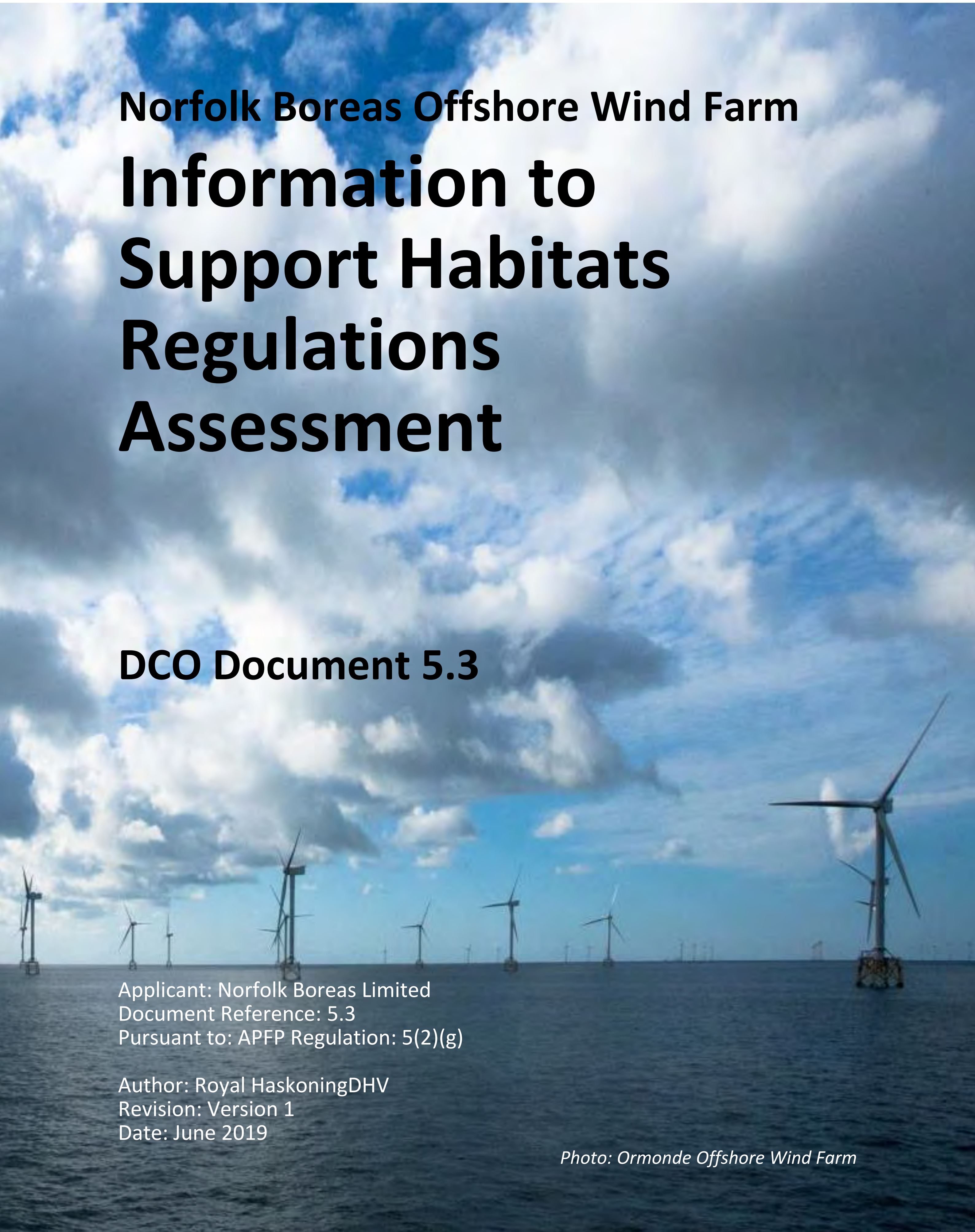

Norfolk Boreas Offshore Wind Farm

Information to Support Habitats Regulations Assessment

DCO Document 5.3

Applicant: Norfolk Boreas Limited
Document Reference: 5.3
Pursuant to: APFP Regulation: 5(2)(g)

Author: Royal HaskoningDHV
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Photo: Ormonde Offshore Wind Farm

Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
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07/05/2019	03D	Third draft for Norfolk Boreas Limited review	GS/JL/ MT/ DT	JL/VR/JKL	JL
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Glossary of Acronyms

AA	Appropriate Assessment
ADDs	Acoustic Deterrent Devices
APEM	APEM is an environmental consultancy with specialist expertise in aerial survey
AWAC	Acoustic Wave and Current
BEIS	Business Energy and Industrial Strategy
Cefas	Centre for Environment Fisheries and Aquaculture Science
CI	Confidence Interval
CIA	Cumulative Impact Assessment
CIS	Celtic and Irish Sea
cSAC	candidate Special Area of Conservation
CV	Coefficient of Variation
DCO	Development Consent Order
DOW	Dudgeon Offshore Wind Farm
DWRs	Deep Water Routes
EATL	East Anglia THREE Ltd
EDR	Effective Deterrence Radius
EIA	Environmental Impact Assessment
EMF	Electromagnetic Fields
EOD	Explosive Ordnance Disposal
EPP	Evidence Plan Process
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Group
EU	European Union
FCS	Favourable Conservation Status
GBS	Gravity Base Structure
GC	Allied designation for German type LMB mine
GNS	Greater North Sea
GSD	Ground Sampling Distance
HE	High Explosive
HRA	Habitat Regulations Assessment
IAMMWG	Inter-Agency Marine Mammal Working Group
IMARES	Institute for Marine Resources and Ecosystem Studies
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
kg	Kilogram
kJ	Kilojoule
km	Kilometre
km2	Kilometre squared
lb	Pound (unit of mass)
LiDAR	Light Detection and Ranging
LMB	Luftmine B (German air-dropped ground mine Type B)
LSE	Likely Significant Effect
m	Meter

m/s	Metres per second
MCA	Maritime and Coastguard Agency
MMMP	Marine Mammal Mitigation Plan
MMO	Marine Management Organisation
MMOs	Marine Mammal Observers
MPCP	Marine Pollution Contingency Plan
MTD	Marine Technical Directorate
MU	Management Units
MW	Megawatts
NE	Natural England
NEQ	net explosive quantities
nm	Nautical miles
NMFS	National Marine and Fisheries Service
NOAA	National Oceanographic and Atmospheric Associate
NS	North Sea
O&M	Operational and Maintenance
OSPAR	Oslo and Paris Convention for the Protection of the Marine Environment
OWF	Offshore Wind Farm
PAM	passive acoustic monitoring
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
PTS	Permanent Threshold Shift
QA	Quality Assurance
RoC	Review of Consent
SAC	Special Area of Conservation
SCANS	Small Cetaceans in the European Atlantic and North Sea
SCI	Site of Community Importance
SCOS	Special Committee on Seals
SD	Standard Deviation
SEL	Sound Exposure Level
SIP	Site Integrity Plan
SMP	Seabird Monitoring Programme
SMRU	Sea Mammal Research Unit
SNCBs	Statutory Nature Conservation Bodies
SNS	Southern North Sea
SoCG	Statement of Common Ground
SPL	Sound Pressure Level
SST	sea surface temperature
TLS	Trinity House
TNT	Trinitrotoluene
TSEG	Trilateral Seal Expert Group
TWT	The Wildlife Trusts
UK	United Kingdom of Great Britain and Northern Ireland
UXO	Unexploded Ordnance
WDC	Whale and Dolphin Conservation
WS	West Scotland

Glossary of Terminology

Array cables	Cables which link wind turbine to wind turbine, and wind turbine to offshore electrical platforms.
Cable pulling	Installation of cables within pre-installed ducts from jointing pits located along the onshore cable route.
Ducts	A duct is a length of underground piping, which is used to house electrical and communication cables.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and information to support the HRA.
Export Cables	Cables that transmit power from an offshore electrical platform to the onshore project substation
Interconnector cables	Offshore cables which link offshore electrical platforms within the Norfolk Boreas site
Jointing pit	Underground structures constructed at regular intervals along the onshore 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
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 a mobilisation area will be located.
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.
Necton National Grid substation	The grid connection location for Norfolk Boreas and Norfolk Vanguard
Norfolk Boreas site	The Norfolk Boreas wind farm boundary. Located offshore, this will contain all the wind farm array.
Norfolk Vanguard	Norfolk Vanguard offshore wind farm, sister project of Norfolk Boreas.
The Norfolk Vanguard OWF sites	Term used exclusively to refer to the two-distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West (also termed NV East and NV West).
Offshore service platform	A platform to house workers offshore and/or provide helicopter refuelling facilities. An accommodation vessel may be used as an alternative for housing workers.
Offshore cable corridor	The corridor of seabed from the Norfolk Boreas site to the landfall site within which the offshore export cables will be located.
Offshore electrical platform	A fixed structure located within the Norfolk Boreas site, containing electrical equipment to aggregate the power from the wind turbines and convert it into a suitable form for export to shore.
Offshore export cables	The cables which transmit power from the offshore electrical platform to the landfall.
Offshore project area	The area including the Norfolk Boreas site, project interconnector search area and offshore cable corridor.
Onshore cable corridor	A 100m wide corridor presented at Scoping within which the onshore cable

	route has now been defined.
Onshore cable route	The up to 35m working width within a 45m wide corridor 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 power and communications from landfall to the onshore project substation
Onshore infrastructure	The combined name for all onshore infrastructure associated with the project from landfall to grid connection
Onshore project area	The area of the onshore infrastructure (landfall, onshore cable route, accesses, trenchless crossing zones and mobilisation areas; onshore project substation and extension to the Necton National Grid substation and overhead line modifications).
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.
Overhead Line	An existing 400kV power line suspended by towers.
Pre-sweeping	A discrete dredging operation designed to lower the seabed level within a distinct identified channel to enable marine cables to be installed to a depth which reduces the risk of cable exposure and minimises the likelihood of reburial operations.
Project interconnector cable	Offshore cables which would link either turbines or an offshore electrical platform in the Norfolk Boreas site with an offshore electrical platform in one of the Norfolk Vanguard sites.
Project interconnector search area	The area within which project interconnector cables would be installed.
Running track	The track along the onshore cable route which the construction traffic would use to access workfronts.
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 Boreas Limited
The Norfolk Vanguard OWF sites	Term used exclusively to refer to the two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West (also termed NV East and NV West) which will contain the Norfolk Vanguard arrays.
The project	Norfolk Boreas 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
Trenchless crossing zone	Areas within the onshore cable route which will house trenchless crossing entry and exit points.
Workfront	A length of onshore cable route within which duct installation works will occur, approximately 150m.

1. INTRODUCTION

1.1. Purpose of the Information to Support 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 Boreas Offshore Wind Farm (hereafter 'Norfolk Boreas' or 'the project'). 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.

2. 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).

3. 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 I) - 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).

4. 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 provides the 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 Boreas 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 Boreas 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 SACs Annex II Species; and
- Section 9 – Onshore Natura 2000 Sites.

1.2. Consultation

5. This report is composed of several sections which have been informed by consultation over the course of the pre-application phase of Norfolk Boreas, as well as pre-application and examination phase of the Norfolk Vanguard project. The vehicles for the consultation have been:

- The Scoping Report and request for a scoping opinion (May 2017);
- The Evidence Plan Process (EPP), including:
    - Consultation on the offshore HRA Screening (also provided as Appendix 10.3 of the Preliminary Environmental Information Report (PEIR) (Norfolk Boreas, 2018));
    - Consultation on the onshore HRA Screening (also provided as Appendix 22.15 of the PEIR);
    - Consultation on the draft HRA (March 2019); and
- The statutory consultation undertaken as part of the pre-application phase of consultation (i.e. the PEIR under Section 42 of the Planning Act 2008) (October to December 2018).
- The Norfolk Vanguard consultation undertaken as part of the pre-application phase of consultation (i.e. the PEIR) (October to December 2017).
- The Norfolk Vanguard EPP.

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

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

8. 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;
  - Centre for Environment Fisheries and Aquaculture Science (Cefas);
  - The Wildlife Trusts (TWT); and
  - Whale and Dolphin Conservation (WDC).
- Onshore ecology ETG:
  - Norfolk County Council;
  - Breckland Council;
  - Environment Agency;
  - Natural England;
  - North Norfolk District Council; and
  - Norfolk Wildlife Trust.

9. Table 1.1 provides a summary of consultation of relevance to the Norfolk Boreas HRA that has been undertaken as part of the Norfolk Vanguard and Norfolk Boreas EPPs. Full details of the consultation undertaken for the EPP are provided as appendices 9.1 to 9.45, 27.1 to 27.8 and 28.1 of the Consultation Report (document reference 5.1) submitted with the DCO application.

Table 1.1 Key Consultation in relation to HRA undertaken as part of the Norfolk Boreas and Norfolk Vanguard EPP.

Date	Contact Type	Organisation	Topic
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).
6th July 2017	Meeting	NE, TWT, WDC, Cefas	Marine mammal HRA Screening agreed and approach to HRA discussed (minutes provided in Appendix 9.26 of the Consultation Report (document 5.1).
14th July 2017	Email	NE, NCC, NWT, EA	Onshore HRA Screening (Appendix 5.2) provided for consultation
18th July 2017	Meeting	NE, NCC, NWT, EA	Onshore HRA Screening discussed and approach agreed (minutes provided in Appendix 9.17 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 9.26 of the Consultation Report (document 5.1)
15th December 2017	S42 feedback	Stakeholders	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 24.1 of the Consultation Report (document 5.1).

Date	Contact Type	Organisation	Topic
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 28.1 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 28.1 of the Consultation 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 28.1 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 28.1 of the Consultation Report (document 5.1)
31st October 2018	S42 Consultation on the PEIR	All	HRA screening and approach to assessments provided as appendix 10.3 and 22.15 of the Norfolk Boreas PEIR.
18th February 2019	Meeting	NE, EA, NCC, Breckland DC, North Norfolk DC	Onshore Ecology EIA and HRA.
21st February 2019	Meeting	NE, MMO and EIFCA	Agreement on the impacts and approach to HRA for Haisborough, Hammond and Winterton SAC.
21st February 2019	Meeting	NE, MMO and TWT	Agreement on the impacts to be assessed as part of the HRA for Marine Mammals
27th February 2019	Meeting	NE and RSPB	Agreement on the impacts to be assessed as part of the HRA for Offshore Ornithology.
22nd March 2019	Review of draft HRA	NE, MMO, TWT, WDC, RSPB, EIFCA, EA, NNDC	Draft Information to support HRA report provided for review by all interested parties.

Date	Contact Type	Organisation	Topic
29th March 2019	Email	MMO	Confirmation that the MMO would not be reviewing the draft Information to support HRA report
29th March 2019	Email	WDC	Confirmation that WDC would not be reviewing the draft Information to support HRA report
5th April 2019	Email	RSPB	Comments on the Norfolk Boreas draft Information to support HRA report
10th April 2019	Email	TWT	Comments on the Norfolk Boreas draft Information to support HRA report
11th April 2019	Email	EIFCA	An update was provided to Norfolk Boreas Limited on status of new byelaws within the SAC.
23rd April 2019	Email	Natural England	Comments on the Norfolk Boreas draft Information to support HRA report

2. LEGISLATION, POLICY AND GUIDANCE

2.1. Legislative Context

10. 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 and the Conservation of Offshore Marine Habitats and Species Regulations 2017.

11. Currently, and subject to future events, the UK is set to exit the European Union on the 31st October. The draft Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 provide for amendments to the Habitats Regulations to enable their continued effective operation from the day on which the UK exits the European Union. Therefore, and notwithstanding the uncertainty of future events, it is expected that effective operation of the Habitat Regulations will continue after the exit day.

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; and
- Natural England and JNCC: Interim Displacement Advice Note.

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. The offshore wind farm comprises the Norfolk Boreas site, within which wind turbines, offshore electrical platforms, an offshore service platform 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.

22. The Norfolk Boreas wind farm may also be connected to the Norfolk Vanguard offshore wind farm (its "sister project") located in an adjacent area of sea. Norfolk Boreas would connect to Norfolk Vanguard via project interconnector cables which would be located within a project interconnector search area.

23. A full project description is given in the Environmental Statement, Chapter 5 Project Description.

24. Once built, Norfolk Boreas would have an export capacity of up to 1,800MW which is enough to power nearly 2 million UK households[1]. The offshore components of the project are as follows:

- Wind turbines;
- Offshore electrical platforms;
- An offshore service platform;
- Met masts;
- Lidar;
- Array cables;
- Inter-connector cables; or project interconnector cables; and
- Export cables.

25. The 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.

26. In order to minimise potential effects associated with onshore construction works for the two projects, VWPL is aiming to carry out enabling works for both projects at

[1] Based on a load factor of 47.3% which is advocated by BEIS for new offshore wind farm projects (BEIS, 2018) and RenewableUK www.renewableuk.com/page/UKWEDExplained

the same time. As such Norfolk Vanguard Limited as part of their DCO application, are seeking to obtain consent to undertake the following:

- Installation of ducts to house Norfolk Boreas cables along the entirety of the onshore cable route from the landfall zone to the onshore project substation;
- A47 junction works for both projects and installation of a shared access road up to the Norfolk Vanguard substation;
- Overhead line modifications at the Necton National Grid substation, which would accommodate both projects.

27. If both projects secure consent these works will be provided for within the Norfolk Vanguard DCO. This is the preferred option and considered to be the most likely however, Norfolk Boreas needs to consider the possibility that Norfolk Vanguard may not proceed to construction. In order for Norfolk Boreas to stand as an independent project, this possibility must be provided for within the Norfolk Boreas DCO. Thus, consent will be sought for the following two alternative scenarios within the DCO, and both scenarios have therefore been assessed as part of the Environmental Impact Assessment (EIA):

- **Scenario 1** – Norfolk Vanguard proceeds to construction and installs ducts and other shared enabling works for Norfolk Boreas.
- **Scenario 2** – Norfolk Vanguard does not proceed to construction and Norfolk Boreas proceeds alone. Norfolk Boreas undertakes all works required as an independent project.

28. Further information on the two Scenarios is provided in Environmental Statement (ES) Chapter 5 Project and Appendix 5.1 to that Chapter. The two scenarios have not materially affected the way the information to support HRA has been undertaken. They have not affected Stage 1- Screening in any way as although the magnitude of a potential effect may differ with scenario, if a source, pathway and receptor (see Appendix 5.2 section 1.6) has been identified under one scenario it has also been identified under the other and likewise if a site or feature has been screened out because of a lack of source, pathway or receptor for one scenario it has also been screened out under the other.

29. Furthermore, the scenarios do not require further consideration during Stage 2 when assessing potential effects linked with the offshore parts of the Project as the Project would be very similar in the offshore environment regardless of the two different scenarios, the only difference being that under Scenario 2 a project interconnector could not be installed (see section 5.4.12 of the ES, Chapter 5 project description for further detail).

30. The Stage 2 assessment of onshore Natura 2000 sites (section 9) does undertake separate assessments for Scenario 1 and Scenario 2, however the overall conclusions

for each assessment are the same. This is also reflected in the integrity matrices (Appendix 6.1) which account for both Scenario 1 and Scenario 2.

31. 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, at the earliest, in 2025. Full details of the design of the proposed project are presented in the ES (Chapter 5 Project Description). Details of the design, where relevant to the HRA, are presented in sections 6 to 9 of this report.

3.1. Norfolk Vanguard

32. Norfolk Boreas Limited (‘the Applicant’ an affiliate company of Vattenfall Wind Power Ltd (VWPL)) is seeking a Development Consent Order for Norfolk Boreas. VWPL is also developing Norfolk Vanguard, a ‘sister project’ to Norfolk Boreas. Norfolk Vanguard is of the same maximum capacity and comprises two distinct areas, Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) (‘the Norfolk Vanguard OWF sites’) which are adjacent to the Norfolk Boreas site (Figure 5.1 of the Norfolk Boreas ES (document reference 6.2)). Norfolk Vanguard’s development schedule is approximately one year ahead of Norfolk Boreas and as such the Development Consent Order (DCO) application for that project was submitted in June 2018.

33. Norfolk Vanguard shares a grid connection location and also much of the offshore and onshore cable corridors with Norfolk Boreas therefore; VWPL has adopted a strategic approach to planning infrastructure for the two projects with the aim of optimising overall design and reducing impacts and disruption where practical.

34. The key areas of interaction between the projects are: consultation (section 1.2), commitment to mitigation (section 7.3.1 and 8.2.1) and the in combination assessment. It should be noted that Norfolk Vanguard is currently in examination and whilst this Information to Support HRA report has taken account of developments in that examination process, it has been necessary to impose a cut-off date after which no significant changes (minor updates have been made in response to deadline 7 where possible) could be made to this assessment as a result of changes to Norfolk Vanguard. The cut-off date was set as the 20th March 2019 to coincide with deadline 5 of the Norfolk Vanguard Examination.

4. NORFOLK BOREAS APPROACH TO HRA

4.1. HRA Process

35. 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 Boreas 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 Boreas project as proposed.

36. The stages of that sequence are described in Planning Inspectorate Advice Note 10 (Planning Inspectorate, 2017) and can be summarised 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.

37. An Offshore Screening Report and Onshore Screening Report were submitted for consultation through the EPP and Preliminary Environmental Information (PEI); updated versions of 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 – Adverse Effect on Integrity 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.

38. 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).

39. 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).
    - o 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.

40. 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

41. 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.

42. 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.

43. 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.

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

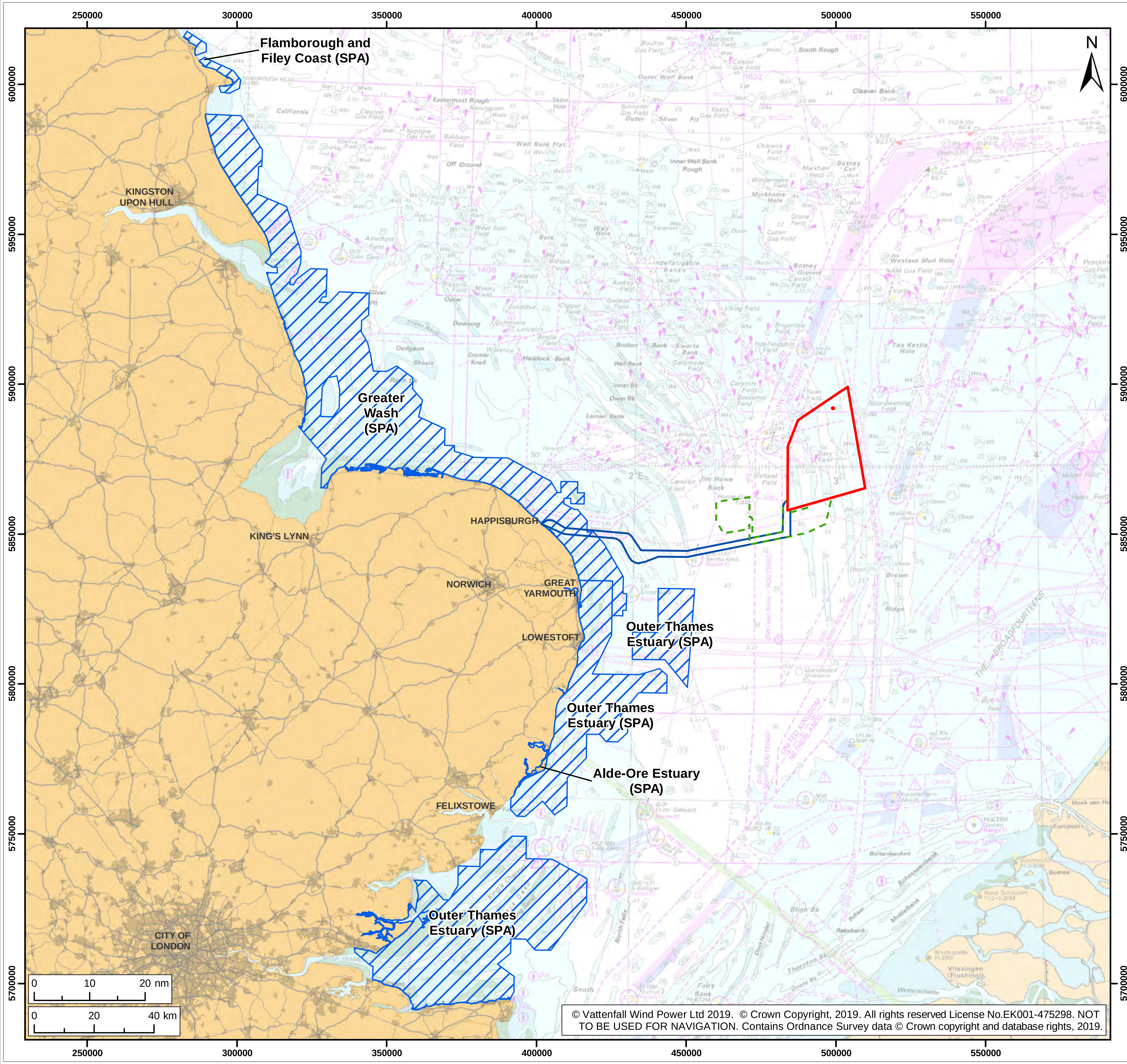
45. Norfolk Boreas Limited has interpreted the JNCC and Natural England advice and, for the proposed Norfolk Boreas project, followed the approach outlined for East Anglia THREE during its examination. Projects are included in the quantitative assessment where there is sufficient certainty and data confidence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

5. SCREENING

46. The Norfolk Boreas HRA Offshore and Onshore Screening process has been undertaken in consultation with relevant stakeholders through the EPP process see Appendix 5.1 (Offshore) and Appendix 5.2 (Onshore) for further detail on the process. Screening matrices are provided in Appendix 5.3.

5.1. Offshore ornithology

47. The Norfolk Boreas HRA Offshore Screening Report (Appendix 5.1), produced in consultation with Natural England and the RSPB (see section 1.2), identified SPAs and features for further assessment for which it was not possible to rule out the potential for LSE as a result of activities during construction, O&M and decommissioning of Norfolk Boreas. These are discussed below.



Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Special Protection Area (SPA)[1]

[1] JNCC, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

SPAs screened into HRA for Norfolk Boreas

Figure: 5.1	Drawing No: PB5640-007-002-025

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	26/02/2019	LB	DT	A3	1:1,250,000

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

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5.1.1. Alde-Ore Estuary SPA

48. Lesser black-backed gulls (a breeding feature) are unlikely to show displacement or barrier effects as a result of Norfolk Boreas 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 Boreas 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 due to displacement or barrier effects at Norfolk Boreas either alone or in-combination is considered to be negligible and no further assessment of these aspects is required.

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

50. Lesser black-backed gulls have a mean maximum foraging range of 141km, and with Norfolk Boreas located 111km 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 Boreas and further consideration is provided in the following sections.

5.1.2. Outer Thames Estuary SPA

51. 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 Boreas).

52. 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; Dierschke et al., 2017, Mendel et al. 2019). Therefore, there is potential for an LSE on the Outer Thames Estuary SPA population due to disturbance and displacement resulting from the movement of operation and maintenance vessels through the SPA and further consideration of this potential impact on the red-throated diver population has been undertaken. Red-throated divers typically fly below collision height and the project collision assessment (Norfolk Boreas ES Chapter 13 Offshore Ornithology) reported very low collision risks. Therefore, no LSE is predicted for red-throated diver from the Outer Thames Estuary SPA in relation to collision risk. Although red-throated divers could modify their migration routes to avoid entering Norfolk Boreas, the additional distance this

could add to their migration route would be very small. Consequently, and consistent with the findings of Dierschke et al. (2017), there is no potential for an LSE for red-throated diver from the Outer Thames Estuary SPA in relation to barrier effects.

5.1.3. Flamborough and Filey Coast SPA

53. The Norfolk Boreas site is located c.220km from Flamborough and Filey Coast SPA and is therefore well beyond the typical foraging ranges for breeding common guillemots and, razorbills, and at or beyond even the maximum recorded ranges reported in that review (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 SPA colony and the site (220km)

Species	Foraging range (km)		
	Mean	Mean maximum	Maximum
Common guillemot	37.8	84.2	135
Razorbill	23.7	48.5	95

54. It can be concluded that auks breeding at the Flamborough and Filey Coast SPA are very unlikely to reach Norfolk Boreas while on foraging trips from the colony. Therefore, breeding season connectivity can be excluded for these species. When birds disperse from the colony in late summer, they may pass Norfolk Boreas, 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 Boreas on auks breeding at the Flamborough and Filey Coast SPA are in relation to displacement or barrier effects.

55. In the context of the large scale of movements of auks post-breeding (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; Furness 2015), the contributions to the regional populations from the Flamborough and Filey coast SPA populations are small (FFC populations are, guillemot: 41,607 pairs, razorbill: 10,570 pairs, which equate to 5% and 3.3% of the relevant BDMPS respectively). No significant cumulative displacement impacts were identified for these species in relation to the regional population, even with the application of highly precautionary assumptions about displacement effects. The same conclusion about the risk of displacement effects applies to the SPA population, therefore the potential for an LSE on the SPA populations of these species due to nonbreeding season displacement or barrier effects from the project alone or in-combination is considered to be negligible.

56. However, Natural England have advised that they consider there is a potential for a likely significant effect due to displacement from the Norfolk Boreas project alone and in-combination and therefore assessment has been undertaken.

57. 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 Boreas and the Flamborough and Filey SPA colony (220km), 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 SPA gannet and kittiwake populations due to collision risk are considered in greater detail in the following sections.

58. Kittiwakes have been found to exhibit either very low rates of displacement from offshore wind farms, or none at all (Krijgsveld et al. 2011, Leopold et al. 2011, Walls et al. 2013, Dierschke et al. 2016). Hence there is no potential for an LSE for kittiwakes from Flamborough and Filey coast SPA due to displacement and the same conclusion applies to the potential for an LSE due to barrier effects.

59. 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 Boreas ES Chapter 13 Offshore Ornithology), alone or cumulatively during any period of the year, including with reference to the Flamborough and Filey Coast SPA 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 SPA.

60. 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 SPA due to barrier effects is considered to be negligible, and no further assessment is required.

5.1.4. Greater Wash SPA

61. 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 Boreas is c. 57km 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).

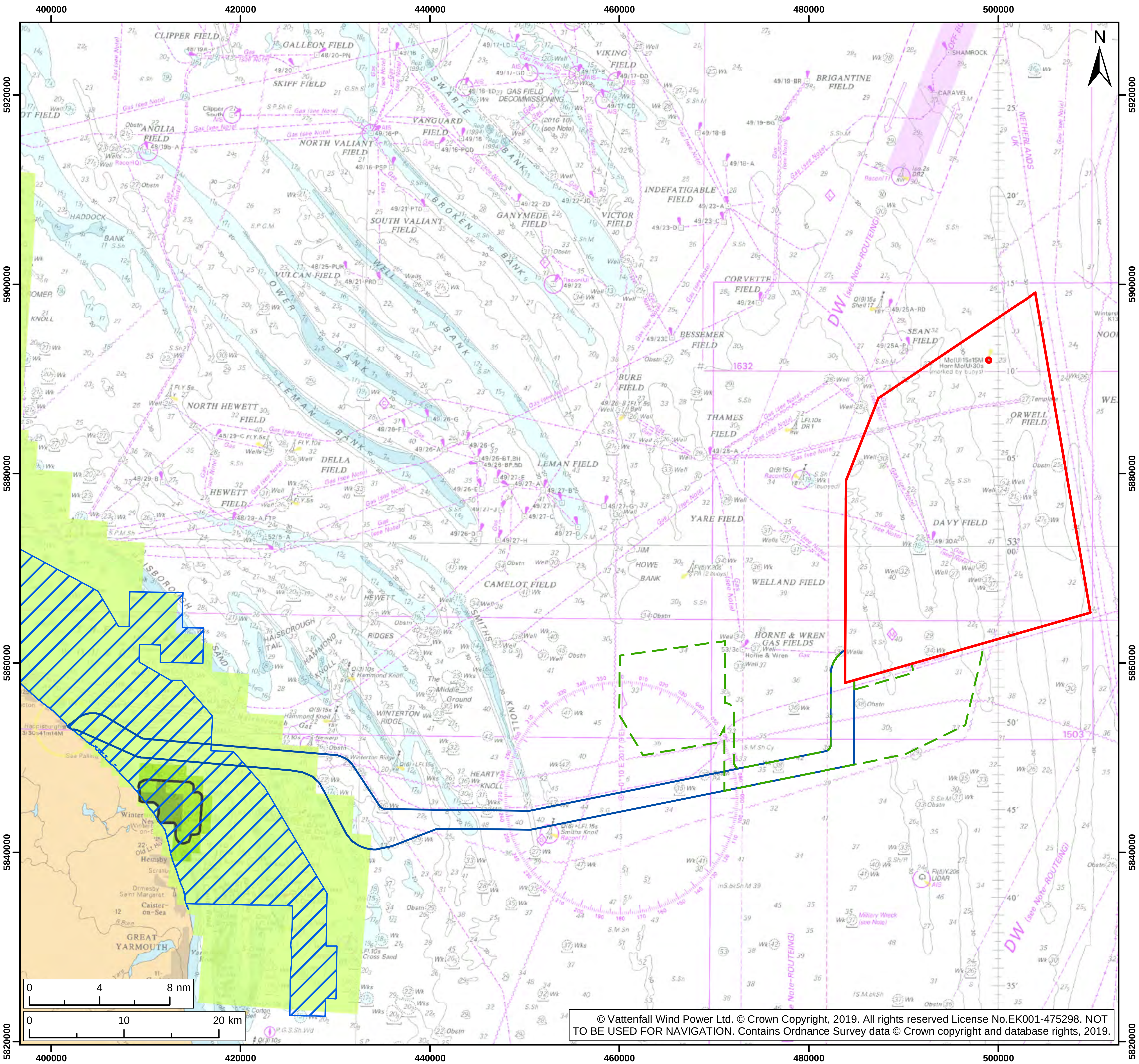
62. The foraging ranges of breeding terns tend to be short, and restricted to coastal waters (Wilson et al. 2014). The mean maximum foraging range of breeding terns was reported by Thaxter et al. (2012a) to be 6.3km for little tern, 15.2km for

common tern and 49km for Sandwich tern. For Sandwich tern, there are two colonies within Greater Wash SPA, both on the western part of the north Norfolk Coast. These are both more than 100km from the nearest point of Norfolk Boreas. Tracking data from studies of Sandwich terns at those colonies indicate that most foraging by Sandwich terns occurs within 20km of the north Norfolk coast (Wilson et al. 2014) and show negligible overlap, with the Norfolk Boreas area. Further tracking of Sandwich terns breeding at Scolt Head has been carried out in summers 2016, 2017, and 2018 by Bureau Waardenburg. Tracks indicated a very similar foraging distribution to that reported by Wilson et al. (2014) (Marc Collier, pers. comm.) It can therefore be concluded that no terns from the Greater Wash SPA colonies are expected to reach the Norfolk Boreas 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 Boreas are likely to come from many different populations, with minimal representation from North Norfolk colonies.

63. 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.

64. 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 Boreas (between August 2016 and July 2018). 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 Boreas 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.

65. 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 (see Figure 5.2). 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.



Legend

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Greater Wash SPA Boundary

Common Scoter Density (Birds per km²)

- 0.00 - 0.70
- 0.71 - 2.34
- 2.35 - 4.51
- Maximum Curvature Analysis (MCA) density threshold

Natural England and JNCC, 2016.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Greater Wash SPA Common Scoter Distribution and Norfolk Boreas Site and Offshore Cable Corridor

Figure: 5.2	Drawing No: Figure_5.2_CX_Density_SPA_NB				
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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66. 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 is 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 Boreas. Little gull has a low sensitivity to disturbance and displacement (Dierschke et al. 2016), 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.

67. 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; Dierschke et al., 2017, Mendel et al. 2019). 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 Boreas and further consideration of this potential impact on the red-throated diver population has been undertaken. Red-throated divers typically fly below collision height and the project collision assessment (Norfolk Boreas 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 divers could modify their migration routes to avoid entering Norfolk Boreas, the additional distance this could add to their migration route would be very small. Consequently, and consistent with the findings of Dierschke et al. (2017), there is no potential for an LSE for red-throated diver from the Greater Wash SPA in relation to barrier effects.

68. The SPAs for which an LSE could not be ruled out, and the species and impacts on which these determinations were based are listed in Table 5.2 and shown in Figure 5.1.

Table 5.2 SPAs and features for which an LSE could not be ruled out and for which further assessment has been conducted for potential impacts by the proposed Norfolk Boreas project alone or in-combination with other plans and projects.

SPA (See Figure 5.1)	Features	Potential impact	Project alone	In-combination
Alde-Ore Estuary	Lesser black-backed gull (breeding)	Collision risk	Yes	Yes
Outer Thames Estuary	Red-throated diver (nonbreeding)	Displacement due to operation and maintenance vessel movements	Yes	Yes
Flamborough and Filey Coast	Gannet (breeding) Kittiwake (breeding)	Collision risk	Yes	Yes
	Gannet (breeding) Guillemot (breeding) Razorbill (breeding)	Displacement during operation	Yes	Yes
Greater Wash	Red-throated diver (nonbreeding)	Construction disturbance and displacement due to cable laying	Yes	Yes
	Red-throated diver (nonbreeding)	Displacement due to operation and maintenance vessel movements	Yes	Yes
	Common scoter (nonbreeding)	Construction disturbance and displacement due to cable laying	No	No
	Little gull (nonbreeding)	Collision risk	Yes	Yes

5.2. Annex I Habitats

69. The Norfolk Boreas HRA Offshore Screening Report (Appendix 5.1) in consultation with Natural England, as part of the Norfolk Boreas EPP (and Section 42 Consultation), identified the Haisborough, Hammond and Winterton SAC (Figure 5.3) as the only site where a LSE associated with the activities during construction, O&M and decommissioning of Norfolk Boreas could not be ruled out.

70. The Haisborough, Hammond and Winterton SAC is located to the west of Norfolk Boreas site 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.

71. The reef-forming tube worm *Sabellaria spinulosa* (*S. spinulosa*) is distributed across the site and is prevalent in the troughs between closely-spaced sandbanks (JNCC, 2018).

72. 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 Boreas.

73. 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.

74. There was an understanding during an EPP meeting with both Norfolk Vanguard and Norfolk Boreas (meeting date: 31/01/18) 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. However Natural England have updated their position on this during the Norfolk Vanguard Examination.

75. 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.

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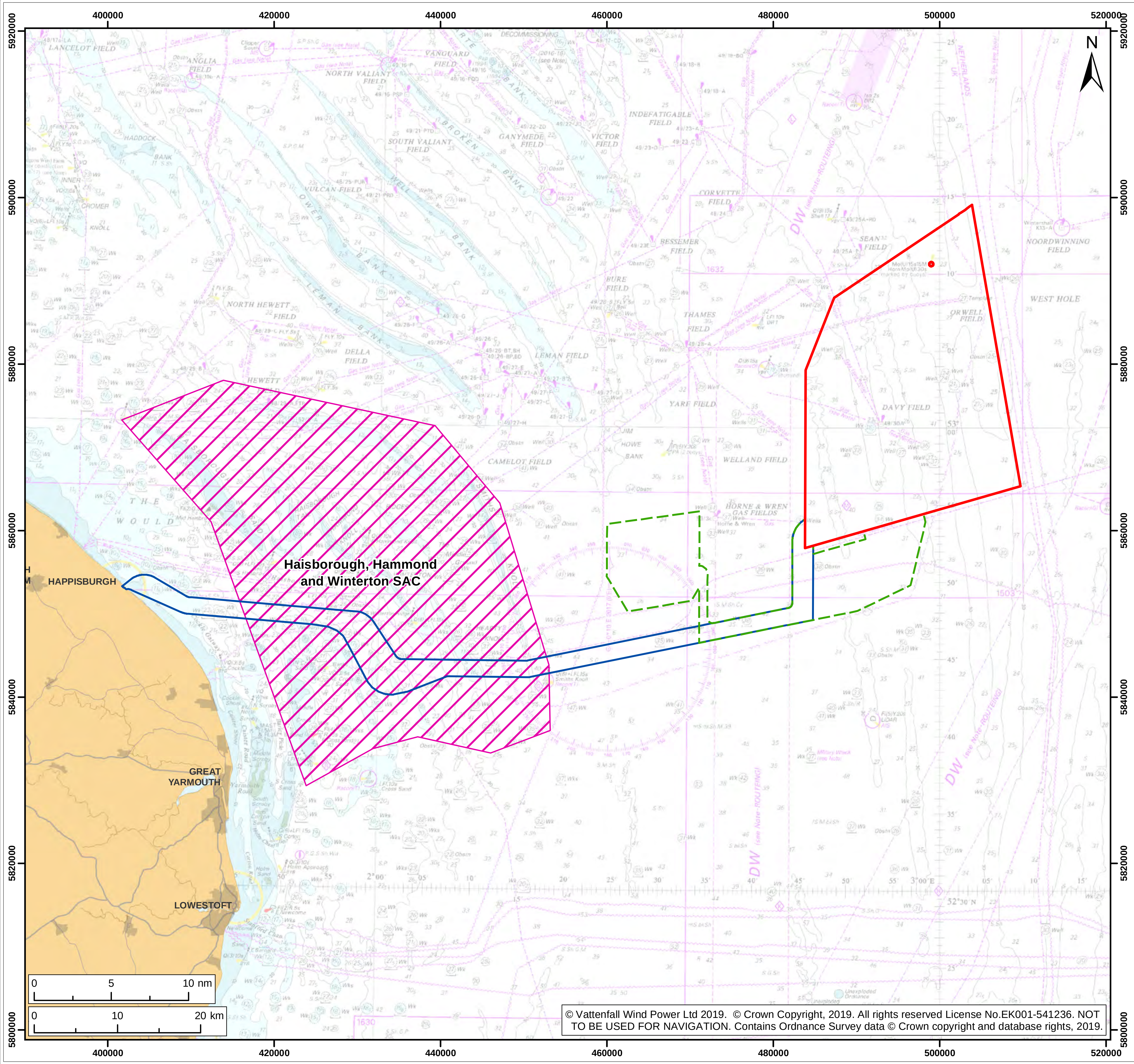

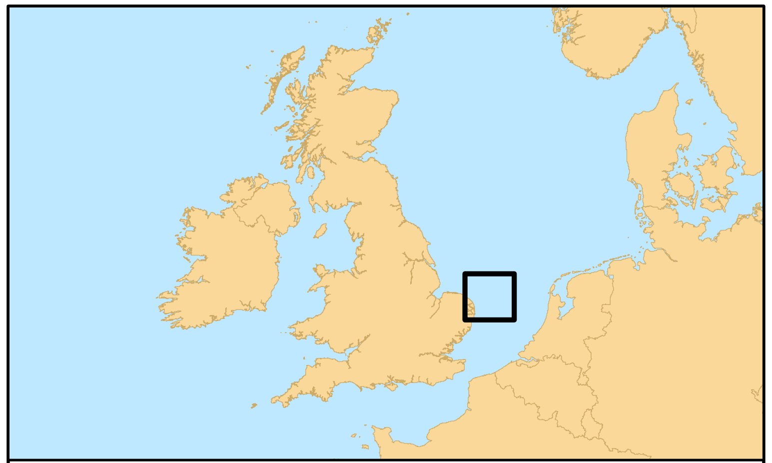

Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Special Area of Conservation (SAC)[1]

[1] JNCC, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Haisborough Hammond and Winterton SAC

Figure: 5.3 Drawing No: PB5640-007-002-001

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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5.3. Annex II Marine Mammals

76. The Norfolk Boreas HRA Offshore Screening Report (Appendix 5.1), in consultation with Natural England, the Marine Management Organisation (MMO), Centre for Environment Fisheries and Aquaculture Science (Cefas), The Wildlife Trusts (TWT) and Whale and Dolphin Conservation (WDC), as part of the Norfolk Boreas 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 Boreas could be ruled out. The following Natura 2000 designated sites were therefore “screened in” for further assessment:

- The Southern North Sea SAC 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*.

77. 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 Wash and North Norfolk SAC or Winterton-Horsey Dunes SAC, to determine if there is the potential for any disturbance at these sites.

78. Bottlenose dolphin *Tursiops truncatus* was not identified during Norfolk Boreas aerial surveys and no bottlenose dolphin were positively sighted during the aerial surveys of the adjacent Norfolk Vanguard site (Norfolk Vanguard Ltd, 2018) or the nearby East Anglia THREE site (EATL, 2015). During the SCANS-III surveys in summer 2016, no bottlenose dolphin were recorded in or around the area of Norfolk Boreas (Hammond et al*.,* 2017). 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 (Coefficient of Variation (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 Boreas is located in the Greater North Sea (GNS) MU, which has an estimated population size of zero (Inter Agency Marine Mammal Working Group (IAMMWG), 2015). Taking into account the very low occurrence of sightings in and around Norfolk Boreas 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).

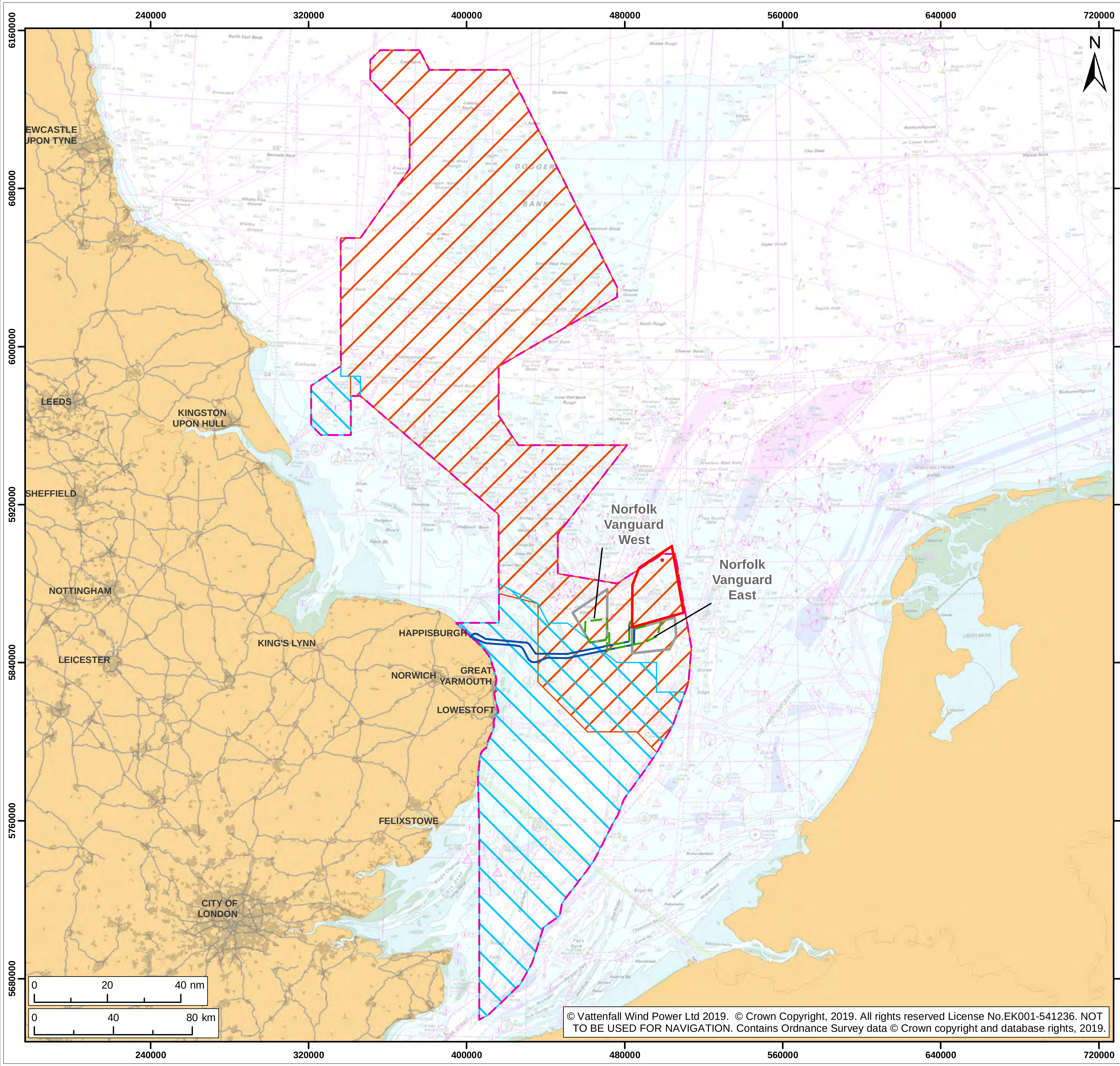
5.3.1. Southern North Sea SAC

79. The Southern North Sea Special Area of Conservation (SAC) has been recognised as an area with persistent high densities of harbour porpoise (Joint Nature Conservation Committee (JNCC), 2017a; Heinänen and Skov, 2015). The SAC 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 SAC being important in the summer and the remaining 33% of the site being important in the winter period (Figure 5.4; JNCC, 2017a).

80. Norfolk Boreas is located within the Southern North Sea SAC (Figure 5.4).

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

- Underwater noise;
- Vessel interactions;
- Changes to water quality;
- Indirect effects through effects on prey species, including habitat loss; and
- Any in-combination effects.



Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Norfolk Vanguard
- Southern North Sea Special Area of Conservation (SAC)[1]
- Summer Area[1]
- Winter Area[1]

[1]JNCC, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Southern North Sea Special Area of Conservation for harbour porpoise

Figure: 5.4 | Drawing No: PB5640-007-002-002

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04	07/05/2019	JT	GS	A3	1:1,900,000
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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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5.3.2. Humber Estuary SAC

82. 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).

83. The Humber Estuary SAC is located 175km from Norfolk Boreas site and 112km from the offshore cable corridor (at closest point; Figure 5.5). The Humber Estuary SAC was screened in to the HRA to take into account the movements of grey seal along the east coast of England (see Plate 8.3).

84. Assessment of potential effects on the Humber Estuary SAC in the Norfolk Boreas HRA Offshore Screening Report (Appendix 5.1), identified that the potential effects during the construction, operation and maintenance and decommissioning of Norfolk Boreas to be considered in the HRA are:

- Underwater noise;
- Vessel interactions;
- Changes to water quality;
- Indirect effects through effects on prey species; and
- Disturbance at seal haul-out sites.

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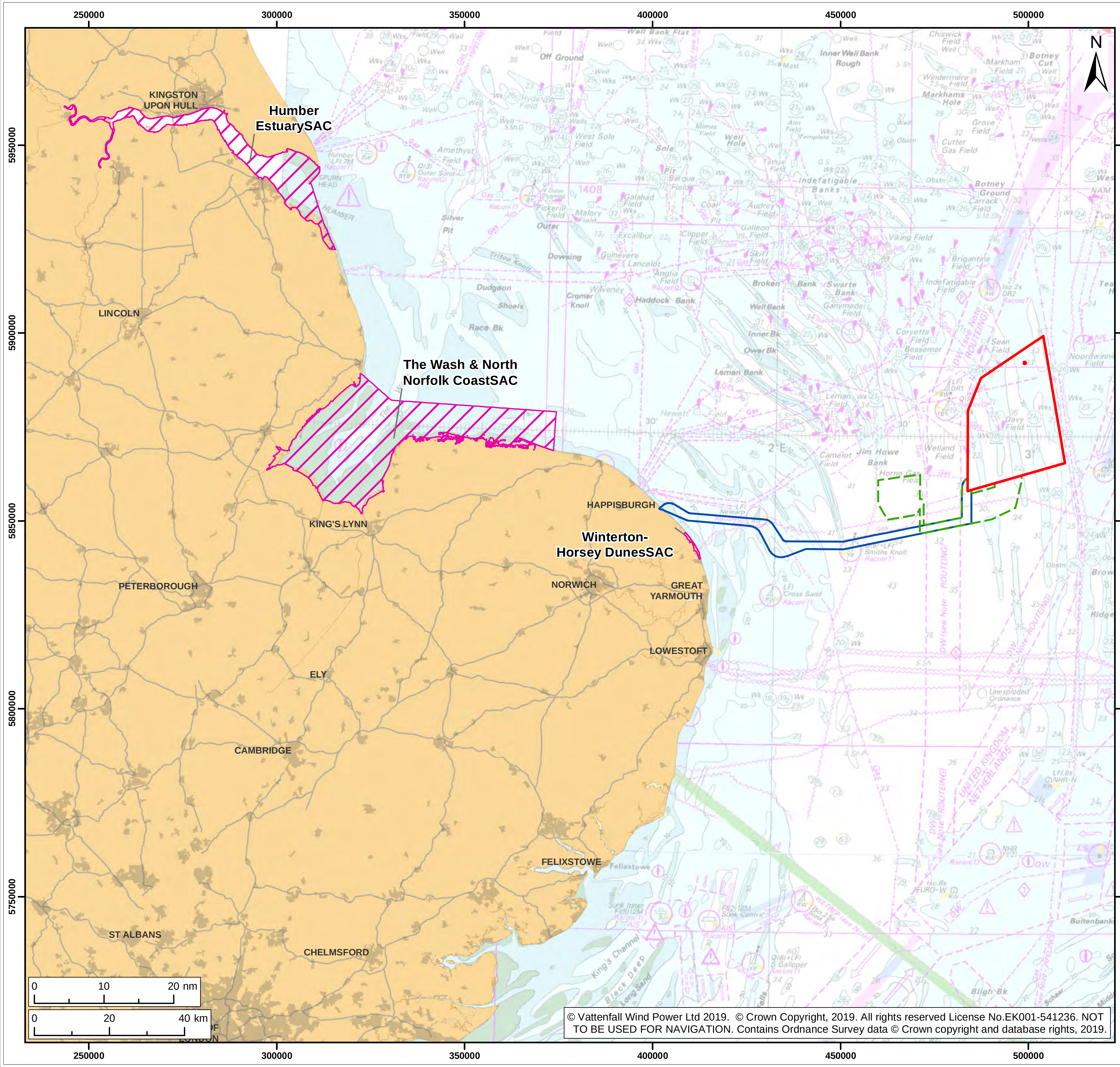

Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Seal Special Area of Conservation (SAC) sites screened in[1]

[1]Natural England, 2018

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Special Area of Conservation sites that list seal species as designated features in proximity to Norfolk Boreas

Figure: 5.5 Drawing No: PB5640-007-002-003

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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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

86. 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.

87. The Wash and North Norfolk Coast SAC is located approximately 110km from the Norfolk Boreas site and 34km from the offshore cable corridor. The distance to Blakeney Point is approximately 44km from the landfall location and 121km from the Norfolk Boreas site (Figure 5.5). The Wash and North Norfolk Coast SAC was screened in to the HRA to take into account the movements of harbour seal along the east coast of England (Plate 8.4).

88. Assessment of potential effects on The Wash and North Norfolk Coast SAC in the Norfolk Boreas HRA Offshore Screening Report (Appendix 5.1), identified that the potential effects during the construction, operation and maintenance and decommissioning of Norfolk Boreas to be considered in the HRA are:

- Underwater noise;
- Vessel interactions;
- Changes to water quality;
- Indirect effects through effects on prey species; and
- Disturbance at seal haul-out sites.

5.3.4. Winterton-Horsey Dunes SAC

89. 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.

90. Norfolk Boreas is located approximately 73km offshore (at the closest point to shore). The landfall for the Norfolk Boreas offshore export cables will approximately 9km from the Horsey seal haul-out site (Figure 5.5).

91. Assessment of potential effects on the Winterton-Horsey Dunes SAC in the Norfolk Boreas HRA Offshore Screening Report (Appendix 5.1), identified that the potential

effects during the construction, operation and maintenance and decommissioning of Norfolk Boreas to be considered in the HRA are:

- Underwater noise in the cable corridor;
- Vessel interactions in the cable corridor;
- Changes to water quality in the cable corridor;
- Indirect effects through effects on prey species in the cable corridor; and
- Disturbance at seal haul-out sites.

5.3.5. Other European Designated Sites

92. Since the initial HRA screening the data has been reviewed. For grey seal, all designated sites within 100km, based on the typical foraging range of grey seal (SCOS, 2017), have also been considered further in the HRA for any potential effects on foraging grey seal. For harbour seal, all designated sites within 80km, based on the typical foraging range of 50-80km for harbour seal (SCOS, 2017), have also been considered further in the HRA for any potential effects on foraging harbour seal. These sites are:

- Klaverbank (NL2008002) located 67km from the Norfolk Boreas site for both grey and harbour seal; and
- Noordzeekustzone (NL9802001) located 94km from the Norfolk Boreas site for grey seal.

5.3.6. Screening summary

93. 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 SAC	Harbour porpoise	The potential effects from underwater noise; vessel interactions; indirect effects through effects on prey species and any changes in water quality. Norfolk Boreas is within the SAC. It is assumed that all harbour porpoise in this area are associated with this SAC.
Humber Estuary SAC [UK0030170]	Grey seal	Potential for effects from underwater noise; vessel disturbance / interaction; disturbance at seal haul-out sites if a port to the north of Norfolk Boreas is selected; indirect effects through impacts to prey species and changes in water quality.
The Wash and North Norfolk Coast SAC [UK0017075]	Harbour seal (and grey seal)	Potential for effects from underwater noise; vessel disturbance / interaction; disturbance at seal haul-out sites if a port to the north of Norfolk Boreas is selected; indirect effects through impacts to prey species and changes in water quality.

Site	Species	Reason for screening decision
Winterton-Horsey Dunes SAC [UK0013043]	(Grey seal)	Potential for effects from underwater noise in the cable corridor (cable laying); vessel disturbance / interaction in the cable corridor; disturbance at seal haul-out sites depending on distance from landfall and vessel routes; indirect effects through impacts to prey species and changes in water quality.
Klaverbank SAC [NL2008002]	Grey and harbour seal	Potential effects for foraging grey and harbour seal.
Noordzeekustzone SAC [NL9802001]	Grey seal	Potential effects for foraging grey seal.

5.4. Onshore Natura 2000 sites

94. The Norfolk Boreas HRA Onshore Screening Report (herein the 'Onshore Screening Report') (Appendix 5.2), in consultation with Natural England (as part of the Norfolk Vanguard and Norfolk Boreas 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 Boreas onshore project area could not be ruled out[2]. These Natura 2000 designated sites were therefore "screened in" for further assessment and include:

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

95. 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 5.4.

5.4.1. River Wensum SAC

96. The River Wensum is designated as a SAC and is intersected by the Norfolk Boreas 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*;

[2] As discussed in section 3, although the different scenarios (outlined in section 3 and described in detail in Chapter 5 of the ES) have been considered when undertaking Screening, this has not resulted in any site being screened in or out for one scenario and not the other.

- Desmoulin's whorl snail *Vertigo moulinsiana*;
- Brook lamprey *Lampetra planeri*; and
- Bullhead Cottus gobio.

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

5.4.1.1. Potential effects

98. 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.

99. 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. HDD). The use of this technique will ensure no direct effects upon any of the qualifying features of the SAC.

100. 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.

101. 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.

102. 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.

103. 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

104. 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 3km from the onshore project area associated with the Norfolk Boreas project.

5.4.2.1. Potential effects

105. 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.

106. 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.

107. 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.

108. As the boundary of the Paston Great Barn SAC is located approximately 3km from the onshore project area, direct effects on the SAC have been screened out from further assessment.

5.4.3. Norfolk Valley Fens SAC

109. 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;

[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.

- 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.

110. 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:

- 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

111. 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.

112. 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.

113. 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]

[4] Following consultation undertaken on a draft version of this report as part of the Norfolk Vangaurd EPP, 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.

5.4.4. The Broads SAC

114. The Broads SAC comprises 28 separate competent SSSIs which support a range of important habitats, 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. Collectively, The Broads support the following features:

- 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*;
- Alkaline fens;
- Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae);
- *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*);
- Desmoulin's whorl snail;
- Fen orchid Liparis loeselii;
- Ramshorn snail Anisus vorticulus;
- Otter Lutra lutra.

115. The qualifying features listed above are indicative of The Broads SAC and not all species have been recorded at every component SSSI. Two component SSSIs of The Broads SAC (Calthorpe Broads SSSI and Broad Fen, Dilham SSSI) have been identified within 5km of the Norfolk Boreas onshore project area. The qualifying features identified at Calthorpe Broads SSSI and Broad Fen, Dilham SSSI include:

- Alkaline fens;
- Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae);
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*;
- Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation;
- Otter Lutra lutra.

5.4.4.1. Potential effects

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

117. 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 3.6km from the onshore project area.

118. Potential direct effects upon qualifying features supported by ex situ habitats have been screened in for further assessment in relation to otter only, due to the large range of this species.

119. Potential indirect effects of the project include effects arising from alterations to the groundwater/hydrology regime. As such, these potential indirect impacts (upon both habitat within the SAC boundary and ex situ habitats supporting otter) have been screened in for further assessment.

5.4.5. Sites screened out from further assessment

120. 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.

121. 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.

122. 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.

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

5.4.6. Summary of Onshore Screening for LSE

124. The onshore Natura 2000 sites (shown in Figure 5.6) screened in to the appropriate assessment stage of the HRA are summarised in Table 5.4.

Table 5.4 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	3km	• 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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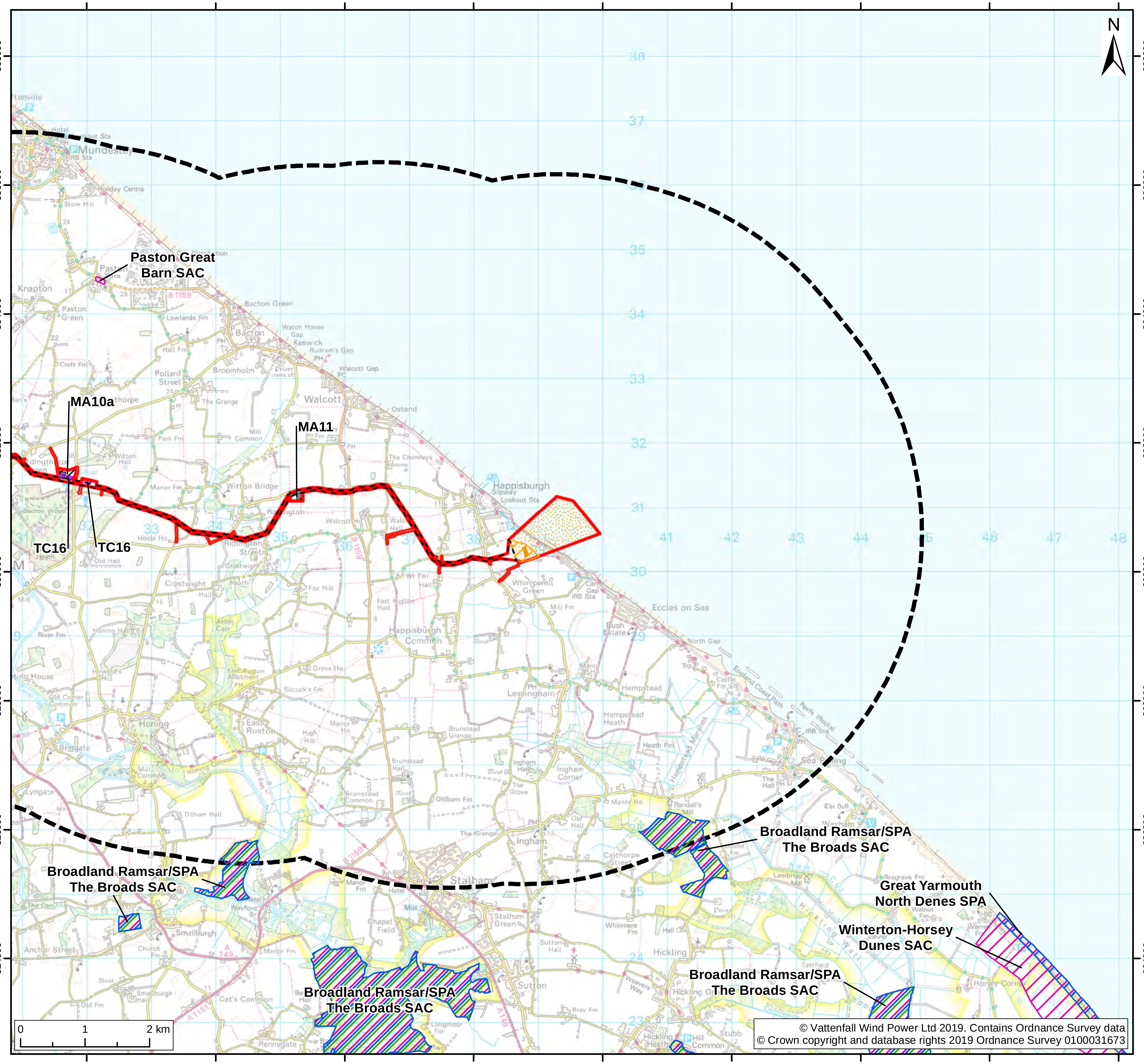

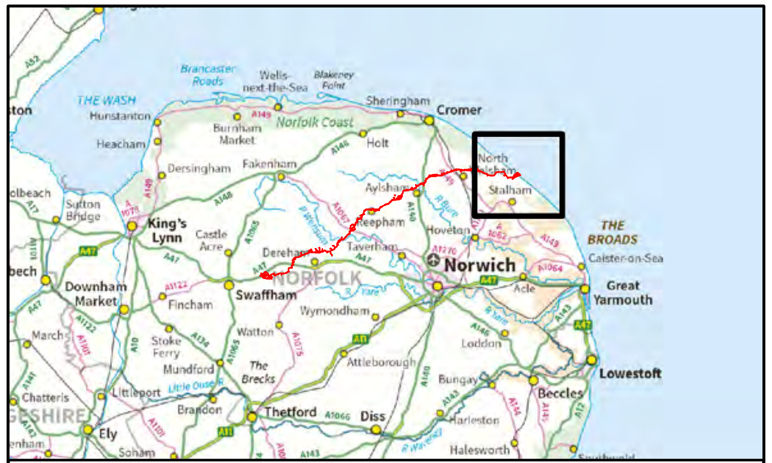

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Landfall zone
- Landfall compound zone
- Indicative landfall compound
- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designation[1]

- Special Area of Conservation (SAC)
- Special Protection Area (SPA)
- Ramsar

[1] Natural England, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

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

Figure: 5.6a Drawing No: PB5640-007-002-004a

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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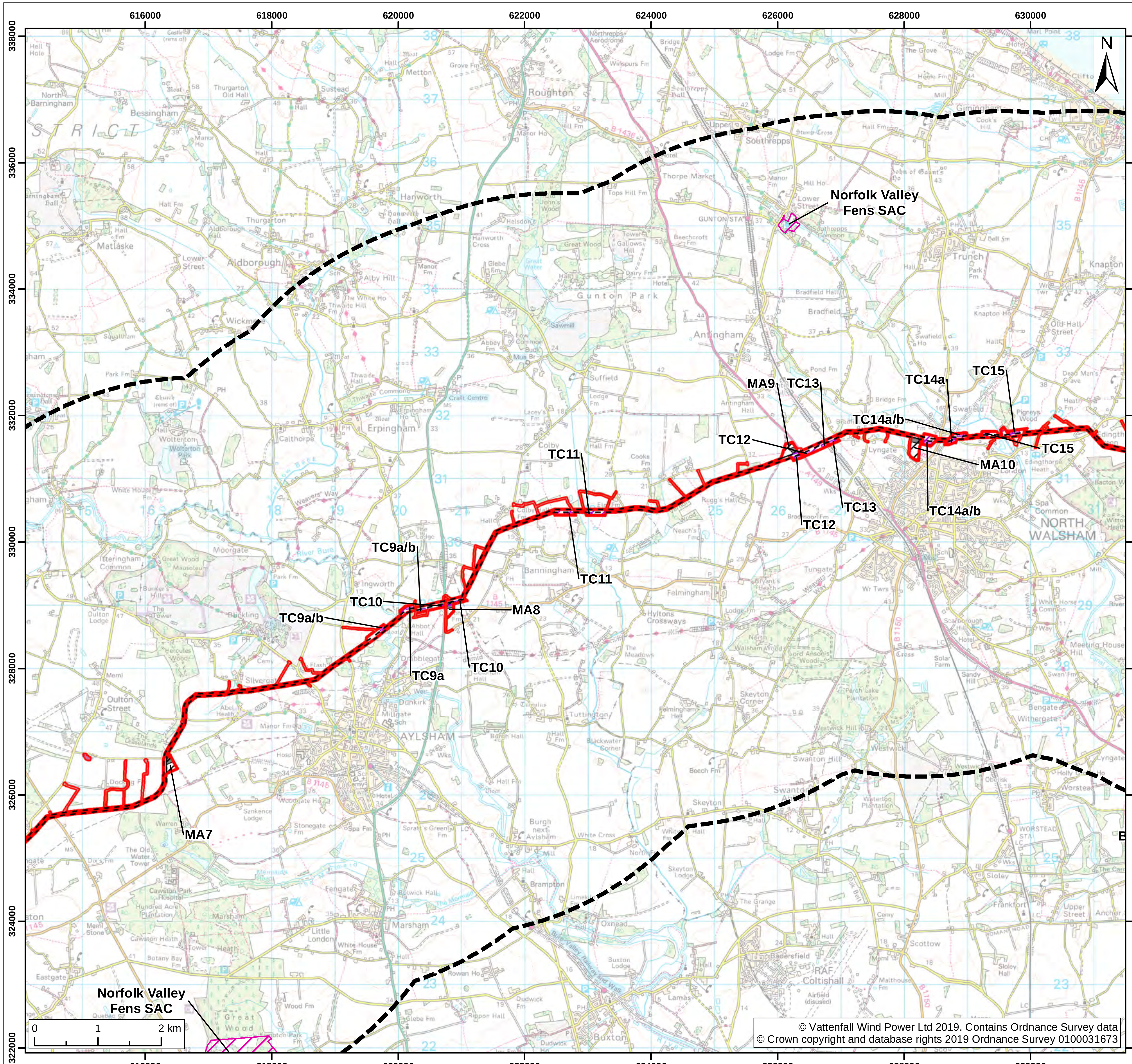

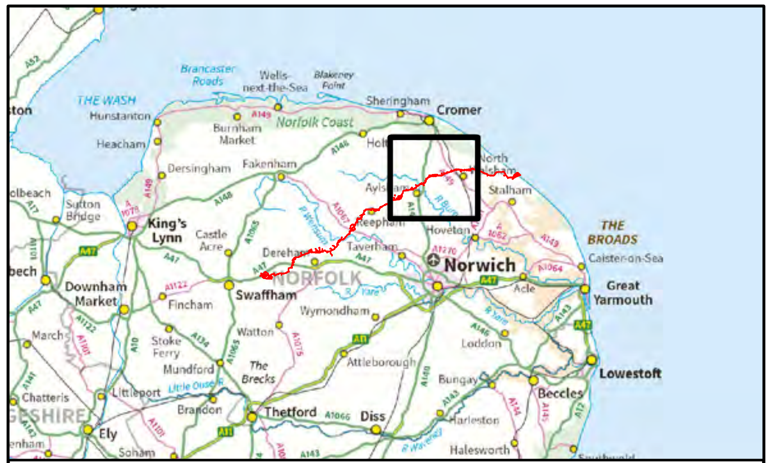

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Cable logistics area
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designation[1]

- Special Area of Conservation (SAC)

[1] Natural England, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

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

Figure: 5.6a Drawing No: PB5640-007-002-004a

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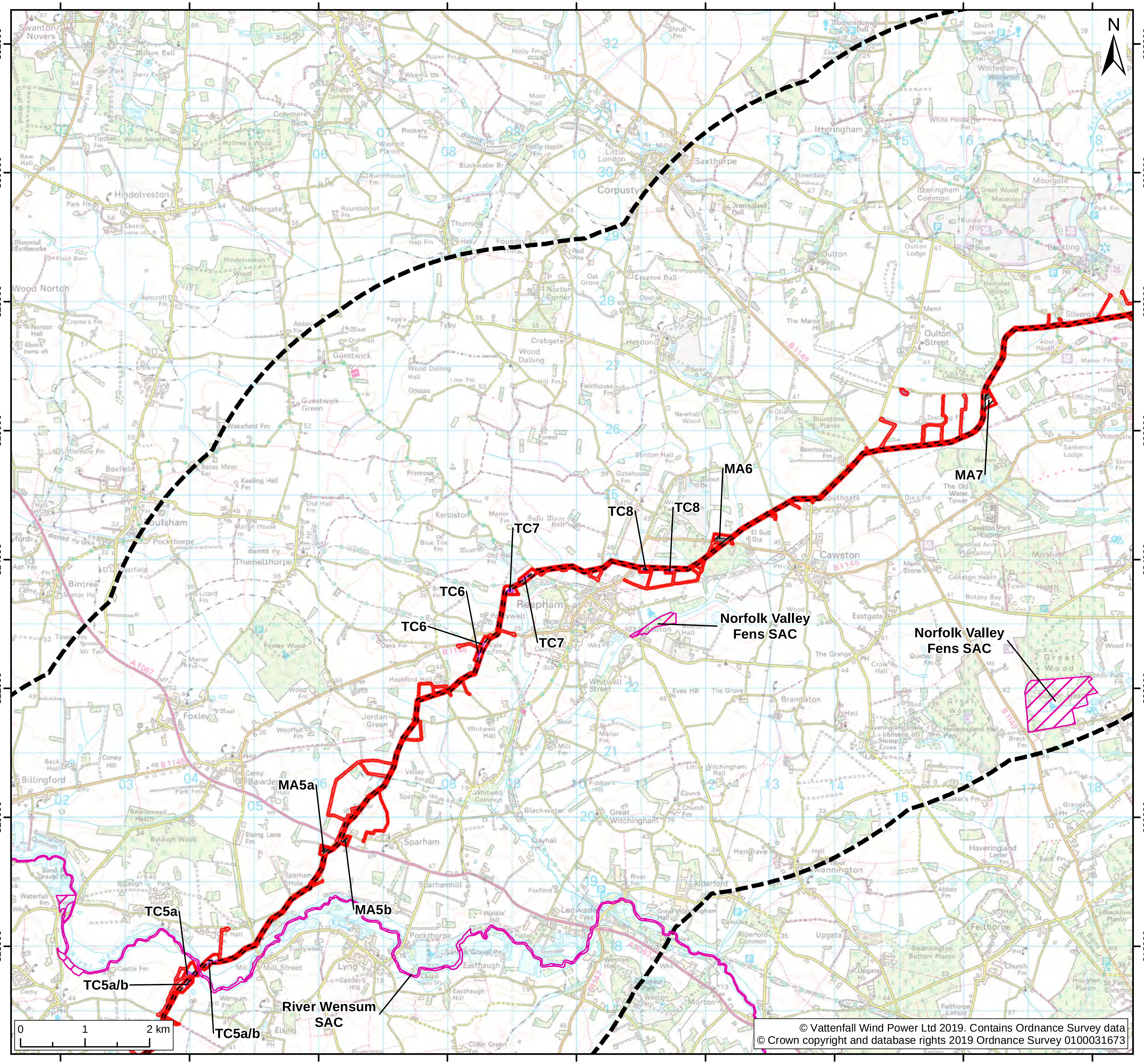

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Cable logistics area
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designation[1]

- Special Area of Conservation (SAC)

[1] Natural England, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

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

Figure: 5.6a Drawing No: PB5640-007-002-004a

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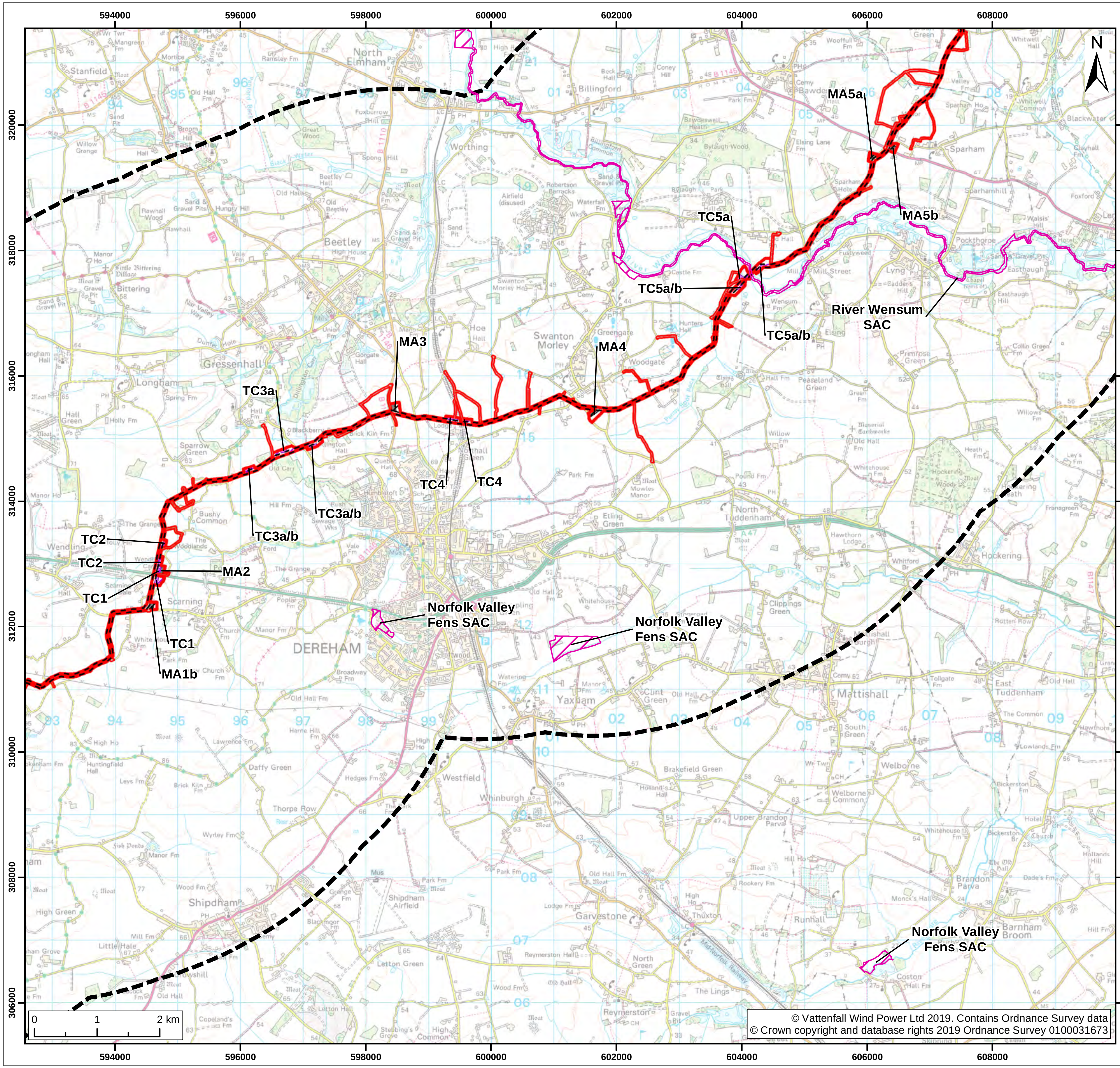

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designation[1]

- Special Area of Conservation (SAC)

[1] Natural England, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

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

Figure: 5.6a — Drawing No: PB5640-007-002-004a

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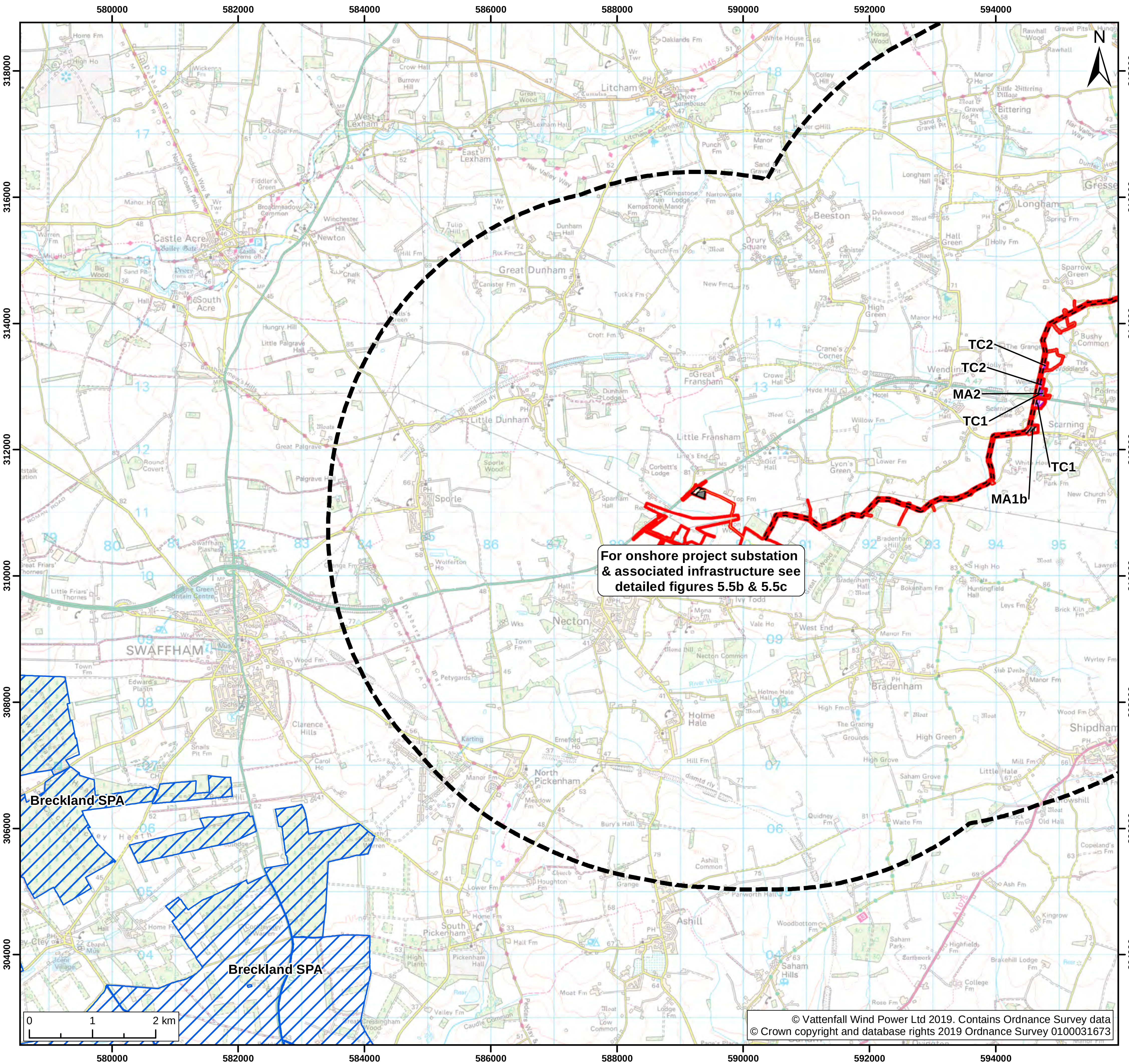

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Mobilisation zone
- Indicative mobilisation area compound
- Construction access
- Operational access
- Permanent access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designation[1]

- Special Protection Area (SPA)

[1] Natural England, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

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

Figure: 5.6a | Drawing No: PB5640-007-002-004a

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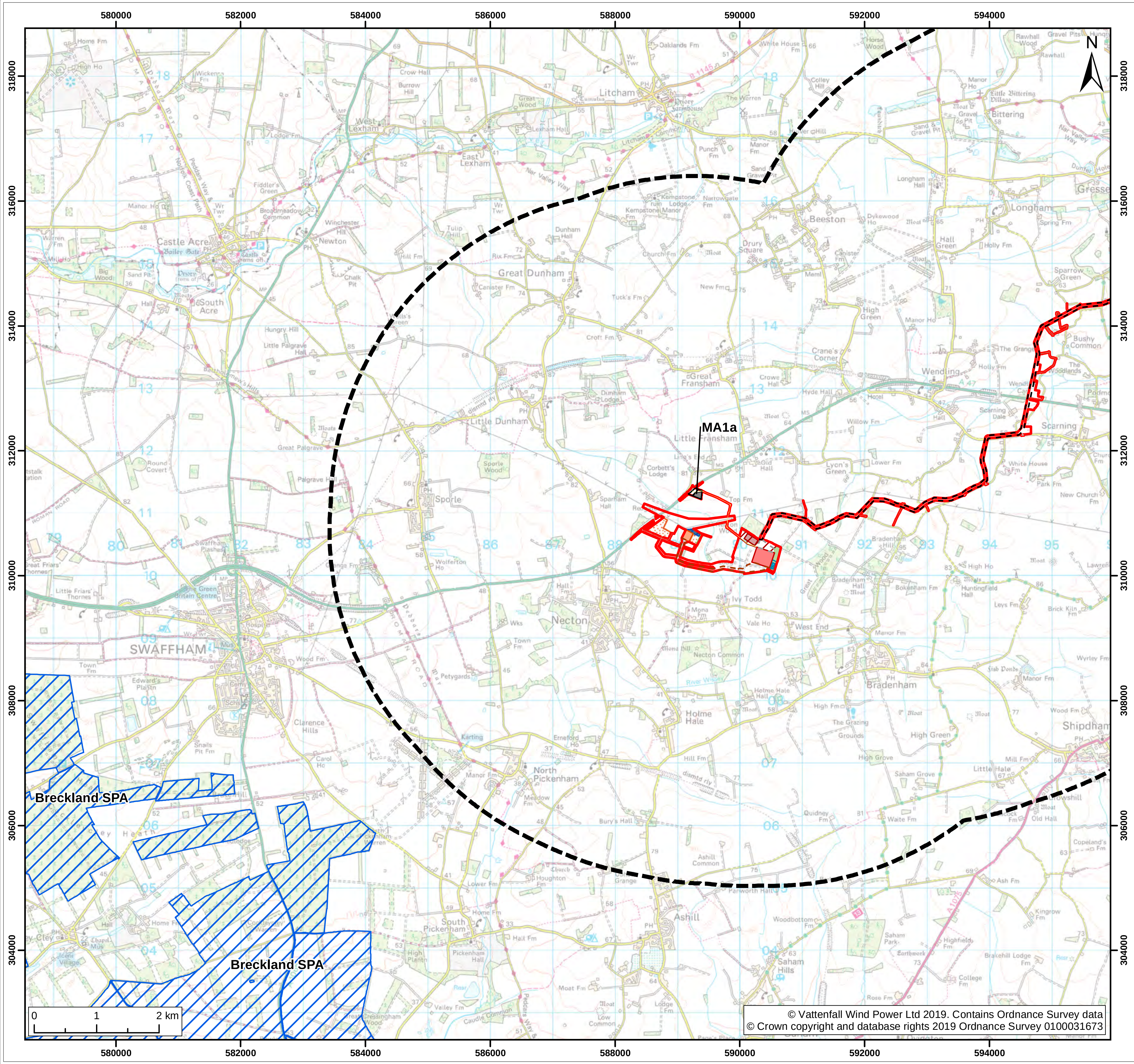

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Norfolk Boreas Onshore Project Infrastructure (Scenario 1)

- Onshore cable route
- Cable route entry to substation
- Onshore 400kV cable route
- Mobilisation zone
- Indicative mobilisation area compound
- Construction access
- Operational access
- Permanent access
- Onshore project substation
- Onshore project substation temporary construction compound zone
- Indicative onshore project substation temporary construction compound
- Attenuation pond zone
- Indicative attenuation pond
- Indicative mitigation planting
- National Grid substation extension
- National Grid temporary works
- National Grid attenuation pond location search area
- Indicative National Grid attenuation pond

Environmental Designation¹

- Special Protection Area (SPA)

¹ Natural England, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

European and Ramsar sites potentially affected by the project

Figure: 5.6b

Drawing No: PB5640-007-002-004b

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	07/05/2019	JT	GC	A3	1:60,000
01	30/01/2019	LB	GC	A3	1:60,000

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

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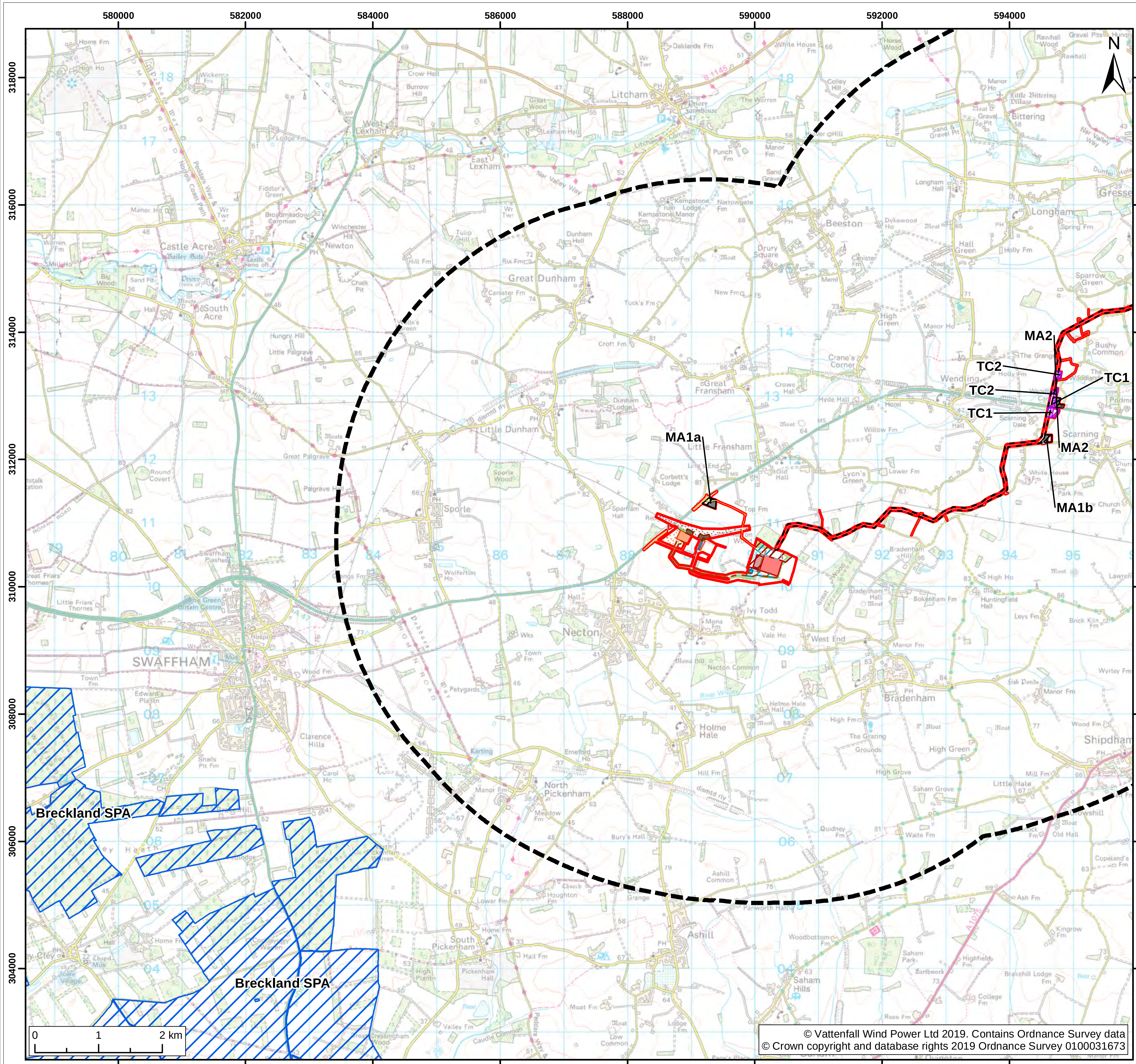

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

- Onshore cable route
- Cable route entry to substation
- Onshore 400kV cable route
- Mobilisation zone
- Indicative mobilisation area compound
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound
- Highways temporary works area
- Construction access
- Operational access
- Permanent access
- Onshore project substation
- Onshore project substation temporary construction compound zone
- Indicative onshore project substation temporary construction compound
- Attenuation pond zone
- Indicative attenuation pond
- Indicative mitigation planting
- National Grid substation extension
- National Grid new / replacement OHL tower search area
- National Grid temporary works
- Overhead line temporary works
- National Grid attenuation pond

Environmental Designation[1]

- Special Protection Area (SPA)

[1] Natural England, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

European and Ramsar sites potentially affected by the project

Figure: 5.6c Drawing No: PB5640-007-002-004c

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6. SPECIAL PROTECTION AREAS

6.1. Baseline/Current Conservation Status

126. 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

127. The Alde-Ore Estuary SPA covers 2,417ha and is located on and around the Suffolk coast, 111km from the proposed Norfolk Boreas 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.

128. 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.

129. 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.

130. 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).

131. The conservation objectives of the site are:

- 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

132. 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 more at sea than females, whereas females forage mainly 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).

133. 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 (a 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.

134. RSPB have published their management aims for Havergate on their website (RSPB, undated). According to that website their main conservation aims include to improve breeding success of avocets and Sandwich terns, by controlling nest predators ‘such as foxes and gulls’. That management may also contribute to the unfavourable conservation status of the lesser black-backed gull population.

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

Year	Colony	
	Orfordness	Havergate
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 SPA

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 (FFC) SPA. The SPA, which represents a geographical extension to the previous Flamborough Head and Bempton Cliffs SPA and adds several species to the citation list, was confirmed in August 2018.

136. Flamborough and Filey Coast SPA covers an area of 7,858ha and is located on the Yorkshire coast between Bridlington and Scarborough. The SPA is in two sections: the southern section extends north from South Landing around Flamborough Head to Speeton; the northern section covers the peninsula of Filey Brigg before extending north west to Cunstone Nab. The seaward boundary extends 2km throughout the two sections of the site into the marine environment, running parallel to the landward boundaries to include the adjacent coastal waters. The SPA includes the RSPB reserve at Bempton Cliffs, the Yorkshire Wildlife Trust Flamborough Cliffs Nature Reserve and the East Riding of Yorkshire Council Flamborough Head Local Nature Reserve.

137. The site description indicates that the FFC qualifies under Article 4.2 of the Bird Directive (2009/147/EC) by supporting over 1% of the biogeographical populations of four regularly occurring migratory species and a breeding seabird assemblage of European importance: kittiwake 44,520 pairs (89,040 breeding adults, 4 year average 2008-2011); gannet 8,469 pairs (16,938 breeding adults, 2008-2012); guillemot 41,607 pairs (83,214 breeding adults, 2008-2011) and razorbill 10,570 pairs (21,140 breeding adults, 2008-2011). In addition, the SPA supports a breeding seabird assemblage of 216,730 individuals (average 2008-2012).

138. The Flamborough and Filey Coast SPA supercedes the Flamborough Head and Bempton Cliffs SPA. It is worth noting that the trend in the kittiwake population for this site has been subject to discussion and disagreement between seabird experts

(e.g. John Coulson) and the SNCBs. At the time of citation, the Flamborough Head and Bempton Cliffs SPA was thought to support 83,370 breeding pairs of kittiwakes (2.6% of the breeding Eastern Atlantic population) (count as of 1987). However, there were 37,617 kittiwake 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. 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 does not correspond 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 are:

- Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring:
    - 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 population of each 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).

6.1.2.3. Guillemot and Razorbill

147. Breeding guillemot (41,607 pairs in 2008-2011) and razorbill (10,570 pairs in 2008-2011) are two of the designated features of the SPA. This is by far the largest colony of guillemots and razorbills in the southern North Sea, holding 100% of the breeding guillemots from County Durham to Kent and over 95% of the breeding razorbills along that stretch of coastline (Mitchell et al. 2004).

148. Auks catch fish by flying underwater, and in order to do so have relatively small wings. This results in high wing loading that constrains their ability to fly and they tend to avoid flying because the energy cost is particularly high for birds with high wing loading. When they fly they tend to fly low over the sea surface, at high speed in a straight line. Therefore, their risk of colliding with offshore wind turbines is low. However, they show displacement from offshore wind farms and are sensitive to disturbance and displacement by ship traffic. When breeding, they have to fly out from the colony to forage, and foraging distances from large colonies can be tens of kilometres. However, guillemot and razorbill chicks fledge when only partly grown, and travel out to sea by swimming, led to foraging areas away from the colony by their male parent. Adults moult rapidly after the breeding season, becoming flightless for a period. It is likely that they select areas with reliable food fish availability for moulting but details of the moult locations used are not yet clear. After the moult, birds move to wintering areas. In general, many guillemots and razorbills spend the winter not far from their breeding area but dispersed over the sea. There is evidence from maps of guillemot and razorbill densities at sea that they tend to aggregate to an extent over some shallow sandbanks. In the southern North Sea the Dogger Bank area is one of these sites with higher density of birds during winter.

6.1.3. Greater Wash SPA

149. 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 was proposed in order to protect areas of importance for over-wintering red-throated diver, little gull and common scoter during the winter period (October to April), and also provide protection to important foraging areas for common, Sandwich and little tern, which breed along the adjacent coastline.

150. The seaward extent of the boundary is a composite of the seaward distribution of red throated diver and the tern species. It encompasses 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 SPA.

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

152. The conservation objectives of the site are:

- 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:
    - 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 each of the qualifying features; and
    - The distribution of the qualifying features within the site.

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

6.1.3.1. Red-throated diver

154. 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).

155. 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

156. 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.

157. 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.

158. 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'.

159. 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).

160. The population of little gull in the Greater Wash SPA in winter was estimated at 1,255 (mean of peak counts in the winter period for 2004-05 and 2005-06; Natural England 2018).

161. 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).

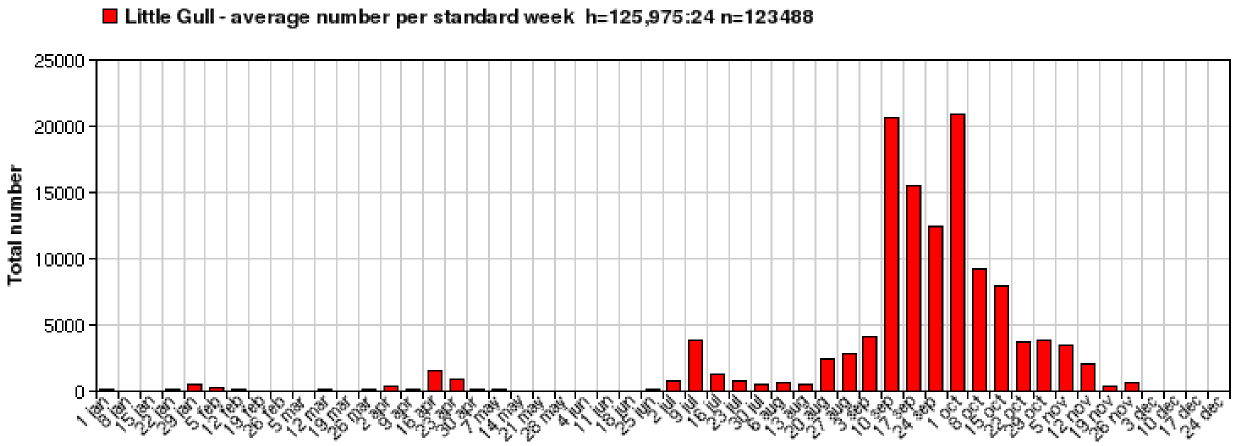


Plate 6.1 Counts of little gulls seen from sea watching vantage points on the east coast of England. Data from the Trektellen web page, summed for all years and sites

162. 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 SPA were carried out.

163. 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.

164. 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*".

165. 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

6.2.1. Embedded mitigation

166. The Norfolk Boreas 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 SPA is more than 220km from the OWF sites and Alde-Ore Estuary SPA is over 111km 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 SPA by the RSPB has indicated that foraging trips from this colony may extend as far as Norfolk Boreas, although the evidence to date indicates such trips are rare rather than typical. Tracking of breeding lesser black-backed gulls has indicated the potential for connectivity with the Norfolk Boreas site (Thaxter et al. 2012b, 2015) and therefore this aspect has been considered in more detail below.

6.2.2. Worst Case Scenario

167. The project design envelope on which the assessment is based was "frozen" in January 2019 to allow the application for development consent to be completed and submitted in June 2019. This design envelope has been used to define realistic worst case scenarios.

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.

169. To maximise the clarity of this assessment the worst case scenario is identified for each impact-species combination assessed (Table 6.2).

Table 6.2 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 180 x 10 MW turbines	Collision risk modelling shows that 180 x 10 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 Boreas 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. Lesser black-backed gull populations in Norfolk and Suffolk

171. Alde-Ore Estuary SPA is located 111km from the closest point of the Norfolk Boreas 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 Boreas 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 Boreas site. The Alde-Ore Estuary SPA is therefore the only British lesser black-backed gull SPA colony that is within maximum foraging range.

172. Non-SPA colonies of lesser black-backed gulls are also located within foraging range of Norfolk Boreas, including rooftop nesting gulls in several towns in Suffolk and Norfolk. As there is a high likelihood that birds from these populations will also be present on Norfolk Boreas it is appropriate to consider the relative population sizes and potential for connectivity. This is discussed below.

173. The national census of seabirds breeding in Britain and Ireland in 1985-86 found 37 pairs of lesser black-backed gulls breeding in Norfolk and fewer than 43 pairs in Suffolk at sites outside the Alde-Ore Estuary SPA (Lloyd et al. 1991). There were at least 5,000 pairs nesting at Orfordness in the Alde-Ore Estuary SPA and 2 or 3 pairs at Havergate (Lloyd et al. 1991 and JNCC Seabird Monitoring Programme (SMP) database), so the Alde-Ore Estuary SPA held 98% of the lesser black-backed gulls breeding in East Anglia in 1985-86. The national census of seabirds breeding in Britain and Ireland in 1998-2002 found 1,605 pairs of lesser black-backed gulls breeding in Norfolk and 1,166 pairs in Suffolk at sites outside the Alde-Ore Estuary SPA (Mitchell et al. 2004), so 2,771 pairs were found nesting at sites in East Anglia away from the Alde-Ore Estuary SPA. The JNCC SCM database shows a huge drop in breeding numbers at Orfordness and Havergate at that time after many years of colony growth (Plate 6.2). According to JNCC, this was apparently caused by foxes which were entering the colony to kill adults and chicks and take gull eggs (Mavor et al. 2001). Numbers have declined further since 2001 (Plate 6.2), as the problem of depredations by foxes has apparently continued.

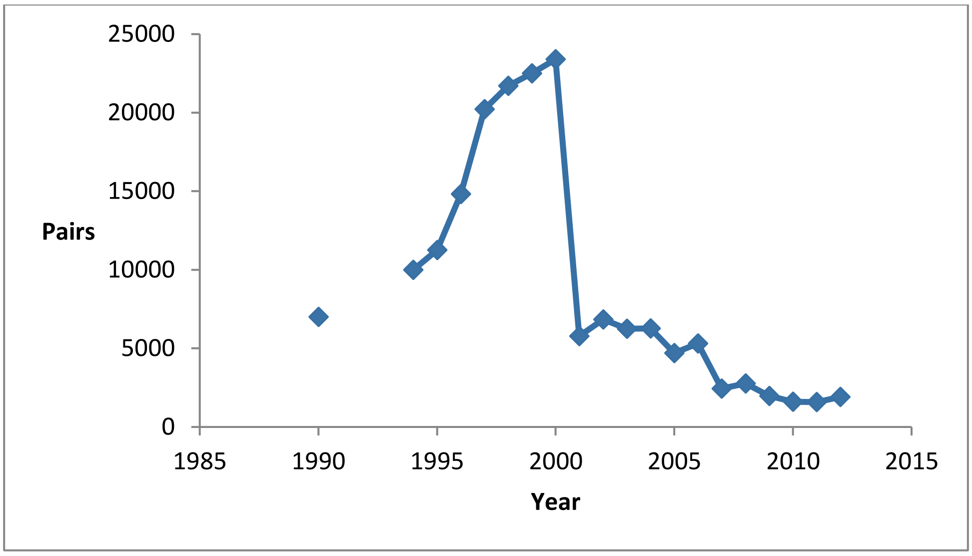


Plate 6.2 Number of breeding pairs of lesser black-backed gulls in the Alde-Ore Estuary SPA; Orfordness plus Havergate (data from JNCC SCM database).

174. There were estimated to be 23,000 pairs at Orfordness and 400 pairs at Havergate in 2000, so an estimated 89% of the lesser black-backed gulls breeding in Norfolk and Suffolk were in the Alde-Ore Estuary SPA in 2000. The colony at Orfordness held 5,500 pairs, and the colony at Havergate held 290 pairs in 2001 (JNCC SMP database). That means that 68% of the breeding population was within the Alde-Ore Estuary SPA in 2001.

175. The Alde-Ore population of lesser black-backed gulls has since decreased considerably, the most recent published counts being 640 pairs at Orfordness in 2012 and 1,668 pairs at Havergate in 2016. It is unclear why no counts have been entered into the JNCC SMPdatabase for Orfordness since 2012 and that limits understanding of any changes that have occurred since 2012.

176. By comparison, numbers breeding elsewhere in East Anglia have increased. There were 743 pairs at urban colonies in Great Yarmouth in 2012, 467 pairs at Southtown/Gorleston in 2012, probably about 2,000-3,000 pairs at Lowestoft in 2008-2011, and a few hundred pairs at other sites in Norfolk and Suffolk (Piotrowski 2013). These urban colonies have only been censused a few times, and counts are not very accurate because many rooftops are impossible to view, so the numbers are likely to be underestimates (Ross et al. 2016), and the 2012 census of urban breeding gulls in Suffolk was carried out after adverse conditions resulted in considerable breeding failure of many gulls (Piotrowski 2013) so is also likely to have underestimated numbers at urban sites. However, despite the relatively incomplete census data, it is clear that urban colonies have been growing very fast, as seen at Lowestoft (Plate 6.3), and Great Yarmouth (Plate 6.4).

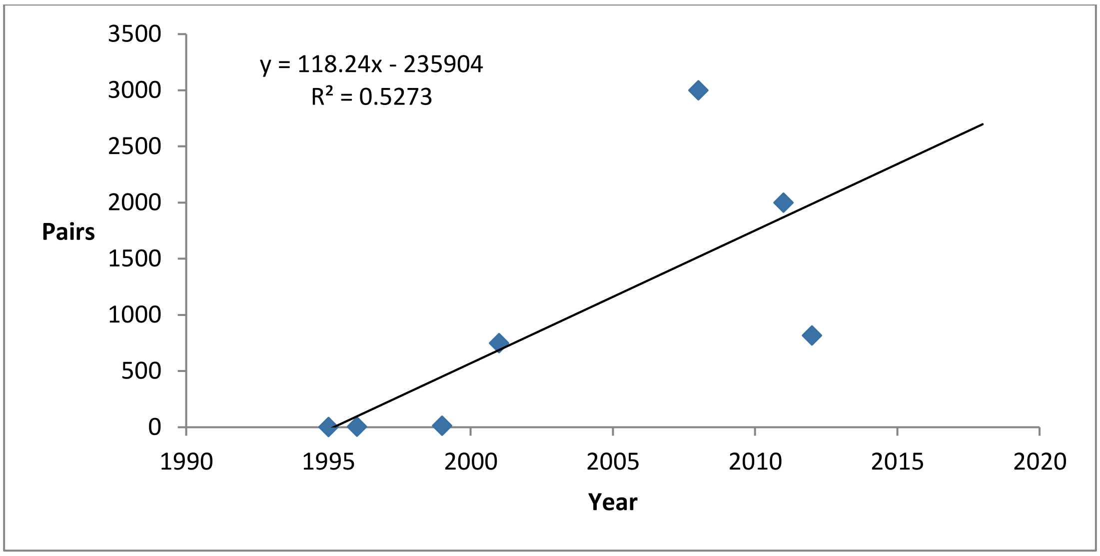


Plate 6.3 Number of breeding pairs of lesser black-backed gulls in Lowestoft (data from JNCC SCM database and Piotrowski 2013).

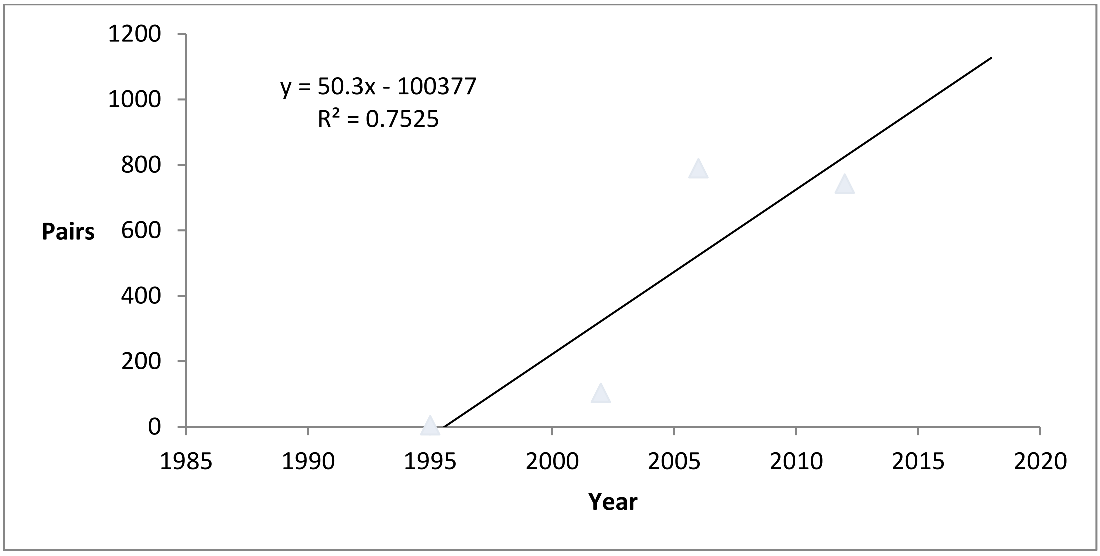


Plate 6.4 Number of breeding pairs of lesser black-backed gulls in Great Yarmouth (data from JNCC SCM database and Piotrowski 2013).

177. In addition, breeding numbers have increased at Felixstowe (1,401 pairs in 2013; Plate 6.5) and Ipswich (99 pairs in 2001, 262 pairs in 2012), which are also urban colonies, and at Outer Trial Bank (1,704 pairs in 2006, 1,457 pairs in 2009 and 1,294 pairs in 2018) (JNCC SCM database).

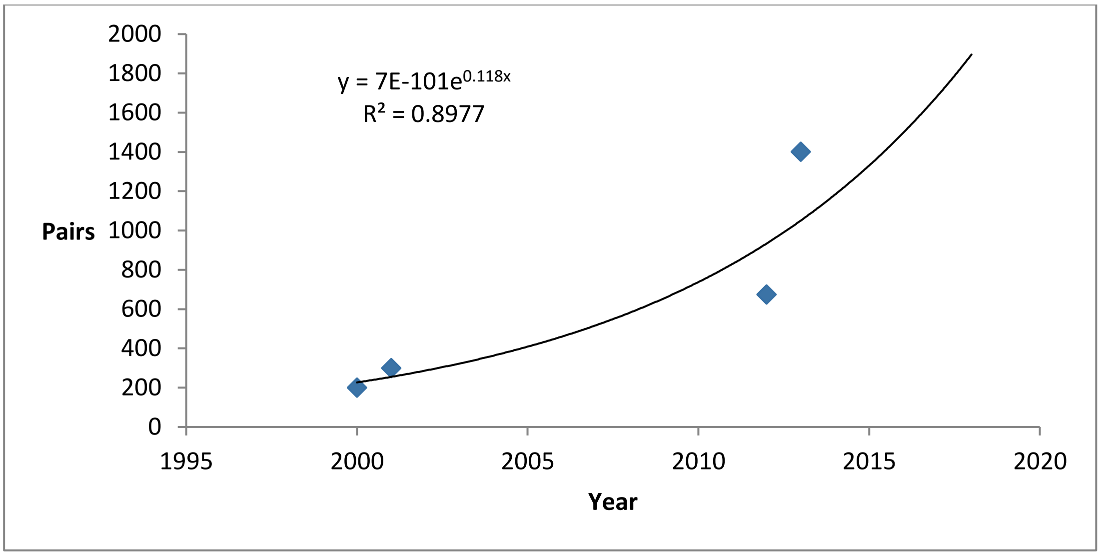


Plate 6.5 Numbers of breeding pairs of lesser black-backed gulls at Felixstowe (data from JNCC SCM database). For this colony an exponential growth curve is a better fit than a linear increase.

178. The numbers at Alde-Ore Estuary SPA colonies in 2012-2016 (ca. 2,300 pairs) compare with ca. 5,100 pairs at sites in Norfolk and Suffolk outside the SPA. This suggests that the percentage of Norfolk and Suffolk lesser black-backed gulls breeding within the SPA had fallen to about 31% of the population.

179. Concerted efforts to make urban areas 'gull-proof' can sometimes result in a reduction in breeding numbers of urban gulls of as much as 25% (Coulson and Coulson 2009) though such reductions may possibly only be temporary until gulls find other urban nest sites where they are tolerated. In general, urban nesting by gulls has increased throughout the UK much faster than total populations of gulls (Raven and Coulson 1997, Nager and O'Hanlon 2016) because the breeding success of gulls tends to be higher at urban sites than in rural colonies (chicks on rooftops are not exposed to predators such as foxes and are less at risk of disturbance or conflict with other gulls; Monaghan 1979, Monaghan and Coulson 1977), and survival of adults at urban colonies is at least as high, and probably higher, than at rural sites (Rock and Vaughan 2013, O'Hanlon and Nager 2018). Piotrowski (pers. comm. who carried out the census of breeding numbers at urban sites in Suffolk in 2012) stated that efforts to deter urban nesting gulls in Suffolk have largely been ineffective and do not seem to have resulted in significant reductions in the population in urban sites overall.

180. Urban nesting lesser black-backed gull numbers in Suffolk increased by over 1000% between 1995 and 2012 (Piotrowski 2013) at a period when numbers breeding in the Alde-Ore Estuary SPA decreased by about 70%. If this trend has continued then the proportion of lesser black-backed gulls at Norfolk Boreas that originate from Alde-Ore Estuary SPA may be decreasing further below 31% since 2012, but this is

uncertain. At a qualitative level, the picture shown quantitatively in 2012 appears not to be much changed since then. However, a repeat census of breeding gull numbers would be helpful to check on that, and may be carried out as part of the current national census of breeding seabirds, and could be made more accurate by use of drones to photograph inaccessible rooftops (Ross et al. 2016, Rush et al. 2018).

181. The available data show that the Alde-Ore Estuary SPA held about 98% of the East Anglia breeding population of lesser black-backed gulls in 1985-86, 89% of the East Anglia breeding population of lesser black-backed gulls in 2000, 68% in 2001, and about 31% in 2012-2016 (Plate 6.6). Since numbers at urban colonies in particular have been on an upward trend, it seems likely that the percentage of the population within the Alde-Ore Estuary SPA will have decreased further since 2012-2016.

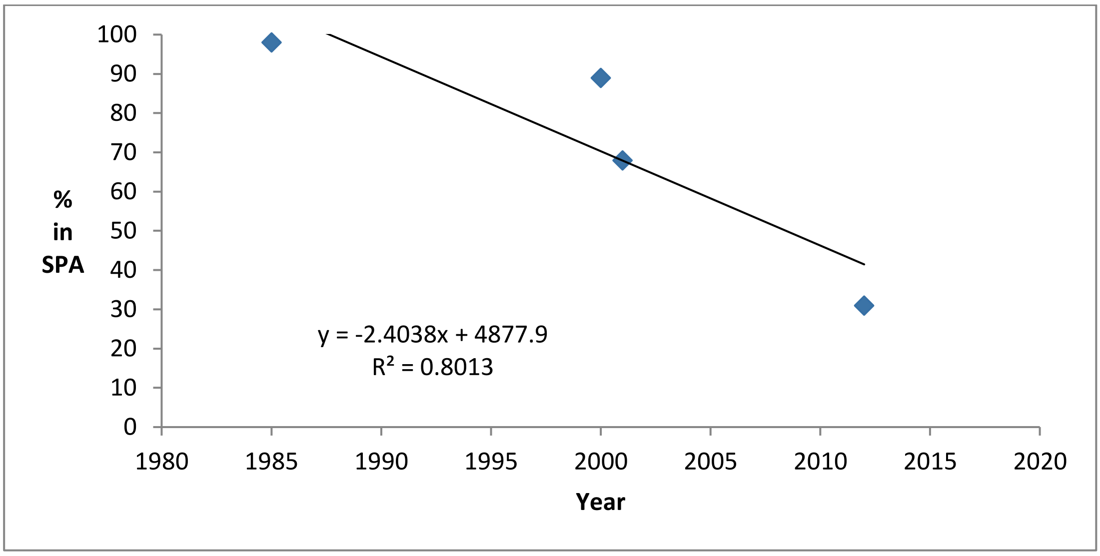


Plate 6.6 The percentage of lesser black-backed gulls breeding in East Anglia that were breeding within the Alde-Ore Estuary SPA in different survey years (based on JNCC SCM database and Piotrowski 2013).

182. It is likely that breeding adult lesser black-backed gulls visiting the Norfolk Boreas site will tend to come from colonies within foraging range, and within that sample, may come more from colonies closer to the site than from colonies further away. In that context, it is worth noting that the SPA population at Alde-Ore Estuary is in the middle of the range of distances of East Anglian lesser black-backed gull colonies from Norfolk Boreas (Table 6.3). Application of the simple population size – distance colony apportioning approach developed jointly by SNH and MacArthur Green indicates that around 12% of the birds recorded on the Norfolk Boreas site would be expected to originate from the Alde Ore Estuary SPA (Table 6.3).

Table 6.3. Colonies of lesser black-backed gulls in East Anglia ranked according to the minimum distance from Norfolk Boreas (noting the maximum foraging range of breeding lesser black-backed gulls is reported by Thaxter et al. (2012a) as 181 km) and estimated proportions of each present on the Norfolk Boreas site based (calculated using SNH tool[5]).

Colony	Minimum distance from Norfolk Boreas (km)	Approximate no. of breeding pairs in period 2008-2015	Colony weighting (population size / distance[2)]	Colony proportion (colony weight / ∑ colony weights)
Great Yarmouth	75	750	0.133	0.10
Southtown	76	450	0.078	0.06
Lowestoft	80	2000	0.313	0.23
Alde-Ore Estuary SPA	111	2000	0.162	0.12
Felixstowe	140	700	0.036	0.03
Ipswich	143	250	0.012	0.01
Outer Trial Bank	170	1300	0.045	0.03

183. On the basis of the population sizes and distances, of all the breeding adults present on Norfolk Boreas in the breeding season, 12% are expected to be breeding adults from Alde Ore Estuary SPA. However, since adults comprise around 58% of the total population (Furness 2015), and since immature birds are more likely to visit areas distant from the main foraging areas, with locations close to colonies used by breeding adults (Wakefield et al. 2017), the overall proportion of birds at Norfolk Boreas during the breeding season that are breeding adults is likely to be at most 58%, and possibly much less. Therefore, the proportion of birds at Norfolk Boreas that are breeding adults from the Alde-Ore Estuary SPA is likely to be 12% of, at most, 58% of the total (i.e. approximately 7% overall). However, tracking data from adults breeding at the Alde-Ore Estuary SPA provide a better approach to estimating numbers at Norfolk Boreas originating from that SPA and so tracking data are considered below.

184. It is likely that the amount of foraging within the marine environment varies among colonies and among years, depending on the relative availability of different feeding opportunities. Lesser black-backed gulls are generalist feeders, able to exploit a wide range of foods from urban waste food to earthworms on rural pasture land to small mammals and insects in grassland to intertidal animals, marine fish caught at sea and fisheries waste (discards and offal) made available behind fishing boats. However, there is evidence from diet studies and from tracking studies, that breeding adult lesser black-backed gulls tend to switch to feeding on marine fish when rearing chicks. This is thought to be at least in part a strategy to provide chicks

[5] https://www.nature.scot/sites/default/files/2018-11/Guidance%20-%20Apportioning%20impacts%20from%20marine%20renewable%20developments%20to%20breeding%20seabird%20populations%20in%20SPAs_0.pdf

with nutritionally better food to support chick growth and development. That switch would, therefore be just as appropriate for urban nesting gulls as for rural nesting gulls.

185. Tracking data (Hayley Douglas, pers. comm.) and diet data (Steve Piotrowski, pers. comm.) for urban nesting lesser black-backed gulls do indeed suggest that those birds feed to an extent in marine habitat, especially when rearing chicks, and do not suggest that urban nesting gulls are significantly less marine than those nesting in rural colonies (based on evidence reviewed below). Lesser black-backed gulls nesting in urban colonies in East Anglia include marine fish in their breeding season diet as well as earthworms, small mammals and urban food waste (Steve Piotrowski, pers. comm.). Those birds clearly forage at sea to some extent, just as some rural nesting gulls do.

186. Some rural nesting lesser black-backed gulls do not seem to feed at sea while breeding. Clewley et al. (2017) reported on tracking data from adult lesser black-backed gulls breeding at Bowland Fells SPA. Two individuals from this rural inland colony spent a small minority of their foraging time in the marine environment but less than 10 km from the coast, whereas 14 others were never tracked over marine habitat (although three spent a small amount of time in estuarine habitat). Scragg et al. (2016) tracked ten adult lesser black-backed gulls breeding at the Ribble and Alt Estuary SPA and found that even for this coastal population, over 90% of their position fixes away from the colony occurred inland, with less than 0.5% occurring in marine habitat. Those studies indicate that rural nesting lesser black-backed gulls can have very low connectivity with marine habitat, even when the colony is at the coast.

187. Tracking of urban nesting gulls has only begun very recently (Rock et al. 2016), is based on small sample sizes, and is mostly not yet published. The 'tag-n-track' project has deployed GPS tags on lesser black-backed gulls breeding on rooftops in Strathclyde (Scotland). The data show that different individuals tend to have particular individual habits (as often found in gulls; Navarro et al. 2017), often returning regularly to the same location. However, birds nesting on rooftops include individuals that forage in the Clyde Estuary and Clyde Sea (Hayley Douglas, pers. comm.). Tracking of a small sample of breeding lesser black-backed gulls nesting in Bristol indicates that those birds do not forage in marine habitat, presumably because the sea is too distant and there are adequate foraging opportunities within closer range (Anouk Spelt, pers. comm.). Coulson and Coulson (2008) found that lesser black-backed gulls nesting in Dumfries did not forage in marine habitat, but fed mainly on agricultural land, especially on earthworms. Thaxter et al. (2017) estimated that up to 41 birds would need to be tracked for about 145 days in order to describe 95% of area use by the population. On that basis, no clear conclusions

can be reached about the relative importance of marine versus terrestrial habitat use from tracking studies based on deployment of very few tags for short periods of time, but the studies mentioned above do indicate that some urban nesting lesser black-backed gulls will forage at sea, and also indicate that birds from some rural colonies will forage almost exclusively inland. There is no evidence that urban nesting lesser black-backed gulls show lower connectivity with marine foraging habitat than rural nesting lesser black-backed gulls, although that possibility cannot be ruled out.

188. Tracking data (Thaxter et al. 2015) indicate very low connectivity between breeding lesser black-backed gulls at Orfordness (Alde-Ore Estuary SPA) and the Norfolk Boreas site. Connectivity appears to vary between zero and very low across the years studied, presumably depending on variations in food availability in different years. Tracking data show a time budget overlap with the former East Anglia Zone of 3.7% in 2010, 1.1% in 2011 and 0.2% in 2012 (Thaxter et al. 2015 Supplementary material Appendix A). The Norfolk Boreas site forms a small part of the former East Anglia Zone. The tracking data indicate that much less than 0.5% of the foraging time of lesser black-backed gulls is spent within the Norfolk Boreas site plus 2km buffer. For the population of about 2,000 breeding pairs at Alde-Ore Estuary SPA that would represent considerably fewer than 10 birds (0.5% of the total number of pairs) at any point in time (assuming that under normal circumstances one adult is at the nest site while the other is away on a foraging trip). Given that there were on average about 370 lesser black-backed gulls in the Norfolk Boreas site during the breeding season (April to August), fewer than 10 birds during the chick-rearing period from the Alde-Ore would represent less than 3% of the lesser black-backed gulls present. This finding is consistent with the fact that the Alde-Ore Estuary SPA population (c. 2,000) represents only about 25% of the population of adult lesser black-backed gulls breeding in East Anglia (c. 7,500, although this total is likely to be incomplete and therefore an underestimate). It also corresponds with the observation that Norfolk Boreas is located towards the upper limit of lesser black-backed foraging range from most breeding colonies and is therefore likely to be used more by nonbreeders than by breeding adults.

189. Tracking data are for chick-rearing periods, so do not necessarily apply at other times during the breeding season. However, lesser black-backed gulls show more marine foraging behaviour during chick-rearing and more terrestrial foraging behaviour earlier in the breeding season, so the overlap with Norfolk Boreas is likely to be highest during the latter part of the breeding season when birds have chicks to provision, and is probably lower than this during the early breeding season.

190. Given the low numbers indicated by tracking this raises the question of where birds observed on Norfolk Boreas come from, if not Alde-Ore SPA. To be precautionary in

relation to the SPA population of Alde-Ore Estuary, we have assumed that no breeding adults from the populations in the Netherlands visit the Norfolk Vanguard site because tracking data from birds in the Netherlands strongly indicate that connectivity for these birds is extremely low (Camphuysen 1995, 2013; Camphuysen et al. 2015). However, it is known that there are large numbers of immature lesser black-backed gulls in the populations (Furness 2015 estimated from demographic data that about 40% of the population will be immature birds and 60% will be breeding age adults). While younger immature birds may remain in the wintering area year round, during spring and summer older immatures move towards breeding areas and may form a significant part of the population at sea in areas such as Norfolk Boreas. Consequently, a substantial part of the birds present at Norfolk Boreas is likely to be immature birds from a variety of populations drawn from a much larger area than just East Anglia. The birds present may also include breeding adults from non-SPA colonies in East Anglia, especially those closer to Norfolk Boreas than is the Alde-Ore Estuary SPA (such as Great Yarmouth, Southtown, and Lowestoft).

191. To conclude, during the breeding season, on the basis of relative population sizes and colony distance, combined with age ratios, the breeding adults from Alde-Ore Estuary SPA would comprise less than 12% of the on-site birds, while tracking data suggest this percentage would most likely be less than 3%. Both of these values have been used in the assessment for the breeding season.

192. The above detailed review of evidence notwithstanding, Natural England advised the Applicant that breeding season apportioning rates of between 10% and 30% should be considered (although it was not apparent in this advice how these values had been derived). The value of 10% lies within the range estimated above (3%-12%) and since this is also very similar to the 12% value no additional consideration of this value has been included. The precautionary upper rate of 30% proposed by Natural England has been included in the assessment.

193. 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 Boreas 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 60% 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 60% 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 Boreas project alone, and to in-combination effects within the region.

194. 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 Boreas 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.

6.3.1.1.2. Potential effects of Norfolk Boreas

195. No works for the proposed Norfolk Boreas 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.

196. 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 Boreas project, are shown in Table 6.4 (data from the Norfolk Boreas ES Chapter 13 Offshore Ornithology Technical Appendix 13.1). For months which are included in both the breeding and migration seasons (as identified in Furness 2015), breeding has been given precedence (i.e. if March is identified as both spring migration and breeding the collisions in that month have been assigned to breeding and not to migration).

Table 6.4 Predicted monthly numbers collision estimates for lesser black-backed gull at the Norfolk Boreas site calculated using Band Option 2 (generic flight heights) for the worst case turbine option (10MW), with upper and lower 95% confidence intervals derived from these metrics for seabird density. Months in bold indicate the migration free breeding months (note that the full breeding season has also been considered in the assessment).

Month	Deterministic collision mortality (mean density and 95% c.i.)	Alde-Ore Estuary SPA collisions (assumed 12% breeding season, 3.3% migration periods and 5% in mid-winter; see text for details)	Alde-Ore Estuary SPA collisions (assumed 30% breeding season, 3.3% migration periods and 5% in mid-winter; see text for details)
January	1.67 (0-4.94)	0.08	0.08
February	0.38 (0-2.32)	0.02	0.02
March	0.46 (0-2.71)	0.02	0.02
April	1.45 (0-6.51)	0.05	0.43
May	1.01 (0-3.03)	0.12	0.30
June	1.47 (0-6)	0.18	0.44
July	5.54 (1.02-13.3)	0.66	1.66
August	7.83 (2.94-13.76)	0.26	2.35
September	16.57 (0-42.37)	0.55	0.55
October	1.31 (0-5.27)	0.04	0.04
November	0.82 (0-4.02)	0.04	0.04
December	1.27 (0-4.06)	0.06	0.06
Total	39.8 (4.0-108.3)	2.08	5.99

197. The majority of collisions are predicted during the second half of the breeding season and early autumn (July to September). This indicates wider movements of failed and nonbreeding individuals and birds on migration through the southern North Sea.

198. During the migration-free breeding season (May to July) the total number of predicted collisions was 8.0. On the basis of the seasonal percentages of Alde-Ore SPA birds predicted to be on the Norfolk Boreas site (figures derived above) and using the migration-free breeding season, the attributable mortality would be up to 2.1 birds and using the full breeding season would be up to 3 birds (Table 6.5). Using the higher breeding season rate of 30% as advised by Natural England the total for the full breeding season is 6 individuals.

Table 6.5 Estimated Alde-Ore lesser black-backed gull collision risk at Norfolk Boreas calculated using deterministic collision estimates and seasonal percentages as detailed in the text.

Month	Migration free breeding season		Full breeding season	
	Total	Alde-Ore	Total	Alde-Ore
Autumn (3.3%)	25.7	0.8	17.9	0.6
Winter (5%)	4.1	0.2	4.1	0.2
Spring (3.3%)	1.9	0.07	0.5	0.02
Breeding season (3%/12%/30%)	8.1	0.24/0.96/2.4	17.3	0.51/2.07/5.2
Total	**39.8**	**1.4/2.1/3.5**	**39.8**	**1.3/2.9/6.0**

199. Natural mortality for the SPA population (assuming approximately 4,000 adults) would be around 460 individuals at an average adult mortality rate of 11.5% (Horswill and Robinson 2015). A total additional worst case mortality of up to 3 (using the evidence based breeding season rate of 12%) or 6 (at Natural England's precautionary rate of 30%) birds due to collisions at the Norfolk Boreas site would increase the mortality rate by 0.6% to 1.3%.

200. A population model was developed to provide further interpretation of the potential impacts (MacArthur Green, 2019). This model was developed following current NE guidance, utilising a matched-run approach to generate counterfactuals of population size (CPS) and counterfactuals of population growth rate (CPGR) and run for a simulated period of 30 years. Summary results are provided in Table 6.6.

Table 6.6 Lesser black-backed gull Alde Ore Estuary SPA population modelling results (see MacArthur Green 2019 for details).

Model	Adult mortality	Counterfactual metric (after 30 years)		Source table (Appendix 1)
		Growth rate	Population size	
Density independent	5	0.996	0.966	Tables A.1 & A.2
	10	0.994	0.930	
Density dependent	5	0.999	0.989	Tables A.3 & A.4
	10	0.998	0.979	

201. Taking the modelled adult mortality of 10 (as the worst case), the population growth rate was predicted to be 0.6% lower (0.994) than the baseline using the density independent model, and 0.2% lower (0.998) using the density dependent model. At the lower modelled adult mortality of 5, the reduction in growth rate was 0.4% for the density independent model and 0.1% for the density dependent model.

202. Although there is a lack of reliable evidence on the population trend at the SPA since 2010 (the last all SPA count available), the predicted reductions in growth rate, which are all less than 1% even at a mortality of 10 which exceeds the most

precautionary collision prediction, are considered very unlikely to have a detectable effect on the population.

203. 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 Boreas project alone.

6.3.1.1.3. In-combination effect

204. 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 6.7), including preliminary estimates for the East Anglia ONE North and East Anglia TWO wind farms.

Table 6.7 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. Note values for East Anglia TWO and East Anglia ONE North are preliminary (derived from those projects PEIRs).

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
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	-
1	Hywind	0	0	0	-
2	Kincardine	0	0	0	-
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	-

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
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	39.7	33.8	5.9	5.9
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	18.0	3.0	15.0	-
5	Thanet Extension	2.3	0.8	1.5	1.5
5	Norfolk Vanguard	40.0	7.8	32.2	32.2
5	Moray West	0	0	0	0
5	*East Anglia TWO*	*0.5*	*0*	*0.5*	*0.5*
5	*East Anglia ONE North*	*0.6*	*0*	*0.6*	*0.6*
5	Norfolk Boreas	39.8	22.5	17.3	6.0
	Total	**588.7**	**391.9**	**197**	**87.2**

205. 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

392 birds (of all age classes), of which the proposed Norfolk Boreas project contributes 22.5 birds.

206. Cumulative breeding season mortality has been estimated as 197. Given that tracking studies have revealed low connectivity for the Alde-Ore SPA population with the Norfolk Boreas site (Thaxter et al. 2012b, 2015), it is questionable both whether the proposed Norfolk Boreas project would contribute to an in-combination total during the breeding season, and also if any 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, Norfolk Vanguard, East Anglia TWO (PEIR only), East Anglia ONE North (PEIR only) and Norfolk Boreas. The total breeding season mortality for these wind farms is 98.5 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, East Anglia TWO, East Anglia ONE North, Galloper, London Array) which indicate a total breeding season mortality estimate of 45 collisions).

207. As discussed above, given the large geographical area from which lesser black-backed gulls migrating through the Norfolk Boreas 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 16 birds (392 x 4%) could die from the Alde-Ore Estuary SPA population during the nonbreeding season.

208. The annual mortality of lesser black-backed gulls from the Alde-Ore SPA is therefore 16 during the nonbreeding season and 26 (87.2 x 30%, allowing for non-SPA birds in Norfolk and Suffolk, Plate 6.6) during the breeding season, 42 in total (of which Norfolk Boreas contributes up to 6).

209. In-combination mortality of up to 42 birds attributable to the Alde-Ore SPA population of lesser black-backed gulls compares with estimated natural mortality of about 460 birds per year. Thus, the additional in-combination mortality would

represent an increase in mortality rate of 9.1%, of which approximately one third is attributable to the estimated collisions at the Galloper wind farm alone.

210. 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, unpublished 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 25, equating to an increase in background mortality of 5.4%.

211. A population model has been developed to provide further interpretation of these potential in-combination impacts (MacArthur Green 2019). This model follows current NE guidance, utilising a matched-run approach to generate counterfactuals of population size (CPS) and counterfactuals of population growth rate (CPGR) and was run for a simulated period of 30 years. Summary results are provided in Table 6.8.

Table 6.8. Lesser black-backed gull Alde Ore Estuary SPA population modelling results (see MacArthur Green 2019 for details).

Model	Adult mortality	Counterfactual metric (after 30 years)	
		Growth rate	Population size
Density independent	25	0.991	0.834
	40	0.987	0.748
Density dependent	25	0.998	0.951
	40	0.996	0.914

212. Taking the modelled adult mortality of 40 (as the worst case), the population growth rate was predicted to be 1.3% lower (0.987) than the baseline using the density independent model, and 0.4% lower (0.996) using the density dependent model. At the lower modelled adult mortality of 25, the reduction in growth rate was 0.9% for the density independent model and 0.2% for the density dependent model.

213. Even with the most precautionary combination estimates these reductions in growth rate are small (no more than 1.3%) and therefore are not considered likely to result in a population decline. The more realistic collision estimates, accounting for the reduced impacts from built wind farms compared with the consented designs, predict a growth rate reduction of no more than 0.4% (density independent), which further reduces any concerns about the impact on the SPA population.

214. It is also worth noting that the in-combination collision total predicted for the consented Galloper Wind Farm was 85 (at a 99.5% avoidance rate), which is more than double the more precautionary estimate of 42 above, and more than three times the more likely prediction of 25.

6.3.1.1.4. Conclusion

215. 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 Boreas site, including the precautionary assumption of an extended breeding season, which can be attributed to the Alde Ore SPA is very small (3 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 Boreas project alone.

216. 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, **there will be no an adverse effect on integrity due to in-combination collisions.**

217. 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). It seems apparent that further efforts in this regard could readily improve this population’s conservation status.

6.3.2. Flamborough and Filey Coast SPA

6.3.2.1. Gannet

6.3.2.1.1. Potential effects of Norfolk Boreas – displacement

218. Natural England advised the Applicant that a cumulative and in-combination assessment of displacement risk for gannet should be presented. To the Applicant’s knowledge this has not been requested for previous wind farm applications, and furthermore gannet has not been consistently included in displacement assessments. Following a review of wind farm assessments gannet abundance data were obtained for all but 8 out of 41 wind farms (Table 6.9).

Table 6.9 Gannet in-combination abundance using the full breeding season and with apportioned values for FFC SPA.

Wind farm	Buffer width (km)	Total			FFC SPA		
		Spring	Breeding	Autumn	Spring	Breeding	Autumn
Greater Gabbard	0	105	252	69	7	0	3
Gunfleet Sands	No data	9	0	12	1	0	1
Kentish Flats	No data available						
Kentish Flats Extension	2	0	0	13	0	0	1
Lincs	No data available						
London Array	No data available						
Lynn and Inner Dowsing	No data available						
Scroby Sands	No data available						
Sheringham Shoal	No data	2	47	31	0	47	1
Teesside	No data	0	1	0	0	1	0
Thanet	No data available						
Humber Gateway	No data available						
Westermost Rough	No data available						
Hywind	1	4	10	0	0	0	0
Kincardine	1	0	120	0	0	0	0
Beatrice	0.5	0	151	0	0	0	0
Dudgeon	1	11	53	25	1	53	1
Galloper	4	276	360	907	17	0	44
Race Bank	1	29	92	32	2	92	2
Rampion	No data	0	0	590	0	0	28
Hornsea Project One	4	250	671	694	15	671	33
Blyth Demonstration Project	No data	0	0	0	0	0	0
Dogger Bank Creyke Beck A	2	176	518	916	11	518	44
Dogger Bank Creyke Beck B	2	218	637	1132	14	637	54
East Anglia ONE	4	76	161	3638	5	161	175
European Offshore Wind Deployment Centre	2	0	35	5	0	0	0
Seagreen Alpha	0	138	1716	296	9	0	14
Seagreen Bravo	0	194	1240	368	12	0	18
Inch Cape	4	212	2398	703	13	0	34
Moray Firth (EDA)	4	27	564	292	2	0	14
Neart na Gaoithe	2	281	1987	552	17	0	26
Dogger Bank Teesside A	2	226	968	379	14	968	18
Dogger Bank Teesside B	2	238	1282	508	15	1282	24
Triton Knoll	1	24	211	15	1	211	1

Wind farm	Buffer width (km)	Total			FFC SPA		
		Spring	Breeding	Autumn	Spring	Breeding	Autumn
Hornsea Project Two	4	124	457	1140	8	457	55
East Anglia THREE	4	524	412	1269	32	412	61
Hornsea Project Three	4	1099	1203	1494	68	1203	72
Thanet Extension	4	384	27	324	24	0	16
Moray West	4	144	2827	439	9	0	21
Norfolk Vanguard East	2	419	176	1630	26	176	78
Norfolk Vanguard West	2	18	95	823	1	95	40
Norfolk Boreas	2	526	1229	1723	32	1229	83
Seasonal total		5734	19900	20019	356	8213	962
				45653			9531

219. Natural England advises presentation of a range of displacement rates of between 60% and 80% displacement and 1% mortality. Predictions using these rates are presented in Table 6.10.

Table 6.10 Gannet seasonal and annual displacement at Norfolk Boreas alone, combined and cumulatively (EIA) across all North Sea wind farms and apportioned to Flamborough and Filey coast SPA (HRA) using the full breeding season.

Site	Season	Total population at risk of displacement	Total impact, displacement & mortality rates:		Population apportioned to FFC SPA	FFC SPA impact, displacement & mortality rates:	
			60% - 1%	80% - 1%		60% - 1%	80% - 1%
Norfolk Boreas	Spring	526	3.2	4.2	32	0.2	0.3
	Breeding	1229	7.4	9.8	1229	7.4	9.8
	Autumn	1723	10.3	13.8	83	0.5	0.7
	Annual	3478	20.9	27.8	1344	8.1	10.8
UK North Sea and Channel wind farms	Spring	5734	34.4	45.9	356	2.1	2.8
	Breeding	19900	119.4	159.2	8213	49.3	65.7
	Autumn	20019	120.1	160.2	962	5.8	7.7
	Annual	45653	273.9	365.2	9531	57.2	76.2

6.3.2.2. Project alone

220. Apportioning the Norfolk Boreas gannet displacement mortality to the FFC SPA on the basis of 100% connectivity in the breeding season and Natural England's preferred rates in spring and autumn (4.8% and 6.2% respectively) the worst case mortality due to Norfolk Boreas was estimated to be between 8 and 11 (Table 6.10).

221. The SPA population at designation was 11,061 pairs (22,122 individuals, although this had increased to 13,391 pairs by 2017). These equate to total population sizes of

approximately 40,222 and 48,700 (designated and 2017 count respectively; calculated as individuals divided by the adult proportion of 0.55 from Furness 2015). At an average natural mortality rate of 0.191 (derived as a weighted average across all age classes, see Norfolk Boreas ES Chapter 13 Offshore Ornithology for details), the natural annual mortality of the population is 7,682 (designated) to 9,300 (2017 count). The addition of up to 11 individuals would therefore increase the mortality rate by a maximum of 0.1% (designated population). Increases in mortality of less than 1% are considered to be undetectable against natural variation and therefore there is no risk of an Adverse Effect on the Integrity of the SPA population due to displacement from the Norfolk Boreas project alone.

6.3.2.3. In-combination

222. Of the total annual displacement, the number apportioned to the Flamborough and Filey Coast SPA was between 57 and 76 (Table 6.10). The percentage increase in background mortality of the FFC SPA all age class population (40,222 for the designated population and 48,700 for the 2017 population) is between 0.7% and (designated) and 0.99% (2017 population). These increases are below the 1% threshold of detectability and therefore no Adverse Effect on Integrity is predicted for the FFC SPA gannet population due to in-combination displacement mortality.

6.3.2.3.1. Potential effects of Norfolk Boreas - Collisions

223. 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).

224. 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.

225. The Norfolk Boreas 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 SPA (Bempton, 220km), 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 Boreas 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 Boreas 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 Boreas site, originate from the Bempton colony within Flamborough & Filey Coast SPA (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 SPA 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 Boreas site will most likely be nonbreeders or immatures from a variety of more distant colonies (Votier et al. 2017, Wakefield et al. 2017).

226. Collision mortality of gannets at the Norfolk Boreas site based on Band Option 2 and an avoidance rate of 98.9% (as recommended by Natural England and other SNCBs) was estimated at 118 birds per year (Table 6.11), with approximately 60% occurring in autumn (Norfolk Boreas ES Chapter 13 Offshore Ornithology Technical Appendix 13.1). It is worth noting that recent analysis of gannet behaviour at an operational wind farm has indicated that a more realistic (and still precautionary) avoidance rate is 99.5% (Bowgen and Cook 2018), which would more than half the estimated collisions (although noting that most of the data collected was outside the breeding season so this conclusion may not apply all year round).

Table 6.11 Predicted monthly collision estimates for gannet at the Norfolk Boreas site calculated using Band Option 2 (generic flight heights) for the worst case turbine option (10MW) . The numbers apportioned to the FFC SPA population using both the migration free breeding months and the full breeding months are included. Note the higher nocturnal rate has been used to estimate these collisions ('2'=25%).

Month	Deterministic collision mortality (mean density and 95% c.i.)	Monthly proportions – migration free breeding season (95% c.i)	Monthly proportions – full breeding season (95% c.i.)
January	0.67 (0-3.29)	0.04 (0-0.2)	0.04 (0-0.2)
February	1.67 (0-3.93)	0.1 (0-0.24)	0.1 (0-0.24)
March	2.07 (0-5.64)	0.13 (0-0.35)	2.07 (0-5.64)
April	0.85 (0-3.46)	0.85 (0-3.46)	0.85 (0-3.46)
May	3.77 (0.97-7.78)	3.77 (0.97-7.78)	3.77 (0.97-7.78)
June	1.46 (0-5.87)	1.46 (0-5.87)	1.46 (0-5.87)
July	0.98 (0-3.96)	0.98 (0-3.96)	0.98 (0-3.96)
August	38.43 (0-91.82)	38.43 (0-91.82)	38.43 (0-91.82)
September	6.57 (1.64-13.94)	0.32 (0.08-0.67)	6.57 (1.64-13.94)
October	8.37 (0.76-19.86)	0.4 (0.04-0.95)	0.4 (0.04-0.95)
November	40.13 (21.96-60.89)	1.93 (1.05-2.92)	1.93 (1.05-2.92)
December	12.65 (7.11-19.17)	0.78 (0.44-1.19)	0.78 (0.44-1.19)
Total	118 (32.4-239.6)	49.2 (2.58-119.42)	57.39 (4.14-137.98)

227. Estimates of the proportion of birds present in the Norfolk Boreas site which originate from Flamborough & Filey Coast SPA during the breeding season and on migration in autumn and spring were calculated previously making use of evidence of the directions of migration flight to and from SPAs (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 Boreas site originate from Flamborough & Filey Coast SPA. During migration in autumn and spring, 4.2% and 5.6% (respectively) of the birds observed are predicted to originate from Flamborough & Filey Coast SPA, based on numbers at the SPA and in the BDMPS population estimate. Natural England have advised that rather than include these movement rates the spring and autumn apportioning rates should be based on just the relative population sizes. Thus, the spring and autumn proportions for the SPA used in this assessment are 6.2% and 4.8% respectively. Note that any months which overlap migration and breeding seasons have been assigned to breeding only.

228. Applying these percentages to the collision estimates based on Band Option 2, generates the following mortality estimates for the Flamborough & Filey Coast SPA population (Table 6.12).

Table 6.12 Estimated FFC SPA gannet collision risk at Norfolk Boreas calculated using deterministic collison estimates and seasonal percentages as detailed in the text.

Month	Migration free breeding season		Full breeding season	
	Total	FFC	Total	FFC
Autumn (4.8%)	55.07	2.64	48.50	2.33
Spring (6.2%)	17.06	1.16	14.99	1.02
Breeding season (100%)	45.50	45.49	54.13	54.13
Total	**118**	**49.2**	**118**	**57.4**

229. The SPA population at designation was 11,061 pairs (22,122 individuals, although this had increased to 13,391 pairs by 2017). At an average natural adult mortality rate of 0.081, the natural annual mortality of the population is 1,792 (designated) to 2,169 (2017 count). The addition of 57.4 individuals would therefore increase the mortality rate by 3.2% (designated) and 2.6% (2017 count). If the upper 95% confidence estimate (138) is used, these increases would be between 7.7% and 6.3%, respectively. While if the lower 95% confidence estimates are used (4.1) these rates are 0.23% and 0.18%.

230. While the mean predictions are slightly above the 1% threshold for detection, with the consequent need to undertake additional assessment, it is important to note that this collision prediction combines several sources of precaution:

- Use of a nocturnal activity rate of 25% (Furness et al. 2018 recommended this should be 8% in the breeding season and 4% in the nonbreeding season);
- Assignment of all collisions between March and September (the full breeding season) to the SPA makes no allowance for the presence of immature birds from a wide range of other colonies which are likely to be present at this time, or for the presence of late and early migrants, and;
- Bowgen and Cook (2018) recently estimated a gannet collision avoidance rate from an empirical study of 99.5%, which would more than halve the estimates above calculated using 98.9%.

231. Outputs from a PVA model for this population were presented for Hornsea Project Three (MacArthur Green 2018). This model was an update of similar models produced for Hornsea Project Two, with the addition of a matched-run approach for calculating counterfactual outputs and an extended simulation period (up to 35 years). Simulations were conducted with and without density dependence and were summarised as the counterfactuals of population size and population growth rate.

Outputs from this model were presented as additional adult mortality at increments of 25, thus the results for additional adult mortality of 25, 50 and 150, the closest values to the current predictions are provided in Table 6.13.

Table 6.13 Gannet FFC SPA population modelling results from MacArthur Green (2018).

Model	Mortality	Counterfactual metric (after 30 years) Growth rate	Population size	Source table (MacArthur Green 2018)
Rate set 1, density independent	25	0.999	0.968	Table A2 1.1 & 1.3
	50	0.998	0.937	
	150	0.993	0.821	
Rate set 1, density dependent	25	0.999	0.978	Table A2 2.1 & 2.3
	50	0.999	0.957	
	150	0.996	0.874	
Rate set 2, density independent	25	0.999	0.968	Table A2 3.1 & 3.3
	50	0.998	0.936	
	150	0.993	0.821	
Rate set 2, density dependent	25	0.999	0.978	Table A2 4.1 & 4.3
	50	0.999	0.957	
	150	0.996	0.873	

232. The maximum reduction in the population growth rate, at an adult mortality of 150, using the most precautionary combination of assumptions (95% confidence estimate, all mortality assigned to adults, assessed using the density independent model) was 0.7% (0.993). Using the more realistic density dependent model the maximum reduction in growth rate was 0.4% (0.996).

233. These compare to the observed rate at which this population has grown over the last 25 years, which has been at least 10% per year. A reduction of no more than 0.7% (and that for a considerably higher mortality than even the most precautionary assumption using the upper 95% confidence estimate) in this growth rate represents a negligible risk for the population.

234. The gannet breeding numbers at the Flamborough and Filey Coast SPA have continued to increase in all counts conducted to date 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.

235. On the basis of the population model predictions the number of predicted project alone gannet collisions attributed to the Flamborough & Filey Coast SPA is not at a level which would trigger a risk of population decline, but would only result in a slight reduction in the growth rate currently seen at this colony, and so would not have an adverse effect on integrity of the SPA.

236. Therefore, it can be concluded that there will be no adverse effect on the integrity of Flamborough & Filey Coast SPA from collision impacts on gannet due to the proposed Norfolk Boreas project alone.

6.3.2.3.2. In-combination effect

237. 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 SPA are presented in Table 6.14.

Table 6.14 Gannet collision mortality for all wind farms with potential connectivity to the Flamborough and Filey Coast SPA

Tier	Wind farm	Predicted collisions (@ 98.9% avoidance rate, Band Model option 1 or 2)					
		Spring migration		Breeding season		Autumn migration	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
1	Beatrice Demonstrator	0.7	0.05	0.6	0.0	0.9	0.04
1	Greater Gabbard	4.8	0.30	14.0	0.0	8.8	0.42
1	Gunfleet Sands	0.0	0.00	0.0	0.0	0.0	0.00
1	Kentish Flats	1.1	0.07	1.4	0.0	0.8	0.04
1	Lincs	1.7	0.10	2.1	2.1	1.3	0.06
1	London Array (Phase 1)	1.8	0.11	2.3	0.0	1.4	0.07
1	Lynn and Inner Dowsing	0.2	0.01	0.2	0.2	0.1	0.01
1	Scroby Sands	0.0	0.00	0.0	0.0	0.0	0.00
1	Sheringham Shoal	0.0	0.00	14.1	14.1	3.5	0.17
1	Teesside	0.0	0.00	4.9	2.4	1.7	0.08
1	Thanet	0.0	0.00	1.1	0.0	0.0	0.00
1	Humber Gateway	1.5	0.09	1.9	1.9	1.1	0.05
1	Westermost Rough	0.2	0.01	0.2	0.2	0.1	0.01
1	Hywind	0.8	0.05	5.6	0.0	0.8	0.04
2	Kincardine	0.0	0.00	3.0	0.0	0.0	0.00
2	Beatrice	9.5	0.59	37.4	0.0	48.8	2.34
2	Dudgeon	19.1	1.18	22.3	22.3	38.9	1.87
2	Galloper	12.6	0.78	18.1	0.0	30.9	1.48
2	Race Bank	4.1	0.25	33.7	33.7	11.7	0.56
2	Rampion	2.1	0.13	36.2	0.0	63.5	3.05
2	Hornsea Project 1	22.5	1.40	11.5	11.5	32.0	1.54
3	Blyth (NaREC Demonstration)	2.8	0.17	3.5	0.0	2.1	0.10
3	Dogger Bank Creyke Beck A & B	4.3	0.27	5.6	2.8	6.6	0.32
3	East Anglia ONE	6.3	0.39	3.4	3.4	131.0	6.29
3	EOWDC (Aberdeen OWF)	0.1	0.00	4.2	0.0	5.1	0.25
3	Firth of Forth Alpha and Bravo	65.8	4.08	800.8	0.0	49.3	2.37

Tier	Wind farm	Predicted collisions (@ 98.9% avoidance rate, Band Model option 1 or 2)					
		Spring migration		Breeding season		Autumn migration	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
3	Inch Cape	5.2	0.32	336.9	0.0	29.2	1.40
3	Moray Firth (EDA)	8.9	0.55	80.6	0.0	35.4	1.70
3	Neart na Goethe	23.0	1.43	143.0	0.0	47.0	2.26
3	Dogger Bank Teesside A & B	10.8	0.67	14.8	7.4	10.1	0.49
3	Triton Knoll	30.1	1.87	26.8	26.8	64.1	3.08
3	Hornsea Project 2	6.0	0.37	7.0	7.0	14.0	0.67
3	East Anglia THREE	9.6	0.60	6.1	6.1	33.3	1.60
5	Hornsea Project Three	8.0	0.50	18.0	18.0	12.0	0.58
5	Thanet Extension	22.9	1.42	0.0	0.0	11.1	0.53
5	Norfolk Vanguard	18.3	1.13	28.6	28.6	64.7	3.11
5	Moray West	1.0	0.06	10.0	0.0	2.0	0.10
5	*East Anglia TWO*	*1.2*	*0.07*	*8.8*	*8.8*	*8.6*	*0.41*
5	*East Anglia ONE North*	*1.3*	*0.08*	*8.8*	*8.8*	*5.5*	*0.26*
5	Norfolk Boreas	15.0	0.93	54.1	54.1	48.5	2.33
	Total	**323.2**	**20.0**	**1771.3**	**260.2**	**826.1**	**39.7**

238. In spring the cumulative gannet collisions were estimated to be 323, in the breeding season 1,771 and in the autumn 826. Using the Flamborough and Filey Coast SPA proportions (as advised by Natural England) for all the wind farms with potential connectivity to the SPA, the proportions of the mortality attributed to the Flamborough and Filey Coast SPA population were 20 (spring), 260 (breeding) and 40 (autumn), an annual total of 320. Of these seasonal totals, the proposed Norfolk Boreas project contributed <1, 54 and 2.3 individuals within each period respectively. Therefore, as discussed above, irrespective of the potential total impact on the Flamborough and Filey Coast SPA gannet population, the contribution from the proposed Norfolk Boreas project is small and would have an undetectable effect on the population. The increase in the background mortality for the estimated in combination collision mortality exceeded 1% therefore further assessment is provided below.

239. Outputs from the gannet PVA model for this population (MacArthur Green 2018) for adult mortality levels of 300 and 325 (the nearest values to this impact prediction) are provided in Table 6.15.

Table 6.15 Gannet FFC SPA population modelling results from MacArthur Green (2018).

Model	Adult mortality	Counterfactual metric (after 30 years)		Source table (MacArthur Green 2018)
		Growth rate	Population size	
Rate set 1, density independent	300	0.986	0.673	Table A2 1.1 & 1.3
	325	0.985	0.651	
Rate set 1, density dependent	300	0.991	0.757	Table A2 2.1 & 2.3
	325	0.991	0.739	
Rate set 2, density independent	300	0.986	0.673	Table A2 3.1 & 3.3
	325	0.985	0.651	
Rate set 2, density dependent	300	0.991	0.757	Table A2 4.1 & 4.3
	325	0.990	0.738	

240. The maximum reduction in the population growth rate, at a mortality of 325, using the more precautionary density independent model was 1.5% (0.985). Using the more realistic density dependent model the maximum reduction in growth rate was 1.0% (0.990).

On the basis of the observed rate at which this population has grown over the last 25 years, which has been at least 10% per year, a maximum reduction of 1.5% to this rate represents a negligible risk for the population.

241. 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.

242. The in-combination mortality of up to 290 individuals predicted for Norfolk Boreas apportioned to the Flamborough and Filey Coast SPA is less than the previously accepted threshold for collisions (for East Anglia ONE this was defined as 286-361; Natural England, 2013) and in the interim the population has almost doubled in size.

243. It is, therefore, reasonable to assess that there will be no adverse effect on the integrity of FFC SPA as a result of gannet collisions at the proposed Norfolk Boreas project in-combination with other projects.

244. 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 with a population size in 2013 estimated at 11,230 (note this is similar in size

to the FFC SPA population), 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.

245. 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 (Trinder 2017). 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 175, equating to an increase in background mortality of 1.8%.

6.3.2.4. Combined displacement and collision risk

6.3.2.5. In-combination

246. Adding the in-combination annual gannet collision estimate of 320 (adults; estimated using Natural England's preferred methods) to the in-combination annual displacement prediction of 33 to 44 (using Natural England's preferred rates, but converted to adults), gives a combined SPA mortality estimate of 353 to 364. It is important to note that, on top of the precaution in the individual collision and displacement assessments, summing these two impacts adds another layer of precaution, since it implies that individuals can both be displaced (and suffer increased mortality as a consequence) and also be at risk of collision mortality.

247. However, the above over-precaution notwithstanding, the increase in the background mortality of the SPA population due to this combined in-combination collision and displacement risk exceeded 1%.

248. Outputs from a PVA model for this population were presented for the Hornsea Project Three wind farm (MacArthur Green 2018). This model was an update of similar models produced for Hornsea Project Two, with the addition of a matched-run approach for calculating counterfactual outputs and an extended simulation period (up to 35 years). Simulations were conducted with and without density dependence and were summarised as the counterfactual of population size and population growth rate. The outputs from these models for mortality levels of 275 and 300 (the nearest values to this impact prediction) are provided in Table 6.16 .

Table 6.16 Gannet FFC SPA population modelling results from MacArthur Green (2018).

Model	Mortality	Counterfactual metric (after 30 years)		Source table (MacArthur Green 2018)
		Growth rate	Population size	
Rate set 1, density independent	350	0.984	0.629	Table A2 1.1 & 1.3
	375	0.983	0.609	
Rate set 1, density dependent	350	0.990	0.720	Table A2 2.1 & 2.3
	375	0.989	0.703	
Rate set 2, density independent	350	0.984	0.630	Table A2 3.1 & 3.3
	375	0.983	0.609	
Rate set 2, density dependent	350	0.990	0.720	Table A2 4.1 & 4.3
	375	0.989	0.701	

249. The maximum reduction in the population growth rate, at a mortality of 375, using the more precautionary density independent model was 1.7% (0.983). Using the more realistic density dependent model the maximum reduction in growth rate was 1.1% (0.989).

250. On the basis of the observed rate at which this population has grown over the last 25 years, which has been at least 10% per year, a maximum reduction of 1.7% to this rate represents a negligible risk for the population.

251. The gannet breeding numbers at the Flamborough and Filey Coast SPA have continued to increase in all counts conducted to date (most recent 2017) 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.

252. On the basis of the population model predictions the number of predicted in-combination gannet collisions and mortality due to displacement attributed to the Flamborough & Filey Coast SPA is not at a level which would trigger a risk of population decline, but would only result in a slight reduction in the growth rate currently seen at this colony, and so would not have an adverse effect on integrity of the SPA.

253. These totals also include several sources of precaution, including over-estimated nocturnal activity for existing projects and the use of consented collision estimates for projects which have since been constructed to designs with much lower collision risks.

254. Therefore, it can be concluded that there will be no adverse effect on the integrity of Flamborough & Filey Coast SPA from impacts on gannet due to the proposed Norfolk Boreas project in-combination with other plans and projects.

6.3.2.5.1. Conclusion

255. The gannet breeding numbers in the Flamborough and Filey Coast SPA 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.

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

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

6.3.2.6. Kittiwake

6.3.2.6.1. Potential effects of Norfolk Boreas

258. 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 Boreas 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).

259. In order to estimate the degree of connectivity between the Flamborough and Filey Coast SPA and the Norfolk Boreas site during the breeding season a review of tracking data has been conducted, including both studies conducted at the Flamborough and Filey Coast SPA and also on similar seabird species more widely.

260. A review of seabird studies reported that 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 reported at 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. More recently, preliminary analysis of data for kittiwakes tracked from Flamborough and Filey Coast SPA by the RSPB reported a mean foraging distance of 89km with a range of 3km to 323km (Wischnewski et al. 2018). Birds in this study were caught from the base of the cliffs using a 12m pole, therefore of necessity the tagged birds were ones nesting at the lower edge of the colony (although the total height of the cliffs at the specific study sites was not reported the cliffs at FFC are among the highest in England at up to 130m). This study reported that tagging itself did not appear to influence breeding success, however there was evidence that nest location (height within the colony) was closely related to the probability of failure (i.e. nests on the lower edge of the colony have lower success rates). Thus, tagged individuals are likely to have been lower quality individuals which, on average, are more likely to suffer breeding failure. Failed breeders will be expected to undertake longer duration trips due to the absence of a need to return to the colony to feed chicks 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.

261. Many tracking studies 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).

262. 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.

263. 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.

264. Thus, while tracking data are undoubtedly very useful in understanding foraging ranges and locations, it is important to note that the data may not be representative of natural behaviour.

265. Earlier RSPB tracking studies conducted at the Flamborough and Filey Coast SPA colony between 2010 and 2013 (and subject to the biases described above) indicated 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 and Filey Coast SPA colony should be assumed to forage within 156km of the colony for impact assessments for offshore wind farms (Natural England 2015a). Since Flamborough and Filey Coast SPA is 220km from the Norfolk Boreas site, following Natural England guidance it is reasonable to assume that only a very small percentage of breeding adults from the SPA will be at risk of collision mortality at the Norfolk Boreas site during the breeding season.

266. 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 Density Estimates (KDE). A figure presenting the results of this analysis does not indicate any overlap with either the former East Anglia Zone or Norfolk Boreas (Figure 1b, Carroll et al. 2017). Therefore, while breeding season connectivity between Norfolk Boreas 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.

267. Kittiwakes from the Flamborough and Filey Coast SPA 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 and Filey Coast SPA 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.

268. 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).

269. 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).

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

271. 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).

272. 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 and Filey Coast SPA 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 and Filey Coast SPA will breed in a different 'population' and not at Flamborough and Filey Coast SPA colony. Apportioning immature birds at risk of collision mortality at the Norfolk Boreas site to the Flamborough and Filey Coast SPA colony is therefore difficult and probably inappropriate, other than to suggest that most immature birds present at Norfolk Boreas may be associated (loosely) with kittiwake populations from within about 500 to 1,000km of the Norfolk Boreas site.

273. A proportion of the birds at the Norfolk Boreas 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 Boreas 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 and Filey Coast SPA colony, as the numbers from elsewhere are uncertain, and any 'association' of immature birds with the Flamborough and Filey Coast SPA 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.

274. This is supported by the results in Wischnewski et al. (2018) which show very low connectivity with the Norfolk Boreas site (see Figure 8 of Wischnewski et al. 2018).

For the adjacent Norfolk Vanguard site the tracking data from this study were analysed to inform estimation of an appropriate apportioning rate for that wind farm. This assessment concluded that a breeding season rate of 26.1% was appropriate, and still precautionary. This rate is considered to be appropriately precautionary for Norfolk Boreas too, and has been applied in this assessment.

275. Collision mortality of kittiwakes at the Norfolk Boreas site based on Band Option 2 and an avoidance rate of 98.9% (as recommended by Natural England and other SNCBs) was estimated to be 203 birds per year, with approximately 60% occurring in autumn (Norfolk Boreas ES Chapter 13 Offshore Ornithology Technical Appendix 13.1). It is worth noting that recent analysis of kittiwake behaviour at an operational wind farm has indicated that a more realistic (and still precautionary) avoidance rate is 99.0% (Bowgen and Cook 2018), which would reduce the estimated collisions by 10% (although noting that most of the data collected was outside the breeding season so this conclusion may not apply all year round).

Table 6.17 Predicted monthly numbers collision estimates for kittiwake at the Norfolk Boreas site calculated using Band Option 2 (generic flight heights) for the worst case turbine option (10MW) with uncertainty in seabird density (95% c.i.) and using the higher nocturnal activity rate ('3'=50%). Months in bold indicate the migration free breeding months (note that the full breeding season has also considered in the assessment). Apportioning in spring, breeding and autumn seasons at 7.2%, 26.1% and 5.4% respectively.

Month	Deterministic collision mortality (mean density and 95% c.i.)	Monthly proportions – migration free breeding season (95% c.i.)	Monthly proportions – full breeding season (95% c.i.)
January	32.52 (11.06-57.7)	2.34 (0.8-4.15)	2.34 (0.8-4.15)
February	9.64 (2.96-17.81)	0.69 (0.21-1.28)	0.69 (0.21-1.28)
March	5.23 (0-13.03)	0.38 (0-0.94)	1.37 (0-3.4)
April	8.9 (4.43-15.12)	0.64 (0.32-1.09)	2.32 (1.16-3.95)
May	12.39 (5.8-19.34)	3.23 (1.51-5.05)	3.23 (1.51-5.05)
June	6.69 (0-17.24)	1.75 (0-4.5)	1.75 (0-4.5)
July	10.84 (1.96-23.44)	2.83 (0.51-6.12)	2.83 (0.51-6.12)
August	2.85 (0-8.46)	0.15 (0-0.46)	0.74 (0-2.21)
September	3.9 (0-10.37)	0.21 (0-0.56)	0.21 (0-0.56)
October	10.08 (0-26.95)	0.54 (0-1.46)	0.54 (0-1.46)
November	30.38 (14.61-49.56)	1.64 (0.79-2.68)	1.64 (0.79-2.68)
December	69.38 (45.34-95.66)	3.75 (2.45-5.17)	3.75 (2.45-5.17)
Total	203 (86-355)	18.16 (6.59-33.44)	21.42 7.43-40.52)

276. Estimates of the proportion of birds present on wind farms in the North Sea which originate from Flamborough and Filey Coast SPA 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 Boreas, a precautionary estimate of the proportion of birds present during the breeding season expected to originate from Flamborough and Filey Coast SPA would be 26.1%. Similarly, during migration in autumn and spring, 5.4% and 7.2% (respectively) of the birds observed are predicted to originate from Flamborough and Filey Coast SPA.

277. Applying these percentages to the collision estimates stated above generates the following mortality estimates for the Flamborough and Filey Coast SPA population Table 6.18).

Table 6.18 Estimated Flamborough and Filey Coast SPA kittiwake collision risk at Norfolk Boreas calculated using deterministic collision estimates and seasonal percentages as detailed in the text.

Month	Migration free breeding season		Full breeding season	
	Total	FFC	Total	FFC
Autumn (5.4%)	56.29 (18.44-103.66)	4.05 (1.33-7.46)	42.17 (14.02-75.51)	3.04 (1.01-5.44)
Spring (7.2%)	29.92 (7.76-60.02)	7.81 (2.03-15.67)	46.9 (12.19-96.63)	12.25 (3.18-25.23)
Breeding season (26.1%)	116.59 (59.96-190.99)	6.3 (3.24-10.31)	113.73 (59.96-182.54)	6.14 (3.24-9.86)
Total		**18.16 (6.59-33.44)**		**21.42 (7.43-40.52)**

278. These sum to annual total maximum adult collision mortality of 18.2 individuals using the migration-free breeding season and 21.4 using the extended breeding season, from a population of approximately 89,040 (44,520 pairs multiplied by 2). 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 adult population for assessment to approximately 102,000.

279. At an average natural adult mortality rate of 0.146 (Horswill and Robinson 2015), the natural mortality of the population is 13,000 (based on the designated population size). The addition of a maximum of 21.4 individuals to this would increase the mortality rate by 0.02%. Using the upper 95% confidence estimate (40.5) the increase in mortality rate would be 0.3% and using the lower 95% confidence interval (7.4) this would be 0.05%.

280. 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 even using the upper 95% confidence estimate, demonstrates that no

significant impact can be attributed to this level of impact arising from the proposed Norfolk Boreas project alone.

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

6.3.2.6.2. In-combination effect

282. 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 SPA are presented in Table 6.19.

Table 6.19 Kittiwake collision mortality for all wind farms with potential connectivity to the Flamborough and Filey Coast SPA

Tier	Wind farm	Spring		Breeding		Autumn		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
1	Beatrice Demonstrator	1.7	0.1	0.0	0.0	2.1	0.1	3.8	0.2
1	Greater Gabbard	11.4	0.8	1.1	0.0	15.0	0.8	27.5	1.6
1	Gunfleet Sands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	Kentish Flats	0.7	0.1	0.0	0.0	0.9	0.0	1.6	0.1
1	Lincs	0.7	0.0	0.7	0.7	1.2	0.1	2.6	0.8
1	London Array	1.8	0.1	1.4	0.0	2.3	0.1	5.5	0.3
1	Lynn and Inner Dowsing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	Scroby Sands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	Sheringham Shoal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	Teesside	2.5	0.2	38.4	0.0	24.0	1.3	64.9	1.5
1	Thanet	0.4	0.0	0.3	0.0	0.5	0.0	1.2	0.1
1	Humber Gateway	1.9	0.1	1.9	1.9	3.2	0.2	7.0	2.2
1	Westermost Rough	0.1	0.0	0.1	0.1	0.2	0.0	0.5	0.1
1	Hywind	0.9	0.1	16.6	0.0	0.9	0.0	18.3	0.1
2	Kincardine	1.0	0.1	22.0	0.0	9.0	0.5	32.0	0.6
2	Beatrice	39.8	2.9	94.7	0.0	10.7	0.6	145.2	3.4
2	Dudgeon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	Galloper	31.8	2.3	6.3	0.0	27.8	1.5	65.9	3.8
2	Race Bank	5.6	0.4	1.9	1.9	23.9	1.3	31.4	3.6
2	Rampion	29.7	2.1	54.4	0.0	37.4	2.0	121.5	4.2
2	Hornsea Project One	20.9	1.5	44.0	36.5	55.9	3.0	120.8	41.0
3	Blyth Demonstration Project	1.4	0.1	1.4	0.0	2.3	0.1	5.1	0.2
3	Dogger Bank Creyke Beck Projects A and B	295.0	21.2	288.0	55.6	135.0	7.3	718.0	84.1
3	East Anglia ONE	46.7	3.4	1.5	0.0	161.0	8.7	209.2	12.1
3	European Offshore Wind Deployment Centre	1.1	0.1	11.8	0.0	5.8	0.3	18.7	0.4
3	Firth of Forth Alpha and Bravo	247.6	17.8	153.1	0.0	313.1	16.9	713.8	34.7
3	Inch Cape	63.5	4.6	13.1	0.0	224.8	12.1	301.4	16.7
3	Moray Firth (EDA)	19.3	1.4	43.6	0.0	2.0	0.1	64.9	1.5

Tier	Wind farm	Spring Total	Spring FFC SPA	Breeding Total	Breeding FFC SPA	Autumn Total	Autumn FFC SPA	Annual Total	Annual FFC SPA
3	Neart na Gaoithe	4.4	0.3	32.9	0.0	56.1	3.0	93.4	3.3
3	Dogger Bank Teesside Projects A and B	216.9	15.6	136.9	26.4	90.7	4.9	444.5	46.9
3	Triton Knoll	45.4	3.3	24.6	24.6	139.0	7.5	209.0	35.4
3	Hornsea Project Two	3.0	0.2	16.0	13.3	9.0	0.5	28.0	14.0
4	East Anglia THREE	37.6	2.7	6.1	0.0	69.0	3.7	112.7	6.4
5	Hornsea Project Three	11.4	0.8	165.3	153.7	61.3	3.3	238.0	157.9
5	Thanet Extension	15.3	1.1	2.3	0.0	5.3	0.3	23.0	1.4
5	Norfolk Vanguard	62.3	4.5	70.6	7.7	53.1	2.9	186.1	15.1
5	Moray West	7.0	0.5	79.0	0.0	24.0	1.3	110.0	1.8
6	*East Anglia TWO*	9.3	0.67	13.6	2.3	2.9	0.16	25.8	3.1
6	*East Anglia ONE North*	17.4	1.252	6.0	1.0	4.3	0.23	27.7	2.5
6	Norfolk Boreas	42.2	3.0	46.9	12.2	113.7	6.1	202.8	21.4
	Total	**1297.7**	**93.322**	**1396.5**	**337.9**	**1687.4**	**90.89**	**4381.8**	**522.5**

283. The cumulative total kittiwake collision estimate in spring is 1,298, in the breeding season 1,396 and in the autumn 1,687. Using the Flamborough and Filey Coast SPA proportions for all the wind farms with potential connectivity to the SPA, the adult mortality attributed to the Flamborough and Filey Coast SPA population is 93 (spring), 338 (breeding season) and 91 (autumn) with an (annual total of 522).

284. Of these, the proposed Norfolk Boreas project contributed a maximum of 22.4 annually (or 18.2 if the migration-free breeding season is applied). Therefore, irrespective of the potential total impact on the Flamborough and Filey Coast SPA kittiwake population, the contribution from the proposed Norfolk Boreas project is very small (=4% annually) and (as discussed above) would have an undetectable effect on the population. However, addition of the in-combination total of 522 adults to the background mortality of 13,000 would increase the mortality rate by 4.0%.

285. A population model was produced for this population for the Hornsea Project Three wind farm (MacArthur Green 2018). This model was an update of similar models produced for Hornsea Project Two, with the addition of a matched-run approach for calculating counterfactual outputs and an extended simulation period (35 years). Simulations were conducted with and without density dependence and were summarised as the counterfactual of population size and population growth rate. The outputs from these models for adult mortality levels of 500 and 550 (the closest values to the total) are provided in Table 6.20.

Table 6.20 Kittiwake FFC SPA population modelling results from MacArthur Green (2018).

Model	Mortality	Counterfactual metric (after 30 years)		Source table (MacArthur Green 2018)
		Growth rate	Population size	
Rate set 1, density independent	500	0.994	0.849	Table A2 5.1 & 5.3
	550	0.994	0.836	
Rate set 1, density dependent	500	0.999	0.954	Table A2 6.1 & 6.3
	550	0.999	0.949	
Rate set 2, density independent	500	0.994	0.850	Table A2 7.1 & 7.3
	550	0.994	0.835	
Rate set 2, density dependent	500	0.999	0.949	Table A2 8.1 & 8.3
	550	0.999	0.946	

286. The maximum reduction in the population growth rate, at a mortality of 550, using the more precautionary density independent model was 0.6% (0.994). Using the more realistic density dependent model the maximum reduction in growth rate was 0.1% (0.999). This growth rate reduction represents a very small risk to the population's conservation status.

287. The kittiwake breeding numbers at the Flamborough and Filey Coast SPA have remained relatively stable around an average of approximately 40,000 pairs over the last 20 years. The RSPB reported that since 2000 the population has grown by 7% which would equate to 0.4% annual growth rate (RSPB unpublished report). Therefore, the kittiwake population appears to be in favourable conservation status and the relevant conservation objective is to maintain this status, subject to natural change. On the basis of the precautionary in-combination collision estimate (including over-estimates for consented vs. built designs and over-estimated nocturnal activity) and the precautionary density independent model predictions for the total adult mortality of 522, there may be a small risk that further population growth will be restricted. However, the much more realistic density dependent model suggests that this level of mortality will have a much smaller effect on the population, with only a very slight reduction in the growth rate, and that the population's conservation status will not be affected.

288. Natural England contend that density dependence should only be included in population models when evidence for this is available for the population in question and that this is not the case for the Flamborough and Filey Coast SPA kittiwake population. However, as noted above, there is evidence for density dependence in the North Sea kittiwake population (EATL 2016b) and exploratory analysis has been used to guide the most appropriate method for inclusion in population models (Trinder 2014). Therefore, while there may not be direct evidence for the SPA population, there is evidence of density dependence for the wider population of

which it is an integral part and there is no reason that the SPA population would not be affected by the same regulatory drivers. Therefore, the arguments against the inclusion of density dependence are not considered to apply in this case.

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

6.3.2.6.3. Conclusion

290. 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 SPA 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.

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

292. The number of predicted in-combination kittiwake collisions attributed to the Flamborough and Filey Coast SPA would not trigger a risk of population decline based on population viability analysis modelling and despite the precautionary nature of collision risk assessments. Therefore, it can be concluded **that there will be no adverse effect on the integrity of Flamborough and Filey Coast SPA** from impacts on kittiwake due to the proposed Norfolk Boreas project in-combination with other projects.

6.3.2.7. Razorbill

293. Norfolk Boreas is located 220km from Flamborough and Filey Coast SPA (the nearest breeding colony), which is beyond the razorbill mean maximum foraging range of 48.5km (Thaxter et al. 2012). Therefore, it is appropriate to assume there is no

breeding season connectivity with Norfolk Boreas. Outside the breeding season, razorbills migrate from their breeding sites. Large numbers are found throughout the North Sea in the nonbreeding seasons (covering the period from August to March).

294. Table 6.21 presents the abundance of razorbills in all wind farms included in the in-combination assessment, including Norfolk Boreas. The annual total of razorbills at risk of displacement on the Norfolk Boreas site (combined across the breeding season and all the nonbreeding seasons) was a mean maximum of 2,303 individuals (Table 6.21).

295. The totals at risk on other North Sea wind farms and apportioned to the Flamborough and Filey Coast SPA are also presented in Table 6.21. In the breeding season it was assumed that for projects within mean maximum foraging range (Westermost Rough) 100% of the individuals originate from this SPA, while the rates advised by Natural England for other projects in the breeding season were 48.2% for Hornsea Projects One and Two; 30% for Dogger Bank Creyke Beck and Dogger Bank Teesside. In the nonbreeding seasons rates of 3.4% (autumn and spring) and 2.7% (mid-winter) were used for all projects.

Table 6.21. Cumulative and in-combination razorbill numbers on wind farms in the North Sea.

	Total				Apportioned to the FFC SPA			
Project	Breeding	Autumn	Winter	Spring	Breeding	Autumn	Winter	Spring
Aberdeen	161	64	7	26	0.0	2.2	0.2	0.9
Beatrice	873	833	555	833	0.0	28.3	15.0	28.3
Blyth Demonstration	121	91	61	91	0.0	3.1	1.6	3.1
Dogger Bank Creyke Beck A	1250	1576	1728	4149	375.0	53.6	46.7	141.1
Dogger Bank Creyke Beck B	1538	2097	2143	5119	461.4	71.3	57.9	174.0
Dogger Bank Teesside A	834	310	959	1919	250.2	10.5	25.9	65.2
Dogger Bank Teesside B	1153	592	1426	2953	345.9	20.1	38.5	100.4
Dudgeon	256	346	745	346	0.0	11.8	20.1	11.8
East Anglia ONE	16	26	155	336	0.0	0.9	4.2	11.4
East Anglia THREE	1807	1122	1499	1524	0.0	38.1	40.5	51.8
East Anglia TWO	288	55	148	263	0.0	1.9	4.0	8.9
East Anglia ONE North	403	85	54	207	0.0	2.9	1.5	7.0
Galloper	44	43	106	394	0.0	1.5	2.9	13.4
Greater Gabbard	0	0	387	84	0.0	0.0	10.4	2.9
Hornsea Project One	1109	4812	1518	1803	534.5	163.6	41.0	61.3
Hornsea Project Two	2511	4221	720	1668	1210.3	143.5	19.4	56.7
Hornsea Project Three	630	2020	3694	1236	0.0	68.7	99.7	42.0
Humber Gateway	27	20	13	20	0.0	0.7	0.4	0.7
Hywind	30	719	10	0	0.0	24.4	0.3	0.0

Project	Total Breeding	Autumn	Winter	Spring	Apportioned to the FFC SPA Breeding	Autumn	Winter	Spring
Inch Cape	1436	2870	651	0	0.0	97.6	17.6	0.0
Kincardine	22	0	0	0	0.0	0.0	0.0	0.0
Lincs and LID6	45	34	22	34	0.0	1.2	0.6	1.2
London Array I & II	14	20	14	20	0.0	0.7	0.4	0.7
Moray East	2423	1103	30	168	0.0	37.5	0.8	5.7
Moray West	2808	3544	184	3585	0.0	120.5	5.0	121.9
Neart na Gaoithe	331	5492	508	0	0.0	186.7	13.7	0.0
Race Bank	28	42	28	42	0.0	1.4	0.8	1.4
Seagreen A	3208	0	0	0	0.0	0.0	0.0	0.0
Seagreen B	886	0	0	0	0.0	0.0	0.0	0.0
Sheringham Shoal	106	1343	211	30	0.0	45.7	5.7	1.0
Teesside	16	61	2	20	0.0	2.1	0.1	0.7
Thanet	3	0	14	21	0.0	0.0	0.4	0.7
Thanet Extension	0	0	34	50	0.0	0.0	0.9	1.7
Triton Knoll	40	254	855	117	0.0	8.6	23.1	4.0
Westermost Rough	91	121	152	91	91.0	4.1	4.1	3.1
Norfolk Vanguard East	599	491	491	752	0.0	16.7	13.3	25.6
Norfolk Vanguard West	280	375	348	172	0.0	12.8	9.4	5.8
Norfolk Boreas	630	263	1065	345	0.0	8.9	28.8	11.7
Seasonal total	**26017**	**35045**	**20537**	**28418**	**3268.3**	**1191.5**	**554.5**	**966.2**
Annual total				**110017**				**5980.6**

296. Natural England advises presentation of a range of displacement rates of between 30% and 70% displacement and 1% and 10% mortality. However, evidence was presented in support of the use of a precautionary displacement rate of 50% within the wind farm, 30% within the 1 km buffer and 0% thereafter, combined with a 1% mortality rate for guillemot and razorbill (Vattenfall 2019; although note that the variable buffer has not been applied in this assessment, with the 50% rate applied across both the wind farm and 2km buffer). Predictions using these alternative rates are presented in Table 6.22.

Table 6.22. Razorbill abundance estimates on Norfolk Boreas and summed across all UK North Sea and Channel wind farms, number apportioned to Flamborough and Filey Coast SPA and estimates of displacement mortality.

Site	Season	Total population at risk of displacement	Total impact, displacement & mortality rates:			Population apportioned to FFC SPA	FFC SPA impact, displacement & mortality rates:		
			30% - 1%	50% - 1%	70%- 10%		30% - 1%	50% - 1%	70%- 10%
Norfolk Boreas	Spring	345	1.0	1.7	24.2	11.7	0.0	0.1	0.8
	Breeding	630	1.9	3.2	44.1	0	0.0	0.0	0.0
	Autumn	263	0.8	1.3	18.4	8.9	0.0	0.0	0.6
	Midwinter	1065	3.2	5.3	74.6	28.8	0.1	0.1	2.0

Site	Season	Total population at risk of displacement	Total impact, displacement & mortality rates:			Population apportioned to FFC SPA	FFC SPA impact, displacement & mortality rates:		
			30% - 1%	50% - 1%	70%- 10%		30% - 1%	50% - 1%	70%- 10%
	Annual	2302	6.9	11.5	161.1	49.4	0.1	0.2	3.5
UK North Sea and Channel wind farms	Spring	28418	85.3	142.1	1989.3	966.2	2.9	4.8	67.6
	Breeding	26017	78.1	130.1	1821.2	3268.3	9.8	16.3	228.8
	Autumn	35045	105.1	175.2	2453.2	1191.5	3.6	6.0	83.4
	Midwinter	20537	61.6	102.6	1437.6	554.5	1.7	2.8	38.8
	Annual	110017	330.0	550.0	7701.2	5980.6	17.9	29.9	418.6

6.3.2.7.1. Potential effects of Norfolk Boreas

297. Natural England considered that an LSE on the razorbill population of the Flamborough and Filey Coast SPA due to displacement from the Norfolk Boreas wind farm could not be ruled out. Apportioning the Norfolk Boreas displacement mortality to the SPA on the basis of no connectivity in the breeding season (as the wind farm is located more than four times the mean maximum foraging range for this species) and an even distribution in the nonbreeding season (on the assumption that the SPA population is evenly distributed within the nonbreeding BDMPS population) the worst case mortality due to Norfolk Boreas was 3.5 individuals (using the 95% confidence intervals on the density estimates gives a range of 1.5 to 5.7). This would increase the baseline mortality of the population (5,051, calculated for adults at a mortality rate of 0.06, Horswill and Robinson 2015) by 0.07% (95% range 0.03% to 0.11%), which would be undetectable. Therefore, displacement of razorbill from Norfolk Boreas would not have an adverse effect on the integrity of the SPA.

6.3.2.7.2. In-combination

298. Given the extremely small mortality due to Norfolk Boreas it is clear that the project will make an extremely small contribution to an in-combination impact. Nonetheless, on the basis of the totals in Table 6.22 the combined displacement mortality across the whole year was estimated to be in the range 18 to 419 individuals. These would increase the baseline mortality rate of the population (all ages) by 0.36% to 8.3%, while assessed using the evidence based displacement and mortality rates, the increase would be 0.6%.

299. On the basis of the most precautionary rates preferred by Natural England, there is potential for an adverse effect on the razorbill population due to in-combination displacement effects. However, using the evidence based prediction, which is below the 1% threshold for detecting increases in mortality, the conclusion would be no adverse effect on the integrity of this SPA for the Project Alone or in-combination

with other plans and projects. Furthermore, the contribution to this from Norfolk Boreas is very small, estimated to comprise 0.8%.

300. Outputs from a PVA model for this population were presented for the Hornsea Project Three wind farm (MacArthur Green 2018). This modelling was an update of similar models produced for Hornsea Project Two, with the addition of a matched-run approach for calculating counterfactual outputs and an extended simulation period (up to 35 years). Simulations were conducted with and without density dependence and were summarised as the counterfactual of population size and population growth rate. The outputs from these models for mortality levels of 50 and 400 (the nearest values to the project alone and in-combination predictions) are provided in Table 6.23.

Table 6.23. Razorbill FFC SPA population modelling results from MacArthur Green (2018).

Model	Mortality	Counterfactual metric (after 30 years)		Source table (MacArthur Green 2018)
		Growth rate	Population size	
Rate set 1, density independent	50	0.998	0.934	Table A2 13.1 & 13.3
	400	0.981	0.574	
Rate set 1, density dependent	50	1.00	0.978	Table A2 14.1 & 14.3
	400	0.996	0.825	
Rate set 2, density independent	50	0.998	0.933	Table A2 15.1 & 15.3
	400	0.981	0.574	
Rate set 2, density dependent	50	0.998	0.949	Table A2 16.1 & 16.3
	400	0.985	0.636	

301. The maximum reduction in the population growth rate, at a mortality of 50 (which is 14 times the Norfolk Boreas alone adult displacement mortality of 3.5 estimated using the worst case displacement and mortality rates), using the more precautionary density independent model was 0.2% (0.998). On the basis of the observed rate at which this population has grown, between 2000 and 2008 (7.2%) and between 2008 and 2017 (7.2%) (RSPB unpubl. Report 2017), a reduction of 0.2% to this rate represents a negligible risk for the population.

302. The maximum reduction in the population growth rate, at a mortality of 400 (which is the nearest modelled value to the in-combination adult total of 418), using the more precautionary density independent model was 1.9% (0.981). On the basis of the observed rate at which this population has grown, between 2000 and 2008 (7.2%) and between 2008 and 2017 (7.2%) (RSPB unpubl. Report 2017), a reduction of 1.9% to this rate, due to the worst case displacement predictions, would still permit population growth at over 5.3% per year.

303. The razorbill breeding numbers at the Flamborough and Filey Coast SPA have shown strong growth over the last 20 years and are continuing to increase so the population is therefore clearly in favourable conservation status. The relevant conservation objective is to maintain favourable conservation status of the razorbill population, subject to natural change.

304. On the basis of the population model outputs the number of predicted in-combination razorbill displacement mortalities attributed to the Flamborough & Filey Coast SPA is not at a level which would trigger a risk of population decline, but would only result in a small reduction in the growth rate currently seen at this colony, and so would not have an adverse effect on integrity of the SPA.

305. Therefore, it can be concluded that there will be no adverse effect on the integrity of Flamborough & Filey Coast SPA from impacts on razorbill due to the proposed Norfolk Vanguard project in-combination with other plans and projects.

6.3.2.8. Guillemot

306. Norfolk Boreas is located 220km from Flamborough and Filey Coast SPA (the nearest breeding colony), which is beyond the guillemot mean maximum foraging range of 84.2km (Thaxter et al. 2012). Outside the breeding season, guillemots disperse from their breeding sites. Large numbers are found throughout the North Sea in the nonbreeding season (covering the period from August to February).

307. Table 6.24 presents the abundance of guillemots in all wind farms included in the cumulative assessment, including Norfolk Boreas. The annual total of guillemots at risk of displacement on the Norfolk Boreas site (combined across the breeding season and the nonbreeding season) was a mean maximum of 21,544 individuals (Table 6.24).

308. The totals at risk on other North Sea wind farms and apportioned to the Flamborough and Filey Coast SPA are also presented in Table 6.24. the following apportioning rates were applied: in the breeding season, 100% for projects within mean maximum foraging range (Teesside, Humber Gateway, Triton Knoll, Westermost Rough), 46.3% for Hornsea One and Two; 35% for Dogger Bank Creyke Beck and Dogger Bank Teesside. In the nonbreeding season 4.4% for all projects.

Table 6.24. Cumulative and in-combination guillemot numbers on wind farms in the North Sea.

	Total		FFC SPA	
Project	Breeding	Nonbreeding	Breeding	Nonbreeding
Aberdeen	547	225	0	9.9
Beatrice	13610	2755	0	121.2
Blyth Demonstration	1220	1321	0	58.1
Dogger Bank Creyke Beck A	5407	6142	1892.5	270.2
Dogger Bank Creyke Beck B	9479	10621	3317.7	467.3

Project	Total Breeding	Nonbreeding	FFC SPA Breeding	Nonbreeding
Dogger Bank Teesside A	3283	2268	1149.1	99.8
Dogger Bank Teesside B	5211	3701	1823.9	162.8
Dudgeon	334	542	0	23.8
East Anglia ONE	274	640	0	28.2
East Anglia THREE	1744	2859	0	125.8
East Anglia TWO	305	593	0	26.1
East Anglia ONE North	345	548	0	24.1
Galloper	9836	8097	0	356.3
Greater Gabbard	7735	13164	0	579.2
Hornsea Project One	13374	17772	6192.2	782.0
Hornsea Project Two	2126	2020	984.3	88.9
Hornsea Project Three	4183	1847	0	81.3
Humber Gateway	99	138	99	6.1
Hywind	249	2136	0	94.0
Inch Cape	4371	3177	0	139.8
Kincardine	632	0	0	0.0
Lincs and LID6	582	814	0	35.8
London Array I & II	192	377	0	16.6
Moray East	9820	547	0	24.1
Moray West	24426	38174	0	1679.7
Neart na Gaoithe	1755	3761	0	165.5
Race Bank	361	708	0	31.2
Seagreen A	13606	4688	0	206.3
Seagreen B	11118	4112	0	180.9
Sheringham Shoal	390	715	0	31.5
Teesside	267	901	267	39.6
Thanet	18	124	0	5.5
Thanet Extension	49	837	0	36.8
Triton Knoll	425	746	425	32.8
Westermost Rough	347	486	347	21.4
Norfolk Vanguard East	2931	2197	0	96.7
Norfolk Vanguard West	1389	2579	0	113.5
Norfolk Boreas	7767	13777	0	606.2
Seasonal total	**159807**	**156109**	**16497.5**	**6868.8**
Annual total		**315916**		**23366**

309. Natural England advises presentation of a range of displacement rates of between 30% and 70% displacement and 1% and 10% mortality. However, evidence was presented in support of the use of a precautionary displacement rate of 50% within the wind farm, 30% within the 1km buffer and 0% thereafter, combined with a 1% mortality rate for guillemot and razorbill (Vattenfall 2019; although note that the variable buffer has not been applied in this assessment, with the 50% rate applied

across both the wind farm and 2km buffer). Predictions using these alternative rates are presented in Table 6.25

Table 6.25. Guillemot abundance estimates on Norfolk Boreas and summed across all UK North Sea and Channel wind farms, number apportioned to Flamborough and Filey Coast SPA and estimates of displacement mortality.

Site	Season	Total population at risk of displacement	Total impact, displacement & mortality rates:			Population apportioned to FFC SPA	FFC SPA impact, displacement & mortality rates:		
			30% - 1%	50% - 1%	70%- 10%		30% - 1%	50% - 1%	70%- 10%
Norfolk Boreas	Breeding	7767	23.3	38.8	543.7	0	0.0	0.0	0.0
	Nonbreeding	13777	41.3	68.9	964.4	606.2	1.8	3.0	42.4
	Annual	21544	64.6	107.7	1508.1	606.2	1.8	3.0	42.4
UK North Sea and Channel wind farms	Breeding	159807	479.4	799.0	11186.5	16498	49.5	82.5	1154.8
	Nonbreeding	156109	468.3	780.5	10927.6	6868.8	20.6	34.3	480.8
	Annual	315916	947.7	1579.6	22114.1	23366	70.1	116.8	1635.6

6.3.2.8.1. Potential effects of Norfolk Boreas

310. Natural England considered that a likely significant effect on the guillemot population of the Flamborough and Filey Coast SPA, due to displacement from Norfolk Boreas, could not be ruled out. Apportioning the Norfolk Boreas displacement mortality to the SPA on the basis of no connectivity in the breeding season (as the wind farm is located more than four times the mean maximum foraging range for this species) and an even distribution in the nonbreeding season (on the assumption that the SPA population is evenly distributed within the nonbreeding BDMPS population) the worst case mortality due to Norfolk Boreas was 42.4 individuals (using the 95% confidence intervals on density the range is 21.5 to 60.5). This would increase the baseline mortality (of 5051 calculated using the adult mortality rate, Horswill and Robinson 2015) by 0.8%, which would be undetectable (95% confidence range 0.5% to 1.2%). Thus, an increase in mortality of 1% (the threshold for detecting an effect) was only obtained with the most precautionary combination of estimates (the upper 95% confidence limit on density combined with the most precautionary displacement rates of 70% displaced and 10% mortality). Therefore, displacement of guillemot from Norfolk Boreas would not have an adverse effect on the integrity of the SPA.

6.3.2.8.2. In-combination

311. Given the small mortality due to Norfolk Boreas it is clear that the Project will also make a small contribution to an in-combination impact. Nonetheless, on the basis of the totals presented in Table 6.25 the combined displacement mortality across the

whole year was estimated to be in the range 70 to 1635 individuals. These would increase the baseline mortality rate of the population by 1.4% to 32.4%. Assessed using the evidence based displacement and mortality rates, the increase would be 2.3%.

312. On this basis, using the worst case approach (70% displacement and 10% mortality) there is potential for an adverse effect on the guillemot population due to in-combination displacement effects, however the contribution from Norfolk Boreas is very small, estimated to comprise 2.6%.

313. Outputs from a PVA model for this population were presented for the Hornsea Project Three wind farm (MacArthur Green 2018). This modelling was an update of similar models produced for Hornsea Project Two, with the addition of a matched-run approach for calculating counterfactual outputs and an extended simulation period (up to 35 years). Simulations were conducted with and without density dependence and were summarised as the counterfactual of population size and population growth rate. The outputs from these models for mortality levels of 50 and 1600 (the nearest values to the project alone and in-combination predictions) are provided in Table 6.26.

Table 6.26. Guillemot FFC SPA population modelling results from MacArthur Green (2018).

Model	Mortality	Counterfactual metric (after 30 years)		Source table (MacArthur Green 2018)
		Growth rate	Population size	
Rate set 1, density independent	50	0.999	0.983	Table A2 9.1 & 9.3
	1600	0.981	0.570	
Rate set 1, density dependent	50	1.000	0.992	Table A2 10.1 & 10.3
	1600	0.992	0.752	
Rate set 2, density independent	50	0.999	0.983	Table A2 11.1 & 11.3
	1600	0.981	0.570	
Rate set 2, density dependent	50	1.000	0.991	Table A2 12.1 & 12.3
	1600	0.991	0.729	

314. The maximum reduction in the population growth rate, at a mortality of 50, using the more precautionary density independent model was 0.1% (0.999). On the basis that the observed rate at which this population grew between 2000 and 2008 (3.0%) and between 2008 and 2017 (4.0%) (RSPB unpubl. Report 2017), a reduction of 0.1% to this rate represents a negligible risk for the population.

315. The maximum reduction in the population growth rate, at a mortality of 1,600 (which is the nearest modelled value to the in-combination total of 1,635), using the more precautionary density independent model was 1.9% (0.981). On the basis that

the observed rate, at which this population has grown between 2000 and 2008 (3.0%) and between 2008 and 2017 (4.0%) (RSPB unpubl. Report 2017), a reduction of 1.9% to this rate represents a minor risk for the population.

316. The guillemot breeding numbers at the Flamborough and Filey Coast SPA have shown strong growth over the last 20 years and the population is therefore clearly in favourable conservation status. The relevant conservation objective is to maintain favourable conservation status of the guillemot population, subject to natural change.

317. On the basis of population model outputs the number of predicted in-combination guillemot displacement mortalities attributed to the Flamborough & Filey Coast SPA is not at a level which would trigger a risk of population decline, but would only result in a small reduction in the growth rate currently seen at this colony, and so would not have an adverse effect on integrity of the SPA.

318. Therefore, it can be concluded that there will be no adverse effect on the integrity of Flamborough & Filey Coast SPA from impacts on guillemot due to the proposed Norfolk Boreas project in-combination with other projects.

6.3.3. Greater Wash SPA

6.3.3.1. Little gull

6.3.3.1.1. Potential effects of Norfolk Boreas

319. Little gulls are mainly seen in the Greater Wash SPA 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 SPA, 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 SPA are unlikely to show regular connectivity with Norfolk Boreas, 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 Boreas area and those seen in the Greater Wash SPA.

320. 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%.

321. The collision mortality for the Norfolk Boreas site was 4 individuals, derived from option 2 of the deterministic Band model (see Norfolk Boreas 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 with an upper estimate of 75,000 (Steinen et al. 2007). 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 Boreas collision mortality of 4 birds represents an increase in mortality of 0.1% to 0.2%. 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 Boreas project alone.

322. The Greater Wash SPA designated population of little gull is 1,255, 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 0.5 individuals from the Greater Wash SPA population of little gull could be killed by collisions (13% of 4), which would be even reduced further on the basis of the more realistic wider population (of 20,000).

323. Thus, it can be concluded that the maximum additional mortality of 0.5 individuals from the SPA population will be undetectable and there will be no adverse effect on the integrity of the Greater Wash SPA as a result of collisions at the Norfolk Boreas project alone.

324. 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

325. Given the extremely small potential impact on little gull due to collisions at Norfolk Boreas it is apparent that the likelihood of the project contributing to an in-combination impact is extremely small.

326. However, following advice from Natural England the predicted mortality at wind farms with potential connectivity to the Greater Wash SPA has been collated and assessed.

327. The predicted mortality of little gull at Norfolk Boreas in-combination with other wind farms with potential connectivity to the Greater Wash SPA little gull population was 67.2 (Table 6.27).

Table 6.27 Assessed collision rates and updated little gull collision predictions for offshore wind farm sites with potential connectivity to the Greater Wash SPA.

Wind farm	Annual collisions	Avoidance rate (%)	Assessed wind farm size	Collisions updated for 99.2% avoidance rate	Built or proposed wind farm size	Collisions updated for built or proposed wind farm
Triton Knoll	65	98	288 * 3.6MW	26	TBC. c. 120	c. 15
Race Bank	52	98	206 * 3MW	21	91 * 6MW	12
Sheringham Shoal	8	98	108 * 3MW	3	88 * 3.6MW	3
Hornsea Project One	10	98	332 * 3.6MW	4	174 * 7MW	2
Hornsea Project Two	1.3	98	360 * 5MW	0.5	N/A	0.5
Hornsea Project Three	0.5	99.2	300 * 6MW	0.5	N/A	0.5
Norfolk Vanguard	8.3	99.2	180 * 10MW	8.3	N/A	8.3
Norfolk Boreas	3.9	99.2	180 x 10MW	3.9	N/A	3.9
In-combination total				**67.2**		**45.2**

328. Given a regional little gull population of between 10,000 and 20,000 this figure (67.2) represents an increase in background mortality of between 1.7% and 3.3% (although as noted above the population may be as large as 75,000, further reducing the magnitude of potential impact, to an increase in mortality of less than 0.5%). The Greater Wash SPA designated population of little gull is 1,255, which is 12.6% of a population of 10,000 or 6.3% 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 8.5 individuals from the Greater Wash SPA population would be at risk of in-combination collisions (12.6% of 67.2), although using the actual built projects (or planned designs) and noting that Triton Knoll has reduced its capacity to 90 turbines this would reduce to 5.7 individuals. Furthermore, the in-combination collisions would be reduced to 2.8 individuals on the basis of the more realistic wider

population (of 20,000). These would give rise to increases in mortality for the SPA population of between 1.1% (for built projects and the realistic population of 20,000) and 3.4% using the most precautionary combination of consented development predictions and the smallest regional population estimate of 10,000.

329. A very similar total collision estimate of 7 individuals was assessed by the Secretary of State (SoS) for the in-combination assessment for the Triton Knoll non-material change application (BEIS 2018). In relation to this estimate the SoS stated:

"Assuming collisions are attributed evenly amongst the regional population, this equates to 7 individuals from the Greater Wash population. Such a small impact would also be undetectable in the SPA population."

And also:

"in view of the small impacts quantified above, the Secretary of State considers that an Appropriate Assessment is not required in this case."

330. Thus, on the basis of an SPA in-combination mortality of 8.5, for the most precautionary interpretation of the potential risk to the population or a more realistic total of 2.8, the likelihood of an adverse effect on the integrity of the Greater Wash SPA population of little gull can be ruled out for the proposed Norfolk Boreas project in-combination with other plans and projects.

6.3.3.1.3. Conclusion

331. The maximum potential impact on the little gull population of the Greater Wash SPA is extremely small and therefore the likelihood of an adverse effect on the integrity of the Greater Wash SPA population of little gull can be ruled out for the proposed Norfolk Boreas project both alone and in-combination with other projects.

6.3.3.2. Red-throated diver

6.3.3.2.1. Potential effects of Norfolk Boreas

332. 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, Mendel et al. 2019). 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).

Operational vessel movements

333. Vessel movements during the operation of the wind farm for maintenance activities have the potential to disturb red-throated divers. However, within the confines of the wind farm site and the 4 km buffer, the magnitude of displacement due to the wind farm itself (assessed as 90-100%) is such that there would be virtually no additional effect caused by vessel movements (i.e. almost all individuals will already have been displaced). Therefore, no further assessment for operational vessel movements within the wind farm site (and buffer) is required.

334. The operation and maintenance port has not been confirmed at this stage. However, it is clear from consideration of the existing volume of shipping traffic through the region (Chapter 15 Shipping and Navigation of the ES, Appendix 15.1 and Figures 15.1 and 15.2 of the ES), which includes the Greater Wash SPA and Outer Thames Estuary SPA, that the addition of vessels transiting to and from the port and the wind farm (approx. 1.2 vessel movements per day) will have a negligible effect on the levels of shipping disturbance over and above the average of almost 100 vessel movements per day (derived from AIS data, and therefore not including smaller vessels).

335. Natural England have indicated for previous projects that, the low additional volumes of vessel traffic notwithstanding, they consider there is still the potential for an adverse effect due to operation and maintenance vessel movements. However, Natural England have also advised that implementation of best practice guidance (as proposed by Natural England) on vessel operation whilst transiting the Greater Wash SPA during sensitive periods of the year (i.e. the red-throated diver nonbreeding season, or key parts thereof) will remove the likelihood of an adverse effect on the integrity of the Greater Wash SPA red-throated diver population. The Applicant will engage with Natural England to agree the terms of these vessel management measures, and this will be reflected in the draft DCO.

Offshore export cable installation

336. 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 Boreas, 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.

337. The magnitude of disturbance to red-throated diver for Norfolk Boreas 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.

338. In order to calculate the number of red-throated divers that would potentially be at risk of displacement from the Norfolk Boreas 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 SPA crossed by the cable route was between 1.36 and 3.38 per km^2.

339. 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 vessel speed of 7m per minute. For context, a modest tidal flow rate for the region is an order of magnitude higher, in the region of 1m per second (i.e. 60m per minute). The tide would therefore be flowing at least nine times faster than the cable laying vessel. Thus, for the purposes of estimating displacement the vessels can be considered as effectively stationary (i.e. from the perspective of the birds affected which will be moving with the tide). 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.

340. 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.

341. For recent wind farm assessments Natural England have advised that a highly precautionary 10% maximum mortality rate should be used for birds displaced by cable laying vessels. This magnitude of impact is not supported in the literature and given that this would equate to more than half the natural adult annual mortality (16%) from a single occasion of disturbance (as described above), it is highly improbable that such an effect would occur. To illustrate this, it is worth considering that disturbance from vessels in the southern North Sea has been ongoing for decades and that mortality due to single instances of vessel disturbance during the course of the winter, as proposed by Natural England, would reduce a population of 1,500 to fewer than 100 within 10 years (alternatively the SPA population would need to have been 16 times larger 10 years prior to the SPA designation surveys in order to have been reduced to 1,500). Neither of these scenarios is supported by the evidence.

342. A review of available evidence for red-throated diver displacement was submitted for the Norfolk Vanguard assessment (MacArthur Green 2019) and that concluded that there would be little or no effect of displacement on diver survival. Consequently, a maximum, and hence precautionary, displacement caused mortality rate of 1% was identified as appropriate for this assessment.

343. This leads to a highly precautionary assumption that a single instance of displacement, as described above, will result in a maximum of 1 individual being 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 to the assessment and the nature of the calculations employed, this almost certainly over-estimates the duration of cable laying by a factor of around 6, since even travelling at the minimum

speed of 30m per hour with a working day of 12 hours, the vessel would traverse the SPA in approximately 40 days (assuming the cable route through the SPA is around 15km) from a winter period of around 240 days. From these considerations it is clear that the assumption of 1% mortality is highly precautionary in relation to disturbance by cable laying vessels.

344. 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 (1,407), would be approximately 280 (calculated using a composite all age class mortality rate of 0.2). The addition of a maximum of 1 to this total during a single year would increase the mortality rate in that year by approximately 0.35%. This is less than the SNCB advised 1% threshold of detectable change in mortality. Therefore, 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 Boreas project alone.

345. Natural England advise that they did not consider the above assumptions to be sufficiently precautionary and that assessment should also consider their advised rates of 100% displacement and 10% mortality. At these rates, between 4 and 8 individuals wold be at risk of mortality (if two vessels are operating within the SPA at the same time) in a single year. This would increase the background mortality in that year by 1.3% to 2.6%.

346. However, since 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 remains 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 Boreas project alone.

6.3.3.2.2. In-combination effect

347. 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).

348. 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 Boreas offshore cable route indicate that the likelihood of an in-combination disturbance effect is negligible.

349. 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. However, the addition of the very small potential impact from cable installation for Norfolk Boreas would be undetectable. It should also be noted that cable installation for the Norfolk Vanguard Wind Farm will almost certainly not overlap with that for Norfolk Boreas (for example due to limitations on available vessels).

350. Natural England advised that there is potential for the cable installation for Norfolk Boreas through the Greater Wash SPA to overlap with that for Hornsea Project Three. It is not clear from Hornsea Project Three's construction timelines how likely such an overlap would be, and given that the actual duration of cable installation through the SPA for Norfolk Boreas is likely to be no longer than 6 weeks, it would seem that the risk of this occurring simultaneously is in fact very small.

351. The predicted mortality of red-throated diver due to cable installation displacement for Hornsea Project Three was two individuals (estimated at 100% displacement and 10% mortality). The in-combination mortality for Norfolk Boreas and Hornsea Project Three is therefore between 6 and 10 individuals, although as noted the likelihood of these occurring over the same period is considered to be very small. Assessed using the Applicant's evidence based rates, the in-combination mortality would be between 0.6 and 1 individual.

352. The addition of a maximum of 6 to 10 to the baseline mortality of 300 during a single year would increase the mortality rate in that year by approximately 2% to 3.3%, while at the Applicant's evidence based rates this would be 0.3%

353. However, this assessment is based on a combination of highly precautionary assumptions about the magnitude and impact of displacement and the potential for temporal overlap between the projects. This in-combination effect would only be expected to occur during a single nonbreeding season, if both cable laying vessels planned for Norfolk Boreas are present at the same time, and this was also at the same time when those for Hornsea Project Three are present, and furthermore that this combination of events occurs within the SPA during the nonbreeding period (which is the least favoured period for such work due to less suitable weather conditions). If any of these conditions is not met, then there would not be an in-combination impact.

354. Thus, an adverse effect on integrity due to in-combination displacement can be seen to be highly improbable since it is contingent on several highly precautionary assumptions. It is therefore 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 Boreas project in-combination with that for Hornsea Project Three.

6.3.3.2.3. Conclusion

355. The maximum potential impact on the red-throated diver population of the Greater Wash SPA is extremely small and therefore it is concluded that **there will be no adverse effect on the integrity of the Greater Wash SPA** population of red-throated diver for the proposed Norfolk Boreas project both alone and in-combination with other projects.

6.3.4. Outer Thames Estuary SPA

6.3.4.1.1. Potential effects of Norfolk Boreas

356. 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, Mendel et al. 2019). 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).

Operational vessel movements

357. Vessel movements during the operation of the wind farm for maintenance activities have the potential to disturb red-throated divers. However, within the confines of the wind farm site and the 4 km buffer, the magnitude of displacement due to the wind farm itself (assessed as 90-100%) is such that there would be virtually no additional effect caused by vessel movements (i.e. almost all individuals will already have been displaced). Therefore, no further assessment for operational vessel movements within the wind farm site (and buffer) is required.

358. The operation and maintenance port has not been confirmed at this stage. However, it is clear from consideration of the existing volume of shipping traffic through the region (Chapter 15 Shipping and Navigation, Appendix 15.1 and Figures 15.1 and 15.2 of the ES (document reference 6.1 6.2 and 6.3), which includes the Greater Wash SPA and Outer Thames Estuary SPA, that the addition of vessels transiting to and from the port and the wind farm (approx. 1.2 vessel movements per day) will have a negligible effect on the levels of shipping disturbance over and above the average of almost 100 vessel movements per day (derived from AIS data, and therefore not including smaller vessels).

359. Natural England have indicated for previous projects that, the low additional volumes of vessel traffic notwithstanding, they consider there is still the potential for an adverse effect due to operation and maintenance vessel movements. However, Natural England have also advised that implementation of best practice guidance (as proposed by Natural England) on vessel operation whilst transiting the Outer Thames Estuary SPA during sensitive periods of the year (i.e. the red-throated diver nonbreeding season, or key parts thereof) will remove the likelihood of an adverse effect on the integrity of the Outer Thames Estuary SPA red-throated diver population. The Applicant will engage with Natural England to agree the terms of these vessel management measures, and this will be reflected in the draft DCO.

360. Therefore, it can be concluded **that there will be no adverse effect on the integrity of Outer Thames Estuary SPA.**

6.3.5. Summary of Potential Effects

361. Following screening, four SPAs and five features were identified for further assessment for the proposed Norfolk Boreas project on the basis of potential impacts either alone or in-combination with other plans or projects (Table 6.28).

Table 6.28 SPAs and features for which further assessment was required in relation to potential impacts from the proposed Norfolk Boreas 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	Gannet	Collision risk
	Kittiwake	Collision risk
Greater Wash	Red-throated diver	Construction disturbance and displacement due to cable laying (project alone and in-combination) Operation and Maintenance vessel movements
	Little gull	Collision risk
Outer Thames Estuary	Red-throated diver	Operation and Maintenance vessel movements

362. A full assessment was undertaken for all the sites and features listed in Table 6.28. 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 6.29. Integrity matrices are provided in Appendix 6.1.

Table 6.29 Conclusions of the full assessment

Qualifying feature	Potential effect	Potential for adverse effect on the integrity alone?	Potential for adverse effect on the integrity in-combination?
Alde-Ore Estuary			
Lesser black-backed gull	**Project alone collision risk** At a predicted maximum mortality level of 3 birds for the proposed Norfolk Boreas project, it can be concluded with confidence for lesser black-backed gull that there will be no adverse effect on the integrity of the Alde-Ore Estuary SPA. **In-combination collision risk** The in-combination mortality attributable to the Alde-Ore SPA population is a precautionary figure of 47 individuals, which represents an increase in mortality of 5% over natural mortality. Since annual mortality at the proposed Norfolk Boreas project is estimated to be fewer than 3 individuals, it is clear that the contribution of the proposed Norfolk Boreas 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 Boreas project in-combination with other projects	×	×
Flamborough and Filey Coast			
Gannet	**Project alone collision risk** At a predicted maximum mortality level of 57 birds for the proposed Norfolk Boreas project, it can be concluded with confidence for gannet that there will be no adverse effect on the integrity of the Flamborough and Filey Coast SPA. **In-combination collision risk** The number of predicted in-combination gannet collisions attributed to the Flamborough & Filey Coast SPA is a precautionary 290 which is not at a level which would trigger a risk of population decline. Furthermore, the impact on the Flamborough and Filey Coast SPA gannet population resulting from in-combination collisions is below the thresholds of concern proposed for previously consented developments, and population modelling indicates that the precautionary estimates of collision	×	×

Qualifying feature	Potential effect	Potential for adverse effect on the integrity alone?	Potential for adverse effect on the integrity in-combination?
	numbers would lead to a slightly reduced rate of population increase rather than a decline in numbers. Therefore, it can be concluded that there will be no adverse effect on the integrity of Flamborough & Filey Coast SPA from impacts on gannet due to the proposed Norfolk Boreas project in-combination with other projects.		
Kittiwake	**Project alone collision risk** At a predicted maximum mortality level of 17 birds for the proposed Norfolk Boreas project, it can be concluded with confidence for kittiwake that there will be no adverse effect on the integrity of the Flamborough and Filey Coast SPA. **In-combination collision risk** The number of predicted in-combination kittiwake collisions attributed to the Flamborough & Filey Coast pSPA is 418 which 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 SPA kittiwake population resulting from in-combination collisions is below the thresholds of concern proposed for previously consented developments and furthermore the contribution to the in-combination total deriving from the proposed Norfolk Boreas 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 SPA from impacts on kittiwake due to the proposed Norfolk Boreas project in-combination with other projects.	×	×
Greater Wash			
Red-throated diver	**Project alone** At a predicted maximum mortality level of 1 birds for the proposed Norfolk Boreas 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. **In-combination** At a predicted maximum mortality level of 1, the potential for the proposed Norfolk Boreas project to contribute to an in-combination impact on the red-throated diver population of the Greater Wash SPA is 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 Boreas project in-combination with other projects.	×	×

Qualifying feature	Potential effect	Potential for adverse effect on the integrity alone?	Potential for adverse effect on the integrity in-combination?
	Adoption of best practice with respect to vessel movements through the SPA (as proposed by Natural England) will remove the risk of an adverse effect due to operation and maintenance vessel traffic.		
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 Boreas is predicted to have 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.	×	×
Outer Thames Estuary			
Red-throated diver	**Project alone and in-combination** Adoption of best practice with respect to vessel movements through the SPA (as proposed by Natural England) will remove the risk of an adverse effect due to operation and maintenance vessel traffic.	×	×

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

363. It is therefore concluded that the Norfolk Boreas Project would **not have an adverse effect on integrity of the Alde-Ore Estuary, Flamborough and Filey Coast, Outer Thames Estuary or the Greater Wash SPAs** in view of the conservation objectives of these sites either alone or in combination with other projects/plans.

7. OFFSHORE SAC ANNEX I HABITATS

7.1. Baseline/Current Conservation Status

364. 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.

365. Further details on the baseline information for these habitats are also provided in the Norfolk Boreas HRA Offshore Screening Report (Appendix 5.1), Chapters 8, 9 and 10 of the ES (document reference 6.1), 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) and the Fugro Environmental Investigation Report Norfolk Vanguard Benthic Characterisation Report (Appendix 7.3).

7.1.1. Sandbanks

366. 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. 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 Boreas passes through the southern end of this sand bank system (Figure 7.1).

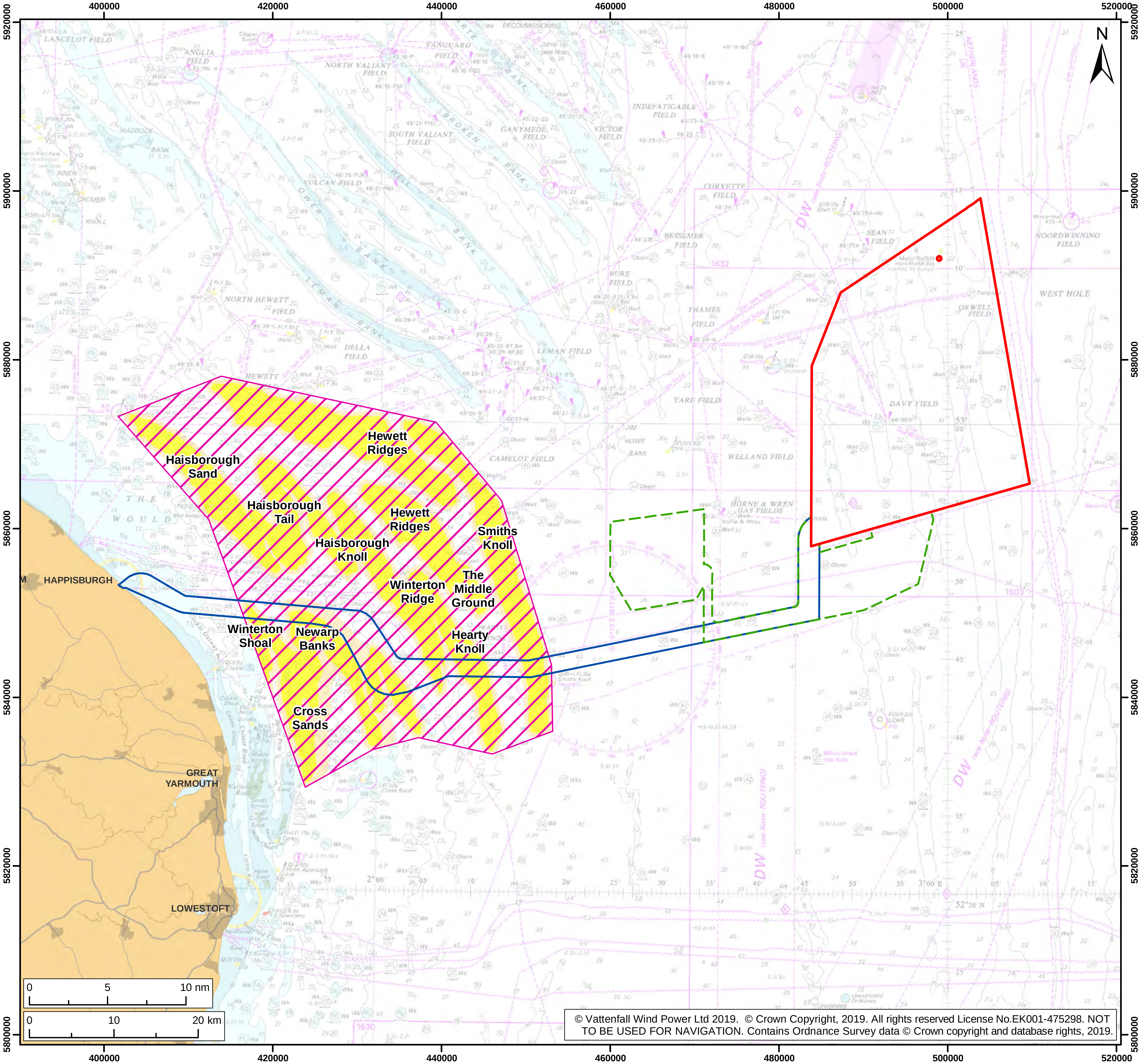
367. Water depths within the Haisborough, Hammond and Winterton SAC range between approximately 12m and 51.8m Lowest Astronomical Tide (LAT). Approximately two thirds of the sandbank habitat occurs in more than 20m water depth. The summits of the sandbanks are in water shallower than 20m LAT; however, 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.

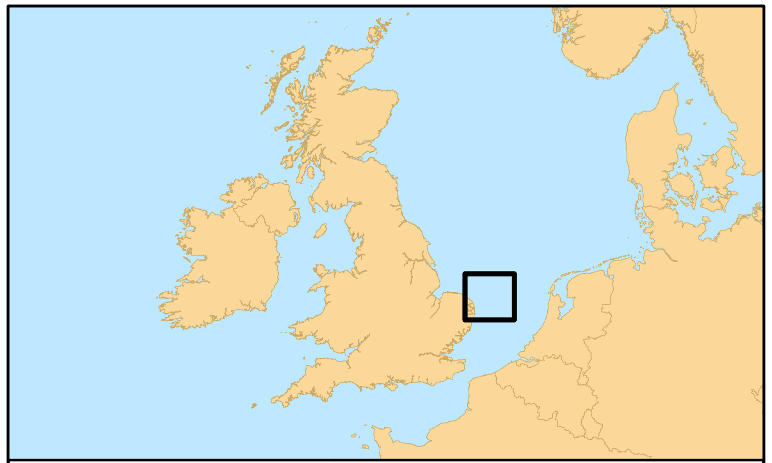
368. Areas of the seabed permanently submerged and rising to a depth of less than 20m LAT were recorded within the Norfolk Boreas offshore cable corridor (Fugro, 2016 The Norfolk Vanguard Benthic Characterisation Report, Appendix 7.3). These form

part of the Annex I Sandbanks known to occur within the Haisborough, Hammond and Winterton SAC.

369. 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).

370. 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 Boreas site
- Offshore cable corridor
- Project interconnector search area
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]

Annex 1 Sandbanks[2]

- Annex 1 Sandbank Area
- Potential Annex 1 Sandbank

[1] JNCC, 2018.
[2] JNCC, 2016.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Annex I Sandbanks in the Haisborough Hammond and Winterton SAC

Figure: 7.1 Drawing No: PB5640-007-002-005

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	29/01/2019	LB	DT	A3	1:450,000

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

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7.1.1.1. Bedload sediment transport

371. 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 that appendix.

372. 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.

373. 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).

374. 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

375. Suspended sediment concentrations across Norfolk Boreas and the offshore cable corridor could range from 0.3 to approximately 100mg/l (see Chapter 8 Marine, Geology, Oceanography and Physical processes). Measurements of turbidity converted to suspended sediment concentrations were carried out at an Acoustic Wave and Current (AWAC) station in Norfolk Vanguard East (immediately to the south of Norfolk Boreas) between December 2012 and December 2013.

376. Overall, suspended sediment concentrations in Norfolk Vanguard East 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

377. The Annex I sandbank feature of the Haisborough, Hammond and Winterton SAC was graded B (good conservation value) (JNCC and Natural England, 2010). However it is understood that Natural England has recently undertaken a condition assessment of the features within Haisborough Hammond and Winterton SAC (provided to the Norfolk Vanguard Examination) and their latest view (which is currently unpublished) is:

378. The "*condition of the sandbank feature is in unfavourable condition and needs to be restored to favourable condition. Restoration of the feature requires an overall reduction, or removal, of pressures associated with human activities that cause impacts to the sandbanks' extent and distribution, delineated by both substratum and biological communities. As such, any human activities which can cause pressures resulting in changes to substratum or biological communities to the sandbank feature may present a risk to the site's restoration*."

7.1.2. *Sabellaria spinulosa*

7.1.2.1. *S. spinulosa* biology and habitat preferences

379. *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).

380. *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).

381. 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

382. 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).

383. 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*.

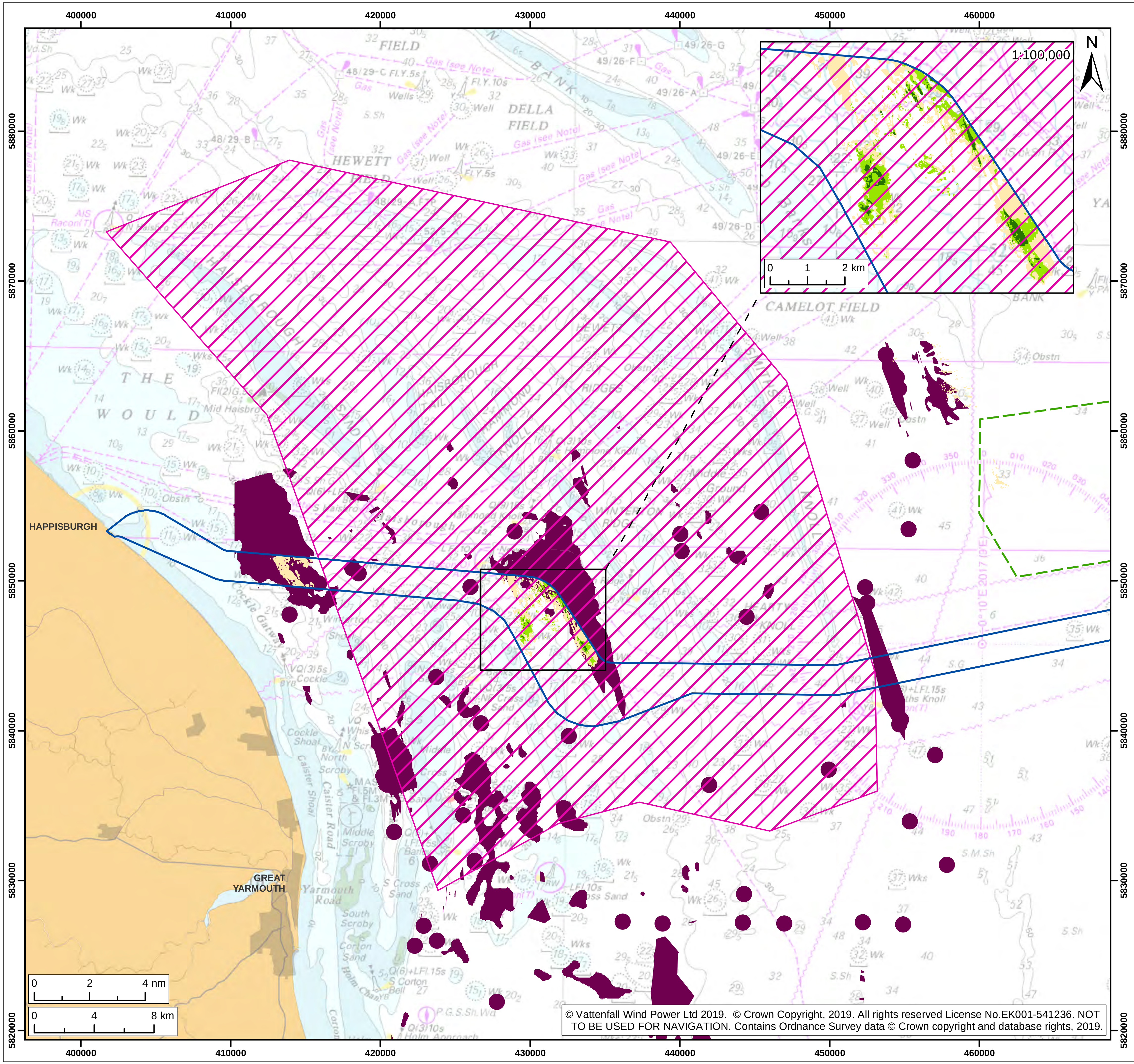
384. *S. spinulosa* reefs within the SAC have been reported by JNCC (2018) at Haisborough Tail, Haisborough Gat and between Winterton Ridge and Hewett Ridge which are located outside the Norfolk Boreas offshore project area. Areas within the Haisborough Tail and Winterton Ridge features (Appendix 7.1, 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).

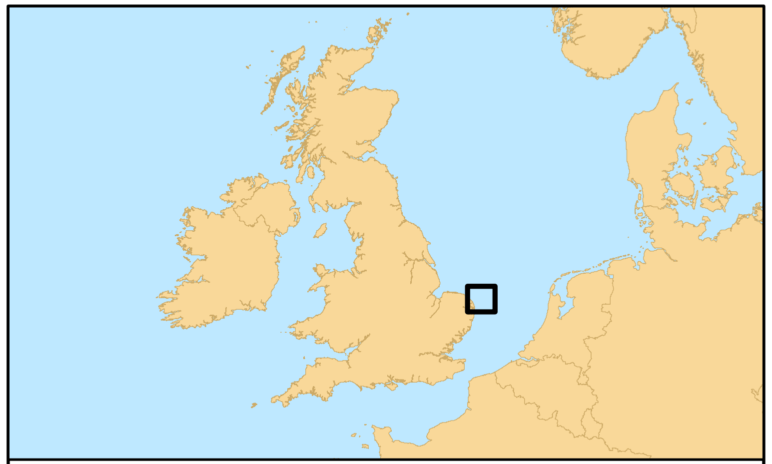
385. JNCC, Natural England, Cefas and the Environment Agency conducted a survey of the SAC in 2016 (McIlwaine et al*.,* 2017). The survey included determining the presence and condition of *S. spinulosa* reef in specific areas within the SAC, including around Haisborough Tail, Haisborough Gat and an area towards the south west of the SAC. In Appendix 7.2 of this HRA Report, Envision Mapping has reviewed and used the data available from that survey to inform their study, however since this data was not finalised at the time of writing they were not able to use that data within their 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 Boreas offshore cable corridor (see Appendix 7.2, Figures 6 and 8).

386. A survey campaign (Fugro, 2016), including geophysical, drop down video and grab sampling of the proposed cable corridor for Norfolk Boreas 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. The area of reef that has been identified with moderate to high confidence within the section of the offshore cable corridor which overlaps with the SAC is estimated to be approximately 8.37km2. This is shown on Figure 7.2

387. Natural England have undertaken a similar mapping process to that conducted by Envision Limited and have identified “areas to be managed as *S.spinulosa* reef”. These areas are also shown in Figure 7.2. The Envision Mapping study only covers

the Norfolk Boreas offshore cable corridor, however in those areas the two studies generally agree on the locations of *S.spinulosa* reef presence.





Legend:
- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]
- Area to be managed as *S.Spinulosa* reef (Natural England)[2]

Reef Extent Confidence[3]
- 3 - Moderate
- 4
- 5 - Highest

[1] JNCC, 2018.
[2] Natural England/MALSF, 2013/2011.
[3] Envision, 2018.

Project: Norfolk Boreas

Report: Habitats Regulation Assessment Report

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

Figure: 7.2 Drawing No: PB5640-007-002-006

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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7.1.2.3. Conservation status

388. 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).

389. The Annex I reef feature of the Haisborough, Hammond and Winterton SAC was graded A (excellent conservation value) by JNCC and Natural England (2010), however Natural England have advised Norfolk Boreas Limited that "*the designated features of the site and some of the sub features are currently in unfavourable condition*" (based on unpublished information).

7.2. Conservation Objectives

7.2.1. Overview

390. 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; and
- The distribution of qualifying species within the site.

391. 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[6].

392. '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;

[6] 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 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
- The conservation status of its typical species is favourable.

393. 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

394. According to the latest published information 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.

395. There are management measures (regulatory and voluntary) that are currently in place to either directly or indirectly help to protect the features of the SAC. These are all related to fishing activity within the SAC.

396. The Eastern Inshore Fisheries Conservation Authority (EIFCA) have already implemented two byelaws within the SAC to protect the designated features from impacts of fishing, neither of which overlap with the Norfolk Boreas offshore cable corridor.

397. Additional management measures are currently being collated by the EIFCA and the MMO and Defra.

398. The EIFCA are proposing to "prohibit fishing using bottom towed gear" at three additional locations within the Haisborough, Hammond and Winterton SAC. One of these proposed sites (North of Winterton Shoal) is located within the Norfolk Boreas offshore cable corridor. At the time of writing (April 2019) consultations on these proposed byelaws are ongoing and the size and shape of the final boundaries will be determined following the consultation.

399. A further measure which would cover a large section of the SAC outside of 6nm from the coast and overlap with the Norfolk Boreas offshore cable corridor has been proposed by Defra. As detailed in the MMOs submission at Deadline 6 of the Norfolk Vanguard Examination (MMO, 2019); under the Common Fisheries Policy (CFP), fisheries management measures for MPAs must be agreed by other Member States' with an active interest in the site. As other Member States with a direct management interest have not yet consented to the proposals, the measures are yet to be introduced.

400. The management measures described above are related to the prohibition of fishing activity and therefore could not be used to restrict works undertaken for the Norfolk Boreas project. However the areas to be "managed as *S.Spinulosa* reef" (Figure 7.2) that underpin the fisheries management proposals have been considered within this report.

401. Although no specific management measures are in place for activities related to the construction or operation of Norfolk Boreas, 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[7]; and
- Biological disturbance[8].

402. 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

[7] For some sites this includes changes in nutrient and / or organic enrichment and / or in salinity.
[8] For some sites this includes the introduction of non-native species and / or the selective extraction of species.

	Sensitivity	Current Exposure	Vulnerability
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

403. 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.

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			

	Sensitivity	Current Exposure	Vulnerability
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

404. The detailed design of Norfolk Boreas (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 Boreas Limited.

7.3.1. Embedded mitigation

405. This section describes various decisions by Norfolk Boreas 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

406. Norfolk Boreas 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 Boreas (and the same for Norfolk Vanguard);
- The volume of sediment arising from pre-sweeping (A discrete dredging operation designed to lower the seabed level within a distinct identified channel to enable marine cables to be installed to a depth which reduces the risk of cable exposure and minimises the likelihood of reburial operations) 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

407. 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 Boreas cables including micrositing where possible. The cable route (including micrositing) would then be agreed with the relevant SNCBs through the Haisborough Hammond and Winterton SAC Site Integrity Plan (see section 7.3.2.1).

7.3.1.3. Micrositing

408. As discussed above, should important seabed features or obstacles (e.g. Annex I 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.

409. VWPL 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 I reef).

410. 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 also takes into account the space required for Norfolk Vanguard export cables. This HRA is for Norfolk Boreas alone, however the worst case scenario for space availability within the cable corridor must take account of Norfolk Vanguard. Norfolk Vanguard is 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 Boreas and four cables in two trenches for Norfolk Vanguard) each with up to 30m width of disturbance with spacing as shown in Plate 7.1[9];
- 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;

[9] 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.

- A total width of approximately 1.35km is required for Norfolk Boreas and Norfolk Vanguard; 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, Appendix 4.2 of the ES; 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.

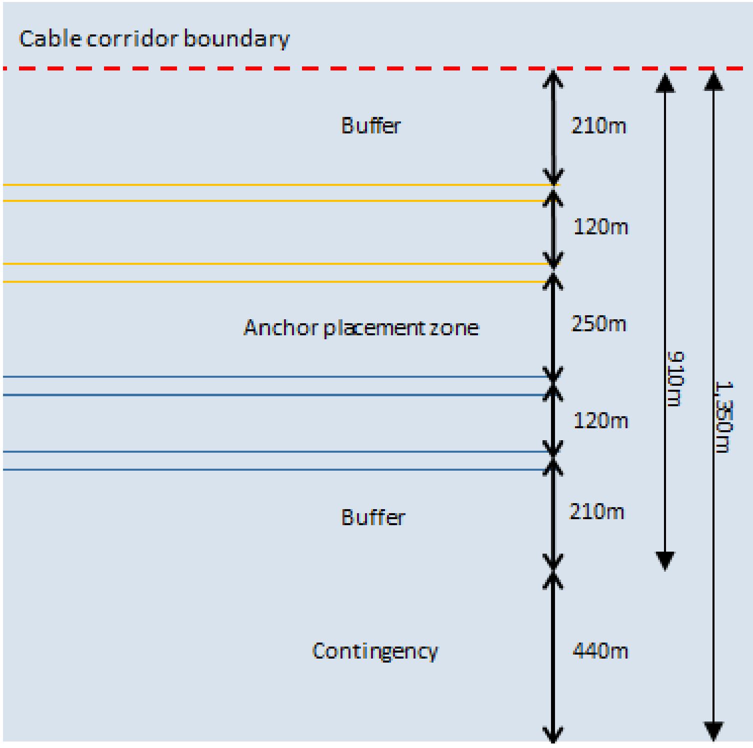

Plate 7.1 Export cables layout (two pairs of cables for Norfolk Vanguard (yellow) and two pairs of cables for Norfolk Boreas (blue)) based on 48m water depth[10]

7.3.1.4. Minimising cable protection

411. Norfolk Boreas 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 5.2 of the ES) was commissioned by VWPL which confirmed that cable burial is expected to be possible throughout the offshore cable corridor, with the exception of cable and pipeline crossing locations.

[10] 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

412. The exact method for cable crossings will be subject to crossings agreements however the worst case scenario for cable protection is described in section 7.3.3.2.5.

7.3.1.4.1. Sand wave levelling

413. 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 (Appendix 5.2 of the ES) 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 7.3.3.2.1). 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.

7.3.1.4.2. Cable protection contingency

414. 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 7.3.3.2.5 in order to provide a conservative and future proofed assessment.

415. As previously discussed, analysis of geophysical data has shown that the substrate along the vast majority of the 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 is unlikely to be Annex I Sandbank.

416. Cable protection would also be required where Norfolk Boreas cables cross other cables or pipelines (see section 7.3.3.2.5).

7.3.1.5. Sediment disposal

417. 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).

418. Sediment would not be disposed of within 50m of *S.spinulosa* reef in accordance with advice from Natural England (Norfolk Vanguard Expert Topic Group meeting 31st January 2018).

7.3.2. Further Mitigation

7.3.2.1. Haisborough Hammond and Winterton SAC Site Integrity Plan.

419. Norfolk Boreas Limited have committed to the production of a Site Integrity Plan (SIP) for the Haisborough Hammond and Winterton SAC. This commitment is

secured through Condition 9(1)(m) of Schedules 11 and 12 (the Transmission Deemed Marine Licence (DMLs)) of the draft DCO. Which states that:

"*The licensed activities, or any phase of those activities must not commence until a site integrity plan which accords with the principles set out in the outline Norfolk Boreas Haisborough, Hammond and Winterton Special Area of Conservation Site Integrity Plan has been submitted to the MMO and the MMO (in consultation with the relevant statutory nature conservation body) is satisfied that the plan provides such mitigation as is necessary to avoid adversely affecting the integrity (within the meaning of the 2017 Regulations) of a relevant site, to the extent that sandbanks and Sabellaria spinulosa reefs are a protected feature of that site.*"

420. The SIP will provide a framework for developing and agreeing mitigation and monitoring measures as is necessary to avoid adversely affecting the integrity of the sandbanks and *S.spinulosa* reef features of the site. As the requirement states, no activities could commence until SIP has been agreed with the MMO and relevant SNCBs.

421. At the time of writing (April 2019) Norfolk Vanguard, in consultation with Natural England, and the MMO are in the process of developing and agreeing the Outline SIP for that project, and it has been submitted at deadline 7 of the Norfolk Vanguard Examination. Norfolk Boreas have included an Outline HHW SIP as part of this DCO application (document reference 8.20). The Norfolk Boreas document is based on the version of the Norfolk Vanguard HHW SIP that was submitted at deadline 7 and it will be updated during the Norfolk Boreas Examination to account for any further changes made to the Norfolk Vanguard document.

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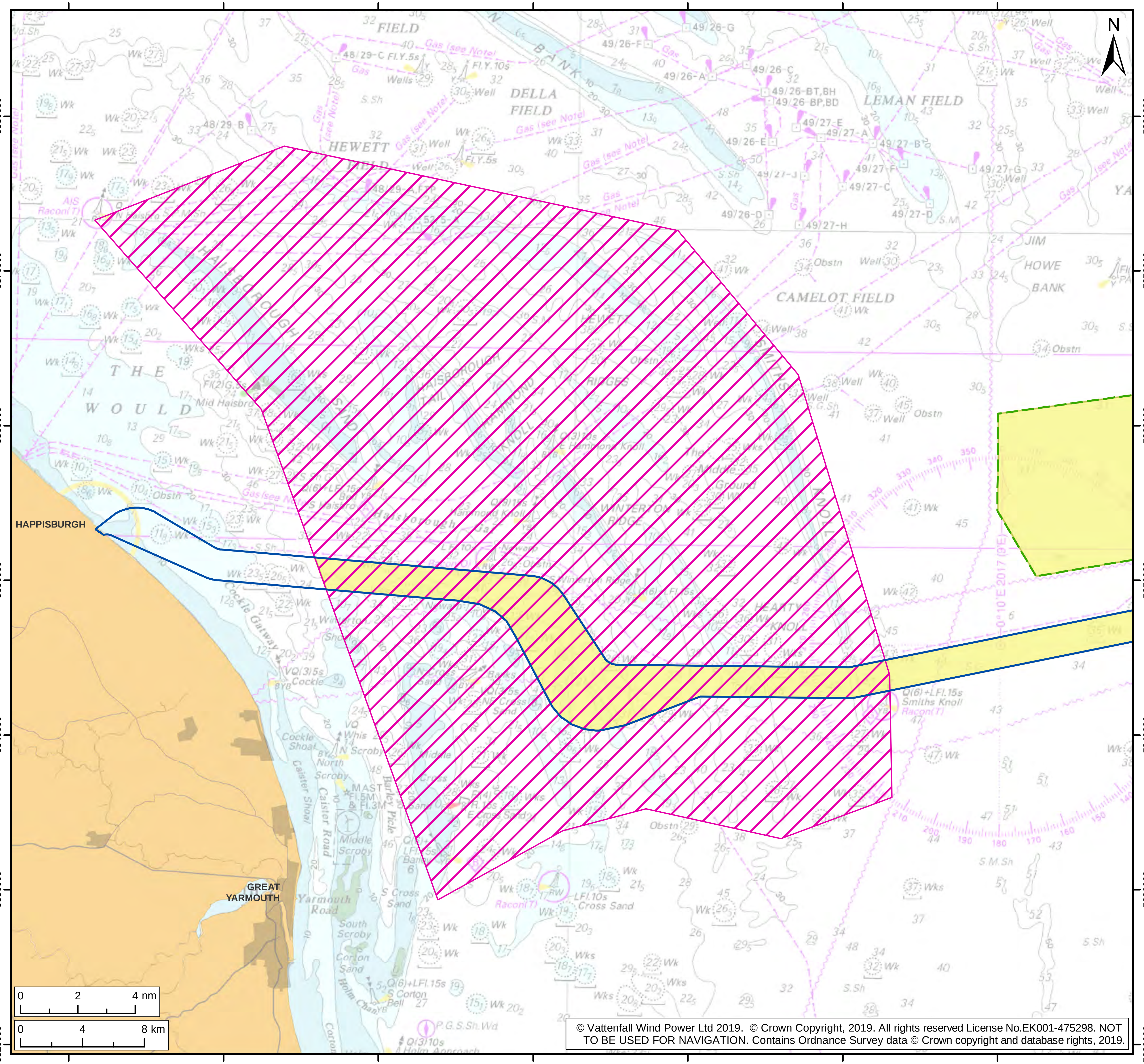

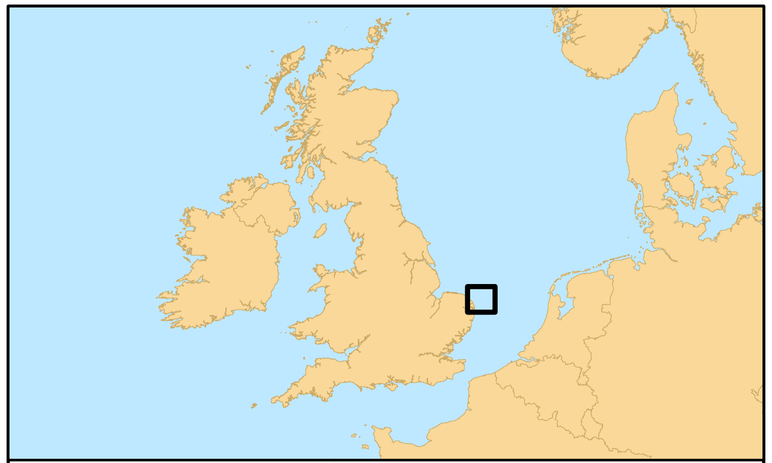

Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Disposal site
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]

[1] JNCC, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Proposed disposal site in the Haisborough Hammond and Winterton SAC

Figure: 7.3 Drawing No: PB5640-007-002-007

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	29/01/2019	LB	DT	A3	1:250,000

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

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7.3.3. Worst Case Scenario

423. The Norfolk Boreas project design envelope on which the assessment is based was "frozen" in January 2019 to allow the application for development consent to be completed and submitted in June 2019. This design envelope has been used to define realistic worst case scenarios. This project design envelope will be refined further as the project develops. Of particular relevance to this assessment are ongoing efforts to reduce the amount of cable protection required to protect unburied cable within the offshore cable corridor. The current envelope allows for 10% of export cables to remain unburied and therefore require protection. An interim cable burial report (submitted to the Norfolk Vanguard Examination as an appendix to the Norfolk Vanguard HHW SIP) has indicated that at least 95% of the export cables will be buried. The Norfolk Vanguard design envelope was updated in April 2019 to reflect this and it is expected that the Norfolk Boreas design envelope will also be updated to reflect this. The assessment of In-combination effects (section 7.4.1.2.2) takes account of the updated Norfolk Vanguard design envelope.

424. The following sections provide an overview of works that have potential to affect the Haisborough, Hammond and Winterton SAC and the worst case parameters associated with those works. A summary of the worst case scenario is provided in Table 7.4.

425. It should be noted that that worst case scenarios described in Table 7.4 are specific to each effect and therefore if combined would result in an over precautionary unrealistic worst case scenario. 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 assumes that no pre-sweeping has taken place during cable installation and therefore the cables are more likely to become exposed. Where applicable, this is outlined in Table 7.4.

7.3.3.1. Construction programme and phasing

426. Norfolk Boreas Limited is currently considering constructing the proposed project in the following phase options of up to 1,800MW total export capacity.

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

427. It is anticipated that Norfolk Boreas export cable installation would be undertaken over a period of approximately 18 months under the single phase, or nine months per phase if constructed in two phases (see Chapter 5 project description, section 5.4.15 of the ES (document reference 6.1.5). Cable installation may be preceded by seabed preparation activity that would occur over a period of up to six months. This

could have a three month overlap with the cable installation period and could also be followed by up to three months of cable protection works. Under the indicative two phased programme there would be gap of approximately three months (see Table 8.6 and Table 8.7) between export cable installations.

428. 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.

7.3.3.2. Cable installation footprints

7.3.3.2.1. Pre-installation works

Boulder clearance

429. Pre-construction surveys will also identify any requirement for boulder clearance within the SAC. Norfolk Boreas 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 and therefore the assessment allows for an area of disturbance as the boulders are lifted and an area of disturbance of the boulder being placed back on the seabed.

Pre-lay grapnel run

430. 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

431. 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. Approval of the approach to cable installation within the HHW SAC would be required by the MMO (in consultation with the relevant statutory nature conservation body) through the Haisborough Hammond and Winterton SAC SIP Condition 9(1)(m) of Schedules 11 and 12 of the draft DCO . Both would be based on information from pre-construction surveys and final design.

432. 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[11]. 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[12] 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).

433. 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, Appendix 5.2 of the ES)

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
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

7.3.3.2.2. Removal of existing disused cables

434. There are up to seven out of service cables in the SAC:

- Five are believed to be 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.

[11] 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.
[12] Based on the 30m proportion of the maximum 37m pre-sweep width that would be overlapping the ploughing footprint

7.3.3.2.3. Cable burial

435. 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 Chapter 5 Project description of the ES:

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

436. 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).

7.3.3.2.4. Anchor placement

437. 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.

7.3.3.2.5. Cable protection

Unburied cable

438. As discussed in section 7.3.1, cable burial is expected to be possible throughout the vast majority of 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 I Sandbank). The maximum width and height of cable protection for unburied cable would be 5m and 0.5m, respectively.

Crossings

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

440. Where each Norfolk Boreas 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 Boreas cable would then be placed on top of the layer of protection with a further layer of cable protection placed on top.

441. 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

442. 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.

443. It is recognised that it may not be possible to retrieve all cable protection during decommissioning and therefore this would represent a permanent impact over a very small area.

7.3.3.3. Maintenance of export cables

444. 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. As stated in the Outline Offshore Operations and Maintenance Plan (document reference 8.11) any new cable protection required during maintenance would be subject to additional licensing.

7.3.3.3.1. Cable repairs

445. 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.

446. 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 reburial

7.3.3.3.2. Cable reburial

447. 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.

448. Reburial of up to 4km 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.

7.3.3.4. 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 I Reef • Annex I Sandbank	Boulder clearance and repositioning – 0.0008km^2 (up to 22 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 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 2.45km^2 (0.17% of the 1,468km^2 SAC area).	Disturbance footprints in the offshore cable corridor due to cable laying operations
Increased suspended sediment and smothering: • Annex I 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	Suspended sediment concentrations and associated sediment deposition from cable

Impact	Parameter	Rationale
	be at least 50m from *S.spinulosa* reef identified during pre-construction surveys. The sediment disturbed due to trenching for the offshore export cables would be up to 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.	installation in the offshore cable corridor
Operation		
Temporary physical disturbance on: • Annex I Reef • Annex I 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 approximately 480,000m^2 (0.48km^2) over the indicative 30 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.	Estimated cable repairs and reburial requirements based on VWPL experience.
Permanent habitat loss on: • Annex I Sandbank	Total habitat loss within the Haisborough, Hammond and Winterton SAC could be 0.052km^2 (0.004% of the 1,468km^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 is encountered,	Maximum potential cable protection in the SAC. Due to the commitment to avoid *S.spinulosa* reef where possible and the known recoverability of *S. spinulosa,* no permanent loss of *S.spinulosa reef* anticipated and so this is assessed for sandbanks only.

Impact	Parameter	Rationale
	resulting in a footprint of 40,000m² (5m width of cable protection).	
Introduction of new substrate/colonisation of cable protection: • Annex I Reef • Annex I Sandbank	Areas as per cable protection above. Maximum volume of new substrate would be: • Crossings footprint of 12,000m² x height of 0.9m = 10,800m³ • Cable protection contingency footprint of 40,000m² x height 0.5m = 20,000m³.	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 I 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

449. The Haisborough, Hammond and Winterton SAC overlaps with the Norfolk Boreas 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 I 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 5.1.1) through the Norfolk Boreas HRA Offshore Screening Report (Appendix 5.1).

450. Through the EPP and specifically a meeting in February 2019, it was agreed with the Benthic Ecology ETG (including Natural England and the MMO) that the following effects associated with Norfolk Boreas 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 Boreas

451. 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[13] 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.

452. 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.

[13] Natural England have recently provided unpublished advice indicating that features of the Haisborough, Hammond and Winterton SAC are currently in unfavourable condition and therefore the objectives will be updated to “restore”

- 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

453. As described in section 7.2, 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.

454. As discussed in section 7.3.3.2.1, 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[14] within the SAC is 669km^2 and the area of the SAC as a whole is 1,468km^2, so the maximum area of temporary physical disturbance (2.45km^2) due to cable laying operations therefore equates to 0.37% of the sandbanks and 0.17% of the total area of the SAC.

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

455. 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 Boreas cables, to ensure the cables can be installed at a depth that is

[14] http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=UK0030369

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.

456. 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).

457. 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.

458. ABPmer (Appendix 7.1) were commissioned by VWPL, 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.

459. 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 *S.spinulosa* 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 0.3m at initial deposition. Also, although the deposition extents may be larger per disposal event, the actual resulting thickness would be far smaller (closer to. 0.02m).

460. 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).

461. 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, 2002). 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.

462. 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.

463. 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).

464. 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).

465. 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.

466. 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 be deposited 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 (i.e. effects of extent, topography and sediment composition) due to temporary physical disturbance during construction**.

Sandbank communities

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

468. 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.

469. 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).

470. 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 Appendix 10.1 of the Norfolk Vanguard ES). Infaunal abundance and diversity was generally low, excluding the area identified as *S. spinulosa* reef.

471. 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).

472. Given this capacity for recoverability, combined with the small total area of the SAC that will be temporarily affected by Norfolk Boreas 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 (i.e. effects on sandbank communities) due to temporary physical disturbance during construction.**

7.4.1.1.2. Potential effects during operation

Temporary physical disturbance

473. 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 7.3.3.2). The effects of the introduction of cable protection on sandbanks are considered within the assessment of permanent habitat loss which is presented in the next section of this report.

474. Based on VWPL's experience an average of one export cable repair per cable pair every 10 years is estimated to be the worst case scenario within the SAC.

475. As discussed in section 7.3.3.3 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 (669km^2). It is highly likely that the sandbank would have recovered from any temporary disturbance from one repair before any other repairs are required.

476. The maximum disturbance area for cable reburial activities within the SAC has been estimated as 480,000m^2 (based on reburial approximately every five years) over the life of the project (0.03% of the total area of the SAC or 0.07% 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

477. 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.

478. The assessment indicates that temporary physical disturbance may occur within the offshore cable corridor, with a maximum disturbance area of 0.48km^2 (0.03% of the total area of the SAC or 0.07% 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 (i.e. on extent, topography and sediment composition) due to temporary physical disturbance during operation.**

<u>Sandbank communities</u>

479. 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.

480. 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 (i.e. effects of sandbank communities) due to temporary physical disturbance during operation.**

Permanent habitat loss

481. As described in section 7.3.3.2.5 there is potential for permanent habitat loss to Annex I Sandbanks in the offshore cable corridor due to the presence of cable protection. As a worst case scenario placement of cable protection has been considered as permanent habitat loss for sandbanks. Due to the patterns of erosion, accretion and movement of sand waves naturally occurring within the offshore cable corridor (discussed in Appendix 7.1) it is expected that the cable protection may undergo some periodic burial and uncovering meaning the impact of habitat loss would be persistent rather than permanent. However, for the purposes of this

assessment the impact of habitat loss is considered permanent as a precautionary worst case scenario.

482. 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 (0.013km^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.

483. 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 be as a result of encountering areas of the SAC that are hard substrate (i.e. not likely to be Annex I Sandbank).

484. As discussed in section 7.1.1.3 Natural England consider the current condition of the sandbank feature as being in unfavourable condition needing to be restored to favourable condition. Measures to reduce pressures associated with fishing activities are discussed in section 7.2.2.

Sandbank extent, topography and sediment composition

485. As discussed previously sandbank features are less likely to be present in the areas where cable protection contingency would be required (i.e. where hard substrate is encountered), it is considered that the area of potential habitat loss to Sandbank features relates primarily to the cable crossings and clump weights. However, as a worst case scenario the total are of cable protection (including cable protection for unburied cable) has been considered. Therefore the total footprint of cable protection considered here is 0.52km^2 (Table 7.4) which equates to less than 0.004% of the total area of the SAC (1,468km^2) and 0.008% of the area of sandbanks within the SAC (669km^2).

486. The assessment indicates that the extent of potential habitat loss is very small in comparison to the total area available within the SAC. Although Natural England believe the sandbanks are currently in unfavourable condition (section 7.1.2.3) the installation of Norfolk Boreas cables within the SAC will not result in a change to the physical processes associated with the sandbank form and function and therefore will not impede the restoration of the sandbanks to favourable condition. 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 (i.e. on extent, topography and sediment composition) due to permanent habitat loss.**

<u>Sandbank communities</u>

487. 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 0.004% of the SAC or 0.008% of the sandbank area in the SAC is very small scale and would therefore 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 (i.e. effects on sandbank communities) due to permanent habitat loss.**

Introduction of new substrate

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

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

489. It is considered that the extremely small areas associated with the new substrate (0.004% of the total area of the Haisborough, Hammond and Winterton SAC and 0.008% 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 (i.e. effects on extent, topography and sediment composition) due to the introduction of new substrate.**

<u>Sandbank communities</u>

490. 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 0.004% of the total area of the Haisborough, Hammond and Winterton SAC (1,468km^2) and 0.008% of the area of sandbanks within the SAC (669km^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 (i.e. effects on sandbank communities) due to the introduction of new substrate.**

7.4.1.1.3. Potential effects during decommissioning

Temporary physical disturbance

491. 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 (i.e. effects on**

extent, topography and sediment composition and sandbank communities) due to temporary physical disturbance during decommissioning.

492. 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

493. 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 Boreas.

494. It is also recognised that persistent impacts such as fishing may be affecting favourable condition of the sandbank features (section 7.1.1.3); this is considered to form part of the baseline. It is also understood that measures aimed at reducing the fishing pressure within the SAC are currently being developed (section 7.2.2).

495. 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 Boreas 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 Vanguard.

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

497. The latest Indicative programme for Norfolk Boreas (Table 8.6 and Table 8.7) and the latest indicative programme for Norfolk Vanguard show that it is likely that installation of the Norfolk Boreas export cables will follow shortly after the installation of the Norfolk Vanguard export cables (expected to be between three and nine months), with no temporal overlap. As described in section 7.3.3.1 the work associated with export cable installation and therefore with potential to affect the SAC would be undertaken over a maximum period of approximately 18 months and this would be the same for Norfolk Vanguard, therefore the total period over which effects could occur would be up to four years. The spatial footprint of installation works for both Norfolk Boreas and Norfolk Vanguard is likely to be double that of Norfolk Boreas alone, as a worst case scenario.

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

498. The assessment of sand wave levelling by ABPmer (Appendix 7.1) considers the cumulative worst case pre-sweeping requirements of both Norfolk Boreas and

Norfolk Vanguard based on a gap of between six and 24 months between projects, this is considered conservative as the latest indicative programmes for construction of both projects show that the gap and therefore overall impact time is likely to be less than this (see section 7.3.3.1 and the Norfolk Vanguard Statement of Common Ground (SoCG) with Natural England submitted at Deadline 8 of the Norfolk Vanguard Examination).

499. The study concludes that given the minimum spacing required between export cables from the two projects and the likely timing of construction 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 Boreas and Norfolk Vanguard 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.

500. The study also predicts that following disposal of material from seabed levelling for both projects, the material would most likely remain within the SAC on the same time frame it would take surficial sediment to move through the SAC as currently occurs.

501. The APBmer report (Appendix 7.1) 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.

502. In summary, as all sediment will be deposited 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

503. There is potential for permanent habitat loss to Annex I Sandbanks in the shared Norfolk Boreas and Norfolk Vanguard offshore cable corridor due to the presence of cable protection. The worst case total area of cable protection installed within the SAC could be 0.084km^2 for Norfolk Boreas and Norfolk Vanguard 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 for Norfolk Boreas and 2km per cable pair for Norfolk Vanguard (see section 7.3.3 for explanation of why a lower value for Norfolk Vanguard), resulting in a footprint of 60,000m^2 (5m width of cable protection).

504. 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. Therefore, the area of potential habitat loss to Sandbank features would relate primarily to the crossing locations and clump weights. However as discussed previously the cable protection for unburied cable has been taken account of as a worst case scenario. Therefore, the total permanent footprint on sandbanks equates to less than 0.006% of the total area of the SAC (1,468km^2) and 0.013% of the area of sandbanks within the SAC (669km^2).

505. 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 either at the scale of an individual sandbank or across the entirety 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 in-combination effects.**

7.4.1.2.3. Introduction of new substrate

506. The maximum volume of cable protection installed within the SAC for Norfolk Boreas and Norfolk Vanguard 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 60,000m^2 x height of 0.5m = 30,000m^3 (should cable burial not be possible).
- This contingency for cable protection is very conservative as cable burial is expected to be possible throughout the vast majority of the cable corridor for both projects, with the exception of cable crossing locations.

507. The 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 be small enough to be

considered de minimus alone and therefore have no significant effect on the governing processes or sandbank communities either at the scale of an individual sandbank or across the entirety 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 Boreas

508. 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.

509. 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

510. *S. spinulosa* reef has been recorded within the Norfolk Boreas 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.

511. 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 avoid potential impacts.

512. 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).

513. A total width of approximately 675m is required for Norfolk Boreas cable installation; including up to two trenches (four cables laid as pairs), a contingency of 440m, an anchor placement zone, and a buffer (GMSL, 2016 unpublished, Appendix 4.2 of the ES).

514. 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 which may be available for micrositing.

515. Due to the considerable width available for micrositing to avoid *S. spinulosa* reef where identified during pre-construction surveys, it is likely that no temporary physical disturbance to the feature 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 (675m for Boreas alone); therefore, 2.65km is likely to be available for micrositing for both projects 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.**

516. 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 of the offshore cable corridor 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 where reef would entirely bisect the Norfolk Boreas offshore cable corridor and Norfolk Boreas has committed to preconstruction surveys which would be used to more accurately determine the area of *S. spinulosa* reef (if any), that may be affected by the Project. However, due to the ephemeral nature of *S. spinulosa*, a hypothetical, contingency scenario has been considered as requested by Natural England during the Norfolk Vanguard EPP, to assess the worst case effects whereby the *S. spinulosa* reef does span the entire width of the cable corridor.

517. Under this theoretical scenario where *S. spinulosa* reef spans the full 2km 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.

518. It is noted that management measures are currently being agreed (section 7.2.2) in the form of fisheries byelaws to protect and enhance *S. spinulosa* reef. It is possible that with protection, *S. spinulosa* reef within these areas would increase in extent and condition, however at the time of assessment (April 2019) the byelaws have not come into effect.

519. 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.

520. *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) as could be the case with the proposed fisheries byelaws described in section 7.2.2.

521. 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. Gibb *et al.* (2014) state that *S. spinulosa* reef is considered to be 'Not Sensitive' to a habitat change which results in increased coarseness as the resulting habitat is suitable for the species. Van Duren *et al.* (2017) found that substrate is not the critical factor for *S. spinulosa* recruitment. They concluded that if there was some hard substrate present for initial settlement, *S. spinulosa* could establish the reef structure and spread across soft substrate. Due to this low sensitivity to substrate type, *S. spinulosa* is often one of the first species to settle on newly exposed and suitable surfaces (OSPAR Commission, 2010).

522. Tillin and Marshall (2015) observed that recovery of *S. spinulosa* reef 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).

523. 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).

524. At the Thanet wind farm post construction surveys in 2012 found a wider distribution of *S. spinulosa* aggregation categorised as moderate (patchy) growth and dense growth as compared with pre construction surveys. The 2012 surveys also found less signs of damage (e.g. rubble and scars) to the *S. spinulosa* aggregations were recorded when compared with earlier surveys however this was partially attributed to the reduction in destructive bottom fishing activities as a result of the presence of the offshore wind farm and associated cable infrastructure (Royal HaskoningDHV, 2016a). Although a small decline of *S. spinulosa* reef was observed shortly after Thanet Offshore Wind Farm was constructed, five years later those reef structures were found to be recovering (van Duren *et al.,* 2017).

525. 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.

526. 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).

527. 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).

528. 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).

529. During the East Coast 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.

530. 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.

531. In the unlikely event that reef is unavoidable in the Norfolk Boreas 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 Boreas (section 7.3.3.2.1).

532. 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.

533. 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.

534. 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.

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

Increased suspended sediment and smothering

536. As discussed in section 7.3.3.2.1, 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.

537. 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 disturbed in the SAC due to trenching and backfilled either naturally or manually.

538. All sediment arising from within the SAC would be deposited within the offshore cable corridor and all dredged sediment will therefore be available within the sandbank system of the SAC. The exact disposal location is still to be finalised; however, the material will be deposited within disposal locations 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.

539. *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).

540. 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.

541. 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

542. 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.

543. Based on VWPL experience, an average of one export cable repair per cable pair every 10 years is estimated to be the worst case scenario within the SAC.

544. As discussed in section 7.3.3.3.1, 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).

545. The maximum disturbance area for cable reburial activities within the SAC has been estimated as 480,000m^2 (based on reburial approximately every five years) over the life of the project (0.03% of the total area of the SAC). This is estimated at up to 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 shorter sections (e.g. 1km) at any one time.

546. 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 (e.g. Tillin and Marshall, 2015; Holt, 1998; Cooper *et al.,* 2007).

547. 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* which could be disturbed 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 every 10 years being a conservative worst case scenario.

548. As a result, changes to the extent of the reef due to temporary physical disturbance during operation are highly unlikely to occur, however if disturbance were to occur the effect would be localised and temporary. 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

549. As described in section 7.3.3.2, there is potential for the introduction of new substrate in the offshore cable corridor due to the presence of cable protection.

550. The total cable protection installed within the SAC is described in section 7.3.3.2.5. The contingency for cable protection is very conservative, as cable burial is expected to be possible throughout the vast majority of the offshore 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).

551. 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, van Duren et al. 2017) 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. For example Annex B of Natural England's Deadline 6 submission to the Norfolk Vanguard Examination (The Joint Nature Conservation Committee's and Natural England's advice to the MMO for protecting designated features in Haisborough Hammond and Winterton SCI/cSAC, document reference Rep6-032) states "*Sabellaria spinulosa reef extent is identified along the Baird Bacton pipeline, as [shown] in the HHW SAC SAD [Selection Assessment Document] and Regulation 35 package*". This pipeline is located just to

the north of the offshore cable corridor (see Chapter 18 Infrastructure and other users and Figure 18.2 of the ES)

552. 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) and in some cases, being the catalyst for the formation of reef structures such as the Van Duren et al. (2017) discussed in section 7.4.2.1.1 above.

553. 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.

554. Leonhard and Pedersen (2006) 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. During the examination of the Hornsea project Three, Ørsted stated that sabellariid aggregations have been found encrusting over several kilometres of exposed subsea pipeline off the north east coast of Scotland, as well as on subtidal wave-breakers in Taiwan and seawalls in Fiji.

555. 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).

556. 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 8th 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.

557. In year 2 (2011), *S. spinulosa* had increased in number to be the 5th 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).

558. The assessment indicates that any new substrata created by cable protection may provide a larger area for suitable *S. spinulosa* colonisation and potentially establishment of reef resulting in a greater area of reef than was previously present. The maximum volume of new substrate could be up to 30,800m^3. Due to the increased area of potential colonisation, 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

559. 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.

560. 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

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

562. 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).

563. 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

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

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

566. As discussed in 7.4.1.2 the latest Indicative programme for Norfolk Boreas (Table 8.6 and Table 8.7) and the latest indicative programme for Norfolk Vanguard show that it is likely that installation of the Norfolk Boreas export cables will follow shortly after the installation of the Norfolk Vanguard export cables (expected to be between three and nine months), with no temporal overlap. As described in section 7.3.3.1 the work associated with export cable installation and therefore with potential to affect the SAC would be undertaken over a maximum period of approximately 18 months and this would be the same for Norfolk Vanguard, therefore the total period over which effects could occur would be up to four years. The spatial footprint of installation works for both Norfolk Boreas and Norfolk Vanguard is likely to be double that of Norfolk Boreas alone, as a worst case scenario.

7.4.2.2.1. Potential in-combination effects during construction

Temporary physical disturbance

567. A total width of approximately 1.35km is required for Norfolk Boreas and Norfolk Vanguard; 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, Appendix 4.2 of the ES).

568. As discussed in section 7.3.1.3, micrositing will be undertaken for both Norfolk Boreas and Norfolk Vanguard, where possible. The assessment indicates that it is likely 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.

569. 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 Boreas and Norfolk Vanguard.

570. As discussed in section 7.4.2.1.1, a hypothetical, contingency scenario has been considered, as requested by Natural England during the Norfolk Vanguard 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. Norfolk Boreas has therefore taken this advice provided to Norfolk Vanguard and have used the same approach in this document.

571. In the unlikely event that reef is unavoidable in the Norfolk Boreas and Norfolk Vanguard 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 Boreas and approximately 37m for pre-sweeping each of the two cable trenches for Norfolk Vanguard.

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

573. 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 could be a gap of between three and nine months between the installation of the Norfolk Vanguard export cables and the installation of the Norfolk Boreas cables which may allow recovery of *S. spinulosa* to occur. Therefore the total disturbance width used for this assessment is highly conservative.

574. 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 temporary physical disturbance effects**.

Increased suspended sediment and smothering

575. 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 Boreas and Norfolk Vanguard export cables and backfilled either naturally or manually.

576. 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 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.

577. 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 increased suspended sediment and smothering effects.**

7.4.2.2.2. Potential in-combination effects during operation

Temporary physical disturbance

578. As discussed in section 7.3.3.3, an average of one repair per Norfolk Boreas 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 Vanguard.

579. 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.

580. Although temporary physical disturbance may occur during Norfolk Boreas and Norfolk Vanguard 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 temporary physical disturbance effects.

Introduction of new substrate

581. The total cable protection installed within the SAC is described in section 7.3.3.2.5. 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) = 10m^3
- Crossings footprint of 24,000m^2 x height of 0.9m = 21,600m^3.
- Cable protection contingency footprint of 60,000m^2 x height of 0.5m = 30,000m^3 (should cable burial not be possible, or cable becoming unburied during operation).

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

583. 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 introduction of a new substrate effects**.

7.4.2.2.3. Potential in-combination effects during decommissioning

Temporary physical disturbance

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

585. 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 temporary physical disturbance effects.**

Increased suspended sediment and smothering

586. 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 increased suspended sediment and smothering effects.**

7.4.3. Summary of Potential Effects

587. Table 7.5 provides a summary of the predicted potential effects on the integrity of the Haisborough Hammond and Winterton SAC alone and in-combination with other projects. Integrity matrices are provided in Appendix 6.1.

Table 7.5 Summary of potential effects of Norfolk Boreas 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.

588. It is therefore concluded that the Norfolk Boreas Project would **not have an adverse effect on integrity of the Haisborough, Hammond and Winterton SAC in view of the conservation objectives either alone or in combination with other projects/plans.**

8. OFFSHORE ANNEX II SPECIES (MARINE MAMMALS)

8.1. Baseline/Current Conservation Status

589. 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;
- Grey seal; and
- Harbour seal.

590. Further details on the baseline information for marine mammal species are also provided in the Norfolk Boreas HRA Offshore Screening Report (Appendix 5.1), the Marine Mammal Method Statement (Royal HaskoningDHV, 2018), and the ES (document reference 6.1).

8.1.1. Harbour Porpoise

8.1.1.1. Distribution

591. 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).

592. 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).

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

594. 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.

595. 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).

596. 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

597. 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).

598. Harbour porpoises are generalist feeders 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).

599. 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).

600. 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

601. 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.

602. 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 SAC were based on the modelling undertaken by Heinänen and Skov (2015).

603. 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

604. The IAMMWG defined three MUs for harbour porpoise: North Sea (NS); West Scotland (WS); and the Celtic and Irish Sea (CIS). Norfolk Boreas is located in the NS MU (Plate 8.1; IAMMWG, 2015).

605. The SCANS-III estimate of harbour porpoise abundance in the NS MU is 345,373 (CV = 0.18; 95% CI = 246,526-495,752; Hammond et al., 2017). This is the reference population for harbour porpoise, as agreed with Natural England as part of the Norfolk Vanguard EPP (letter dated 03/01/2018) and this approach was agreed for the Norfolk Boreas at the ETG meeting on 12th March 2018.

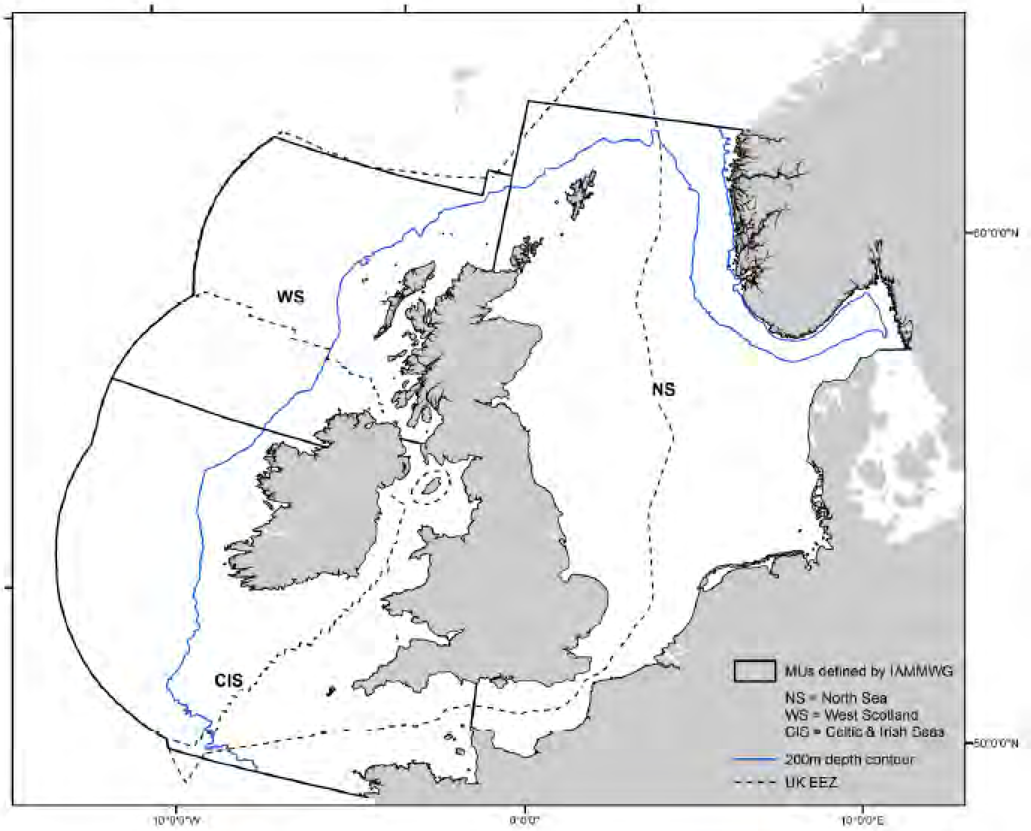


Plate 8.1 Harbour porpoise MUs (IAMMWG, 2015)

606. Norfolk Boreas is located in SCANS-III survey block L and survey block O (Plate 8.2).

- 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).

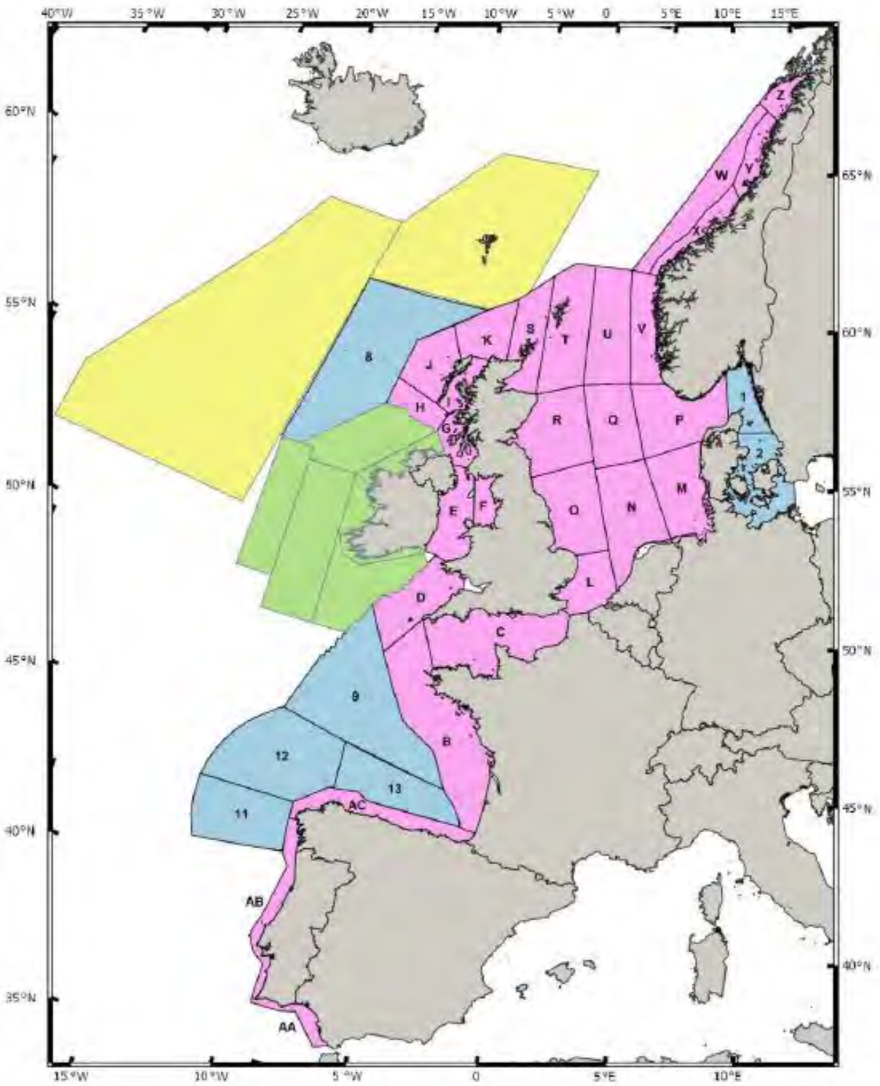


Plate 8.2: Survey blocks covered by SCANS-III and adjacent surveys (Source: Hammond et al., 2017)[15].

8.1.1.4.2. Density in the Norfolk Boreas site

607. APEM collected high resolution aerial digital still imagery for marine mammals over the Norfolk Boreas site, with a 4km buffer area, covering a total of 1,223km^2. In total, 24 months of survey data have been collected for Norfolk Boreas, covering the period from August 2016 to July 2018.

608. All images were analysed to enumerate marine mammals to species level, where possible. 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

[15] SCANS-III = pink lettered blocks surveyed by air; blue numbered blocks were surveyed by ship. Blocks coloured green to the south, west and north of Ireland were surveyed by the Irish ObSERVE project. Blocks coloured yellow were surveyed by the Faroe Islands as part of the North Atlantic Sightings Survey in 2015.

visibility. Further information on the data analysis, including correction factors, is provided in Appendix 12.2 of the ES.

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

610. Turbidity can affect the ability to detect marine mammals below the surface. Measurements of suspended sediment concentrations were carried out at the Acoustic Wave and Current (AWAC) station in Norfolk Vanguard between December 2012 and December 2013 Chapter 8 Marine Geology, Oceanography and Physical Processes). Overall it was concluded that the baseline suspended sediment concentrations across the Norfolk Boreas offshore project area are likely to vary from 0.3 to 100mg/l, but are less than 30mg/l most of the time.

611. 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} (Standard Deviation (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).

612. There is no indication of any limitations in observing marine mammals up to 2m below the surface at Norfolk Boreas. 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

613. At the Norfolk Boreas site, when unidentified small cetaceans[16] are included with the harbour porpoise data, the highest monthly density estimate was for December; using the seasonal correction factor is 3.453/km^2. However, the other monthly density estimates for harbour porpoise, including unidentified small cetaceans, are considerably lower than the December estimate at the Norfolk Boreas site (Table 8.2).

[16] 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.

614. The annual mean density estimate, when using the seasonal correction factor, is 1.06/km^2 for the Norfolk Boreas site.

615. The seasonal mean density for the summer period (April-September) is 0.66/km^2 and for the winter period (October-March) is 1.46/km^2.

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

By Month	Density Estimate (individuals / km^2) based on raw data (97.5% CI)	Density Estimate (individuals / km^2) with seasonal CF
Jan	0.566 (0.385-0.783)	1.2
Feb	0.75 (0.543-0.974)	1.59
Mar	0.302 (0.127-0.509)	0.529
Apr	0.167 (0.06-0.299)	0.293
May	0.376 (0.225-0.545)	0.658
Jun	0.094 (0.019-0.179)	0.172
Jul	0.334 (0.159-0.54)	0.61
Aug	0.263 (0.119-0.43)	0.48
Sep	0.807 (0.581-1.051)	1.773
Oct	0.155 (0.06-0.274)	0.341
Nov	0.745 (0.516-0.997)	1.637
Dec	1.63 (1.274-2.001)	3.453
Annual	**0.516 (0.339-0.715)**	**1.061**

616. The Norfolk Boreas density estimate of 1.06/km^2, based on the mean annual density and using the seasonal correction factors will be used in the assessment[17].

617. 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 Norfolk Boreas is located only within the summer area for the Southern North Sea SAC (Figure 5.4). In addition, it is 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.

8.1.1.5. Reference Population

618. 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;

[17] 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 SAC 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 SAC 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**).

Hammond et al., 2017). As outlined above, this reference population has been agreed with Natural England (letter dated 3rd January 2018).

8.1.1.6. Conservation Status

619. Member states report back to the European Union (EU) every six years on the Conservation Status of marine European Protected Species (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 SAC

620. In January 2017, the Southern North Sea (SNS) cSAC was submitted to the European Commission to become designated as a SAC. Harbour porpoise is the primary and only listed feature of the site. The site was designated as a SAC in February 2019 and therefore is referred throughout as the Southern North Sea SAC.

621. The Southern North Sea site has important habitat areas for the harbour porpoise both in summer and winter periods. 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 SAC, Margate and Long Sands SAC, Haisborough, Hammond and Winterton SAC and North Norfolk Sandbanks and Saturn Reef SAC, all of which have important sandbank and gravel beds.

622. The Southern North Sea SAC has a surface area of 36,951km^2 and covers both winter and summer habitats of importance to harbour porpoise, with approximately 27,018km^2 of the site being important in the summer and 12,697km^2 of the site being important in the winter period (Figure 5.4; JNCC, 2017a).

623. Norfolk Boreas is located within the Southern North Sea SAC summer area (Figure 5.4).

624. The Southern North Sea cSAC Site Selection Report (JNCC 2017a) identifies that the Southern North Sea 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 on the site (i.e. HRA), as they need to take into consideration population estimates at the MU level, to account for daily and seasonal movements of the animals (JNCC 2017a).

8.1.1.7.1. Conservation Objectives

625. The Conservation Objectives for the Southern North Sea SAC are designed to help 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.

626. The Conservation Objectives for the site are (JNCC and Natural England, 2019):

To ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining Favourable Conservation Status (FCS) for Harbour Porpoise in UK waters.

In the context of natural change, this will be achieved by ensuring that:

1. Harbour porpoise is a viable component of the site;

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

3. The condition of supporting habitats and processes, and the availability of prey is maintained.

627. These Conservation Objectives '*are a set of specified objectives that must be met to ensure that the site contributes in the best possible way to achieving Favourable Conservation Status (FCS) of the designated site feature(s) at the national and biogeographic level (EC, 2012)* (JNCC and Natural England, 2019).

Conservation Objective 1: The species is a viable component of the site.

628. This Conservation Objective is designed to minimise the risk of injury and killing or other factors that could restrict the survivability and reproductive potential of harbour porpoise using the site. Specifically, this objective is primarily concerned with operations that would result in unacceptable levels of those impacts on harbour porpoise using the site. Unacceptable levels can be defined as those having an impact on the FCS of the populations of the species in their natural range.

629. Harbour porpoise are considered to a *viable component of the site* if they are able to live successfully within it. This site has been selected primarily based on the long term, relatively higher densities of porpoise in contrast to other areas of the North Sea. The implication is that the SAC provides relatively good foraging habitat and may also be used for breeding and calving. However, because the number of harbour porpoise using the site naturally varies there is no exact value for the number of animals expected within the site (JNCC and Natural England, 2019).

630. 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.

631. 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*'.

632. In addition, Article 12 (4) of the Habitats Directive is concerned with incidental capture and killing. It states that Member States '*shall establish a system to monitor the incidental capture and killing of the species listed on Annex IV (all cetaceans). In light of the information gathered, Member States shall take further research or conservation measures as required to ensure that incidental capture and killing does not have a significant negative impact on the species concerned*'.

Conservation Objective 2: There is no significant disturbance of the species.

633. The disturbance of harbour porpoise typically, but not exclusively, originates from operations that cause underwater noise, including activities such as seismic surveys, pile driving and sonar. Responses to noise can be physiological and/or behavioural. JNCC has produced guidelines to minimise the risk of physical injury to cetaceans from various sources of loud, underwater noise[18]. However, disturbance is primarily a behavioural response to noise and may, for example, lead to harbour porpoises being displaced from the affected area.

634. As outlined above, JNCC and Natural England (2019) note that harbour porpoises in UK waters are considered part of a wider European population and 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.

635. Disturbance of harbour porpoise may lead to displacement from an area, and the temporary loss of habitat. As such, JNCC and Natural England (2019) suggest that activities within the Southern North Sea SAC should be managed to ensure that the

[18] http://jncc.defra.gov.uk/page-4273

animals' potential usage of the site is maintained 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. Disturbance is considered significant if it leads to the exclusion of harbour porpoise from a significant portion of the site.

636. The draft SNCB advice / guidance for the assessment of significant noise disturbance on harbour porpoise in the Southern North Sea SAC is that:

> '*Noise disturbance within an SAC from a plan/project individually or in-combination is significant if it excludes harbour porpoise from more than:*
> 1. *20% of the seasonal component of the Southern North Sea SAC in any given day, and*
> 2. *An average of 10% of the relevant area of the site over a season.*'

Conservation Objective 3: The condition of supporting habitats and processes, and the availability of their prey is maintained.

637. Supporting habitats, in this context, means the characteristics of the seabed and water column. Supporting processes encompasses the movements and physical properties of the habitat. The maintenance of these supporting habitats and processes contributes to ensuring prey is maintained within the site and is available to harbour porpoise using the site. Harbour porpoise are strongly reliant on the availability of prey species year round due to their high energy demands, and their distribution and condition may strongly reflect the availability and energy density of prey.

638. This Conservation Objective is designed to ensure that harbour porpoise are able to access food resources year round, and that activities occurring in the Southern North Sea SAC will not affect this.

8.1.1.7.2. Management measures

639. Specific management measures are yet to be developed for the Southern North Sea SAC, however JNCC and Natural England (2019) advise that '*the maintenance of supporting habitats and processes contributes to ensuring that prey is maintained within the site and is available to harbour porpoises using the site*.'

640. JNCC and Natural England (2019) also state that '*management measures (e.g. the scale and type of mitigation) are the responsibility of the relevant regulatory or management bodies. These bodies will consider SNCB advice and hold discussions with the sector concerned, where appropriate.*'

8.1.1.7.3. Advice on activities

641. JNCC and Natural England (2019) have provided advice on activities that specifically occur within or near to the Southern North Sea SAC site that could be expected to

impact on the site's integrity. The key impacts and activities that JNCC and Natural England (2019) consider to have the greatest impact on the population of UK harbour porpoise and therefore the Southern North Sea SAC are:

- Removal of non-target species by commercial fisheries with by-catch of harbour porpoise (predominantly static nets);
- 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 activity;
- Death or injury by collision from shipping, recreational boating and tidal energy installations; and
- Reduction in prey resources by commercial fisheries.

642. 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 monitoring programmes to areas that may need management measures (JNCC and Natural England, 2019).

643. For the purposes of this assessment, the potential effects are considered in relation to the Southern North Sea SAC draft Conservation Objectives; as outlined in Table 8.3.

Table 8.3 Potential effects of Norfolk Boreas in relation to the Conservation Objectives for the Southern North Sea SAC

Draft Conservation Objective	Potential effect
Harbour porpoise 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.

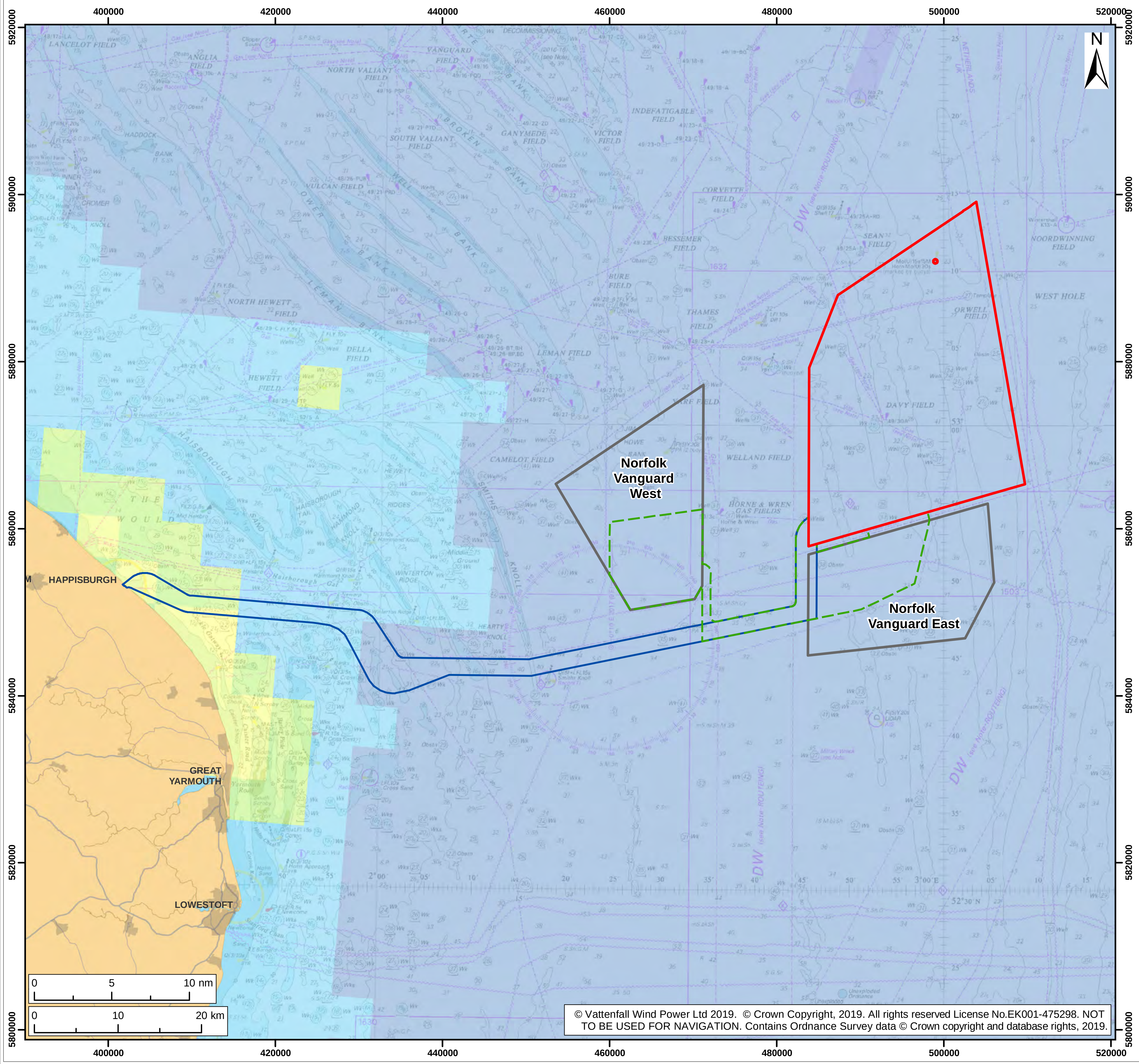
Draft Conservation Objective	Potential effect
The condition of supporting habitats and processes, and the availability of prey is maintained	Changes in prey availability and water quality have potential to affect the site and will be considered further.

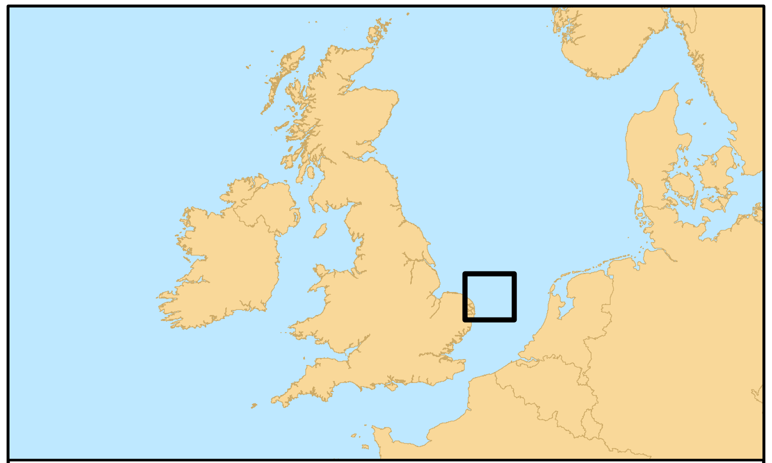
8.1.2. Grey Seal

8.1.2.1. Distribution

644. 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; Special Committee on Seals (SCOS), 2017).

645. 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 5km x 5km grid cell) within UK waters. The maps indicate that grey seal usage is relatively low in and around the Norfolk Boreas offshore project area (Figure 8.1; Russell et al*.,* 2017).





Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Norfolk Vanguard

Grey seal at-sea usage¹ (density of seals per 25km²)

- 0-1
- 1-5
- 5-10
- 10-50
- 50-100
- 100-150
- 150+

¹Russel et al., 2017.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Mean grey seal-at sea usage around Norfolk Boreas offshore project area

Figure: 8.1 Drawing No: PB5640-007-002-008

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	05/02/2019	LB	GS	A3	1:450,000

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

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646. 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 Boreas offshore project area, 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 Boreas offshore project area (Russell and McConnell, 2014).

647. 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 (Russell, 2016). Of the 21 tagged individuals, 16 used multiple haul-out sites; one hauling out in the Netherlands and one in Northern France (Russell, 2016). Plate 8.3 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.

648. 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[19]). 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 (note that East Anglia THREE is located 13km south of the Norfolk Boreas site). However, the tracks did indicate the movement of grey seals between MUs on the east coast of England and Scotland. A total of 77 grey seal were tagged at haul out sites in the Netherlands between 2005 and 2013 (Appendix 12.4 of the East Anglia THREE ES; EATL, 2015[20]). 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-

[19] 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

[20] 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

at-sea' within the East Anglia THREE site. However, the study did indicate the movement of grey seal between the UK and Dutch sites.

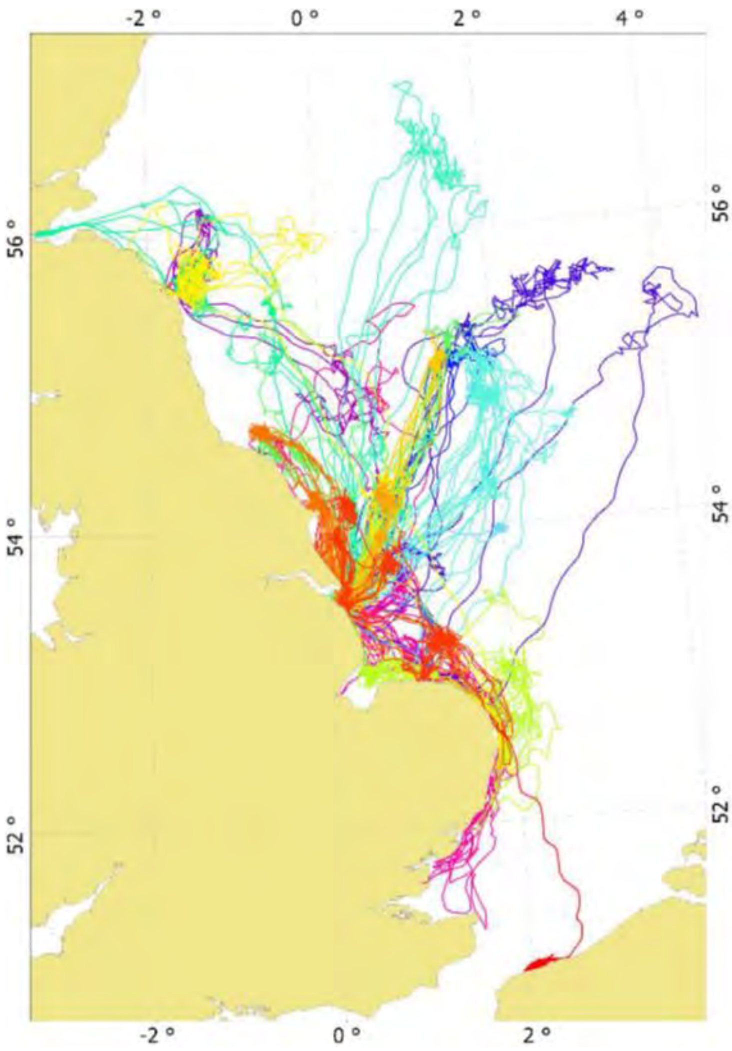

Plate 8.3 Tagged grey seal movements along the East coast of England (Russel, 2016)

649. 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).

650. 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).

651. 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).

8.1.2.2. Haul-out sites

652. 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).

653. 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).

654. 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).

655. The Norfolk Boreas site is located approximately 73km offshore (at the closest point). The principal grey seal haul-out sites are as follows with distance from Norfolk Boreas site in parentheses; Horsey (76km), Scroby Sands (67km), Blakeney Point (121km), The Wash (168km) and Donna Nook (180km) (Figure 5.4).

656. 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).

657. 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.

658. 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.

659. 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). The 2018/2019 season counts (one a week between 1st November 2018 and 17th January 2019) indicates an overall increase of 245 pups compared to the 2017/2018 season (Friends of Horsey Seals per. Comm.).

660. The landfall for the Norfolk Boreas offshore export cables will be at Happisburgh South, approximately 9km from the Horsey seal haul-out site to the south and 44km from the Blakeney Point haul-out site to the north (Figure 5.5).

8.1.2.3. Abundance

661. 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).

662. 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).

663. 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).

664. 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).

665. 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).

666. 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).

667. 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).

668. The grey seal density estimates for Norfolk Boreas 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 Boreas offshore project area. Within the Norfolk Boreas site (725km^2) the upper at-sea density of grey seal is estimated to be 0.001/km^2. Within the offshore cable corridor area and project interconnector search areas (453km^2) the upper at-sea density of grey seal is estimated to be 0.08/km^2. For the total Norfolk Boreas offshore project area (1,178km^2) the upper at-sea density of grey seal is estimated to be 0.032/km^2.

8.1.2.4. Reference population

669. 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).

670. 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.

671. 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.

672. 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).

673. 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

674. The Humber Estuary SAC is located 175km from the Norfolk Boreas site and 112km from the offshore cable corridor (at closest point; Figure 5.4). Grey seal (are present as a qualifying feature, but not a primary reason for site selection (JNCC, 2017c). The Humber Estuary SAC was screened in to the HRA to take into account the movements of grey seal along the east coast of England (see Plate 8.3).

675. 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).

676. The reference population for grey seal that encompasses Humber Estuary SAC is the south-east England MU (IAMMWG, 2013). 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 (SCOS, 2017).

677. For the in-combination assessment, to take into account the wide area covered by the in-combination project locations and evidence from telemetry studies, movements and potential foraging ranges, the reference population for grey seal incorporates the south-east England, north-east England MUs and East Coast Scotland MU (IAMMWG 2013; SCOS 2017) and the Wadden Sea region (TSEG 2017a). The total reference population for the in-combination assessment is 22,290 grey seal, as outlined in section 8.1.2.4.

678. For the purposes of this assessment, the potential effects are considered in relation to the SAC Conservation Objectives; as outlined in Table 8.4.

Table 8.4 Potential effects of Norfolk Boreas 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.	Screened out
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.	Increased collision risk with vessels associated with Norfolk Boreas 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.

8.1.2.6. Winterton-Horsey Dunes SAC

679. 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.

680. The landfall for the Norfolk Boreas offshore export cables will be at Happisburgh South, approximately 9km from the Horsey seal haul-out sites and the Norfolk Boreas offshore wind farm site is approximately 76km from the grey seal haul-out sites at Horsey (Figure 5.4).

681. 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.

682. For the in-combination assessment, to take into account the wide area covered by the in-combination project locations and evidence from telemetry studies, movements and potential foraging ranges, the reference population for grey seal incorporates the south-east England, north-east England MUs and East Coast Scotland MU (IAMMWG 2013; SCOS 2017) and the Wadden Sea region (TSEG 2017a). The total reference population for the in-combination assessment is 22,290 grey seal, as outlined in section 8.1.2.4.

683. 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 8.4).

8.1.2.7. The Wash and North Norfolk Coast SAC

684. 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.

685. The Wash and North Norfolk Coast SAC is located approximately 110km from the Norfolk Boreas site and 34km from the offshore cable corridor. The distance to Blakeney Point is approximately 44km from the landfall location and 121km from the Norfolk Boreas site (Figure 5.5).

686. The most recent August count (2016) of grey seal at haul-out sites was 355 grey seal at Blakeney Point and 431 at The Wash (SCOS, 2017). Therefore, a total count of 786 grey seal for the Wash and North Norfolk Coast SAC will be used in the assessment.

687. 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).

688. For the in-combination assessment, to take into account the wide area covered by the in-combination project locations and evidence from telemetry studies, movements and potential foraging ranges, the reference population for grey seal incorporates the south-east England, north-east England MUs and East Coast Scotland MU (IAMMWG 2013; SCOS 2017) and the Wadden Sea region (TSEG 2017a). The total reference population for the in-combination assessment is 22,290 grey seal, as outlined in section 8.1.2.4.

689. 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 8.4).

8.1.2.8. Other European Designated Sites

690. As outlined in section 5.3.5, Klaverbank SAC (NL2008002) located 67km from the Norfolk Boreas site and Noordzeekustzone SAC (NL9802001) located 94km from the Norfolk Boreas site have also been considered further in the HRA for any potential effects on foraging grey seal.

691. For these designated sites, to take into account the locations and evidence from telemetry studies, movements and potential foraging ranges, the reference population is 22,290 grey seal (see section 8.1.2.4).

692. These European Designated Sites use the OSPAR Conservation Objectives:

- To maintain, conserve or restore biodiversity, natural heritage, habitats, species or landscapes with legal protections status;
- To maintain key ecological functions (spawning areas, nursery grounds, feeding zones, resting areas, areas of high productivity, etc.);
- To manage the exploitation of natural resources;
- To improve governance on MPA territory;
- To educate on environmental issues and improve public awareness;
- To foster scientific research; and
- To create added socio-economic values.

693. The Conservation Objective for grey seal at the Klaverbank SAC is to “maintain the distribution, extent and quality of habitat for the purpose of maintaining the population” (Jak et al., 2009).

694. The Conservation Objective for grey seal at the Noordzeekustzone SAC is to “maintain the extent and quality of habitat in order to maintain the population”. The estimated population of grey seal at the site is 3,000[21]

8.1.3. Harbour Seal

8.1.3.1. Distribution

695. 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).

696. 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).

697. 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

[21] http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=NL9802001

seals at haul-out sites, indicate that harbour seal usage is relatively low in and around the Norfolk Boreas offshore project area and slightly higher along the coast (Figure 8.3; Russell et al*.,* 2017).

698. 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 the Norfolk Boreas offshore project area, 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 Boreas site compared to the offshore cable corridor, see below, although harbour seal numbers in the Norfolk Boreas site and the offshore cable corridor are very low (Figure 8.3). 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).

699. 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 (note that East Anglia THREE is located 13km south of the Norfolk Boreas site). The study indicated that movements of harbour seal were mostly restricted to the south-east MU.

700. 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 East Anglia THREE 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 (EATL, 2015).

701. arbour 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).

702. Tagging studies of 118 harbour seals from seven major populations around the UK included 24 seals from The Wash (Sharples et al*.,* 2012;Plate 8.4). The tracks indicate that most harbour seals are moving along the coastline and not in the Norfolk Boreas site.

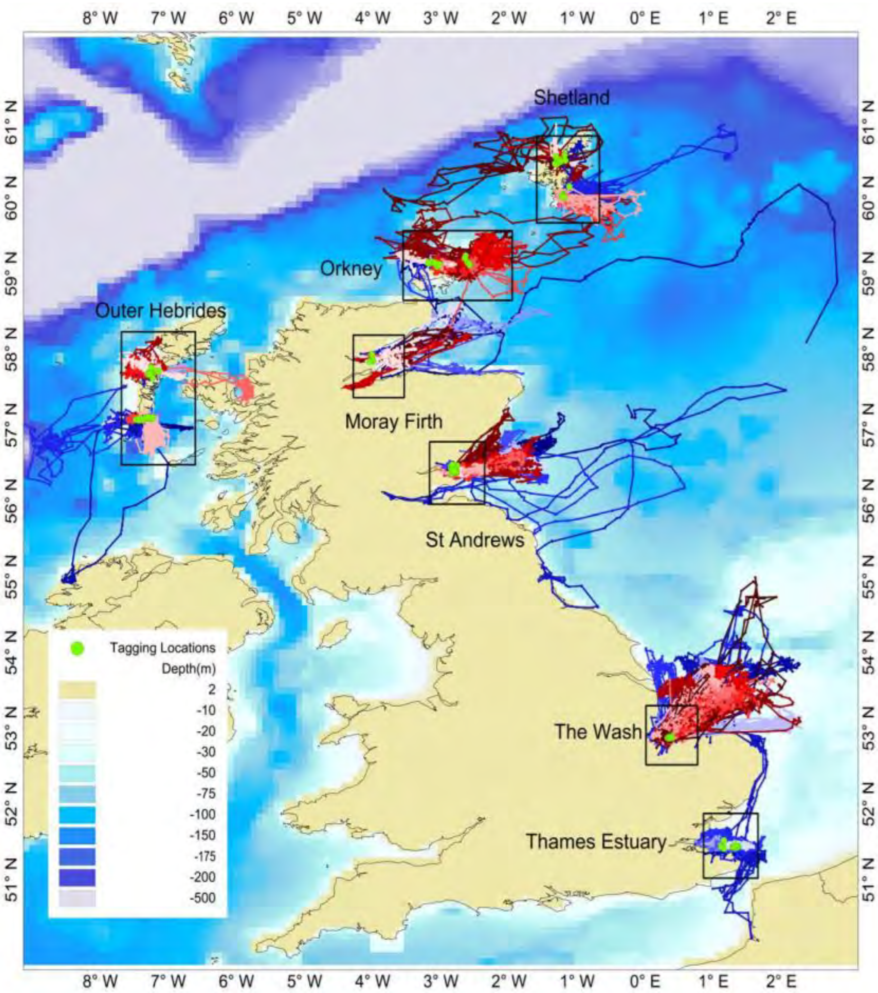

Plate 8.4 Results of the harbour seal tagging study showing foraging ranges for the population in The Wash (Sharples et al*.,* 2012)

8.1.3.2. Haul-out sites

703. 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).

704. 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).

705. As previously discussed, the Norfolk Boreas site is located approximately 72km offshore (at the closest point). There are principal harbour seal haul-out sites at Scroby Sands which is approximately 67km from the Norfolk Boreas site, at Blakeney Point which is approximately 121km from the Norfolk Boreas site and The Wash, approximately 168km from the Norfolk Boreas site (Figure 5.5). The main breeding site for harbour seal on the east coast of England is in The Wash (SCOS, 2017).

706. As previously discussed, the Happisburgh South landfall location is approximately 9km from the Horsey seal haul-out site to the south, 22km from the Scroby Sands seal haul-out site to the south, and 44km 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 34km from the landfall site (Figure 5.5).

8.1.3.3. Abundance

707. Approximately 30% of European harbour seal are found in the UK (SCOS, 2017).

708. 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).

709. 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).

710. 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).

711. The harbour seal density estimates for Norfolk Boreas 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 Boreas offshore project area. Within the Norfolk Boreas site (725km^2) the upper at-sea density of harbour seal is estimated to be 0.0001/km^2. Within the offshore cable corridor area and project interconnector

search areas (453km^2) the upper at-sea density of harbour seal is estimated to be 0.02/km^2. Within the total Norfolk Boreas offshore project area (1,178km^2) the harbour seal upper at-sea density is estimated to be 0.02km^2.

8.1.3.4. Reference population

712. 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.

713. 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.

714. 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.

715. 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).

716. 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

717. 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).

718. The Wash and North Norfolk Coast SAC is located approximately 110km from the Norfolk Boreas site and 34km from the offshore cable corridor.

719. The mean harbour seal count for the Wash in 2016 was 3,377 (SCOS, 2017). 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).

720. For the in-combination assessment, to take into account the wide area covered by the in-combination project locations and evidence from telemetry studies, movements and potential foraging ranges, the reference population for harbour seal

incorporates the south-east England MU (IAMMWG 2013; SCOS 2017) and the Wadden Sea region (TSEG 2017b). The total reference population for the in-combination assessment is 43,161 harbour seal, as outlined in section 8.1.3.4.

721. 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 Boreas 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.	Screened out
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.	Increased collision risk with vessels associated with Norfolk Boreas 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.

8.1.3.6. Other European Designated Sites

722. As outlined in section 5.3.5, Klaverbank SAC (NL2008002) located 67km from the Norfolk Boreas site has also been considered further in the HRA for any potential effects on foraging harbour seal.

723. For these designated sites, to take into account the locations and evidence from telemetry studies, movements and potential foraging ranges, the reference population is 43,161 harbour seal (see section 8.1.3.4).

724. The Conservation Objective for harbour seal at the Klaverbank SAC is to "Maintain the distribution, extent and quality of habitat for the purpose of maintaining the population" (Jak et al., 2009).

8.2. Assessment Scenarios

725. The offshore project area consists of:

- The offshore wind turbines and their associated foundations;
- Scour protection around foundations as required;
- Offshore electrical platforms supporting required electrical equipment, possibly also incorporating offshore facilities;
- An offshore service platform;
- Meteorological masts (met masts);
- Monitoring equipment including Light Detection and Ranging (LiDAR) and wave buoys;
- Array cables;
- Inter-connector cables; or project interconnector cables; and
- Export cables.

726. The realistic worst-case scenario for each category of potential impact has been determined. For this assessment, the realistic worst-case scenario involves consideration of both the timing of impacts, as well as the physical parameters that define the project design envelope for Norfolk Boreas.

727. Norfolk Boreas Limited is currently considering constructing the project in either a single phase or two phases (up to a maximum of 1,800MW). Offshore construction of the project under either approach would be expected to commence in 2026.

728. 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. However, if a two-phase construction approach was undertaken, the overall duration of the construction works could be longer. See Table 8.6 and Table 8.7 for the indicative construction programmes for both the single and two-phase approaches respectively.

729. Consideration is given to the effects on marine mammals over the full construction window which is expected to be up to approximately 36 months for single phase scenario (Table 8.6) or up to 39 months for the two phase scenario (Table 8.7). If Norfolk Vanguard has not progressed, the programmes presented could be brought forward by approximately one year. Under this scenario (i.e. Norfolk Vanguard does not progress) a project interconnector would not be installed.

730. Within Norfolk Boreas, several different sizes of wind turbine are being considered in the range of 10MW and 20MW. In order to achieve the maximum 1,800MW export capacity, there would be between:

- 90 x 20MW wind turbines; or
- 180 x 10MW wind turbines.

731. A range of foundation options are currently being considered for the wind turbines and electrical platforms, offshore service platforms, met masts and Lidar as shown in section 8.2.2.

Table 8.6 Indicative Norfolk Boreas construction programme – single phase

Indicative Programme	Approximate duration	2024				2025				2026				2027				2028			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Pre-construction survey	9 months				■	■	■														
UXO survey	9 months				■	■	■														
UXO clearance following licencing	9 months							■	■	■											
Foundation seabed preparation	3 months									■											
Foundation installation	18 months										■	■	■	■	■	■					
Scour protection installation	12 months									■	■	■	■								
Offshore electrical platform Installation Works	12 months										■	■	■	■							
Array & interconnector cable seabed preparation	6 months									■	■										
Array & interconnector cable installation	18 months										■	■	■	■	■	■					
Export cable installation seabed preparation	6 months								■	■											
Export cable installation	18 months									■	■	■	■	■	■						
Cable protection installation	18 months										■	■	■	■	■	■					
Wind turbine installation	18 months														■	■	■	■	■	■	
Total construction works	36 months								■	■	■	■	■	■	■	■	■	■	■	■	

Table 8.7 Indicative Norfolk Boreas construction programme – two phase

Indicative Programme	Approximate duration	2024				2025				2026				2027				2028			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Pre-construction survey	9 months				■	■	■														
UXO survey	9 months				■	■	■														
UXO clearance following licencing	9 months							■	■	■											
Foundation seabed preparation	3 months									■											
Foundation installation	2 x 9 months										■	■	■		■	■	■				
Scour protection installation	2 x 6 months									■	■			■	■						
Offshore electrical platform Installation Works	2 x 6 months										■	■			■	■					
Array & interconnector cable seabed preparation	2 x 3 months									■				■							
Array & interconnector cable installation	2 x 9 months										■	■	■		■	■	■				
Export cable installation seabed preparation	2 x 3 months								■				■								
Export cable installation	2 x 9 months									■	■	■		■	■	■					
Cable protection installation	2 x 9 months										■	■	■		■	■	■				
Wind turbine installation	2 x 9 months														■	■	■		■	■	■
Total construction works	39 months								■	■	■	■	■	■	■	■	■	■	■	■	■

8.2.1. Mitigation

8.2.1.1. Embedded mitigation

732. 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.

733. Where possible, the embedded mitigation has been taken into account in each relevant assessment when assessing the potential magnitude of the effect.

734. 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 8.3.5.

8.2.1.1.1. Reduction of turbine numbers

735. Since the Scoping stage, Norfolk Boreas Limited has reduced the maximum number of turbines from 257 to 180, while maintaining the maximum export capacity of 1,800MW by committing to using 10MW to 20MW turbines.

736. 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

737. Norfolk Boreas 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.

- o 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 (0.9km during the 10 minute soft-start and 1.8km during the 20 minute ramp-up), based on a precautionary average marine mammal swimming speed of 1.5m/s Otani et al*.,* 2000) (e.g. Kastelein et al*.* (2018) recorded harbour porpoise swimming speeds of 1.97m/s during playbacks of pile driving sounds).

8.2.1.2. Further mitigation

8.2.1.2.1. Marine Mammal Mitigation Plan for piling

738. The Marine Mammal Mitigation Plan (MMMP) for piling will be developed in the pre-construction period and based upon best available information, methodologies, industry best practice, latest scientific understanding, current guidance and detailed project design. The MMMP for piling will be developed in consultation with the relevant SNCBs and the Marine Management Organisation (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 and any additional mitigation measures required in order to minimise potential impacts of any physical or permanent auditory injury (PTS), for example, the activation of acoustic deterrent devices (ADDs) prior to the soft-start.

739. The MMMP for piling will determine a suitable mitigation zone around the piling location before piling commences. Appropriate mitigation measures considered adequate to exclude marine mammals from within the mitigation zone will be implemented prior to piling, to reduce the risk of any permanent auditory injury (PTS).

740. For example, the activation of ADDs for just 10 minutes prior to the soft-start would allow harbour porpoise, grey and harbour seal to move at least 0.9km from the piling location (based on a precautionary average swimming speed of 1.5m/s), which is beyond the maximum PTS predicted impact range for the starting hammer energy of up to 500kJ (see Table 8.16).

741. 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. Marine Mammal Mitigation Plan for UXO clearance

742. A detailed MMMP will be prepared for UXO clearance (as part of a separate marine licence application) following the pre-construction UXO survey when there is more detailed information on the UXO clearance which could be required.

743. It should be noted that the UXO clearance is not part of this DCO application and Norfolk Boreas Limited are not currently applying for consent for UXO clearance, as a separate application will be submitted once there is further information on what UXO clearance could be required and the MMMP has been prepared. The UXO MMMP will be secured when removal of UXO is licensed. Information on UXO clearance has been included in the information for the HRA, to provide a precautionary assessment of all the potential effects.

744. The MMMP for UXO clearance 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.

745. The MMMP for UXO clearance will involve the establishment of a suitable mitigation zone around the UXO location before any detonation. Norfolk Boreas Limited will implement mitigation measures to reduce the risk of physical or permanent auditory injury (PTS) to marine mammals within the mitigation zone prior to any UXO detonation.

746. 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:

- 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.
- 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.

- The activation of acoustic deterrent devices (ADDs).
- If required and where possible and safe to do so, a soft-start procedure using scare charges.
- 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.
- Noise reduction mitigation measures.

747. The final MMMP for UXO clearance will detail what is required for all agreed mitigation measures to ensure that they are successfully undertaken, including if marine mammals are observed in the mitigation zone.

8.2.1.2.3. In Principle Site Integrity Plan

748. In addition to the MMMPs for piling and UXO clearance, a Norfolk Boreas Southern North Sea SAC Site Integrity Plan (SIP) will be developed based on the In-Principle SIP submitted that has been submitted with the DCO application (document reference 8.17). The SIP will set out the approach to deliver any project mitigation or management measures in relation to the Southern North Sea SAC for harbour porpoise.

749. The SIP will be an adaptive management tool, which can be used to ensure that the most adequate, effective and appropriate measures, if required, are put in place to reduce the significant disturbance of harbour porpoise in the Southern North SAC.

8.2.1.3. Project Environmental Management Plan

750. Norfolk Boreas Limited will produce a Project Environmental Management Plan (PEMP) which will be mechanisms for securing the commitments made above. The PEMP will identify stakeholder requirements, ensure compliance with current legislation, minimises any potential adverse environmental effects during construction and translate committed mitigation into committed site procedure. An outline PEMP has been submitted as part of the DCO application (document reference 8.14).

8.2.1.4. In-Principle Monitoring Plan

751. The In-Principle Monitoring Plan will identify relevant offshore monitoring as required by the deemed marine licence conditions, establish the objectives of such monitoring and set out the guiding principles for delivering any monitoring measures as required. An outline of the In-Principle Monitoring Plan has been submitted as part of the DCO application (document reference 8.12).

8.2.2. Worst Case Scenario

752. The project design envelope on which the assessment is based was “frozen” in January 2019 to allow the application for development consent to be completed and submitted in June 2019. This design envelope has been used to define realistic worst case scenarios.

753. 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 Boreas.

754. Table 8.8 provides a summary of the worst-case parameters of Norfolk Boreas that could have a potential effect on marine mammals.

Table 8.8 Worst-case parameters for marine mammal receptors

Impact	Parameter	Maximum worst-case	Notes
Construction			
Underwater noise from UXO clearance	Possible number of UXO	• up to 30 in the Norfolk Boreas site • 28 in the offshore cable corridor • up to 22 in the project interconnector search areas Total = up to 80	Indicative only, based on initial geophysical data (Fugro, 2016; 2017), but numbers will be determined by a pre-construction UXO survey.
	Possible type and size of UXO	• German LMB (GC) Ground Mine (up to 700kg NEQ) • British A Mk6 Ground Mine (up to 430kg 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)	Indicative only, based on initial risk assessment (Ordtek, 2018). A detailed UXO survey would be completed prior to construction. The exact 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	180 (10MW turbines) or • 90 (20MW turbines)	
	Number of other offshore platforms	2 x offshore electrical platforms 2 x Met masts 2 x LiDAR 1 x offshore service platform = 7	
	Proportion of foundations that are piled	100%	The maximum number of piled foundations represents the worst-case scenario for underwater noise.
	Number of piles per foundation	1 (monopile) 3 (tripod with pin-piles of the same diameter as the quadropod) • 4 (quadropod with 4 legged jacket pin-piles)	

Impact	Parameter	Maximum worst-case	Notes
	Maximum number of piles - Wind turbines	180 x 4 pin-piles (10MW quadropod) Total = 720	10MW = 180 monopiles or 720 pin-piles 20MW = 90 monopiles or 360 pin-piles
	Maximum number of piles - Other offshore platforms	2 x offshore electrical platforms with 18 pin-piles = 36 pin piles 2 x Met masts quadropod = 8 pin-piles 2 x LiDAR monopile = 2 monopiles 1 x offshore service platform with 6 pin-piles = 6 piles Total = 52	Assumes a worst-case of 6 pin-piles/piled anchors per offshore service platform and 18 pin-piles per electrical platform.
	Maximum number of piled foundations	772	Maximum number of pin-piles = 720 (10MW) + 42 (platforms) plus 2 LiDAR monopiles = 772 Or Maximum number of monopiles = 180 (10MW) + 2 LiDAR monopiles plus 50 platform pin-piles = 232
	Maximum hammer energies	• 2,700kJ (for piled tripod or quadropod foundations 10-20MW pin-pile and platform pin-piles) • 5,000kJ (20MW monopile) Starting hammer energies of 10% will be used followed by ramp-up to the maximum hammer energy.	
	Pile diameter	• 10m (10MW monopile) • 3m (10MW pin-pile) • 15m (20MW monopile) • 5m (20MW pin-pile)	

Impact	Parameter	Maximum worst-case	Notes
	Total piling time – per turbine foundation (providing allowance for soft start and issues such as low blow rate, refusal)	• 6hrs per pile (10MW monopile) x 180 piles = 1,080 hours (4,000kJ hammer); or • 1.5hrs per pile (10MW quadropod) x 720 piles = 1,080 hours (2,700kJ hammer); or • 6hrs per pile (20MW monopile) x 90 piles = 540 hours (5,000kJ hammer); or • 3hrs per pile (20MW quadropod) x 360 turbines = 1,080 hours (2,700kJ hammer)	The maximum piling duration of 1,080 hours (including soft-start and ramp-up) associated with 10MW monopile, 10MW or 20MW quadropod with pin-piles, represents the worst case scenario for total piling duration for turbine foundations.
	Total piling time – per platform foundation (providing allowance for soft start and issues such as low blow rate, refusal)	• 1.5hrs per pile (18 pin-piles for offshore electrical platforms) x 36 piles = 54 hours • 1.5hrs (six pin-piles for offshore service platform) x 6 piles = 9 hours • 1.5hrs per pile (Met masts quadropod) x 8 = 12 hours • 6hrs per pile (LiDAR monopiles) x 2 = 12 hours • Total = 87 hours	Assumes a worst-case of 18 pin-piles per offshore electrical platforms and six pin-piles per offshore service platform.
	Maximum total active piling time for wind turbines and platforms	1,167 hours (48.6 days)	Based on the worst-case scenario of maximum number of pin-piles for wind turbines (up to 45 days) and platforms (up to 3.6 days).
	Activation of Acoustic Deterrent Devices (ADDs)	10 minutes per pile Up to 128.7 hours for 772 piled foundations	Maximum of 128.7 hours for 720 pin-piles (10MW) + 42 pin-piles (platforms) + 8 pin-piles (met masts) plus 2 LiDAR monopiles Or Maximum of 38.7 hours for 180 monopiles (10MW) + 2 LiDAR monopiles plus 50 platform pin-piles
	Foundation installation period within construction period	• Single phase = 18 months • Two phase = 2 x 9 months	This is an indicative period within which foundation installation, including piling is anticipated to occur.

Impact	Parameter	Maximum worst-case	Notes
	Number of concurrent piling events	2	Maximum number of pile installation vessels on site at any one time.
	Min. spacing between piling vessels	720m	Based on the closest turbine spacing.
	Max. spacing between piling vessels	Approximately 46km	Based on the limits of the OWF site boundaries.
Underwater noise from seabed preparation, rock dumping and cable installation	Cable installation methods	• Ploughing • Jetting • Trenching or cutting	
	Array cable length	600km	
	Max no. of array cable laying vessels on site	5	
	Max no. of export cable laying vessels on site	5	
	Indicative duration of cable installation	• Single phase = 18 months • Two phase = 2 x 9 months = 18 months	18 months represents the indicative maximum cable installation duration.
	Project Interconnection cable length	90km (a pair of HVDC cables in one trench and a single AC cable in a second trench; therefore, 60km of trench, within the Norfolk Boreas site)*. 100km (a pair of DC cables in one trench and 9 AC cables in individual trenches resulting in 92km worth of trench within the project interconnector search areas)*.	

Impact	Parameter	Maximum worst-case	Notes
	Total export cable length	500km (100km in Norfolk Boreas site and 400km in export cable corridor) based on four cables laid as pairs with a total of 2 trenches, up to 250km trench length.	
Vessels • Underwater noise and disturbance from vessels • Collision risk • Disturbance at seal haul-out sites	Maximum number of vessels on site at any one time during construction	Maximum = 57	
	Indicative number of movements	1,180 during construction period	
	Vessel types	Vessel types that could be on site during construction include a range of large and small vessels from Dynamic Position Heavy Lift Vessel to Crew transfer vessels	
	Port locations	Will be determined post consent. Assessment will consider Great Yarmouth, Lowestoft and Hull, with Great Yarmouth considered to be most likely.	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.
Changes in prey availability	Temporary loss of sea bed habitat; increased suspended sediments and sediment re-deposition; and underwater noise	• Maximum area of physical disturbance and temporary loss of sea bed habitat = 23.31km^2 • Maximum volume of increased suspended sediments and sediment re-deposition = 0.054km^3 • Underwater noise during UXO clearance = parameters as outlined above. • Underwater noise during piling = parameters as outlined above. • Underwater noise from construction activities = parameters as outlined above.	Temporary habitat loss/disturbance in the Norfolk Boreas site = 15.4km^2; in the offshore cable corridor = 6.07km^2; and in the project interconnector search area = 1.84km^2. Temporary increases in suspended sediment concentrations and associated sediment deposition in the Norfolk Boreas site = 47,885,774m^3; in the offshore cable corridor = 3,750,000m^3; and in the project interconnector search area = 2,760,000m^3.

Impact	Parameter	Maximum worst-case	Notes
Operation and maintenance			
Underwater noise from turbines	Number of wind turbines	180 (10MW devices); or 90 (20MW devices)	
	Wind turbine size	10-20MW	
Underwater noise from maintenance activities, such as any additional rock dumping and cable re-burial	Unplanned repairs and reburial of cables may be required during O&M: • One export cable repair and two array cable repairs per year. • Up to 20km of export cable reburial at five year intervals. • Reburial of 25% of array cable once every five years. • One interconnector and one project interconnect cable repair per year. 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.	445	Approximately 37 per month
Changes in prey availability	Permanent footprint of offshore infrastructure.	• Worst-case turbine for all infrastructure within the Norfolk Boreas site (including foundations for turbines platforms and other infrastructure as well as cable protection) footprint = 6.18km^2 • Worst-case cable protection within the offshore cable corridor = 0.17km^2 • Worst-case cable protection within the project interconnector search area = 0.061km^2 Total worst-case = 6.4km^2	

Impact	Parameter	Maximum worst-case	Notes
	Temporary seabed disturbances from maintenance operations	• Cable repairs/reburial, turbine maintenance and maintenance vessel footprints in the Boreas site = 1.07km^2 • Cable repairs and reburial in the offshore cable corridor = 0.12km^2 • Cable repairs and reburial in the project interconnector area = 0.07km^2 Total worst-case = 1.26km^2	
	EMF from installed array, interconnector, project connector and export cables	Worst case scenario total length of cable that is not buried = 119.76km	
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, project 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).		
Changes to prey resources	Assumed to no greater than during construction phase.		

* Either “Interconnector cables” would be installed or “project interconnector cables” would be installed. Under no scenario would both be required.

8.3. Assessment of Potential Effects

8.3.1. Southern North Sea SAC

755. Assessment of the potential effects on the Southern North Sea SAC for harbour porpoise, is based on draft SNCB advice that:

- Displacement of harbour porpoise should not exceed 20% of the seasonal component of the SAC area in any given day / or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.
- The effect of the project should be considered in the context of the seasonal components of the SAC area, rather than the SAC area as a whole.
- A distance of 26km from an individual percussive piling location should be used to assess the area of SAC 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 SAC habitat harbour porpoise may be disturbed.

756. The total Southern North Sea SAC area is 36,951km^2 (JNCC, 2017a). The northern ‘summer’ area is approximately 27,018km^2 and covers the period from April to September (183 days). The southern ‘winter’ area is approximately 12,697km^2 and covers the period from October to March (182 days) (Heinänen and Skov, 2015)[22].

757. The maximum and minimum potential overlap on the seasonal SAC areas has been calculated to enable an average potential effect to be approximated.

758. 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 Boreas (letter dated 3rd January 2018; Ref: 10430 Consultation 234941).

759. 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).

760. The Southern North Sea SAC Site Selection Report (JNCC, 2017a) identifies that the Southern North Sea SAC site could support approximately 17.5% of the UK North Sea reference population 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

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[22] Summer and winter areas of these have been estimated using GIS overlays and based on areas in BEIS HRA scoping report

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, 2017a).

761. However, it was agreed with the marine mammal ETG at the EPP meeting on 15th February 2017 that the estimate that the Southern North Sea SAC 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 Southern North Sea SAC winter and summer areas. Therefore, for information purposes, Appendix 8.1 presents an assessment on the estimated number of harbour porpoise that the Southern North Sea SAC 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.

762. The potential effects during the construction, operation, maintenance and decommissioning of the proposed Norfolk Boreas project to be assessed as part of the HRA process for the Southern North Sea SAC have been agreed in consultation with the marine mammal ETG as part of the EPP.

763. The potential effects assessed for construction are:

- The risk of permanent 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 permanent 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 presence of vessels;
- Barrier effects as a result of underwater noise associated with activities above;
- Vessel interaction (collision risk);
- Changes to prey resource, including habitat loss;
- Changes to water quality; and
- Overall potential effects during construction of Norfolk Boreas.

764. The potential effects assessed for operation and maintenance 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 presence of vessels;
- Vessel interaction (collision risk);
- Changes to prey resource, including habitat loss; and
- Overall potential effects during operation and maintenance of Norfolk Boreas.

765. The potential effects assessed for decommissioning are:

- The risk of permanent auditory injury from the underwater noise associated with foundation removal;
- Disturbance resulting from the noise associated with foundation removal;
- Disturbance resulting from underwater noise and presence of vessels;
- Barrier effects as a result of underwater noise associated with activities above;
- Vessel interaction (collision risk);
- Changes to prey resource, including habitat loss;
- Overall potential effects during decommissioning of Norfolk Boreas.

8.3.1.1. Potential effects during construction of Norfolk Boreas (alone)

766. The realistic worst-case scenario on which the assessment is based for harbour porpoise is outlined in Table 8.8.

767. The impacts of the entire project are assessed as a whole, although where relevant the impacts have been assessed separately for the Norfolk Boreas site, the project interconnector search areas and the offshore cable corridor. Therefore, for impacts that span across the Norfolk Boreas site, the project interconnector search area and the offshore cable corridor, magnitude may be discussed separately (under the same impact), however consideration is given to the combined effect for the project overall. It should be noted that not all the assessed effects occur in reality, as either the interconnector cables or the project interconnector cables would be installed, dependent on whether Norfolk Vanguard is built or not. Under no circumstance would both the interconnector cables and the project interconnector cables be installed; therefore, not all assessed effects would occur. Further information relating to this is provided within each relevant assessment.

8.3.1.1.1. Potential effects resulting from the underwater noise associated with clearance of UXO at Norfolk Boreas (alone)

768. 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.

769. A detailed UXO survey would be completed prior to construction. The exact number of possible detonations and duration of UXO clearance operations is therefore not known at this stage. It has been estimated (Fugro, 2016; 2017) that up to 30 UXO detonations may be required within the Norfolk Boreas site, 28 in the offshore cable corridor and 22 within the project interconnector search area. It is not currently known what size or type of the UXO could be located within the offshore project area and therefore a strategic UXO risk management assessment has been conducted.

770. The risk management assessment, is based on practical offshore industry experience, open-source studies and principles applied by military Explosive Ordnance Disposal (EOD) specialists:

- 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.

771. The assessment indicates that the principal UXO to consider are German and British sea mines; with German High Explosive (HE) bombs, torpedoes and depth charges regarded as a lower residual background threat. In addition, there are munitions related wrecks within the area and therefore naval projectiles are also a consideration. From experience of UK North Sea developments, the presence of Allied HE bombs are considered to also be a principal UXO hazard.

772. Other items of UXO may be encountered, however the wide range of 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 Boreas. Table 8.9 illustrates the NEQ of the potential types of UXO that may be encountered at within the Norfolk Boreas offshore project area (Ordtek, 2018).

Table 8.9 Potential UXO that could be located at Norfolk Boreas

UXO item	Nominal NEQ (kg)	TNT Equivalent (kg)
German SC-50 bomb (amatol)	25kg	25kg
250lb Allied bomb (Hexogen/TNT)	50kg	60kg
German SC-250 bomb (amatol)	145kg	145kg
500lb Allied bomb (Hexogen/TNT)	126kg	151kg
1000lb Allied bomb (Hexogen/TNT)	260kg	312kg

UXO item	Nominal NEQ (kg)	TNT Equivalent (kg)
500lb Allied mine (minol)	227kg	340kg
German LMB (GC) Ground Mine (Hexanite)	700kg	770kg

Permanent auditory injury

773. As outlined in section 8.2.1.2.2, 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, guidance and pre-construction UXO surveys at the Norfolk Boreas 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. 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 in this assessment.

774. Subacoustech (2019a) has undertaken predictive underwater noise modelling for the Norfolk Boreas project (Appendix 5.5 of the ES), based on the Ordtek (2018) strategic UXO risk management assessment. This underwater noise modelling has been used to estimate the potential impact ranges for marine mammals that could arise during UXO clearance at Norfolk Boreas.

775. As outlined above, a number of UXOs with a range of charge weights could be located within the boundary of the Norfolk Boreas 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. A range of explosive sizes has been considered based on site surveys and it has been assumed that the maximum explosive charge in each device is present and detonates with the clearance.

776. 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 Trinitrotoluene (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.

777. 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.

778. The assessment also does not take into account the variation in the noise level at different depths. Where animals are swimming near the surface, the acoustics at the surface cause the noise level, and hence the exposure, to be lower at this position (Marine Technical Directorate (MTD) 1996). The risk to animals near the surface may therefore be lower than indicated by the range estimate and therefore this can be considered conservative in respect of impact at different depths.

779. The impact criteria use thresholds and weightings based on the National Oceanographic and Atmospheric Associate (NOAA) (National Marine and Fisheries Service (NMFS), 2018) criteria. The thresholds indicate the onset of PTS, or the point at which there is an increase in risk of permanent hearing damage (although not all individuals within the maximum PTS range will have permanent hearing damage, this is assumed as a worst-case scenario). These indicators 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.

780. Harbour porpoise are classed as high-frequency cetaceans, as they are more sensitive to high frequency sound. The weighted thresholds 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.

781. The number of harbour porpoise that could potentially be affected has been estimated for Norfolk Boreas, based on the maximum potential PTS impact ranges of UXO clearance (Table 8.10).

782. Caution should also be raised over the longer range peak Sound Pressure Level (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 3km compared to real data.

783. With increased distance from the source, impulsive noise, such as UXO detonation, noise becomes more of a non-impulsive noise, unfortunately it is currently difficult to determine the distance at which an impulsive noise becomes more like a non-impulsive noise. Therefore, modelling was conducted using both the impulsive and non-impulsive criteria for PTS weighted Sound Exposure Levels (SEL) to give an indication of the difference between maximum potential impact ranges.

784. NMFS (2018) suggest 3km as an estimate of a distance at which transition away from this impulse to a more non-pulse type of noise could occur, although the sound will not go through a ‘step change’ and this distance will change depending on the type of sound and situation. It is suggested that, for any injury ranges calculated using the impulsive criteria in excess of 5km, the non-pulse criteria should be considered more appropriate, however, this is still under review (Subacoustech, 2019a).

785. The use of NOAA (NMFS, 2018) weighted Sound Exposure Level (SEL) is considered more suitable, especially over long ranges. 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 8.10). However, it is considered that the maximum potential impact range for PTS is likely to be 5km.

786. The range of equivalent charge weights of the potential UXO devices that could be present within the Norfolk Boreas site boundaries have been estimated as from 25 to 770kg (Table 8.10). Estimation of the source noise level for each charge weight was carried out in accordance with the methodology of Soloway and Dahl (2014), which follows Arons (1954) and MTD (1996). These charge weights cannot take into account the range of variables noted above and thus will only provide an indication of the noise output from each detonation. They also assume a worst-case freely suspended charge.

Table 8.10 Unweighted SPL_{peak} and SEL_{ss} source levels used for UXO modelling

Charge weight	25kg	60kg	145kg	151kg	312kg	340kg	770kg
SPL_{peak} dB re 1 µPa	284.9	287.7	290.6	290.7	293.1	293.4	296.1
SEL_{ss} dB re 1 µPa^{2}s	227.9	230.3	232.8	232.9	234.9	235.1	237.4

Table 8.11 Potential effects of permanent auditory injury (PTS) on harbour porpoise during UXO clearance without mitigation

Potential Effect	Criteria threshold	Possible maximum charge weights (TNT equivalent)						
		25kg	60kg	145kg	151kg	312kg	340kg	770kg
Permanent auditory injury (PTS) – without mitigation	PTS SPL_{peak} unweighted (NMFS, 2018) 202 dB re 1 µPa Impulsive criteria	4.6km	6.1km	8.3km	8.4km	10.7km	11.0km	14.4km
	PTS SEL weighted (NMFS, 2018) 155 dB re 1 µPa^{2}s Impulsive criteria	0.56km	0.76km	1.0km	1.0km	1.2km	1.2km	1.5km

Potential Effect	Criteria threshold	Possible maximum charge weights (TNT equivalent)						
		25kg	60kg	145kg	151kg	312kg	340kg	770kg
	Number of harbour porpoise and % of reference population based on maximum impact range (14.4km) for PTS unweighted SPL_{peak} (NMFS, 2018)	Maximum impact area* based on unweighted SPL_{peak} = 651.4km^2 578 harbour porpoise (0.17% of NS MU) based on SCANS-III survey density (0.888/km^2). 690.5 harbour porpoise (0.2% of NS MU) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.						

*Maximum area based on area of circle with maximum impact range for radius.

Mitigation

787. 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, guidance and pre-construction UXO surveys at the Norfolk Boreas 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.

788. As outlined in section 8.2.1.2.2, the MMMP for UXO clearance will involve the establishment of a suitable mitigation zone around the UXO location before any detonation. Norfolk Boreas Limited will ensure that the mitigation measures are adequate to exclude marine mammals from within the mitigation zone prior to any UXO detonation, to reduce the risk of any physical or permanent auditory injury (PTS).

789. The effective implementation of the UXO MMMP will reduce the risk of permanent auditory injury (PTS) to harbour porpoise during any underwater detonations at Norfolk Boreas (alone), therefore, there would be **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise.**

790. 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

791. 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.

Spatial assessment

792. The current SNCBs recommendation is that an Effective Deterrent Radius (EDR) 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 SAC. 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 the Norfolk Boreas offshore project area (Table 8.12).

793. Only one UXO would be detonated at a time during UXO clearance operation at Norfolk Boreas; there would be no concurrent UXO detonations.

Table 8.12 Estimated area of Southern North Sea SAC that harbour porpoise could potentially be disturbed from during UXO clearance at Norfolk Boreas

UXO clearance	Maximum potential overlap with Southern North Sea SAC	Average potential overlap with Southern North Sea SAC	Potential adverse effect on site integrity
UXO detonation located in the Norfolk Boreas site	296.82km^2 in the winter SNS SAC area (approximately 2.3% of the winter SNS SAC area); Or 2,112.22km^2 in the summer SNS SAC area (approximately 7.8% of the summer SNS SAC area).	148.41km^2 in the winter SNS SAC area (minimum = 0km^2) (approximately 1.2% of the winter SNS SAC area); Or 1,249.4km^2 in the summer SNS SAC area (minimum = 386.65km^2) (approximately 4.6% of the summer SNS SAC area).	**No** Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC area at any one time during any UXO clearance at Norfolk Boreas (alone), based on the worst-case scenario.
UXO detonation located in project interconnector search area in NV East	601.06km^2 in the winter SNS SAC area (approximately 4.4% of the winter SNS SAC area); Or 2,124km^2 in the summer SNS SAC area (approximately 7.9% of the summer SNS SAC area).	322.58km^2 in the winter SNS SAC area (minimum = 44.09km^2) (approximately 2.5% of the winter SNS SAC area); Or 1,912.6km^2 in the summer SNS SAC area (minimum = 1,701.29km^2) (approximately 7.1% of the summer SNS SAC area).	
UXO detonation located in project interconnector search area in NV West	1,087.56km^2 in the winter SNS SAC area (approximately 8.6% of the winter SNS SAC area); Or 2,124km^2 in the summer SNS SAC area (approximately 7.9% of the summer SNS SAC area).	725.41km^2 in the winter SNS SAC area (minimum = 363.25km^2) (approximately 5.7% of the winter SNS SAC area); Or 2,055.74km^2 in the summer SNS SAC area (minimum = 1,987.47km^2)	

UXO clearance	Maximum potential overlap with Southern North Sea SAC	Average potential overlap with Southern North Sea SAC	Potential adverse effect on site integrity
		(approximately 7.6% of the summer SNS SAC area).	
UXO detonation in the cable corridor	2,001.38km^2 in the winter SNS SAC area (approximately 15.8% of the winter SNS SAC area). Or 2,124km^2 in the summer SNS SAC area (approximately 7.9% of the summer SNS SAC area).	1,000.7km^2 in the winter SNS SAC area (minimum = 0km^2) (approximately 7.9% of the winter SNS SAC area); Or 2,055.74km^2 in the summer SNS SAC area (minimum = 1,987.47km^2) (approximately 7.6% of the summer SNS SAC area).	

794. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the Southern North Sea SAC area at any one time during any UXO clearance at Norfolk Boreas (alone), based on the worst-case scenario (Table 8.12). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

795. It is currently not possible to determine the number of days per season that UXO clearance would be undertaken, if required, at Norfolk Boreas. An estimated worst-case of up to 30 clearance operations in the Norfolk Boreas site, up to 22 in the project interconnector search areas 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; 2017) and VWPL experience. 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.

796. Disturbance from UXO detonations would be instantaneous and occur for a very 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 80 days, based on one detonation per day assuming no previous UXO clearance operations in the project interconnector search areas and offshore cable corridor as part of the Norfolk Vanguard development.

797. 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 SAC and number of UXO clearance days per season).

798. The assessment indicates, on average, less than 10% of the seasonal component of the Southern North Sea SAC over the duration of that season could be affected during any UXO clearance at Norfolk Boreas (alone), based on the worst-case scenario (Table 8.13). Therefore, under these circumstances, **there would be no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

799. However, based on a more 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 21 days. The assessment indicates, on average, less than 10% of the seasonal component of the Southern North Sea SAC 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 adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.13 Estimated seasonal area averages for the Southern North Sea SAC winter and summer areas during UXO clearance at Norfolk Boreas

UXO clearance	Number of UXO clearance days per season	Average area within Southern North Sea SAC seasonal areas	Estimated seasonal area average	Potential adverse effect on site integrity
One detonation per day				
UXO detonation location within the Norfolk Boreas site	• 30 days (16.4% of the summer season; or 16.5% of the winter season)	• Summer SNS SAC area = 4.6% • Winter SNS SAC area = 1.2%	• Summer SNS SAC area = 0.8% • Winter SNS SAC area = 0.2%	**No** Temporary effect. Displacement of harbour porpoise would not exceed 10% of the seasonal component of the SNS SAC over the duration of that season during any UXO clearance at Norfolk Boreas (alone), based on the worst-case scenario.
UXO detonation located in project interconnector search area (NV East)	• 11 days (6.0% of the summer season; or 6.0% of the winter season)	• Summer SNS SAC area = 2.5% • Winter SNS SAC area = 7.1%	• Summer SNS SAC area = 0.2% • Winter SNS SAC area = 0.4%	
UXO detonation located in project interconnector search area (NV West)	• 11 days (6.0% of the summer season; or 6.0% of the winter season)	• Summer SNS SAC area = 5.7% • Winter SNS SAC area = 7.6%	• Summer SNS SAC area = 0.3% • Winter SNS SAC area = 0.5%	
UXO detonation located in cable corridor	• 28 days (15.3% of the summer season; or 15.4%	• Summer SNS SAC area = 7.9%; or • Winter SNS SAC area = 7.6%	• Summer SNS SAC area = 1.2%; or • Winter SNS SAC area = 1.2%	

UXO clearance	Number of UXO clearance days per season	Average area within Southern North Sea SAC seasonal areas	Estimated seasonal area average	Potential adverse effect on site integrity
	of the winter season)			
Four detonations per day				
UXO detonation is location within the Norfolk Boreas site	• 8 days (4.4% of the summer season; or 4.4% of the winter season)	• Summer SNS SAC area = 4.6% • Winter SNS SAC area = 1.2%	• Summer SNS SAC area = 0.2% • Winter SNS SAC area = 0.05%	No Temporary effect. Displacement of harbour porpoise would not exceed 10% of the seasonal component of the SNS SAC over the duration of that season during any UXO clearance at Norfolk Boreas (alone), based on the precautionary scenario.
UXO detonation is located in project interconnector search area (NV East)	• 3 days (1.6% of the summer season; or 1.6% of the winter season)	• Summer SNS SAC area = 2.5% • Winter SNS SAC area = 7.1%	• Summer SNS SAC area = 0.04% • Winter SNS SAC area = 0.1%	
UXO detonation is located in project interconnector search area (NV West)	• 3 days (1.6% of the summer season; or 1.6% of the winter season)	• Summer SNS SAC area = 5.7% • Winter SNS SAC area = 7.6%	• Summer SNS SAC area = 0.1% • Winter SNS SAC area = 0.1%	
UXO detonation located in cable corridor	• 7 days (3.8% of the summer season; or 3.8% of the winter season)	• Summer SNS SAC area = 7.9%; or • Winter SNS SAC area = 7.6%	• Summer SNS SAC area = 0.3%; or • Winter SNS SAC area = 0.3%	

Assessment in relation to North Sea MU

800. The estimated number of harbour porpoise that could be disturbed during underwater UXO clearance at Norfolk Boreas is presented in Table 8.14. As outlined above, only one UXO would be detonated at a time during UXO clearance operation at Norfolk Boreas; there would be no concurrent UXO detonations.

Table 8.14 Estimated number of harbour porpoise potentially disturbed during UXO clearance at Norfolk Boreas

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). 2,251 harbour porpoise based on site specific survey density	0.55% of NS MU based on SCANS-III density. 0.65% of NS MU based on the site specific survey density at the Norfolk Boreas site.	**No** Temporary effect. 0.65% or less of the reference population could

Potential Effect	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
	($1.06/km^2$) at the Norfolk Boreas site.		be temporarily displaced during any UXO clearance at Norfolk Boreas (alone), based on the worst-case scenario.

[1]Based on density estimates and reference populations (see section 8.1.1).

801. The assessment indicates that 0.65% or less of the North Sea MU reference population could be temporarily displaced during any UXO clearance at Norfolk Boreas (alone), based on the worst-case scenario (Table 8.14). Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

802. In addition, the number of harbour porpoise that could be displaced during underwater UXO clearance at Norfolk Boreas has been estimated based on the maximum potential Temporary Threshold Shift (TTS) range (Table 8.15). The TTS onset thresholds based on the NOAA (NMFS, 2018) SEL weighted criteria is the point at which there is an increase in risk of temporary hearing impairment in an underwater receptor. Although not all individuals within the maximum TTS range will have temporary hearing impairment, it is assumed as a worst-case scenario that all animals could be displaced.

803. The assessment indicates that 0.7% or less of the North Sea MU reference population could be temporarily displaced (maximum TTS range) during any UXO clearance at Norfolk Boreas (alone), based on the worst-case scenario (Table 8.15). Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.15 Potential effects of temporary auditory injury (TTS) and displacement on harbour porpoise during UXO clearance without mitigation

Potential Effect	Criteria threshold	Possible maximum charge weights (TNT equivalent)						
		25kg	60kg	145kg	151kg	312kg	340kg	770kg
Temporary auditory injury (TTS) – without mitigation	TTS SPL_{peak} unweighted (NMFS, 2018) 196 dB re 1 µPa Impulsive criteria	8.5km	11.3km	15.2km	15.4km	19.6km	20.2km	26.5km
	TTS SEL weighted (NMFS, 2018) 140 dB re 1 μPa^2s	2.4km	2.8km	3.3km	3.3km	3.7km	3.7km	4.2km

Potential Effect	Criteria threshold	Possible maximum charge weights (TNT equivalent)						
		25kg	60kg	145kg	151kg	312kg	340kg	770kg
	Impulsive criteria							
	Number of harbour porpoise and % of reference population based on maximum impact range (26.5km) for TTS weighted SEL (NMFS, 2018)	Maximum impact area* based on weighted TTS SEL = 2,206km^2 1,959 harbour porpoise (0.6% of NS MU) based on SCANS-III survey density (0.888/km^2). 2,339 harbour porpoise (0.7% of NS MU) based on the site specific survey density at the Norfolk Boreas site (1.06/km^2).						

*Maximum area based on area of circle with maximum impact range for radius.

8.3.1.1.2. *Potential effects resulting from underwater noise during piling at Norfolk Boreas (alone)*

804. A range of foundation options are being considered for the proposed Norfolk Boreas project, including monopiles, either piled or with suction caisson; quadropod or tripod jackets, either pin-piles or suction caissons; gravity base structure; and TeraBase foundations. Of these, monopiles, jackets (pin-piles) and TetraBase may require piling.

805. As a worst-case scenario for underwater noise, it has been assumed that all foundations would be hammer piled, using the maximum hammer energy and pile diameter for the maximum potential duration to install (Table 8.8).

Permanent auditory injury

806. Subacoustech (2019a) has undertaken predictive underwater noise modelling to estimate the noise levels likely to arise during construction of Norfolk Boreas (Appendix 5.4 of Chapter 5 Project Description document reference 6.1.5.4) and determine the potential effects on harbour porpoise.

807. 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, 2018) criteria for unweighted SPL_{peak} and PTS from cumulative exposure (weighted SEL_{cum}) are presented in Table 8.16.

808. 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 0.4 individuals (0.0001% of the North Sea MU reference population), based on the site specific density (1.06 harbour porpoise per km^2).

809. 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 0.03 individuals (0.00001% 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 0.2 harbour porpoise (up to 0.00006% of the North Sea MU reference population), based on the site specific density (1.06 harbour porpoise per km^2).

Table 8.16 Maximum predicted impact ranges (and areas) for permanent auditory injury (PTS) from a single strike and from cumulative exposure based on NOAA (NMFS, 2018) 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	0.07km (0.014km^2)	0.34km (0.373km^2)	<0.05km (0.004km^2)	0.25km (0.204km^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	<0.1km (0.031km^2)	N/A	0.3km (0.203km^2)•

*areas for maximum hammer energies for monopile and pin-pile and for monopile starting hammer energy based on modelled contour area; area for pin-pile starting hammer energy based on precautionary area of circle with maximum impact range as radius.

• based on the modelling undertaken with a six-hour piling duration for four pin-piles (1.5 hours per pin-pile) as the most realistic worst-case scenario.

Mitigation

810. 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. A draft MMMP for piling has been submitted with the DCO application. 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.

811. 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 section8.2.1) 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 0.34km 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 8.16).

812. 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 Boreas (alone), therefore, **there would be no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

813. Although the mitigation will increase the distance of harbour porpoise from the piling location, it cannot mitigate the potential for disturbance to harbour porpoise.

Disturbance during proposed mitigation

814. 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), with a potential disturbance area of 41km^2. This is approximately 0.31% of the winter Southern North Sea SAC area or 0.15% of the summer Southern North Sea SAC area. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC at any one time and / or on average exceed 10% of the seasonal component of the SAC over the duration of that season as a result of the proposed mitigation for piling at Norfolk Boreas (alone). Therefore, under these circumstances, **there would be no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

815. The number of harbour porpoise that could potentially be disturbed as a result of the proposed mitigation would be 43.54 individuals (0.013% of the NS MU reference population), based on the site specific density for Norfolk Boreas (1.06 harbour porpoise per km^2) as a worst-case scenario. The assessment indicates that 0.013% or less of the NS MU reference population could be temporarily affected as a result of the proposed mitigation for piling at Norfolk Boreas (alone). Therefore, **there would be no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

816. 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

817. The SNCBs (Natural England, 2017b) 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) SAC. This approach has been used in this assessment for:

- Single piling at the Norfolk Boreas site.

818. 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 Norfolk Boreas site (Table 8.17).

Table 8.17 Estimated area of Southern North Sea SAC that harbour porpoise could potentially be disturbed from during single pile installation at Norfolk Boreas

Single pile installation	Maximum potential overlap with Southern North Sea SAC	Average potential overlap with Southern North Sea SAC	Potential adverse effect on site integrity
Single pile installation in the Norfolk Boreas site	296.82km^2 in the winter SNS SAC area (approximately 2.3% of the winter SNS SAC area); Or 2,112.22km^2 in the summer SNS SAC area (approximately 7.8% of the summer SNS SAC area).	148.41km^2 in the winter SNS SAC area (minimum = 0km^2) (approximately 1.2% of the winter SNS SAC area); Or 1,249.4km^2 in the summer SNS SAC area (minimum = 386.65km^2) (approximately 4.6% of the summer SNS SAC area).	**No** Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC area at any one time during any single pile installation at Norfolk Boreas (alone), based on the worst-case scenario

819. Disturbance of harbour porpoise would not exceed 20% of the seasonal component of the Southern North Sea SAC area at any one time during single pile installation at Norfolk Boreas (alone), based on the worst-case scenario (Table 8.17). Therefore, under these circumstances, **there would be no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

820. Indicative installation programmes for the different phasing options (Table 8.6 and Table 8.7) include:

- Single phase – up to 18 months of foundation installation and 36 months for overall construction; or

- Two phase – up to 2 x 9 months of foundation installation and 39 months for overall construction.
- The maximum piling duration for Norfolk Boreas would be up to 1,295 hours and 40 minutes (equivalent of up to 54 days) based on the following (Table 8.8):
- Installation of the turbine foundations, based on the maximum piling duration would be up to 1,080 hours for 180 10MW turbines based on 6 hours of piling per foundation;
- 120 hours for 10 minute ADD activation per turbine pile (up to 720 piles),
- Resulting in approximately 1,200 hours of disturbance within the overall construction programme;
- Piling for the eight offshore platforms would be up to 87 hours; and
- Eight hours 40 minutes for 10 minute ADD activation per pile for the 52 platform piles.

821. Table 8.18 presents the worst cases for each of the single and two phase options per season, assuming the maximum number of possible days of piling (54 days) is 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.

822. 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, the foundation installation period could in reality be around 18 months.

823. The seasonal averages have been calculated by multiplying the maximum effect on any one day (as shown in Table 8.18Table 8.17) 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 SAC and number of days piling per season).

Table 8.18 Estimated worst-case scenarios for seasonal area averages for single and two phase options using pin-piles for 10MW turbines and offshore platforms (including ADD activation)

Phasing option	Duration based on worst-case scenario	Maximum area within SNS SAC seasonal area	Maximum seasonal area averages	Potential adverse effect on site integrity
Single Phase option	All 54 days in one season: • 29.5% of the summer period; or • 29.7% of the winter period.	• 7.8% of the summer SNS SAC area; or • 2.3% of the winter SNS SAC area.	• 2.3% of SNS SAC summer area for single piling; or • 0.7% of SNS SAC winter area for single piling.	**No** Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SAC area over the duration of that season.

Phasing option	Duration based on worst-case scenario	Maximum area within SNS SAC seasonal area	Maximum seasonal area averages	Potential adverse effect on site integrity
Two Phase option	Approximately up to 27 days for either season over two seasons: • 14.8% of the summer period; or • 14.8% of the winter period.	• 7.8% of the summer SNS SAC area; or • 2.3% of the winter SNS SAC area.	• 1.2% of SNS SAC summer area for single piling; or • 0.3% of SNS SAC winter area for single piling.	**No** Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SAC area over the duration of that season.

824. 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 555 hours (equivalent of 23.1 days in total) within the overall construction programme. In addition, piling for the seven offshore platforms (based on up to six hours for each installation; Table 8.8) would be up to 42 hours plus an estimated 1.2 hours for 10 minute ADD activation per pile, resulting in approximately 1.8 days of potential disturbance. Therefore, the estimated total duration would be a total of 25 days.

825. 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 8.19.

826. 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 18 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.

827. The two phase option would have lower seasonal averages than the single phase option, as shown for the pin-piles.

Table 8.19 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 area within Southern North Sea SAC seasonal area	Maximum seasonal area averages	Potential adverse effect on site integrity
Single Phase option	All 25 days were in one season: • 13.7% of the summer period; or • 13.7% of the winter period.	• 7.8% of the summer SNS SAC area; or • 2.3% of the winter SNS SAC area.	• 1.07% of SNS SAC summer area for single piling; or • 0.32% of SNS SAC winter area for single piling.	**No** Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SAC 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 8.18).			

828. 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.

829. 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.

830. 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.

831. The results indicate that for single piling at Norfolk Boreas (alone), based on the worst-case scenarios (Table 8.18 and Table 8.19) displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the seasonal Southern North Sea SAC area over the duration of that season. Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on**

the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise.

Assessment in relation to North Sea MU

832. The estimated number of harbour porpoise that could be disturbed during single pile installation at Norfolk Boreas is presented in Table 8.20.

Table 8.20 Estimated number of harbour porpoise potentially disturbed during piling based on 26km range from a single piling location at Norfolk Boreas

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). 2,251 harbour porpoise based on site specific survey density (1.06/km^2).	0.55% of NS MU based on SCANS-III density. 0.65% of NS MU based on site specific survey density.	**No** Temporary effect Less than 1% of the reference population could be temporarily displaced during any single pile installation at Norfolk Boreas (alone), based on the worst-case scenario.

[1]Based on density estimates and reference populations (see section 8.1.1).

833. 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 Boreas (alone), based on the worst-case scenario (Table 8.20). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Disturbance during concurrent piling

Spatial assessment

834. 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 the Norfolk Boreas site.

835. The spatial worst-case is the maximum area (4,174km^2) over which displacement could occur at any one time based on two concurrent foundations being installed at the Norfolk Boreas site, not taking into account the area that would be within the Southern North Sea SAC site boundaries. The maximum impact area is less than double the single impact area due to the overlap in potential impact areas.

836. Table 8.21 summarises the spatial assessment for the concurrent piling options in relation to the Southern North Sea SAC summer and winter areas. The maximum potential area of effect is based on the maximum possible overlap with the Southern North Sea SAC 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 SAC winter or summer areas.

Table 8.21 Spatial assessment for the concurrent piling options in relation to the Southern North Sea SAC summer and winter areas

Concurrent piling option	Maximum potential area of effect in summer Southern North Sea SAC area	Maximum potential area of effect in winter Southern North Sea SAC area	Average potential area of effect in summer Southern North Sea SAC area	Average potential area of effect in winter Southern North Sea SAC area
Two concurrent piling events in the Norfolk Boreas site	2,443.83km^2 (9.0%)	280.24km^2 (2.2%)	1,425.81km^2 (minimum 407.8km^2) (5.3%)	140.12km^2 (minimum 0km^2) (1.1%)

837. During concurrent piling at Norfolk Boreas (alone) and based on the worst-case scenarios (Table 8.21), the temporary displacement of harbour porpoise would not exceed 20% of the seasonal component of the Southern North Sea SAC 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 SAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

838. 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.

839. For two concurrent piling events using pin-piles for the single phase option the total piling duration would be up to 27 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 8.22.

840. 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 8.22.

841. The two phase option would have lower seasonal averages than the single phase option, as demonstrated for single piling.

Table 8.22 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 area within Southern North Sea SAC seasonal area	Maximum seasonal area averages	Potential adverse effect on site integrity
Single Phase option with two concurrent piling events for pin-piles	All 27 days were in one season: • 14.8% of the summer period; or • 14.8% of the winter period.	• 9% of the summer SNS SAC area; or • 2.2% of the winter SNS SAC area.	• 1.3% of SNS SAC summer area for two concurrent piling events; or • 0.3% of SNS SAC winter area for two concurrent piling events.	**No** Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SNS SAC area over the duration of that season.
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.	• 9% of the summer SNS SAC area; or • 2.2% of the winter SNS SAC area.	• 0.6% of SNS SAC summer area for two concurrent piling events; or • 0.2% of SNS SAC winter area for two concurrent piling events.	**No** Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SAC area over the duration of that season.
Two Phase option	The two phase option would have lower seasonal averages than the single phase option.			

842. The seasonal averages, based on the worst-case scenarios, indicate that for concurrent piling at Norfolk Boreas (alone), displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SAC area over the duration of that season (Table 8.22). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

<u>Assessment in relation to North Sea MU</u>

843. The estimated number of harbour porpoise that could be disturbed during concurrent pile installation at Norfolk Boreas is presented in Table 8.23 based on the maximum disturbance areas for the North Sea MU.

Table 8.23 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 the Norfolk Boreas site (4,147km^2)	3,682.5 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 4,396 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km^2).	1.1% NS MU based on SCANS-III density. 1.3% of NS MU based on the Norfolk Boreas site specific survey density.	**No** Temporary effect Less than 1.1% of the reference population could be temporarily displaced during concurrent piling at the Norfolk Boreas site, based on the worst-case scenario.

[1]Based on density estimates and reference populations (see section 8.1.1).

844. The assessment indicates that 1.3% or less of the North Sea MU reference population could be temporarily disturbed during concurrent piling at Norfolk Boreas (alone), based on the worst-case scenario (Table 8.23). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC 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 Boreas (alone)

845. Potential sources of underwater noise during other construction activities, include seabed preparation, rock dumping and cable installation.

846. The construction activity likely to have the greatest potential noise effects, other than piling, is cable installation (including rock dumping) and has therefore been assessed as a worst-case scenario (Table 8.8).

847. 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).

848. 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.

849. 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).

850. 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.

851. Results of the underwater noise modelling (Table 8.23) for other construction activities indicate that harbour porpoise would have to remain within close proximity (within 460m for rock dumping, within 150m for dredging and within 100m for all other activities including drilling, cable laying and trenching) for a period of 24 hours to be at risk of the onset of permanent auditory injury (PTS) as per the NMFS (2016) threshold criteria.

Table 8.24 Maximum predicted impact ranges and areas for auditory injury (PTS) for construction activities, other than piling at Norfolk Boreas

Potential Impact	Criteria and Threshold	Impact range km (and area km^2)*				
		Dredging	Drilling	Cable Laying	Rock Placement	Trenchin g
Permanent auditory injury (PTS) from cumulative exposure	NMFS (2016) 155dB SEL_{cum}	0.15km 0.07km^2	<0.1km 0.03km^2	<0.1km 0.03km^2	0.46km 0.66km^2	<0.1km 0.03km^2

* Area of a circle based on the impact range

Spatial assessment

852. The indicative maximum number of harbour porpoise that could potentially be at risk of PTS from cumulative SEL as a result of rock placement (the worst-case impact range from other construction activities as shown in Table 8.24) is 0.7 individuals (0.0002% of the North Sea MU reference population), based on the site specific density (1.06 harbour porpoise per km^2).

853. As a precautionary worst-case scenario, the assessment for the disturbance as a result of underwater noise during construction from activities other than piling has been assessed based on the entire offshore project area, and the number of harbour porpoise that could be present. 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 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.

854. The Norfolk Boreas site (725km^2) is approximately 2.7% of the summer SAC area; the project interconnector search areas (total of 227km^2) are mostly within the summer area, overlapping with 0.8% of the summer SAC area and 0.01% of the winter area. For the offshore cable corridor area (226km^2), approximately 56% is located in the summer SAC area (0.5% of the summer SAC area) and approximately 76% of the entire offshore cable corridor area is located in the winter SAC area (1.3% of the winter SAC area) (note that a large section on the cable corridor lies within the summer and winter overlap area, and that the overlap of the project interconnector search area and the cable corridor has not been included to remove any overlap in area assessments) (Figure 5.4).

855. Disturbance of harbour porpoise would not exceed 20% of the seasonal component of the Southern North Sea SAC at any one time during any construction activities, other than piling, at Norfolk Boreas (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 adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

856. The indicative duration of the cable installation (Table 8.6 and Table 8.7), is estimated to be:

- 21 months for single phase option; and
- 12 months per phase for two phase option.

857. The indicative total programme for construction of the full 1,800MW capacity is estimated to be up to three years.

858. 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.

859. 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 offshore project area (i.e. 100% disturbance) (Table 8.25).

Table 8.25 Estimated worst-case scenarios for seasonal area averages for construction activities, other than piling in Norfolk Boreas

Potential Effect Area	Duration based on worst-case scenario	Maximum seasonal area averages	Potential adverse effect on site integrity
Norfolk Boreas site (2.7% of the summer SAC area)	Throughout the summer period (183 days).	• 2.7% of the SNS SAC summer area	**No** Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SAC area over the duration of that season.
Project interconnector search area (0.8% of the summer SAC area)	Throughout the summer period (183 days).	• 0.8% of the SNS SAC summer area	
Project interconnector search area (0.01% of the winter SAC area)	Throughout the winter period (182 days).	• 0.01% of the SNS SAC winter area	
Offshore cable corridor area (0.5% of the summer SAC area)	Throughout the summer period (183 days).	• 0.5% of the SNS SAC summer area	
Offshore cable corridor area (1.3% of the winter SAC area)	Throughout the winter period (182 days).	• 1.3% of the SNS SAC winter area	
Two Phase option	The two phase option would have the same seasonal averages as the single phase option for each phase.		

860. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the Southern North Sea SAC over the duration of that season during any construction activities (with a total of 4% of the summer area potentially disturbed, and 1.31% of the winter area), other than piling at Norfolk Boreas (alone). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

<u>Assessment in relation to North Sea MU</u>

861. The estimated maximum number of harbour porpoise that could be disturbed during construction activities, other than piling at Norfolk Boreas (alone) is presented in Table 8.26. 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 Boreas (alone), based on the worst-case scenario. Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.26 Estimated number of harbour porpoise that could be present in the Norfolk Boreas offshore project area

Potential Effect Area	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
Norfolk Boreas site (725km²)	643.8 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 768.5 harbour porpoise based on site specific survey density (1.06/km²).	0.19% of NS MU based on SCANS-III density. 0.2% of NS MU based on site specific survey density.	**No** Temporary effect. Maximum of 0.2% of the reference population could be temporarily displaced during construction activities, other than piling, at the Norfolk Boreas site based on the worst-case scenario.
Offshore cable corridor (226km²)	200.7 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 239.6 harbour porpoise based on site specific survey density (1.06/km²).	0.06% of NS MU based on SCANS-III density. 0.07% of NS MU based on site specific survey density.	**No** Temporary effect. Maximum of 0.07%% of the reference population could be temporarily displaced during construction activities, other than piling, within the offshore cable corridor based on the worst-case scenario.
Project interconnector search area in NV East (106.4km²)	94.5 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 134.1 harbour porpoise based on site specific survey density (1.26/km²) at NV East.	0.03% of NS MU based on SCANS-III density. 0.04% of NS MU based on site specific survey density at NV East.	**No** Temporary effect. Maximum of 0.04% 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.
Project interconnector search area in NV West (120.6km²)	107.1 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 95.3 harbour porpoise based on site specific survey density (0.79/km²) at NV West.	0.03% of NS MU based on SCANS-III density. 0.03% of NS MU based on site specific survey density at NV East.	**No** Temporary effect. Maximum of 0.03% 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.

Potential Effect Area	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
Total offshore project area (1,178km^2)	1,046.1 harbour porpoise based on SCANS-III survey block O density. 1,237.5 harbour porpoise based on site specific survey densities for each area.	0.30% of NS MU based on SCANS-III density. 0.36% of NS MU based on site specific survey density.	**No** Temporary effect. Maximum of 0.36% of the reference population could be temporarily displaced during construction activities, other than 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 Boreas (alone)

862. 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.

863. 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.

864. Underwater noise generated by vessels would not be sufficient to cause PTS or other injury to marine mammals. The underwater noise modelling (Appendix 5.4 of Chapter 5 Project Description document reference 6.1.5.4) shows that potential for TTS is only likely if the animal remains in very close proximity to either a medium or large vessel (within 100m) for a prolonged period of time (of at least 24 hours), which is highly unlikely. Disturbance is therefore the only potential underwater noise effect associated with vessels.

865. 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 within a 5km^2 area).

866. A number of busy shipping lanes pass in close proximity to the Norfolk Boreas site, with a large number of vessels recorded using two Deep Water Routes (DWRs), one passing approximately 1.9km) to the west of the Norfolk Boreas site and the other passing approximately 6.3km at its closest point to the east of the Norfolk Boreas site.

867. Baseline surveys for shipping and navigation indicate that throughout the summer period of the marine traffic survey, there were on average 79, 106 and 24 unique vessels per day recorded within the Norfolk Boreas site study area, the offshore cable corridor study area and project interconnector search area, respectively. Throughout the winter period, there were on average 36, 84 and 15 unique vessels per day recorded within the Norfolk Boreas site study area, the offshore cable corridor study area and project interconnector search area, respectively. 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 out with the DWRs, including routes which intersected the Norfolk Boreas site. Fishing activity was also notable in the area. These baseline figures indicate relatively high level of shipping activity in and around Norfolk Boreas.

868. During construction there will be an increase in vessels within offshore project area associated with installation of the foundations, the wind turbines, array and export cables, despite the potential displacement of existing vessel traffic. Table 8.8 provides details of the worst-case scenario for vessels during construction.

869. 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 43% 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).

870. The maximum number of 57 vessels at any one time in the offshore project area (1,178km^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 (approximately 16 vessels per km^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.

Spatial assessment

871. 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 offshore project area could be disturbed. However, any disturbance is likely to be limited to the immediate vicinity around the vessel.

872. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the Southern North Sea SAC at any one time, based on the worst-case scenario of 100% disturbance from the offshore project area. Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

873. The indicative duration of the overall construction activity is estimated to be:

- 36 months for single phase option; and
- 39 months for two phase option.

874. The indicative total programme for construction of the full 1,800MW capacity is estimated to be four years.

875. 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 offshore project area (i.e. 100% disturbance from the Norfolk Boreas site, project interconnector search areas and offshore cable corridor) (Table 8.27).

Table 8.27 Estimated worst-case scenarios for seasonal area averages for construction activities, other than piling in Norfolk Boreas

Potential Effect Area	Duration based on worst-case scenario	Maximum seasonal area averages	Potential adverse effect on site integrity
Norfolk Boreas site (2.7% of the summer SAC area)	Throughout the summer period (183 days).	• 2.7% of the SNS SAC summer area	**No** Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of
Project interconnector search area (0.8% of the summer SAC area)	Throughout the summer period (183 days).	• 0.8% of the SNS SAC summer area	
Project interconnector search area (0.01% of the winter SAC area)	Throughout the winter period (182 days).	• 0.01% of the SNS SAC winter area	

<table>
<tr><th>Potential Effect Area</th><th>Duration based on worst-case scenario</th><th>Maximum seasonal area averages</th><th>Potential adverse effect on site integrity</th></tr>
<tr><td>Total offshore cable corridor area (0.5% of the summer SAC area)</td><td>Throughout the summer period (183 days).</td><td>• 0.5% of the SNS SAC summer area</td><td rowspan="3">the seasonal component of the SAC area over the duration of that season.</td></tr>
<tr><td>Total offshore cable corridor area (1.3% of the winter SAC area)</td><td>Throughout the winter period (182 days).</td><td>• 1.3% of the SNS SAC winter area</td></tr>
<tr><td>Two Phase option</td><td colspan="2">The two phase option would have the same seasonal averages as the single phase option for each phase.</td></tr>
</table>

876. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the Southern North Sea SAC over the duration of that season as a result of vessels on site during construction activities at Norfolk Boreas (alone). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

877. The indicative maximum number of harbour porpoise that could potentially be at risk of PTS from cumulative SEL as a result of vessel noise (based on the area of a circle using the impact range of 100m) is 0.03 individuals (0.00001% of the North Sea MU reference population), based on the site specific density (1.06 harbour porpoise per km^2).

878. The estimated number of harbour porpoise that could be disturbed as a result of construction vessels at Norfolk Boreas is presented in Table 8.26. The assessment indicates that 0.36% or less 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 Boreas (alone). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.1.5. Vessel interaction (collision risk) during construction at Norfolk Boreas (alone)

879. During the construction of Norfolk Boreas, there will be an increase in vessel traffic. Vessels will follow established shipping routes utilising the shipping lane to the west of Norfolk Boreas and routes to the relevant ports in order to minimise vessel traffic in the wider area.

880. For Norfolk Boreas, 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.

881. The construction port to be used for Norfolk Boreas is not yet known. Indicative daily vessel movements (return trips to a local port) during construction of Norfolk Boreas are estimated to be an average of two per day. The maximum number of vessels on site at any one time would be 57.

882. The baseline conditions indicate an already relatively high level of shipping activity in and around Norfolk Boreas. 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.

883. The additional vessel movements associated with the construction of Norfolk Boreas could have the potential to increase the collision risk with harbour porpoise.

884. 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.

885. 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.

886. Of the 273 reported harbour porpoise strandings in 2015 (latest UK Cetacean Strandings Investigation Programme Report currently available), 53 were investigated at post mortem. A cause of death was established in 51 examined individuals (approximately 96%). 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).

887. 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 offshore

project area and the number that could potentially be at increased collision risk based on 90-95% avoidance rates (Table 8.28).

888. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the Norfolk Boreas 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. In addition, it should be noted that the total area of offshore construction works would be less than as assessed below, as either the interconnector cables or the project interconnector cables (and therefore project areas), would be constructed, dependant on whether Norfolk Vanguard is built. Under no circumstance would construction take place for both the interconnector cable and the project interconnector cable.

889. The estimated number of harbour porpoise that could be at increased risk of collision with vessels during construction is presented in Table 8.28. The assessment indicates that 0.04% or less of the North Sea MU reference population could be at increased collision 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.

890. 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.

891. In addition, based on the assumption that harbour porpoise would be disturbed from a 26km radius during piling and disturbed from the offshore project area 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 Boreas during the construction period.

892. Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise.**

Table 8.28 Estimated number of harbour porpoise that could be present in the entire offshore project area (Norfolk Boreas site, project interconnector search areas and offshore cable corridor; Table 8.26) at 5-10% potential increased collision risk

Potential Effect Area	Estimated number at potential collision risk based on 5-10% increased risk	% of reference population[1]	Potential adverse effect on site integrity
Total offshore project area (1,178km^2)	52-105 harbour porpoise based on SCANS-III survey block O density. 62-125 harbour porpoise based on site specific survey densities.	0.015-0.03% of NS MU based on SCANS-III density. 0.02-0.04% of NS MU based on site specific survey densities.	**No** Maximum of 0.04% 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 including habitat loss during construction at Norfolk Boreas (alone)

893. 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 reference 6.1).

894. 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 5.4 of Chapter 5 Project Description document reference 6.1.5.4) indicates that fish species in which the swim bladder is both involved and not involved in hearing are the most sensitive to piling noise with ranges of up to 0.17km for mortality and potential mortal injury (for a monopile with full hammer energy of 5,000kJ) and up to 6.5km for recoverable injury, based on maximum potential ranges for cumulative exposure (SEL_{cum} for monopile with full hammer energy).

895. Additional underwater noise modelling was undertaken to assess the effects using a stationary animal approach on cumulative exposure. This is considered to be a highly precautionary approach, as it is unlikely that an individual would remain within the vicinity of the high noise levels of piling activity. For stationary fish species, exposed to piling noise over 12 hours, a maximum impact range of 18km was determined for the onset of TTS in all fish species.

896. 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.

897. 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 15.4km^2 in total for the wind farm site (this would account for a very small proportion (2.1%) of the area of the wind farm site); 6.07km^2 for the offshore cable corridor; and 1.84km^2 in the project interconnector search area. The total area of potential habitat loss during construction is estimated to be up to 23.31km^2. 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).

898. Similarly, the magnitude of impact on prey from any increased suspended sediment concentrations and sediment re-deposition would be low (maximum volume of increased suspended sediments and sediment re-deposition is 0.054km^3), 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).

899. 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 offshore project area (Table 8.26). However, it is highly unlikely that any changes in prey resources could occur over the entire offshore project area during construction. It is more likely that effects would be restricted to an area around the working sites. It should be noted that the total area of offshore construction works would be less than as assessed below, as either the interconnector cables or the project interconnector cables (and therefore project areas), would be constructed, dependant on whether Norfolk Vanguard is built. Under no circumstance would construction take place for both the interconnector cable and the project interconnector cable.

Spatial assessment

900. As a precautionary approach, changes in prey resource across the whole area of the offshore project area, would be approximately 4% and 1.31% for the summer or winter areas of the SAC, respectively.

901. Any changes to prey availability at Norfolk Boreas (alone) resulting in the displacement of all harbour porpoise from the offshore project area would not exceed 20% of the seasonal component of the Southern North Sea SAC 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 SAC in relation to the conservation objectives for harbour porpoise.

Seasonal averages

902. 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 offshore project area (Table 8.25).

903. 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 SAC over the duration of that season during construction at Norfolk Boreas (alone). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

904. The estimated maximum number of harbour porpoise that could potentially be affected by any potential changes to prey availability during construction at Norfolk Boreas (alone) is less than 0.36% of the NS MU reference population, based on the worst-case scenario (Table 8.26). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.1.7. Changes to water quality during construction at Norfolk Boreas (alone)

905. 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 ES Chapter 9 Marine Water and Sediment Quality (document 6.1), Norfolk Boreas 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. An outline Project Environmental Management Plan (PEMP) will be 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.

906. 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 2017 indicates that levels of contaminants within the offshore project area 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 Cefas Action Level 1. 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).

907. There is the potential for increased suspended sediments as a result of construction activities, such as installation of foundations, 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 seconds / minutes) to the seabed as a highly turbid dynamic plume immediately upon its discharge (within tens of metres along the axis of tidal flow).

908. 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 Boreas. 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.

909. 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 offshore project area (Table 8.26). This is very precautionary, as it is highly unlikely that any changes in water quality could occur over the offshore project area during construction. It is more likely that effects would be restricted to an area around the working sites.

<u>Spatial assessment</u>

910. As a precautionary approach, changes in water quality across the offshore project area, would be approximately 4% and 1.3% for the summer or winter areas of the SAC, respectively (see Table 8.26).

911. Any changes to water quality at Norfolk Boreas (alone) that could result in the displacement of all harbour porpoise from the offshore project area would not exceed 20% of the seasonal component of the Southern North Sea SAC 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 SAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

912. 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 offshore project area (Table 8.25).

913. Displacement of harbour porpoise as a result of any changes in water quality would not on average exceed 10% of the seasonal component of the Southern North Sea SAC over the duration of that season during construction at Norfolk Boreas (alone). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

914. The estimated maximum number of harbour porpoise that could potentially be affected by any potential changes to water quality during construction at Norfolk Boreas (alone) is less than 0.36% of the NS MU reference population, based on the worst-case scenario (Table 8.26). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.1.8. Potential overall effects during construction of Norfolk Boreas (alone)

Potential overall effects during UXO clearance at Norfolk Boreas (alone)

915. Only one UXO would be detonated at a time during UXO clearance operations at Norfolk Boreas; there would be no concurrent UXO detonations.

916. 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.

Spatial Assessment

917. The maximum potential area of disturbance is 4,248km^2, based on 26km disturbance range around each piling location and UXO location, and assuming no overlap in the potential impact areas and the impact area is wholly within the Southern North Sea SAC.

918. Table 8.29 includes the potential maximum, minimum and average overlap with the summer and winter seasonal areas of the Southern North Sea SAC, taking into account the overlap with the impact areas for the UXO detonation (in any location within the offshore project area) and piling activity (within the Norfolk Boreas site). The assessment shows that if a UXO clearance and piling activity were to be undertaken concurrently, at any location, then the maximum impact ranges for the concurrent activities would not exceed the seasonal threshold in either summer or winter. Therefore, if any UXO clearance in the offshore project area was undertaken in either the summer or winter, during piling within the Norfolk Boreas site, there would be **no for an adverse effect of the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.29 Estimated area of Southern North Sea SAC winter and summer areas that harbour porpoise could be disturbed from during concurrent UXO clearance and piling at Norfolk Boreas

UXO clearance	Maximum potential overlap with Southern North Sea SAC	Average potential overlap with Southern North Sea SAC	Potential adverse effect on site integrity
UXO detonation is located in the Norfolk Boreas site	296.82km^2 in the winter SNS SAC area (approximately 2.3% of the winter SNS SAC area); Or 2,112.22km^2 in the summer SNS SAC area (approximately 7.8% of the summer SNS SAC area).	148.41km^2 in the winter SNS SAC area (minimum = 0km^2) (approximately 1.2% of the winter SNS SAC area); Or 1,249.4km^2 in the summer SNS SAC area (minimum = 386.65km^2) (approximately 4.6% of the summer SNS SAC area).	**No** Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC area at any one time during any UXO clearance at Norfolk Boreas (alone), based on the worst-case scenario.
UXO detonation is located in project interconnector search area in NV East	601.06km^2 in the winter SNS SAC area (approximately 4.4% of the winter SNS SAC area); Or 2,124km^2 in the summer SNS SAC area (approximately 7.9% of the summer SNS SAC area).	322.58km^2 in the winter SNS SAC area (minimum = 44.09km^2) (approximately 2.5% of the winter SNS SAC area); Or 1,912.6km^2 in the summer SNS SAC area (minimum = 1,701.29km^2) (approximately 7.1% of the summer SNS SAC area).	
UXO detonation is located in project interconnector search area in NV West	1,087.56km^2 in the winter SNS SAC area (approximately 8.6% of the winter SNS SAC area); Or 2,124km^2 in the summer SNS SAC area (approximately 7.9% of the summer SNS SAC area).	725.41km^2 in the winter SNS SAC area (minimum = 363.25km^2) (approximately 5.7% of the winter SNS SAC area); Or 2,055.74km^2 in the summer SNS SAC area (minimum = 1,987.47km^2) (approximately 7.6% of the summer SNS SAC area).	

UXO clearance	Maximum potential overlap with Southern North Sea SAC	Average potential overlap with Southern North Sea SAC	Potential adverse effect on site integrity
UXO detonation in the cable corridor	2,001.38km^2 in the winter SNS SAC area (approximately 15.8% of the winter SNS SAC area). Or 2,124km^2 in the summer SNS SAC area (approximately 7.9% of the summer SNS SAC area).	1,000.7km^2 in the winter SNS SAC area (minimum = 0km^2) (approximately 7.9% of the winter SNS SAC area); Or 2,055.74km^2 in the summer SNS SAC area (minimum = 1,987.47km^2) (approximately 7.6% of the summer SNS SAC area).	

Seasonal averages

919. The assessment (as shown in Table 8.30) indicates that less than 10% of either the summer or winter seasonal component of the Southern North Sea SAC would be impacted during any UXO clearance and piling operation that occurs concurrently within the Norfolk Boreas offshore project area, based on the worst-case scenario of 54 days of piling, or 80 days of UXO clearance within each season, and the maximum spatial overlap with the Southern North Sea SAC. Therefore, under these circumstances, there would be **no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise.**

Table 8.30 Estimated seasonal averages for UXO clearance and piling at Norfolk Boreas

Potential Effect Area	Duration based on worst-case scenario	Maximum seasonal area averages	Potential adverse effect on site integrity
UXO detonation in offshore project area and piling at Norfolk Boreas site.	54 days of piling per season (see Table 8.18); • 29.0% of the summer season; or 29.1% of the winter season.	• Winter area (based on 15.8% maximum overlap of UXO in the cable corridor) = 5% • Summer area (based on 7.9% overlap of UXO in the project interconnector search areas or cable corridor) = 2.3%	**No** Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SAC area over the duration of that season.
	80 days of UXO clearance per season (see Table 8.13); • 43.7% of the summer season; or 44.0% of the winter season.	• Winter area (based on 15.8% maximum overlap of UXO in the cable corridor) = 6.9% • Summer area (based on 7.9%	

Potential Effect Area	Duration based on worst-case scenario	Maximum seasonal area averages	Potential adverse effect on site integrity
		overlap of UXO in the project interconnector search areas or cable corridor) = 3.5%	
Two Phase option	The two phase option would have the same seasonal averages as the single phase option for each phase.		

Assessment in relation to the North Sea Management Unit

920. The estimated maximum number of harbour porpoise that could be disturbed during any UXO clearance in the offshore project area at the same time as piling in the Norfolk Boreas site is presented in Table 8.31. The assessment indicates that less than 1.3% of the North Sea MU reference population could be temporarily disturbed from the total offshore project area for Norfolk Boreas (alone), based on the worst-case scenario. Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.31 Estimated number of harbour porpoise that could be disturbed during concurrent UXO clearance and piling at Norfolk Boreas

Potential Effect Area	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
Area of disturbance ($4,248km^2$) during concurrent underwater UXO clearance and piling (based on the 26km disturbance range for each event)	3,772.2 harbour porpoise based on SCANS-III survey block O density ($0.888/km^2$). 4,502.9 harbour porpoise based on site specific survey density ($1.06/km^2$).	1.1% of NS MU based on SCANS-III density. 1.3% of NS MU based on site specific survey density.	**No** Temporary effect. Maximum of 1.3% of the reference population could be temporarily displaced during construction activities, other than piling, at the Norfolk Boreas site based on the worst-case scenario.

[1]Based on density estimates and reference populations (see section 8.1.1).

Potential overall effects during piling at Norfolk Boreas (alone)

921. As a worst-case scenario, it is assumed the piling is undertaken at one location and construction activities are underway at another location with no overlap in the areas of potential disturbance.

Spatial assessment

922. 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 SAC at any one time during any construction activities, other than piling, at Norfolk Boreas (alone), based on the worst-case scenario (Table 8.32). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.32 Estimated area of Southern North Sea SAC that harbour porpoise could potentially be disturbed from during single pile installation and other construction actives, including vessels, at Norfolk Boreas

Potential effect	Maximum potential overlap with Southern North Sea SAC	Minimum potential overlap with Southern North Sea SAC	Average potential overlap with Southern North Sea SAC	Potential adverse effect on site integrity
Piling at Norfolk Boreas site and other construction activities and vessels in the cable corridor and project interconnector search areas	726.99km^2 (approximately 5.7%) in the winter area (with up to 296.82km^2 from piling and 430.17km^2 of cable corridor and project interconnector search area) 2,271.35km^2 (approximately 8.4%) in the summer area (with up to 2,112.22km^2 from piling and 159.13km^2 of cable corridor and project interconnector search area)	445.22km^2 (approximately 3.5%) in the winter area (with up to 0km^2 from piling and 445.22km^2 of cable corridor and project interconnector search areas) 831.87km^2 (approximately 3.1%) in the summer area (with up to 386.65km^2 from piling and 445.22km^2 of cable corridor and project interconnector search areas)	586.11km^2 (approximately 4.6%) in the winter area (with up to 148.41km^2 from piling and 437.70km^2 of cable corridor and project interconnector search area) 1,551.61km^2 (approximately 5.7%) in the summer area (with up to 1,254.44km^2 from piling and 302.18km^2 of cable corridor and project interconnector search area)	**No** Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC area during pile installation in-combination with other construction activities and vessels at Norfolk Boreas (alone), based on the worst-case scenario.

Seasonal averages

923. 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 8.32) and worst-case scenario for single phased option using pin-piles for 10MW turbines and offshore platforms (see section 8.3.1.1.2).

924. 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 SAC area over the duration of that season at Norfolk Boreas (alone), based on the worst-case scenario (Table 8.33). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.33 Estimated worst-case scenarios for seasonal averages for single phase options using pin-piles for 10MW turbines and offshore platforms (including ADD activation) in-combination with other construction activities and vessels at Norfolk Boreas

Potential Effect Area	Duration based on worst-case scenario	Maximum seasonal area averages	Potential adverse effect on site integrity
Piling at Norfolk Boreas site and other construction activities and vessels in the cable corridor and project interconnector search areas	54 days of piling per season (see Table 8.18).); • 29.0% of the summer season; or • 29.1% of the winter season.	• Winter area (based on 5.7% maximum overlap of piling and other construction activities) = 1.7% • Summer area (based on 8.4% overlap of piling and other construction activities) = 2.5%	**No** Temporary effect. Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SAC area over the duration of that season.
	• Throughout the summer period (183 days); or • Throughout the winter period (182 days).	• Winter area (based on 5.7% maximum overlap of piling and other construction activities) = 5.7% • Summer area (based on 8.4% overlap of piling and other construction activities) = 8.4%	

Assessment in relation to North Sea MU

925. The estimated number of harbour porpoise that could be disturbed during single pile installation at Norfolk Boreas 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 8.34.

926. 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 Boreas (alone), based on the worst-case scenario (Table 8.34). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.34 Estimated number of harbour porpoise potentially disturbed during piling in-combination with other construction activities and vessels at Norfolk Boreas

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 the Norfolk Boreas site, plus disturbance within	2,281.3 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). Or	0.7% of NS MU based on SCANS-III density. Or 0.8% of NS MU based on site specific survey density.	**No** Temporary effect Less than 1% of the reference population could be temporarily displaced during any

Potential Effect	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
the cable corridor ($226km^2$) and project interconnector search areas ($219km^2$) (**$2,569km^2$**)	2,723.1 harbour porpoise based site specific survey density of $1.06/km^2$).		single pile installation in-combination with construction and vessels at Norfolk Boreas (alone), based on the worst-case scenario.

[1]Based on density estimates and reference populations (see section 8.1.1).

Potential overall effects during construction at Norfolk Boreas (alone)

927. There would be no further overall effects during construction other than those assessed above, as the potential disturbance from underwater noise during construction has been based on the entire offshore project 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 adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.2. Potential effects during operation and maintenance at Norfolk Boreas (alone)

8.3.1.2.1. Disturbance from the underwater noise associated with operational turbines at Norfolk Boreas (alone)

928. 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).

929. The MMO (2014) of data 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 estimated to be small, with behavioural response only likely at ranges close to the wind turbine. It is however noted that the measured data were mainly for smaller capacity wind turbines.

930. 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.

931. 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).

Spatial assessment

932. The Norfolk Boreas site is approximately 2.7% of the summer SAC area. Therefore, as a precautionary approach, disturbance from the entire area of the wind farm as a result of operational turbines would be approximately 2.7% of the summer area of the SAC.

933. Any disturbance of harbour porpoise as a result of underwater noise from operational turbines at Norfolk Boreas (alone) would not exceed 20% of the seasonal component of the SAC 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 SAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

934. The potential disturbance of harbour porpoise as a result of underwater noise from operational turbines at Norfolk Boreas (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 that, as a worst-case scenario, all harbour porpoise could be disturbed from the entire wind farm area (Table 8.35).

Table 8.35 Estimated worst-case scenarios for seasonal averages for potential disturbance from operational turbines at Norfolk Boreas

Potential Effect Area	Duration based on worst-case scenario	Maximum seasonal averages	Potential adverse effect on site integrity
Norfolk Boreas site (approximately 2.7% of the summer SAC area)	Throughout the summer period (183 days).	• 2.7% of the SNS SAC summer area	**No** Displacement of harbour porpoise would not on average exceed 10% of the seasonal component of the SAC area over the duration of that season.

935. Disturbance of harbour porpoise as a result of underwater noise from operational turbines at Norfolk Boreas (alone) would not on average exceed 10% of the seasonal

component of the Southern North Sea SAC, based on the worst-case scenario (Table 8.35). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

936. The estimated maximum number of harbour porpoise that could potentially be disturbed as a result of underwater noise from operational turbines at Norfolk Boreas (alone) is 0.2% or less of the NS MU reference population, based on the worst-case scenario (Table 8.36). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.36 Estimated number of harbour porpoise that could be present in the Norfolk Boreas offshore wind farm areas during operation

Potential Effect Area	Estimated number in area[1]	% of reference population[1]	Potential adverse effect on site integrity
Norfolk Boreas site (725km²)	643.8 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 768.5 harbour porpoise based on site specific survey density (1.06/km²).	0.2% of NS MU based on SCANS-III density. 0.2% of NS MU based on site specific survey density.	**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 at Norfolk Boreas (alone)

937. 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.

938. 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.

939. 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 offshore project 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

940. Using a worst-case scenario approach, potential effects would be approximately 4% and 1.31% for the winter or summer areas of the SAC respectively.

941. Disturbance of harbour porpoise as a result of underwater noise during maintenance activities at Norfolk Boreas (alone) would not exceed 20% of the seasonal component of the Southern North Sea SAC at any one time, based on the worst-case scenario. Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

942. 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 Boreas (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 offshore project area (Table 8.25).

943. Disturbance of harbour porpoise as a result of underwater noise during maintenance activities at Norfolk Boreas (alone) would not on average exceed 10% of the seasonal component of the Southern North Sea SAC over the duration of that season during any maintenance activities at Norfolk Boreas (alone). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

944. The estimated maximum number of harbour porpoise that could potentially be disturbed during maintenance activities at Norfolk Boreas (alone) is 0.36% of the NS MU reference population, based on the worst-case scenario (Table 8.26). Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.2.3. Disturbance from maintenance vessels at Norfolk Boreas (alone)

945. 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 445 support vessel round trips per year, with an average of 1-2 vessel movements per day, during operation and maintenance.

946. 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.

947. Taking into account the existing vessel movements in around the Norfolk Boreas area (see section 8.3.1.1.3) and the potential 1-2 vessel movements per day during operation and maintenance across the whole Norfolk Boreas offshore project area (1,178km^2), the number of vessels would not exceed the Heinänen and Skov (2015) threshold level of approximately 80 vessels per day (within 5km^2). 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 Boreas.

Spatial assessment

948. Using the worst-case scenario, of the disturbance of all harbour porpoise over the entire area of the offshore project area, as outlined above, potential effects would be approximately 4% and 1.31% for the summer or winter areas of the Southern North Sea SAC, respectively.

949. Disturbance of harbour porpoise as a result of underwater noise from maintenance vessels at Norfolk Boreas (alone), based on the worst-case scenario, would not exceed 20% of the seasonal component of the Southern North Sea SAC 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 SAC in relation to the conservation objectives for harbour porpoise**.

Seasonal averages

950. For the worst-case scenario, it is assumed that disturbance of harbour porpoise as a result of maintenance vessels at Norfolk Boreas (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 offshore project area (Table 8.25).

951. Disturbance of harbour porpoise as a result of maintenance vessels at Norfolk Boreas (alone) would not on average exceed 10% of the seasonal component of the Southern North Sea SAC over the duration of that season during any operation and maintenance at Norfolk Boreas (alone). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

952. The estimated maximum number of harbour porpoise that could potentially be disturbed as a result of maintenance vessels at Norfolk Boreas (alone) is 0.36% of the NS MU reference population, based on the worst-case scenario (Table 8.26). Therefore, under these circumstances**, there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.2.4. Vessel interaction (collision risk) at Norfolk Boreas (alone)

953. The operation and maintenance ports to be used for Norfolk Boreas 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 445 vessel movements per year, with an average of approximately 1-2 vessel movements per day.

954. Current shipping activity in and around Norfolk Boreas 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 Boreas site (up to approximately 445 round trips per year) during operation and maintenance is relatively small compared to existing vessel traffic.

955. 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 offshore project area, the number of animals that could be present in these areas and assuming that 5-10% of individuals will be at increased risk of collision (Table 8.28).

956. This is very precautionary, as it is highly unlikely that all marine mammals present in the Norfolk Boreas offshore project 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.

957. The estimated number of harbour porpoise that could be at increased risk of collision with vessels during maintenance is 0.04% or less of the NS MU reference population, based on the worst-case scenario.

958. Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise.**

959. 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.

960. In addition, based on the assumption that harbour porpoise would be disturbed from the offshore project area 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 Boreas during the operation and maintenance period.

8.3.1.2.5. Changes to prey resource at Norfolk Boreas (alone)

961. 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 ES Chapter 11 Fish and Shellfish Ecology (document reference 6.1.11).

962. The introduction of hard substrate, such as turbines, foundations and associated scour protection as well as cable protection, associated with Norfolk Boreas 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 8.8).

963. 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.

964. 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 offshore project area, 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.

965. 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 8.8). The worst-case scenario foot print for the infrastructure within the Norfolk Boreas site (11.54km^2) is located entirely in the summer SAC area (Figure 5.4), the potential effects would be approximately 0.04% of the summer SAC area.

966. The area of seabed loss for the export cables and project interconnector search areas would also be very small, being limited to areas where cable protection measures may be required, particularly those associated with cable crossings, up to 0.216km^2 along the entire export cable route (Table 8.8). The export cable route is located within both the summer and winter SAC areas (Figure 5.4). If, as a worst-case scenario, the loss of seabed along the cable route and within the project interconnector search areas were all within either the summer SAC area or all within the winter SAC area, the potential effects would be approximately 0.0008% of the summer area or 0.002% of the winter area, respectively.

<u>Spatial assessment</u>

967. As a worse-case scenario, the changes to prey resources during operation and maintenance have also been assessed based on the entire offshore project area. This is very precautionary, as outlined above it is highly unlikely that any changes in prey resources could occur over the offshore project area. It is more likely that effects would be restricted to an area of any habitat loss, which is a small percentage of the offshore project area.

968. Using the approach for construction, potential effects could be up to 4% and 1.31% for the summer or winter areas of the SAC, respectively.

969. Any changes to prey availability resulting in the displacement of all harbour porpoise from the offshore project area would not exceed 20% of the seasonal component of the Southern North Sea SAC 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 SAC in relation to the conservation objectives for harbour porpoise**.

<u>Seasonal averages</u>

970. 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 offshore project area (Table 8.25).

971. Displacement of all harbour porpoise as a result of any changes in prey availability from the entire offshore project area would not on average exceed 10% of the

seasonal component of the Southern North Sea SAC over the duration of that season during operation and maintenance at Norfolk Boreas (alone). Therefore, under these circumstances, **there is no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Assessment in relation to North Sea MU

972. The estimated maximum number of harbour porpoise that could potentially be affected by any potential changes to prey availability at Norfolk Boreas (alone) during operation and maintenance is 0.36% of the NS MU reference population, based on the worst-case scenario (Table 8.26). Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.2.6. Potential overall effects during operation and maintenance at Norfolk Boreas (alone)

973. There would be no further overall 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 offshore project area. Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3. Potential effects during decommissioning of Norfolk Boreas (alone)

974. 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 at Norfolk Boreas (alone)

975. 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 and the project interconnector 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.

976. 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).

977. 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.

978. 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 adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3.2. Disturbance from vessels at Norfolk Boreas (alone)

979. For this assessment, it is assumed that the potential effects would be no greater than during construction. Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3.3. Vessel interaction (collision risk) at Norfolk Boreas (alone)

980. For this assessment, it is assumed that the potential effects would be no greater than during construction. Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3.4. Changes to prey resource at Norfolk Boreas (alone)

981. For this assessment, it is assumed that the potential effects would be no greater than during construction. Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3.5. Changes to water quality at Norfolk Boreas (alone)

982. For this assessment, it is assumed that the potential effects would be no greater than during construction. Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.3.6. Potential overall effects during decommissioning at Norfolk Boreas (alone)

983. There would be no further overall 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 offshore project area. Therefore, under these circumstances, **there is no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

8.3.1.4. Summary of Potential Effects of Norfolk Boreas (alone)

984. Table 8.37 summarises the potential effects of Norfolk Boreas alone.

Table 8.37 Summary of the potential effects of Norfolk Boreas alone

Potential Effect	Assessment in relation to the North Sea MU population	Spatial assessment and seasonal averages in relation to the SAC summer and winter areas	Potential adverse effect on site integrity
During Construction at Norfolk Boreas (alone)			
Permanent auditory injury associated with clearance of UXO	Without mitigation, up to 0.13% 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 implementation 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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Permanent auditory injury associated during piling	Without mitigation, 0.00001% 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 implementation 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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Disturbance from underwater noise during concurrent piling	1.1% 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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Disturbance from underwater noise during construction	0.36% or less of the NS MU reference population could be	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC	**No**

Potential Effect	Assessment in relation to the North Sea MU population	Spatial assessment and seasonal averages in relation to the SAC summer and winter areas	Potential adverse effect on site integrity
activities, other than piling	temporarily disturbed.	area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	
Disturbance from vessels	0.36% 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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Vessel interaction (collision risk)	0.04% or less of the NS MU reference population could be at increased risk	N/A	**No**
Changes to prey resource	0.36% or less of the NS MU reference population could be temporarily displaced.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Changes to water quality	0.36% or less of the NS MU reference population could be temporarily displaced.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Overall effects during UXO clearance (alone)	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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Overall effects during piling (alone)	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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC 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 SAC summer and winter areas	Potential adverse effect on site integrity
Overall effects during construction, other than piling (alone)	0.36% 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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
During Operation and Maintenance at Norfolk Boreas (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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Disturbance from the underwater noise associated with maintenance activities	0.36% 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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Disturbance from vessels	0.36% 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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Vessel interaction (collision risk)	0.04% or less of the NS MU reference population could be at increased risk.	N/A	**No**
Changes to prey resource	0.36% or less of the NS MU reference population could be displaced.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Overall effects during operation and maintenance	0.36% 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 SAC area at any one time or on average exceed 10% of the seasonal	**No**

Potential Effect	Assessment in relation to the North Sea MU population	Spatial assessment and seasonal averages in relation to the SAC summer and winter areas	Potential adverse effect on site integrity
		component of the SAC area over the duration of that season.	
During Decommissioning at Norfolk Boreas (alone)			
Disturbance from the noise associated with foundation removal	0.36% 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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Disturbance from underwater noise and disturbance from vessels	0.36% 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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Vessel interaction (collision risk)	0.04% or less of the NS MU reference population could be at increased risk.	N/A	**No**
Changes to prey resource	0.36% or less of the NS MU reference population could be temporarily displaced.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Changes to water quality	0.36% or less of the NS MU reference population could be temporarily displaced.	Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**
Overall effects during operation and maintenance	0.36% 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 SAC area at any one time or on average exceed 10% of the seasonal component of the SAC area over the duration of that season.	**No**

8.3.1.5. In-combination effects

8.3.1.5.1. Plans and projects considered

985. 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 Boreas project.

986. 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).

987. 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.

988. This approach and definitions of the Tiers used (as outlined in Table 8.38) was agreed at the Evidence Plan Process (EPP) meeting in February 2017. These Tiers are based on guidance issued by JNCC and Natural England in September 2013 on 'Suggested Tiers for Cumulative Impact Assessment'.

989. 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 Boreas construction.

Table 8.38 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 Description	Consenting or Construction Phase	Data Availability
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.

Commercial fisheries

990. Commercial fisheries within the North Sea and underwater noise associated with vessels from industries other than offshore wind farms, have the potential to cause a cumulative impact on marine mammals, including harbour porpoise, alongside the construction of the Norfolk Boreas project, through both the direct impact of by-catch and the indirect impact through the loss of marine mammal prey species (from commercial fisheries) and the disturbance from underwater noise (from vessel presence).

991. By-catch by commercial fisheries is recognised as a historic and continuing cause of harbour porpoise mortality in the Southern North Sea and will therefore be a factor in shaping the size of the current North Sea (NS) Management Unit (MU) population. The available prey resource for harbour porpoise has also been influenced by historic and continuing commercial fishing. Noise from vessels associated with other (than offshore wind farm industries) plans or projects such as oil and gas, aggregates and commercial fisheries, are also considered to be part of the baseline conditions.

992. This approach is in accordance with the Planning Inspectorate Advice Note 17 Cumulative Effects Assessment, which states that:

"*Where other projects are expected to be completed before construction of the proposed NSIP and the effects of those projects are fully determined, effects arising from them should be considered as part of the baseline*".

993. The potential for cumulative impacts associated with commercial fisheries has been considered in the recent draft HRA for the Review of Consents (RoC) (which was consulted upon in November 2018; BEIS, 2018). With regard to effects to habitats, the draft RoC HRA states that:

“*19.152 There have been no quantified assessments undertaken on the extent impacts from commercial fishing may have within the SAC and therefore information to inform this assessment is not available.*

19.154 Without knowing the extent of impact on the seabed arising from the fishing industry and aggregate extraction it is not possible to undertake an in-combination assessment that addresses all the potential impacts on the habitats within the SAC.”

994. The conservation status of harbour porpoise has not declined in the years that commercial fishing has been undertaken in the North Sea and remains at a favourable level within North Sea and in UK waters as a whole; therefore, the historical and current levels of commercial fishing in the North Sea is not considered to have affected the conservation status of the species (BEIS, 2018).

995. With regard to direct effects on harbour porpoise, the draft RoC HRA (BEIS, 2018) also states that:

“*19.213 Commercial fishing has occurred within the SAC for many years and has had, and will continue to have, direct and indirect impacts on harbour porpoise, their habitat and prey within the SAC. As the conservation status of harbour porpoise in UK waters and the SAC is considered favourable (JNCC 2016, 2017a) current and historical levels of fishing in the SAC are not considered to have affected the conservation status of the species.*

19.214 There are no known plans to suggest that the level of fishing within the SAC will significantly increase over the period the consented wind farms are planned to be constructed, such that, it is predicted that the current level of impacts from fishing on harbour porpoise within the SAC will not increase.”

996. It is also noted that Natural England’s Deadline 4 Response to the Further Examiners’ Questions and Requests for information for Hornsea Project 3 (15th January 2019) (page 46, Q 2.2.73) was that:

“*Where there is ongoing fishing activity in the site it, is important that the impacts of the activity are captured within the assessment in the context of the conservation objectives of the affected designated site(s). This assessment will likely take place as part of the baseline characterisation of the development area, however, as fishing activity is mobile, variable and subject to change, there may be instances whereby fishing impacts are not adequately captured in the baseline characterisation and therefore may need to be considered as part of the in-combination assessment. This could be due to a change in effort; change in management; or a change in legislation amongst other things, and fishery managers (i.e. MMO and IFCAs) would be best placed to advise on this.*

In relation to the assessment of impacts on the SNS SAC, Natural England……. are not currently aware of anything that would have significantly altered the levels of fishing activity within the site; any current plans for new fisheries, or changes to existing fisheries that have not been captured, but we would look to fisheries managers to advise more definitively on these points."

997. This, along with the draft RoC, suggests that by-catch has not affected a population considered to be in Favourable Conservation Status (FCS), whilst Natural England acknowledge that there is no known change to the fishing activity which would alter this position.

998. Therefore, the potential impacts from commercial fishing (including by-catch and loss of prey species) and from the underwater noise associated with other, non-offshore wind farm industries (including oil and gas, aggregates and commercial fisheries) are considered to be a part of the environmental baseline for marine mammals of the North Sea, including for harbour porpoise, and are not considered further in the assessment for Norfolk Boreas.

8.3.1.5.2. Effects considered

999. The types of effect considered in the in-combination assessment have been agreed as part of the EPP with the marine mammal Expert Topic Group (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 Boreas 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 Southern North Sea SAC or within 26km of the Southern North Sea SAC boundary.

1000. 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.

1001. Therefore, the assessment will be based on the most realistic 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.

1002. 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 Boreas Limited is supportive of these strategic initiatives, and will continue to work alongside other developers, Regulators and SNCBs in order to further understand the potential for significant in-combination effects, and how to reduce these effects, where appropriate.

1003. 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.

8.3.1.5.3. Disturbance from underwater noise during Offshore Wind Farm piling (in-combination)

1004. 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 Boreas.

1005. The commitment to the MMMP for piling (a draft of which is provided with the DCO Application) 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 Boreas 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.

1006. The approach to the in-combination assessment for disturbance from underwater noise follows the current advice from the SNCBs. This approach has been used for the Norfolk Boreas ES (document 6.1), including the Cumulative Impact Assessment (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.

1007. 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).

1008. There is a high level of uncertainty in relation to the in-combination scenarios that will arise by the time of Norfolk Boreas construction. The approach taken to this in-combination assessment is based on a range of indicative single piling and concurrent scenarios.

1009. 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 Boreas. This scenario is based on a precautionary approach using the maximum duration of piling periods.

1010. The UK Tier 3, 4 and 5 Offshore Wind Farm projects (see Table 8.38 for definitions) considered the potential worst-case scenario by assessing the potential for in-combination effects of disturbance to harbour porpoise during Offshore Wind Farm piling, based on the periods of piling as outlined in Table 8.39. The European Tier 3 Offshore Wind Farm projects considered for the potential worst-case scenario, based on the periods of piling, where available, are also included in Table 8.39.

1011. The Offshore Wind Farm projects included in the potential worst-case scenario are located within the Southern North Sea SAC or up to 26km from the Southern North Sea SAC boundary (Table 8.39).

1012. 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 Boreas, Thanet Extension and Norfolk Vanguard, 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).

1013. For the in-combination assessment, the potential construction period of Norfolk Boreas has been based on the widest likely range of construction dates between 2026 and 2029, based on a worst-case maximum four year construction period.

1014. As a precautionary worst-case, it has been assumed that piling could occur at any time during the potential Norfolk Boreas 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 54 days, approximately 4% of the four year construction period.

1015. 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 8.39 Offshore wind farms included in the in-combination assessment for the potential disturbance of harbour porpoise where there is the potential of piling occurring at the same time as piling at Norfolk Boreas. 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 Southern North Sea SAC	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 Boreas piling[2]
Norfolk Boreas	**Within SNS SAC**	**1,800**	**90-180**	**2020 (2020-2025)**	**Construction and piling: 2026 – 2028**	**Yes**
Tier 3: consented						
Blyth Demonstration site (3A & 4)	More than 26km	58.4	10	2013 (2013-2020)	Unknown	No
Creyke Beck A, UK	**Within SNS SAC**	1,200	200	Feb-15 (2015-2022)	2021-2027	**Yes**
Creyke Beck B, UK	**Within SNS SAC**	1,200	200	Feb-15 (2015-2022)	2021-2028	No[3]
Teesside A, UK	**Less than 26km**	1,200	200	Aug-15 (2015-2022)	2021-2028	**Yes**
Sofia, UK (formerly Teesside B), UK	**Within SNS SAC**	1,200	200	Aug-15 (2015-2022)	2020-2028	No[3]
East Anglia THREE, UK	**Within SNS SAC**	1,200	172	Aug-17 (2017-2024)	Piling: 2020 – 2022	No
Hornsea Project Two, UK	**Within SNS SAC**	1,386	165	Aug-16 (2016-2023)	2018-2021 Piling: 2018-2020	No
Triton Knoll phase 1-3, UK	**Less than 26km**	860	90	Jul-13 (2013-2020)	2018-2021	No
Moray Firth East, UK	More than 26km	950	100	2014 (2014-2021)	2019-2022	No
Mermaid, Belgium	**Less than 26km**	235	28	2015 (2015-2022)	2017-2019	No
Northwester 2, Belgium	**Less than 26km**	219	228	2015 (2015-2022)	Unknown	No
SeaStar, Belgium	More than 26km	252	30	2014	Unknown	No

Name and country of project	Distance from Southern North Sea SAC	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 Boreas piling[2]
				(2014-2021)		
Borssele I and II, Netherlands	**Less than 26km**	752	94	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
Eoliennes du Calvados, France	More than 26km	450	75	2016 (2016-2023)	Unknown	No
Parc éolien en mer de Fécamp, France	More than 26km	498	83	2016 (2016-2023)	Unknown	No
Borkum Riffgrund West II, Germany	More than 26km	240	16-18	2017 (2017-2024)	Unknown	No
Gode Wind 03, Germany	More than 26km	110	8	2016 (2016-2023)	From 2020	No
Kaskasi, Germany	More than 26km	325	34	2018 (2018-2025)	Completed by 2022	No
Hollandse Kust Zuid Holland I and II	More than 26km	700	126	2018 (2018-2025)	2023	No
Windpark Fryslan	More than 26km	382.7	89	2018 (2018-2025)	2019-2021	No
Kvitsøy Wind Turbine Demonstration Area, Norway	More than 26km	10	2	2010 (2010-2017)	Unknown	No
Rennesøy Wind Turbine Demonstration Area, Norway	More than 26km	10	2	2010	Unknown	No

Name and country of project	Distance from Southern North Sea SAC	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 Boreas piling[2]
				(2010-2017)		
Tier 4: application submitted and project on-hold						
Norfolk Vanguard, UK	**Within SNS SAC**	1,800	90-200	2019 (2019-2026)	2024-2028	No[4]
Thanet Extension, UK	**Within SNS SAC**	340	34	2019 (2019-2026)	2024-2028	No[4]
Hornsea Project Three, UK	**Less than 26km**	2,400	160-300	2019 (2019-2026)	2022-2029 Possible piling: 2022-2023 and 2029-2030	**Yes**
Firth of Forth Phase 1 Seagreen Alpha and Bravo, UK	More than 26km	1,500	120	Oct-14 (2014-2021)	Unknown – on-hold	No
Inch Cape, UK	More than 26km	784	75	Oct-14 (2014-2021)	Unknown – on-hold	No
Neart na Gaoithe, UK	More than 26km	448	54	Oct-14 (2014-2021)	Unknown – on-hold	No
Moray Firth Western Development Area, UK	More than 26km	750	85	2014 (2014-2021)	Unknown – on-hold	No
Dounreay Tri, UK	More than 26km	10	2	2017 (2017-2024)	Unknown – project postponed	No
Tier 5: application in preparation						
East Anglia ONE North, UK	**Within SNS SAC**	Up to 800	Up to 67	2020 (2020-2027)	2026 - 2029	**Yes**
East Anglia TWO, UK	**Within SNS SAC**	Up to 900	Up to 75	2020 (2020-2027)	2025 - 2029	No[5]
Hornsea Project Four, UK	**Within SNS SAC**	1,000	180	2021 (2021-2028)	Unknown	No[6]

[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 Boreas.
[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 SAC for harbour porpoise, concurrent piling with Thanet Extension and Norfolk Vanguard 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.

[6]There is currently not enough information on the Hornsea Project Four construction timelines in order to inform an assessment, however, as a precautionary approach, the potential for the overlap in offshore construction with Norfolk Boreas is included for activities other than piling.

Spatial assessment in relation to the SAC summer and winter areas

1016. For each project, the area of potential disturbance for single and concurrent piling that overlaps the SAC winter and summer areas has been estimated, based on the worst-case scenarios for the maximum, minimum and average overlap with the Southern North Sea SAC winter and summer areas.

1017. The Offshore Wind Farms included in the assessment are located within the Southern North Sea SAC or less than 26km from the boundary of the Southern North Sea SAC (Table 8.39).

1018. 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.

1019. 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.

1020. The conservative potential worst-case scenario for Offshore Wind Farms piling at the same time as Norfolk Boreas in and within 26km of the Southern North Sea SAC include four other Offshore Wind Farms, identified in Table 8.39:

- Creyke Beck A;
- Teesside A;
- Hornsea Project 3; and
- East Anglia ONE North.

1021. The estimated maximum, minimum and average overlap with the Southern North Sea SAC winter and summer areas, if all five Offshore Wind Farms were piling at exactly the same time, using single piling on each Offshore Wind Farm site, is outlined in Table 8.40, taking into account the overlap in disturbance areas (Figure 8.4 and Figure 8.5).

1022. In the case of concurrent piling with two locations at each Offshore Wind Farm site, the estimated maximum, minimum and average overlap with the Southern North Sea SAC winter and summer areas is outlined in Table 8.40, taking into account the overlap in disturbance areas (Figure 8.6 and Figure 8.7).

Table 8.40 Estimated maximum, minimum and average overlap with Southern North Sea SAC winter and summer areas for potential worst-case scenarios (Creyke Beck A, Teesside A, Hornsea Project Three, East Anglia ONE North and Norfolk Boreas) for single and concurrent piling

In-combination assessment scenario	Maximum overlap with Southern North Sea SAC (% of seasonal component)	Minimum overlap with Southern North Sea SAC (% of seasonal component)	Average overlap with Southern North Sea SAC (% of seasonal component)
Potential worst-case scenario (5 Offshore Wind Farms) – single piling	Maximum overlap with summer SNS SAC area = 4,741km² (17.5,422km² (20.1%) Maximum overlap with winter SNS SAC area = 2,395km²399km² (18.9%)	Minimum overlap with summer SNS SAC area = 2,493km²497km² (9.2%) Minimum overlap with winter SNS SAC area = 2,123km²124km² (16.7%)	Average overlap with summer SNS SAC area = 3,958km² (14.6619km² (13.4%) Average overlap with winter SNS SAC area = 2,259km²262km² (17.8%)
Potential worst-case scenario (5 Offshore Wind Farms) – concurrent piling	Maximum overlap with summer SNS SAC area = 7,542km² (27.9556km² (28.0%) Maximum overlap with winter SNS SAC area = 3,421km² (26.9428km² (25.6%)	Minimum overlap with summer SNS SAC area = 2,592km²596km² (9.6%) Minimum overlap with winter SNS SAC area = 2,155km²159km² (17.0%)	Average overlap with summer SNS SAC area = 5,067km²076km² (18.8%) Average overlap with winter SNS SAC area = 2,788km²794km² (22.0%)

1023. The assessment indicates that less than 20% of the Southern North Sea SAC summer area and Southern North Sea SAC winter area could be affected based on the minimum and average potential overlap of the potential worst-case scenario, and less than 20% of the Southern North Sea SAC winter area could be affected based on the maximum overlap, if single piling at the five Offshore Wind Farms was undertaken at the same time.

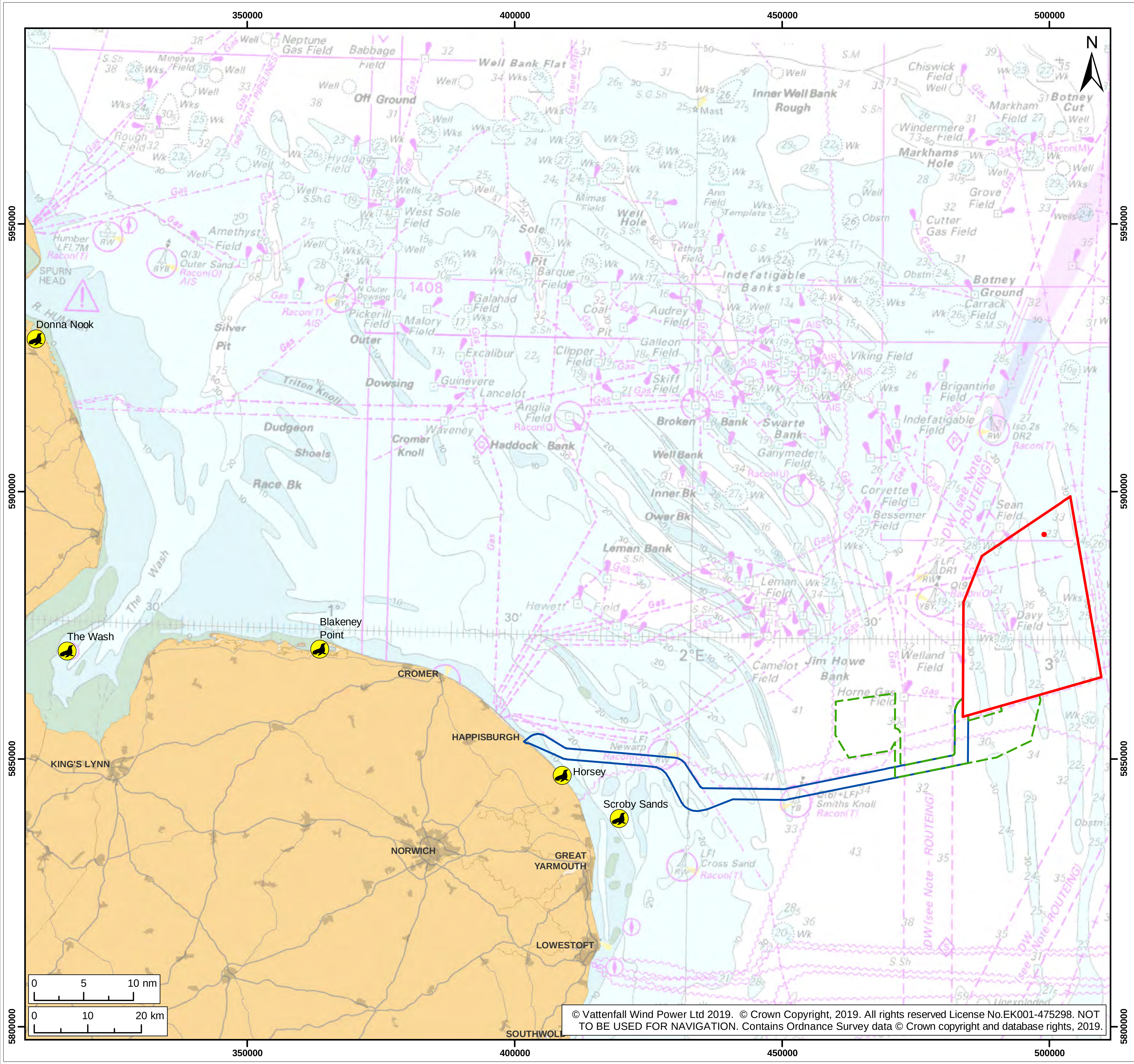
1024. However, the assessment also indicates that there is the potential for more than 20% of the Southern North Sea SAC summer area to be affected based on the maximum potential overlap for single or concurrent piling; or more than 20% of the Southern North Sea SAC winter area could be affected based on the maximum and average overlap of the potential worst-case scenario with concurrent piling at each of the five Offshore Wind Farms.

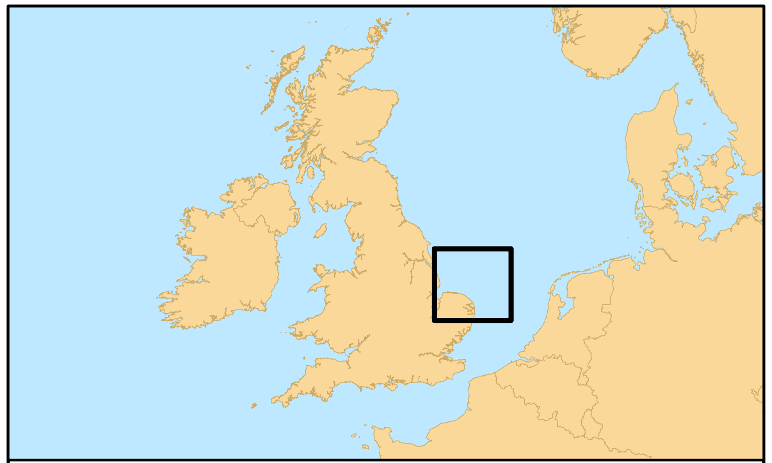
1025. The scenarios presented in this assessment are indicative of what the actual in-combination scenarios could be and it is considered unlikely that concurrent piling would occur at all five sites at exactly the same time. Therefore, the assessment based on the concurrent piling scenario is highly conservative.

1026. As outlined above, Norfolk Boreas 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 Boreas and other Offshore Wind Farm projects. This would be addressed through the MMMP and SIP.

1027. With the use of mitigation and the proposed approach outlined in the SIP, a scenario can be reached that would not exceed 20% disturbance of the winter or summer SAC 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 SAC in relation to the conservation objectives for harbour porpoise as a result of in-combination effects from underwater noise during Offshore Wind Farm piling.**

1028. Section 8.4 outlines the proposed management and mitigation of the potential effects on harbour porpoise.





Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Seal haul out area

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Grey and harbour seal haul-out sites around Norfolk Boreas offshore project area

Figure: 8.2 Drawing No: PB5640-007-002-009

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	05/02/2019	LB	GS	A3	1:700,000

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

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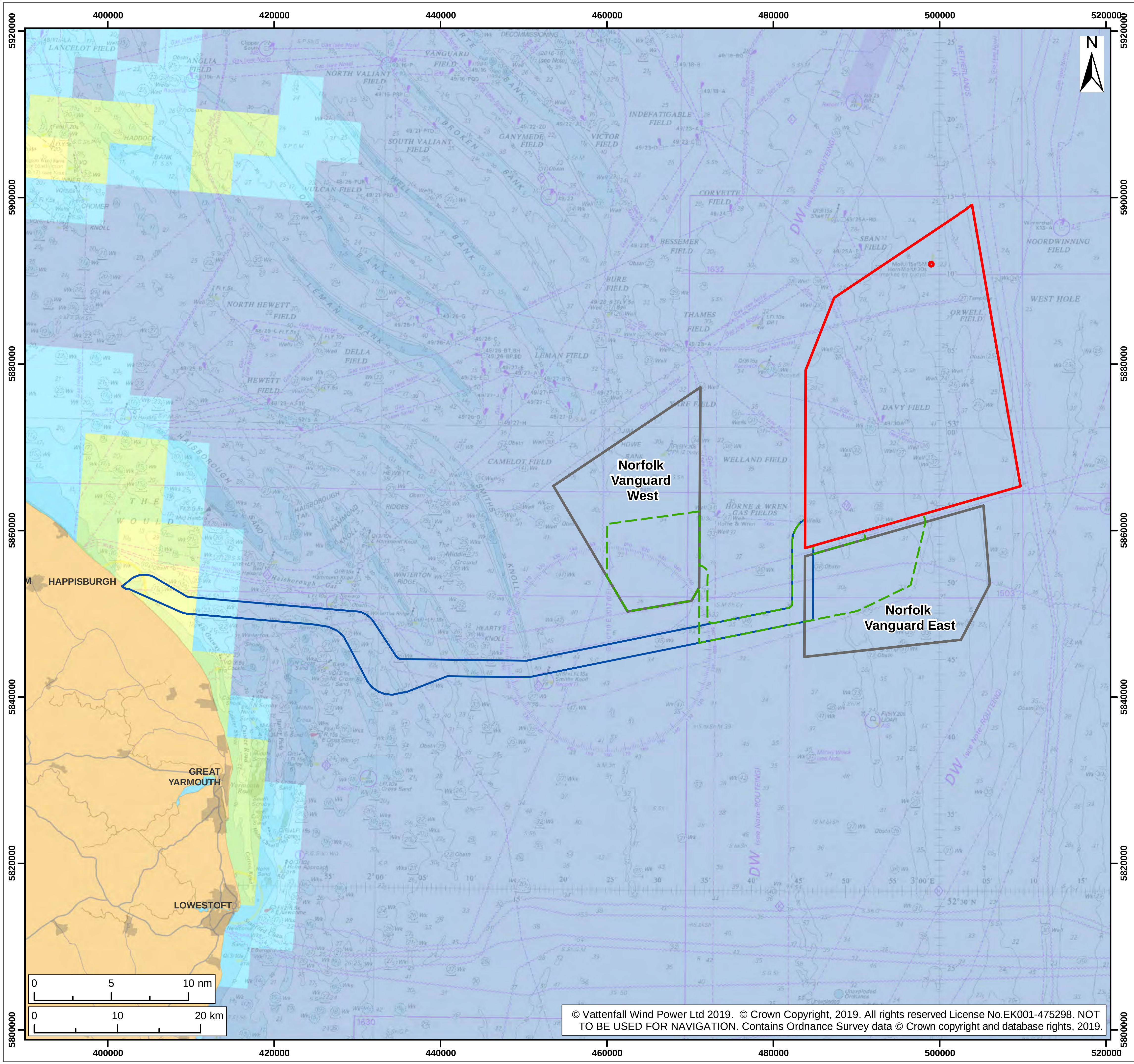

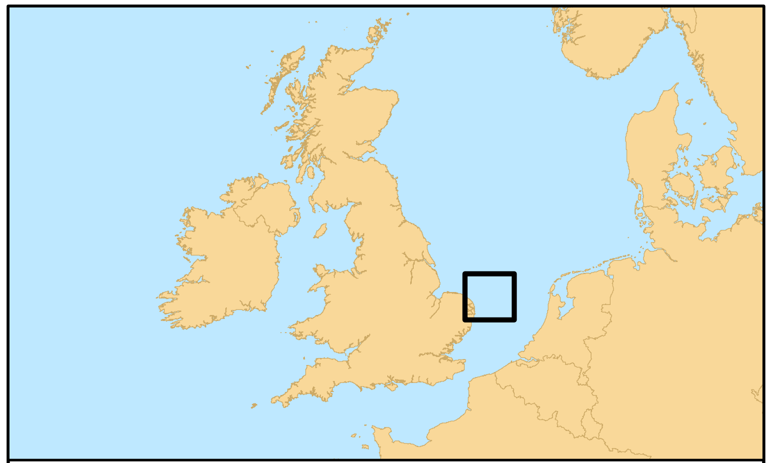

Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Norfolk Vanguard

Harbour seal at-sea usage[1] (density of seals per 25km²)

- 0-1
- 1-5
- 5-10
- 10-50
- 50-100
- 100-150
- 150+

[1]Russel et al., 2017.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Mean harbour seal at-sea usage around Norfolk Boreas offshore project area

Figure: 8.3 Drawing No: PB5640-007-002-010

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	05/02/2019	LB	GS	A3	1:450,000

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

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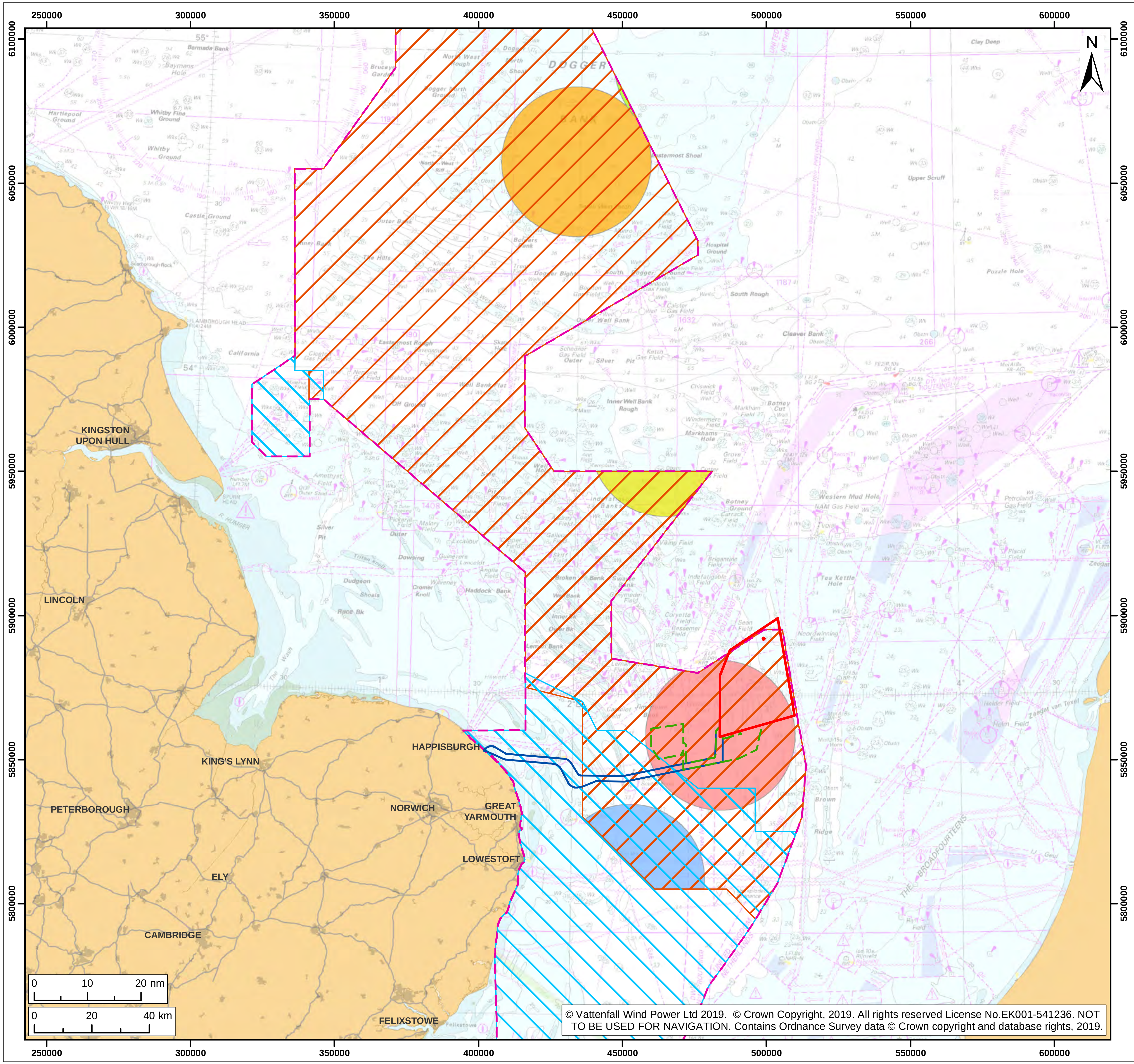

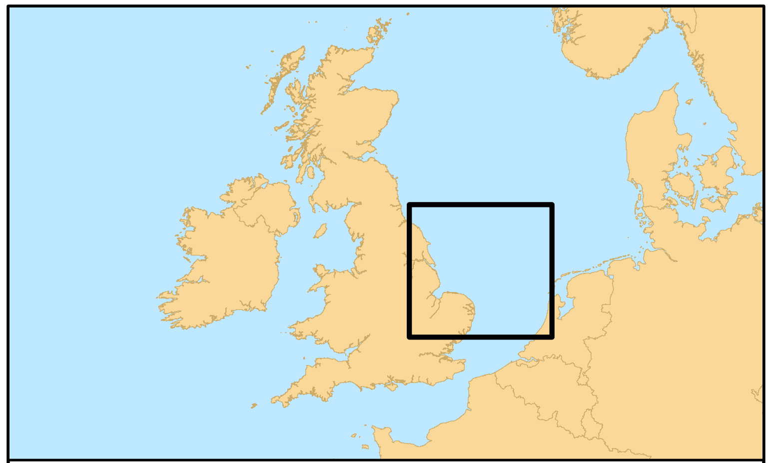

Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Southern North Sea Special Area of Conservation (SAC)¹
- Summer Area¹
- Winter Area¹

Maximum Overlap of Single Piling Events of 5 Offshore Wind Farms and the Southern North Sea Winter Area

- Dogger Bank Creyke Beck A
- Dogger Bank Teesside
- East Anglia 1N
- Hornsea Project 3
- Norfolk Boreas

¹JNCC, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Estimated maximum overlap with Southern North Sea Special Area of Conservation summer area for the 'most likely' scenario for single piling

Figure: 8.4 Drawing No: PB5640-007-002-011

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
05	07/05/2019	LB	GS	A3	1:1,300,000
04	20/03/2019	LB	GS	A3	1:1,300,000

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

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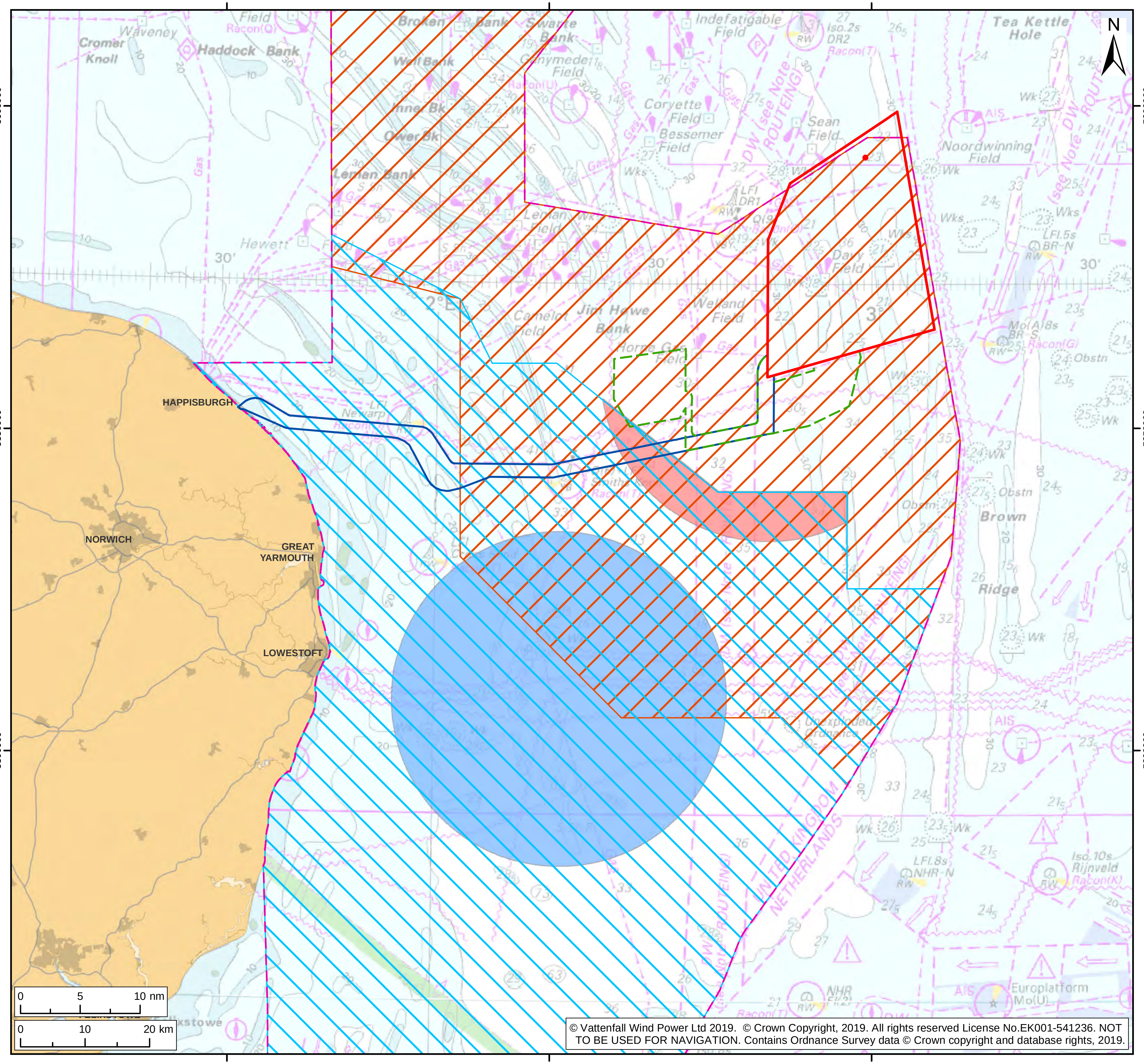

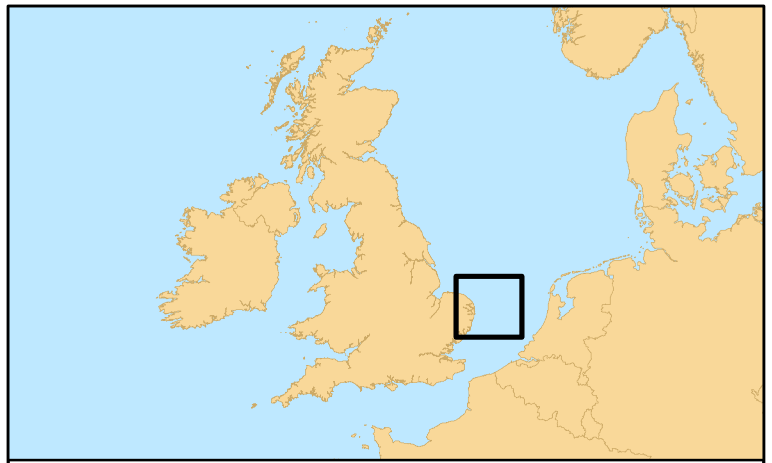

Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Southern North Sea Special Area of Conservation (SAC)¹
- Summer Area¹
- Winter Area¹

Maximum Overlap of Single Piling Events of 5 Offshore Wind Farms and the Southern North Sea Winter Area

- East Anglia 1N
- Norfolk Boreas

¹JNCC, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Estimated maximum overlap with Southern North Sea Special Area of Conservation winter area for the 'most likely' scenario for single piling

Figure: 8.5 Drawing No: PB5640-007-002-012

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
04	07/05/2019	JT	GS	A3	1:600,000
03	20/03/2019	LB	GS	A3	1:600,000

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

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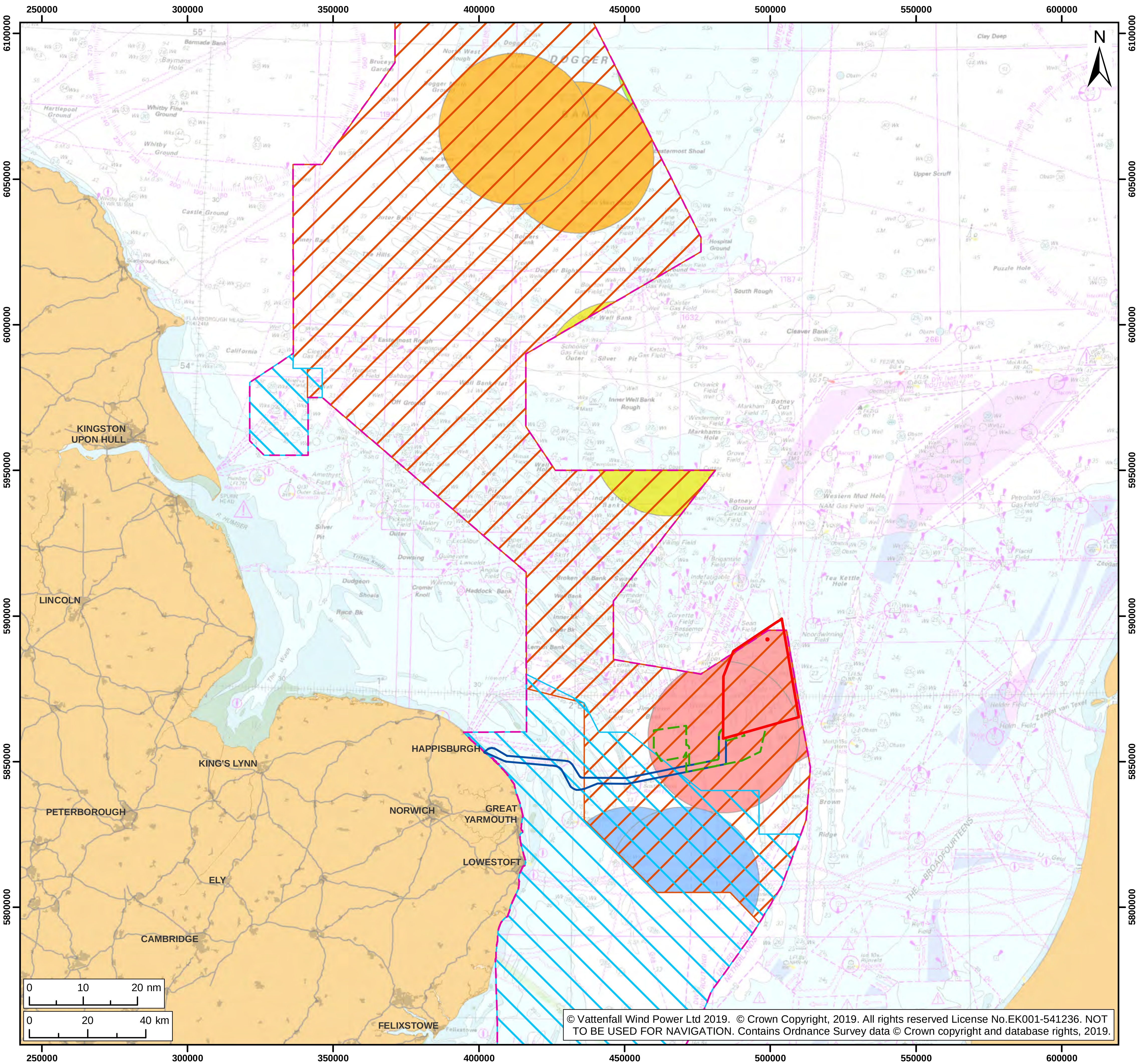

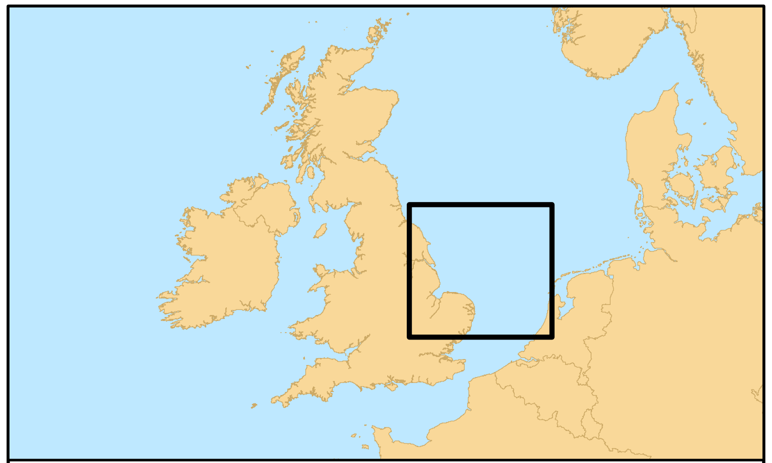

Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Southern North Sea Special Area of Conservation (SAC)[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

- Dogger Bank Creyke Beck A
- Dogger Bank Teesside
- East Anglia 1N
- Hornsea Project 3
- Norfolk Boreas

[1]JNCC, 2019.

Project: Norfolk Boreas

Report: Habitats Regulation Assessment Report

Title: Estimated maximum overlap with Southern North Sea Special Area of Conservation summer area for the 'most likely' scenario for concurrent piling

Figure: 8.6 Drawing No: PB5640-007-002-013

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
04	07/05/2019	LB	GS	A3	1:1,300,000
03	20/03/2019	LB	GS	A3	1:1,300,000

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

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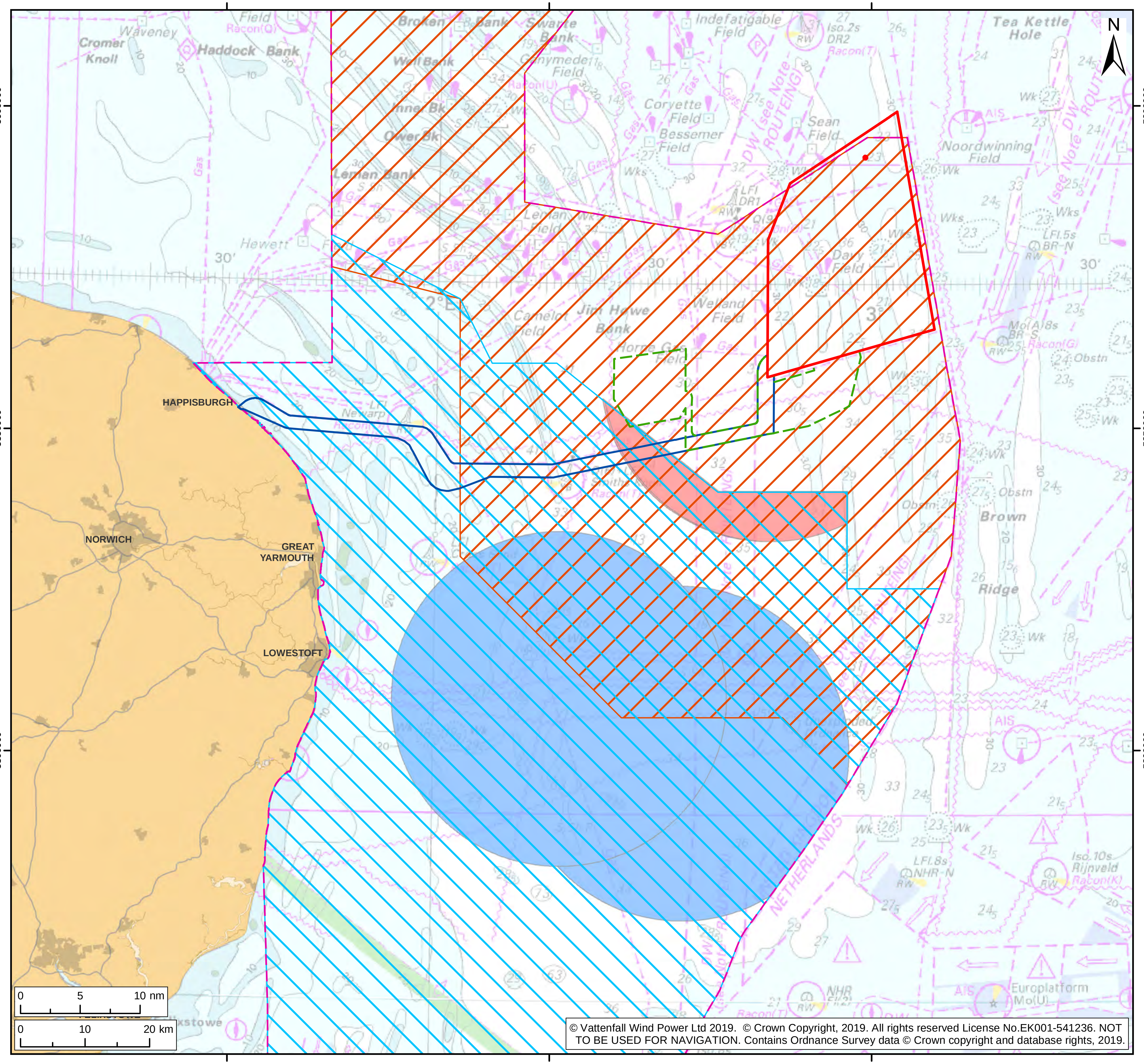

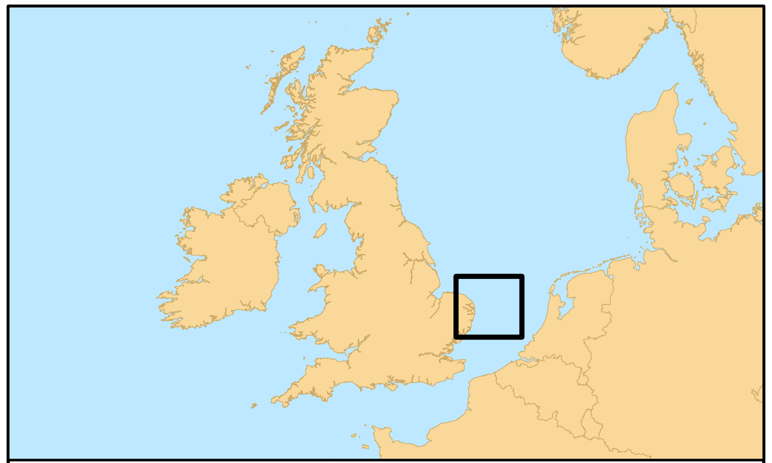

Legend:

- Norfolk Boreas site
- Offshore cable corridor
- Project interconnector search area
- Southern North Sea Special Area of Conservation (SAC)[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 1N
- Norfolk Boreas

[1]JNCC, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulation Assessment Report

Title:

Estimated maximum overlap with Southern North Sea Special Area of Conservation winter area for the 'most likely' scenario for concurrent piling

Figure: 8.7 Drawing No: PB5640-007-002-014

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
04	07/05/2019	LB	GS	A3	1:600,000
03	20/03/2019	LB	GS	A3	1:600,000

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

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Seasonal averages

1029. 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 SAC and number of days piling per season).

1030. 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.

1031. The assessment indicates on average more than 10% of the seasonal component of the SAC over the duration of that season could be affected (Table 8.41), based on the average potential overlap of the Southern North Sea SAC summer area and Southern North Sea SAC winter area for piling at the five Offshore Wind Farms occurring at the same time.

1032. However, the assumptions outlined above are highly conservative and with the use of mitigation and the proposed approach outlined in the SIP, the number of piling days in each season could be managed. Therefore, with the appropriate measures in place **there would be no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise as a result of in-combination effects from underwater noise during Offshore Wind Farm piling.**

Table 8.41 Estimated seasonal averages based on average overlap with Southern North Sea SAC winter and summer areas taking into account number of potential piling days per season for potential worst-case scenarios for single and concurrent piling

Southern North Sea SAC area	Number of potential piling days per season	Average overlap with Southern North Sea SAC	Estimated seasonal average
Summer area	173 days (94.5%)	• Single piling = 14.613.4% • Concurrent piling = 18.8%	• Single piling = 13.812.7% • Concurrent piling = 17.8%

Southern North Sea SAC area	Number of potential piling days per season	Average overlap with Southern North Sea SAC	Estimated seasonal average
Winter area	154 days (84.6%)	• Single piling = 17.8% • Concurrent piling = 22%	• Single piling = 15.1% • Concurrent piling = 18.6%

Assessment in relation to the North Sea MU population

1033. 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.

1034. The Offshore Wind Farms that were considered in this assessment were those located within the North Sea MU, not just in the Southern North Sea SAC or within 26km of the Southern North Sea SAC (Table 8.39).

1035. 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 Boreas and Thanet Extension.

1036. 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.

1037. This highly conservative potential worst-case scenario for Offshore Wind Farms that could be piling at the same time as Norfolk Boreas in the North Sea MU includes four other UK Offshore Wind Farms (Table 8.39):

- Creyke Beck A;
- Teesside A;
- Hornsea Project 3; and
- East Anglia ONE North.

1038. 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, the maximum number of harbour porpoise that could potentially be temporarily disturbed is 17,451 individuals, which represents approximately 5.1% of the North Sea MU reference population (Table 8.42).

1039. Based on a single pile installation at each of the five Offshore Wind Farms, 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 8,725 individuals, which represent, approximately 2.5% of the North Sea MU reference population (Table 8.42).

1040. The assessment indicates that approximately 2.5-5.1% 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 Offshore Wind Farm piling at the same time as Norfolk Boreas, with single or concurrent pile installation at each site.

1041. The approach to the in-combination assessment, based on the five UK Offshore Wind Farms single piling, would allow for some of these sites not to be piling at the same time while others, including Norfolk Boreas, could be concurrent piling. This is also more realistic, as five Offshore Wind Farms concurrently piling at exactly the same time is overly precautionary.

1042. As outlined above, although the potential piling duration for Norfolk Boreas 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 54 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.

1043. 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 Offshore Wind Farm 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%.

1044. Norfolk Boreas 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 Boreas and other Offshore Wind Farm projects. This would be addressed through the development and agreement of both a MMMP and SIP.

1045. With the use of appropriate mitigation measures which will be developed and agreed within the SIP there would be **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise as a result of in-combination effects from underwater noise during Offshore Wind Farm piling.**

Table 8.42: Quantified in-combination assessment for the potential disturbance of harbour porpoise during single and concurrent piling of Offshore Wind Farms for the potential worst-case scenario based on the Offshore Wind Farm projects which could be piling at the same time as Norfolk Boreas.

Name of Project	Tier	Distance to NB (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 Boreas	5	0	O[1]	0.888	1,886	3,772
Creyke Beck A	3	173	O	0.888	1,886	3,772
Teesside A	3	191	N	0.837	1,778	3,556
Hornsea Project 3	4	53	O	0.888	1,886	3,772
East Anglia ONE North	5	51	L	0.607	1,289	2,579
Total					**8,725**	**17,451**
% of North Sea MU reference population (345,373 harbour porpoise)					**2.5%**	**5.1%**

[1]Norfolk Boreas is located in both SCANS-III survey block L and survey block O; therefore, higher density estimate from survey block O is used.

8.3.1.5.4. Disturbance from all other noise sources

1046. During the construction period at Norfolk Boreas, there are other potential noise sources in addition to Offshore Wind Farm piling that could also disturb harbour porpoise, these sources include:

- UXO clearance;
- Seismic surveys;
- Offshore Wind Farm construction activities and vessels (excluding piling); and
- Offshore Wind Farm operation and maintenance, including vessels.

1047. 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

1048. The commitment to the MMMP for UXO clearance for Norfolk Boreas would result in no potential effects for lethal injury, physical injury and permanent auditory injury (PTS). As such, the proposed Norfolk Boreas 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.

1049. 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 Southern North Sea harbour porpoise SAC 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.

<u>Spatial assessment in relation to the SAC summer and winter areas</u>

1050. It is currently not possible to estimate the number of potential UXO clearance operations that could be undertaken in the Southern North Sea SAC. It has 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 SAC area; (ii) both are in the winter SAC area; or (iii) one is in the summer SAC area and one is in the winter SAC area.

1051. If two UXO detonations were undertaken at the same time the potential area of disturbance could be 4,248km^2, which is approximately 15.7% of summer SAC area (27,018km^2) and 33.5% of the winter SAC area (12,697km^2).

1052. If one UXO detonation was undertaken, the potential area of disturbance could be (2,124km^2) which would be approximately 7.9% of summer SAC area and 16.7% of the winter SAC area.

1053. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC area at any one time during single UXO detonations in the summer and winter SAC areas, or if two detonations were undertaken at the same time in the summer SAC area. Therefore, under these circumstances, there would be **no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

1054. However, if two UXO detonations were conducted at the same time in the winter SAC area, the potential area of disturbance could be up to a maximum of 33.5% of the winter SAC area, depending on the locations of the UXO. Therefore, the displacement of harbour porpoise could exceed 20% of the seasonal component of the SAC 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 SAC in relation to the conservation objectives for harbour porpoise.

<u>Seasonal averages</u>

1055. It is currently not possible to determine the number of days per season that UXO clearance, if undertaken, would be in the Southern North Sea SAC 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.

1056. 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 SAC and number of days piling per season).

1057. The assessment indicates on average less than 10% of the seasonal component of the SAC over the duration of that season could be affected, if there were one UXO operation in the summer and winter SAC areas or two UXO operations in the summer SAC area (Table 8.43). Therefore, under these circumstances, there would be **no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise.**

1058. The assessment indicates that if there were two UXO operations in the winter area of the SAC, 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 SAC over the duration of that season could be affected. However, with the use of appropriate mitigation measures which will be developed and agreed within the SIP, there would be no significant disturbance and **no adverse effect on the integrity of the Southern**

North Sea SAC in relation to the conservation objectives for harbour porpoise as a result of in-combination effects from underwater noise during UXO clearance.

Table 8.43 Estimated seasonal averages based on one or two UXO clearance operations within the Southern North Sea SAC winter and summer areas

Southern North Sea SAC area	Number of UXO clearance days per season	Area within Southern North Sea SAC	Estimated seasonal average
Summer area	• One UXO operation = 40 days (21.9%) • Two UXO operations = 80 days (43.7%)	• One UXO operation = 7.9% • Two UXO operations = 15.7%	• One UXO operation = 1.7% • Two UXO operations = 6.9%
Winter area	• One UXO operation = 40 days (22.0%) • Two UXO operations = 80 days (44.0%)	• One UXO operation = 16.7% • Two UXO operations = 33.5%	• One UXO operation = 3.7% • Two UXO operations = 14.7%

Assessment in relation to the North Sea MU population

1059. 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 has 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.

1060. 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.

1061. 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 8.44).

1062. 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).

1063. 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 8.44).

1064. 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 8.44). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.44 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%)

Seismic surveys

1065. 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 Southern North Sea harbour porpoise SAC, 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.

1066. 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 that 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.

1067. The draft RoC HRA for the Southern North Sea SAC (BEIS, 2018) undertook underwater noise modelling to determine the potential impact ranges of geophysical surveys for harbour porpoise. The assessment used the maximum source levels that could be expected from geophysical equipment: sub-bottom profilers, with a maximum source noise level of 267 dB re 1 µPa-m. The noise modelling indicates that the onset of PTS in harbour porpoise could occur within a maximum range of 23m (an area of 0.0017km^2) from the source location (BEIS, 2018) for the PTS cumulative threshold of 155dB SEL weighted (NMFS, 2018). For possible behavioural disturbance of harbour porpoise, based on a threshold of 140 dB re 1 µPa SPL unweighted the maximum range was 3.77km (44.65km^2) (BEIS, 2018).

1068. The potential disturbance of harbour porpoise during offshore wind farm construction has been assessed based on the disturbance during piling and for other construction activities, therefore the potential for any disturbance during any geophysical surveys at these sites has already been taken into account (i.e. the areas of potential disturbance has already been included / covered as part of these assessments).

<u>Spatial assessment in relation to the SAC summer and winter areas</u>

1069. It is currently not possible to estimate the number of potential seismic surveys that could be undertaken in the Southern North Sea SAC. It has therefore been assumed, as a very worst-case scenario, that there could potentially be up to two seismic surveys in the summer SAC area and / or winter SAC area at any one time.

1070. 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 SAC area (27,018km^2) and less than 5% of winter SAC area (12,697km^2).

1071. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC 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 SAC in relation to the conservation objectives for harbour porpoise**.

1072. 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 SAC area (27,018km^2) and less than 2.5% of winter SAC area (12,697km^2). Therefore, under these circumstances, there would be no significant disturbance and **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

<u>Seasonal averages</u>

1073. It is currently not possible to determine the number of days per season that seismic surveys, if undertaken, would be in the Southern North Sea SAC 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).

1074. 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 SAC and number of days piling per season).

1075. The assessment indicates on average less than 10% of the seasonal component of the SAC over the duration of that season could be affected (Table 8.45). Therefore, under these circumstances, there is no significant disturbance and **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.45 Estimated seasonal averages based on one or two seismic surveys within the Southern North Sea SAC winter and summer areas

Southern North Sea SAC area	Number of potential seismic survey days per season	Average overlap with Southern North Sea SAC area	Estimated seasonal average overlap with Southern North Sea SAC area
Summer area	• One survey = 10 days (5.5%) • Two surveys = 20 days (10.9%)	• One survey = 1.2% • Two surveys = 2.5%	• One survey = 0.07% • Two surveys = 0.3%
Winter area	• One survey = 10 days (5.5%) • Two surveys = 20 days (11.0%)	• One survey = 2.5% • Two surveys = 5%	• One survey = 0.1% • Two surveys = 0.6%

Assessment in relation to the North Sea MU population

1076. 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 Boreas.

1077. It has 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.

1078. 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.

1079. 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 8.46).

1080. 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).

1081. 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 8.46). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

1082. 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 8.46). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.46 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%)

Offshore Wind Farm construction, other than piling

1083. During the construction of Norfolk Boreas there is the potential for overlap with effects from the construction activities, other than piling, with other offshore wind farms. Noise sources which could cause potential disturbance during Offshore Wind Farm 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.

1084. The potential ranges of these noise sources during Offshore Wind Farm construction will be localised and significantly less than the ranges predicted for piling. There could be potential in-combination effects from construction of Offshore Wind Farms in and around the area of Norfolk Boreas.

1085. As a precautionary approach, the in-combination assessment considered all UK and European Offshore Wind Farms in the southern North Sea which could potentially have construction activities, other than piling, during the Norfolk Boreas construction period. This is based on the 'theoretical worst-case' scenario, which includes all Tier 3 UK and European Offshore Wind Farm projects, taking into account a potential seven year construction window (although most have a five year construction window) and the Tier 5 UK Offshore Wind Farm projects (see Appendix 5.1).

1086. This highly conservative approach for Offshore Wind Farms that could potentially have construction activities, other than piling, during the Norfolk Boreas construction period includes six UK Offshore Wind Farms (Table 8.39):

- Creyke Beck B, UK;
- Sofia;
- Norfolk Vanguard;
- Thanet Extension;
- East Anglia TWO; and
- Hornsea Project Four.

1087. The potential temporary disturbance during Offshore Wind Farm construction activities, other than pile driving noise sources, has been based on the area of the Offshore Wind Farm 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.

Spatial assessment in relation to the SAC summer and winter areas

1088. For each project within (wholly or partly) the Southern North Sea SAC, the area of the Offshore Wind Farm that overlaps the SAC winter and summer areas has been estimated (Table 8.39). Based on this potential worst-case scenario, seven UK Offshore Wind Farms located in the Southern North Sea SAC potentially have construction activities, other than piling, during the Norfolk Boreas construction (Table 8.47).

1089. The in-combination assessment indicates that if all six of these Offshore Wind Farms, within (wholly or partly) the Southern North Sea SAC, were conducting construction activities, other than piling, the estimated maximum in-combination area of disturbance, based on the worst-case scenario of the entire Offshore Wind Farm area, is 3,259km^2 (Table 8.47).

1090. Five of these Offshore Wind Farms are located in or overlap with the summer SAC area and the estimated maximum in-combination area of disturbance for the summer SAC area is 2,466km^2, which represents approximately 9.1% of the summer SAC area (Table 8.47).

1091. Four of these Offshore Wind Farms are located in or overlap with the winter SAC area and the estimated maximum in-combination area of disturbance for the winter SAC area is 490km^2, which represents approximately 3.9% of the winter SAC area (Table 8.47).

1092. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC 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 SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.47 Quantified in-combination assessment for the potential disturbance of harbour porpoise during construction activities (other than piling) at Offshore Wind Farms in the Southern North Sea SAC during construction at Norfolk Boreas

Name of Project	Area of Offshore Wind Farm site (km^2)*	Area in summer SAC area (km^2)	Area in winter SAC area (km^2)
Dogger Bank Zone Creyke Beck B	599	599	0
Sofia (formerly Dogger Bank Zone Teesside B)	593	128	0
Norfolk Vanguard	592	592	1
Thanet Extension	73	0	31
East Anglia TWO	255	0	255
Hornsea Project Four	846	846	0
Total area	**2,958**	**2,165**	**287**
% of SAC area		**8%**	**2.3%**

Seasonal averages

1093. 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).

1094. 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 SAC and number of days piling per season).

1095. The assessment indicates on average less than 10% of the seasonal component of the SAC over the duration of that season could be affected, based on 100% disturbance from the offshore wind farm areas (Table 8.48). Therefore, under these circumstances, there is no significant disturbance and **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.48 Estimated seasonal averages based on construction activities, other than piling, at other Offshore Wind Farms in the Southern North Sea SAC summer and winter areas during construction at Norfolk Boreas

Southern North Sea SAC area	Number of days per season	Average overlap with Southern North Sea SAC	Estimated seasonal average
Summer area	183 days	8%	8%
Winter area	182 days	2.3%	2.3%

Assessment in relation to the North Sea MU population

1096. For each project, the number of harbour porpoise in the area of each Offshore Wind Farm 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.

1097. The in-combination assessment indicates that if all six of these Offshore Wind Farms 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 2,958km^2 and the maximum number of harbour porpoise that could potentially be disturbed is 2,535 individuals, which represents approximately 0.7% of the North Sea MU reference population (Table 8.49). Therefore, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.49 Quantified in-combination assessment for the potential disturbance of harbour porpoise during construction activities (other than piling) at UK and European Offshore Wind Farms in the southern North Sea during construction at Norfolk Boreas

Name of Project	Distance to NB (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of Offshore Wind Farm site (km^2)*	Potential number of harbour porpoise disturbed
Creyke Beck B	196	O	0.888	599	532
Sofia	185	O[1]	0.888	593	527
Norfolk Vanguard	30	O[3]	0.888	592	526
Thanet Extension	175	L	0.607	73	44
East Anglia TWO	73	L	0.607	255	155
Hornsea Project Four	119	O	0.888	846	751
Total				**2,958**	**2,535**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.8%**

*Source: http://www.4coffshore.com/

[1]Sofia overlaps SCANS-III survey block O & N; therefore, higher density estimate from survey block O is used.

[3]Norfolk Vanguard overlaps SCANS-III survey block O & L, therefore, higher density estimate from survey block O is used.

Offshore Wind Farm operation and maintenance

1098. There is the potential for disturbance from other Offshore Wind Farms that have already been constructed as a result of any operational and maintenance activities, including vessels, during the Norfolk Boreas construction period. The potential disturbance from operational Offshore Wind Farms and maintenance activities could include the operational turbines, vessels, any rock dumping or cable re-burial.

1099. Operational Offshore Wind Farms were considered part of the baseline if they were operational at the time of the start of the Norfolk Boreas site specific surveys (August 2016). Therefore, Offshore Wind Farms were screened into the CIA as having the potential to be newly operational by the Norfolk Boreas construction period, in that they are currently under construction or will be constructed and operational by 2026.

1100. The potential disturbance from operational Offshore Wind Farms and maintenance activities has also been based on the worst-case scenario of the entire area of the Offshore Wind Farm sites. This is again a very precautionary approach, as it is highly unlikely that operational Offshore Wind Farms 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.

Spatial assessment in relation to the SAC summer and winter areas

1101. For operational UK and European Offshore Wind Farms within (wholly or partly) the Southern North Sea SAC that could have potential in-combination effects during the

Norfolk Boreas construction period, the area of the Offshore Wind Farm that overlaps the SAC winter and summer areas has been estimated.

1102. The in-combination assessment indicates that, based on the potential worst-case scenario, five UK Offshore Wind Farms located in the Southern North Sea SAC could potentially have disturbance from operational Offshore Wind Farms and maintenance activities that overlap with construction of Norfolk Boreas, the estimated maximum in-combination area of disturbance is 1,488km^2 (Table 8.50).

1103. Three of these Offshore Wind Farms is located in the summer SAC area and the estimated maximum area of disturbance for the summer SAC area is 651km^2, which represents approximately 2.4% of the summer SAC area (Table 8.50).

1104. Three of these Offshore Wind Farms are located in the winter SAC area and the estimated maximum in-combination area of disturbance for the winter SAC area is 521km^2, which represents approximately 4% of the winter SAC area (Table 8.50).

1105. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SAC area at any one time, based on 100% disturbance for the entire offshore wind farm area of operational Offshore Wind Farms. Therefore, under these circumstances, there is no significant disturbance and **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.50 Quantified in-combination assessment for the potential disturbance of harbour porpoise during operation and maintenance activities at UK Offshore Wind Farms in the southern North Sea during construction at Norfolk Boreas

Name of Project	Area of Offshore Wind Farm site (km^2)*	Area in summer SAC area (km^2)	Area in winter SAC area (km^2)
Galloper	113	0	113
Hornsea Project One	407	52	0
Hornsea Project Two	462	298	0
East Anglia ONE	205	0	205
East Anglia THREE	301	301	203
Total	**1,488**	**651**	**521**
% of SAC area		**2.4%**	**4%**

*Source: http://www.4coffshore.com/

Seasonal averages

1106. 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).

1107. 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 SAC and number of days piling per season).

1108. The assessment indicates on average less than 10% of the seasonal component of the SAC over the duration of that season could be affected, based on 100% disturbance from the offshore wind farm areas (Table 8.51). Therefore, under these circumstances, there is **no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.51 Estimated seasonal averages for operational and maintenance activities at other Offshore Wind Farms in the Southern North Sea SAC summer and winter areas during construction at Norfolk Boreas

Southern North Sea SAC area	Number of days per season	Average overlap with Southern North Sea SAC	Estimated seasonal average
Summer area	183 days	2.4%	2.4%
Winter area	182 days	4%	4%

<u>Assessment in relation to the North Sea MU population</u>

1109. Operational UK and European Offshore Wind Farms in the southern North Sea that could have potential in-combination effects during the Norfolk Boreas construction period have an estimated maximum potential in-combination area up to 4,770km^2 and the maximum number of harbour porpoise that could be temporarily disturbed would be up to 2,783 individuals which represents approximately 0.86% of the North Sea MU reference population (Table 8.52). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.52 Quantified in-combination assessment for the potential disturbance of harbour porpoise during operation and maintenance activities at Offshore Wind Farms in the southern North Sea during construction at Norfolk Boreas

Name of Project	Distance to Norfolk Boreas (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of Offshore Wind Farm site (km^2)*	Potential number of harbour porpoise disturbed from entire Offshore Wind Farm area
Beatrice	665	S	0.152	131	20
Blyth Offshore Wind Demo 2[1]	353	R	0.599	<1	0.6
Blyth Offshore Wind Demo 3A & 4[2]	351	R	0.599	4	2
Borkum Riffgrund II[2]	237	N	0.837	36	30

Name of Project	Distance to Norfolk Boreas (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km²)	Area of Offshore Wind Farm site (km²)*	Potential number of harbour porpoise disturbed from entire Offshore Wind Farm area
Borkum Riffgrund West I[2]	225	N	0.837	30	25
Borkum Riffgrund West II[2]	218	N[3]	0.837	16	13
Borssele I and II	121	L	0.607	126	76
Borssele III and IV	128	L	0.607	133	81
Borssele Site V - Leeghwater - Innovation Plot	126	L	0.607	<2	1
Deutsche Bucht (DeBu)	213	N	0.837	18	15
Deutsche Bucht Pilot Park	213	N	0.837	1	1
Dounreay Tri	766	S	0.152	25	4
Dudgeon[1]	90	O	0.888	55	49
East Anglia ONE	62	L	0.607	162	98
East Anglia THREE	13	L	0.607	301	183
EnBW He Dreiht	236	M	0.277	62	17
EnBW Hohe See (Hochsee Windpark 'Nordsee')	250	M	0.277	40	11
Eoliennes du Calvados	441	C	0.213	78	17
European Offshore Wind Deployment Centre EOWDC (Aberdeen Demonstration)	530	R	0.599	20	12
Galloper[1]	108	L	0.607	113	69
Gemini[1]	214	N	0.837	70	59
Gode Wind 1 and 2[1]	271	M	0.277	70	19
Gode Wind 03[2]	276	M	0.277	4	1
Gode Wind 04[2]	277	M	0.277	29	8
Hollandse Kust Zuid Holland II	83	N	0.837	103	86
Hornsea Project Two	101	O	0.888	462	410
Horns Rev 3[2]	397	M	0.277	144	40
Hornsea Project One	86	O	0.888	407	361
Hywind Pilot Park[1]	546	R	0.599	15	9
Inch Cape	490	R	0.599	150	90
Kaskasi[2]	333	M	0.277	17	5
Kincardine	574	R	0.599	110	66
KvitsØy Wind Turbine Demonstration Area[2]	657	V	0.137	<1	0.1
Merkur[2]	243	M	0.277	39	11
Mermaid	126	L	0.607	16	10

Name of Project	Distance to Norfolk Boreas (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km²)	Area of Offshore Wind Farm site (km²)*	Potential number of harbour porpoise disturbed from entire Offshore Wind Farm area
Moray Firth East	657	S	0.152	295	45
Moray Firth West	659	S	0.152	226	34
Neart na Gaoithe	470	R	0.599	105	63
Nissum Bredning Vind[1]	504	P	0.823	5	4
Nobelwind[1]	129	N	0.837	22	18
Nordsee One	257	M	0.277	31	9
Nordergrunde[1]	338	M	0.277	3	0.8
Norther[2]	132	L	0.607	38	23.1
Northwester 2[2]	130	L	0.607	12	7
OWP Albatros	249	M	0.277	11	3
OWP West[2]	220	N	0.837	14	12
Parc éolien en mer de Fécamp	363	C	0.213	88	19
Race Bank[1]	124	O	0.888	62	55
Rampion Wind Farm	318	C	0.213	79	17
RennesØy Wind Turbine Demonstration Area[2]	663	V	0.137	1	0.1
RENTEL[2]	140	L	0.607	23	14
Sandbank[1]	325	M	0.277	47	13
Seagreen Alpha and Bravo	500	R	0.599	391	234
SeaStar[2]	134	L	0.607	18	11
TetraSpar Demo (Metcentre)[2]	668	V	0.137	<1	0
Trianel Windpark Borkum Phase 2 (Borkum West II phase 2)[2]	240	M	0.277	23	6
Triton Knoll Phase 1-3	124	O	0.888	146	130
Veja Mate[1]	216	N	0.837	8	7
Vesterhav Nord/Syd[2]	519	P	0.823	10	8
Windpark Fryslan	136	N[1]	0.837	35	29
Total				**4,770km²**	**2,783**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.8%**

*Source: http://www.4coffshore.com/
[1]closest block, but is not actually within the SCANS-III area.

8.3.1.5.5. In-combination effects from underwater noise for Offshore Wind Farm piling and all other noise sources at Norfolk Boreas (in-combination)

1110. The potential in-combination effects from all noise sources including Offshore Wind Farm piling during construction at Norfolk Boreas is summarised in Table 8.53. This assessment is based on highly conservative assumptions, including:

- Five Offshore Wind Farms (including Norfolk Boreas) 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.

1111. 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 Boreas as the ranges for piling would be significantly greater than those from other construction noise sources.

1112. The maximum number of harbour porpoise that could potentially be temporarily disturbed as a result of underwater noise from Offshore Wind Farm piling and all other potential noise sources during piling at Norfolk Boreas is 16,579 individuals, which represents approximately 4.8% of the North Sea MU reference population (Table 8.53).

1113. The estimated maximum potential in-combination area of disturbance for the summer SAC area is 9,222km^2, which represents approximately 34.1% of the summer SAC area (Table 8.53). The estimated maximum in-combination area of disturbance for the winter SAC area is 5,515km^2, which represents approximately 43.4% of the winter SAC area (Table 8.53). It is highly likely that with the refinement of build scenarios and the final design for each project, these areas would be significantly less.

1114. Norfolk Boreas 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 (a draft MMMP and In Principle SIP have been submitted with the DCO application (document reference 8.17).

1115. With the use of appropriate mitigation measures which will be developed and agreed within the SIP, **there would be no significant disturbance and no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise.**

1116. Section 8.4 outlines the proposed management and mitigation of the potential effects on harbour porpoise.

Table 8.53 Quantified in-combination assessment for the potential disturbance of harbour porpoise in the North Sea MU and Southern North Sea SAC summer and winter areas from all possible noise sources during piling at Norfolk Boreas based on worst-case scenario

Potential noise sources during piling at Norfolk Boreas	Potential number of harbour porpoise disturbed (% of reference population)	Area in summer SAC area (km^2) (percentage of seasonal area)	Area in winter SAC area (km^2) (percentage of seasonal area)	Seasonal average for summer SAC area	Seasonal average for winter SAC area
Piling at Offshore Wind Farm projects, based Offshore Wind Farm projects that could be piling at the same time AAONE North Boreas for single pile installation at each site and average overlap with SAC seasonal area	8,725 (2.5%)	3,958km^2 (14.6%)	2,259km^2 (17.8%)	13.8%	15.1%
Offshore Wind Farm construction activities, based on Offshore Wind Farms that are not piling but potential for other construction activities during piling at Norfolk Boreas and 100% disturbance	2,535 (0.8%)	2,165km^2 (8%)	287km^{22} (2.3%)	8%	2.3%
Offshore Wind Farm operation and maintenance, based on constructed Offshore Wind Farms that could have O&M activities during piling at Norfolk Vanguard and 100% disturbance	2,783 (0.8%)	651$km^2$350km^2 (2.4%)	521km^2 (4%)	2.4%	4%
Sub-total (without UXO clearance and seismic surveys)	***14,043 (4%)***	***6,774km^2 (25.1%)***	***3,067km^2 (24.2%)***	***24.2%***	***20.7%***
UXO clearance, based on up two locations, one in each SAC seasonal area	2,210 (0.6%)	2,124km^2 (7.9%)	2,124km^2 (16.7%)	1.7%	3.7%
Seismic surveys, based on up two locations, one in each SAC seasonal area	326 (0.09%)	324km^2 (1.2%)	324km^2 (2.5%)	0.07%	0.1%
Total	**16,579 (4.8%)**	**9,222km^2 (34.1%)**	**5,515km^2 (43.4%)**	**26.0%**	**24.5%**

8.3.1.5.6. Indirect effects – changes in prey resources

1117. 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.

1118. 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.

1119. 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. 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.

1120. 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 SAC in relation to the conservation objectives for harbour porpoise arising from changes in prey resources**.

8.3.1.5.7. Direct interaction - collision risk

1121. An increase in vessel movements and wave / tidal arrays can pose a potential collision risk for harbour porpoise.

1122. During the construction of Offshore Wind Farms, 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).

1123. Any increase in vessel movements during the operation and maintenance of Offshore Wind Farms 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 Offshore Wind Farms and as a result this has not been included in the in-combination assessment.

1124. 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.

1125. 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 Southern North Sea SAC. 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.

1126. 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.

1127. 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.

1128. The precautionary in-combination assessment has determined that the number of harbour porpoise that could have a potential increased collision risk with vessels in Offshore Wind Farm sites in the North Sea MU during construction would be 243 individuals, which represents 0.07% of the North Sea MU reference population (Table 8.54). Therefore, under these circumstances, there is **no adverse effect on the integrity of the Southern North Sea SAC in relation to the conservation objectives for harbour porpoise**.

Table 8.54 Quantified in-combination assessment for the potential increased collision risk with vessels for harbour porpoise in the North Sea MU during the Norfolk Boreas construction period

Name of Project	Tier	Distance to NB (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of Offshore Wind Farm site*	Potential number of harbour porpoise based on 5% at increased risk of collision
Norfolk Boreas	5	0	O[1]	0.888	725	32
Creyke Beck A	3	173	O	0.888	515	23
Creyke Beck B	3	196	O	0.888	599	27
Teesside A	3	191	N	0.837	562	24
Sofia	3	185	O[2]	0.888	593	26
Norfolk Vanguard	4	30	O[3]	0.888	592	26
Hornsea Project Three	4	53	O	0.888	695	31
Thanet Extension	4	175	L	0.607	73	2
East Anglia ONE North	5	51	L	0.607	206	6
East Anglia TWO	5	73	L	0.607	255	8
Hornsea Project Four	5	119	O	0.888	846	38
Total						**243**
% of North Sea MU reference population (345,373 harbour porpoise)						**0.07%**

[1]Norfolk Boreas overlaps SCANS-III survey block O & L; therefore, higher density estimate from survey block O is used.
[2]Sofia overlaps SCANS-III survey block O & N, but majority of site is in block O.
[3]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.
*Source: http://www.4coffshore.com/

8.3.1.5.8. Summary of potential in-combination effects for Norfolk Boreas and all other projects and plans

1129. Table 8.55 summarises the potential in-combination effects for harbour porpoise during the construction period at Norfolk Boreas. The in-combination effects during operation and maintenance or decommissioning would be less than those assessed for construction.

Table 8.55 Summary of the potential in-combination effects for Norfolk Boreas

Potential Effect	Assessment in relation to the North Sea MU population	Spatial assessment in relation to the SAC summer and winter areas	Potential adverse effect on site integrity
Disturbance from underwater noise	14,043-16,579 harbour porpoise (4-4.8% of NS MU)	Average overlap with summer SNS SAC area = 6,774-9,222km^2 (25.1-34.1%) Average overlap with winter SNS SAC area = 3,067-5,515km^{2}518 (24.2-43.4%)	Norfolk Boreas 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 Boreas and other offshore wind farm projects. This would be addressed through the MMMP or a Site Integrity Plan. With the use of 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 SAC 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 underwater noise.

8.3.2. The Wash and North Norfolk Coast SAC

8.3.2.1. Potential disturbance of seals foraging at sea

8.3.2.1.1. Potential overall disturbance effects during UXO clearance and piling at Norfolk Boreas (alone)

1130. Only one UXO would be detonated at a time during UXO clearance operations at Norfolk Boreas; there would be no concurrent UXO detonations.

1131. 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 Norfolk Boreas site.

1132. 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 harbour seal reference population, South-east MU and the Wash and North Norfolk Coast SAC and the grey seal reference population and South-east MU (Table 8.56).

1133. The Wash and North Norfolk Coast SAC is located approximately 110km from Norfolk Boreas site and 34km 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 offshore project 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 Boreas, therefore, **there is no adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1134. 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 during UXO clearance and piling based on 26km range for Norfolk Boreas alone

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Piling in Norfolk Boreas site (2,124km^2) and UXO event in cable corridor (2,124km^2)	0.2 harbour seal in offshore wind farm area (based on offshore wind farm area density of 0.0001/km^2); and 42.5 harbour seal in cable corridor area (based on offshore cable corridor and project interconnector search area density of 0.02/km^2)	0.1% of ref pop; or 0.8% of SE England MU; or 1.3% of Wash and North Norfolk Coast SAC.
	2 grey seal in offshore wind farm area (based on offshore wind farm density of 0.001/km^2); and	0.8% of ref pop; or 2.8% of SE England MU.

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
	170 grey seal in offshore cable corridor (based on offshore cable corridor and project interconnector search area density of 0.08/km^2).	

8.3.2.1.2. Potential overall disturbance effects during piling and other construction activities, including vessels at Norfolk Boreas (alone)

1135. As a worst-case scenario, it is assumed the piling is undertaken at the Norfolk Boreas site and construction activities are underway within the project interconnector search areas and the cable corridor with no overlap in the areas of potential disturbance and all seal are disturbed (Table 8.57). Under these circumstances, it is estimated that 0.3% or less of harbour seal from the Wash and North Norfolk Coast SAC or 0.6% or less of the grey seal South-east MU population would be temporarily disturbed, therefore **there is no adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1136. The Wash and North Norfolk Coast SAC is located approximately 110km from the Norfolk Boreas site and 34km 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 offshore project area are from the Wash and North Norfolk Coast SAC, therefore, **there is no adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1137. There would be no direct effect or overlap with the Wash and North Norfolk Coast SAC area.

Table 8.57 Estimated maximum number of harbour and grey seal potentially disturbed during piling and other construction activities and vessels at Norfolk Boreas 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 the Norfolk Boreas site, plus disturbance at in the project interconnector search area (227km^2) and cable corridor (226km^2)	0.2 harbour seal in offshore wind farm area (based on offshore wind farm area density of 0.0001/km^2); and 9 harbour seal in cable corridor area (based on offshore cable corridor and project interconnector search area density of 0.02/km^2).	0.02% of ref pop; or 0.2% of SE England MU; or 0.3% of Wash and North Norfolk Coast SAC.
	2 grey seal in offshore wind farm area (based on Norfolk Boreas site density of 0.001/km^2); and 36 grey seal in offshore cable corridor (based on offshore cable corridor and	0.2% of ref pop; or 0.6% of SE England MU.

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
	project interconnector search area density of 0.08/km^2).	

8.3.2.1.3. Potential disturbance during construction, other than UXO clearance and piling, at Norfolk Boreas (alone)

1138. 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 offshore project area; this includes any potential disturbance from vessels and any changes in prey availability (Table 8.58). Under these circumstances, it is estimated that 0.3% or less of harbour seal from the Wash and North Norfolk Coast SAC or 0.6% or less of the grey seal South-east MU population would be temporarily disturbed, therefore, **there is no adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1139. The Wash and North Norfolk Coast SAC is located approximately 110km from the Norfolk Boreas site and 34km 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 Boreas offshore project area are from the Wash and North Norfolk Coast SAC, therefore, **there is no adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1140. There would be no direct effect or overlap with the Wash and North Norfolk Coast SAC area.

Table 8.58 Estimated maximum number of harbour and grey seal potentially disturbed from the offshore project area

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Area of disturbance from underwater noise during construction activity, including vessels at the Norfolk Boreas site (725km^2), project interconnector search areas (227km^2) and cable corridor (226km^2)	0.07 harbour seal in offshore wind farm area (based on offshore wind farm area density of 0.0001/km^2); and 9 harbour seal in cable corridor area (based on offshore cable corridor and project interconnector search area density of 0.02/km^2).	0.02% of ref pop; or 0.2% of SE England MU; or 0.3% of Wash and North Norfolk Coast SAC.
	0.7 grey seal in offshore wind farm areas (based on offshore wind farm density of 0.001/km^2); and 36 grey seal in offshore cable corridor (based on offshore cable corridor and	0.2% of ref pop; or 0.6% of SE England MU.

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
	project interconnector search area density of 0.08/km^2).	

8.3.2.1.4. Potential disturbance during operation and maintenance at Norfolk Boreas (alone)

1141. 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 offshore project area; this includes any potential disturbance from operational turbines, maintenance activities, vessels and any changes in prey availability (Table 8.58). Under these circumstances, it is estimated that 0.3% or less of harbour seal from the Wash and North Norfolk Coast SAC or 0.6% or less of then grey seal South-east MU population would be temporarily disturbed, therefore, **there is no adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1142. The Wash and North Norfolk Coast SAC is located approximately 110km from the Norfolk Boreas site and 34km 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 Boreas offshore project area are from the Wash and North Norfolk Coast SAC, therefore, **there is no adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1143. There would be no direct effect or overlap with the Wash and North Norfolk Coast SAC area.

8.3.2.1.5. Potential disturbance during decommissioning at Norfolk Boreas (alone)

1144. 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 offshore project area ; this includes any potential disturbance from foundation removal, other activities, vessels and any changes in prey availability (Table 8.58). Under these circumstances, it is estimated that 0.3% or less of harbour seal from the Wash and North Norfolk Coast SAC harbour seal population or 0.6% or less of the grey seal South-east MU population would be temporarily disturbed, therefore, **there is no adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1145. The Wash and North Norfolk Coast SAC is located approximately 110km from the Norfolk Boreas site and 34km 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 Boreas offshore project area are from the Wash and North Norfolk Coast SAC, therefore, **there is no adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1146. There would be no direct effect or overlap with the Wash and North Norfolk Coast SAC area.

8.3.2.1.6. Potential in-combination effects for Norfolk Boreas and all other projects and plans

1147. Table 8.59 summarises the potential in-combination effects for harbour and grey seal, based on the same approach as assessed for harbour porpoise, during the construction period at Norfolk Boreas. The in-combination effects during operation and maintenance or decommissioning would be less than those assessed for construction.

1148. 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 0.6% and 6.9% 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 adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

Table 8.59 In-combination effects for the potential disturbance of all harbour and grey seal from all other possible noise sources during piling at Norfolk Boreas 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 Offshore Wind Farm projects, including Norfolk Boreas, with the potential of single piling at the same time	10,620km^2	471[1]	22[1]
UXO clearance (up to 2 operations)	4,248km^2	425[3]	85[3]
Seismic surveys (up to 2 surveys)	628km^2	63[3]	13[3]

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 Offshore Wind Farm construction activities (i.e. Offshore Wind Farms that are not piling but potential construction activities) and 100% disturbance	2,112km^2	230[4]	40[4]
Operation and maintenance of UK and European Offshore Wind Farms and 100% disturbance	1,832km^2	275[5]	97[5]
Total		**1,464**	**257**
% of reference population (22,290 grey seal; 43,161 harbour seal)		**6.6%**	**0.6%**
% of South-east MU (6,085 grey seal; 5,061 harbour seal)		**24%**	**5.1%**
% of Wash and North Norfolk Coast SAC (3,377 harbour seal)		**N/A**	**7.6%**

[1]based on the Russell et al (2017) seals at sea density for each project (plus 26km buffer) with the potential for piling at the same time as Norfolk Boreas (Creyke Beck A, Teesside A, Hornsea Project Four and East Anglia ONE North).
[3]based on the Russell et al (2017) grey seals at sea density maps and an average density based on a 50km buffer around all Offshore Wind Farm included in the in-combination assessment; 0.1/km^2 and 0.02/km^2 for harbour seal.
[4]based on the Russell et al (2017) seals at sea density for each project with the potential for construction activities, other than piling, at the same time as Norfolk Boreas piling.
[5]based on the Russell et al (2017) seals at sea density for each project with the potential for operation and maintenance activities at the same time as Norfolk Boreas piling.

8.3.2.2. Disturbance at seal haul-out sites

1149. The HRA screening identified the potential for vessels associated with Norfolk Boreas 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 Boreas 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.

1150. 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.

1151. 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.

1152. Therefore, it is concluded that there would be **no adverse effect on the integrity of the SAC in relation to the conservation objectives for harbour seal.**

8.3.2.3. Vessel interaction (collision risk)

1153. The construction port to be used for Norfolk Boreas 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 Boreas are estimated to be an average of two per day.

1154. 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.

1155. 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.

1156. Therefore, it is concluded that **there would be no adverse effect on the integrity of the SAC in relation to the conservation objectives for harbour seal**.

8.3.2.4. Potential overall effects for disturbance at seal haul-out sites and vessel interaction

1157. 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.

1158. 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.

1159. 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 adverse effect on the integrity of the SAC in relation to the conservation objectives for harbour seal**.

8.3.2.5. Changes in water quality

1160. Disturbance of seabed sediments 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. The accidental release of contaminants (e.g. through spillage) also has the potential to affect water quality. There is the potential for increased suspended sediments.

1161. However, as outlined in section 8.3.1.1.7, 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 and the re-suspension of contaminated sediment from construction activities is anticipated to be negligible.

1162. Any increase in suspended sediments as a result of construction activities, such as installation of foundations, cable installation and during any levelling or dredging activities, would be temporary and over a relatively small area, as the majority of the sediment released during seabed preparation would be coarse and would fall within seconds / minutes) to the seabed as a highly turbid dynamic plume immediately upon its discharge (within tens of metres along the axis of tidal flow).

1163. Therefore, any changes to water quality during construction or decommissioning is highly unlikely to have a significant, if any, impact on foraging grey and harbour seal. Therefore, it is concluded that there would be **no adverse effect on the integrity of the SAC in relation to the conservation objectives for harbour seal**.

1164. There would be no additional effects to those assessed for the disturbance of foraging seals, as the areas and duration of any potential changes in water quality would be within those assessed for underwater noise disturbance.

1165. There would also be no potential for any in-combination effects for any changes in water quality.

8.3.2.6. Changes to prey resource

1166. 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 reference 6.1).

1167. As outlined in section 8.3.1.1.6, additional underwater noise modelling was undertaken to assess the effects using a stationary animal approach on cumulative exposure. This is considered to be a highly precautionary approach, as it is unlikely that an individual would remain within the vicinity of the high noise levels of piling activity. For stationary fish species, exposed to piling noise over 12 hours, a maximum impact range of 18km was determined for the onset of TTS in all fish species.

1168. The maximum (worst-case scenario) potential area of physical disturbance and/or temporary loss of habitat to fish during construction could be 15.4km^2 in total for the wind farm site (this would account for a very small proportion (2.1%) of the area of the wind farm site); 6.07km^2 for the offshore cable corridor; and 1.84km^2 in the project interconnector search area. The total area of potential habitat loss during construction is estimated to be up to 23.31km^2.

1169. The potential of effect on prey from any increased suspended sediment concentrations and sediment re-deposition would be low (maximum volume of increased suspended sediments and sediment re-deposition is 0.054km^3), with only a small proportion of fine sand and mud staying in suspension long enough to form a passive plume.

1170. Potential effects on fish species during operation and maintenance can result from permanent loss of habitat; introduction of hard substrate; operational noise; and EMF. 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. Studies at operational offshore wind farms, indicate that 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. 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 again be not significant.

1171. As a precautionary worst-case scenario, the number of grey and harbour seal that could be affected as a result of changes to prey resources during construction and operation has been assessed based on the number of animals that could be present in the offshore project area (Table 8.58). However, it is highly unlikely that any changes in prey resources could occur over the entire offshore project area during construction or operation. It is more likely that effects would be restricted to an area around the working sites.

1172. It should also be noted that the total area of offshore construction works would be less than as assessed, as either the interconnector cables or the project interconnector cables (and therefore project areas), would be constructed, dependant on whether Norfolk Vanguard is built. Under no circumstance would construction take place for both the interconnector cable and the project interconnector cable.

1173. Under these circumstances, it is estimated that 0.3% or less of harbour seal from the Wash and North Norfolk Coast SAC or 0.6% or less of the grey seal South-east MU population could be affected by any changes in prey esources, therefore, **there is no adverse effect on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal**.

1174. There would be no additional effects to those assessed for the disturbance of foraging seals, as the areas and duration of any potential changes in prey resources would be within those assessed for underwater noise disturbance.

1175. There would also be no potential for any further in-combination effects for any changes in prey resources in addition to those assessed for for the disturbance of foraging seals.

8.3.3. Humber Estuary SAC

8.3.3.1. Potential disturbance of seals foraging at sea

8.3.3.1.1. Potential overall disturbance effects during UXO clearance at Norfolk Boreas (alone)

1176. Only one UXO would be detonated at a time during UXO clearance operation at Norfolk Boreas; there would be no concurrent UXO detonations.

1177. 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 Norfolk Boreas site.

1178. 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 8.60).

1179. The Humber Estuary SAC is located 175km from Norfolk Boreas Offshore Wind Farm 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 offshore project area are all from the Humber Estuary SAC. It is also unlikely that UXO clearance and piling would be undertaken at the same time during the construction of Norfolk Boreas, therefore, **there is no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1180. There would be no direct effect or overlap with the Humber SAC area.

Table 8.60 Estimated maximum number of grey seal potentially disturbed during UXO clearance and piling based on 26km range for Norfolk Boreas 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 or project interconnector search areas (2,124km^2)	2 grey seal in offshore wind farm area (based on offshore wind farm density of 0.001/km^2); and 170 grey seal in offshore cable corridor (based on worst-case offshore cable corridor or project interconnector search area density of 0.08/km^2).	0.8% of ref pop; or 2.8% of SE England MU; or 4.3% of Humber Estuary SAC.

8.3.3.1.2. Potential overall disturbance effects during piling at Norfolk Boreas (alone)

1181. As a worst-case scenario, it is assumed that piling is undertaken at the Norfolk Boreas site and construction activities are underway within the project interconnector search areas and the cable corridor. It is assumed that all seals are disturbed from these areas (Table 8.61). Under these circumstances, it is estimated that up to a maximum of 1.0% of grey seal from the Humber Estuary SAC would be temporarily disturbed, therefore **there is no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1182. The Humber Estuary SAC is located 175km from the Norfolk Boreas site 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 offshore project area are all from the Humber Estuary SAC, therefore **there is no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1183. There would be no direct effect or overlap with the Humber SAC area.

Table 8.61 Estimated maximum number of grey seal potentially disturbed during and other construction activities and vessels at Norfolk Boreas 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 the Norfolk Boreas site, plus disturbance in the project interconnector search areas (227km^2) and cable corridor (226km^2)	2 grey seal in offshore wind farm area (based on offshore wind farm density of 0.001/km^2); and 36 grey seal in offshore cable corridor (based on worst-case project interconnector search area or offshore cable corridor area density of 0.08/km^2).	0.2% of ref pop; or 0.6% of SE England MU; or 1.0% of Humber Estuary SAC.

8.3.3.1.3. Potential disturbance during construction, other than UXO clearance and piling, at Norfolk Boreas (alone)

1184. 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 offshore project area; this includes any potential disturbance from vessels and any changes in prey availability (Table 8.62). Under these circumstances, it is estimated that up to a maximum of 0.9% of grey seal from the potential Humber Estuary SAC would be temporarily disturbed, therefore, **there is no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1185. The Humber Estuary SAC is located 175km from Norfolk Boreas site 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 Boreas offshore project area are all from the Humber Estuary SAC, therefore **there is no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1186. There would be no direct effect or overlap with the Humber SAC area.

Table 8.62 Estimated maximum number of grey seal potentially disturbed from the offshore project area

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Area of disturbance from underwater noise during construction activity, including vessels at the Norfolk Boreas site (725km^2), project interconnector search areas (227km^2) and cable corridor (226km^2)	1 grey seal in offshore wind farm areas (based on offshore wind farm density of 0.001/km^2); and 36 grey seal in offshore cable corridor (based on worst-case project interconnector search area or offshore cable corridor area density of 0.08/km^2).	0.2% of ref pop; or 0.6% of SE England MU; or 0.9% of Humber Estuary SAC.

8.3.3.1.4. Potential disturbance during operation and maintenance at Norfolk Boreas (alone)

1187. 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 offshore project area, this includes any potential disturbance from operational turbines, maintenance activities, vessels and any changes in prey availability (Table 8.62). Under these circumstances, it is estimated that up to a maximum of 0.9% of grey seal from the Humber Estuary SAC would be temporarily disturbed, therefore, **there is no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1188. The Humber Estuary SAC is located 175km from the Norfolk Boreas site 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 offshore project area are from the Humber Estuary SAC, therefore **there is no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1189. There would be no direct effect or overlap with the Humber SAC area.

8.3.3.1.5. Potential disturbance during decommissioning at Norfolk Boreas (alone)

1190. 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 offshore project area; this includes any potential disturbance from foundation removal, other activities, vessels and any changes in prey availability (Table 8.62). Under these circumstances, it is estimated that up to a maximum of 0.9% of grey seal from the Humber Estuary SAC would be temporarily disturbed, therefore, **there is no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1191. The Humber Estuary SAC is located 175km from the Norfolk Boreas Offshore Wind Farm 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 offshore project area are all from the Humber Estuary SAC, therefore **there is no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1192. There would be no direct effect or overlap with the Humber SAC area.

8.3.3.1.6. Potential in-combination effects for Norfolk Boreas and all other projects and plans

1193. Table 8.63 summarises the potential in-combination effects for grey seal, based on the same approach as assessed for harbour porpoise, during the construction period at Norfolk Boreas. The in-combination effects during operation and maintenance or decommissioning would be less than those assessed for construction.

1194. 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 6.9% 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 adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

Table 8.63 In-combination effects for the potential disturbance of all grey seal from all other possible noise sources during piling at Norfolk Boreas based on worst-case scenario

Potential noise sources during Norfolk Boreas piling	Area of potential disturbance	Potential number of grey seal disturbed
UK and European Offshore Wind Farm projects, including Norfolk Boreas, with the potential of single piling at the same time	10,620km^2	471[1]
UXO clearance (up to 2 operations)	4,248km^2	425[3]
Seismic surveys (up to 2 surveys)	628km^2	63[3]
UK and European Offshore Wind Farm construction activities (i.e. Offshore Wind Farms that are not piling but potential construction activities) and 100% disturbance	2,112km^2	230[4]
Operation and maintenance of UK and European Offshore Wind Farms and 100% disturbance	1,832km^2	275[5]
Total		**1,464**
% of reference population (22,290 grey seal)		**6.6%**
% of South-east MU (6,085 grey seal)		**24%**
% of Humber Estuary SAC (3,964 grey seal)		**37%**

[1]based on the Russell et al (2017) seals at sea density for each project (plus 26km buffer) with the potential for piling at the same time as Norfolk Boreas (Creyke Beck A, Teesside A, Hornsea Project Four and East Anglia ONE North).
[3]based on the Russell et al (2017) grey seals at sea density maps and an average density based on a 50km buffer around all Offshore Wind Farm included in the in-combination assessment; 0.1/km^2.
[4]based on the Russell et al (2017) seals at sea density for each project with the potential for construction activities, other than piling, at the same time as Norfolk Boreas piling.
[5]based on the Russell et al (2017) seals at sea density for each project with the potential for operation and maintenance activities at the same time as Norfolk Boreas piling.

8.3.3.2. Disturbance at seal haul-out sites

1195. The HRA screening identified the potential for vessels associated with Norfolk Boreas 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.

1196. 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.

1197. 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.

1198. 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).

1199. Whether during construction, operation or decommissioning phases of the project, 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.

1200. 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.

8.3.3.3. Vessel interaction (collision risk)

1201. The construction port to be used for Norfolk Boreas 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.

1202. 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.

1203. Therefore, it is concluded that there would be **no adverse effect on the integrity of the SAC in relation to the conservation objectives for grey seal**.

8.3.3.4. Potential overall effects for disturbance at seal haul-out sites and vessel interaction

1204. 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.

1205. During the construction of Offshore Wind Farms, 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 Offshore Wind Farm construction would be part of the current baseline for vessels.

1206. Any increase in vessel movements during the operation and maintenance of Offshore Wind Farms would be relatively small in relation to current ship movements in the area. Therefore, there is unlikely to be any significant effect.

1207. 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.

1208. 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 adverse effect on the integrity of the SAC in relation to the conservation objectives for grey seal**.

8.3.3.5. Changes in water quality

1209. As outlined in section 8.3.1.1.7, 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 and the re-suspension of contaminated sediment from construction activities is anticipated to be negligible.

1210. Any increase in suspended sediments as a result of construction activities, such as installation of foundations, cable installation and during any levelling or dredging activities, would be temporary and over a relatively small area, as the majority of the sediment released during seabed preparation would be coarse and would fall within seconds / minutes) to the seabed as a highly turbid dynamic plume immediately upon its discharge (within tens of metres along the axis of tidal flow).

1211. Therefore, any changes to water quality during construction or decommissioning is highly unlikely to have a significant, if any, impact on foraging grey seal. Therefore, it is concluded that there would be **no adverse effect on the integrity of the SAC in relation to the conservation objectives for grey seal**.

1212. There would be no additional effects to those assessed for the disturbance of foraging seals, as the areas and duration of any potential changes in water quality would be within those assessed for underwater noise disturbance.

1213. There would also be no potential for any in-combination effects for any changes in water quality.

8.3.3.6. Changes to prey resource

1214. As outlined in section 8.3.1.1.6, additional underwater noise modelling was undertaken to assess the effects using a stationary animal approach on cumulative exposure. This is considered to be a highly precautionary approach, as it is unlikely that an individual would remain within the vicinity of the high noise levels of piling activity. For stationary fish species, exposed to piling noise over 12 hours, a maximum impact range of 18km was determined for the onset of TTS in all fish species.

1215. The maximum (worst-case scenario) potential area of physical disturbance and/or temporary loss of habitat to fish during construction could be 15.4km^2 in total for the wind farm site (this would account for a very small proportion (2.1%) of the area of the wind farm site); 6.07km^2 for the offshore cable corridor; and 1.84km^2 in the project interconnector search area. The total area of potential habitat loss during construction is estimated to be up to 23.31km^2.

1216. The potential of effect on prey from any increased suspended sediment concentrations and sediment re-deposition would be low (maximum volume of increased suspended sediments and sediment re-deposition is 0.054km^3), with only a small proportion of fine sand and mud staying in suspension long enough to form a passive plume.

1217. Potential effects on fish species during operation and maintenance can result from permanent loss of habitat; introduction of hard substrate; operational noise; and EMF. 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. Studies at operational offshore wind farms, indicate that 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. 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 again be not significant.

1218. As a precautionary worst-case scenario, the number of grey seal that could be affected as a result of changes to prey resources during construction and operation has been assessed based on the number of animals that could be present in the offshore project area (Table 8.62). However, it is highly unlikely that any changes in prey resources could occur over the entire offshore project area during construction or operation. It is more likely that effects would be restricted to an area around the working sites.

1219. It should also be noted that the total area of offshore construction works would be less than as assessed, as either the interconnector cables or the project interconnector cables (and therefore project areas), would be constructed, dependant on whether Norfolk Vanguard is built. Under no circumstance would construction take place for both the interconnector cable and the project interconnector cable.

1220. Under these circumstances, it is estimated that 0.9% or less of grey seal from the Humber Estuary SAC could be affected by any changes in prey esources, therefore, **there is no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal**.

1221. There would be no additional effects to those assessed for the disturbance of foraging seals, as the areas and duration of any potential changes in prey resources would be within those assessed for underwater noise disturbance.

1222. There would also be no potential for any further in-combination effects for any changes in prey resources in addition to those assessed for for the disturbance of foraging seals.

8.3.4. Winterton-Horsey Dunes SAC

1223. 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.

8.3.4.1. Potential disturbance of grey seal in the cable corridor

1224. As outlined above, the landfall at Happisburgh South is approximately 9km from the Horsey seal haul-out site to the south of the landfall search area. Given the distances between the Norfolk Boreas 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.

1225. 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 8.64). 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, it is concluded that there should be no potential for any significant effects on seals from the site.

1226. 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 offshore cable corridor area are all from the Winterton-Horsey Dunes SAC.

1227. There would be no direct effect or overlap with the Winterton-Horsey Dunes SAC area.

1228. There are currently no known or anticipated further activities, other than current baseline levels of vessel activity in the offshore cable corridor area, therefore there are no further in-combination effects for grey seal in this area.

Table 8.64 Estimated maximum number of grey seal potentially disturbed from the offshore cable corridor

Potential Effect	Estimated maximum number potentially disturbed	% of reference population
Area of disturbance / cable corridor (226km^2)	36 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.

8.3.4.2. Disturbance at seal haul-out sites

1229. As outlined above, vessels would be highly unlikely to be within 300m of the coast, except within the offshore cable corridor, therefore there would be no potential to directly disturb seals hauled out at sites in the Winterton-Horsey Dunes SAC.

1230. The landfall at Happisburgh South is approximately 9km from the Horsey seal haul-out site to the south of the landfall search area. Given the distances between the Norfolk Boreas 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.

1231. Therefore, it is concluded that there would be no potential for any significant effects on seals hauled-out at the site.

8.3.4.3. Vessel interaction (collision risk)

1232. The construction port to be used for Norfolk Boreas 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 Boreas are estimated to be an average of two per day.

1233. 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.

1234. 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.

1235. Therefore, it is concluded that there would be no potential for any significant effects on seals from the site.

8.3.4.4. Potential overall effects for disturbance at seal haul-out sites and vessel interaction

1236. 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.

1237. 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.

1238. 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.

8.3.4.5. Changes in water quality

1239. As outlined in section 8.3.1.1.7, 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 and the re-suspension of contaminated sediment from construction activities is anticipated to be negligible.

1240. Any increase in suspended sediments as a result of construction activities in the cable corridor, such as cable installation and during any levelling or dredging activities, would be temporary and over a relatively small area, as the majority of the sediment released during seabed preparation would be coarse and would fall within seconds / minutes) to the seabed as a highly turbid dynamic plume immediately upon its discharge (within tens of metres along the axis of tidal flow).

1241. Therefore, any changes to water quality during construction or decommissioning in the cable corridor is highly unlikely to have a significant, if any, impact on grey seal.

1242. There would also be no potential for any in-combination effects for any changes in water quality.

8.3.4.6. Changes to prey resource

1243. As a precautionary worst-case scenario, the number of grey seal that could be affected as a result of changes to prey resources during construction and operation has been assessed based on the number of animals that could be present in the cable corridor area (Table 8.64). However, it is highly unlikely that any changes in prey resources could occur over the entire cable corridor area during construction or operation. It is more likely that effects would be restricted to an area around the working sites.

1244. 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 affected by any changes in prey resources, therefore, it is concluded that there should be no potential for any significant effects on seals from the site.

1245. There would be no additional effects to those assessed for the disturbance of foraging seals, as the areas and duration of any potential changes in prey resources would be within those assessed for underwater noise disturbance.

8.3.5. Other European Designated Sites Where Grey and Harbour Seal are a Qualifying Feature

1246. Table 8.65 summarises the assessment of potential disturbance of foraging seals from underwater noise for other European Designated Site that were screened in for further assessment as grey and / or harbour seal are a qualifying feature.

1247. All these European Designated Site use the OSPAR Conservation Objectives, with some sites also having sites reiterate individual objectives:

- To maintain, conserve or restore biodiversity, natural heritage, habitats, species or landscapes with legal protection status;
- To maintain key ecological functions (Spawning areas, nursery grounds, feeding zones, resting areas, areas of high productivity, etc.);
- To manage the exploitation of natural resources;
- To improve governance on MPA territory;
- To educate on environmental issues and improve public awareness;
- To foster scientific research; and
- To create added socio-economic values.

1248. The assessment uses the same approach as the assessment of the potential disturbance of foraging grey and harbour seal for The Wash and North Norfolk Coast SAC.

1249. As summarised in Table 8.59, piling at offshore windfarm projects; offshore windfarm construction activities and vessels; offshore windfarm operation and maintenance, including vessels; up to two UXO clearance operations; and up to two seismic surveys has a maximum total area of up to 19,440km^2, as a worst-case scenario. The maximum of 257 harbour seal (0.6% of reference population) and up to 1,464 grey seal (6.6% of reference population) could potentially be temporarily disturbed.

1250. Disturbance from in-combination effects, including Norfolk Boreas, of underwater noise is unlikely to be any significant disturbance or barrier effects for foraging harbour and grey seal, especially taking into the SIP proposed for harbour porpoise in the Southern North Sea SAC. Under these circumstances, there is **no adverse effect on the integrity of the other European Designated Sites in relation to the conservation objectives for grey seal and harbour seal.**

Table 8.65 Assessment of potential disturbance of foraging seals from underwater noise for other European Designated Site that were screened in for grey and / or harbour seal

European Designated Site	Distance from Norfolk Boreas	Screened in for	Species Status and Ecology	European Designated Site Conservation Objectives	Assessment of potential disturbance of foraging seals	Potential adverse effect on site integrity in relation to the conservation objectives
Klaverbank SAC (NL2008002)	67km	Harbour seal and grey seal	Harbour seal population = unknown Grey seal population = unknown	OSPAR Conservation Objectives	Up to 1,464 grey seal (6.6% of reference population). Up to 257 harbour seal (0.6% of reference population). Not all from this site alone.	**No**
Noordzeekustzone SAC (NL9802001)	94km	Grey seal	Grey seal population = 3,000	OSPAR Conservation Objectives, plus to maintain the	Up to 1,464 grey seal (6.6% of in-combination	**No**

European Designated Site	Distance from Norfolk Boreas	Screened in for	Species Status and Ecology	European Designated Site Conservation Objectives	Assessment of potential disturbance of foraging seals	Potential adverse effect on site integrity in relation to the conservation objectives
				habitat extent and quality, maintain population levels.	reference population). Not all from this site alone.	

8.4. Mitigation and Management

8.4.1. Proposed Management and Mitigation of Potential Effects on Harbour Porpoise

8.4.1.1. UXO Clearance

1251. 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

1252. 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.

1253. A draft MMMP for piling (document reference 8.13) has been submitted with the DCO Application.

1254. 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.

1255. In addition to the MMMP, a Norfolk Boreas Southern North Sea SAC SIP will be developed (based on the In Principle SIP that has been 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 SAC and therefore allow the conclusion of 'no adverse effect beyond reasonable scientific doubt'.

8.4.1.3. Water quality

1256. As outlined in the ES Chapter 9 Marine Water and Sediment Quality (document reference 6.1), Norfolk Boreas 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. An outline PEMP will be 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.
- Where possible, structures would be transported to site having been pre-assembled or manufactured on land.
- Where grout is required, careful use would be ensured at all times to avoid excess grout being discharged into the environment.
- 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 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 I 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

1257. Mitigation for in-combination disturbance effects will be discussed with the relevant SNCBs and MMO.

1258. 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 SAC for harbour porpoise (Natural England, June 2017) that:

- Displacement of harbour porpoise should not exceed 20% of the seasonal component of the SAC area at any one time and / or on average exceed 10% of the seasonal component of the SAC area over the duration of that season

1259. In order to address the overall potential in-combination effects, Norfolk Boreas 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) that have been submitted with the DCO application) and would be based on the final design of Norfolk Boreas and the actual in-combination scenarios resulting from the final design and programmes of other projects.

1260. In the absence of current management measures for the Southern North Sea SAC, Norfolk Boreas Limited is confident that their commitment to develop a MMMP and the Norfolk Boreas Southern North Sea SAC 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 adverse effect on the integrity of the Southern North Sea SAC as defined by its conservation objectives.

1261. 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

1262. The assessment of the potential effects during the construction of Norfolk Boreas alone and in-combination has been summarised in relation to the Conservation Objectives of the European Designated Sites where harbour porpoise (Table 8.66), grey seal (Table 8.67) and harbour seal (Table 8.68) are a qualifying feature. Integrity matrices are provided in Appendix 6.1.

Table 8.66 Summary of the assessment of the potential effects of Norfolk Boreas (alone and in-combination) on the Southern North Sea SAC in relation to the draft Conservation Objectives for harbour porpoise

Conservation Objectives	Potential effect	Potential for adverse effect on the integrity alone?	Potential for adverse effect on the integrity in-combination?
Harbour porpoise is a viable component of the site	Disturbance from underwater noise	×	×
	Increased collision risk	×	×
	Changes to prey resources	×	×
There is no significant disturbance of the species	Disturbance from underwater noise	× with SIP	×
	Increased collision risk	×	×
	Changes to prey resources	×	×
The condition of supporting habitats and processes, and the availability of prey is maintained	Disturbance from underwater noise	×	×
	Increased collision risk	×	×
	Changes to prey resources	×	×

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

Table 8.67 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	Potential effect	Potential for adverse effect on the integrity alone?	Potential for adverse effect on the integrity in-combination?
The extent and distribution of qualifying natural habitats and habitats of qualifying species.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×
The structure and function (including typical species) of qualifying natural habitats.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×
The structure and function of the habitats of qualifying species.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×
The supporting processes on which qualifying natural	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision	×	×

Conservation Objective	Potential effect	Potential for adverse effect on the integrity alone?	Potential for adverse effect on the integrity in-combination?
habitats and the habitats of qualifying species rely.	risk)		
The populations of qualifying species.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×
The distribution of qualifying species within the site.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×

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

Table 8.68 Summary of the assessment of the potential effects of Norfolk Boreas (alone and in-combination) on the Wash and North Norfolk Coast SAC in relation to the Conservation Objectives for harbour seal

Conservation Objective	Potential effect	Potential for adverse effect on the integrity alone?	Potential for adverse effect on the integrity in-combination?
The extent and distribution of qualifying natural habitats and habitats of qualifying species.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×
The structure and function (including typical species) of qualifying natural habitats.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×
The structure and function of the habitats of qualifying species.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×
The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×
The populations of qualifying species.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×
The distribution of qualifying species within the site.	Disturbance at seal haul-out sites	×	×
	Vessel interaction (increased collision risk)	×	×

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

1263. It is therefore concluded that the Norfolk Boreas Project would not have an adverse effect on integrity of the Southern North Sea SAC, The Wash and Norfolk Coast SAC, the Humber Estuary SAC, Winterton-Horsey Dunes SAC or other sites where grey or harbour seal are a qualifying feature in view of the conservation objectives of these sites either alone or in combination with other projects/plans.

9. ONSHORE NATURA 2000 SITES

9.1. Baseline and Current Conservation Status

1264. 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

1265. 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 (document reference 6.1.22).

9.1.1. River Wensum SAC

9.1.1.1. Description of Designation

1266. 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.

1267. 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

1268. The site is described in the SAC citation as follows:

1269. "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.

1270. "*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 water crowfoot *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

1271. The SAC intersects the Norfolk Boreas cable route at Elsing. At the point where the SAC is crossed by the cable route, 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 route. The location of the onshore cable route with respect to the SAC boundary and its associated ex-situ habitats is shown in Figure 5.6.

1272. 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, within the cable route. 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.

1273. Following consultation with Natural England during the Norfolk Vanguard 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. Surveys were subsequently undertaken in July 2017 and August – September 2018[23] 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.

1274. These surveys covered the River Wensum within the SAC boundaries and the floodplain habitat on the right-hand (southern) and left-hand (northern) bank of the River Wensum (herein referred to as the 'survey area'). The location of these surveys is shown in Figure 9.1. The scope for this survey was agreed with the Norfolk Vanguard ETG in March 2017 (Royal HaskoningDHV, 2017b).

1275. The River Wensum within the cable route 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*.

1276. 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.

1277. The semi-improved grassland adjacent to the River Wensum consisted of three main NVC communities (following Rodwell, 2006), which were often transitional to each other:

- MG1 - *Arrhenatherum elatius* grassland Festuca rubra sub-community;

[23] Only survey results for the River Wensum and the floodplain habitats on the right-hand (southern) bank of the River Wensum were available to inform the Norfolk Vanguard HRA, due to survey access constraints. Data for the floodplain habitats on left-hand (northern) bank were collected in 2018 and have therefore informed the assessment undertaken for Norfolk Boreas.

- MG6 – Lolium perenne-Cynosusus cristatus grassland; and
- MG10 – *Holco-Juncetum effusi* rush pasture.

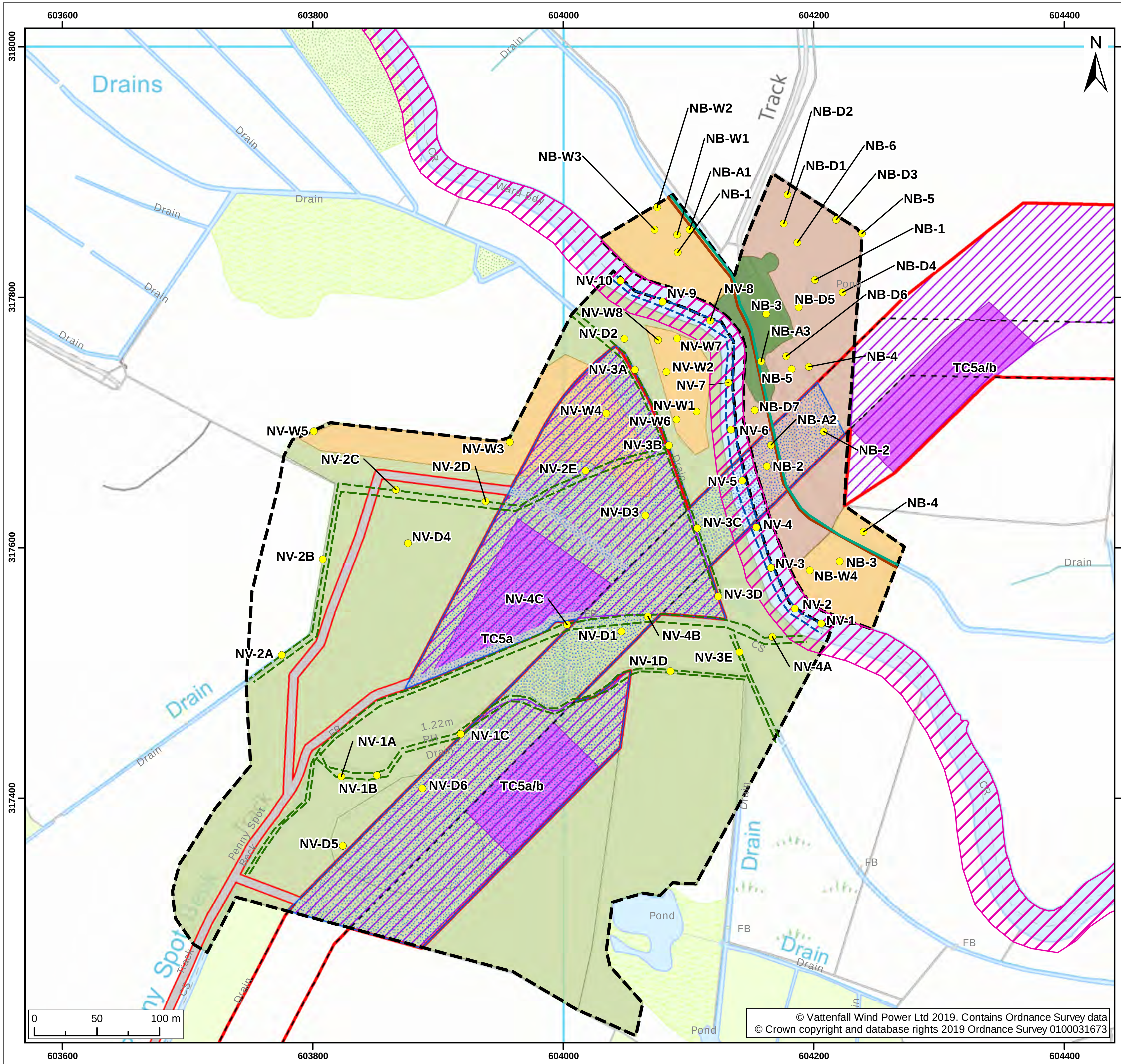
1278. Five separate communities (following Doarks and Leach, 1990) were identified within the drain ditches of the River Wensum floodplain within the survey area:

- 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.*

1279. 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*.

1280. There was no evidence of calcareous ground water spring or seepage activity with the survey area.

1281. The full findings of the botanical survey are shown in Appendix 9.1.



Legend:

Norfolk Boreas red line boundary

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound

Environmental Designations[1]

- Special Area of Conservation (SAC)

Survey Area

- Botanical survey area
- River Wensum floodplain located within the Norfolk Boreas red line boundary
- Ditch surveys[2]
- River Wensum survey[2]

National Vegetation Classification (NVC) survey results[2]

- MG10
- MG6
- MG1
- Woodland
- A5B
- E2
- Sampling locations

[1] Natural England, 2019.
[2] NWS, 2017/2018.

Project: Norfolk Boreas

Report: Habitats Regulations Assessment Report

Title: River Wensum SAC - Botanical survey results

Figure: 9.1 Drawing No: PB5640-007-002-015

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	26/02/2019	LB	GC	A3	1:3,000
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Co-ordinate system: British National Grid **EPSG:** 27700

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9.1.1.3. Desmoulin's whorl snail

9.1.1.3.1. Details of the qualifying feature

1282. 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).

1283. The site is described in the SAC citation as follows:

1284. "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

1285. As noted above, the SAC intersects the Norfolk Boreas cable route at Elsing, and at the point where the SAC is crossed by the cable route, the SAC boundary covers the River Wensum river channel only (i.e. no floodplain habitat). The location of the onshore cable route 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.

1286. 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.

1287. Following consultation with Natural England during the Norfolk Vanguard EPP 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.

1288. Desmoulin's whorl snail surveys of the banks of the River Wensum and the ditches of the floodplain on the southern and northern banks of the River Wensum (the 'survey area') were carried out in August 2017 and August 2018[24], following the monitoring protocol developed by Killen and Morkens (2003). The location of the surveys is shown in Figure 9.2.

1289. 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

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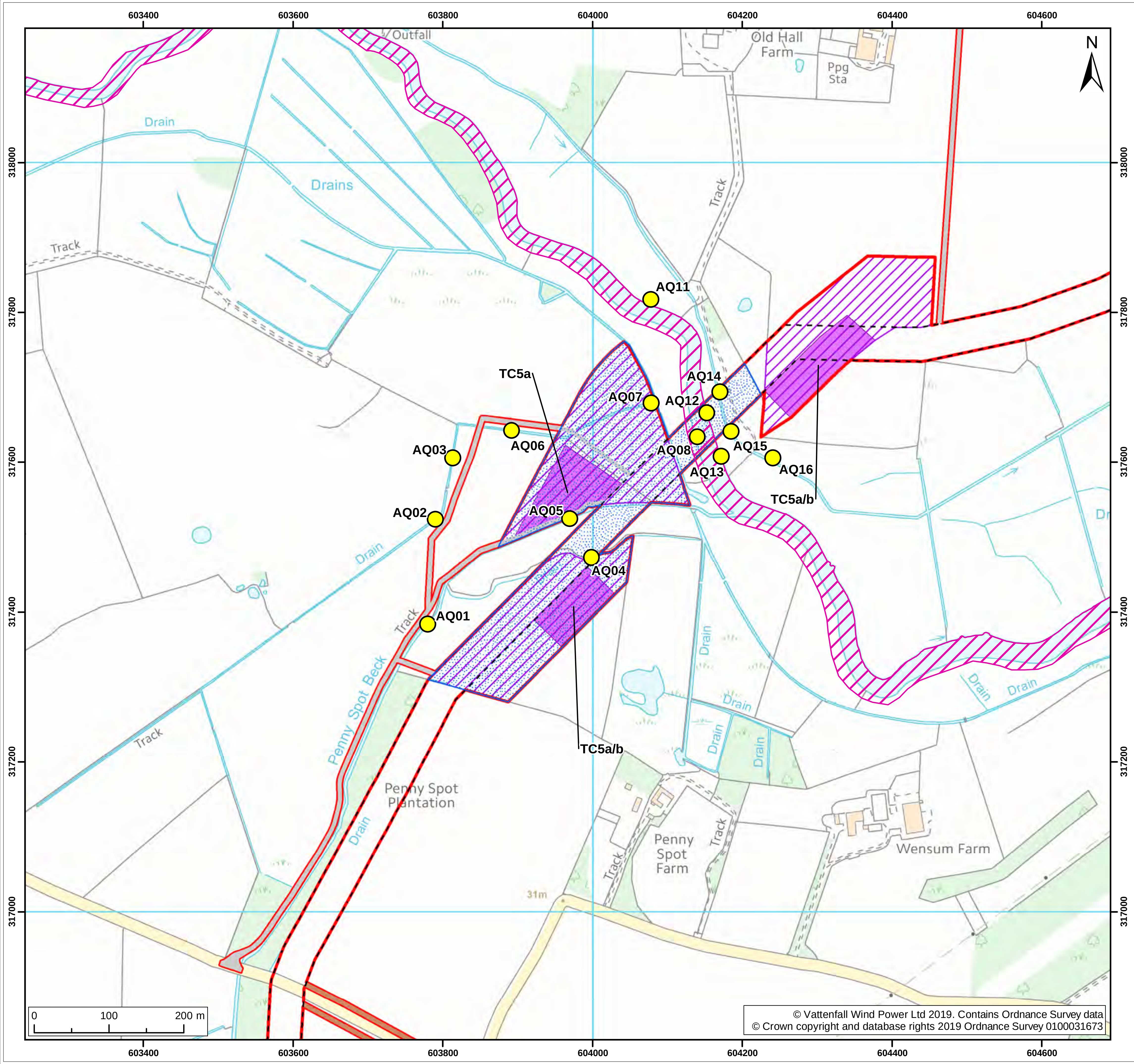
[24] Only survey results for the right-hand (southern) bank of the River Wensum and ditches of the floodplain habitats on the right-hand (southern) bank were available to inform the Norfolk Vanguard HRA, due to survey access constraints. Data for the left-hand (northern) bank and ditches of the floodplain habitats on the left-hand (northern) bank were collected in 2018 and have therefore informed the assessment undertaken for Norfolk Boreas.

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.

1290. The full findings of the Desmoulin's whorl snail survey are shown in Appendix 9.2.



Legend:

Norfolk Boreas red line boundary

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

Onshore cable route

Construction access

Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

Trenchless crossing zone (e.g. HDD)

Indicative trenchless crossing compound

Environmental Designations¹

Special Area of Conservation (SAC)

Survey results²

Invertebrate survey location

Desmoulin's whorl snail likely absent

River Wensum floodplain located within the Norfolk Boreas red line boundary

¹ Natural England, 2019.
² NWS, 2017/2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

River Wensum SAC - Desmoulin's Whorl snail survey results

Figure: 9.2	Drawing No: PB5640-007-002-016			
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Co-ordinate system: British National Grid **EPSG:** 27700

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9.1.1.4. Other qualifying features

1291. 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 Norfolk Vanguard EPP 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

1292. 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

1293. 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 3km 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

1294. 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.

1295. 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).

1296. 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).

1297. 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

1298. The Paston Great Barn SAC is situated approximately 3km 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 study area[25], the land is predominantly arable crop and hedgerows. Extended Phase 1 Habitat Surveys of the land within the onshore project area plus a 50m buffer were undertaken in February 2017 and in February 2018. Table 9.1 summarises the habitats which are present within this 5km study area and their approximate area in hectares (ha) as identified during these Extended Phase 1 Habitat Surveys.

Table 9.1 Habitat footprints within the onshore project area within 5km of Paston Great Barn SAC

Habitat type	Area (ha)
Broadleaved woodland - semi-natural	1.56
Broadleaved woodland - plantation	0.56
Scrub - dense/continuous	0.62
Broadleaved Parkland/scattered trees	0.15
Improved grassland	1.76
Marsh/marshy grassland	4.23
Poor semi-improved grassland	0.68
Standing water	0.11
Cultivated/disturbed land - arable	52.24
Habitat	**Length (m)**
Hedge with trees - native species-rich	533
Hedge with trees - native species-poor	227

1299. The hedgerow habitat listed in Table 9.1 includes 18 separate hedgerows located within the study area. A habitat assessment of the accessible hedgerows was conducted during the Extended Phase 1 Habitat Surveys, and the quality of each hedgerow for supporting commuting or foraging bats was assessed against the criteria set out in Table 4.1 of the BCT bat surveys guidance (Collins, 2016). Through this exercise, 11 of the 12 accessible hedgerows surveyed were identified as providing moderate or high suitability for supporting commuting or foraging bats. All hedgerows which could not be surveyed were assumed to be of moderate or high suitability for supporting commuting or foraging bats (adopting a precautionary principle), therefore 17 of the 18 hedgerows were identified as providing moderate or high suitability.

1300. Table 9.2 below provides a summary of the 18 hedgerows located within the study area that may be affected by the project. It includes details of the quality of the habitat, and its suitability for supporting commuting / foraging bats, based on Table 4.1 of the BCT bat survey guidelines (Collins, 2016).

[25] The process for determining this 5km study area for identifying suitable habitats and for identifying potential effects upon barbastelle bats associated with the Paston Great Barn colony is described in section 9.3.2.

Table 9.2 Hedgerows potentially affected by the project (hedgerow numbering as shown on Important Hedgerows Plan (DCO document 2.11)

Hedgerow	Habitat assessment[26]	Assessed potential for support commuting / foraging bats[27]	Length potentially affected (m)	Quality factors					Further comments
				Height (m)	Width (m)	Gaps/Solid hedge ratio	Aspect	Species composition	
15	Species-poor	Moderate - High	20	5-10	4	0% gappy	E-W facing	Intact species poor.	Hedgerow connected to drainage ditch and rank grassland network foraging habitat at Ridlington Street, which also provides good connectivity in the wider area.
16	Species-poor with trees	Moderate - High	15	3-5	7	0% gappy	E-W facing	Species poor hedgerow with mature trees; hawthorn, oak, bramble, ivy and dry ditch.	As above (Hedgerow 15).
18	N/A	Moderate - High	25	1-2	2	5% gappy	NW-SE facing	[No information available]	No assessment conducted as access was not granted. Under a precautionary principle, these hedgerows are assumed to be of moderate – high suitability for supporting commuting foraging bats.
19	N/A	Moderate - High	23	2-3	3	5% gappy	NE-SW facing	[No information available]	
21	N/A	Moderate - High	23	2-3	3	5% gappy	NE-SW facing	[No information available]	
22	N/A	Moderate - High	25	2-3	3	5% gappy	NW-SE facing	[No information available]	
23	Species-poor with trees	Moderate - High	23	1	3	5% gappy	E-W facing	Intact species poor.	Hedgerows with trees providing minimum shelter and isolated from higher quality areas of foraging

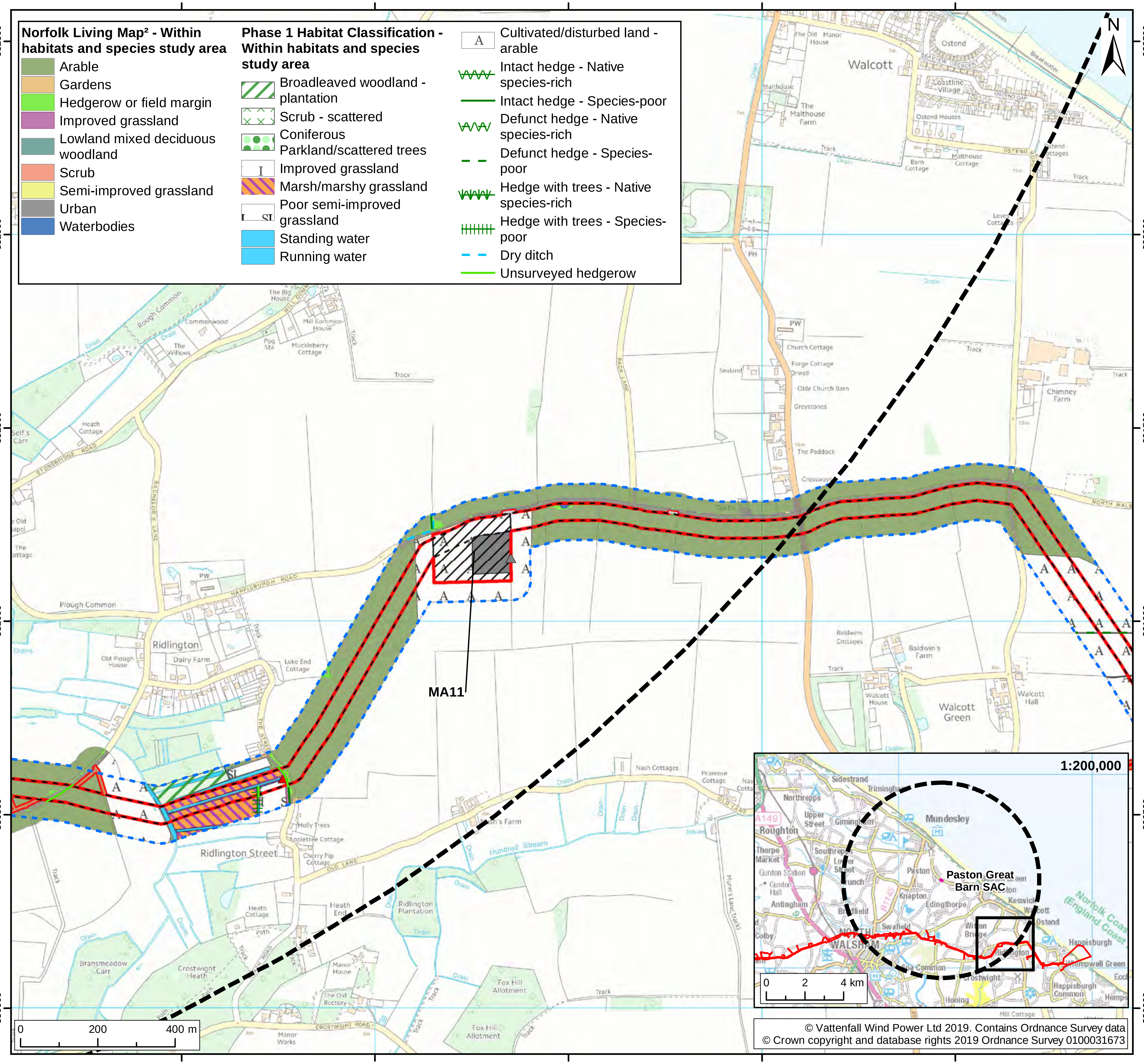
[26] Based on Extended Phase 1 Habitat Surveys conducted in February 2017 and February 2018.
[27] Based on Extended Phase 1 Habitat Surveys conducted in February 2017 and February 2018.

Hedgerow	Habitat assessment[26]	Assessed potential for support commuting / foraging bats[27]	Length potentially affected (m)	Quality factors					Further comments
				Height (m)	Width (m)	Gaps/Solid hedge ratio	Aspect	Species composition	
									habitat. May be important as part of wider commuting / foraging routes.
24	Species-poor with trees	Moderate - High	20	1	3	10% gappy	E-W facing	Intact species poor. Common oak, bramble, hawthorn.	As above Hedgerow 23).
25	N/A	Moderate - High	20	3-5	4	0% gappy	E-W facing	Intact species poor with trees. Common oak, bramble, hawthorn.	No assessment conducted as access was not granted. Under a precautionary principle, this hedgerow was assumed to be of moderate – high suitability for supporting commuting foraging bats.
26	Species-rich with trees	Moderate - High	25	3-5	4	10% gappy	N-S facing	Intact species-rich with trees. Hawthorn, blackthorn, holly, ash, common oak. Ground flora: red dead nettle, cleavers, herb robert, nipplewort, ground ivy, ribwort plantain, fern sp.	Mature hedgerow with occasional gaps and mature trees. Provides good shelter between large open fields.
Unnamed	Species-rich with trees (woodland)	Moderate - High	N/A	N/A	N/A	N/A	N/A	N/A	80m wide plantation woodland block at Witton. Provides connectivity with Bacton Wood (coniferous plantation) to the south, and Northern Plantation (broadleaved plantation

Hedgerow	Habitat assessment[26]	Assessed potential for support commuting / foraging bats[27]	Length potentially affected (m)	Quality factors					Further comments
				Height (m)	Width (m)	Gaps/Solid hedge ratio	Aspect	Species composition	
									woodland) to the north.
32	Species-rich	Moderate - High	21	1-2	2	20% gappy	E-W facing	Intact species-rich with trees.	Narrow, low hedgerow surrounded by open arable landscapes. Provides connectivity between Bacton Wood and species-rich hedgerows at Edingthorpe.
33	Species-poor with trees	Moderate - High	20	2-3	3	10% gappy	NW-SE facing	Intact species poor.	Semi-mature hedgerow with gaps and trees running along North Walsham Road. Provides some connectivity with the wider hedgerow network.
34	Species-poor with trees	Moderate - High	20	5-10	4	10% gappy	NW-SE facing	Intact species poor.	As above (Hedgerow 33).
36a	Species-poor with trees	Moderate - High	25	15-20	8	10% gappy	NW-SE facing	Intact species poor with trees. Hawthorn, ash, common oak; bramble, nettle, ferns, dog rose, cocks foot.	Mature hedgerow with gas adjacent to wider network for semi-improved grassland for foraging.
36b	Species-poor with trees	Moderate - High	25	5-10	7	10% gappy	NW-SE facing	Intact species poor with trees. Hawthorn, ash, common oak; bramble, nettle, ferns, dog rose, cocks foot.	Hedgerow with gaps adjacent to good network of superior hedgerows (species-rich with trees) and for semi-improved grassland for foraging.

Hedgerow	Habitat assessment[26]	Assessed potential for support commuting / foraging bats[27]	Length potentially affected (m)	Quality factors					Further comments
				Height (m)	Width (m)	Gaps/Solid hedge ratio	Aspect	Species composition	
37	Defunct hedgerow	Low	25	1	2	60% gappy	NW-SE facing	Defunct, species-poor. Hawthorn; ground flora ivy, bramble and nettle.	Defunct hedgerow, with low vegetated bank and occasional shrubs only.
39	Species-poor with trees	Moderate - High	23	2-3	3	20% gappy	NE-SW facing	Intact species-poor. Hawthorn with scattered ash and common oak, bramble.	Mature hedgerow with gaps adjacent to wider network for semi-improved grassland for foraging.

1301. The locations of these habitats within the onshore project area are shown on Figure 9.3 and Figure 9.5.



Legend:

- Norfolk Boreas red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

- Mobilisation zone
- Indicative mobilisation area compound

Environmental Designations¹

- Special Area of Conservation (SAC)

Study area

- Habitats and species study area

Bat Roost Feature

- Low suitability
- Negligible suitability

¹ Natural England, 2019.
² NBIS, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - Habitats located within onshore project area (Map 1 of 4)

Figure: 9.3 Drawing No: PB5640-007-002-017

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
02	26/02/2019	LB	GC	A3	1:10,000
01	04/02/2019	LB	GC	A3	1:10,000

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

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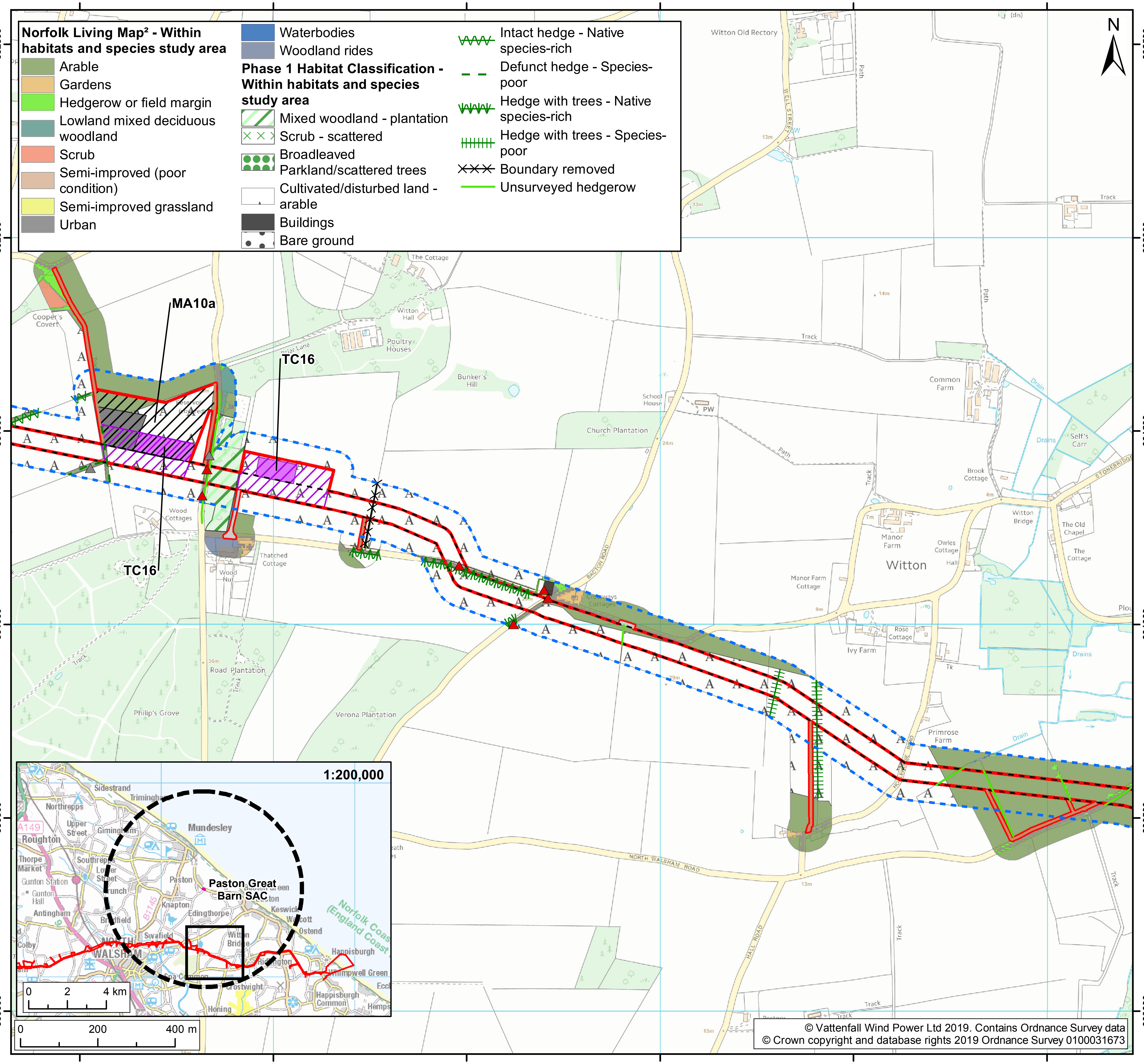

Legend:

Norfolk Boreas red line boundary

Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

Onshore cable route

Construction access

Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

Trenchless crossing zone (e.g. HDD)

Indicative trenchless crossing compound

Mobilisation zone

Indicative mobilisation area compound

Environmental Designations¹

Special Area of Conservation (SAC)

Study area

Habitats and species study area

Bat Roost Feature

Low suitability

Negligible suitability

¹ Natural England, 2019.
² NBIS, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - Habitats located within onshore project area (Map 2 of 4)

Figure: 9.3 Drawing No: PB5640-007-002-017

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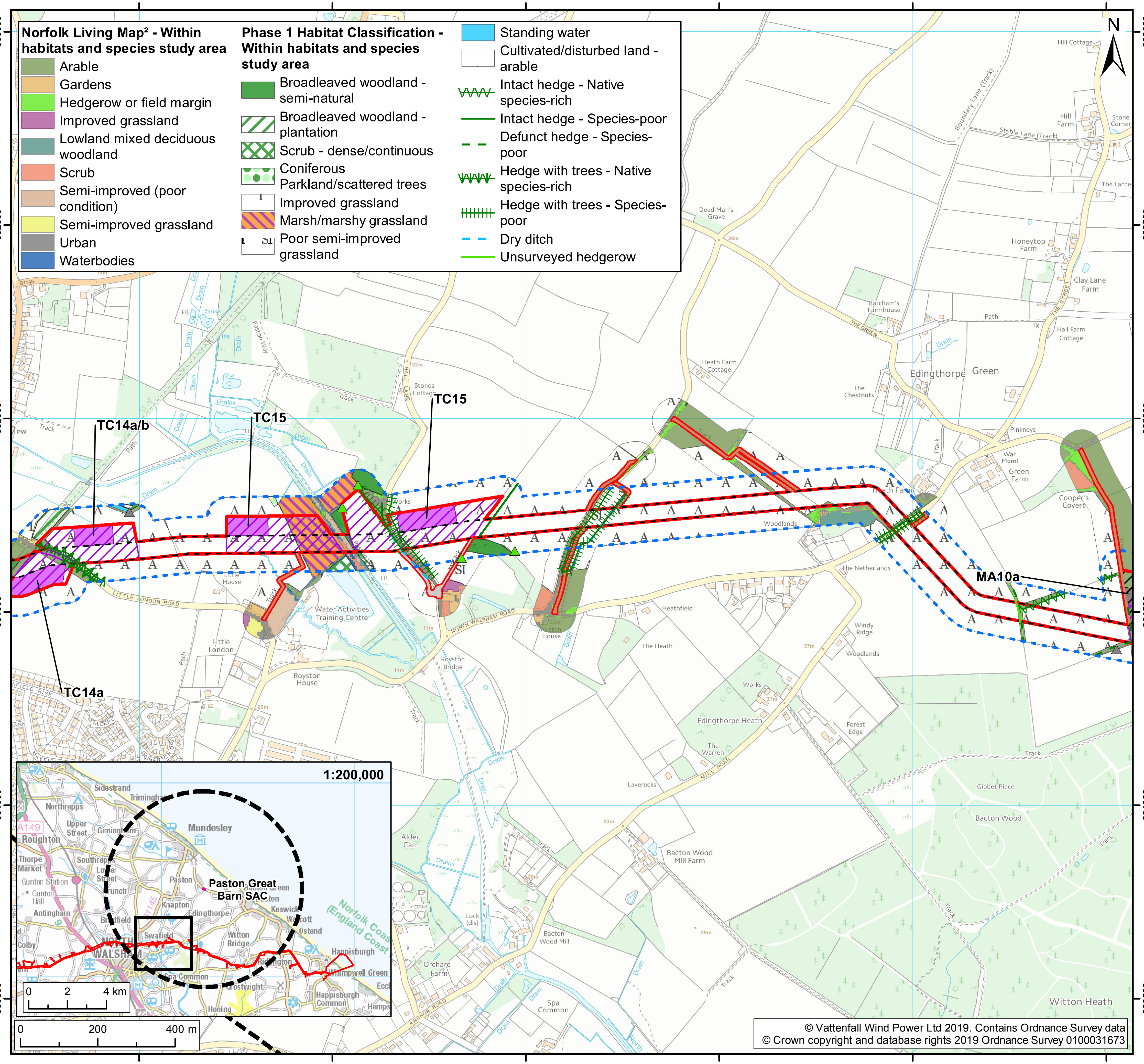

Legend:

- Norfolk Boreas red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designations¹

- Special Area of Conservation (SAC)

Study area

- Habitats and species study area

Bat Roost Feature

- High suitability
- Negligible suitability

¹ Natural England, 2019.
² NBIS, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - Habitats located within onshore project area (Map 3 of 4)

Figure: 9.3 Drawing No: PB5640-007-002-017

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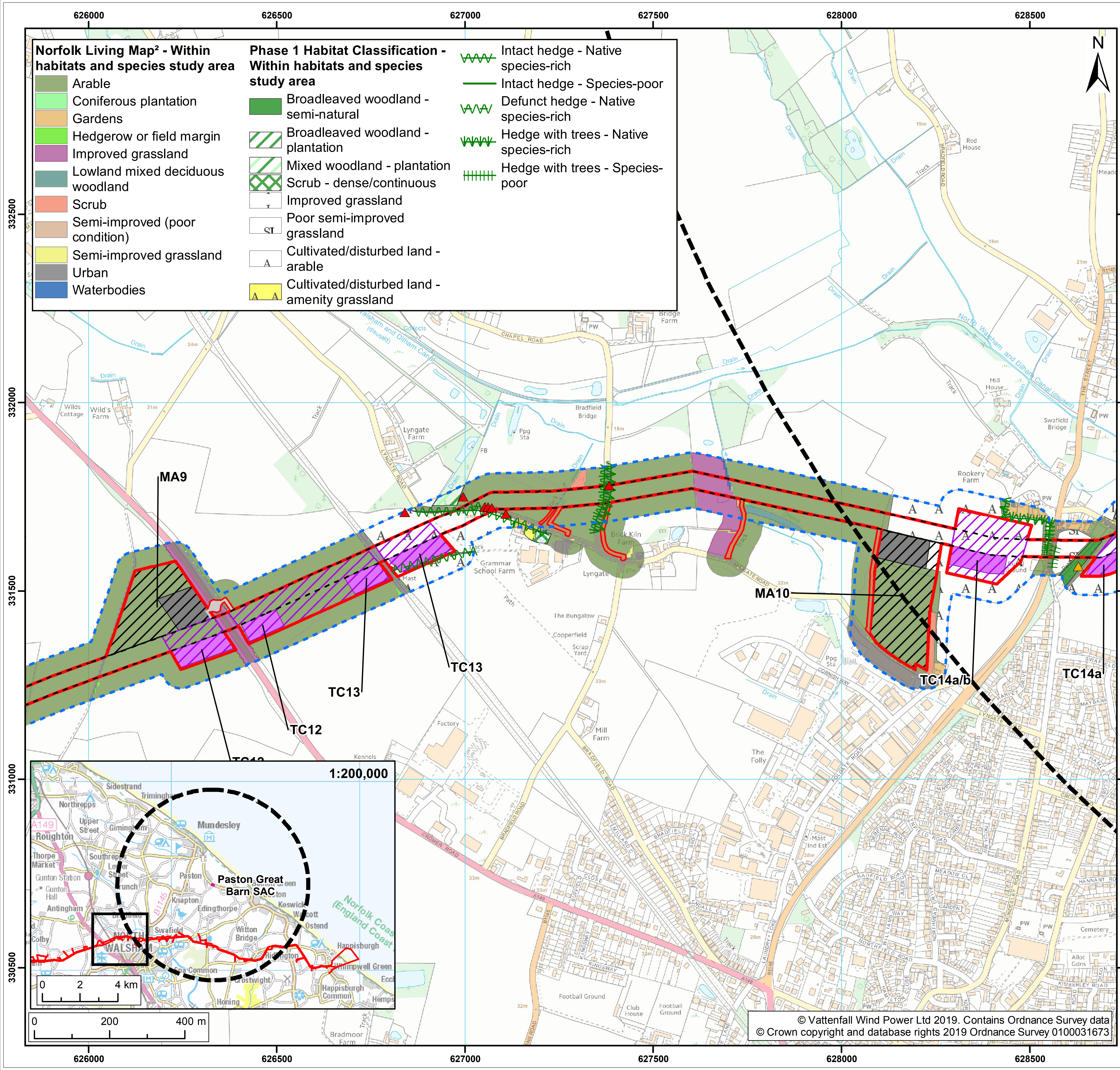

Legend:

Norfolk Boreas red line boundary

Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

Onshore cable route

Construction access

Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

Trenchless crossing zone (e.g. HDD)

Indicative trenchless crossing compound

Mobilisation zone

Indicative mobilisation area compound

Environmental Designations¹

Special Area of Conservation (SAC)

Habitats and species study area

Bat Roost Feature

Moderate suitability

Low suitability

¹ Natural England, 2019.
² NBIS, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC - Habitats located within onshore project area (Map 4 of 4)

Figure: 9.3 Drawing No: PB5640-007-002-017

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1302. 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).

1303. 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).

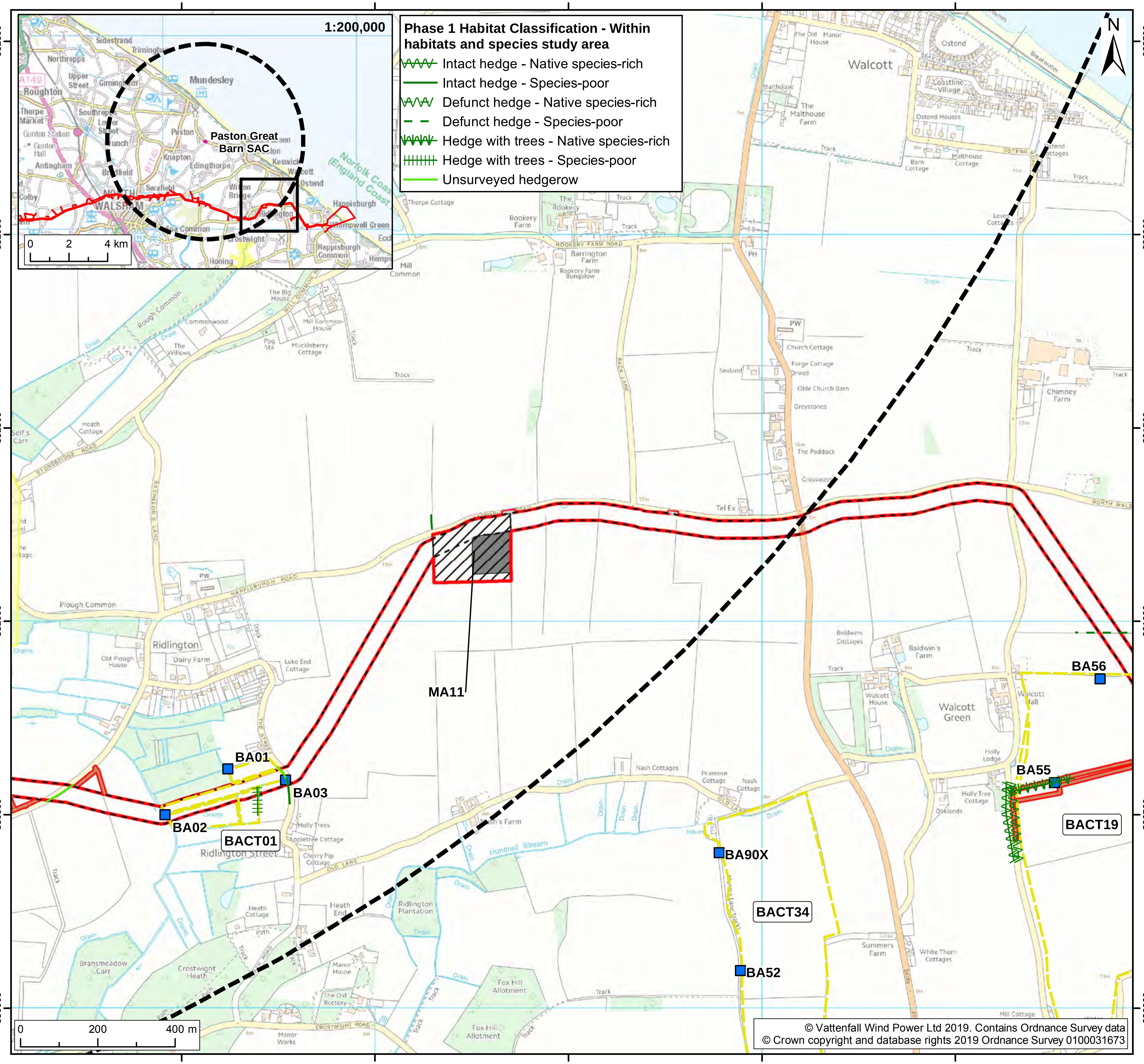
1304. Occasional foraging has also been recorded at the following location:

- Drains and hedgerows at Ridlington Street.

1305. 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.

1306. During 2017 and 2018, a suite of bat activity surveys were undertaken within the onshore project area between April and October. This included four transects within 5km of the Paston Great Barn SAC. The location of these transects is shown in Figure 9.4.



Legend:

Norfolk Boreas red line boundary

Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

Onshore cable route

Construction access

Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

Mobilisation zone

Indicative mobilisation area compound

Environmental Designations¹

Special Area of Conservation (SAC)

Survey area

Bat activity transects surveyed²

Static bat detectors²

Norfolk Barbastelle Study Group Survey Results³

Commuting/foraging routes

Commuting routes

Core foraging areas

¹ Natural England, 2019.
² NWS, 2017/2018.
³ Norfolk Barbastelle Study Group, 2017.

Project: Norfolk Boreas

Report: Habitats Regulations Assessment Report

Title: Paston Great Barn SAC – Radio-tracking and bat activity survey results (Map 1 of 4)

Figure: 9.4 Drawing No: PB5640-007-002-018

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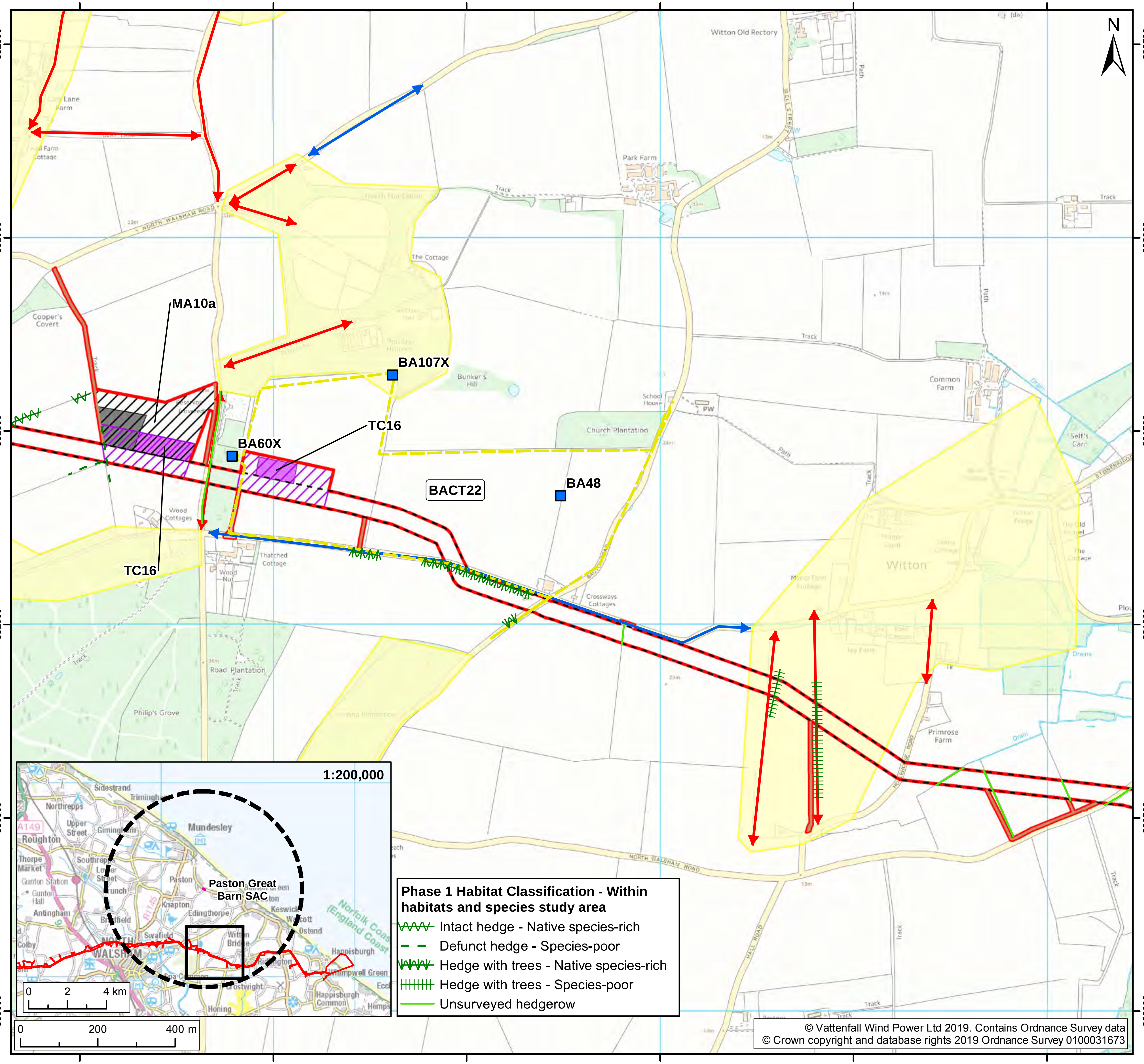

Legend:

Norfolk Boreas red line boundary

Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

Onshore cable route

Construction access

Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

Trenchless crossing zone (e.g. HDD)

Indicative trenchless crossing compound

Mobilisation zone

Indicative mobilisation area compound

Environmental Designations[1]

Special Area of Conservation (SAC)

Survey area

Bat activity transects surveyed[2]

Static bat detectors[2]

Norfolk Barbastelle Study Group Survey Results[3]

Commuting/foraging routes

Commuting routes

Core foraging areas

[1] Natural England, 2019.
[2] NWS, 2017/2018.
[3] Norfolk Barbastelle Study Group, 2017.

Project: Norfolk Boreas

Report: Habitats Regulations Assessment Report

Title: Paston Great Barn SAC – Radio-tracking and bat activity survey results (Map 2 of 4)

Figure: 9.4 | Drawing No: PB5640-007-002-018

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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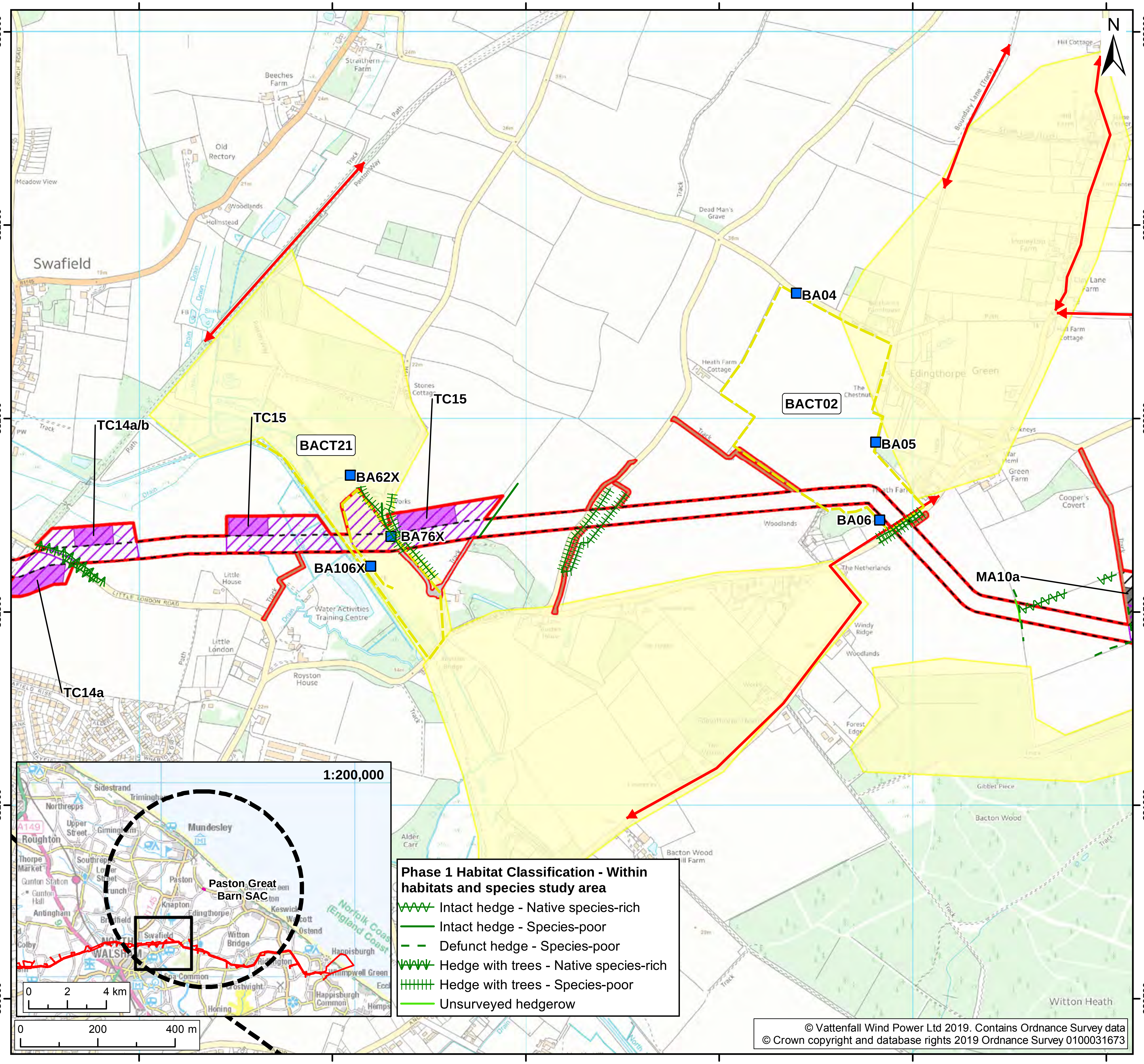

Legend:

- Norfolk Boreas red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designations[1]

- Special Area of Conservation (SAC)

Survey area

- Bat activity transects surveyed[2]
- Static bat detectors[2]

Norfolk Barbastelle Study Group Survey Results[3]

- Commuting/foraging routes
- Commuting routes
- Core foraging areas

[1] Natural England, 2019.
[2] NWS, 2017/2018.
[3] Norfolk Barbastelle Study Group, 2017.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC – Radio-tracking and bat activity survey results (Map 3 of 4)

Figure: 9.4 Drawing No: PB5640-007-002-018

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: British National Grid **EPSG:** 27700

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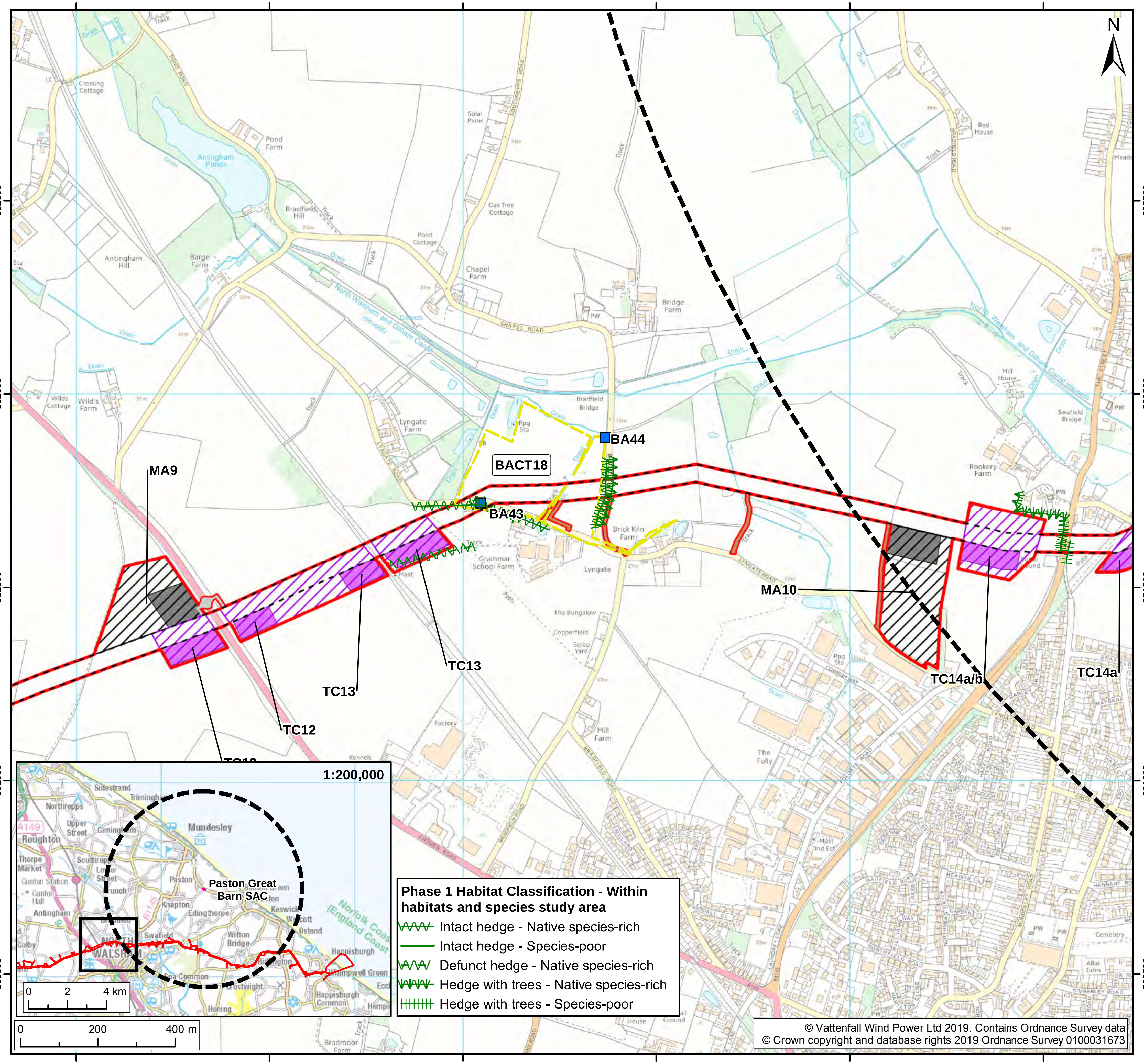

Legend:

Norfolk Boreas red line boundary

Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

Onshore cable route

Construction access

Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

Trenchless crossing zone (e.g. HDD)

Indicative trenchless crossing compound

Mobilisation zone

Indicative mobilisation area compound

Environmental Designations¹

Special Area of Conservation (SAC)

Survey area

Bat activity transects surveyed²

Static bat detectors²

Norfolk Barbastelle Study Group Survey Results³

Commuting/foraging routes

Commuting routes

Core foraging areas

¹ Natural England, 2019.
² NWS, 2017/2018.
³ Norfolk Barbastelle Study Group, 2017.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC – Radio-tracking and bat activity survey results (Map 4 of 4)

Figure: 9.4 Drawing No: PB5640-007-002-018

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1307. Data were collected over six months at each transect 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 and 2018 bat activity surveys are provided within Appendix 9.3.

1308. These transects covered the following areas identified above using the NBSG's radio-tracking data:

- 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
- Drains and hedgerows at Ridlington Street.

1309. Barbastelles were recorded commuting and foraging along all four transects. The key findings from the 2017 and 2018 transect surveys are summarised in Table 9.3 below.

Table 9.3 Barbastelle records for all transects located within 5km of Paston Great Barn

Transect	Associated hedgerows[28]	Transect location	Total species peak count	Barbastelle peak count (per night)	Months barbastelle recorded	Further comments
BACT21	39	Dilham Canal and land east of Dilham Canal	529	2	October only	Occasional barbastelle record only, barbastelles only associated with hedgerow along Hall Lane
BACT22	26, Unnamed (Witton)	Witton Hall, Witton Hall Plantation and Edingthorpe Road	1650	13	Full survey period (May – October)	Barbastelles recorded throughout transect

[28] Hedgerow numbering as shown on Important Hedgerows Plan (DCO document 2.11).

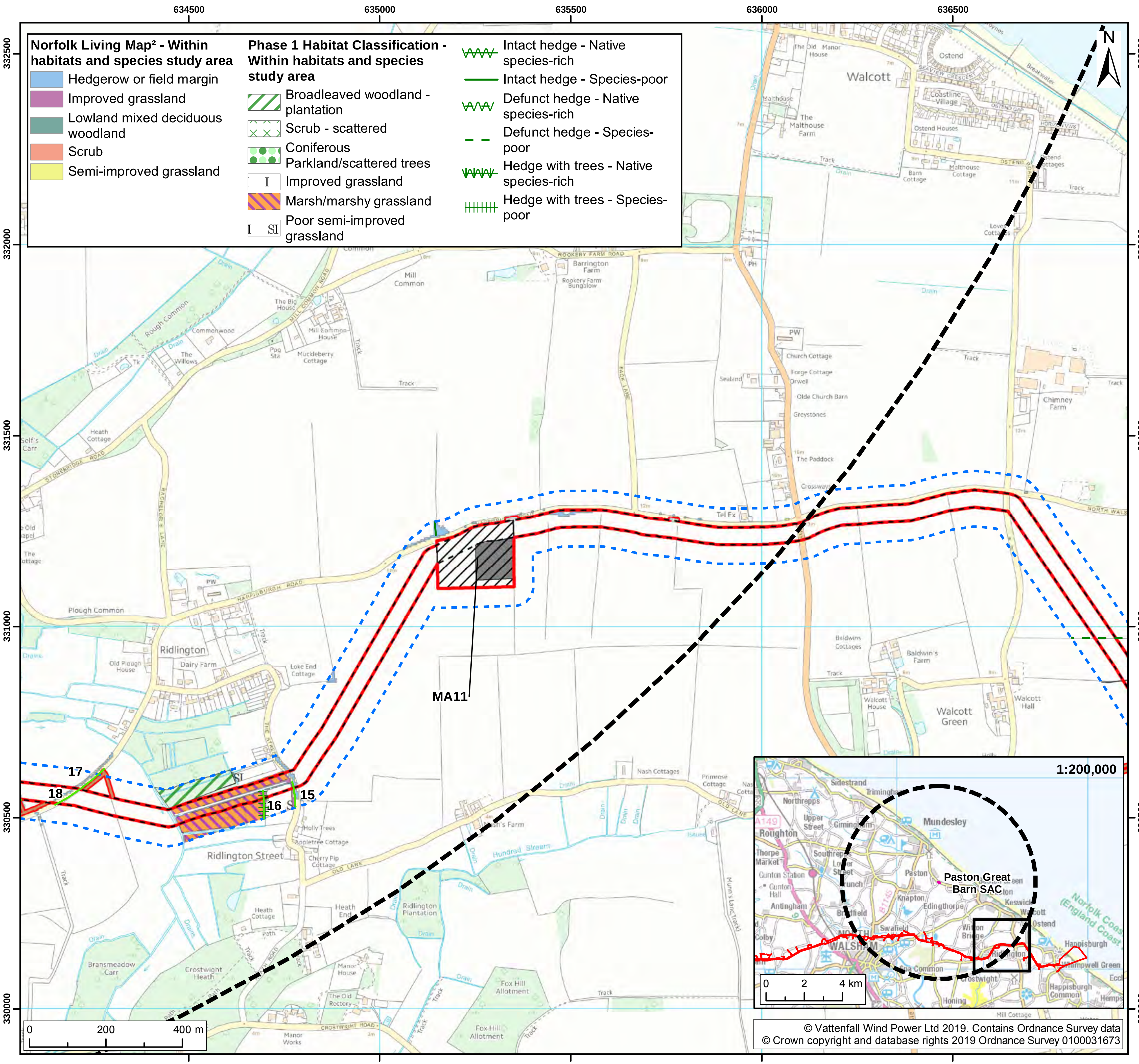
Transect	Associated hedgerows[28]	Transect location	Total species peak count	Barbastelle peak count (per night)	Months barbastelle recorded	Further comments
BACT01	15, 16	Grazing marshes and drains at Ridlington Street	1050	1	April – July, October	Occasional barbastelle record only
BACT02	33, 34	Land along and north of North Walsham Road	1553	2	July and August	Occasional barbastelle record only

1310. Any commuting / foraging feature where bats have been recorded during more than a single visit (i.e. BACT 22 and BACT 01, BACT 02) 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 barbastelle bats.

1311. The activity data recorded during 2017 and 2018 indicates that barbastelles are an occasional presence on all habitats where recording took place. Furthermore, given the territories of barbastelles of the Paston Great Barn colony indicated in the NBSG's radio-tracking data, it is possible that the barbastelles recorded during the activity surveys are from the Paston Great Barn colony. Consequently, it has been assumed that all 17 hedgerows located within the study area with moderate or high suitability to support roosting bats are potentially important for barbastelles from the Paston Great Barn colony, as part of their occasional foraging range. Based on the radio-tracking data the following habitats areas are of particular importance 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); and
- Drains and hedgerows at Ridlington Street.

1312. The locations of these features can be seen on Figure 9.5.



Legend:

- Norfolk Boreas red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

- Mobilisation zone
- Indicative mobilisation area compound

Environmental Designations¹

- Special Area of Conservation (SAC)

Study area

- Habitats and species study area
- Commuting / foraging features with in the study area
- 11 Hedgerow number (following important hedgerow Plan Document Reference 2.11)

¹ Natural England, 2019.
² NBIS, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Paston Great Barn SAC – Location of features of particular importance for barbastelle (Map 1 of 4)

Figure: 9.5 | Drawing No: PB5640-007-002-019

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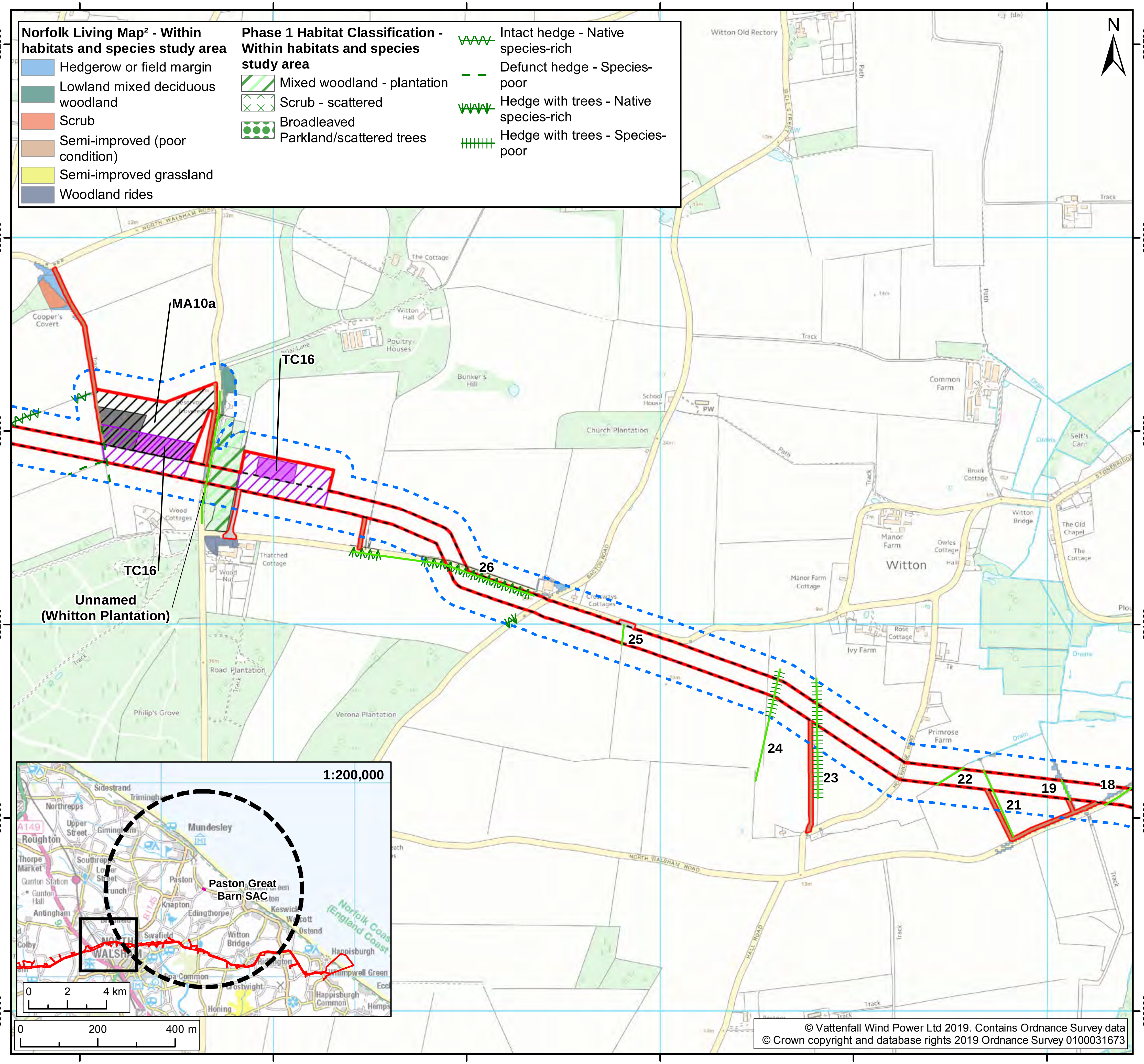

Legend:

Norfolk Boreas red line boundary

Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

Onshore cable route

Construction access

Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

Trenchless crossing zone (e.g. HDD)

Indicative trenchless crossing compound

Mobilisation zone

Indicative mobilisation area compound

Environmental Designations¹

Special Area of Conservation (SAC)

Study area

Habitats and species study area

Commuting / foraging features with in the study area

11 Hedgerow number (following important hedgerow Plan Document Reference 2.11)

¹ Natural England, 2019.
² NBIS, 2018.

Project:	Report:
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Paston Great Barn SAC – Location of features of particular importance for barbastelle (Map 2 of 4)

Figure: 9.5	Drawing No: PB5640-007-002-019				
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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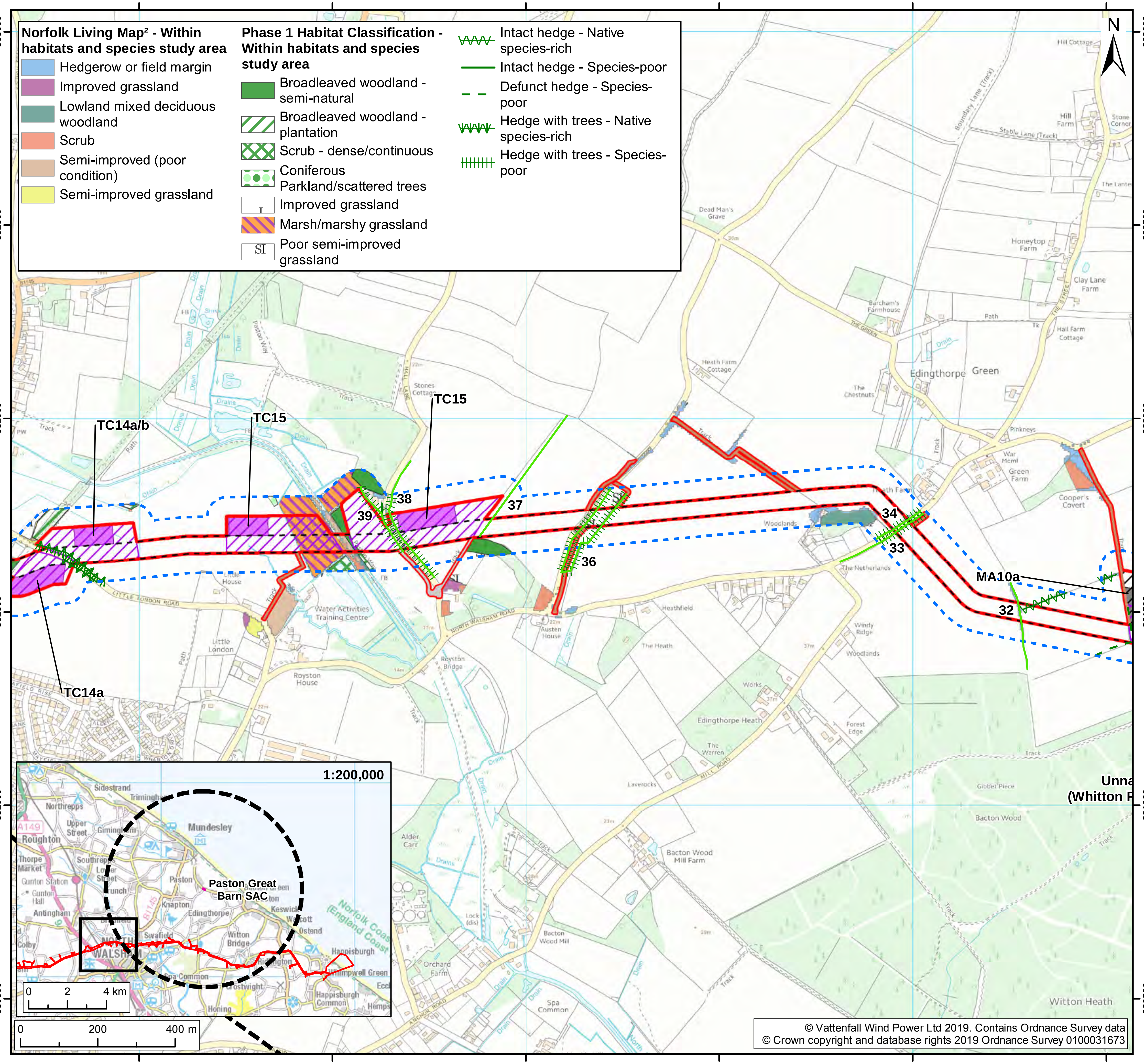

Legend:

- Norfolk Boreas red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designations¹

- Special Area of Conservation (SAC)

Study area

- Habitats and species study area
- Commuting / foraging features with in the study area
- 11 Hedgerow number (following important hedgerow Plan Document Reference 2.11)

¹ Natural England, 2019.
² NBIS, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Paston Great Barn SAC – Location of features of particular importance for barbastelle (Map 3 of 4)

Figure: 9.5 Drawing No: PB5640-007-002-019

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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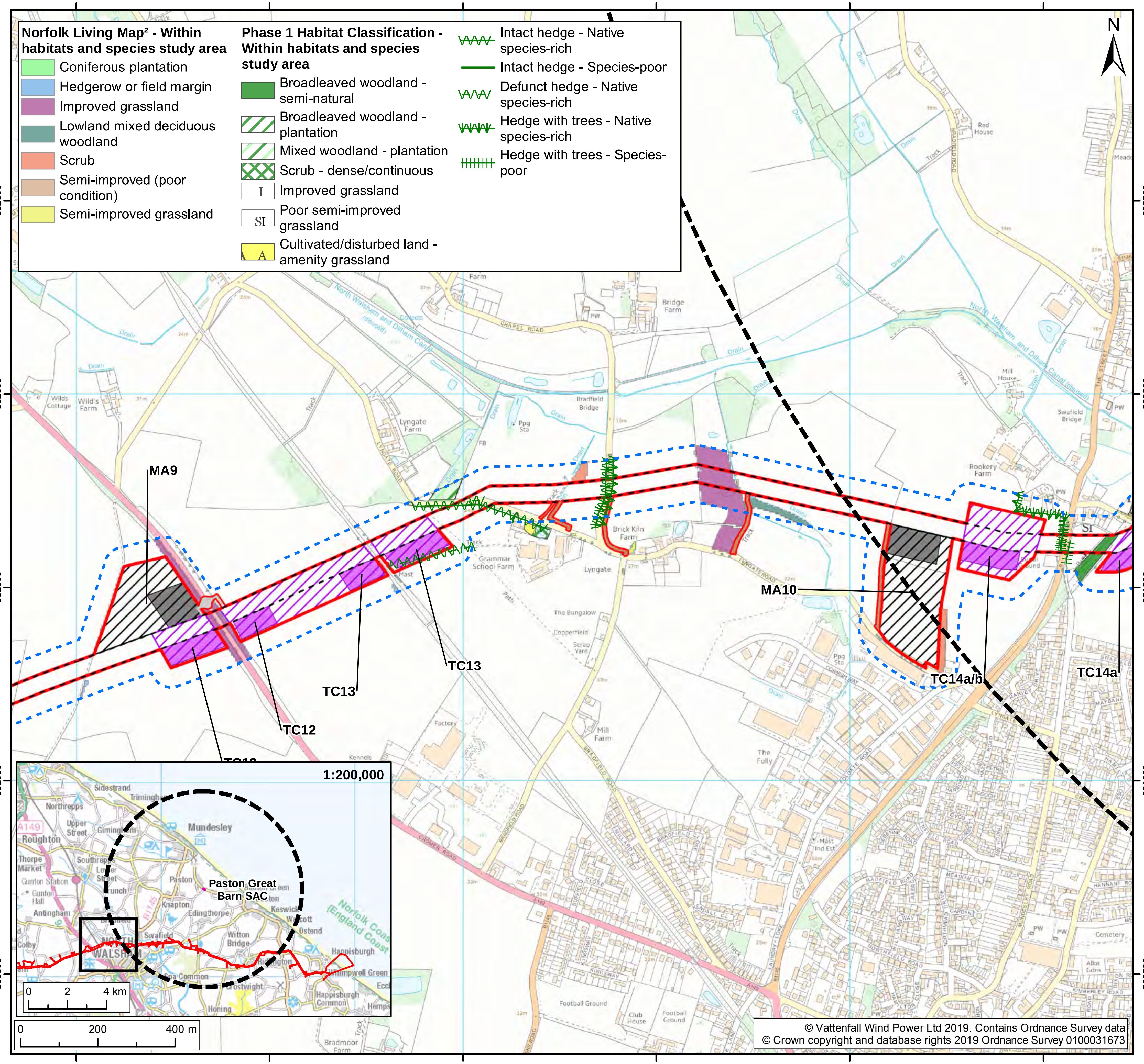

Legend:

- Norfolk Boreas red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designations¹

- Special Area of Conservation (SAC)

Study area

- Habitats and species study area
- Commuting / foraging features with in the study area
- 11 Hedgerow number (following important hedgerow Plan Document Reference 2.11)

¹ Natural England, 2019.
² NBIS, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Paston Great Barn SAC – Location of features of particular importance for barbastelle (Map 4 of 4)

Figure: 9.5 Drawing No: PB5640-007-002-019

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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British National Grid EPSG: 27700

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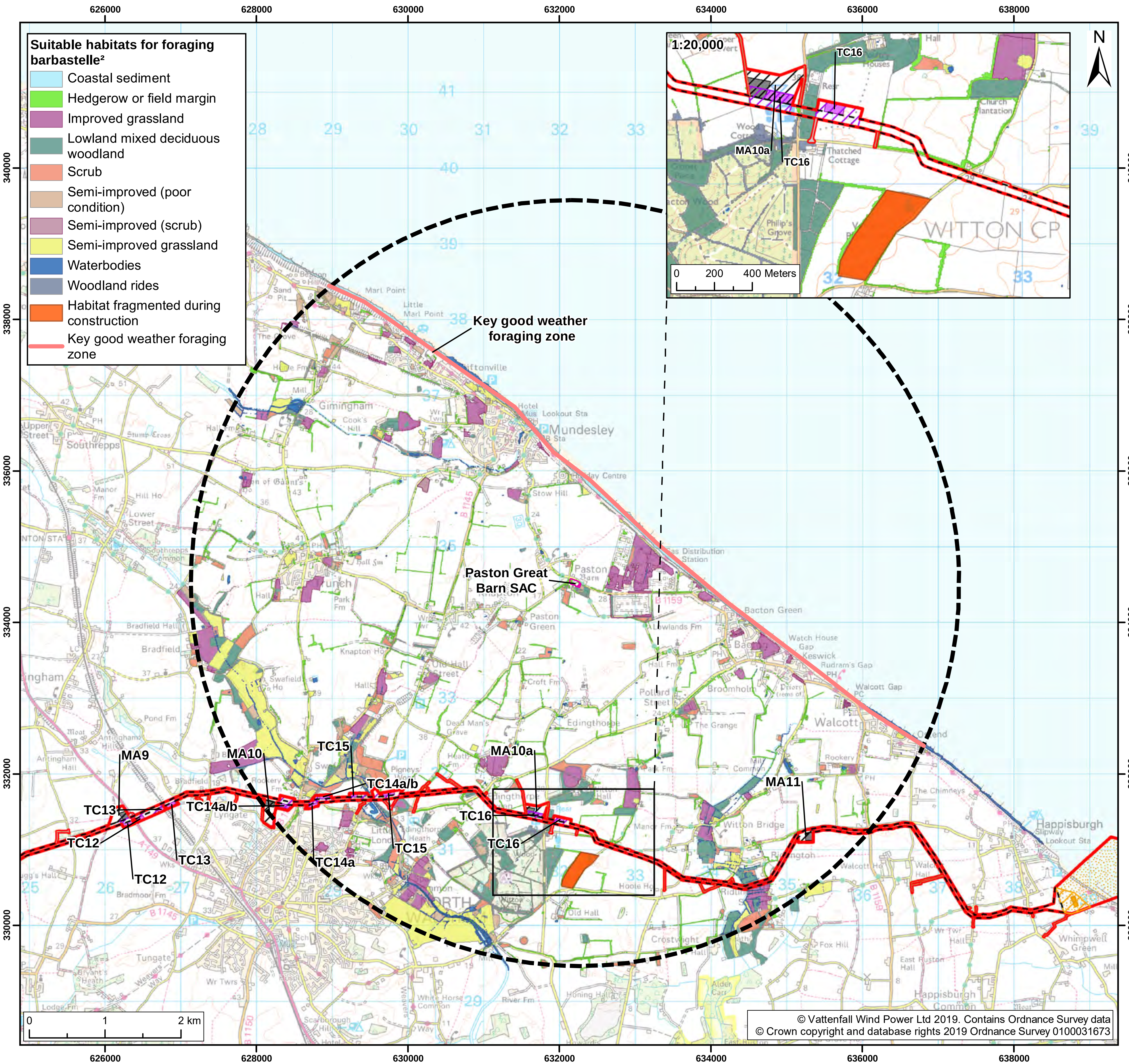

Legend:

- Norfolk Boreas red line boundary
- Paston Great Barn Special Area of Conservation (SAC) 5km buffer

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Landfall zone
- Landfall compound zone
- Indicative landfall compound

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designations¹

- Special Area of Conservation (SAC)

¹ Natural England, 2019.
² NBIS, 2019.

Project: Norfolk Boreas

Report: Habitats Regulations Assessment Report

Title: Paston Great Barn SAC – Available barbastelle foraging habitat within the study area

Figure: 9.6 | Drawing No: PB5640-007-002-026

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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9.1.2.3. Conservation Objectives

1313. 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.

1314. 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

1315. 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*.

1316. 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 9.4 below.

Table 9.4 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))

1317. Only one of these component sites, 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).

1318. 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).

1319. 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

1320. 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

1321. 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 9.5 below.

Table 9.5 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*.

1322. Data from the Environment Agency's 'WetMecs' assessment (Environment Agency, 2000) has been obtained to provide an understanding of the water inflows and outflows for water-dependant sites of the Norfolk Valley Fens SAC. Furthermore, the depth of the water-bearing strata in proximity to the onshore project area has been sourced from British Geological Survey (BGS) borehole online data and from site investigations undertaken at the trenchless crossing locations (Norfolk Boreas ES Chapter 19 Ground Conditions and Contamination, section 19.6.2.1) in order to characterise the ground conditions in the proximity of water-dependant sites of the Norfolk Valley Fens SAC.

1323. Table 9.6 summarises the existing water supply mechanism and groundwater conditions at those sites located within the ZOI (i.e. within 1km of) the onshore project area.

1324. In general terms, the underlying solid geology throughout the part of Norfolk in which the onshore project area is located is Chalk overlain by diamicton (boulder clay), with Crag and Quaternary (drift) deposits at the surface. The solid geology and drift geology are presented on Figures 19.1 and 19.2 of ES Chapter 19 Ground Conditions and Contamination (document reference 6.2). The depth of the Chalk aquifer along the cable route is identified within Table 9.6.

Table 9.6 Booton Common SSSI water supply mechanism

Designated site	Distance to nearest trenching works	Distance to nearest trenchless crossing	Approximate depth of chalk aquifer at nearest trenchless crossing (based on BGS boreholes)	Designated site water supply (WetMecs data)
Norfolk Valley Fens SAC (Booton Common component SSSI)	0.6km	0.6km	18m	The following WetMecs are present at Booton Common: SSSI • ***WETMEC 10a ('Type 1'):*** Localised Strong Seepage • ***WETMEC 10b ('Type 1'):*** Diffuse Seepage • ***WETMEC 11a ('Type 2'):*** Permeable Partial Seepage • ***WETMEC 11b ('Type 2'):*** Slowly Permeable Partial Seepage • ***WETMEC 13a ('Type 4'):*** Seepage Percolation Surface (small hollow) • ***WETMEC 17a ('Type 1'):*** Groundwater-Flushed Slope (part of slope). The site is an elongated mire developed on a narrow seepage slope above the Blackwater Drain. There are two main ecohydrological facets to the site: (i) near the west end there is a small, sloping permanent seepage face, occupying and adjoining a shallow, flushed gully, which supports the primary conservation interest (M13); (ii) East of this, and continuous with it, are various types of less rich fen vegetation (mainly fen meadow and tall herb fen) in locations where – for the most part – the water table scarcely reaches the surface, or does so only intermittently. Groundwater discharge to the site is considered to be predominantly artesian water from the Upper Chalk aquifer beneath the site, particularly in its western end. The water supply for the eastern site is less certain, and may either arise due to upward leakage from the chalk water, or intermittent lateral seepage from the drift deposits, or both. Surface water flows are considered to have little relevance to the site water balance. The main stream to the north of the site is IDB managed, and does not regularly flood the site. ***Summary:*** Predominantly fed by artesian water from the semi-confined chalk aquifer (vertical flows), with the possibility of some additional lateral flows from the drift aquifer feeding the eastern site.

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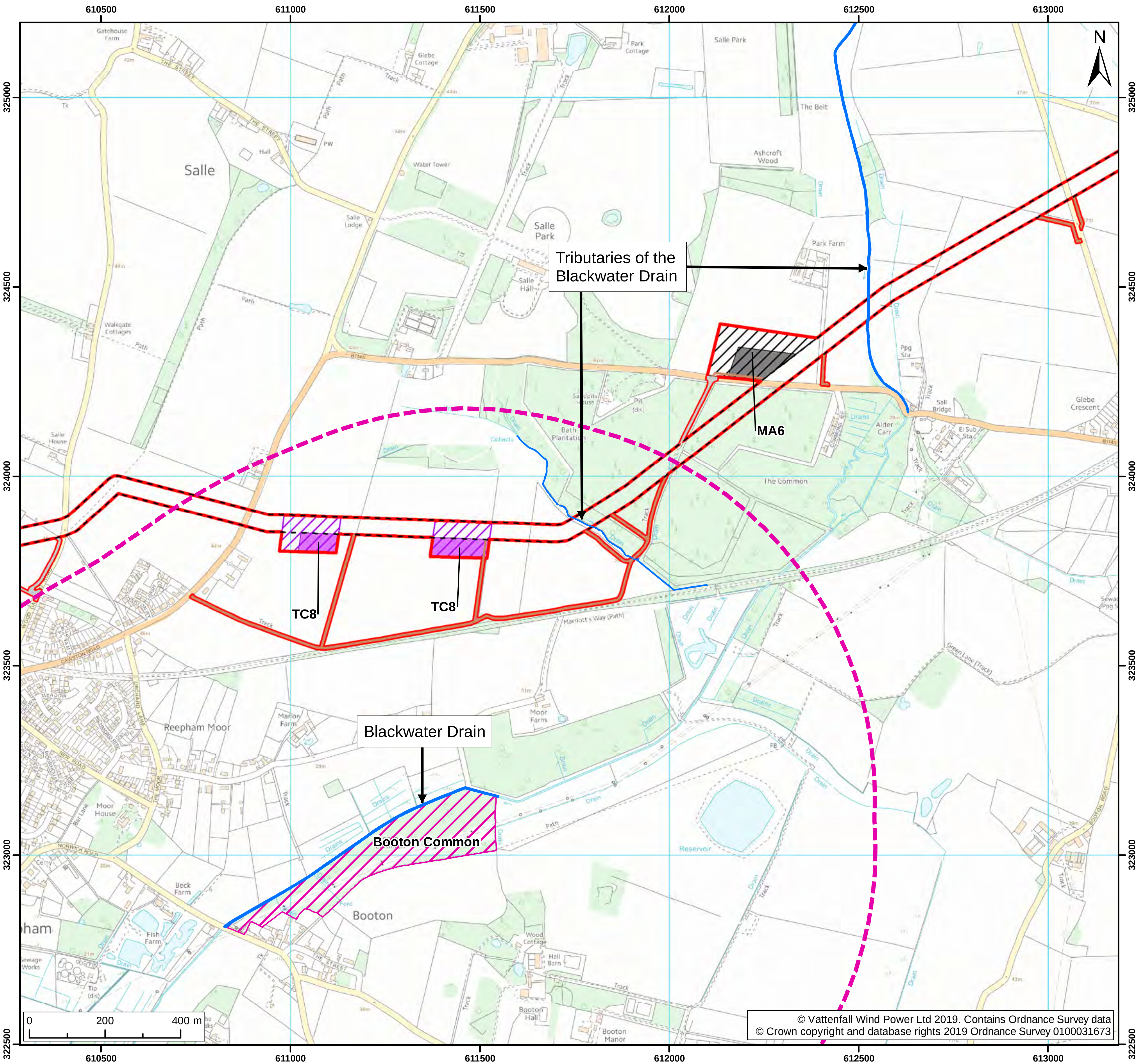

Legend:

- Norfolk Boreas red line boundary

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

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

Environmental Designations[1]

- Special Area of Conservation (SAC)
- Booton Common 1km zone of influence buffer
- Blackwater Drain tributaries[2]

[1] Natural England, 2019.
[2] Ordnance Survey, 2019.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Norfolk Valley Fens SAC - Booton Common and associated watercourses

Figure: 9.7 Drawing No: PB5640-007-002-020

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
03	12/03/2019	LB	GC	A3	1:10,000
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Co-ordinate system: British National Grid **EPSG:** 27700

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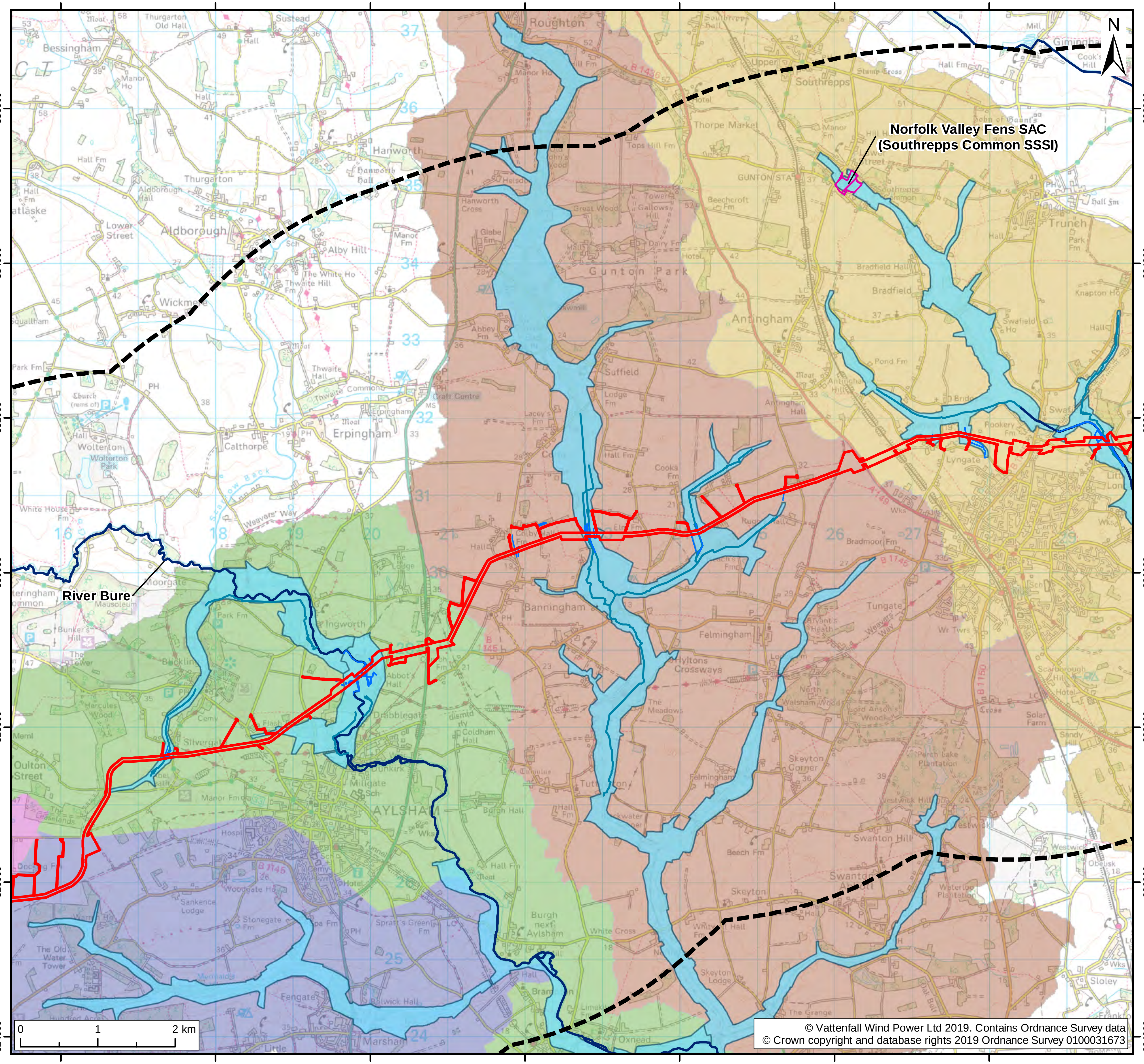

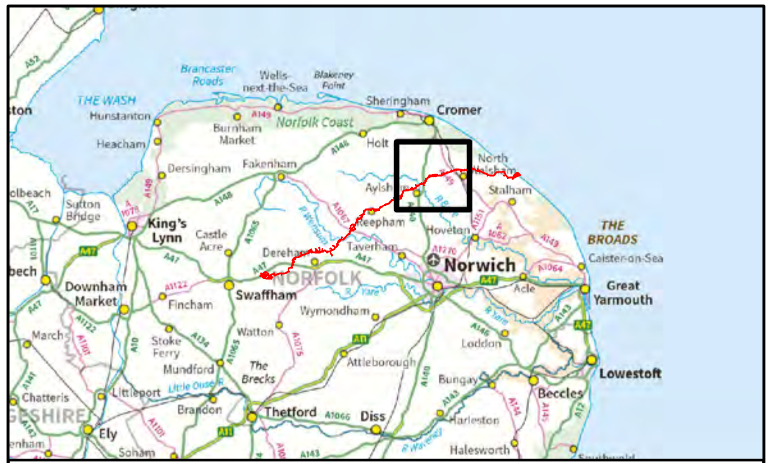

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Environmental Designations¹

- Special Area of Conservation (SAC)

Watercourses

- IDB drain²
- IDB catchment²
- Other watercourses³
- Main river⁴

WFD river water body catchments⁴

- 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, 2019.
² Internal Drainage Board, 2017.
³ Ordnance Survey, 2019.
⁴ Environment Agency, 2017.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Norfolk Valley Fens SAC - Watercourses and their functional connectivity to the SAC (Map 1 of 3)

Figure: 9.8 Drawing No: PB5640-007-002-021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: British National Grid **EPSG:** 27700

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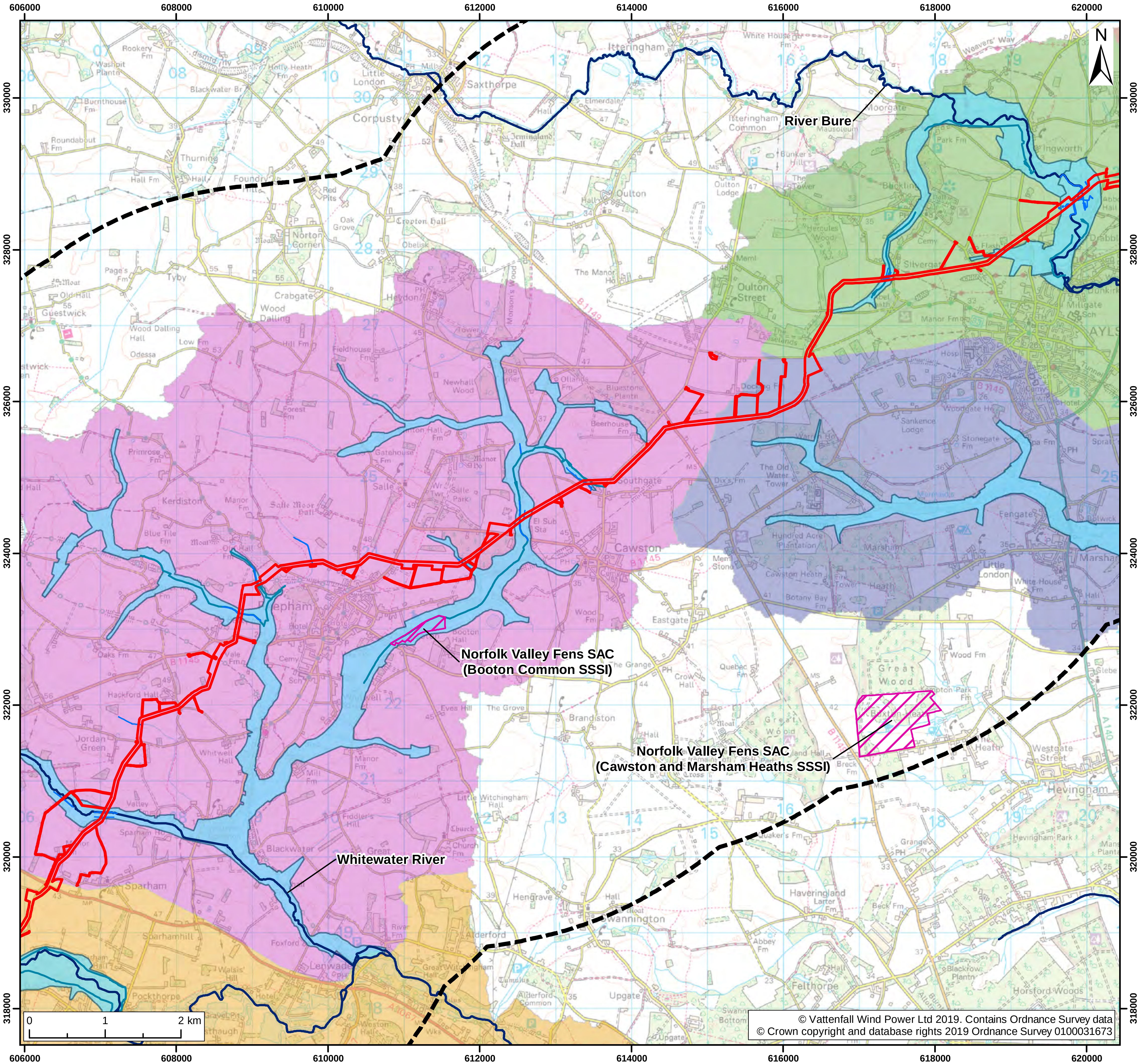

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Environmental Designations[1]

- Special Area of Conservation (SAC)

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
- Wensum US Norwich

NOTE: IDB = Internal Drainage Board; WFD = Water Framework Directive
[1] Natural England, 2019.
[2] Internal Drainage Board, 2017.
[3] Ordnance Survey, 2019.
[4] Environment Agency, 2017.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Norfolk Valley Fens SAC - Watercourses and their functional connectivity to the SAC (Map 2 of 3)

Figure: 9.8 Drawing No: PB5640-007-002-021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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02	26/02/2019	LB	GC	A3	1:50,000

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

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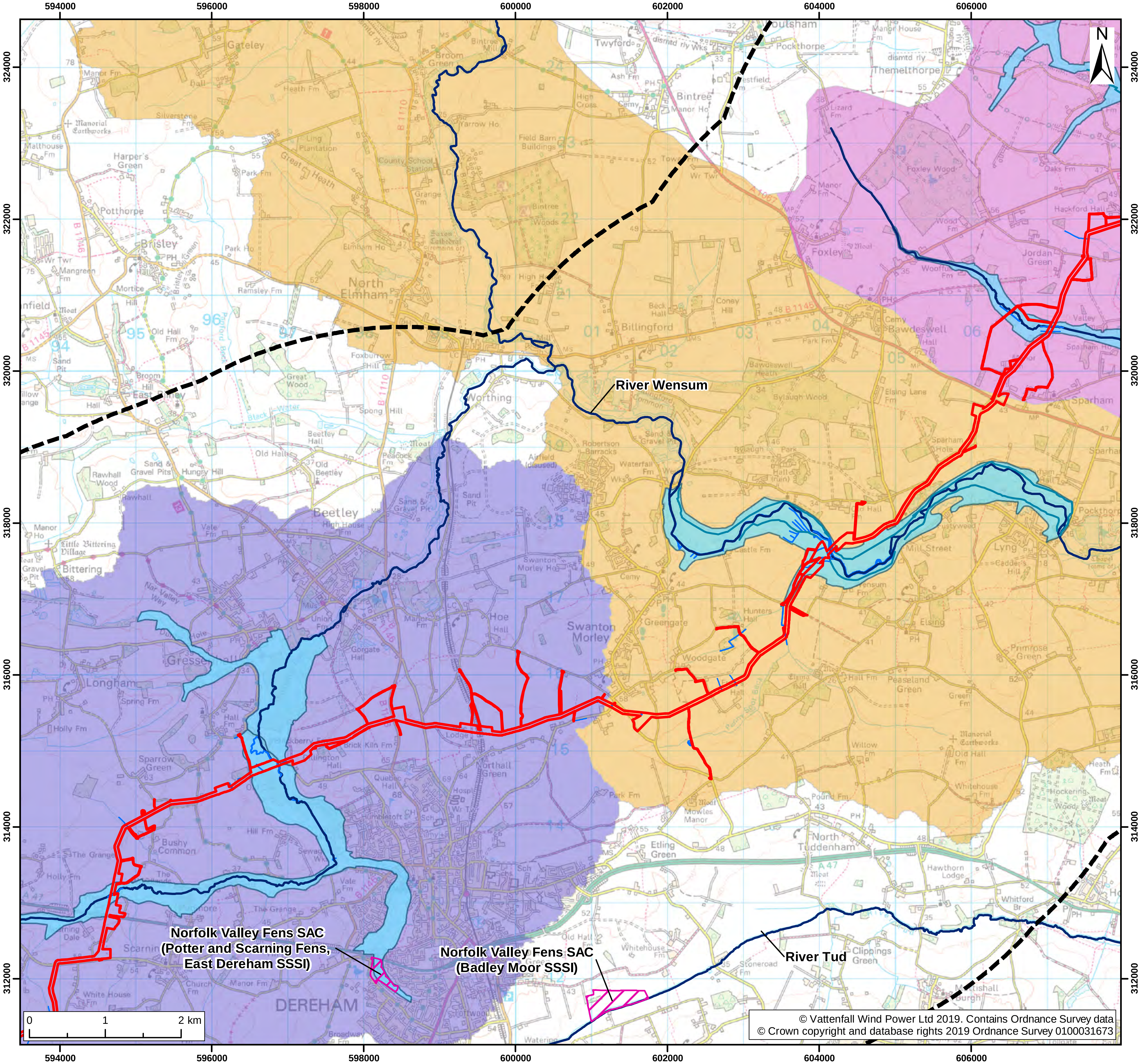

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Environmental Designations[1]

- Special Area of Conservation (SAC)

Watercourses

- IDB drain[2]
- IDB catchment[2]
- Other watercourses[3]
- Main river[4]

WFD river water body catchments[4]

- Blackwater Drain (Wensum)
- Wendling Beck
- Wensum US Norwich

NOTE: IDB = Internal Drainage Board;WFD = Water Framework Directive
[1] Natural England, 2019.
[2] Internal Drainage Board, 2017.
[3] Ordnance Survey, 2019.
[4] Environment Agency, 2017.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Norfolk Valley Fens SAC - Watercourses and their functional connectivity to the SAC (Map 3 of 3)

Figure: 9.8 Drawing No: PB5640-007-002-021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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02	26/02/2019	LB	GC	A3	1:50,000

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

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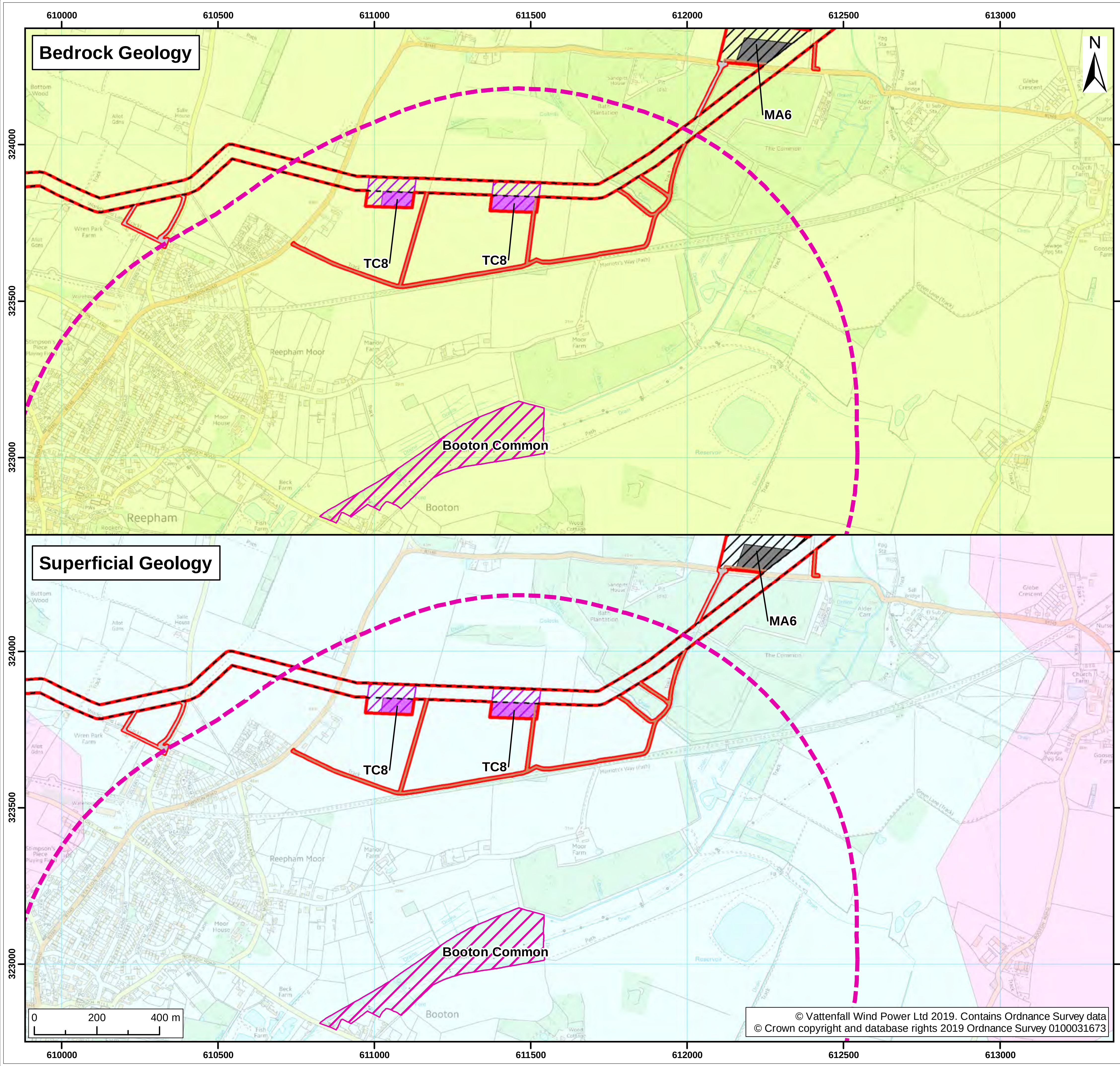

Legend:

Norfolk Boreas red line boundary

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

Onshore cable route

Construction access

Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

Trenchless crossing zone (e.g. HDD)

Indicative trenchless crossing compound

Mobilisation zone

Indicative mobilisation area compound

Environmental Designations[1]

Special Area of Conservation (SAC)

Booton Common 1km zone of influence buffer

Bedrock geology[2]

White chalk subgroup

Superficial geology[2]

Glacial sand and gravel

Till - diamicton

[1] Natural England, 2019.
[2] British Geological Survey, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Norfolk Valley Fens SAC - Underlying geology

Figure: 9.9 Drawing No: PB5640-007-002-022

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: British National Grid **EPSG:** 27700

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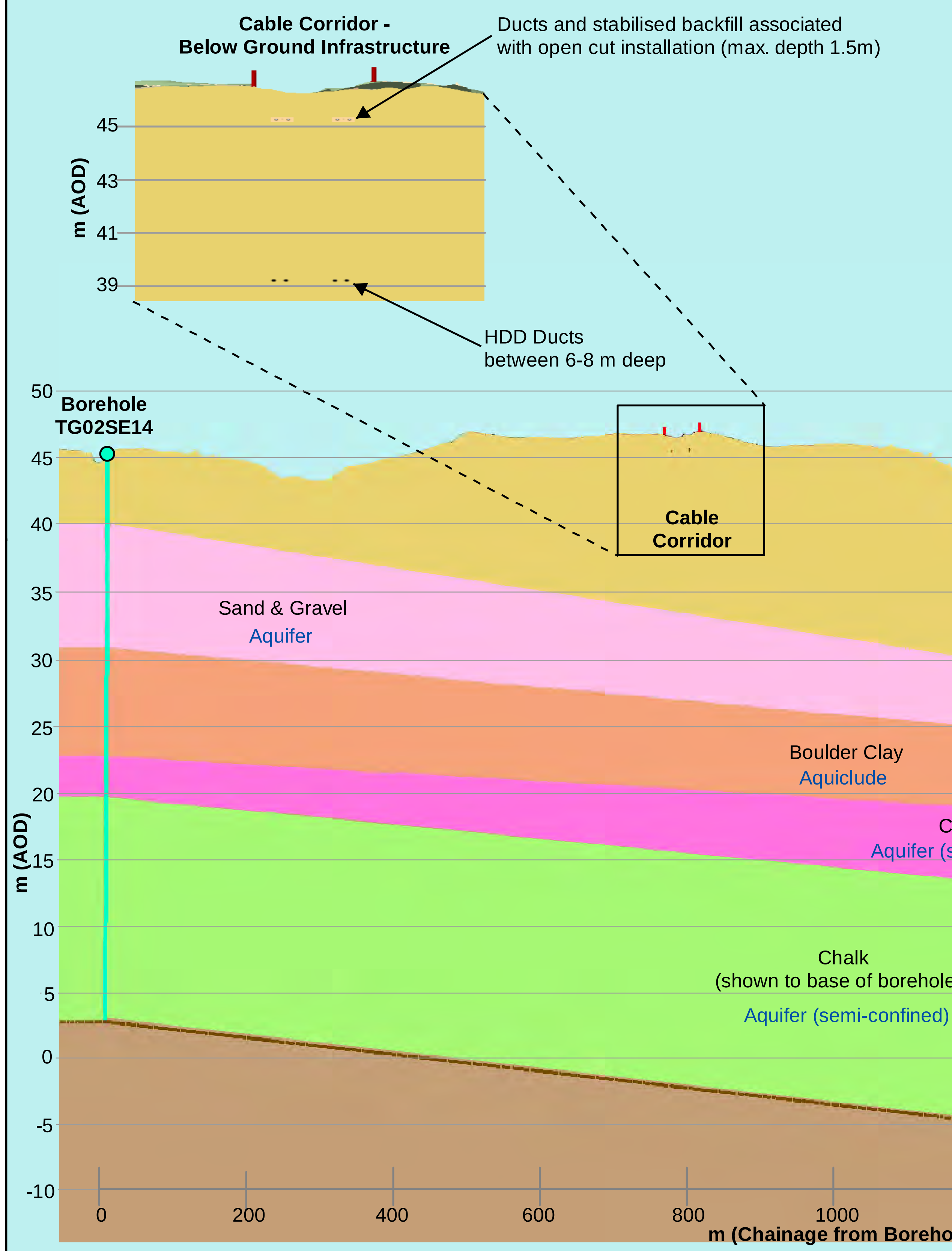

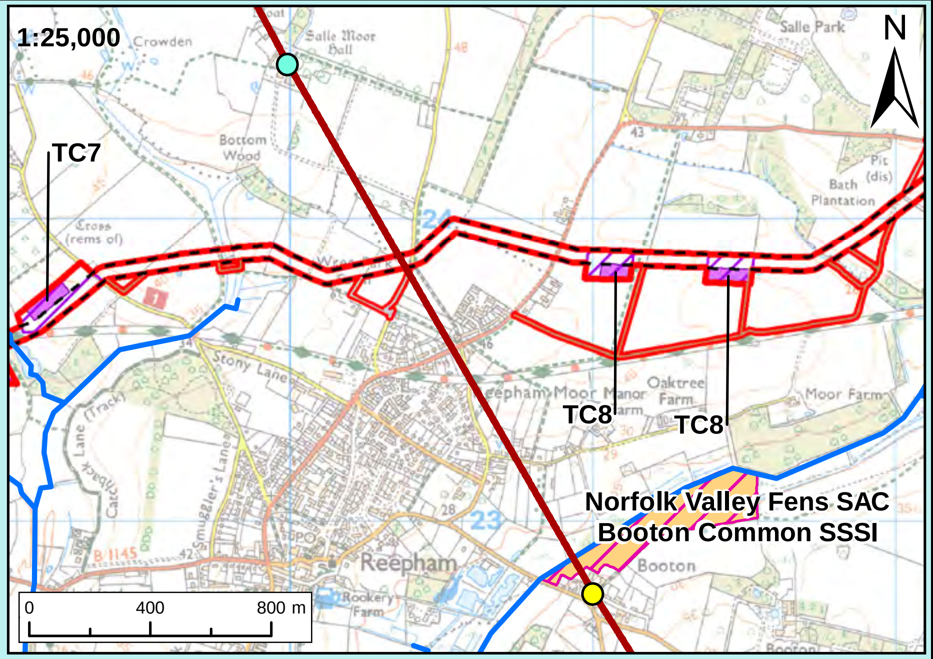

Legend:

Norfolk Boreas red line boundary

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)
- Onshore cable route
- Construction access
- Operational access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)
- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound

Environmental Designations[1]
- Special Area of Conservation (SAC)
- Site of Special Scientific Interest (SSSI)

Boreholes[2]
- Borehole TG02SE14[2]
- Borehole TG12SW11[2]
- Location of cross-section
- Watercourse[3]

Note: Height / Depth is extruded
[1] Natural England, 2019.
[2] British Geological Survey materials © NERC 2019
[3] Ordance Survey, 2019.

Project: Norfolk Boreas

Report: Habitats Regulations Assessment Report

Title: Norfolk Valley Fens SAC - Booton Common hydrogeological conceptual model

Figure: 9.10 Drawing No: PB5640-007-002-027

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: British National Grid **EPSG:** 27700

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9.1.3.3. Conservation Objectives

1325. 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.

1326. 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

1327. 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.

1328. 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 9.11). 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 Calthorpe Broads component SSSI of The Broads SAC is considered unlikely.

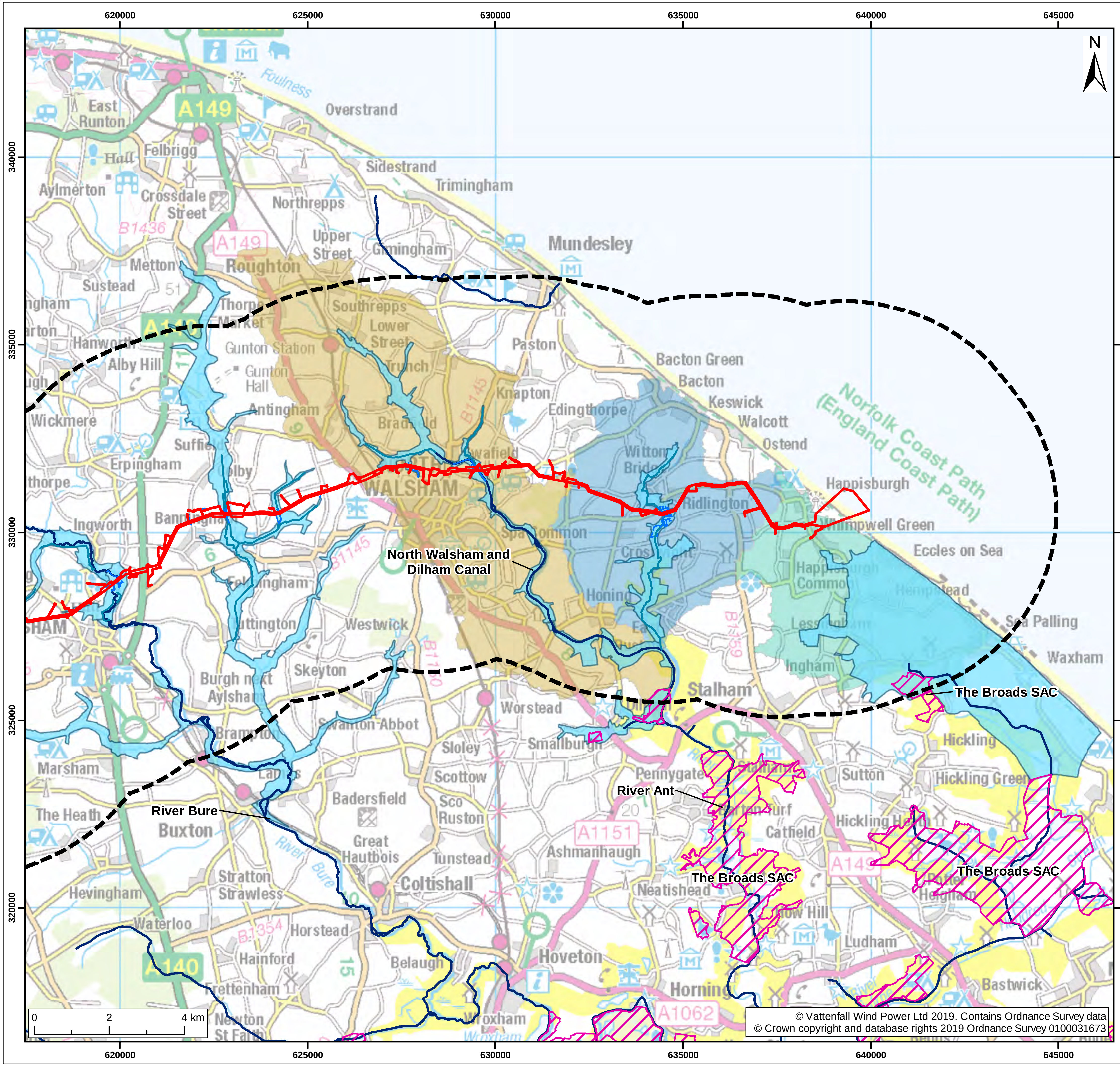
1329. The Broad Fen, Dilham component SSSI of The Broads SAC is located 3.6km from onshore project area at its closest point. Following a review of the Broad Fen, Dilham SSSI citation and accompanying condition assessment, the following Annex I habitats and Annex II species that are a primary reason 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).

1330. 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.

1331. 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 Boreas red line boundary

5km buffer zone

Environmental Designations[1]

Special Area of Conservation (SAC)

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, 2019.
[2] Internal Drainage Board, 2017.
[3] Ordnance Survey, 2019.
[4] Environment Agency, 2017.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

Watercourses and their functional connectivity toThe Broads SAC

Figure: 9.11 Drawing No: PB5640-007-002-023

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: British National Grid **EPSG:** 27700

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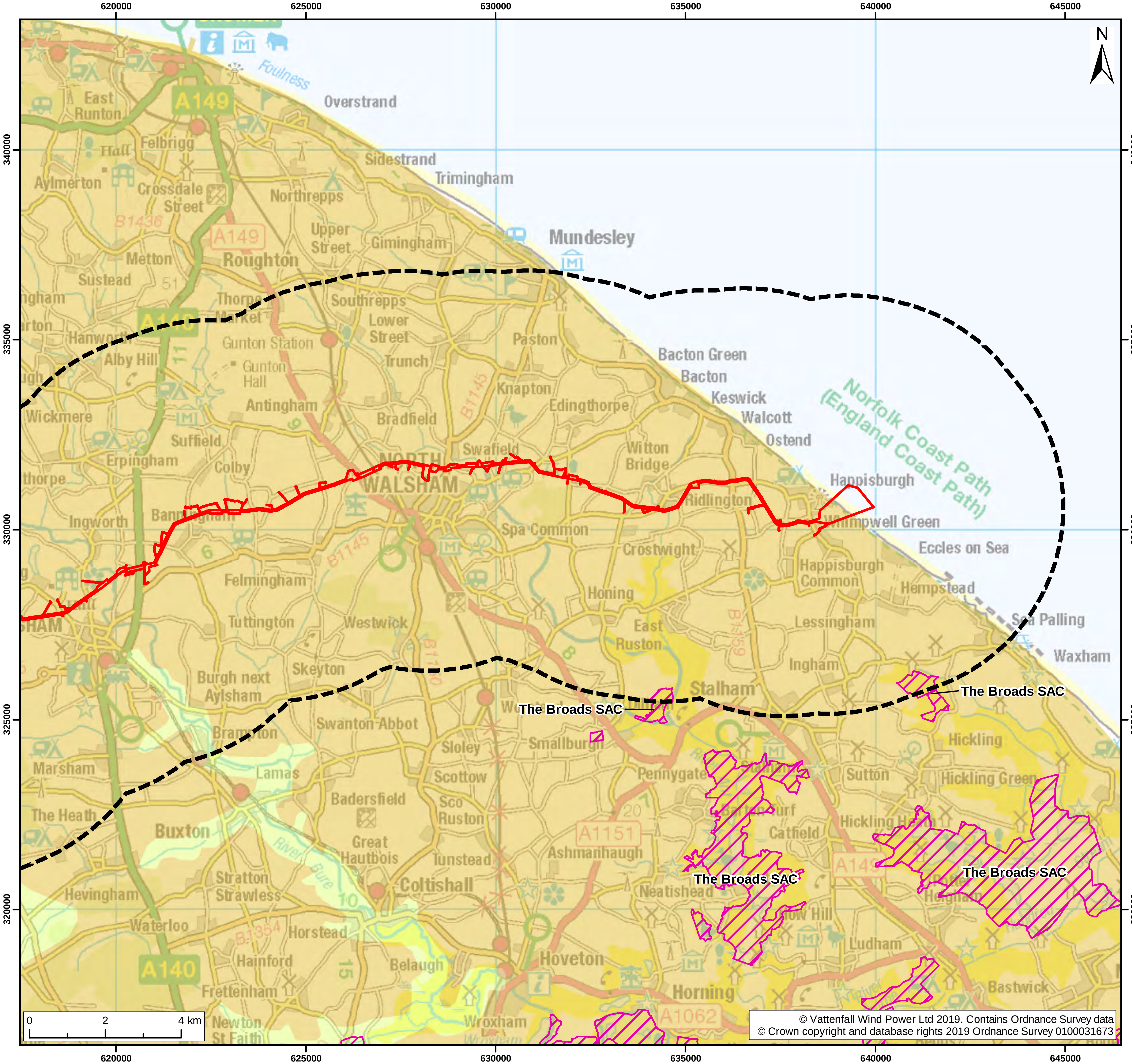

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Environmental Designations[1]

- Special Area of Conservation (SAC)

Bedrock geology[2]

- Neogene To Quaternary Rocks (Undifferentiated)
- White chalk subgroup

[1] Natural England, 2019.
[2] British Geological Survey, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

The Broads SAC - Underlying geology (sheet 1 of 2)

Figure: 9.12 Drawing No: PB5640-007-002-024

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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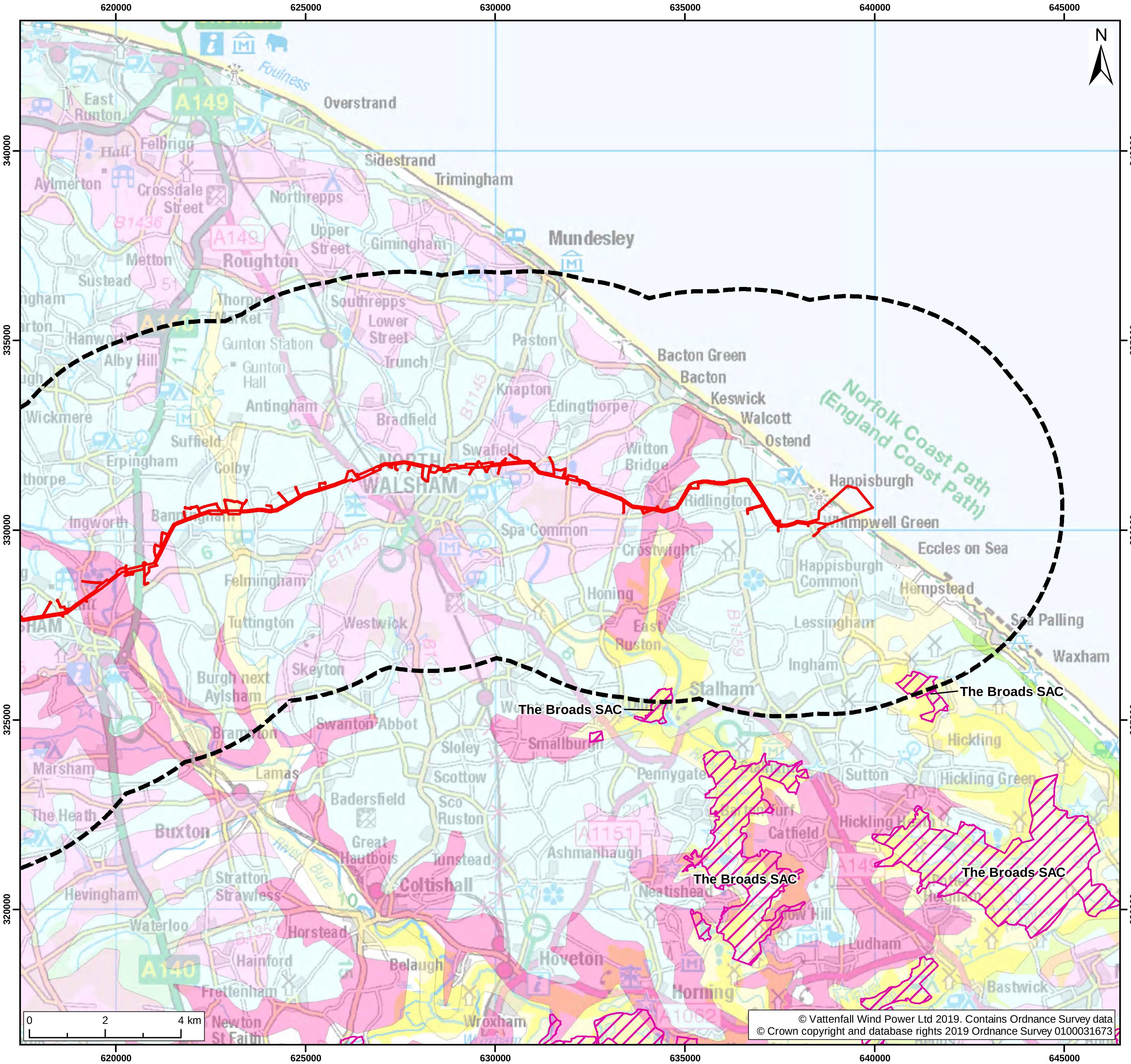

Legend:

- Norfolk Boreas red line boundary
- 5km buffer zone

Environmental Designations[1]

- Special Area of Conservation (SAC)

Superficial geology[2]

- Alluvium - clay, silt and sand
- Blown sand
- Crag group - sand and gravel
- Glacial sand and gravel
- Till - diamicton
- Unknown

[1] Natural England, 2019.
[2] British Geological Survey, 2018.

Project:	Report:
Norfolk Boreas	Habitats Regulations Assessment Report

Title:

The Broads SAC - Underlying geology (sheet 2 of 2)

Figure: 9.12	Drawing No: PB5640-007-002-024				
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9.1.4.2. Qualifying features

9.1.4.2.1. Details of the qualifying features

1332. 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.

1333. 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.

1334. “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

1335. 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.

1336. 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).

1337. Data from the Environment Agency's 'WetMecs' assessment (Environment Agency, 2000) has been obtained to provide an understanding of the water-inflows and outflows for water-dependant sites of The Broads SAC. Furthermore, the depth of the water-bearing strata in proximity to the onshore project area has been sourced from BGS borehole online data and from site investigations undertaken at the trenchless crossing locations (Norfolk Boreas PEIR Chapter 19 Ground Conditions and Contamination, section 19.6.2.1) in order to characterise the ground conditions in the proximity of water-dependant sites of The Broads SAC. Table 9.7 summarises the existing groundwater conditions at the closest site to the onshore project area.

Table 9.7 Broad Fen, Dilham SSSI water supply mechanism

Designated site	Distance to nearest trenching works	Distance to nearest trenchless crossing	Approximate depth of chalk aquifer at nearest trenchless crossing (based on BGS boreholes)	Designated site water supply (WetMecs data)
The Broads SAC (Broad Fen, Dilham component SSSI)	3.6km	4km	40m	The exact WetMecs present at Broad Fen, Dilham have not been determined. The following WetMecs may be present (Wheeler & Shaw, 2000): • ***WETMEC Type 4:*** Seepage Percolation Basins • ***WETMEC Type 5:*** Summer 'Dry' Percolation Surfaces • ***WETMEC Type 6:*** Surface Water Percolation Floodplains • ***WETMEC Type 7:*** Summer 'Dry' Floodplains The site is a large area of fen, counting a series of ponds and terrestrialised turf ponds. Access constraints in recent years mean that rather little is known about the characteristics of the site. It is possible that groundwater flows predominantly from the underlying Contorted Drift and Crag, contribute to the site's water supply. The fen is also regularly flooded, and although this is likely to be surface water the provenance of the water is not known. ***Summary:*** Water supply for this site has not been established with any certainty. It is likely that groundwater supply (predominantly from the underlying Drift and Crag) and surface water supply (predominantly from winter flooding from adjacent watercourses) are important, but no evidence is available as to what extent these play a role is maintaining site integrity.

9.1.4.3. Conservation objectives

1338. 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.

1339. 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

9.2.1. Embedded Mitigation

1340. Norfolk Boreas Limited has committed to 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. Embedding mitigation into the project design is a type of primary mitigation and is an inherent aspect of the EIA process.

1341. A range of different information sources have 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 Chapter 7 Technical Consultation) including engineering requirements, feedback from the community and landowners, ongoing discussions with stakeholders and regulators, commercial considerations and environmental best practice.

1342. The following sections outline the key embedded mitigation measures relevant for this assessment. These measures are presented in Table 9.8. Where embedded mitigation measures have been developed into the design of the project with specific regard to onshore Natura 2000, these are described in Table 9.9.

Table 9.8 Embedded mitigation

Parameter	Mitigation measures embedded into the project design	Notes
Project Wide		
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 Boreas to 35m from the previously identified worst case of 50m. As a result, the overall footprint of the onshore cable route required for the duct installation phase is reduced from approx. 300ha to 210ha; • The width of permanent cable easement is also reduced from 25m to 13m; • Removes the requirement for a cable relay station as permanent above ground infrastructure; • Reduces the maximum duration of the cable pulling phase from three years down to two years; • Reduces the total number of jointing pits for Norfolk Boreas from 450 to 150; and • Reduces the number of drills needed at trenchless crossings (including landfall).	Norfolk Boreas 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.
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 Necton National Grid extension and associated 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 EIA 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;	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 EIA process. Norfolk Boreas Limited has reviewed consultation received to inform the site selection process (including from 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 Chapter 4 Site Selection and Assessment of Alternatives.

Parameter	Mitigation measures embedded into the project design	Notes
	• 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.	
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 Boreas Limited have also agreed to not use the beach car park at Happisburgh South.	Norfolk Boreas 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.
Scenario 1		
Strategic approach to delivering Norfolk Boreas and Norfolk Vanguard	Under Scenario 1, 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 Boreas and Norfolk Vanguard 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 Boreas and Norfolk Vanguard in order to minimise environmental impacts has been a consideration from the outset.
Scenario 2		
Duct Installation Strategy	Under Scenario 2, the onshore cable duct installation strategy is to install ducts in sections to minimise impacts. Construction teams would work on a short section (approximately 150m length) and once the cable ducts have been installed, the section would be back filled and the top soil reinstated 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.	This has been a project commitment from the outset. Chapter 5 Project Description provides a detailed description of the process.
Trenchless Crossings	Commitment to trenchless crossing techniques to minimise impacts to the following specific features;	A commitment to a number of trenchless crossings at certain

Parameter	Mitigation measures embedded into the project design	Notes
	• 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.	sensitive locations was identified at the outset. However, Norfolk Boreas Limited has committed to certain additional trenchless crossings as a direct response to stakeholder requests.

Table 9.9 Embedded mitigation for onshore Natura 2000 sites

Parameter	Mitigation measures embedded for onshore ecology	Notes
Designated sites	Constraints mapping was undertaken prior to the publication of the Norfolk Vanguard EIA Scoping Report (Royal HaskoningDHV, 2016b). This 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 sites 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. This mitigation measure is applicable to both Scenario 1 and 2	More information can be found in 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;	Further information on the route refinement process can be found in Chapter 4 Site Selection and Assessment of Alternatives.

Parameter	Mitigation measures embedded for onshore ecology	Notes
	• 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. This mitigation is applicable to both Scenario 1 and 2	
Hedgerow and watercourse crossings	Under Scenario 2 the working width at hedgerow and watercourse crossings is 13m[29] (reduced from 25m) due to the selection of a HVDC electrical solution. (under Scenario 1 ducts will have been installed by Norfolk Vanguard therefore hedgerows and water courses will not require crossing. Under both scenarios where hedgerow gaps are required for the duration of the two-year cable pulling 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 Chapter 5 Project Description.
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 (under Scenario 2 only), each duct installation team will work along a short section of the cable route, 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 two year cable pulling phase, a reduced 12km by 6m strip along the onshore cable route is anticipated to be lost potentially for a further 16 weeks in any one area per annum for the running track, thus minimising the number of hedgerow gaps required for the duration of construction down to approximately 20%. The hedgerow gap has also been reduced to the width of the running track (6m) for the cable pull; 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	For further details on the construction approach and programme, please see Chapter 5 Project Description.

[29] 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 16.5m. Where this is the case for a particular receptor, it is noted within this report.

Parameter	Mitigation measures embedded for onshore ecology	Notes
	may be disturbance to a small number of watercourses which need to be crossed when the running track is reinstated to facilitate the cable pulling operations.	

9.2.1.1. Outline Landscape and Environmental Management Strategy

1343. The mitigation measures set out within this report and within the Norfolk Boreas Ecological Impact Assessment (EcIA) will be delivered via an Outline Landscape and Environmental Management Strategy (OLEMS) (document reference 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.

1344. 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 2019) will be implemented via the OLEMS.

9.2.2. Worst Case Scenario

1345. The project design envelope on which the assessment is based was "frozen" in January 2019 to allow the application for development consent to be completed and submitted in June 2019. This design envelope has been used to define realistic worst case scenarios.

9.2.2.1. Build-out Scenarios 1 and 2

1346. VWPL is also developing Norfolk Vanguard, a 'sister project' to Norfolk Boreas. In order to minimise impacts associated with onshore construction works for the two projects, Norfolk Vanguard are seeking to obtain consent to undertake enabling works for both projects at the same time. However, Norfolk Boreas needs to consider the possibility that Norfolk Vanguard may not proceed to construction.

1347. The HRA will therefore be undertaken using the following two alternative scenarios (further details are presented in Chapter 5 Project Description of the Environmental Statement) and an assessment of potential impacts has been undertaken for each scenario:

- **Scenario 1** – Norfolk Vanguard proceeds to construction, and installs ducts and other shared enabling works for Norfolk Boreas; and

- **Scenario 2** – Norfolk Vanguard does not proceed to construction and Norfolk Boreas proceeds alone. Norfolk Boreas undertakes all works required as an independent project.

9.2.2.2. Realistic worst case scenario

1348. 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.

1349. The onshore project area relevant to the HRA Report comprises the onshore cable route element of the onshore project area only. 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.

1350. 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).

1351. 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.

1352. Table 9.10 sets out those parameters which comprise the worst case assumptions for onshore Natura 2000 sites under Scenario 1, and Table 9.11 sets out those parameters which comprise the worst case assumptions for Natura 2000 sites under Scenario 2.

Table 9.10 Worst case assumptions – Scenario 1

Worst case assumptions			
Parameter	**Worst case criteria**	**Worst case definition**	**Notes**
Landfall			
Construction	Method	Trenchless technique (e.g. HDD)	
	Maximum drill length	1,000m	
	Temporary works footprint	6,000m^2	
	Maximum temporary works duration	20 weeks	Based on 7am-7pm normal working hours.

Worst case assumptions			
Parameter	**Worst case criteria**	**Worst case definition**	**Notes**
	Worst case construction and operation noise levels are as set out within Chapter 25 Noise and Vibration.		
Landfall compounds	Maximum number and maximum land take for temporary landfall compounds	Assumes 2 at 3,000m^2	Two compounds (50m x 60m) to support parallel drilling rigs.
Onshore cable route			
Construction – cable installation only	Cable installation maximum footprint Gaps at hedgerow / other crossing points Excavated material for running track	85,500m^2 6m 21,600m^3	Cable installation footprints include the running track and jointing pits.
Permanent jointing pits	Maximum number and required dimensions	Assume 150 at 90m^2 and 2m deep each	Spaced approximately one per circuit per 800m cable.
Construction programme – cable pulling, jointing and commissioning	Hardstand area Running track topsoil storage area Total construction window	10 weeks 16 weeks 2 years	2 years phased cable installation
Decommissioning		Jointing pits and ducts left in-situ	Where cables are in pre-installed ducts, cables may be extracted once de-energised.
Onshore project substation			
Construction	Maximum land take for temporary works area at the onshore project substation Maximum land take for temporary works area at Spicers Corner Maximum duration	20,000m^2 10,000m^2 30 months	Substation compound 200m x 100m. Spicers corner compound 100m x 100m. Indicative construction window 24 months
	Worst case construction and operation noise levels are as set out within Chapter 25 Noise and Vibration.		
Operation	Maximum land take for permanent footprint Access	75,000m^2 One visit per week	Operational footprint 250m x 300m Site lighting required during maintenance visits
Decommissioning	No decision has been made regarding the final decommissioning policy for the onshore project substation, as it is recognised that industry best practice, rules and legislation change over time. However, the onshore project equipment will likely be		

Worst case assumptions Parameter	Worst case criteria	Worst case definition	Notes
	removed and reused or recycled. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the regulator. A decommissioning plan will be provided. As such, for the purposes of a worst case scenario, impacts as for the construction phase are assumed.		
National Grid extension and overhead line modification			
Construction	Maximum land take for temporary works area – substation extension Maximum duration	30,000m^2 30 months	Compound 150m x 200m adjacent to eastern extension site. Indicative construction timing 24 months
Operation	Maximum land take for substation extension permanent footprint Access	18,602m^2 1 visit per month	Permanent eastern extension footprint 131m x 142m Site lighting required during maintenance visits

Table 9.11 Worst case assumptions – Scenario 2

Worst case assumptions Parameter	Worst case criteria	Worst case definition	Notes
Landfall			
Construction	Method Maximum drill length Temporary works footprint Maximum temporary works duration	Trenchless technique (e.g. HDD) 1,000m 6,000m^2 20 weeks	Worst case construction noise levels are as set out within Chapter 25 Noise and Vibration.
Landfall compounds	Maximum number and maximum land take for temporary landfall compounds	Assumes 2 at 3,000m^2 each to support parallel drill rigs	Two compounds (50m x 60m) to support parallel drilling rigs
Onshore cable route			
Construction	Construction method Maximum working width and length Onshore cable route maximum footprint Total maximum duct installation footprint	Open cut trenching and trenchless crossing methods 35m and 60km 2,100,000m^2 2,452,500m^2	Includes the onshore cable route footprint plus all associated works

Worst case assumptions			
Parameter	**Worst case criteria**	**Worst case definition**	**Notes**
			footprints (mobilisation areas, trenchless launch and reception sites).
	Gaps at hedgerow / other crossing points	13m[30]	Assumes perpendicular crossing, angled crossing up to 16.5m
	Maximum hedgerows to be removed	165[31]	
	Running track excavated material	108,000m^3	
	Trench excavated material	180,000m^3	
	Cable installation maximum footprint	85,500m^2	Cable installation footprints include the running track and jointing pit. Onshore cable route footprint covers all works required for duct installation (trenching, spoil storage, etc.).
Permanent jointing pits	Maximum number and required dimensions	Assume 150 at 90m^2 and 2m deep each	Spaced approximately one per circuit per 800m cable.
Mobilisation areas	Maximum number and required dimensions	Assumes 14 at 10,000m^2	Including area at Spicers Corner
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	
Construction programme - ducting	Ducting at any 150m workfront	2 weeks	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
	Trenchless works at each watercourse	8 weeks	
	Running track topsoil storage area	2 years	

[30] 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 16.5m. Where this is the case for a particular receptor, it is noted within this report. Mitigation by design with respect to hedgerows already included in Chapter 5 Project Description.

[31] Hedgerows estimated based on 110 hedgerows surveyed within the onshore infrastructure 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	this stage that no hedgerows will be reinstated during the construction phase, i.e. between trenching and cable pulling.
Construction programme - cable pulling, jointing and commissioning	Hardstanding area Running track topsoil storage area Total construction window	10 weeks 16 weeks 2 years	
Construction programme	Total construction window	6 years	Includes 2 years pre-construction works.
Decommissioning		Jointing pits and ducts left in-situ	Where cables are in pre-installed ducts, cables may be extracted once de-energised.
Onshore project substation			
Construction	Maximum land take for temporary works area Maximum duration	20,000m^2 30 months	Substation compound 200m x 100m. Indicative construction timing 24 months
	Worst case construction and operation noise levels are as set out within Chapter 25 Noise and Vibration.		
Operation	Maximum land take for permanent footprint Access	75,000m^2 One visit per week, site lighting required during maintenance visits	Operational footprint 250m x 300m
Decommissioning	No decision has been made regarding the final decommissioning policy for the onshore project substation, as it is recognised that industry best practice, rules and legislation change over time. However, the onshore project equipment will likely be removed and reused or recycled. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the regulator. A decommissioning plan will be provided. As such, for the purposes of a worst case scenario, impacts as for the construction phase are assumed.		
National Grid extension and overhead line modification			
Construction	Maximum land take for temporary works area – substation extension Maximum land take for temporary works area – overhead line Maximum duration	67, 500m^2 174,264m^2 30 months	Indicative construction window 24 months

Worst case assumptions			
Parameter	**Worst case criteria**	**Worst case definition**	**Notes**
Operation	Maximum land take for substation extension permanent footprint	28,258m^2	Permanent western extension footprint 199m x 141m
	Maximum land take for overhead line permanent footprint	9,250m^2	
	Access	1 visit per month, site lighting required during maintenance visits	

1353. Chapter 5 Project Description outlines the timings to be assessed in relation to the phasing of the works. In all cases for onshore ecology; the two phase option, where cables are installed in two consecutive years to facilitate the commissioning of the offshore wind turbine planting, is assumed to be the worst case. This is due to the increased length of time that ecological receptors will be potentially impacted by the project.

9.3. Assessment of Potential Effects

9.3.1. River Wensum SAC

9.3.1.1. Potential effects of Norfolk Boreas

1354. The potential effects during the construction, operation and decommissioning of Norfolk Boreas 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 Norfolk Vanguard and Norfolk Boreas EPP.

1355. During construction of the proposed Norfolk Boreas project, the construction effects that have the potential for adverse effect upon site integrity are listed in Table 9.12.

Table 9.12 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

Qualifying feature	Potential 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

1356. 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

Scenarios 1 and 2

1357. The 2017 and 2018 botanical surveys concluded that the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation for which the River Wensum SAC is designated is not present within the River Wensum or in the drains and ditches of the floodplain habitats of the River Wensum on the right-hand (southern) bank or left-hand (northern) bank of the river (see Figure 9.1).

1358. As the qualifying feature is not present within the onshore project area or ex-situ habitats are being avoided through the use of trenchless techniques, with regards to direct effects, there is **no 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

Scenario 2

1359. As described in section 9.3.1.2.1, the 2017 and 2018 botanical surveys 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.

1360. Potential changes to local hydrological conditions from the construction and operation of Norfolk Boreas 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 and 2018 botanical survey concluded that there are no springs or seepages located within the floodplain habitats on the right-hand (southern) or left-hand (northern) bank of the River Wensum. 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.

1361. 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.

1362. As outlined in the Statement of Common Ground with Natural England issued during the Norfolk Vanguard DCO Examination (Document reference: Rep1 - SOCG - 13.1), the effects of the cable trench arrangement upon local hydrological conditions at the River Wensum have been considered in this assessment. The cable trench arrangement is described within Environmental Statement Chapter 5 Project Description. Plate 5.16 shows the trench arrangement and the extent of stabilised backfill (cement bound sand). The cement bound sand will represent a stabilised layer within which the cable ducts are secured. There will be approximately 10cm of cement bound sand above and below the cable ducts. Above the cement bound sand will be approximately 1m of subsoil and topsoil. The cement bound sand will represent an impermeable barrier. A detailed assessment of potential changes to subsurface flows is presented in Chapter 20 Water Resources and Flood Risk at section 20.7.6.1.1. As a result of the limited spatial extent of permanent impermeable development along the cable route, the effect is considered to be of negligible magnitude.

1363. 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.

1364. 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 tracking 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 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.

1365. 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:

Sediment management – works within the functional floodplain

1366. The practices set out below 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. An outline CoCP will be submitted alongside the DCO application (Document reference 8.1):

- The preferred way of working within the functional floodplain will be to establish the trenchless crossing compounds by placing geotextile on top of the existing pasture grassland. Whilst it is accepted that grass covered by geotextile for 8 weeks will die back, it will not expose bare soils beneath and the grass will recover more quickly than reseeding or natural regeneration in the case of topsoil stripping.
- Where a topsoil strip is required, for existing grassland located within the functional floodplain, this will be undertaken using a turf cutter. Turf rolls will be retained and reinstated after the works are complete (approximately eight weeks) to maximise the potential for reinstatement / restoration to be effective.
- Removed topsoil and turf will be stored outside of the functional floodplain.
- Any damage to ground conditions caused by vehicle tracking will be rectified prior to the reinstatement of topsoil/turf. Land reinstatement will be undertaken in adherence to Defra's Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (2009). These measures will be secured through the final CoCP produced post-consent, which will be in accordance with the certified Outline CoCP.
- Construction drainage will be introduced along the onshore cable route in advance of the works. The drainage will be designed to minimise water entering works areas and to ensure ongoing drainage of surrounding land. A surface water drainage plan will be included within the final CoCP produced post-consent, which will be in accordance with the certified Outline CoCP. This will include the following measures:
  - The surface water drainage introduced in advance of construction will include interceptor drains for surface water flows. The interceptor drains will include areas for the settlement of sediment (sediment traps). Sediment traps are locally wider/deeper areas of the drains that will encourage passive sediment deposition.
  - Sediment traps will be monitored weekly (visual inspection) during the trenchless crossing works (with increased monitoring during inclement weather). If required these traps can be pumped via settling tanks to remove sediment, based on a pre-defined level / depth of sediment.
  - Where water enters the construction areas, this will be pumped via settling tanks or ponds to remove sediment before being discharged into local ditches or drains via the interceptor drains in order to prevent increases in fine sediment supply to the watercourses.
  - When the interceptor drains and associated sediment traps are decommissioned any standing water within the drains would be pumped

out to settling tanks as described above. Sediment that has settled out within the interceptor drain would be left in place. Soils would be replaced in the reverse order that they were removed and turf reinstated.

- o Existing tracks and roadways will be utilised for access where possible. Temporary construction accesses within the functional floodplain are required if the third trenchless crossing compound (north of Penny Spot Beck) is used. Any topsoil removal and subsequent post-construction reinstatement will follow the steps outlined above.

<u>Sediment management – measures to be applied throughout the onshore work areas (*as detailed within the outline CoCP – (Document reference: 8.1)*)</u>

- The area of open ground at any one time within one sub-catchment will be restricted, across a notional 5 km length, to 2 working areas (configured as 45m x 300m strips); with the assumptions that 50% of one mobilisation area, 50% of one set of trenchless crossing compounds and 25% of 5km running track will be open ground. This represents a maximum area of disturbed open ground of 0.068 km2 per 5km of cable at any one time.
- Topsoil would be stripped from the entire width of the onshore cable route for the length of each approximately 150m workfront, and stored and capped to minimise wind and water erosion within the onshore cable route.
- Once all the trenching is completed and back-filled within each workfront, the stored topsoil will be re-distributed over the area of the workfront, with the exception of the running track and any associated drainage.
- Mobilisation areas within the onshore project area will comprise hardstanding of permeable gravel aggregate underlain by geotextile, or other suitable material.
- Subsoil exposure will be minimised and strips of undisturbed vegetation will be retained on the edge of the working area where possible.
- Within the functional floodplain, where surface vegetation has been removed (with the exception of arable crops), turf stripping and reinstatement of grassland for all grassland habitats located within 10m of any watercourse within the River Wensum catchment will be undertaken. This mitigation measure is being proposed to ensure that grassland adjacent to all watercourses is managed so as to reduce the risk of sediment release into the tributaries of the River Wensum by reinstating a 10m buffer strip of re-laid turf adjacent to each watercourse[32].
- On-site retention of sediment will be maximised by routing all drainage through the site drainage systems.

[32] The majority of the watercourses within the Wensum catchment do not have a floodplain the extends beyond each watercourse's channel, hence 10m either side of all watercourses in the Wensum catchment is additional to the commitments already made for those that do have a functional floodplain.

- The drainage system will include silt fences at the foot of soil storage areas to intercept sediment runoff at source. Where practicable, runoff will be routed into swales, which incorporate check dams to further intercept sediment and/or attenuation ponds which incorporate sediment forebays. Suitable filters will be used to remove sediment from any water discharged into the surface drainage network.
- Additional silt fences will be included in parts of the working area that are in proximity to surface drainage channels. It is not intended that silt fences will be used where works are located in the functional floodplain as spoil will not be stored in these locations. Sediment traps would be incorporated into the design of the surface water drainage.
- Soil and sediment will not be allowed to accumulate on roads. Traffic movement would be restricted to minimise the potential for surface disturbance.

Pollution prevention

- 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), including:
    - Spill kits will be available on site at all times and staff will be trained in their use
    - Sand bags or stop logs will also be available for deployment on the outlets from the site drainage system in case of emergency spillages.
    - Equipment will be regularly checked to ensure leakages do not occur.
    - Refuelling of construction plant will be restricted to designated impermeable areas.
    - All fuels, oils, lubricants and other chemicals will be stored in an impermeable bund with at least 110% of the stored capacity.
    - Suitable biosecurity protocols (such as those outlined by the Non-Native Species Secretariat (NNSS)) would be put in place during the works in order to minimise the risk of contamination and the spread of the invasive non-native species.

Bentonite breakout

1367. Bentonite is an inert clay-based material used as a lubricant at the drill head during trenchless crossing techniques – comprising 95% water and 5% clay. It does not represent a pollutant but can cause smothering of habitats if not contained.

1368. For small breakouts it may cause more damage to the sensitive habitats to attempt to contain the breakout and remove the escaped material, i.e. trampling of grassland associated with responding to the breakout and the potential for exposing bare ground. A break-out contingency plan will be developed and will be included in the final CoCP, which will define the approach for responding to breakouts. The steps of the contingency plan will include:

- Measures to ensure drilling stops once a breakout is reported (there will be a drop in pressure at the drill head).
- Measures to contain the breakout, for example sand bags, to minimise the extent of any smothering.
- Measures to remove the released bentonite if a significant volume of material is contained – for example pumped back to the bentonite lagoon within the trenchless crossing compound, or pumped to the interceptor drains, or pumped to the mobile settling tanks that will be used for managing sediment traps.
- The exact specification for the contingency plan will be informed by further ground investigation and the specific design of the trenchless crossing.

1369. 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.

1370. In light of the negligible risk of the proposed works affecting local groundwater and hydrology following implementation of the mitigation measures outlined above, **no 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.**

Scenario 1

1371. Under Scenario 1, works within the River Wensum floodplain to install ducts will have already take place as part of the Norfolk Vanguard.

1372. Although the exact location of jointing pits and associated running track required for the cable installation works for Norfolk Boreas are not known prior to detailed design undertaken post-consent, there is some design flexibility governing the location of jointing pits. A pit is required every 500-1000m along the cable route. This allows for the option, in some cases, to avoid sensitive locations, particularly around locations of cable 'stop ends'. For example, a jointing pit would not be required within the floodplain habitat of the River Wensum (as shown in Figure 9.1). Therefore, under Scenario 1, no works will take place within the River Wensum floodplain during the construction of Norfolk Boreas.

1373. Under Scenario 1, although no running track will be required within the River Wensum floodplain, a small area of 6m wide running track will be required within other areas of the River Wensum catchment. The sediment management measures detailed above for Scenario 2 would also be applied for Scenario 1 and would be secured through a CoCP post-consent (document reference 8.1). A Construction Surface Water and Drainage Plan (Requirement 20 (2)(i) of Schedule 1 of the DCO) will be developed post consent as part of the CoCP. This will be agreed with the relevant regulators and implemented to minimise runoff and ensure ongoing drainage of surrounding land. This typically includes interceptor drainage ditches being temporarily installed parallel to excavations and soil storage areas to provide interception of surface water runoff and the use of pumps to remove water from the jointing pits, if required. Drainage would remain in place for the duration of the construction period.

1374. As works will not take place within the River Wensum or its floodplain during the construction works for Norfolk Boreas, **no 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.**

9.3.1.2.3. 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

Scenarios 1 and 2

1375. 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 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 within the SAC boundary and within ex-situ habitats of the SAC

Scenarios 1 and 2

1376. The 2017 and 2018 Desmoulin’s whorl snail survey concluded that this species is not present within the banks of the River Wensum or within the drains and ditches of the floodplain habitats on the right-hand (southern) and left-hand (northern) banks of the river (see Figure 9.2).

1377. As the qualifying feature is not present within the onshore project area, with regards to direct effects there is **no 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

Scenarios 1 and 2

1378. As described in section 9.3.1.3.1, the 2017 and 2018 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 in the River Wensum downstream of the onshore project area, and therefore for the purposes of this assessment it has been assumed that they may be present within the reaches of the River Wensum immediately downstream of the onshore project area.

1379. 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.

1380. In light of the negligible risk of the proposed works affecting local groundwater and hydrology following implementation of the mitigation measures outlined above, **no 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 habitat of the SAC arising from geology / contamination and groundwater / hydrology effects

Scenarios 1 and 2

1381. 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 9.3.1.3.3). 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 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 Boreas in-combination with other plans and projects

1382. 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 Boreas 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 Boreas, there is no real prospect of an in-combination effect occurring with another plan or project.

1383. The assessment for the potential adverse effect upon site integrity to arise from the development of the Norfolk Boreas 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 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

1384. Table 9.13 below summarises the potential effects arising from the construction phase of the proposed Norfolk Boreas project.

Table 9.13 Summary of the potential effects of Norfolk Boreas 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?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
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	×	×	×	×

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?		Potential for adverse effect upon site integrity in-combination?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
	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 Boreas

1385. The potential effects during the construction, operation and decommissioning of the proposed Norfolk Boreas 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 Norfolk Vanguard EPP.

1386. The potential effects during construction, operation and decommissioning of the proposed Norfolk Boreas 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)

Scenario 2

1387. 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.

1388. The proposed works for Norfolk Boreas involve hedgerow removal at 16 of the 17 hedgerows of moderate or greater suitability to support roosting bats within the onshore project area. This also includes five of the six features of particular importance for barbastelles identified above. The hedgerow located at Witton Hall Plantation along Old Hall Road (see Table 9.3), 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.

1389. Hedgerow removal is required at these 16 hedgerows across five features 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 25m down to 13m. Where the cable route crosses the linear features at oblique angles, the actual length of hedgerow removal required can be greater than 13m (up to 16.5m). Table 9.14 summarises the length of hedgerow removal required for the project at each of these 16 hedgerows. The total potential amount of hedgerow removal required is approximately 198m (<0.1ha of habitat). Of this, approximately 108m include features of particular importance for barbastelle, as identified using the 2017 and 2018 activity survey data and radio-tracking data from the NBSG. The radio-tracking data indicates that there is at least approximately 2,000ha[33] of habitat within the home range of the bats associated with the Paston Great Barn bat colony. 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.

1390. This length of hedgerow will be removed in advance of construction, 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

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[33] This figure is an underestimate of the extent of forgaing habitat used by barbstelles of the Paston Great Barn colony. It does not include habitats along the coast, which is the primary good weather foraging habitat used by bats of the Paston Great Barn colony (NBSG, 2017).

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)[34], 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).

Table 9.14 Habitats to be removed during construction

Important barbastelle area	Hedgerow	Use by barbastelle [35]	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	37	Occasional foraging	Species poor hedgerow with trees	13m	None
Hedgerow along North Walsham Road from Edingthorpe Green to Edingthorpe Heath	30, 31	Occasional commuting / foraging	Hedgerow (no detailed hedgerow information available)	14m (each)	None
Witton Hall Plantation along Old Hall Road	Unnamed (Witton)	Regular commuting / foraging	Mixed deciduous woodland	-	None (trenchless techniques used at this location)
Road from Bacton Wood to Witton	26	Occasional commuting	Species-rich hedgerows with trees	15m	11ha (0.6%)
Two hedgerows between Witton and North Walsham Road	23, 24	Commuting / foraging	Two species-poor hedgerows with trees	13m (each)	Negligible (<0.01ha)
Drains and hedgerows at Ridlington Street	15, 16	Occasional commuting	Two species poor hedgerow with trees	13m (each)	None
Other hedgerows	18, 19, 21, 22, 25, 29, 34a, 34b	*No data*	One species-rich hedgerow; two species-poor hedgerows with	15m (each)	Negligible (<0.01ha)

[34] 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.
[35] Derived from 2017 and 2018 activity survey and NBSG radio-tracking data

Important barbastelle area	Hedgerow	Use by barbastelle [35]	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)
			trees; five unsurveyed hedgerows.		
TOTAL				**198m**	

1391. 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). The criteria for determining 'poor weather' will be stipulated in the final CoCP the outline version of which will be submitted as part of the DCO application (Document reference: 8.1).
- 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 where possible and hedges will be double-planted with 2m grassland strips on both sides so there is always a leeward side to forage. Replanting will also include hedgerow improvements works within the onshore cable route where required. These include gapping-up and tree management.
- Subject to landowner permissions, the 16 hedgerows that suitable for supporting 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 22m 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 (Bat Conservation Trust, 2015).

- A Hedgerow Mitigation Plan will be developed in consultation with Natural England prior to the removal of hedgerows. This mitigation plan will detail the reinstatement approach for hedgerows removed during construction and the monitoring and maintenance requirements following hedgerow planting. This commitment is captured within the OLEMS (document reference 8.7).
- Pre-construction habitat assessment surveys of the 18 hedgerows to confirm the habitat condition prior to removal and pre-construction activity surveys of all of the 18 hedgerows which remain suitable for supporting commuting and foraging bats following the updated habitat assessment will be undertaken to provide an updated baseline for these features in advance of construction. This includes activity surveys of the six hedgerows for which data was not collected in in 2017 and 2018.

1392. In addition to the above mitigation measures, during detailed project design, the Norfolk Boreas 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).In addition to the area of habitat directly lost during the construction phase of Norfolk Boreas, 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 Boreas project. Although through iterations of the project design, the potential hedgerow gap created during construction of the project has been reduced down to 13m, 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 9.14.

1393. No habitat is estimated to be potentially subject to fragmentation at Dilham Canal and land east of Dilham Canal (Hedgerow 39). 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., 31st January 2018).

1394. No habitat is estimated to be potentially subject to fragmentation at hedgerow along North Walsham Road from Edingthorpe Green to Edingthorpe Heath (Hedgerows 33, 34). Barbastelle have been recorded commuting here, but land to the south of this habitat has not been identified as core foraging habitat (NBSG, 2017).

1395. 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 (unnamed hedgerow) 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.

1396. 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 (Hedgerow 26) 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.

1397. The remaining hedgerows within the study area (two sections of hedgerows between Witton and North Walsham Road (Hedgerows 23, 24), drains and hedgerows at Ridlington Street (Hedgerows 15, 16) and the remaining six hedgerows within the study area (Hedgerows 18, 19, 21, 22, 25, 32, 36a, 36b)) are all located on the edge of the Paston Great Barn colony home range (NBSG, 2017), and therefore the creation of gaps in these hedgerows will result in a negligible area of habitat fragmented. 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.

1398. The total home range of barbastelle bats of the Paston Great Barn colony is estimated, based on the radio tracking data, to cover at least approximately 2,000ha from the coast between Mundesley and Keswick, to Knapton Cutting foraging habitat in the west and to day roosts at Spa Common and Witton in the south.

1399. 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. The suitability of this habitat as a foraging resource is provided in Table 9.15.

Table 9.15 Suitability of habitat mosaic as a potential foraging resource (see Figure 9.6)

Location	Habitat assessment	Assessed potential for support foraging bats	% of all suitable habitats located within barbastelle home range
Witton	Mosaic of habitats associated within the upper reaches of the Hundred Stream. Habitats include	Moderate - High	0.6%

Location	Habitat assessment	Assessed potential for support foraging bats	% of all suitable habitats located within barbastelle home range
	semi-natural broadleaved woodland (approximately 7ha) and semi-improved grassland (approximately 4ha) and an intersecting drainage ditch network associated with the Hundred Stream, plus approximately 1km of species-rich hedgerow with trees.		

1400. This 11ha represents approximately 0.6% of the potentially suitable habitats for supporting commuting / foraging bats located within the Paston Great Barn study area. The extent of the potentially suitable habitats for supporting commuting / foraging bats located within the Paston Great Barn study area is shown on Figure 9.6.

1401. 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 (NBSG, 2017)). Given the very small percentage of the available habitat which will be potentially fragmented, and the fact that this is both not part of the key foraging area along the coast near Mundesley and is on the edge of the study area, fragmentation of these 11ha are not considered to give rise to likely significant effects on the integrity of the Paston Great Barn SAC.

1402. 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 within the study area. Chapter 22 Onshore Ecology of the Norfolk Boreas ES (document 6.1.22) 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.

1403. The assessment for the potential for adverse effect upon site integrity arising from the development of the Norfolk Boreas 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 adverse effect on the integrity of the Paston Great Barn SAC in relation to the conservation objectives for the site.**

Scenario 1

1404. Under Scenario 1, any hedgerow removal required within the onshore project area required to facilitate construction of the Norfolk Boreas project will have been undertaken by the Norfolk Vanguard project. No further hedgerow removal will be undertaken for the Norfolk Boreas project under Scenario 1.

1405. Scenario 1 will require approximately 20% of the running track originally installed for to facilitate construction of Norfolk Vanguard to remain in place to facilitate construction of Norfolk Boreas. This will include retention of a 6m gap in 20% of hedgerows along the route. The exact location of these gaps will be determined during detailed design, therefore at this stage it is assumed that they may be required at all hedgerows removed by the Norfolk Vanguard project. These 6m gaps will need to be retained for a further 16 weeks over two years to construct the Norfolk Boreas project. Following construction, the remaining 6m gaps will be replanted. 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.

1406. All UK bat species are considered able to traverse gaps of 10m or less (JNCC, 2001; BCT, 2012), therefore retention of this 6m gap for up to 2 years following completion of the Norfolk Vanguard project is not considered likely to give rise to an effect on commuting / foraging barbastelle bats. As a consequence, there will be no direct effects arising from hedgerow removal, and there is **no 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

Scenarios 1 and 2

1407. The proposed works will involve ground excavation of up to 1.5m depth to facilitate cable trench construction and cable jointing, and therefore will have a small, localised effect upon surface water flows. These excavations will be fully reinstated following completion of construction. Reinstatement will be undertaken following best practices as set out in the outline CoCP (document reference 8.1) to minimise the long term effect on local drainage patterns arising from construction. 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 (document reference 8.1).

1408. Construction phase lighting for cable duct installation and cable jointing 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 during cable duct installation 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.

1409. 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 198m 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 Boreas. 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 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)

Scenario 1 and 2

1410. 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 Boreas project. As a consequence, there will be no direct effects arising during operation, and there is **no 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

Scenario 1 and 2

1411. All earthworks will be reinstated following completion of the duct installation and cable jointing, and hydrological conditions are anticipated to return to their situation prior to the construction phase works.

1412. There will be no lighting required during the operational phase of the Norfolk Boreas project.

1413. 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 Boreas, and therefore there is **no 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

Scenario 1 and 2

1414. 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 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 Boreas.**

1415. 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 Boreas in-combination with other plans and projects

9.3.2.2.1. Introduction

1416. In-combination effects refer to effects on certain receptors from the Norfolk Boreas 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.

1417. Table 9.16 summarises those projects which have been identified as potentially giving rise to effects upon Paston Great Barn SAC in-combination with the Norfolk

Boreas project, due to their temporal or spatial overlap with the potential effects arising from Norfolk Boreas. The remainder of the section details the nature of the in-combination effects upon Paston Great Barn SAC.

Table 9.16 Summary of projects considered for the in-combination assessment

Project	Status	Development period	[36]Distance from Norfolk Boreas (km)	Project data status	Rationale
Norfolk Vanguard Offshore Wind Farm (Scenario 1 only)	DCO Examination in progress	Expected construction 2022.	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)

Scenario 1 and 2

1418. Under Scenario 2 Norfolk Vanguard would not be constructed, therefore in-combination effects are considered under Scenario 1 only.

1419. Under Scenario 1, the construction of Norfolk Vanguard would result in the effects identified in section 9.3.2.1.1 for Scenario 2 (i.e. the loss of hedgerow habitat at 16 hedgerows within the study area). The construction of Norfolk Boreas would not result in any further loss of hedgerow, but would act cumulatively to extend the period during which a 6m gap would exist within each of the 16 hedgerows within the study area by up to a further two years following completion of construction for the Norfolk Vanguard project. As all UK bat species are considered able to traverse gaps of 10m or less (JNCC, 2001; BCT, 2012), this is not considered likely to affect barbastelle bats using these hedgerows.

1420. 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

[36] Shortest distance between the considered project and Norfolk Boreas – unless specified otherwise.

to forage in good weather. Both of these projects are due to be completed by 2019 at the latest. Pre-construction works for Norfolk Boreas will not commence before 2024. 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.

1421. As a consequence, **no 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

Scenarios 1 and 2

1422. Under Scenario 2 Norfolk Vanguard would not be constructed, therefore in-combination effects are considered under Scenario 1 only.

1423. Under Scenario 1, the construction of Norfolk Boreas would involve minimal lighting during low light conditions encountered during normal daytime working hours (7am-7pm) only during cable jointing phase of works. As identified in section 9.3.2.1.1, these effects will be localised, giving rise to negligible effects upon commuting foraging bats, therefore there is not likelihood of in-combination effects occurring.

1424. As outlined above in relation to direct effects, the Bacton Gas Terminal coastal protection project and the Bacton Coastal Protection Scheme construction will be completed prior to construction of Norfolk Boreas. 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.

1425. As a consequence, **no 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

1426. Table 9.17 below summarises the potential effects arising from the construction, operation and decommissioning phases of the proposed Norfolk Vanguard project.

Table 9.17 Summary of the potential effects of Norfolk Boreas 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?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
Construction phase					

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?		Potential for adverse effect upon site integrity in-combination?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
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 Boreas

1427. The potential effects during the construction, operation and decommissioning of the proposed Norfolk Boreas 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 Norfolk Vanguard EPP.

1428. The potential effects during construction of the proposed Norfolk Boreas 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.

1429. 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

Scenario 2

1430. 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.

1431. The qualifying features of the Norfolk Valley Fens SAC present at the five component SSSIs located within 5km of the onshore project area are all water-sensitive habitats, and are reliant on the surface and groundwater conditions to ensure a maintenance of water flow. Figure 9.8 shows the location of these sites within the local surface water catchments. Table 9.18 summarises the location of these four sites in relation to the onshore project area.

Table 9.18 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

1432. As indicated in Figure 9.8 and Table 9.18, 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.

1433. 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. This site has also been identified as the designated site of concern through consultation with Natural England on this topic[37].

1434. The qualifying features of the Norfolk Valley Fens SAC present at Booton Common are water-sensitive habitats, reliant groundwater supply, and to a lesser degree surface water supply, to maintain their structure and function.

1435. The proposed works are not located within the Blackwater Drain, but do cross two of its tributaries, 1.5km and 1.8km upstream respectively (seeFigure 9.7). 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.

1436. 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. As part of the project's mitigation to minimise any impacts arising during watercourse crossings, a scheme and programme for each watercourse crossing, diversion and reinstatement, which will include site specific details regarding sediment management and pollution prevention measures will be developed. This scheme will be submitted to and, approved by the relevant planning

[37] Discussed at the meeting between the Applicant and Natural England on 22nd January 2019, as part of the Norfolk Vanguard Examination.

authority in consultation with Natural England. This commitment is secured through Requirement 25 (Watercourse Crossings) of the draft DCO. Furthermore, a Construction Surface Water and Drainage Plan (Requirement 20 (2)(i) of Schedule 1 of the DCO) will be developed, agreed with the relevant regulators and implemented to minimise water within the cable trench and other working areas and ensure ongoing drainage of surrounding land. This typically includes interceptor drainage ditches being temporarily installed parallel to the trenches and soil storage areas to provide interception of surface water runoff and the use of pumps to remove water from the trenches during cable installation. Drainage would remain in place for the duration of the construction period, including during the cable pulling phase.

1437. The Environment Agency's 'WetMecs' data (Wheeler and Shaw, 2000) for Booton Common was also reviewed to understand the water supply mechanism for maintaining the habitats present in Booton Common (see Table 9.6). Based on the WetMecs and geological information available, a hydrogeological conceptual model has been developed for Booton Common in order to illustrate the likely risks to groundwater and to habitats most likely affected by any changes to groundwater supply. This conceptual model is shown in Figure 9.10, and is discussed in more detail in the remainder of this section.

1438. The WetMecs site account for Booton Common conclude that the groundwater supply to the site is most likely from artesian water from the semi-confined Chalk aquifer (vertical flows) (Wheeler and Shaw, 2000), with typically only intermittent or weak localised lateral flows through the drift deposits (Wheeler and Shaw, 2000). Lateral flow from the drift deposits, if it does provide any contribution to the water supply, will be localised. A review of BGS borehole data (see Chapter 19 Ground Conditions and Contamination) for the crossing of the Blackwater Drain indicates that chalk depths are approximately 18m below ground at this location, with the chalk overlain by diamicton (boulder clay).

1439. The onshore cable installation works comprise open cut trenching (to 1.5m) and a number of trenchless crossings (typically 6-8m below ground level) at selected locations. As shown on the conceptual model (Figure 9.10), based on the known depths of the Chalk aquifer, this would locate the installation of the cables at least 7m above the chalk aquifer at the shallowest point. All works associated with construction of the cable route will not extend beneath the diamicton (boulder clay) layer. This is lower permeability material than the overlying sand and gravel of the glaciofluvial deposits (where present) and means there is only weak connectivity between the Chalk and the superficial deposits.

1440. Given that there will be no excavation into the Chalk aquifer, and there is at most weak connectivity between superficial deposits and the Chalk aquifer within the onshore project area, there will be no direct and indirect interaction between cable installation works for Norfolk Boreas and the groundwater supply mechanisms to Booton Common.

1441. During consultation with Norfolk Wildlife Trust (NWT) as part of the Norfolk Vanguard 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).

1442. 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 Boreas to understand the potential effects of dust and fine particle emissions, and is presented in full in Chapter 26 Air Quality of the ES (Document reference 6.1.26). 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.

1443. 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 adverse effect on the integrity of the Norfolk Valley Fens SAC in relation to the conservation objectives for the site.**

Scenario 1

1444. Under Scenario 1, works to install ducts will have already take place as part of the Norfolk Vanguard project. As such, the only below-ground works which would take place within the Blackwater Drain catchment will be the creation of jointing pits. These small pits ($90m^2$) with a maximum depth in line with open-cut trenching (i.e. 2m) which will be located every 500-1000m along the cable route. This represents a much smaller and more localised below-ground works than is required under Scenario 2.

1445. Under Scenario 1, a small area of 6m wide running track will be required within the catchment of the Blackwater Drain. As for Scenario 2, a Construction Surface Water and Drainage Plan (Requirement 20 (2)(i) of Schedule 1 of the DCO) will be developed, agreed with the relevant regulators and implemented to minimise runoff and ensure ongoing drainage of surrounding land. This typically includes interceptor drainage ditches being temporarily installed parallel to excavations and soil storage areas to provide interception of surface water runoff and the use of pumps to remove water from the jointing pits, if required. Drainage would remain in place for the duration of the construction period. The 6m wide track would introduce a very localised, short term change in ground conditions during construction within the Blackwater Drain and is likely to have a minimal effect on local surface water drainage patterns.

1446. As works are localised and within the design envelop identified for Scenario 2, **no 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 Boreas in-combination with other plans and projects

1447. 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 Boreas 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 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

1448. Table 9.19 below summarises the potential effects arising from the construction phase of the proposed Norfolk Boreas project.

Table 9.19 Summary of the potential effects of Norfolk Boreas 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?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
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*	Indirect effects on Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* present within ex-situ habitats of the SAC	×	×	×	×

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?		Potential for adverse effect upon site integrity in-combination?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
and species of the *Caricion davallianae*	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 Boreas

1449. The potential effects during the construction, operation and decommissioning of the proposed Norfolk Boreas 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 the Norfolk Vanguard Information to Support HRA Document (23rd April 2018).

1450. The potential effects during construction of the proposed Norfolk Boreas 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.

1451. 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.

Scenarios 1 and 2

1452. 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 9.9 .

1453. 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.

1454. 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]

1455. 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.

1456. As part of the project's embedded mitigation, under Scenario 2 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 (under Scenario 1, ducts would already have been installed beneath the North Walsham and Dilham Canal as part of the Norfolk Vanguard project). This means that the North Walsham and Dilham Canal and its immediate bankside habitat will be avoided, and under both Scenarios 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.

1457. 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 adverse effect on the integrity of The Broads SAC in relation to the conservation objectives for otter.**

1458. 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

Scenario 2

1459. 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.

1460. As part of the project's embedded mitigation, under Scenario 2 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 (under Scenario 1, ducts would already have been installed beneath the North Walsham and Dilham Canal as part of the Norfolk Vanguard project). This means that the North Walsham and Dilham Canal will be avoided, and under both Scenarios no works will take place within this watercourse. As a consequence, no potential effects upon this watercourse are anticipated.

1461. 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 watercourse, 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 surface water pollution effects at The Broads SAC is low. However good practice pollution prevention measures set out in section 9.3.1 will be employed.

1462. In order to minimise the potential effects of using a trenching methodology on surface watercourses, 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 Internal Drainage Board (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.

1463. 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.

1464. 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.

1465. 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.

1466. A diagram of how temporary damming and diverting would operate is shown in Plate 9.2 and Plate 9.3 below.

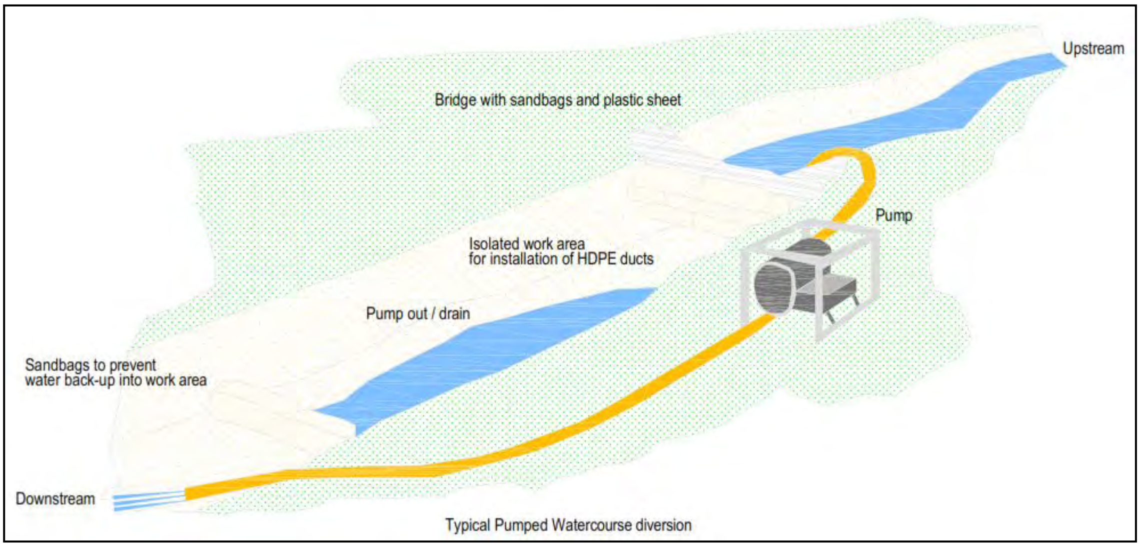

Plate 9.2 Indicative Temporary Dam and Divert (Construction Isometric View)

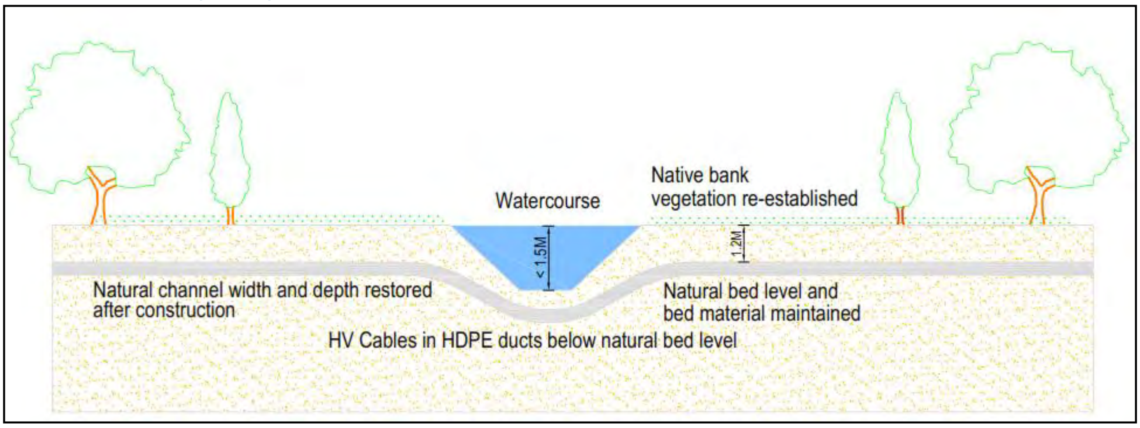

Plate 9.3 Indicative Temporary Dam and Divert (Post-Installation Cross-Sectional View)

1467. 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 Boreas ES. The above measures will be captured within a scheme and programme for each watercourse crossing, diversion and reinstatement which will be developed in advance of construction. This scheme will be submitted to and, approved by the relevant planning authority in consultation with Natural England. This commitment is secured through Requirement 25 (Watercourse Crossings) of the DCO. Furthermore, a Surface Water and Drainage Plan (Requirement 20 (2)(i) of the DCO) will be developed, agreed with the relevant regulators and implemented to minimise water within the cable trench and other working areas and ensure ongoing drainage of surrounding land. This typically includes interceptor drainage ditches being temporarily installed parallel to the trenches and soil storage areas to provide interception of surface water runoff and the use of pumps to remove water from the trenches during cable installation. Drainage would remain in place for the duration of the construction period, including during the cable pulling phase.

1468. No component sites of The Broads SAC are located within the ZOI (i.e. within 1km of) the onshore project area. The nearest site, Broad Fen, Dilham SSSI, is located 3.6km from the onshore project area at its closest point. Given the distance between this site and the onshore project area, there will be no pathway of effect between cable installation works for Norfolk Boreas and the groundwater supply mechanisms to the Broads SAC.

1469. 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 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.**

Scenario 1

1470. Under Scenario 1, works to install ducts will have already take place as part of the Norfolk Vanguard project. As such, the only below-ground works which would take place within the North Walsham and Dilham Canal and Hundred Stream catchments will be the creation of jointing pits. These small pits ($90m^2$) with a maximum depth in line with open-cut trenching (i.e. 2m) which will be located every 500-1000m along the cable route. This represents much smaller and more localised below-ground works than is required under Scenario 2.

1471. Under Scenario 1, a small area of 6m wide running track will be required within the catchments of the North Walsham and Dilham Canal and Hundred Stream. As for Scenario 2, a Surface Water and Drainage Plan (Requirement 20 (2)(i) of Schedule 1 of the DCO) will be developed, agreed with the relevant regulators and implemented to minimise runoff and ensure ongoing drainage of surrounding land. This typically includes interceptor drainage ditches being temporarily installed parallel to excavations and soil storage areas to provide interception of surface water runoff and the use of pumps to remove water from the jointing pits, if required. Drainage would remain in place for the duration of the construction period. The 6m wide track would introduce a very localised, short term change in ground conditions during construction within the North Walsham and Dilham Canal and Hundred Stream and is likely to have a minimal effect on local surface water drainage patterns.

1472. As works are localised and within the design envelope identified for Scenario 2, there is **no adverse effect on the integrity of The Broads SAC in relation to the conservation objectives for the site.**

9.3.4.4. Potential effects of Norfolk Boreas in-combination with other plans and projects

1473. 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 Boreas 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 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

1474. Table 9.20 below summarises the potential effects arising from the construction phase of the proposed Norfolk Boreas project.

Table 9.20 Summary of the potential effects of Norfolk Boreas 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?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
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	Indirect effects upon habitats and species within the SAC boundary	×	×	×	×

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?		Potential for adverse effect upon site integrity in-combination?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
Annex II species of the Broads SAC	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

1475. This section summarises the mitigation measures which have been set out in the preceding sections.

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

Scenario 2

1476. 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:

<u>Sediment management – works within the functional floodplain</u>

1477. The practices set out below 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. An outline CoCP will be submitted alongside the DCO application (Document reference: 8.1):

- The preferred way of working within the functional floodplain will be to establish the trenchless crossing compounds by placing geotextile on top of the existing pasture grassland. Whilst it is accepted that grass covered by geotextile for 8 weeks will die back, it will not expose bare soils beneath and the grass will recover more quickly than reseeding or natural regeneration in the case of topsoil stripping.
- Where a topsoil strip is required, for existing grassland located within the functional floodplain, this will be undertaken using a turf cutter. Turf rolls will be retained and reinstated after the works are complete (approximately eight weeks) to maximise the potential for reinstatement / restoration to be effective.
- Removed topsoil and turf will be stored outside of the functional floodplain.
- Any damage to ground conditions caused by vehicle tracking will be rectified prior to the reinstatement of topsoil/turf. Land reinstatement will be

undertaken in adherence to Defra's Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (2009). These measures will be secured through the final CoCP produced post-consent, which will be in accordance with the certified Outline CoCP.

- Construction drainage will be introduced along the onshore cable route in advance of the works. The drainage will be designed to minimise water entering works areas and to ensure ongoing drainage of surrounding land. A Surface Water and Drainage Plan (Requirement 20 (2)(i) of the DCO) will be included within the final CoCP produced post-consent, which will be in accordance with the certified Outline CoCP. This will include the following measures:
  - The surface water drainage introduced in advance of construction will include interceptor drains for surface water flows. The interceptor drains will include areas for the settlement of sediment (sediment traps). Sediment traps are locally wider/deeper areas of the drains that will encourage passive sediment deposition.
  - Sediment traps will be monitored weekly (visual inspection) during the trenchless crossing works (with increased monitoring during inclement weather). If required these traps can be pumped via settling tanks to remove sediment, based on a pre-defined level / depth of sediment.
  - Where water enters the construction areas, this will be pumped via settling tanks or ponds to remove sediment before being discharged into local ditches or drains via the interceptor drains in order to prevent increases in fine sediment supply to the watercourses.
  - When the interceptor drains and associated sediment traps are decommissioned any standing water within the drains would be pumped out to settling tanks as described above. Sediment that has settled out within the interceptor drain would be left in place. Soils would be replaced in the reverse order that they were removed and turf reinstated.
  - Existing tracks and roadways will be utilised for access where possible. Temporary construction accesses within the functional floodplain are required if the third trenchless crossing compound (north of Penny Spot Beck) is used. Any topsoil removal and subsequent post-construction reinstatement will follow the steps outlined above.

<u>Sediment management – measures to be applied throughout the onshore work areas (*as detailed within the outline CoCP – (Document reference: 8.1)*)</u>

- The area of open ground at any one time within one sub-catchment will be restricted, across a notional 5 km length, to 2 working areas (configured as 45m x 300m strips); with the assumptions that 50% of one mobilisation area, 50% of one set of trenchless crossing compounds and 25% of 5km running track will be open ground. This represents a maximum area of disturbed open ground of 0.068 km2 per 5km of cable at any one time.

- Topsoil would be stripped from the entire width of the onshore cable route for the length of each approximately 150m workfront, and stored and capped to minimise wind and water erosion within the onshore cable route.
- Once all the trenching is completed and back-filled within each workfront, the stored topsoil will be re-distributed over the area of the workfront, with the exception of the running track and any associated drainage.
- Mobilisation areas within the onshore project area will comprise hardstanding of permeable gravel aggregate underlain by geotextile, or other suitable material.
- Subsoil exposure will be minimised and strips of undisturbed vegetation will be retained on the edge of the working area where possible.
- Within the functional floodplain, where surface vegetation has been removed (with the exception of arable crops), turf stripping and reinstatement of grassland for all grassland habitats located within 10m of any watercourse within the River Wensum catchment will be undertaken. This mitigation measure is being proposed to ensure that grassland adjacent to all watercourses is managed so as to reduce the risk of sediment release into the tributaries of the River Wensum by reinstating a 10m buffer strip of re-laid turf adjacent to each watercourse.
- On-site retention of sediment will be maximised by routing all drainage through the site drainage systems.
- The drainage system will include silt fences at the foot of soil storage areas to intercept sediment runoff at source. Where practicable, runoff will be routed into swales, which incorporate check dams to further intercept sediment and/or attenuation ponds which incorporate sediment forebays. Suitable filters will be used to remove sediment from any water discharged into the surface drainage network.
- Additional silt fences will be included in parts of the working area that are in proximity to surface drainage channels. It is not intended that silt fences will be used where works are located in the functional floodplain as spoil will not be stored in these locations. Sediment traps would be incorporated into the design of the surface water drainage.
- Soil and sediment will not be allowed to accumulate on roads. Traffic movement would be restricted to minimise the potential for surface disturbance.

<u>Pollution prevention</u>

- 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, PPG22, and

CIRIA's 'Control of water pollution from construction sites – A guide to good practice' (2001), including:
    - Spill kits will be available on site at all times and staff will be trained in their use
    - Sand bags or stop logs will also be available for deployment on the outlets from the site drainage system in case of emergency spillages.
    - Equipment will be regularly checked to ensure leakages do not occur.
    - Refuelling of construction plant will be restricted to designated impermeable areas.
    - All fuels, oils, lubricants and other chemicals will be stored in an impermeable bund with at least 110% of the stored capacity.
    - Suitable biosecurity protocols (such as those outlined by the Non-Native Species Secretariat (NNSS)) would be put in place during the works in order to minimise the risk of contamination and the spread of the invasive non-native species.

<u>Bentonite breakout</u>

1478. Bentonite is an inert clay-based material used as a lubricant at the drill head during trenchless crossing techniques – comprising 95% water and 5% clay. It does not represent a pollutant but can cause smothering of habitats if not contained.

1479. For small breakouts it may cause more damage to the sensitive habitats to attempt to contain the breakout and remove the escaped material, i.e. trampling of grassland associated with responding to the breakout and the potential for exposing bare ground. A break-out contingency plan will be developed and will be included in the final CoCP, which will define the approach for responding to breakouts. The steps of the contingency plan will include:

- Measures to ensure drilling stops once a breakout is reported (there will be a drop in pressure at the drill head).
- Measures to contain the breakout, for example sand bags, to minimise the extent of any smothering.
- Measures to remove the released bentonite if a significant volume of material is contained – for example pumped back to the bentonite lagoon within the trenchless crossing compound, or pumped to the interceptor drains, or pumped to the mobile settling tanks that will be used for managing sediment traps.
- The exact specification for the contingency plan will be informed by further ground investigation and the specific design of the trenchless crossing.

Scenario 1

1480. As for Scenario 2, a Construction Surface Water and Drainage Plan (Requirement 20 (2)(i) of the DCO) will be developed, agreed with the relevant regulators and implemented to minimise runoff and ensure ongoing drainage of surrounding land.

This typically includes interceptor drainage ditches being temporarily installed parallel to excavations and soil storage areas to provide interception of surface water runoff and the use of pumps to remove water from the jointing pits, if required. Drainage would remain in place for the duration of the construction period.

9.3.5.2. Potential direct effects on barbastelle present in ex-situ habitats of the Paston Great Barn SAC (hedgerows / watercourses)

Scenario 2 only

- 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). The criteria for determining ‘poor weather’ will be stipulated in the final CoCP the outline version of which will be submitted as part of the DCO application (Document reference: 8.1).
- 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 where possible and hedges will be double-planted with 2m grassland strips on both sides so there is always a leeward side to forage. Replanting will also include hedgerow improvements works within the onshore cable route where required. These include gapping-up and tree management.
- Subject to landowner permissions, the 16 hedgerows that suitable for supporting 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 22m 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 (Bat Conservation Trust, 2015).
- A Hedgerow Mitigation Plan will be developed in consultation with Natural England prior to the removal of hedgerows. This mitigation plan will detail the reinstatement approach for hedgerows removed during construction and the monitoring and maintenance requirements following hedgerow planting. This commitment is captured within the OLEMS (document reference 8.7).
- Pre-construction habitat assessment surveys of the 18 hedgerows to confirm the habitat condition prior to removal and pre-construction activity surveys of all of

the 18 hedgerows which remain suitable for supporting commuting and foraging bats following the updated habitat assessment will be undertaken to provide an updated baseline for these features in advance of construction. This includes activity surveys of the six hedgerows for which data was not collected in in 2017 and 2018.

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

Scenarios 1 and 2

- 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.
- A Construction Surface Water and Drainage Plan (Requirement 20 (2)(i) of the DCO) will be developed, agreed with the relevant regulators and implemented to minimise water within the cable trench and other working areas and ensure ongoing drainage of surrounding land. This typically includes interceptor drainage ditches being temporarily installed parallel to the trenches and soil storage areas to provide interception of surface water runoff and the use of pumps to remove water from the trenches during cable installation. Drainage would remain in place for the duration of the construction period, including during the cable pulling phase.

9.3.5.4. Potential indirect effects on selected qualifying features of the Norfolk Valley Fens SAC present within ex-situ habitats of the SAC arising from groundwater / hydrology effects

Scenario 2

- A scheme and programme for each watercourse crossing, diversion and reinstatement, which will include site specific details regarding sediment management and pollution prevention measures will be developed in advance of construction. This scheme will be submitted to and, approved by the relevant planning authority in consultation with Natural England. This commitment is secured through Requirement 25 (Watercourse Crossings) of the draft DCO.
- A Construction Surface Water and Drainage Plan (Requirement 20 (2)(i) of the DCO) will be developed, agreed with the relevant regulators and implemented to minimise water within the cable trench and other working areas and ensure ongoing drainage of surrounding land. This typically includes interceptor drainage ditches being temporarily installed parallel to the trenches and soil storage areas to provide interception of surface water runoff and the use of

pumps to remove water from the trenches during cable installation. Drainage would remain in place for the duration of the construction period, including during the cable pulling phase.

Scenario 1

1481. As for Scenario 2, a Construction Surface Water and Drainage Plan (Requirement 20 (2)(i) of the DCO) will be developed, agreed with the relevant regulators and implemented to minimise runoff and ensure ongoing drainage of surrounding land. This typically includes interceptor drainage ditches being temporarily installed parallel to excavations and soil storage areas to provide interception of surface water runoff and the use of pumps to remove water from the jointing pits, if required. Drainage would remain in place for the duration of the construction period.

9.3.5.5. Potential direct effects upon ex-situ habitats which may support the qualifying feature otter of The Broads SAC

Scenarios 1 and 2

- 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.
- Where overnight lighting is required for trenchless crossing works near Dilham Canal, any lighting used will be directional i.e. angled downwards and a cowl provided for the light to minimise light spill.

9.3.5.6. Potential indirect effects upon habitats and species within the SAC boundary arising from changes in local groundwater / hydrology conditions

Scenario 2

- A scheme and programme for each watercourse crossing, diversion and reinstatement, which will include site specific details regarding sediment management and pollution prevention measures will be developed in advance of construction. This scheme will be submitted to and, approved by the relevant planning authority in consultation with Natural England. This commitment is secured through Requirement 25 (Watercourse Crossings) of the draft DCO.
- A Construction Surface Water and Drainage Plan will be developed (Requirement 20 (2)(i) of the DCO) will be developed, agreed with the relevant regulators and implemented to minimise water within the cable trench and other working areas and ensure ongoing drainage of surrounding land. This typically includes interceptor drainage ditches being temporarily installed parallel to the trenches and soil storage areas to provide interception of surface water runoff and the use of pumps to remove water from the trenches during

cable installation. Drainage would remain in place for the duration of the construction period, including during the cable pulling phase.

Scenario 1

- As for Scenario 2, a Construction Surface Water and Drainage Plan (Requirement 20 (2)(i) of the DCO) will be developed, agreed with the relevant regulators and implemented to minimise runoff and ensure ongoing drainage of surrounding land. This typically includes interceptor drainage ditches being temporarily installed parallel to excavations and soil storage areas to provide interception of surface water runoff and the use of pumps to remove water from the jointing pits, if required. Drainage would remain in place for the duration of the construction period.

9.3.6. Summary of Potential Effects

1482. Table 9.21 below summarises the potential effects arising from the construction phases of the proposed Norfolk Boreas project. Integrity matrices are provided in Appendix 6.1.

1483. It is concluded that the Norfolk Boreas Project would not have an adverse effect on integrity of the River Wensum SAC, Paston Great Barn SAC, Norfolk Valley Fens SAC or The Broads SAC in view of the conservation objectives of these sites either alone or in combination with other projects/plans.

Table 9.21 Summary of the potential effects of Norfolk Boreas

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?		Potential for adverse effect upon site integrity in-combination?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
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 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)	×	×	×	×

Qualifying feature	Potential effects	Potential for adverse effect upon site integrity alone?		Potential for adverse effect upon site integrity in-combination?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
	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?	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
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	×	×	×	×
Annex I habitats and Annex II species dependant on upstream hydrological conditions	Indirect effects upon habitats and species within the SAC boundary arising from changes in local groundwater / hydrology conditions	×	×	×	×

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