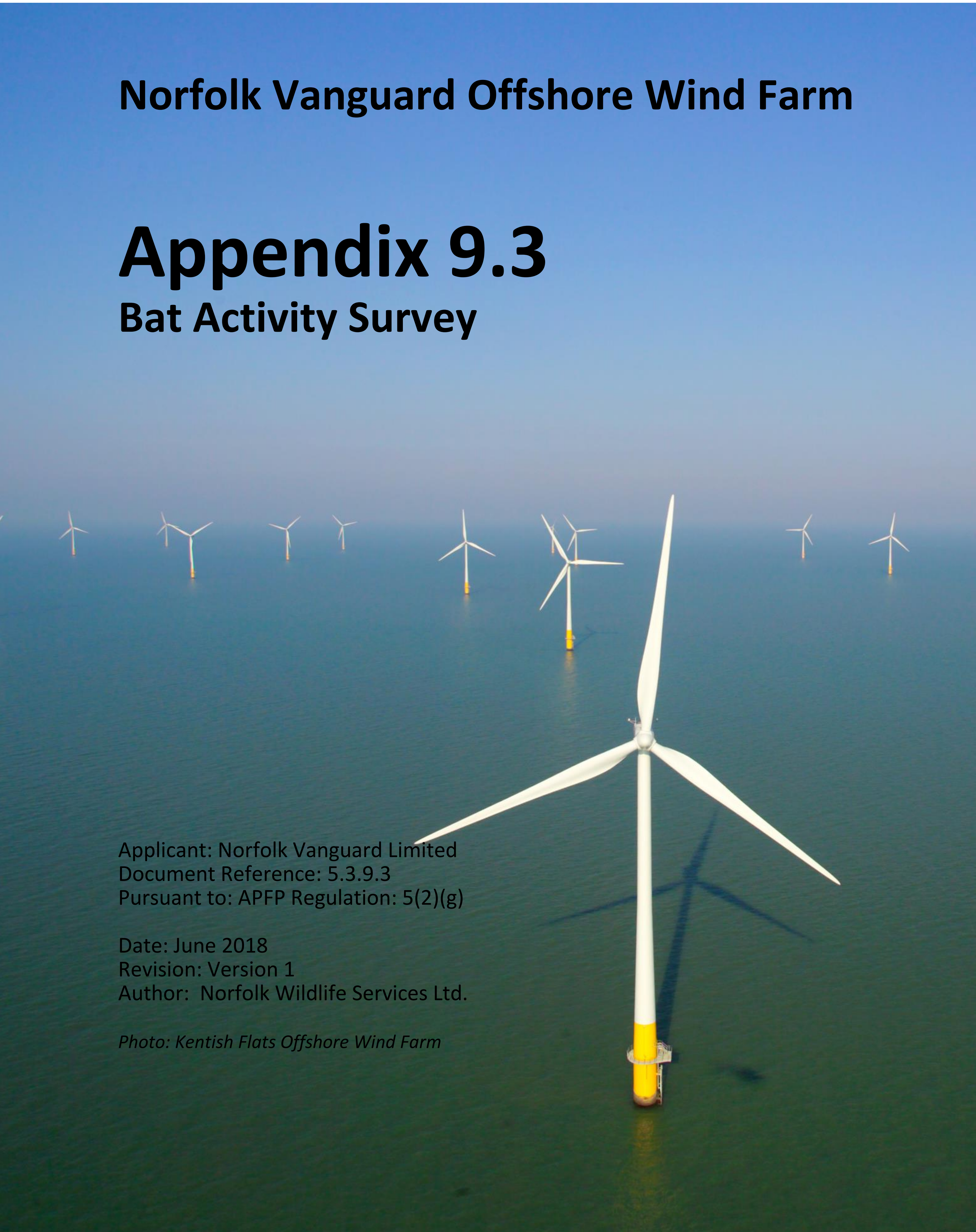
The River Wensum and adjacent land and ditches as shown on the attached maps.

Signed for Natural England: [signature]

Date: **24/07/2017** …………………………………

Norfolk Vanguard Offshore Wind Farm

Appendix 9.3
Bat Activity Survey



Applicant: Norfolk Vanguard Limited
Document Reference: 5.3.9.3
Pursuant to: APFP Regulation: 5(2)(g)

Date: June 2018
Revision: Version 1
Author: Norfolk Wildlife Services Ltd.

Photo: Kentish Flats Offshore Wind Farm

Information for the Habitats Regulations Assessment

Document Reference: 5.3.9.3

June 2018

For and on behalf of Norfolk Vanguard Limited

Approved by: Ruari Lean and Rebecca Sherwood

Signed: [redacted] [redacted]

Date: 8th June 2018

Norfolk Vanguard
Bat activity surveys

Report prepared by Norfolk Wildlife Services Ltd.
on behalf of Royal HaskoningDHV
February 2018

Reference: 2016/131.3

Table of contents

Index of tables

1. Document details

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Version Number	Date	Section(s)	Page(s)	Summary of Changes	Approved by
1	09/11/17	All	All	First draft for client	CS
5	22/12/17	All	All	Second draft for client	CS
6	12/01/18	All	All	Third draft for client	CS
7	08/02/18	All	All	Final report	CS

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2. Executive Summary

2.1. The Norfolk Vanguard Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a) identified 167 linear features as providing “moderate” or “high” suitability to support commuting or foraging bats. Following a review of the linear features data, groupings of these features were made which identified 59 survey locations. For practical purposes of data collection and proportionality, these 59 survey locations were proposed to be surveyed using 25 separate transects.

2.2. The purpose of the surveys was to ascertain, based on transect and static detector surveys, whether bats are commuting or foraging along linear features identified by the Extended Phase 1 Habitat Survey as providing “moderate” or “high” suitability for supporting commuting or foraging bats, and if so, which species and in what numbers.

2.3. The following guidance document was used to inform development of the survey methodology: Bat surveys for professional ecologists: good practice guidelines. Bat Conservation Trust. (Collins (Ed), 2016). A specific protocol is set out in this document and any divergences in practice from this protocol during delivery are noted to allow an assessment of constraints.

2.4. Between May and October 2017, a total of 1839 complete nights of static detection at 68 locations and 184 transects at 27 transect locations were carried out. Recordings were subject to analysis using Kaleidoscope acoustic analysis software, and the results subsequently quality assured[1].

2.5. Bats were recorded on all transects. Evidence of the following species were found within the study area:

Barbastelle	*Barbastella barbastellus*
Serotine	*Eptesicus serotinus*
Myotis aggregate	*Myotis spp*
Daubenton’s	*Myotis daubentonii*
Noctule	*Nyctalus noctula*
Leisler’s bat	*Nyctalus leisleri*
Nathusius’ pipistrelle	*Pipistrellus nathusii*
Common pipistrelle	*Pipistrellus pipistrellus*
Soprano pipistrelle	*Pipistrellus pygmaeus*
Brown long-eared	*Plecotus auritus*

2.6. Of the 27 transects surveyed, evidence of barbastelles was recorded at 22, including transects BACT 4, 5, 8, 9, 10, 13, 14, 16, 17, 18, 19, 20, 21, 22, 24, 26, 28, 30, 31, 32, 33, and 34.

2.7. Summary results, including number of bat passes along key transects for each species, are presented for each locality and additional details are given in a short separate report for each location. Full field survey results and associated static and transect recordings are available.

2.8. No surveys were able to be carried out on any transects in April 2017. Some limited data was available from statics in early May from this spring 2017 period. There is therefore

[1] Quality assurance is ongoing at the time to writing.

a general limitation with lack of survey information during the early spring period for a number of transects surveyed. Nevertheless, these transects are considered to provide valuable data for understanding bat activity levels along the linear features covered by these transects.

2.9. No surveys were carried out on the following transects due to access issues: BACT 1, 2, 6, 7, 11, 12, 23 and 25. Only one survey was carried out at BACT 15 and 35 before access was rescinded. This was considered a significant limitation to being able to assess the suitability of the linear features for supporting commuting or foraging bats on these two transects.

3. Introduction

3.1. Project background

3.1.1. Norfolk Vanguard is a proposed offshore wind farm being developed by Norfolk Vanguard Limited (or an affiliate company), with a capacity of 1800MW, enough to power 1.3 million UK households. The offshore wind farm comprises two distinct areas, Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) and will be connected to the shore by offshore export cables installed within the provisional offshore cable corridor. The project will also require onshore infrastructure in order to connect the offshore wind farm to the National Grid at the existing National Grid substation at Necton, which in summary will comprise the following:

- Landfall;
- Cable relay station (if required);
- Underground cables;
- Onshore substation; and
- Extension to the existing Necton National Grid substation.

3.1.2. The location of the onshore electrical infrastructure is shown on Figure 1, Appendix A: of the Extended Phase 1 Habitat Survey Report (Royal HaskoningDHV, 2017a). Collectively the onshore electrical infrastructure is herein referred to as the 'onshore project area'.

3.1.3. During the development of the project, the onshore Scoping Area that was initially defined has been refined, to include three landfall options, associated cable relay search zones, as well as an onshore substation search zone in proximity to the Necton National Grid substation. A 200m wide cable corridor has been identified within which the buried cable will be located, and Horizontal Directional Drilling (HDD) zones and mobilisation zones have been identified along the cable corridor.

3.1.4. The surveys described within this report were designed and based on the onshore project area which was in use when the project Extended Phase 1 Habitat Survey was undertaken (February 2017). As the project design is further refined, these search zones will decrease in size, and the final options for the siting of infrastructure (i.e. one cable relay station, one landfall, one onshore substation) will be taken forward for the final Development Consent Order (DCO) application in June 2018.

3.2. Aim of report

3.2.1. As Norfolk Vanguard is a Nationally Significant Infrastructure Project (NSIP) an Environmental Impact Assessment (EIA) is required as part of a DCO application under the Planning Act 2008.

3.2.2. Norfolk Wildlife Services were appointed in late April 2017 to undertake additional ecological surveys to support this application as set out within the Survey Scope (Royal HaskoningDHV, 2017b).

3.3. Survey objective

3.3.1. To ascertain, based on transect and static detector surveys, whether bats are commuting or foraging along linear features identified by the Extended Phase 1 Habitat Survey as providing “moderate” or “high” suitability for supporting commuting or foraging bats, which species and in what numbers.

3.4. Survey scope

3.4.1. Development of survey scope

3.4.1.1. An Extended Phase 1 Habitat Survey of the project area was undertaken during February 2017, and reported in Norfolk Vanguard Offshore Wind Farm Extended Phase 1 Habitat Survey Report (Document ref: PB4476-003-040)).

3.4.1.2. The Extended Phase 1 Habitat Survey identified the potential for legally protected species located within the project area plus a 50m buffer surrounding the project area, and provided recommendations for further surveys required to characterise the ecological baseline for the project area.

3.4.1.3. Potential habitat features were identified and evaluated as to their suitability for foraging or commuting bats in the Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a). All those with “medium” or “high” potential were recommended by Royal HaskoningDHV (2017b) for additional surveys.

3.4.1.4. Norfolk Wildlife Services were appointed in late April 2017 to undertake additional ecological surveys to support this application as set out within the Survey Scope (Royal HaskoningDHV 2017b).

3.4.2. Scoping of survey locations

Transects

3.4.2.1. The Extended Phase 1 Habitat Survey (Royal HaskoningDHV, 2017a) identified 167 linear features as providing moderate or high suitability to support commuting or foraging bats. Following a review of the linear features data, groupings of these features were made which identified 59 survey locations.

3.4.2.2. In practice, survey access was not possible for all areas of each survey location. Therefore, for the purposes of data collection the 59 survey locations were proposed to be surveyed as 25 transects, each indexed by a number (BACT1, BACT2, etc.), encompassing as far as possible the groupings of identified linear features and in particular 59 survey locations (Royal HaskoningDHV 2017b).

Statics

3.4.2.3. 59 provisional static detector locations were set out within the Survey Scope (Royal HaskoningDHV, 2017b). These original locations identified potential representative points for groups of linear features and are shown within the maps for the Survey Scope.

3.4.2.4. The 59 identified survey locations were subsequently amended so that static detectors were grouped into the 25 transects areas (BACT1, BACT2) as far as possible, and each static detector location indexed by a number (BA1, BA2, etc.). Three detectors have been used on linear feature networks with at most “high suitability” to support commuting and foraging bats, and two detectors have been used on linear feature networks with at most “moderate suitability” to support commuting and foraging bats.

3.4.2.5. There was a maximum survey effort of 60 static locations proposed, one greater than the 59 static sampling points identified by the Extended Phase 1 Habitat survey.

4. Methodology

4.1. Section 4.1 sets out the proposed survey protocol as agreed between Royal HaskoningDHV and Norfolk Wildlife Services prior to any field work commencing, and Section 4.2 sets out how the surveys were delivered in practice in relation to the protocol and identifies any deviations or modifications that took place during the delivery phase.

4.1. Survey protocol

4.1.1. This Section details the proposed survey protocol as agreed between Royal HaskoningDHV and Norfolk Wildlife Services prior to any field work commencing.

Relevant guidance

4.1.2. The following guidance document was used to inform development of the survey methodology:

Collins, J. (Ed.). (2016). Bat surveys for professional ecologists: good practice guidelines. Third edition. Bat Conservation Trust.

Survey locations

4.1.3. Subsequent to the commencement of contract, a further area located along the Dilham Canal (BACT21) was identified as an additional site which may support commuting and foraging bats and included within the scope of works.

4.1.4. Survey locations are described in the table in Appendix 1: Transect details and descriptions Appendix 2: Static locations descriptions and are presented on maps in Appendix 5: Maps.

Survey methodology

4.1.5. A full technical protocol for the collection of data using SM4s and subsequent analysis is given in Annex 1: Process for auto identification.

Transects

4.1.6. Proposed transect routes will be designed in 25 locations, encompassing as many previously identified static points as possible.

4.1.7. For all habitats scoped into the assessment, bat activity transect surveys will be undertaken.

4.1.8. Transect surveys will involve walking at a constant speed along each linear bat habitat (or the one edge of the two-dimensional bat habitat) recording observations such as number of bats, flight direction, flight height, behaviour, appearance and relative speed. Weather conditions including temperature, wind speed and precipitation, will be recorded at the start and end of each survey visit.

4.1.9. Field observation will be relied upon as the primary method for species identification. Bat detectors will be used to listen to bats during surveys. An SM4 ZC unit with an attached GPS will be used to make a permanent record of the transect.

4.1.10. A field recording set will be retained in the compressed Zero Crossing Analysis (ZCA) format. Laboratory sound-analysis will subsequently be used to identify the calls of any bat species picked up using the bat detectors.

Statics

4.1.11. For all transects identified in the previous section, static detector surveys will be set up in parallel.

4.1.12. These will involve placement of a static detector at locations identified as suitable through judgement of the surveying ecologist whilst on site. SM4 ZC recorders will be deployed in suitable locations separated from stock and other potential hazards. Where an SM4 ZC fails during deployment, the survey will be repeated.

4.1.13. Data from these surveys will be recorded and subject to sound-analysis to identify species and pass numbers following the survey.

Survey timing and weather conditions

Transects

4.1.14. For transects of "moderate" suitability for commuting or foraging bats scoped into the survey, these will be subject to one transect survey visit per month from April to October 2017(eight visits), including one dusk and pre-dawn survey within a 24-hour period.

4.1.15. For localities of "high" suitability for commuting or foraging bats, these will be subject to two survey visits per month from April to October (16 visits), including one dusk and pre-dawn survey within a 24-hour period.

4.1.16. The transect surveys will commence at sunset, and cease a minimum of 2 hours after sunset. Sunset and sunrise times will be standardised using the time and date website: https://www.timeanddate.com/sun/uk/norwich.

4.1.17. Surveys will not be carried out when the temperature is below 10°C at sunset/sunrise, or during heavy rain or strong wind unless justified by the surveying ecologist.

Statics

4.1.18. The surveys will use SM4 ZC static detectors. Deployment of SM4 ZC recorders will follow the user guide[1].

4.1.19. For transects identified as being of moderate habitat for commuting or foraging bats, static bat detector surveys will take place at two locations on five consecutive nights per month between April and October.

4.1.20. For transects identified as being of high suitability for commuting or foraging bats, static bat detector surveys will take place at three locations on five consecutive nights per month between April and October.

4.1.21. Static detector surveys will be programmed to commence 30 minutes before sunset, and cease 30 minutes after sunrise.

4.1.22. Periods of prolonged bad weather will be noted for static detectors.

Equipment

4.1.23. Whilst walking the transect, surveyors will use SM4 ZCA units with an attached GPS as well as their personal bat detectors to listen to any echolocation calls. The make of bat detector used by each surveyor will be recorded.

4.1.24. Wildlife Acoustics Kaleidoscope software will be used for analysis.

Personnel

4.1.25. All surveys will be undertaken by suitably experienced bat surveyors, who will either be members of CIEEM or act according to its code of conduct.

4.1.26. No lone working is permitted, each transect will be undertaken by a single surveyor. An additional safety worker will be present, but will only assist the surveyor (e.g. by note taking).

4.2. *Survey delivery*

4.2.1. The following section details how the work was delivered in relation to the protocol and identifies any deviations or modifications that took place during the delivery phase. The protocol was followed for the emergence surveys as far as possible or reasonable. Variations from this are noted in 4.2.2. Limitations.

4.2.1. Survey methodology as delivered

Survey access

4.2.1.1. Surveys were delivered on a total of 27 transects and 64 static detectors. A further four static detectors were also deployed outside of any established transect, due to changes in transect location (BA05, BA39, BA57 and BA61X).

4.2.1.2. Access to survey sites was on a voluntary basis by landowners and some proposed[2] transect routes could not be surveyed. Furthermore, some landowners withdrew access during the project. Details of access for each transect and any resultant alterations are given in Table 2.

Table 1 : Summary of areas where activity surveys carried out

Transect Habitat Suitability	Number
High	10
Medium	17
TOTAL	**27**

Table 2 : Transects surveys – details of access

Transects #	Habitat Suitability Assessment	Related statics	Details of access	Changes to transect
BACT01	Medium	None	Access not achieved	Replaced with BACT27
BACT02	Low	BA07, BA08	Access not achieved	Withdrawn
BACT03	Medium	BA06, BA69X	Access granted	-
BACT04	High	BA70X, BA71X	Access permission withdrawn by landowner on 24.08.17	No further surveys after that date
BACT05	High	BA10, BA11, BA95X	Access granted	-
BACT06	Medium	BA14, BA15, BA16	Access not achieved	Replaced with BACT28
BACT07	Medium	BA17, BA18, BA19	Access not achieved	Withdrawn
BACT08	Medium	BA20, BA21	Access granted	-
BACT09	High	BA23, BA92X, BA97X	Access granted	-
BACT10	High	BA24, BA72X, BA98X	Access granted	-
BACT11	Medium	BA27, BA28	Access not achieved	Replaced with BACT29
BACT12	Medium	BA29	Access not achieved	Replaced with BACT30
BACT13	Medium	BA73X, BA74X	Access granted	-
BACT14	High	BA63X, BA66X, BA100X	Access granted	-
BACT15	Medium	BA32, BA33	Access permission withdrawn by landowner on 12.06.17	Replaced with BACT31
BACT16	Medium	BA35, BA75	Access granted	-
BACT17	Medium	BA91X, BA37	Access granted	-

[2] Transects proposed within the Royal HaskoningDHV Survey Scope (Royal HaskoningDHV, 2017b)

Transects #	Habitat Suitability Assessment	Related statics	Details of access	Changes to transect
BACT18	Medium	BA43, BA44	Access granted	-
BACT19	Medium	BA55, BA56	Access granted	-
BACT20	High	BA02, BA03, BA04	Access permission withdrawn by landowner on 30.08.17	No further surveys after that date
BACT21	High	BA62X, BA76X, BA106X	Access granted	-
BACT22	High	BA48, BA60X, BA107X	Access granted	-
BACT23	Medium	None	Access not achieved	Withdrawn
BACT24	Medium	BA65X, BA108X	Access permission withdrawn by landowner on 24.08.17	Replaced by BACT34; no further surveys after that date
BACT25	Medium	BA77X, BA78X	Access not achieved	Replaced with BACT28
BACT26	Medium	BA79X, BA08X	Access granted	-
BACT27	Medium	BA81X, BA82X	Access granted	-
BACT28	Medium	BA13, BA111X	Access granted	-
BACT29	Medium	BA25, BA26	Access granted	-
BACT30	Medium	BA64X, BA87X,	Access granted	-
BACT31	High	BA67X, BA68X, BA114X	Access granted	-
BACT32	Medium	BA88X, BA89X	Access granted	-
BACT33	Medium	BA40, BA41	Access granted	-
BACT34	Medium	BA52, BA90X	Access granted	-
BACT35	Medium	BA118X, BA119X	Access permission withdrawn by landowner on 24.08.17	No further surveys after that date

Transects survey effort

4.2.1.3. A summary of survey effort by month is given in Table 3 below.

Table 3 : Transects surveys – dates of surveys by month

Transects #	Habitat Suitability Assessment	April 2017	May 2017	June 2017	July 2017	August 2017	September 2017	October 2017	Total number of surveys
BACT03	Medium	No survey	No survey	No survey	03/07/17; 04/07/17	03/08/17	01/09/17	26/10/17	5
BACT04	High	No survey	No survey	20/06/17; 21/06/17	03/07/17	03/08/17; 14/08/17	No survey	No survey	5
BACT05	High	No survey	25/05/17	12/06/17; 26/06/17	18/07/17	08/08/17; 22/08/17	06/09/17; 19/09/17	03/10/17; 04;10;17; 17;10;17	11
BACT08	Medium	No survey	22/05/17	02/06/17; 12/06/17	11/07/17; 14/07/17	07/08/17	04/09/17; 12/09/17	02/10/17	9
BACT09	High	No survey	10/05/17	13/06/17; 29/06/17	13/07/17; 27/07/17	29/08/17	12/09/17; 26/09/17; 27/09/17	10/10/17; 24/10/17	11
BACT10	High	No survey	10/05/17	No survey	07/07/17; 18/07/17	04/08/17; 25/08/17	22/09/17; 29/09/17	06/10/17; 20/10/17	9
BACT13	Medium	No survey	26/05/17	19/06/17; 21/06/17	No survey	18/08/17; 19/08/17	18/09/17	31/10/17	7
BACT14	High	No survey	No survey	08/06/17; 22/06/17	06/07/17; 27/07/17	10/08/17; 31/08/17	14/09/17; 15/09/17; 28/09/17	12/10/17; 26/10/17	11
BACT 15	Medium	No survey	No survey	07/06/17	No survey	No survey	No survey	No survey	1
BACT16	Medium	No survey	No survey	No survey	04/07/17	02/08/17; 15/08/17	07/09/17	05/10/17; 06/10/17	6
BACT17	Medium	No survey	30/05/17	23/06/17	24/07/17	14/08/17	11/09/17; 12/09/17	09/10/17	7
BACT18	Medium	No survey	24/05/17	01/06/17	12/07/17	16/08/17	20/09/17; 21/09/17	23/10/17	7
BACT19	Medium	No survey	No survey	09/06/17; 25/06/17	05/07/17	16/08/17	06/09/17; 07/09/17	18/10/17	7
BACT20	High	No survey	15/05/17; 30/05/17	26/06/17	12/07/17; 13/07/17; 31/07/17	21/08/17	No survey	No survey	7
BACT21	High	No survey	22/05/17; 31/05/17	19/06/17; 29/06/17	31/07/17	07/08/17; 30/08/17	04/09/17; 18/09/17; 19/09/17	03/10/17; 17/10/17	12
BACT22	High	No survey	22/05/17	15/06/17	No survey	22/08/17; 23/08/17; 29/08/17	12/09/17; 26/09/17	10/10/17; 24/10/17	9
BACT24	Medium	No survey	No survey	07/06/17	No survey	No survey	No survey	No survey	1

Transects #	Habitat Suitability Assessment	April 2017	May 2017	June 2017	July 2017	August 2017	September 2017	October 2017	Total number of surveys
BACT26	Medium	No survey	No survey	20/06/17; 21/06/17	31/07/17	08/08/17	21/09/17	05/10/17	6
BACT27	Medium	No survey	No survey	13/06/17	03/07/17	30/08/17	08/09/17; 09/09/17	13/10/17	6
BACT28	Medium	No survey	No survey	21/06/17; 30/06/17	19/07/17	23/08/17	13/09/17; 14/09/17	11/10/17	7
BACT29	Medium	No survey	No survey	No survey	04/07/17	11/08/17; 30/08/17	04/09/17; 05/09/17	02/10/17	6
BACT30	Medium	No survey	26/05/17	28/06/17	25/07/17	22/08/17	19/09/17; 20/09/17	19/10/17	7
BACT31	High	No survey	No survey	12/06/17; 26/06/17	12/07/17; 26/07/17	23/08/17; 31/08/17	01/09/17; 15/09/17	09/10/17; 25/10/17	10
BACT32	Medium	No survey	No survey	15/06/17	12/07/17	15/08/17; 16/08/17	19/09/17	No survey	5
BACT33	Medium	No survey	No survey	14/06/17	21/07/17	24/08/17; 25/08/17	29/09/17	No survey	5
BACT34	Medium	No survey	No survey	30/06/17	05/07/17;	17/08/17	12/09/17	10/10/17; 11/10/17	6
BACT35	Medium	No survey	No survey	No survey	30/07/17	No survey	No survey	No survey	1

Statics survey effort

4.2.1.4. Full dates for static deployments are given in Appendix 4 : Details of static deployments.

Table 4 : Static surveys –total deployment nights for each transect

Transect location	Total nights deployment on transect for all statics
BACT03	37
BACT04	55
BACT05	88
BACT08	90
BACT09	95
BACT10	92
BACT13	45
BACT14	95
BACT15	10
BACT16	54
BACT17	77
BACT18	68
BACT19	54
BACT20	173
BACT21	106
BACT22	77
BACT24	6
BACT26	48
BACT27	45
BACT28	52
BACT29	52
BACT30	66
BACT31	113
BACT32	64
BACT33	55
BACT34	50
BACT35	18
Unassociated	54
Grand Total	**1839**

4.2.1.5. A summary of survey effort by month is given in the following table. Please note that deployments at end of months may overlap into the following month.

Table 5 : Static surveys –total nights each month deployment per static detector

Transect reference	Static point	May 2017	June 2017	July 2017	August 2017	September 2017	October 2017
BACT03	BA06	0	0	3	4	6	5
BACT03	BA69X	0	0	3	4	6	6
BACT04	BA70X	0	6	4	6	0	0
BACT04	BA71X	0	5	0	14	0	0
BACT04	BA93X	0	2	4	14	0	0
BACT05	BA10	7	11	3	6	4	5
BACT05	BA11	7	7	0	6	7	6
BACT05	BA95X	0	4	0	5	4	6
BACT08	BA20	0	18	13	1	8	9
BACT08	BA21	0	18	6	0	8	9
BACT09	BA23	10	5	9	6	5	7
BACT09	BA92X	0	9	8	6	2	9
BACT09	BA97X	0	0	8	6	0	5
BACT10	BA24	9	0	12	6	5	5
BACT10	BA72X	0	0	11	6	5	5
BACT10	BA98X	0	0	12	6	5	5
BACT13	BA73X	0	4	0	5	7	6
BACT13	BA74X	0	4	0	6	7	6
BACT14	BA100X	0	5	5	6	5	5
BACT14	BA63X	6	5	5	5	5	5
BACT14	BA66X	0	11	10	5	6	6
BACT15	BA32	0	5	0	0	0	0
BACT15	BA33	0	5	0	0	0	0
BACT16	BA35	0	0	6	13	3	5
BACT16	BA75X	0	0	6	14	3	4
BACT17	BA36	8	0	0	0	0	0
BACT17	BA37	8	4	0	0	8	7
BACT17	BA38	8	0	4	0	0	0
BACT17	BA91X	0	4	4	7	8	7

Transect reference	Static point	May 2017	June 2017	July 2017	August 2017	September 2017	October 2017
BACT18	BA43	8	5	5	5	4	6
BACT18	BA44	8	5	5	5	5	7
BACT19	BA55	0	9	6	0	5	5
BACT19	BA56	0	9	6	9	0	5
BACT20	BA02	16	15	5	24	0	0
BACT20	BA03	16	9	13	24	0	0
BACT20	BA04	16	14	4	17	0	0
BACT21	BA106X	0	7	7	7	9	4
BACT21	BA62X	14	7	6	7	14	5
BACT21	BA76X	0	7	0	6	0	6
BACT22	BA107X	0	0	0	3	8	6
BACT22	BA48	7	5	0	6	8	6
BACT22	BA60X	9	0	0	7	6	6
BACT24	BA65X	0	6	0	0	0	0
BACT26	BA79X	0	6	1	8	5	6
BACT26	BA80X	0	6	3	2	5	6
BACT27	BA81X	0	6	4	13	0	5
BACT27	BA82X	0	6	4	2	0	5
BACT28	BA111X	0	5	5	5	5	5
BACT28	BA13	0	6	5	6	5	5
BACT29	BA25	0	0	6	9	7	4
BACT29	BA26	0	0	1	10	8	7
BACT30	BA64X	11	6	4	5	5	5
BACT30	BA87X	0	6	6	7	6	5
BACT31	BA114X	0	4	5	8	5	5
BACT31	BA67X	0	11	5	8	6	8
BACT31	BA68X	0	11	13	6	10	8
BACT32	BA88X	0	8	5	5	6	7
BACT32	BA89X	0	8	5	6	7	7
BACT33	BA40	0	5	5	6	5	7
BACT33	BA41	0	5	5	5	5	7
BACT34	BA52	0	11	6	7	7	0
BACT34	BA90X	0	5	6	3	0	5

Transect reference	Static point	May 2017	June 2017	July 2017	August 2017	September 2017	October 2017
BACT35	BA118X	0	0	0	9	0	0
BACT35	BA119X	0	0	0	9	0	0
External	BA05	21	0	0	0	0	0
External	BA39	8	0	0	0	0	0
External	BA57	0	5	0	0	0	0
External	BA61X	15	5	0	0	0	0

4.2.1.6. No surveys were carried out at the following static points.

Table 6 : Static surveys

Static point	Transect reference	May 2017	June 2017	July 2017	August 2017	September 2017	October 2017
BA01	None	0	0	0	0	0	0
BA09	None	0	0	0	0	0	0
BA12	None	0	0	0	0	0	0
BA30	None	0	0	0	0	0	0
BA31	None	0	0	0	0	0	0
BA45	None	0	0	0	0	0	0
BA46	None	0	0	0	0	0	0
BA47	None	0	0	0	0	0	0
BA49	None	0	0	0	0	0	0
BA50	None	0	0	0	0	0	0
BA51	None	0	0	0	0	0	0
BA59	None	0	0	0	0	0	0

Timing and weather conditions

4.2.1.7. The weather conditions and timings during the surveys are given in the following table. An assessment of any related limitations for each survey can be found in 4.2.2. Limitations.

4.2.1.8. In general, the weather throughout the 2017 survey season was warm and dry with light wind conditions consistent as specified in Survey Protocol as suitable survey conditions, with only occasional surveys being cancelled due to bad weather. Storm Aileen impacted the UK on 12 -13 September 2017 and associated weather effects persisted for a week which impacted on static surveys during this period. Otherwise no extreme weather events were noted.

Personnel and Equipment

4.2.1.9. All surveys were undertaken by experienced bat surveyors, who are listed below in Table 7 below. Surveyors were accompanied by a safety worker on all surveys.

4.2.1.10. Bat surveys were recorded using an SM4, but surveyors also had personal equipment as shown below.

Table 7 : Surveyor experience

Team member	Experience	Memberships	Equipment used
James Allitt	14 years' experience of ecological surveying, including bats	-	Batbox Duet
Karl Charters	20 years' experience in ecological surveying, including bats. Holds a level 1 bat licence	-	Batbox Duet
Ben Christie	5 years' experience in ecological surveying, including bats. Holds a level 1 bat licence	GradCIEEM	Batbox Duet
James Goldsmith	8 years' experience in ecological surveying, including bats. Holds a level 1, 3 and 4 bat licence	-	Echo Meter Touch
Abi Gray	6 years' experience in ecological surveying, including bats. Holds a level 2 bat licence	ACIEEM	Echo Meter EM3
Ben Moore	2 years' experience of ecological surveying, including bats	GradCIEEM	Batbox Duet
Sally McColl	10 years' experience of ecological surveying, including bats	-	Batbox Duet
Carolyn Smith	4 years' experience of ecological surveying, including bats	GradCIEEM	Batbox Duet
Sue Traer	15 years' experience in ecological surveying, including bats. Holds a level 1 bat licence	MCIEEM	Echo Meter Touch
John Worthington-Hill	6 years' experience in ecological surveying, including bats.	-	Batbox Duet
Lisa Treadwell	8 years' experience of ecological surveying, including bats	-	Batbox Duet
Chris Bawler	2 years' experience of ecological surveying, including bats.	-	Batbox Duet

4.2.2. Limitations

4.2.2.1. A summary of the survey limitations encountered for all transects is set out below. Detailed limitations for each survey transect, including any notable limitations which may affect data quality, are set out in Table 9.

Survey timing

4.2.2.2. No surveys were able to be carried out on any transects in April 2017. Some limited data was available from statics in early May from this spring 2017 period. There is therefore a general issue in lack of survey information during the spring period. This may affect results in habitats where there is significant seasonal variation in food supply availability e.g. flood plains and broadleaved woodland.

4.2.2.3. For many transects the length of the proposed transect route took less than two hours to survey in full. For these transects, surveyors visited at different times within the period from 30 minutes before dusk to two hours after dusk to ensure that species which are active early or late were covered. This is not anticipated to affect the quality of the data received.

4.2.2.4. The duration of surveys is given in Appendix 3: Transect survey effort

Weather conditions

4.2.2.5. Weather was calm, dry and mild during October 2017, and early autumn coverage for bats was therefore good where access was available to carry out the surveys. Weather conditions encountered during each survey are provided within Appendix 3.

Survey approach

4.2.2.6. Transects were limited in length by landownership boundaries in relation to features of interest meaning that in general transects were quicker than a two-hour walked duration. Where a circuit substantially exceeded an hour, a second circuit of the route was not made, due to the logistics e.g. taking the total duration to well over 2 hours and the difficulties of interpreting data e.g. where there was uneven coverage between survey visits.

4.2.2.7. Consequently many transects had below two hours of transect walking for bats, although some differences are relatively small. Each transect continued to have 12 two-minutes stopping points. Surveyors were generally present at the transect location for additional periods of time, where:

1. They were awaiting the start time or had to walk to the start point for the survey
2. During or after the transect surveys, whilst deploying the static detectors.

4.2.2.8. This reduced walked effort deviates from the protocol. The duration of individual surveys is given in Appendix 3: Transect survey effort. Practically the differences are not seen as substantial since:

1. The walked transects are backed by substantial static datasets over an extended period
2. The statics are "back-to-back" with the walked transects, so form a logical continuation of them
3. The behavioural observations by surveyors are most powerful at sunset and during twilight when bats are still visible and this coverage remained.

4.2.2.9. No behavioural observations were available for static detector surveys, when deployed following transect surveys, but this was not seen as significant limitation. In practice since all transect surveys continued until complete darkness, surveyors' observations would have been limited to contacts on bat detectors with bats without further details e.g. on their exact locations or direction of flight, etc. In total there were 1839 complete nights of static detection compared to 184 transects. The curtailment of transects is not therefore seen as being a significant constraint on the results, especially with respect to presence/absence of particular species.

4.2.2.10. Statics were deployed by attachment to suitable objects such as trees and could not be placed in the open due to farming operations. The microphones on the statics are affected by surrounding clutter for example trees and buildings, but also the availability of suitable deployment sites means that they cannot be placed in open wetland areas. This is not seen as a major limitation, but may alter relative numbers of tracks.

Data analysis

4.2.2.11. Detectability of bats varies by species and the intensity and loudness of their calls. A classification for this is given within Barataud (2015). In general this is not seen as presenting a limitation to the survey results, but means that numerical results between species are not comparable.

4.2.2.12. It is likely that brown long-eared bat *Plecotus auritus*, which are exceptionally quiet in echolocating, will be significantly underrepresented within the results and may be present at sites where survey results indicate absence. This is a known issue and provide that this caveat is placed on the data, no other significant constraints are envisaged.

Limitations by transect

4.2.2.13. The table below (Table 8) compares the number of survey visits achieved for each transect throughout the year against the recommended number of visits set out in the survey protocol.

4.2.2.14. Table 9 summarises for each transect: Access limitations, including any visibility issues, weather and survey effort limitations for transects and static. It makes a categorical assessment as to whether these limitations significantly affect the quality of the data. Transects highlighted in orange have significant limitations.

Table 8 : Details of specified transect visit effort versus actual survey effort

		SPRING			SUMMER		AUTUMN				
Transects #	**Habitat Suitability Assessment**	**April 2017**	**May 2017**	**June 2017**	**July 2017**	**August 2017**	**September 2017**	**October 2017**	**Total number of surveys**	**Programmed number**	***Variation***
BACT03	Medium	No survey	No survey	No survey	2	1	1	1	5	8	*3*
BACT04	High	No survey	No survey	2	1	2	No survey	No survey	5	15	*10*
BACT05	High	No survey	1	2	1	2	2	3	11	15	*4*
BACT08	Medium	No survey	1	2	2	1	2	1	9	8	*-1*
BACT09	High	No survey	1	2	2	1	3	2	11	15	*4*
BACT10	High	No survey	1	No survey	2	2	2	2	9	15	*6*
BACT13	Medium	No survey	1	2	No survey	2	1	1	7	8	*1*
BACT14	High	No survey	No survey	2	2	2	3	2	11	15	*4*
BACT 15	Medium	No survey	No survey	1	No survey	No survey	No survey	No survey	1	8	*7*
BACT16	Medium	No survey	No survey	No survey	1	2	1	2	6	8	*2*
BACT17	Medium	No survey	1	1	1	1	2	1	7	8	*1*
BACT18	Medium	No survey	1	1	1	1	2	1	7	8	*1*
BACT19	Medium	No survey	No survey	2	1	1	2	1	7	8	*1*
BACT20	High	No survey	2	1	3	1	No survey	No survey	7	15	*8*
BACT21	High	No survey	2	2	1	2	3	2	12	15	*3*
BACT22	High	No survey	1	1	No survey	3	2	2	9	15	*6*
BACT24	Medium	No survey	No survey	1	No survey	No survey	No survey	No survey	1	15	*14*
BACT26	Medium	No survey	No survey	2	1	1	1	1	6	8	*2*

		SPRING			SUMMER		AUTUMN				
Transects #	**Habitat Suitability Assessment**	**April 2017**	**May 2017**	**June 2017**	**July 2017**	**August 2017**	**September 2017**	**October 2017**	**Total number of surveys**	**Programmed number**	***Variation***
BACT27	Medium	No survey	No survey	1	1	1	2	1	6	8	*2*
BACT28	Medium	No survey	No survey	2	1	1	2	1	7	8	*1*
BACT29	Medium	No survey	No survey	No survey	1	2	2	1	6	8	*2*
BACT30	Medium	No survey	1	1	1	1	2	1	7	8	*1*
BACT31	High	No survey	No survey	2	2	2	2	2	10	15	*5*
BACT32	Medium	No survey	No survey	1	1	2	1	No survey	5	8	*3*
BACT33	Medium	No survey	No survey	1	1	2	1	No survey	5	8	*3*
BACT34	Medium	No survey	No survey	1	1	1	1	2	6	8	*2*
BACT35	Medium	No survey	No survey	No survey	1	No survey	No survey	No survey	1	8	*7*

Table 9 : Survey limitations – combined static and manual surveys

Survey Location	Habitat Suitability Assessment	Access limitations, including any visibility issues	Weather limitations	Survey effort – Transect Static	Limitation to survey results
BACT01		N/A	N/A	N/A	**Significant impact**. Unable to assess any potential bat activity.
				N/A	
BACT02		N/A	N/A	N/A	**Significant impact**. Unable to assess any potential bat activity.
				N/A	
BACT03	Medium	None	None	No survey in April, May or June 2017	**Moderate impact.** Limited data regarding bat activity early in the season.
				No survey in April, May 2017; Statics deployed for less than 10 days in July and August 2017	
BACT04	High	Access permission withdrawn by landowner on 24.08.17	03/08/17 – Wind BWS4; 14/08/17 – Rain at start	No surveys in April, May, September or October 2017; Only 1 survey in July 2017; Two surveys not carried out within 24hour period	**Moderate impact.** Limited data regarding bat activity early or late in the season.
				No surveys April, May, September or October 2017; Statics deployed for less than 15 days in June and July 2017	
BACT05	High	None	10/05/17 – Starting temperature less than 10°C; 08/08/17 – Heavy rain for last 30minutes of survey	No survey in April 2017; Only 1 survey in May and July 2017.	**No impact.** Sufficient survey data to indicate bat activity.
				No surveys in April, May 2017	
BACT06		N/A	N/A	N/A	**Significant impact**. Unable to assess any potential bat activity.
				N/A	
BACT07		N/A	N/A	N/A	**Significant impact**. Unable to assess any potential bat activity.
				N/A	

Survey Location	Habitat Suitability Assessment	Access limitations, including any visibility issues	Weather limitations	Survey effort – Transect Static	Limitation to survey results
BACT08	Medium	None	None	No survey in April 2017 ; Two surveys not carried out within 24hour period No survey in April or May 2017; Statics deployed for less than 10 days in August 2017	**No impact.** Sufficient survey data to indicate bat activity.
BACT09	High	None	29/08/17 and 12/09/17 – Wind BWS4	No survey in April 2017; Only 1 survey carried out in May and August 2017 No survey April 2017; Statics deployed for less than 15 days in May, June and September 2017	**No impact.** Sufficient survey data to indicate bat activity.
BACT10	High	None	None	No survey in April or June 2017; Only 1 survey carried out in May 2017; Two surveys not carried out within 24hour period No survey in April or June 2017; Statics deployed for less than 15 days in May 2017	**No impact.** Sufficient survey data to indicate bat activity.
BACT11		N/A	N/A	N/A N/A	**Significant impact**. Unable to assess any potential bat activity.
BACT12		N/A	N/A	N/A N/A	**Significant impact**. Unable to assess any potential bat activity.
BACT13	Medium	None	None	No survey in April or July 2017 No survey in April, May or July 2017; Statics deployed for less than 10 days in June 2017	**No impact.** Sufficient survey data to indicate bat activity.
BACT14	High	None	15/09/17 - Starting temperature less than 10°C; 27/07/17 – rain preceding survey; 14/09/17 – rain for last 10 minutes of survey	No survey in April or May 2017 No survey in April 2017; Statics deployed for less than 15 days in May 2017	**No impact.** Sufficient survey data to indicate bat activity.
BACT15	Medium	Access permission withdrawn by landowner on 12.06.17	N/A	N/A	**Significant impact**. Limited data regarding bat activity at the site.

Survey Location	Habitat Suitability Assessment	Access limitations, including any visibility issues	Weather limitations	Survey effort – Transect Static	Limitation to survey results
				No surveys in April, May or July-October 2017	
BACT16	Medium	None	07/09/17 - Rain	No surveys in April, May or June 2017	**Moderate impact.** Limited data regarding bat activity early in the season.
				No surveys in April-June 2017; Statics deployed for less than 10 days in September and October 2017	
BACT17	Medium	None	11/09/17 – Wind BWS4; 24/07/17 – Heavy drizzle before survey and for last hour	No survey in April 2017	**No impact.** Sufficient survey data to indicate bat activity.
				No survey in April 2017; Statics deployed for less than 10 days in June-August 2017	
BACT18	Medium	None	None	No survey in April 2017	**No impact.** Sufficient survey data to indicate bat activity.
				No survey in April 2017; Statics deployed for less than 10 days in September 2017	
BACT19	Medium	None	18/10/17 – Wind BWS4	No surveys in April or May 2017	**Moderate impact.** Limited data regarding bat activity early in the season.
				No surveys in April or May 2017; Statics deployed for less than 10 days in August and September 2017	
BACT20	High	Access permission withdrawn by landowner on 30.08.17	15/05/17 – Wind BWS4	No surveys in April, September or October 2017	**Moderate impact.** Limited data regarding bat activity late in the season.
				No surveys in April, September or October 2017	
BACT21	High	None	None	No survey in April 2017; Only 1 survey in July 2017	**No impact.** Sufficient survey data to indicate bat activity.
				No survey in April 2017; Statics deployed for less than 15 days in May 2017	
BACT22	High	None	None	No surveys in April or July 2017; Only 1 survey in May and June 2017	**No impact.** Sufficient survey data to indicate bat activity.
				No surveys in April or July 2017; Statics deployed for less than 15 days in June 2017	

Survey Location	Habitat Suitability Assessment	Access limitations, including any visibility issues	Weather limitations	Survey effort – Transect Static	Limitation to survey results
BACT23		N/A	N/A	N/A N/A	**Significant impact**. Unable to assess any potential bat activity.
BACT24	Medium	Access permission withdrawn by landowner on 24.08.17	None	No surveys in April- May or July-October 2017; Two surveys not carried out within 24hour period No survey in April, May or July-October 2017; Statics deployed for less than 15 days in June 2017	**Moderate impact.** Limited data regarding bat activity mid and late in the season.
BACT25		N/A	N/A	N/A N/A	**Significant impact**. Unable to assess any potential bat activity.
BACT26	Medium	None	08/08/17 – Rain for last hour of survey; 05/10/17 – Rain showers	No surveys in April or May 2017 No surveys in April or May 2017; Statics deployed for less than 10 days in July 2017	**Moderate impact.** Limited data regarding bat activity early in the season.
BACT27	Medium	None	None	No surveys in April or May 2017 No surveys in April, May or September 2017; Statics deployed for less than 10 days in July 2017	**Moderate impact.** Limited data regarding bat activity mid and late in the season.
BACT28	Medium	None	14/09/17 - Starting temperature less than 10°C	No surveys in April or May 2017 No surveys in April or May 2017	**Moderate impact.** Limited data regarding bat activity early in the season.
BACT29	Medium	None	02/10/17 – Wind BWS4	No surveys in April or May 2017 No surveys in April or May 2017; Statics deployed for less than 10 days in July 2017	**Moderate impact.** Limited data regarding bat activity early in the season.
BACT30	Medium	None	20/09/17 - Starting temperature less than 10°C	No survey in April 2017	**No impact.** Sufficient survey data to indicate bat activity.

Survey Location	Habitat Suitability Assessment	Access limitations, including any visibility issues	Weather limitations	Survey effort – <u>Transect</u> Static	Limitation to survey results
				No survey in April 2017	
BACT31	High	None	None	No surveys in April or May 2017; Two surveys not carried out within 24hour period	**Moderate impact.** Limited data regarding bat activity early in the season.
				No surveys in April or May 2017	
BACT32	Medium	None	None	No surveys in April, May or October 2017	**Moderate impact.** Limited data regarding bat activity early in the season.
				No surveys in April or May 2017	
BACT33	Medium	None	None	No surveys in April, May or October 2017	**Moderate impact.** Limited data regarding bat activity early in the season.
				No surveys in April or May 2017	
BACT34	Medium	None	30/06/07 and 10/10/17 – Wind BWS4; 12/09/17 – Rain mid survey for 5 minutes	No surveys in April or May 2017	**Moderate impact.** Limited data regarding bat activity early in the season.
				No surveys in April or May 2017; Statics deployed for less than 10 days in September and October 2017	
BACT35	Medium	Access permission withdrawn by landowner on 24.08.17	None	No surveys in April-June or August-October 2017; Two surveys not carried out within 24hour period	**Significant impact**. Limited data regarding bat activity at the site.
				No surveys in April-June or August-October 2017	
BA05	N/A	None	None	21 days in May 2017 only	**Significant impact**. Limited data regarding bat activity at the site but may be of value.
BA39	N/A	None	None	8 days in May 2017 only	**Significant impact**. Limited data regarding bat activity at the site but may be of value.
BA57	N/A	None	None	5 days in June 2017 only	**Significant impact**. Limited data regarding bat activity at the site but may be of value.

Survey Location	Habitat Suitability Assessment	Access limitations, including any visibility issues	Weather limitations	Survey effort – Transect Static	Limitation to survey results
BA61X	N/A	None	None	15 days in May 2017; 5 days June 2017	**Significant impact**. Limited data regarding bat activity at the site but may be of value.

5. Results

5.1. A description of each site can be found in Appendix 1: Transect details and descriptions.

5.2. Summary results for each transect are given in Table 11 : Summary of results for each transect below.

5.3. Full results are provided in the standalone 'Transect Summary' documents provided alongside this report.

Table 10 : Explanation of species, status and categories in results

Species	Latin	Code	Notes[3]	UK status[4]
Barbastelle	*Barbastella barbastellus*	BARBAR	Sec 41; Annx II; IUCN NT	Rare
Serotine	*Eptesicus serotinus*	EPTSER	IUCN LT	Uncommon, largely restricted to south
Large bat	*Not applicable*	LARGEBAT	Bat calls with FME<30kHz, but not identifiable further	Not applicable
Myotis aggregate	*Myotis spp*	MYOSPP	Aggregated; sometimes identifiable in field	Various
Daubenton's	*Myotis daubentonii*	MYODAU	IUCN LT; Identifiable by behavior when foraging over water bodies	Common
Noise	*Not applicable*	NOISE	Noise includes non-bat sounds, ambient sounds and any track <3 pulses	Not applicable
Noctule	*Nyctalus noctula*	NYCNOC	Sec 41; IUCN LT;	Uncommon
Leisler's bat	*Nyctalus leisleri*	NYCLEI	IUCN LT; confirmed potential calls from statics	Uncommon in GB although may be under recorded, common in Ireland
Other	*Not applicable*	OTHER	All bats not identifiable to another level; any non-identifiable potential social calls	Not applicable
Nathusius' pipistrelle	*Pipistrellus nathusii*	PIPNAT	IUCN LT;	Uncommon but widespread, may be under recorded
Common pipistrelle	*Pipistrellus pipistrellus*	PIPPIP	IUCN LT;	Common
Soprano pipistrelle	*Pipistrellus pygmaeus*	PIPPYG	Sec 41'; IUCN LT;	Common
Brown long-eared	*Plecotus auritus*	PLEAUR	Sec 41; IUCN LT; low detectability	Common

Abbreviations

*IUCN categories: LC is Least Concern, NT is Near Threatened, DD is Data deficient; see www.iucnredlist.org for more details.

Sec 41 : Section 41 species of principal importance; often referred to as BAP species.

Annx II : Annex II of European Habitats Directive; all bats are protected under Annex IV.

[3] Source : Bat Conservation Trust (2016) Table of legal and conservation status of UK bat species. www.bats.org.uk/publications.../Table_of_legal_and_conserv_status_of_UK_bats.pdf

[4] Source : Bat Conservation Trust (2014) The state of the UK's bats 2014 National Bat Monitoring Programme Population Trends http://www.bats.org.uk/pages/nbmp.html

Table 11 : Summary of results for each transect

Transect	Habitat suitability assessment	Associated species	Species present		Key habitats and features for bats	Additional notes on bat activity
			Identified by transects	Identified by statics		
BACT01	N/A	N/A	✘	✘	N/A	N/A
BACT02	N/A	N/A	✘	✘	N/A	N/A
BACT03	Medium	NYCNOC*, PIPNAT*, PIPPIP, PIPPYG, PIPSPP*, PLEAUR*	✓	✓	The tree line around the lodge in the centre north of the transect was a good commuting route for bats. The hedgerow along the southern boundary with the road provided good commuting links. The eastern boundary of the transect was good foraging habitat.	N/A
BACT04	High	BARBAR*, EPTSER*, LARGEBATSPP*, MYOSPP*, NYCNOC*, PIPNAT*, PIPPIP, PIPPYG, PIPSPP PLEAUR*	✓	✓	The tree belt was an excellent commuting and foraging route. The pond was used by foraging bats. Common and soprano pipistrelles were only recorded between walk 5 and stop 12. Even on the dawn where the transect was reversed and started at stop 12 bats were only recorded up until walk 5.	Occasional barbastelles recorded to the north of the transect at BA70X.
BACT05	High	BARBAR*, EPTSER*, LARGEBATSPP*, MYOSPP*, NYCLEI*, NYCNOC*, PIPNAT*, PIPPIP, PIPPYG, PIPSPP PLEAUR*	✓	✓	Key commuting features were hedgerows along field boundaries and the minor road. There were no major breaks in commutable habitat throughout the transect route, with largely intact hedgerows between woodlands. Key foraging habitat was evident within the western section between Walk 1 and Stop 5 and between Walk 8 and Stop 10 in the eastern section.	Barbastelles recorded by statics at the eastern and western areas on the transect at BA11 and BA95X.
BACT06	N/A	N/A	✘	✘	N/A	N/A
BACT07	N/A	N/A	✘	✘	N/A	N/A

Transect	Habitat suitability assessment	Associated species	Species present		Key habitats and features for bats	Additional notes on bat activity
			Identified by transects	Identified by statics		
BACT08	Medium	BARBAR*, EPTSER*, MYOSPP, NYCNOC, PIPPIP, PIPPYG, PLEAUR*	✓	✓	The hedgerows provide good commuting routes with the woodlands providing good connecting habitat. The area of wet grassland to the north provides good foraging habitat	Barbastelles recorded by static detector along the eastern boundary of the transect.
BACT09	High	BARBAR*, MYOSPP, NYCLEI*, NYCNOC, PIPNAT*, PIPPIP, PIPPYG	✓	✓	Along the north small tree lined stream runs E-W and adjoins the nearby river Wensum. This stream and tree line also connects to the west of the transect where there is a strip of deciduous woodland. The woodland running along the western edge of the transect provides a good foraging route.	Barbastelles foraging along the northern edge of the transect above tree lined stream.
BACT10	High	BARBAR*, EPTSER*, MYOSPP, NYCNOC, PIPNAT*, PIPPIP, PIPPYG	✓	✓	River Wensum provides a high quality commuting and foraging route, most notably Daubentons. Hedgerow through the centre of the site also follows drainage ditches and along its length includes large oak standards. A cut channel runs parallel to the river is wider and more open than the other drainage ditches, a key corridor feature for pipistrelles.	Barbastelles recorded along the north-western corner along native species rich hedgerow.
BACT11	N/A	N/A	✗	✗	N/A	N/A
BACT12	N/A	N/A	✗	✗	N/A	N/A
BACT13	Medium	BARBAR*, LARGEBATSPP NYNOC, MYOSPP*, PIPPIP, PIPPYG, PIPSPP	✓	✓	The Marriott's way is an excellent commuting route connecting woodlands to the east at Reepham to wet grassland areas in the west.	Single barbastelle pass recorded by transect detector.

Transect	Habitat suitability assessment	Associated species	Species present		Key habitats and features for bats	Additional notes on bat activity
			Identified by transects	Identified by statics		
BACT14	High	BARBAR*, EPTSER*, NYNOC, MYOSPP*, PIPPIP, PIPPYG, PLEAUR*	✓	✓	Northern section parallel to the road, less favourable to bats with only commuting Noctules registering. Mixed native species along the southern boundary - good linking habitat from East (deciduous woodland) to the West boundary (wet deciduous woodland). Marriott's way (runs east to West to the south of the site) excellent commuting route, which connects other nearby patches of woodland.	Barbastelles frequently recorded along the south and western edges of the transect.
BACT15	Medium	EPTSER*, NYCNOC*, PIPNAT*, PIPPIP, PIPPYG, PLEAUR*	✓	✓	The woodland strip has good connectivity with the wider landscape through adjoining hedgerows which further link to other nearby woodland patches. The woodland and wet grassland to the SW of the transect provide excellent foraging and commuting habitat for bats.	N/A
BACT16	Medium	BARBAR*, EPTSER*, LARGEBATSPP, MYOSPP*, NYCLEI, NYCNOC, PIPNAT*, PIPPIP, PIPPYG, PIPSPP, PLEAUR*	✓	✓	The hedgerows along the western edge of the transect provided a commuting and foraging route for both common and soprano pipistrelles.	Occasional barbastelles records across the transect being recorded at both statics.

Transect	Habitat suitability assessment	Associated species	Species present		Key habitats and features for bats	Additional notes on bat activity
			Identified by transects	Identified by statics		
BACT17	Medium	BARBAR*, EPTSER*, LARGEBATSPP, MYOSPP*, NYCLEI*, NYCNOC, PIPNAT*, PIPPIP, PIPPYG, PIPSPP*, PLEAUR	✓	✓	Colby Road was a good commuting route. The hedgerow which runs south from stop point three was another commuting route with bats recorded commuting south into the transect area. The south-western field margins were key foraging areas for common and soprano pipistrelles.	Occasional barbastelles records across the transect being recorded at both statics.
BACT18	Medium	BARBAR*, EPTSER*, LARGEBATSPP, MYOSPP*, NYCNOC, PIPNAT*, PIPPIP, PIPPYG, PLEAUR*	✓	✓	The pond was a key foraging area for common pipistrelles. Lyngate Road (along the southern boundary of the transect) was noted as a key foraging route, as was the northern boundary for common and soprano pipistrelle.	Within 10km of Paston SAC. Barbastelle activity recorded by BA43 along Lyngate Road to the west of the transect.
BACT19	Medium	BARBAR*, EPTSER*, LARGEBATSPP, MYOSPP*, NYCNOC, PIPNAT, PIPPIP, PIPPYG, PIPSPP	✓	✓	Key foraging area for bats, road and hedgerow to the west of the transect	Within 10km of Paston SAC. Scarce records on BA55, north-west area
BACT20	High	BARBAR*, EPTSER*, LARGEBATSPP*, MYOSPP*, NYCNOC, PIPNAT*, PIPPIP, PIPPYG, PIPSPP*, PLEAUR*	✓	✓	Features for commuting and foraging bats were largely restricted to arable hedgerows with field margins. There were two small areas of woodland suitable for foraging bats.	Active on the transect, recorded on static detectors BA03 and BA04.

Transect	Habitat suitability assessment	Associated species	Species present		Key habitats and features for bats	Additional notes on bat activity
			Identified by transects	Identified by statics		
BACT21	High	BARBAR*, LARGEBATSPP, MYOSPP*, NYCNOC, PIPNAT, PIPPIP, PIPPYG	✓	✓	Noctules were often seen commuting from the south-west of the transect from an area of wet grassland with scattered standards. Common and soprano pipistrelles were frequently seen foraging above Hall Lane. Species of *Myotis* bats were recorded foraging along the North Walsham and Dilham Canal. Common and soprano pipistrelles were frequently seen and recorded foraging along the northern most edge of the arable field.	Within 10km of Paston SAC. Recorded between June and August, adjacent to the water treatment plant.
BACT22	High	BARBAR, EPTSER, LARGEBATSPP, MYOSPP, NYCNOC, PIPNAT, PIPPIP, PIPPYG	✓	✓	Excellent woodland habitat connecting to foraging areas within Witton Heath and beyond to the North Walsham and Dilham Canal. The western edge adjacent to the woodland was a key foraging and commuting route for bats. The road along the southern edge was a good foraging route for common pipistrelles	Within 10km of Paston SAC. Across the transect at all static detector locations. Foraging along the north-western and western woodland edges.
BACT23	N/A	N/A	✗	✗	N/A	N/A
BACT24	Medium	BARBAR*, EPTSER*, LARGEBATSPP, NYCNOC, PIPNAT*, PIPPIP, PIPPYG*,	✓	✓	Munn's Track foraging corridor for pipistrelle bats. Common pipistrelles foraged above alder lined drainages ditches within the grassland to the north.	Within 10km of Paston SAC. Limited data. Single barbastelle pass at BA65X on western edge by wood.
BACT25	N/A	N/A	✗	✗	N/A	N/A

Transect	Habitat suitability assessment	Associated species	Species present		Key habitats and features for bats	Additional notes on bat activity
			Identified by transects	Identified by statics		
BACT26	Medium	BARBAR*, EPTSER*, LARGEBATSPP*, MYOSPP*, NYCLEI*, NYCNOC*, PIPNAT*, PIPPIP, PIPPYG, PIPSPP*, PLEAUR*	✓	✓	Pipistrelle foraging activity is high to the south of the transect at stop ten where the road joins the field. The western hedgerow is an important foraging and commuting route for bats.	One barbastelle recording on static detector BA80X.
BACT27	Medium	LARGEBATSPP*, MYOSPP*, NYCLEI*, NYCNOC*, PIPNAT*, PIPPIP, PIPPYG, PIPSPP*, PLEAUR*	✓	✓	Hedgerows to the south and west of the site provided important foraging and commuting habitat for bats, including the woodland areas to the north east and south east. The oak tree near to stop 7 was an important foraging area for bats.	N/A
BACT28	Medium	BARBAR*, EPTSER*, LARGEBATSPP, MYOSPP*, NYCNOC*, PIPNAT*, PIPPIP, PIPPYG, PIPSPP*, PLEAUR*	✓	✓	The eastern and western hedgerows provided good commuting and foraging habitat for bats. The southern edge also provided opportunities for bats to forage along.	Solitary barbastelle calls across the summer
BACT29	Medium	EPTSER*, LARGEBATSPP, MYOSPP, NYCLEI, NYCNOC, PIPNAT*, PIPPIP, PIPPYG, PIPSPP, PLEAUR*	✓	✓	The western hedgerow has good connectivity within the wider landscape with other linear features and patches of deciduous woodland. The stream which runs along the north also has good links to other nearby linear features and joins to a large patch of woodland to the NW of the transect.	N/A

Transect	Habitat suitability assessment	Associated species	Species present		Key habitats and features for bats	Additional notes on bat activity
			Identified by transects	Identified by statics		
BACT30	Medium	BARBAR*, EPTSER, NYCLEI*, MYOSPP, NYCNOC, PIPNAT, PIPPIP, PIPPYG, PIPSPP, PLEAUR*	✓	✓	Along the northern section of the transect is an optimal commuting and foraging habitat for bats. Due to the nature of its design, the old tree lined railway embankments provide cover from the weather for bats. The south-western and western lengths of the transect also provide good foraging habitat for bats.	Occasional barbastelle records on both static detectors.
BACT31	High	BARBAR*, EPTSER*, LARGEBATSPP*, MYOSPP*, NYCNOC*, PIPNAT*, PIPPIP, PIPPYG,PIPSPP, PLEAUR*	✓	✓	The River Bure which borders the transect from the north border all the way around to the eastern border provides an excellent foraging and commuting route for bats due to its linear characteristics and bankside tree line. The river is of particular interest for foraging Daubenton's which appear to forage most in areas where the river is widest due to cattle poaching. The short section along the south-western edge bordering the small patch of mature deciduous woodland proved excellent foraging ground for Pipistrelles. The low lying wet grassland contained abundant scattered dead (and living) trees with plenty of roost features for bats, although none were spotted entering or leaving. Centrally, an established, native, species-rich hedge bordered the arable field, and was favored by bats as both a commuting and foraging route.	Solitary barbastelle calls across the summer

Transect	Habitat suitability assessment	Associated species	Species present		Key habitats and features for bats	Additional notes on bat activity
			Identified by transects	Identified by statics		
BACT32	Medium	BARBAR*, EPTSER*, LARGEBATSPP*, MYOSPP*, NYCLEI, NYCNOC*, PIPNAT*, PIPPIP, PIPSPP, PIPPYG,	✓	✓	The tree belt along the north and western boundary provides a linear feature and shelters from winds from the south to the north east. The road through the tree belt at the north of the transect creates a tunnel effect and a high proportion of activity was recorded. The site has good connectivity with the extended landscape.	Barbastelle activity across the transect, recorded on all statics and during transect visits.
BACT33	Medium	BARBAR*, EPTSER, LARGEBATSPP*, MYOSPP*, NYCLEI, NYCNOC*, PIPNAT, PIPPIP, PIPPYG, PIPSPP	✓	✓	The section of road along the north west of the transect (between stop eight and nine) was well sheltered by mature poplar trees and was a particularly popular foraging route. The hedgerows surrounding the transect provided foraging routes for pipistrelles. From the east of the site (continuing from walk three) a mature tree line extends southwards and adjoins a woodland which has further linear features running into the wider landscape. BACT33 is situated within 10km of Paston Great Barn.	Recorded across the transect but only a single pass on each static detector.
BACT34	Medium	BARBAR*, EPTSER*, LARGEBATSPP, MYOSPP*, NYCNOC, PIPNAT, PIPPIP, PIPPYG, PIPSPP, PLEAUR*	✓	✓	The key area for commuting and foraging bats was the western track with hedgerows either side. Intense use by common pipistrelles during some static deployments	Barbastelles recorded in the northwestern corner of the transect.

Transect	Habitat suitability assessment	Associated species	Species present		Key habitats and features for bats	Additional notes on bat activity
			Identified by transects	Identified by statics		
BACT35	Medium	LARGEBATSPP*, NYCNOC*, PIPPIP*, PIPPYG*, PIPSPP*	✓	✓	Hedgerows are good connecting features between the two woodlands at either end of the transect and foraging areas beyond. The north-western woodland has a ditch running along the eastern boundary and a small pond at the north-western end.	N/A

* - indicates limited or only possible records

6. References

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Appendix 1: Transect details and descriptions

Transect reference	OS grid references	Habitat Suitability Assessment	Description of transect context
BACT03	TF944124	Medium	Arable with minor road, Dale Road, splitting the eastern and western areas.
BACT04	TF916108	High	Arable with blocks of mixed woodland; small stream.
BACT05	TF970148	High	Mosaic of agricultural land, lowland deciduous woodland and lowland fen. Minor river valley at Dillington
BACT08	TG033166	Medium	Within river valley . Mixture of grassland and arable fields, bordered by hedgerows on all sides.
BACT09	TG038172	High	Within river valley. Arable at south; northern end wet grassland used for grazing by cattle.
BACT10	TG038176	High	Within river valley and the eastern and north-eastern bordered by the River Wensum.
BACT13	TG079236	Medium	A linear transect along the Marriots Way which is decommissioned railway line with grassland, tree and scrub mosaic and adjacent arable land.
BACT14	TG119240	High	Forestry plantation for Christmas trees of varied age with acid grassland patches and adjacent woodland and nearby minor river valley and Marriots Way
BACT15	TG203288	Medium	Arable land with bordering hedgerows and a small strip of woodland within the centre of the transect.
BACT16	TG212293	Medium	Arable land bordered by roads on the southern and northern edge with a main road, the A140 to the west.
BACT17	TG223304	Medium	Arable land, excluding the Western most field which was used for cattle grazing
BACT18	TG273317	Medium	Mainly arable land
BACT19	TG369304	Medium	Mainly arable land
BACT20	TF904104	High	Dominated by arable fields with hedgerows; links between large blocks of adjacent woodland
BACT21	TG295316	High	Adjacent land includes deciduous woodland and rough grassland; adjacent to Dilham Canal and river valley; Pigneys Wood nearby
BACT22	TG323313	High	Following field boundaries on two arable fields. Extensive woodlands of Witton Hall and Bacton Woods surround transect
BACT24	TG356303	Medium	Mainly arable land, with a track and double hedgerow running along the eastern section of the transect
BACT26	TF947132	Medium	Mainly arable land; small stream on parts
BACT27	TF955144	Medium	Network of arable fields with tall mixed native hedgerows with tree standards
BACT28	TF986154	Medium	Single arable field with continuous hedgerows along most boundaries.
BACT29	TG062203	Medium	Mainly arable land as was surrounding areas
BACT30	TG074228	Medium	Mainly arable land as was surrounding areas

Transect reference	OS grid references	Habitat Suitability Assessment	Description of transect context
BACT31	TG196288	High	At south-west along two lengths of an arable field ; adjacent patch of mature deciduous woodland to the west. River bure, Blickling estate
BACT32	TG167269	Medium	Mainly arable fields with pockets of planted woodland.
BACT33	TG237304	Medium	Mainly arable land as was surrounding areas
BACT34	TG360302	Medium	Mainly arable land, with a track and double hedgerow running along the western section of the transect; small stream
BACT35	TF917102	Medium	Mixture of arable land, adjacent blocks of broadleaved woodland and conifer plantation.

Appendix 2: Static locations descriptions

Transect	BA point	Grid reference	Static position
BACT03	BA06	TF 94050 12417	Mature Ash Tree at the end of hedgerow.
BACT03	BA69X	TF 94800 12503	Mature Oak standard, between two arable fields.
BACT04	BA70X	TF 91624 10974	Holly tree within thin deciduous woodland strip.
BACT04	BA71X	TF 91425 10548	End of established hedgerow.
BACT04	BA93X	TF 91241 10801	Medium Oak tree at S corner of deciduous woodland.
BACT05	BA10	TF 97059 14824	Mature Oak along established tree line long road.
BACT05	BA11	TF 97289 15030	Mature Ash at end of established hedgerow.
BACT05	BA95X	TF 96742 14985	Mature Oak along established tree line long road.
BACT08	BA20	TG 03408 16490	Fence post next to mature Oak tree along established hedgerow.
BACT08	BA21	TG 03550 16531	Fence post parallel to fence *Salix* tree line.
BACT09	BA23	TG 04025 17321	Fence post below line of mature Poplar trees.
BACT09	BA92X	TG 03800 17304	Mature oak outside NE corner of strip of woodland.
BACT09	BA97X	TG 03962 17027	Fence post within gap of established hedgerow.
BACT10	BA24	TG 03958 17632	Mature oak along mature tree line through grazing pasture.
BACT10	BA72X	TG 03803 17569	Large Hawthorn at end of hedgerow at arable field entrance.
BACT10	BA98X	TG 04109 17738	Mature Willow tree standard along the bank of the river Wensum.
BACT13	BA73X	TG 07910 23729	Ivy covered Holly tree, amongst small copse of trees.
BACT13	BA74X	TG 08896 23590	Mature Ash tree on top of disused railway embankment, other nearby trees.
BACT14	BA100X	TG 11897 23791	Fencepost with deer fencing surrounding Christmas tree plantation.
BACT14	BA63X	TG 11616 24210	Medium Beech tree along mixed woodland edge.
BACT14	BA66X	TG 12104 24228	Within established Hawthorn hedgerow within Christmas tree plantation.
BACT15	*BA32*	*TG 20280 29069*	*Mature Oak on corner of woodland.*

Transect	BA point	Grid reference	Static position
BACT15	*BA33*	*TG 20446 28851*	*End of hedgerow.*
BACT16	BA35	TG 21203 29278	Young oak tree along open arable field edge.
BACT16	BA75X	TG 20936 29023	Mature Oak tree standard, surrounded by open arable land.
BACT17	*BA36*	*TG 21826 30308*	*Mature Oak, field side along road.*
BACT17	BA37	TG 21936 30206	Holly tree along well established hedgerow.
BACT17	BA91X	TG 22730 30573	Holly tree on edge of woodland strip.
BACT18	BA43	TG 27047 31731	Young oak tree along open arable field edge.
BACT18	BA44	TG 27367 31887	Mature Ash tree along well established hedgerow.
BACT19	BA55	TG 37014 30872	Large Hawthorn tree surrounded by open arable fields.
BACT19	BA56	TG 36703 30570	Mature tree along short, mature tree line.
BACT20	BA02	TF 89638 10399	Young Horse Chestnut alongside pond edge and established hedgerow.
BACT20	BA03	TF 90225 10470	Young Ash tree along patchy hedgerow.
BACT20	BA04	TF 90595 10221	Medium Oak tree within established hedgerow.
BACT21	BA106X	TG 29645 31559	Mature Willow tree within small copse of willow trees adjacent to Dilham Canal.
BACT21	BA62X	TG 29559 31866	Medium Oak tree within woodland.
BACT21	BA76X	TG 29763 31562	Young Oak within patchy hedgerow.
BACT22	BA107X	TG 32305 31646	Medium tree alongside woodland edge and arable field.
BACT22	BA48	TG 32748 31347	Small gap within established hedgerow.
BACT22	BA60X	TG 31932 31475	Medium tree along woodland edge, adjacent to reservoir and arable field.
BACT24	*BA65X*	TG 35600 30300	*Medium Oak on NE corner of mixed woodland.*
BACT26	BA79X	TF 94666 13130	Mature Ash tree, surrounded by open meadow.
BACT26	BA80X	TF 94888 13497	Young Oak tree along hedgerow.
BACT27	BA81X	TF 95794 14308	Mature Oak tree along established hedgerow.

Transect	BA point	Grid reference	Static position
BACT27	BA82X	TF 95726 14763	Mature Oak tree along established hedgerow.
BACT28	BA111X	TF 98582 15988	Trunk of dead tree at end of short tree line.
BACT28	BA13	TF 98418 15408	On trunk of dense Field Maple along well established hedgerow
BACT29	BA25	TG 06192 20259	Mature tree within established Blackthorn hedgerow.
BACT29	BA26	TG 06353 20317	In opening along established Blackthorn hedgerow.
BACT30	BA64X	TG 07785 22996	Crab apple tree amongst scrub along arable field edge.
BACT30	BA87X	TG 07302 23130	Large Hazel coppice within small copse of trees at base of disused railway embankment.
BACT31	BA114X	TG 19628 28557	Dead tree on arable field edge.
BACT31	BA67X	TG 19822 28632	Fence post adjacent to river Bure.
BACT31	BA68X	TG 19313 28758	Medium Hawthorn adjacent to small patch of woodland.
BACT32	BA88X	TG 16539 27154	Mature Sweet Chestnut tree within deciduous woodland.
BACT32	BA89X	TG 16395 26653	Mature Oak tree within established hedgerow.
BACT33	BA40	TG 23607 30424	Medium Oak tree within established Hawthorn hedgerow.
BACT33	BA41	TG 23911 30428	Ivy covered tree at gap in hedgerow.
BACT34	BA52	TG 35947 30027	Mature Ash tree at end of established hedgerow, surrounded by arable fields.
BACT34	BA90X	TG 35894 30426	Mature Oak Tree within established hedgerow and tree line.
BACT35	BA118X	TF 91252 10081	Outside corner of deciduous woodland plantation.
BACT35	BA119X	TF 90017 10766	Outside corner of deciduous woodland plantation.
Non-transect	*BA05*	*TF 93733 11836*	*Coppice Hazel along hedgerow.*
Non-transect	*BA38*	*TG 22219 30417*	*Medium Ash tree within established hedgerow.*
Non-transect	*BA39*	*TG 22467 30444*	*Within established hedgerow.*
Non-transect	*BA57*	*TG 37245 30441*	*Within established hedgerow.*
Non-transect	*BA61*	*TF 91128 09618*	*Mature Oak along woodland edge.*

Appendix 3: Transect survey effort

Transect	Surveyor	Date	Sunrise/Sunset	Start	End	Start Temp	End Temp	Wind	Cloud cover	Precipitation
BACT03	JG , JH	03/07/17	21:20	21:20	23:22	16°C	15°C	BWS1	2/8	None
BACT03	JG , JH	04/07/17	04:38	02:30	04:39	10°C	13°C	BWS1	1/8	None
BACT03	JWH, JH	03/08/17	20:43	20:54	21:58	19.5°C	18°C	BWS2	6/8	None
BACT03	KC, JH	01/09/17	19:42	19:45	20:47	13°C	14°C	BWS0	3/8	None
BACT04	BC, CB	20/06/17	21:22	21:28	23:25	18°C	14°C	BWS2	8/8	None
BACT04	BC, CB	21/06/17	21:22	02:30	04:33	16°C	14°C	BWS2	4/8	None
BACT04	BM, KC	03/07/17	21:20	21:20	23:04	16°C	15°C	BWS0	1/8	None
BACT04	JA, CB	03/07/17	21:20	20:28	22:45	16°C	18°C	BWS4	6/8	None
BACT04	KC, JA	14/08/17	20:22	20:16	21:42	17°C	18°C	BWS2	8/8	Rain at start
BACT05	BC, AB	25/05/17	20:59	20:58	21:41	15°C	13°C	BWS1	1/8	None
BACT05	BC, AV	12/06/17	21:18	21:22	23:16	15°C	15°C	BWS1	7/8	None
BACT05	KC, BM	26/06/17	21:22	21:20	22:57	12°C	14°C	BWS0	1/8	None
BACT05	AG, JH	18/07/17	21:07	21:18	22:49	17°C	17°C	BWS0	5/8	None
BACT05	AG, JH	08/08/17	05:25	20:39	21:58	15°C	14°C	BWS2	8/8	Heavy rain 21:24>
BACT05	AG, JH	22/08/17	05:48	20:07	21:28	19°C	17°C	BWS2	6/8	None
BACT05	JH, AG	06/09/17	06:14	19:45	21:17	18°C	15°C	BWS0	5/8	light rain at start
BACT05	JWH, JH	19/09/17	19:00	19:06	20:24	13°C	15°C	BWS0	2/8	None
BACT05	JWH, JH	03/10/17	18:26	18:25	20:17	14°C	12°C	BWS1	8/8	None
BACT05	BC, BM	04/10/17	07:01	05:02	07:07	10°C	10°C	BWS2	7/8	None
BACT05	JWH, JH	17/10/17	17:55	17:58	19:38	15°C	11°C	BWS0	8/8	None
BACT08	KC, LT	22/05/17	20:55	20:30	23:00	18°C	15°C	BWS0	6/8	None

Transect	Surveyor	Date	Sunrise/Sunset	Start	End	Start Temp	End Temp	Wind	Cloud cover	Precipitation
BACT08	KC, BH	02/06/17	21:09	21:15	23:44	17.5°C	14°C	BWS0	8/8	None
BACT08	LT, JA	12/06/17	21:18	21:24	23:04	16°C	15°C	BWS2	7/8	None
BACT08	KC, JH	11/07/17	04:44	02:40	04:11	14°C	14°C	BWS0	5/8	None
BACT08	BM, AV	14/07/17	04:48	21:13	23:00	15°C	15°C	BWS0	4/8	None
BACT08	KC, LT	07/08/17	20:36	20:42	22:22	18.9°C	17°C	BWS0	7/8	None
BACT08	KC, JH	04/09/17	19:35	19:36	21:03	18°C	18°C	BWS0	3/8	None
BACT08	KC, JH	12/09/17	06:24	19:12	20:28	15°C	15°C	BWS3	*4/8*	*Light rain*
BACT08	LT, KC	02/10/17	06:57	18:36	20:08	15°C	14°C	BWS3	5/8	None
BACT09	BM, JA	10/05/17	20:37	20:30	22:20	8 °C	5 °C	BWS2	1/8	None
BACT09	RM	13/06/17	21:19	21:20	23:22	17°C	15°C	BWS0	5/8	None
BACT09	JA, PK-W	29/06/17	21:21	21:08	23:22	16°C	13°C	BWS1	6/8	None
BACT09	AG, BM	13/07/17	21:13	21:17	22:42	15°C	15°C	BWS0	8/8	Rain/drizzle - 21:50 - 22:02
BACT09	BM, JWH	27/07/17	20:55	20:56	23:05	15°C	13°C	BWS0	4/8	Dry, misty at northern end
BACT09	AG, JH	29/08/17	19:49	19:52	21:08	16°C	16°C	BWS4	8/8	None
BACT09	AG, JH	12/09/17	19:16	19:17	20:25	12°C	12°C	BWS4	8/8	Light rain 19:40-19:58
BACT09	AG, JH	26/09/17	18:43	18:45	20:03	17°C	14°C	BWS1	1/8	None
BACT09	AG, BB	27/09/17	06:49	05:24	06:40	11°C	9°C	BWS0	8/8 - Fog	None
BACT09	AG, JH	10/10/17	18:10	18:13	19:55	14°C	14°C	BWS1	6/8	None
BACT09	BM, JH	24/10/17	17:40	17:41	19:16	17°C	18°C	BWS2	8/8	None
BACT 10	BC	10/05/17	20:37	20:45	22:15	12°C	6°C	BWS1	0/8	None
BACT10	BM, JH	07/07/17	21:18	21:18	22:45	19°C	18 °C	BWS0	7/8	None
BACT10	KC, JH	17/07/17	21:08	21:10	22:54	17°C	15°C	BWS0	1/8	None

Transect	Surveyor	Date	Sunrise/Sunset	Start	End	Start	End	Wind	Cloud cover	Precipitation
						Temp	Temp			
BACT10	KC, JH	18/07/17	04:53	02:45	04:15	13°C	12°C	BWS0	1/8	None - mist
BACT10	KC, AV	04/08/17	20:41	20:45	22:04	19°C	17°C	BWS1	4/8	None
BACT10	KC, AV	25/08/17	19:58	20:06	21:18	19°C	17°C	BWS0	2/8	None
BACT10	KC, JH	22/09/17	18:53	19	19:52	15°C	14°C	BWS0	2/8	02-Aug
BACT10	BM, CB	27/09/17	18:41	18:40	20:02	15°C	16°C	BWS2	4/8	None
BACT10	KC, BM	06/10/17	07:04	18:19	20:09	11°C	9°C	BWS1	5/8	05-Aug
BACT10	KC, BM	20/10/17	17:48	17:49	19:24	14°C	13°C	BWS2	8/8	08-Aug
BACT13	SM, RE	26/05/17	21:08	21:08	22:52	21°C	15°C	BWS1	0/8	None
BACT13	JG, BM	19/06/17	21:18	21:49	23:50	22.9°C	20°C	BWS1	2/8	None
BACT04	BC, CB	21/06/17	21:22	02:30	04:33	16°C	14°C	BWS2	4/8	None
BACT13	KC, JH	18/08/17	20:13	20:45	22:13	17°C	14°C	BWS2	0/8	None
BACT13	KC, JH	19/08/17	05:43	04:15	05:38	10°C	10°C	BWS2	0/8	None
BACT13	LT, KC	18/09/17	19:02	19:02	20:36	14°c	11°c	BWS0	2/8	None
BACT13	BM, CB	31/10/17	16:26	16:25	18:21	12°C	12°C	BWS3	3/8	None
BACT14	AG, BM	08/06/17	21:15	21:15	23:03	18°C	15°C	BWS0	7/8	None
BACT14	AG, BM	22/06/2017	21:22	21:21	22:51	17°C	17°C	BWS0	3/8	None
BACT14	AG, JH	06/07/2017	21:18	21:20	22:55	20°C	18°C	BWS1	3/8	None
BACT14	AG, AV	27/07/17	20:55	20:58	22:34	15°C	14°C	BWS2	5/8	Rain prior
BACT14	AG, JH	10/08/17	20:30	20:31	21:55	14°C	12°C	BWS1	2/8	None
BACT14	AG, JH	31/08/17	06:04	19:43	21:10	14°c	13°c	BWS2	*6/8*	*None*
BACT14	AG, BM	14/09/17	19:12	19:17	20:35	12°C	11°C	BWS0	6/8	Rain 20:24>
BACT14	AG, BM	15/09/17	06:29	04:35	05:54	8°C	6°C	BWS0	0/8	None

Transect	Surveyor	Date	Sunrise/Sunset	Start	End	Start Temp	End Temp	Wind	Cloud cover	Precipitation
BACT14	AC, BM	28/09/17	18:38	18:37	19:59	18°C	15°C	BWS0	3/8	None
BACT14	AB, BM	12/10/17	18:06	18:08	20:15	15°C	11°C	BWS1	4/8	None
BACT14	BM, CB	26/10/17	17:36	17:39	19:25	14°C	12°C	BWS0	5/8	None
BACT 15	BC, JH	07/06/17	21:14	21:10	22:47	16°C	13°C	BWS2	7/8	Light rain from 22:15
BACT16	AG, AV	04/07/17	21:20	21:21	22:46	19°C	18°C	BWS1	6/8	None
BACT16	JWH, AV	02/08/17	20:45	20:45	22:08	17 °C	18 °C	BWS2	8/8	Slight drizzle
BACT16	AG, JH	15/08/17	05:37	20:23	21:47	18°C	16°C	BWS1	2/8	None
BACT16	AG, JH	07/09/17	19:28	19:32	20:30	16°C	15°C	BWS3	8/8	Rain
BACT16	JG, JH	06/10/17	07:04	05:04	07	10°C	8°C	BWS3	4/8	None
BACT16	AG, JH	05/10/17	07:03	18:24	20:20	14°C	12°C	BWS2	3/8	None
BACT17	BB, BM	30/05/17	21:06	20:57	23:12	15°C	14°C	BWS1	1/8	None
BACT17	KC, JH	23/06/17	21:22	21:23	23:30	19°C	18°C	BWS2	6/8	None
BACT17	JWH, BM	24/07/17	20:59	21	22:29	15°C	15°C	BWS2	8/8	Heavy drizzle before survey and from 21:30
BACT17	JG, BM	14/08/17	20:22	20:22	22	17°C	15°C	BWS3	4/8	None
BACT17	JG, BM	11/09/17	06:22	19:23	21	15°C	13°C	BWS4	7/8	None
BACT17	JG, BM	12/09/17	06:24	04:20	06:36	10°C	10°C	BWS2	1/8	None
BACT17	JG, BM	09/10/17	18:13	18:20	20:30	12°C	12°C	BWS0	8/8	None
BACT18	BM, GH	24/05/17	20:58	20:58	23:21	18°C	15°C	BWS0	0/8	None
BACT18	AG, BM	01/06/17	21:08	21:08	23:10	15°C	15°C	BWS0	4/8	None
BACT18	GH, JH	12/07/17	21:15	21:14	22:53	14°C	11°C	BWS0	0/8	None
BACT18	RM	16/08/17	20:18	20:20	21:20	18°C	18°C	BWS2	3/8	None
BACT18	GH, JH	20/09/17	18:57	19:00	20:03	17°C	16°C	BWS0	8/8	None

Transect	Surveyor	Date	Sunrise/Sunset	Start	End	Start Temp	End Temp	Wind	Cloud cover	Precipitation
BACT18	BM, JWH	21/09/17	18:55	04:30	06:44	13°C	14°C	BWS2	7/8	None
BACT18	JWH, BM	23/10/17	17:42	17:40	19:30	14°C	13°C	BWS0	8/8	None
BACT19	BM, JH	09/06/17	21:16	21:15	22:50	15°C	14°C	BWS0	4/8	None
BACT19	GH, JH	25/06/17	21:22	21:20	22:55	16.5°C	16°C	BWS1	7/8	None
BACT19	GH, BM	05/07/17	21:19	21:19	23:01	17°C	15°C	BWS0	0/8	Misty
BACT19	GH, MP	16/08/17	20:18	20:20	21:34	18°C	18°C	BWS3	0/8	None
BACT19	GH, BM	06/09/17	06:14	19:31	20:51	16°C	15°C	BWS3	7/8	None
BACT19	JWH, CB	07/09/17	06:15	04:15	05:40	14°C	11°C	BWS1	6/8	None
BACT19	GH, MP	18/10/17	17:52	18:20	20:05	14°C	14°C	BWS4	8/8	Drizzle (start and end)
BACT 20	JG, BC	15/05/17	20:45	20:46	23:29	15°C	12°C	BWS4	8/8	Drizzle at start
BACT20	JA. JH	30/05/17	21:06	21:15	23:20	19°C	15°C	BWS2	8/8	None
BACT20	JG, BM	26/06/17	21:22	21:25	23:45	14.5°C	12.6°C	BWS3	8/8	None
BACT20	BC, LT	12/07/17	21:15	21:14	23	15°C	12°C	BWS0	1/8	None
BACT20	BC, LT	13/07/17	04:47	02:56	03:52	10°C	8.7°C	BWS0	1/8	None
BACT20	JG, BM	31/07/17	20:48	20:30	23:30	17°c	16°c	BWS1	8/8	Drizzle at start
BACT20	JG, LT	21/08/17	05:45	20:08	22:15	17°c	16°c	BWS1	8/8	None
BACT21	JG, JH	22/05/17	20:55	20:50	23:09	16°C	15°C	BWS2	2/8	None
BACT21	BM, JH	31/05/17	21:07	21:07	23	13°C	12°C	BWS0	0/8	None
BACT21	RM, JH	19/06/17	21:18	22:44	23:27	27°C	20°C	BWS2	5/8	None
BACT21	AG, JH	29/06/17	21:21	21:21	23:11	17°C	13°C	BWS1	7/8	None
BACT21	JWH, JH	31/07/17	20:48	20:50	22:35	19°C	17°C	BWS0	6/8	Light rain at end
BACT21	JG, JH	07/08/17	20:36	20:47	23:00	15°C	16°C	BWS1	8/8	None

Transect	Surveyor	Date	Sunrise/Sunset	Start	End	Start Temp	End Temp	Wind	Cloud cover	Precipitation
BACT21	JWH, AV	30/08/17	19:47	19:50	20:47	18°C	12°C	BWS0	8/8	Drizzle
BACT21	JG, BM	04/09/17	19:35	19:36	22	17°C	15°C	BWS0	0/8	None
BACT21	JG, JH	18/09/17	19:02	19:06	21:05	13°C	11°C	BWS3	6/8	None
BACT21	JG, JWH	19/09/17	06:35	04:49	06:35	10°c	11°c	BWS3	8/8	AT Start. Called off until 05.19
BACT21	BM, CB	03/10/17	18:26	18:21	20:24	12°C	12°C	BWS0	8/8	None
BACT21	BM, CB	17/10/17	17:55	17:54	19:53	14°C	13°C	BWS1	8/8	Light rain, 18:17 for 10 minutes
BACT22	BM, CS	22/05/17	20:55	21:19	23:06	16°C	15°C	BWS1	1/8	None
BACT22	AG , BM	15/06/17	21:20	21:20	22:52	18°C	17°C	BWS1	3/8	None
BACT22	JWH, CB	22/08/17	05:48	20:05	21:45	19°C	16°C	BWS1	8/8	None
BACT22	JWH, CB	23/08/17	05:50	03:54	05:40	19°C	17°C	BWS2	8/8	None
BACT22	JWH, CB	29/08/17	19:49	19:49	21:29	16°C	16°C	BWS2	8/8	None
BACT22	JWH, CB	12/09/17	06:24	19:17	20:41	19°C	15°C	BWS1	7/8	None
BACT22	JWH , CB	26/09/17	18:43	18:42	20:12	15°c	13°c	BWS0	0/8	None
BACT22	JWH, CB	10/10/17	18:10	18:12	20:11	16°C	15°C	BWS3	2/8	None
BACT22	JWH, BB	24/10/17	17:40	17:50	19:35	18°C	17°C	BWS2	7/8	None
BACT26	BM, JH	20/06/17	21:22	21:20	23:31	15°C	14°C	BWS3	1/8	None
BACT26	BM, JH	21/06/17	21:22	02:30	04:11	14°C	14°C	BWS1	0/8	None
BACT26	KC, AV	31/07/17	20:48	20:55	22:17	18°C	17°C	BWS0	4/8	Drizzle first 10 minutes
BACT26	BM, AV	08/08/17	05:25	20:34	21:48	16°C	14°C	BWS3	6/8	Rain started at 21:36
BACT26	BM, JWH	21/09/17	18:55	19:05	20:04	16°C	16°C	BWS3	8/8	Light rain
BACT26	BM, CB	05/10/17	07:03	18:22	19:35	13°C	10°C	BWS2	5/8	Rain showers - getting heavier/longer
BACT27	BC, JH	13/06/17	21:19	21:19	23:25	17°C	15°C	BWS0	3/8	None

Transect	Surveyor	Date	Sunrise/Sunset	Start	End	Start Temp	End Temp	Wind	Cloud cover	Precipitation
BACT27	SM, RE	03/07/17	21:20	21:23	23:11	14^{O}C	15^{O}C	BWS0	6/8	None
BACT27	GH, MP	30/08/17	19:47	20:04	21:10	18^{O}C	12^{O}C	BWS0	4/8	Heavy rain prior
BACT27	JWH, JH	08/09/17	19:26	19:30	20:38	19^{O}C	12^{O}C	BWS0	1/8	Rain prior
BACT27	JWH, JH	09/09/17	06:19	05:00	06:00	10^{O}C	9^{O}C	BWS0	8/8	None
BACT27	JWH, JH	13/10/17	18:04	18:04	19:49	19^{O}C	17^{O}C	BWS3	*1/8*	*None*
BACT28	JA, NT	21/06/17	21:22	21:18	23:20	22^{o}C	21^{o}C	BWS2	6/8	None
BACT28	BC, CB	29/06/17	21:21	21:20	23:25	15^{o}C	13^{o}C	BWS1	3/8	None
BACT28	GH, MP	19/07/17	04:45	21:06	22:37	21^{o}C	21^{o}C	BWS2	8/8	None
BACT28	JG, MP	23/08/17	20:03	20.18	21.58	19^{O}C	18^{O}C	BWS1	6/8	None
BACT28	GH, JH	13/09/17	19:14	19:21	20:31	11^{O}C	10^{O}C	BWS2	7/8	None
BACT28	JWH, GH	14/09/17	06:27	05:08	06:20	8^{o}c	9^{o}c	BWS1	0/8	None
BACT28	GH, JH	11/10/17	18:08	18:30	19:52	16.5^{O}C	15.5^{O}C	BWS2	7/8	V. light Speckles
BACT29	BM, BB	04/07/17	21:20	21:20	23:11	18oC	18oC	BWS0	7/8	None
BACT29	KC, BM	11/08/17	05:30	20:23	21:25	16oC	17oC	BWS0	7/8	None
BACT29	BM, AV	04/09/17	19:35	19:36	21:30	13oc	18oc	BWS0	5/8	None
BACT29	BM, AV	05/09/17	06:12	04:15	06:03	15OC	17OC	BWS0	8/8	None
BACT29	JG, CB	02/10/17	06:57	18:31	20:34	14OC	13OC	BWS4	8/8	None
BACT29	JG, CB	30/08/17	19:47	19:48	21:35	12OC	11OC	BWS1	1/8	Drizzle at start
BACT30	BM, KC	26/05/17	21:06	21:04	22:59	17oC	15oC	BWS2	0/8	None
BACT30	SM, MP	29/06/17	21:21	21:24	23:31	13°C	13°C	BWS3	8/8	Drizzle for first 10 minutes then dry.
BACT30	CB, AV	25/07/17	20:58	20:58	22:40	16oC	13oC	BWS0	0/8	None
BACT30	BM, AV	22/08/17	05:48	20:05	22:01	17OC	16OC	BWS1	6/8	None

Transect	Surveyor	Date	Sunrise/Sunset	Start	End	Start Temp	End Temp	Wind	Cloud cover	Precipitation
BACT30	BM, CB	19/09/17	19:00	19:12	20:25	16OC	10OC	BWS0	0/8	None
BACT30	BM, CB	20/09/17	06:37	03:52	06:02	6OC	6OC	BWS0	0/8	None
BACT30	BM, CB	19/10/17	17:50	17:49	18:51	16OC	15OC	BWS3	8/8	None
BACT31	KC, BM	12/06/17	21:18	21:18	23:18	16.1°C	13°C	BWS1	7/8	None
BACT31	RM, AV	26/06/17	21:22	21:24	22:28	13°C	11°C	BWS1	3/8	None
BACT31	BM, AV	12/07/17	21:15	21:15	23:18	12°C	12°C	BWS0	1/8	Misty
BACT31	BM, AV	26/07/17	20:56	20:56	22:58	18°C	17°C	BWS3	6/8	None
BACT31	BM, AV	23/08/17	20:03	20:03	21:54	17°C	18°C	BWS0	8/8	None
BACT31	JWH, BM	31/08/17	06:04	20:52	21:56	13°C	13°C	BWS0	2/8	None
BACT31	JWH, BM	01/09/17	06:05	04:02	05:45	11°C	8°C	BWS0	0/8	None
BACT31	KC, JH	15/09/17	19:09	19:41	20:37	13°C	12°C	BWS0	2/8	None
BACT31	KC, CB	09/10/17	18:13	18:12	20:19	13°C	12°C	BWS3	4/8	None
BACT31	BM, ML	25/10/17	17:38	17:32	19:35	15°C	14°C	BWS1	7/8	None
BACT32	BC, JH	15/06/17	21:20	21:24	23:07	18°C	17°C	BWS1	4/8	None
BACT32	JA, CB	12/07/17	21:15	21:06	23:03	24°C	11°C	BWS1	1/8	None
BACT32	RM, CB	15/08/17	05:37	20:23	22:39	15°C	14°C	BWS0	1/8	None
BACT32	JWH, BM	16/08/17	05:38	03:47	05:55	12°C	10°C	BWS0	0/8	None
BACT32	JWH, BB	19/09/17	19:00	19:02	20:13	12°C	10°C	BWS2	*2/8*	*None*
BACT33	JA, CB	14/06/17	21:19	21:12	23:05	17°C	15°C	BWS1	1/8	None
BACT33	KC, BM	21/07/17	21:03	21:03	22:30	18°C	18°C	BWS1	2/8	None
BACT33	AG, BM	24/08/17	20:07	20:14	21:34	17°c	15°c	BWS1	2/8	None
BACT33	AG, BM	25/08/17	19:58	03:50	05:15	10°c	10°c	BWS0	1/8	None

Transect	Surveyor	Date	Sunrise/Sunset	Start	End	Start Temp	End Temp	Wind	Cloud cover	Precipitation
BACT33	KC, BM	29/09/17	18:36	18:35	19:54	16^{o}c	15^{o}c	BWS0	7/8	None
BACT34	BC, AV	30/06/17	21:21	21:25	21:59	12^{o}C	15^{o}C	BWS4	8/8	None
BACT34	RB, JH	05/07/17	21:19	21:35	23:01	17^{o}C	15^{o}C	BWS0	0/8	None
BACT34	CB, JWH	17/08/17	05:30	20:16	21:50	18^{o}C	17^{o}C	BWS2	0/8	None
BACT34	BB, JA	12/09/17	06:24	19:40	20:33	13^{o}c	13^{o}c	BWS2	0/8	Rain at 20:00, 5 minutes
BACT34	JG, BM	10/10/17	18:19	18:10	20:25	13^{o}c	13^{o}c	BWS4	2/8	None
BACT34	JG, BM	11/10/17	07:13	05:04	07:06	15^{o}c	15^{o}c	BWS1	8/8	None
BACT35	JWH	30/07/17	21:20	21	22:36	14^{O}C	13^{O}C	BWS1	7/8	None

Appendix 4 : Details of static deployments

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA02	BACT20	09/05/2017	25/05/2017	16
BA02	BACT20	30/05/2017	05/06/2017	6
BA02	BACT20	26/06/2017	05/07/2017	9
BA02	BACT20	12/07/2017	17/07/2017	5
BA02	BACT20	31/07/2017	17/08/2017	17
BA02	BACT20	21/08/2017	28/08/2017	7
BA03	BACT20	09/05/2017	25/05/2017	16
BA03	BACT20	26/06/2017	05/07/2017	9
BA03	BACT20	04/07/2017	17/07/2017	13
BA03	BACT20	31/07/2017	17/08/2017	17
BA03	BACT20	21/08/2017	28/08/2017	7
BA04	BACT20	09/05/2017	25/05/2017	16
BA04	BACT20	26/06/2017	10/07/2017	14
BA04	BACT20	13/07/2017	17/07/2017	4
BA04	BACT20	31/07/2017	17/08/2017	17
BA05	External	28/04/2017	19/05/2017	21
BA06	BACT03	04/07/2017	07/07/2017	3
BA06	BACT03	03/08/2017	07/08/2017	4
BA06	BACT03	01/09/2017	07/09/2017	6
BA06	BACT03	26/10/2017	31/10/2017	5
BA10	BACT05	25/05/2017	01/06/2017	7
BA10	BACT05	12/06/2017	19/06/2017	7

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA10	BACT05	26/06/2017	30/06/2017	4
BA10	BACT05	18/07/2017	21/07/2017	3
BA10	BACT05	08/08/2017	14/08/2017	6
BA10	BACT05	31/08/2017	04/09/2017	4
BA10	BACT05	03/10/2017	08/10/2017	5
BA100X	BACT14	22/06/2017	27/06/2017	5
BA100X	BACT14	27/07/2017	01/08/2017	5
BA100X	BACT14	31/08/2017	06/09/2017	6
BA100X	BACT14	28/09/2017	03/10/2017	5
BA100X	BACT14	12/10/2017	17/10/2017	5
BA106X	BACT21	19/06/2017	26/06/2017	7
BA106X	BACT21	31/07/2017	07/08/2017	7
BA106X	BACT21	07/08/2017	14/08/2017	7
BA106X	BACT21	04/09/2017	13/09/2017	9
BA106X	BACT21	17/10/2017	21/10/2017	4
BA107X	BACT22	22/08/2017	25/08/2017	3
BA107X	BACT22	12/09/2017	20/09/2017	8
BA107X	BACT22	24/10/2017	30/10/2017	6
BA11	BACT05	25/05/2017	01/06/2017	7
BA11	BACT05	12/06/2017	19/06/2017	7
BA11	BACT05	22/08/2017	28/08/2017	6
BA11	BACT05	19/09/2017	26/09/2017	7
BA11	BACT05	17/10/2017	23/10/2017	6

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA111X	BACT28	22/06/2017	23/06/2017	1
BA111X	BACT28	29/06/2017	03/07/2017	4
BA111X	BACT28	19/07/2017	24/07/2017	5
BA111X	BACT28	23/08/2017	28/08/2017	5
BA111X	BACT28	13/09/2017	18/09/2017	5
BA111X	BACT28	11/10/2017	16/10/2017	5
BA114X	BACT31	26/06/2017	30/06/2017	4
BA114X	BACT31	12/07/2017	17/07/2017	5
BA114X	BACT31	26/07/2017	03/08/2017	8
BA114X	BACT31	01/09/2017	06/09/2017	5
BA114X	BACT31	25/10/2017	30/10/2017	5
BA118X	BACT35	30/07/2017	08/08/2017	9
BA119X	BACT35	30/07/2017	08/08/2017	9
BA13	BACT28	21/06/2017	27/06/2017	6
BA13	BACT28	19/07/2017	24/07/2017	5
BA13	BACT28	22/08/2017	28/08/2017	6
BA13	BACT28	14/09/2017	19/09/2017	5
BA13	BACT28	11/10/2017	16/10/2017	5
BA20	BACT08	02/06/2017	12/06/2017	10
BA20	BACT08	12/06/2017	20/06/2017	8
BA20	BACT08	14/07/2017	27/07/2017	13
BA20	BACT08	07/08/2017	08/08/2017	1
BA20	BACT08	04/09/2017	12/09/2017	8

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA20	BACT08	02/10/2017	11/10/2017	9
BA21	BACT08	02/06/2017	12/06/2017	10
BA21	BACT08	12/06/2017	20/06/2017	8
BA21	BACT08	11/07/2017	17/07/2017	6
BA21	BACT08	04/09/2017	12/09/2017	8
BA21	BACT08	02/10/2017	11/10/2017	9
BA23	BACT09	09/05/2017	19/05/2017	10
BA23	BACT09	14/06/2017	19/06/2017	5
BA23	BACT09	13/07/2017	18/07/2017	5
BA23	BACT09	27/07/2017	31/07/2017	4
BA23	BACT09	29/08/2017	04/09/2017	6
BA23	BACT09	27/09/2017	02/10/2017	5
BA23	BACT09	24/10/2017	31/10/2017	7
BA24	BACT10	10/05/2017	19/05/2017	9
BA24	BACT10	07/07/2017	12/07/2017	5
BA24	BACT10	17/07/2017	24/07/2017	7
BA24	BACT10	25/08/2017	31/08/2017	6
BA24	BACT10	27/09/2017	02/10/2017	5
BA24	BACT10	06/10/2017	11/10/2017	5
BA25	BACT29	04/07/2017	10/07/2017	6
BA25	BACT29	11/08/2017	15/08/2017	4
BA25	BACT29	30/08/2017	04/09/2017	5
BA25	BACT29	05/09/2017	12/09/2017	7

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA25	BACT29	02/10/2017	06/10/2017	4
BA26	BACT29	04/07/2017	05/07/2017	1
BA26	BACT29	11/08/2017	16/08/2017	5
BA26	BACT29	30/08/2017	04/09/2017	5
BA26	BACT29	04/09/2017	12/09/2017	8
BA26	BACT29	02/10/2017	09/10/2017	7
BA32	BACT15	07/06/2017	12/06/2017	5
BA33	BACT15	07/06/2017	12/06/2017	5
BA35	BACT16	04/07/2017	10/07/2017	6
BA35	BACT16	02/08/2017	08/08/2017	6
BA35	BACT16	15/08/2017	22/08/2017	7
BA35	BACT16	08/09/2017	11/09/2017	3
BA35	BACT16	05/10/2017	10/10/2017	5
BA36	BACT17	22/05/2017	30/05/2017	8
BA37	BACT17	22/05/2017	30/05/2017	8
BA37	BACT17	23/06/2017	27/06/2017	4
BA37	BACT17	14/08/2017	14/08/2017	0
BA37	BACT17	11/09/2017	19/09/2017	8
BA37	BACT17	09/10/2017	16/10/2017	7
BA38	BACT17	24/07/2017	28/07/2017	4
BA38	BACT17	22/05/2017	30/05/2017	8
BA39	External	22/05/2017	30/05/2017	8
BA40	BACT33	14/06/2017	19/06/2017	5

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA40	BACT33	21/07/2017	26/07/2017	5
BA40	BACT33	24/08/2017	30/08/2017	6
BA40	BACT33	29/09/2017	04/10/2017	5
BA40	BACT33	23/10/2017	30/10/2017	7
BA41	BACT33	14/06/2017	19/06/2017	5
BA41	BACT33	21/07/2017	26/07/2017	5
BA41	BACT33	25/08/2017	30/08/2017	5
BA41	BACT33	29/09/2017	04/10/2017	5
BA41	BACT33	23/10/2017	30/10/2017	7
BA43	BACT18	22/05/2017	30/05/2017	8
BA43	BACT18	01/06/2017	06/06/2017	5
BA43	BACT18	12/07/2017	17/07/2017	5
BA43	BACT18	16/08/2017	21/08/2017	5
BA43	BACT18	21/09/2017	25/09/2017	4
BA43	BACT18	23/10/2017	29/10/2017	6
BA44	BACT18	22/05/2017	30/05/2017	8
BA44	BACT18	01/06/2017	06/06/2017	5
BA44	BACT18	12/07/2017	17/07/2017	5
BA44	BACT18	16/08/2017	21/08/2017	5
BA44	BACT18	21/09/2017	26/09/2017	5
BA44	BACT18	23/10/2017	30/10/2017	7
BA48	BACT22	30/05/2017	06/06/2017	7
BA48	BACT22	15/06/2017	20/06/2017	5

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA48	BACT22	23/08/2017	29/08/2017	6
BA48	BACT22	12/09/2017	20/09/2017	8
BA48	BACT22	24/10/2017	30/10/2017	6
BA52	BACT34	07/06/2017	13/06/2017	6
BA52	BACT34	30/06/2017	05/07/2017	5
BA52	BACT34	05/07/2017	11/07/2017	6
BA52	BACT34	17/08/2017	24/08/2017	7
BA52	BACT34	18/09/2017	25/09/2017	7
BA52	BACT34	10/10/2017	10/10/2017	0
BA55	BACT19	09/06/2017	14/06/2017	5
BA55	BACT19	25/06/2017	29/06/2017	4
BA55	BACT19	05/07/2017	11/07/2017	6
BA55	BACT19	07/09/2017	12/09/2017	5
BA55	BACT19	18/10/2017	23/10/2017	5
BA56	BACT19	09/06/2017	14/06/2017	5
BA56	BACT19	25/06/2017	29/06/2017	4
BA56	BACT19	05/07/2017	11/07/2017	6
BA56	BACT19	21/08/2017	30/08/2017	9
BA56	BACT19	18/10/2017	23/10/2017	5
BA57	External	09/06/2017	14/06/2017	5
BA60X	BACT22	16/05/2017	25/05/2017	9
BA60X	BACT22	29/08/2017	05/09/2017	7
BA60X	BACT22	26/09/2017	02/10/2017	6

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA60X	BACT22	10/10/2017	16/10/2017	6
BA61X	External	22/05/2017	06/06/2017	15
BA61X	External	15/06/2017	20/06/2017	5
BA62X	BACT21	22/05/2017	30/05/2017	8
BA62X	BACT21	31/05/2017	06/06/2017	6
BA62X	BACT21	19/06/2017	26/06/2017	7
BA62X	BACT21	29/06/2017	05/07/2017	6
BA62X	BACT21	31/07/2017	07/08/2017	7
BA62X	BACT21	30/08/2017	04/09/2017	5
BA62X	BACT21	04/09/2017	13/09/2017	9
BA62X	BACT21	03/10/2017	08/10/2017	5
BA63X	BACT14	24/05/2017	30/05/2017	6
BA63X	BACT14	08/06/2017	13/06/2017	5
BA63X	BACT14	27/07/2017	01/08/2017	5
BA63X	BACT14	10/08/2017	15/08/2017	5
BA63X	BACT14	15/09/2017	20/09/2017	5
BA63X	BACT14	26/10/2017	31/10/2017	5
BA64X	BACT30	26/05/2017	06/06/2017	11
BA64X	BACT30	28/06/2017	04/07/2017	6
BA64X	BACT30	27/07/2017	31/07/2017	4
BA64X	BACT30	25/08/2017	30/08/2017	5
BA64X	BACT30	20/09/2017	25/09/2017	5
BA64X	BACT30	19/10/2017	24/10/2017	5

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA65X	BACT24	07/06/2017	13/06/2017	6
BA66X	BACT14	08/06/2017	13/06/2017	5
BA66X	BACT14	22/06/2017	28/06/2017	6
BA66X	BACT14	06/07/2017	11/07/2017	5
BA66X	BACT14	27/07/2017	01/08/2017	5
BA66X	BACT14	10/08/2017	15/08/2017	5
BA66X	BACT14	14/09/2017	20/09/2017	6
BA66X	BACT14	12/10/2017	18/10/2017	6
BA67X	BACT31	12/06/2017	19/06/2017	7
BA67X	BACT31	26/06/2017	30/06/2017	4
BA67X	BACT31	12/07/2017	17/07/2017	5
BA67X	BACT31	26/07/2017	03/08/2017	8
BA67X	BACT31	31/08/2017	06/09/2017	6
BA67X	BACT31	09/10/2017	17/10/2017	8
BA68X	BACT31	12/06/2017	19/06/2017	7
BA68X	BACT31	26/06/2017	30/06/2017	4
BA68X	BACT31	12/07/2017	17/07/2017	5
BA68X	BACT31	26/07/2017	03/08/2017	8
BA68X	BACT31	23/08/2017	29/08/2017	6
BA68X	BACT31	15/09/2017	25/09/2017	10
BA68X	BACT31	09/10/2017	17/10/2017	8
BA69X	BACT03	04/07/2017	07/07/2017	3
BA69X	BACT03	03/08/2017	07/08/2017	4

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA69X	BACT03	01/09/2017	07/09/2017	6
BA69X	BACT03	18/10/2017	24/10/2017	6
BA70X	BACT04	20/06/2017	26/06/2017	6
BA70X	BACT04	03/07/2017	07/07/2017	4
BA70X	BACT04	03/08/2017	09/08/2017	6
BA71X	BACT04	21/06/2017	26/06/2017	5
BA71X	BACT04	03/08/2017	09/08/2017	6
BA71X	BACT04	14/08/2017	22/08/2017	8
BA72X	BACT10	07/07/2017	12/07/2017	5
BA72X	BACT10	18/07/2017	24/07/2017	6
BA72X	BACT10	25/08/2017	31/08/2017	6
BA72X	BACT10	27/09/2017	02/10/2017	5
BA72X	BACT10	06/10/2017	11/10/2017	5
BA73X	BACT13	19/06/2017	23/06/2017	4
BA73X	BACT13	19/08/2017	24/08/2017	5
BA73X	BACT13	18/09/2017	25/09/2017	7
BA73X	BACT13	24/10/2017	30/10/2017	6
BA74X	BACT13	19/06/2017	23/06/2017	4
BA74X	BACT13	29/08/2017	04/09/2017	6
BA74X	BACT13	18/09/2017	25/09/2017	7
BA74X	BACT13	24/10/2017	30/10/2017	6
BA75X	BACT16	04/07/2017	10/07/2017	6
BA75X	BACT16	02/08/2017	08/08/2017	6

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA75X	BACT16	07/08/2017	15/08/2017	8
BA75X	BACT16	08/09/2017	11/09/2017	3
BA75X	BACT16	06/10/2017	10/10/2017	4
BA76X	BACT21	19/06/2017	26/06/2017	7
BA76X	BACT21	07/08/2017	13/08/2017	6
BA76X	BACT21	17/10/2017	23/10/2017	6
BA79X	BACT26	20/06/2017	26/06/2017	6
BA79X	BACT26	31/07/2017	01/08/2017	1
BA79X	BACT26	08/08/2017	16/08/2017	8
BA79X	BACT26	21/09/2017	26/09/2017	5
BA79X	BACT26	05/10/2017	11/10/2017	6
BA80X	BACT26	20/06/2017	26/06/2017	6
BA80X	BACT26	31/07/2017	03/08/2017	3
BA80X	BACT26	08/08/2017	10/08/2017	2
BA80X	BACT26	21/09/2017	26/09/2017	5
BA80X	BACT26	05/10/2017	11/10/2017	6
BA81X	BACT27	13/06/2017	19/06/2017	6
BA81X	BACT27	03/07/2017	07/07/2017	4
BA81X	BACT27	30/08/2017	12/09/2017	13
BA81X	BACT27	13/10/2017	18/10/2017	5
BA82X	BACT27	13/06/2017	19/06/2017	6
BA82X	BACT27	03/07/2017	07/07/2017	4
BA82X	BACT27	30/08/2017	01/09/2017	2

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA82X	BACT27	13/10/2017	18/10/2017	5
BA87X	BACT30	28/06/2017	04/07/2017	6
BA87X	BACT30	25/07/2017	31/07/2017	6
BA87X	BACT30	22/08/2017	29/08/2017	7
BA87X	BACT30	19/09/2017	25/09/2017	6
BA87X	BACT30	19/10/2017	24/10/2017	5
BA88X	BACT32	15/06/2017	23/06/2017	8
BA88X	BACT32	12/07/2017	17/07/2017	5
BA88X	BACT32	16/08/2017	21/08/2017	5
BA88X	BACT32	19/09/2017	25/09/2017	6
BA88X	BACT32	16/10/2017	23/10/2017	7
BA89X	BACT32	15/06/2017	23/06/2017	8
BA89X	BACT32	12/07/2017	17/07/2017	5
BA89X	BACT32	15/08/2017	21/08/2017	6
BA89X	BACT32	19/09/2017	26/09/2017	7
BA89X	BACT32	16/10/2017	23/10/2017	7
BA90X	BACT34	30/06/2017	05/07/2017	5
BA90X	BACT34	05/07/2017	11/07/2017	6
BA90X	BACT34	21/08/2017	24/08/2017	3
BA90X	BACT34	12/09/2017	12/09/2017	0
BA90X	BACT34	11/10/2017	16/10/2017	5
BA91X	BACT17	23/06/2017	27/06/2017	4
BA91X	BACT17	24/07/2017	28/07/2017	4

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA91X	BACT17	14/08/2017	21/08/2017	7
BA91X	BACT17	11/09/2017	19/09/2017	8
BA91X	BACT17	09/10/2017	16/10/2017	7
BA92X	BACT09	14/06/2017	19/06/2017	5
BA92X	BACT09	29/06/2017	03/07/2017	4
BA92X	BACT09	13/07/2017	17/07/2017	4
BA92X	BACT09	27/07/2017	31/07/2017	4
BA92X	BACT09	29/08/2017	04/09/2017	6
BA92X	BACT09	27/09/2017	29/09/2017	2
BA92X	BACT09	10/10/2017	19/10/2017	9
BA93X	BACT04	21/06/2017	23/06/2017	2
BA93X	BACT04	03/07/2017	07/07/2017	4
BA93X	BACT04	03/08/2017	09/08/2017	6
BA93X	BACT04	14/08/2017	22/08/2017	8
BA95X	BACT05	26/06/2017	30/06/2017	4
BA95X	BACT05	08/08/2017	13/08/2017	5
BA95X	BACT05	19/09/2017	23/09/2017	4
BA95X	BACT05	17/10/2017	23/10/2017	6
BA97X	BACT09	13/07/2017	17/07/2017	4
BA97X	BACT09	27/07/2017	31/07/2017	4
BA97X	BACT09	29/08/2017	04/09/2017	6
BA97X	BACT09	24/10/2017	29/10/2017	5
BA98X	BACT10	07/07/2017	12/07/2017	5

Static point	Transect reference	Deployment start date	Deployment end date	No. nights deployed
BA98X	BACT10	17/07/2017	24/07/2017	7
BA98X	BACT10	25/08/2017	31/08/2017	6
BA98X	BACT10	27/09/2017	02/10/2017	5
BA98X	BACT10	06/10/2017	11/10/2017	5

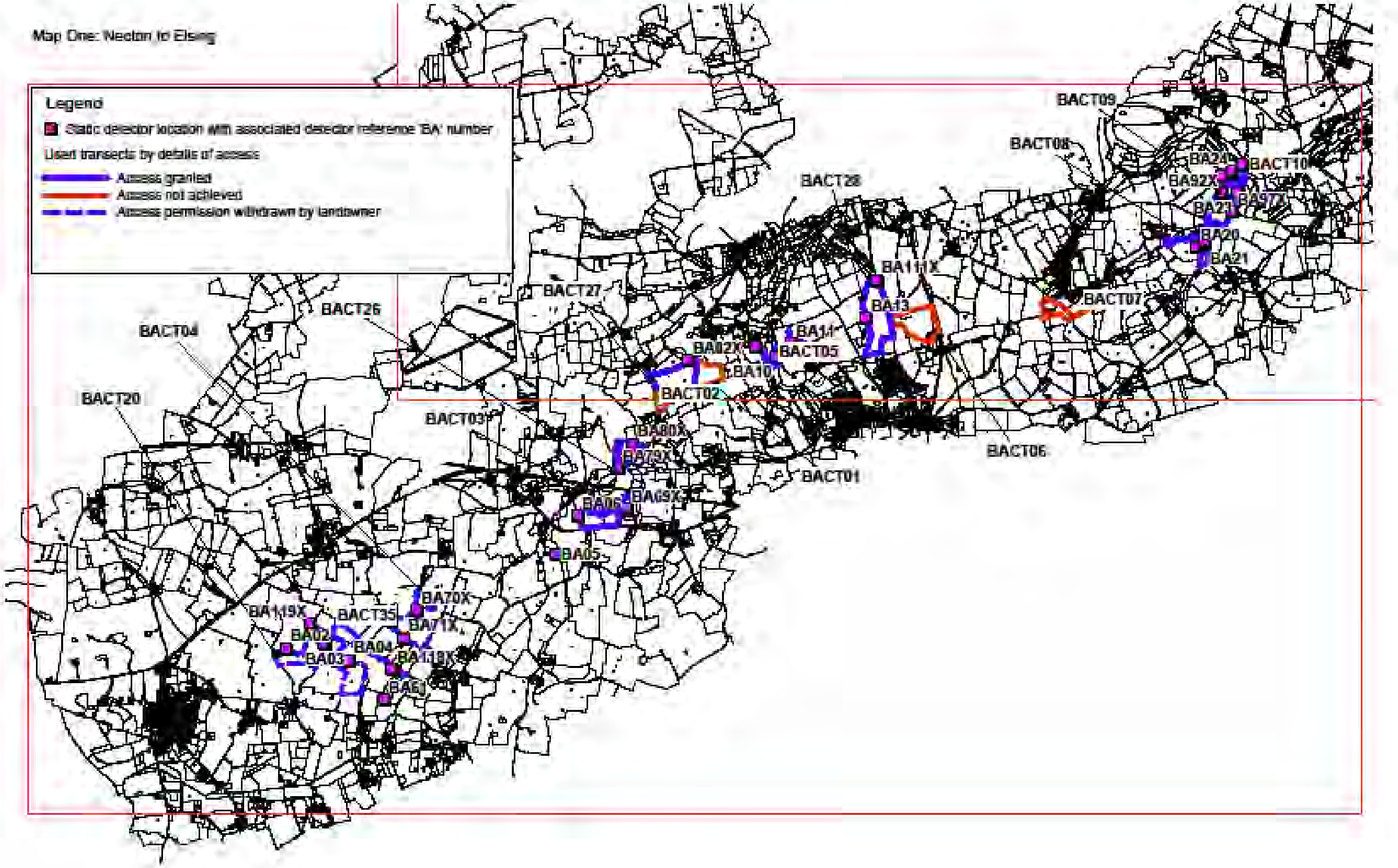
Appendix 5: Maps

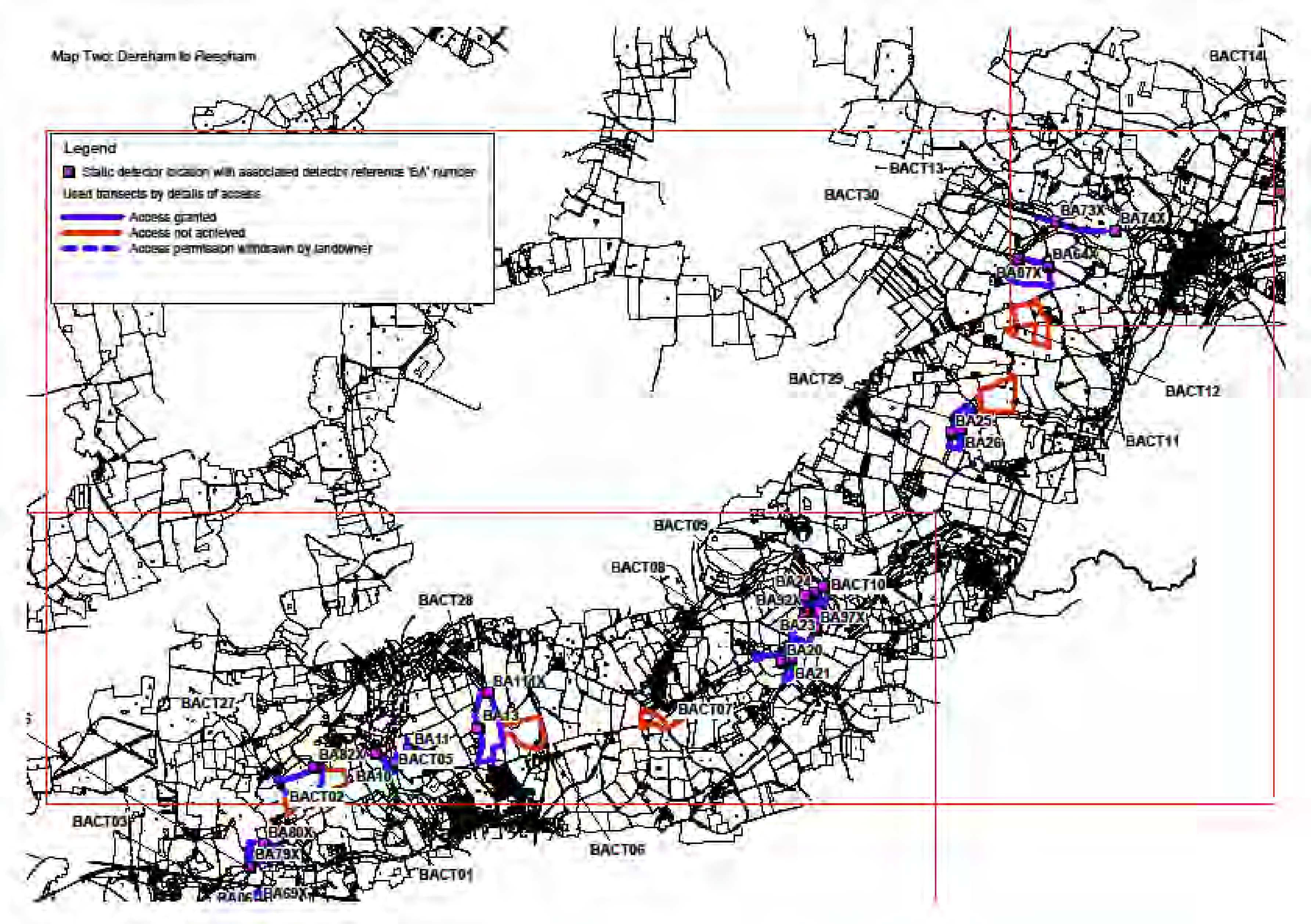
Four overview maps are provided below showing the locations of the following transects.

Transects #

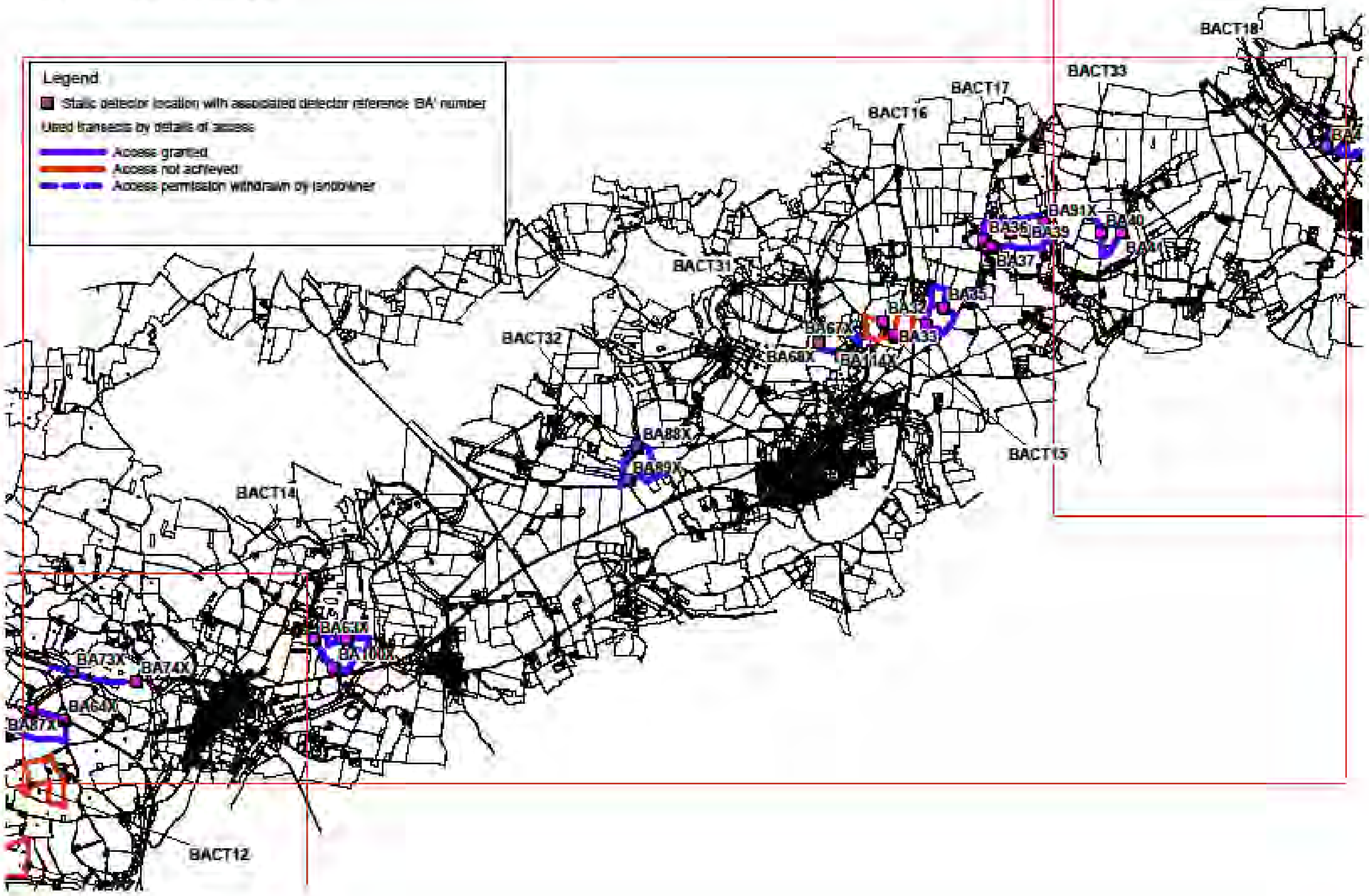
BACT01
BACT02
BACT03
BACT04
BACT05
BACT06
BACT07
BACT08
BACT09
BACT10
BACT11
BACT12
BACT13
BACT14
BACT15
BACT16
BACT17
BACT18
BACT19
BACT20
BACT21
BACT22
BACT23
BACT24
BACT25
BACT26
BACT27
BACT28
BACT29
BACT30
BACT31
BACT32
BACT33
BACT34
BACT35

Map One: Necton to Elsing




Map Two: Dereham to Reepham
Legend
Static detector location with associated detector reference 'BA' number
Used transects by details of access
Access granted
Access not achieved
Access permission withdrawn by landowner
BACT14
BACT13
BACT30
BA73X
BA74X
BA64X
BA97X
BACT29
BACT12
BA25
BA26
BACT11
BACT09
BACT08
BA24
BACT10
BA92X
BA23
BA97X
BA20
BA21
BACT28
BA110X
BA13
BACT07
BACT27
BA11
BA82X
BACT05
BA10
BACT02
BACT03
BA80X
BA79X
BACT06
BACT01
BA69X

Map Three: Reepham to Felmingham



Map Four: Felmingham to Walcott