Norfolk Boreas Offshore Wind Farm

Chapter 19

Ground Conditions and Contamination

Environmental Statement

Volume 1

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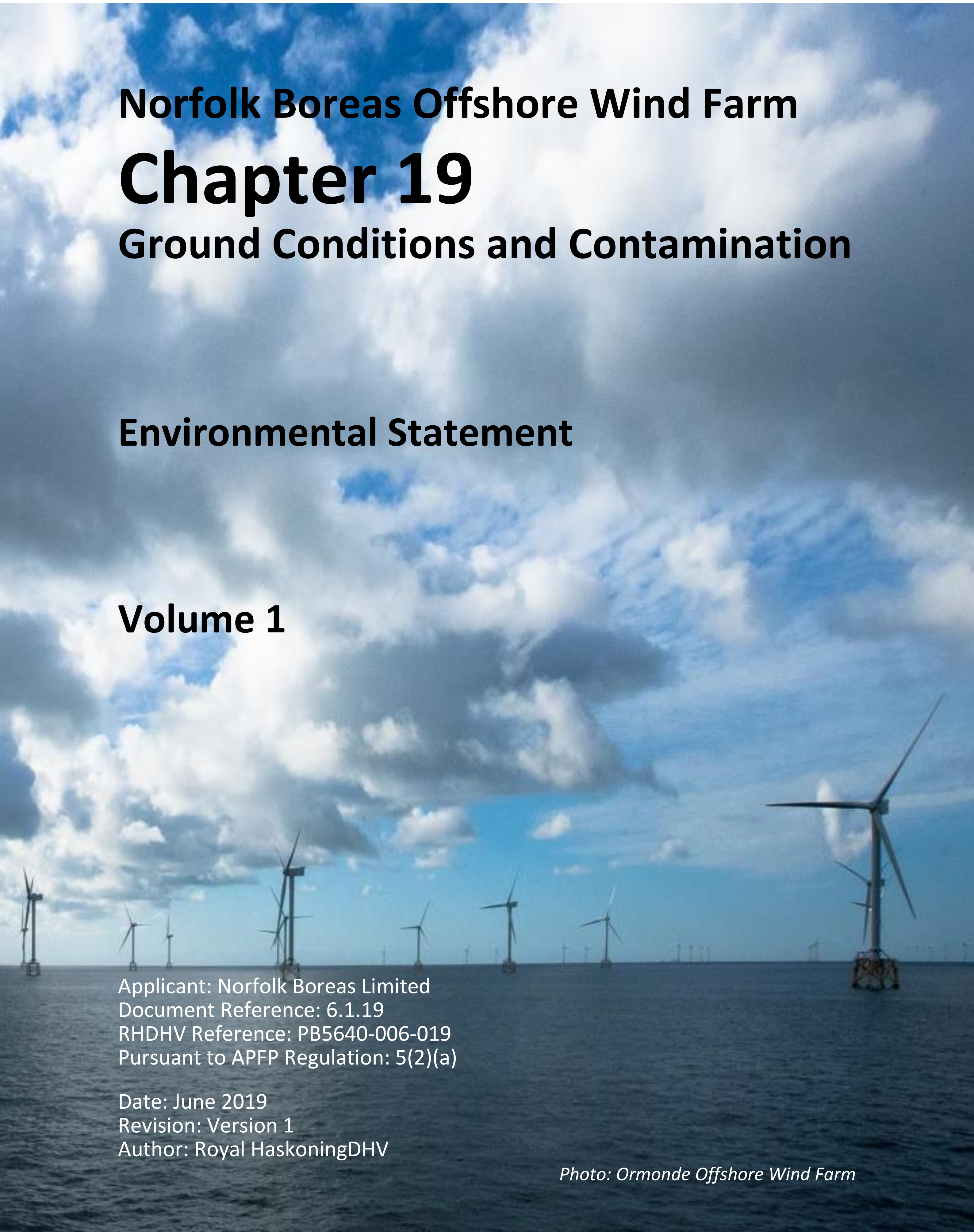

Photo: Ormonde Offshore Wind Farm

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Glossary of Acronyms

BAT	Best Available Technique
BGS	British Geological Survey
BGL	Below ground level
CIA	Cumulative Impact Assessment
CMS	Construction Method Statement
CoCP	Code of Construction Practice
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
DrWPAs	Drinking Water Protected Areas
EIA	Environmental Impact Assessment
EPP	Evidence Plan Process
ES	Environmental Statement
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IPC	Infrastructure Planning Commission
kV	Kilovolt
LNR	Local Nature Reserve
m	Metre
MHWS	Mean High Water Spring
MMP	Materials Management Plan
MPA	Mineral Planning Authority
MSAs	Mineral Safeguarding Areas
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OCoCP	Outline Code of Construction Practice
O&M	Operation and Maintenance
PAH	Polyaromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCOC	Potential Contaminant of Concern
PEIR	Preliminary Environmental Information Report
PPE	Personal Protective Equipment
PPG	Pollution Prevention Guidance
PRA	Preliminary Risk Assessment
RPE	Respiratory Protective Equipment
SoS	Secretary of State
SAC	Special Area of Conservation
SgZs	Groundwater Safeguard Zones
SMP	Shoreline Management Plan
SNCI	Site of Nature Conservation Interest
SPA	Special Protection Area
SPZ	Source Protection Zone
SSSI	Sites of Special Scientific Interest
SVOC	Semivolatile Organic Compound

VOC	Volatile Organic Compound
VWPL	Vattenfall Wind Power Limited
WCS	Worst Case Scenario
WFD	Water Framework Directive

Glossary of Terminology

Cable logistics area	Existing hardstanding area to allow the storage of cable drums and associated materials and to accommodate a site office, welfare facilities and associated temporary infrastructure to support the cable pulling works.
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.
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
Link boxes	Underground chambers or above ground cabinets next to the cable trench housing low voltage electrical earthing links.
Mobilisation area	Areas approx. 100 x 100m used as access points to the running track for duct installation. Required to store equipment and provide welfare facilities. Located adjacent to the onshore cable route, accessible from local highways network suitable for the delivery of heavy and oversized materials and equipment.
Mobilisation zone	Area within which a mobilisation area will be located.
National Grid new / replacement overhead line tower	New overhead line towers to be installed at the National Grid substation.
National Grid overhead line modifications	The works to be undertaken to complete the necessary modification to the existing 400kV overhead lines.
National Grid overhead line temporary works	Area within which the work will be undertaken to complete the necessary modification to the existing 400kV overhead lines.
National Grid substation extension	The permanent footprint of the National Grid substation extension.
National Grid temporary works area	Land adjacent to the Necton National Grid substation which would be temporarily required during construction of the National Grid substation extension.
Necton National Grid substation	The 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.
Onshore 400kV cable route	Buried high-voltage cables linking the onshore project substation to the Necton National Grid substation.
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.
Project interconnector search area	The area within which the project interconnector cable would be installed.
Running track	The track along the onshore cable route which the construction traffic would use to access workfronts.
The Applicant	Norfolk Boreas Limited.
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 compound	Pairs of compounds at each trenchless crossing zone to allow boring to take place from either side of the crossing.
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.

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19 GROUND CONDITIONS AND CONTAMINATION

19.1 Introduction

1. This chapter of the Environmental Statement (ES) considers the potential impacts of the proposed Norfolk Boreas Offshore Wind Farm (hereafter 'the project') relating to ground conditions and contamination. This assessment focusses on the potential presence of contamination and pollutant linkages to sensitive receptors such as site workers, future site users, geology, surface water and groundwater. The assessment also considers the potential for impacts on mineral resources. This chapter does not assess potential impacts on soil quality in the context of an agricultural resource or an ecosystem service; this is discussed separately in Chapter 21 Land Use and Agriculture.

2. Potential impacts to the groundwater and surface waters are discussed in Chapter 20 Water Resources and Flood Risk.

3. Vattenfall Wind Power Limited (VWPL) (the parent company of Norfolk Boreas Limited) is also developing Norfolk Vanguard, a 'sister project' to Norfolk Boreas.

4. 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.

5. The Environmental Impact Assessment (EIA) will therefore be undertaken using the following two alternative scenarios (further details are presented in Chapter 5 Project Description) 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.

6. The assessment also considers cumulative impacts of existing and proposed projects. The proposed methodology adhered to for the EIA and Cumulative Impact Assessment (CIA) is discussed in section 19.8.

7. As a result of the close association between ground conditions, groundwater, surface water and ecology topics, this chapter should also be read in conjunction with the other related ES chapters (and their appendices and supporting documents). The relevant chapters are:

- Chapter 8 Marine Geology, Oceanography and Physical Processes;
- Chapter 9 Marine Water and Sediment Quality;
- Chapter 20 Water Resources and Flood Risk;
- Chapter 21 Land Use and Agriculture; and
- Chapter 27 Human Health.

19.2 Legislation and Policy

8. The following sections provide detail on key pieces of international and UK legislation and policy which are relevant to this chapter.

19.2.1 Legislation and Policy

9. The National Planning Policy Framework (2018) sets out the Government's planning policies for England and how these should be applied. It provides a framework within which locally-prepared plans for housing and other development can be produced. It outlines the requirement for managing and mitigating contamination and land instability risks associated with future site uses; the requirements to protect Best and Most Versatile agricultural land, geological conservation interests and soils and outlines the requirement for mineral safeguarding and extraction through the planning system. The National Planning Policy Framework provides guidance on the "planning for mineral extraction" (UK Government, July 2018). The guidance recommends that "*Mineral planning authorities should plan for the steady and adequate supply of industrial minerals*". The document recommends ways in which this can be accomplished.

10. The assessment of potential impacts upon ground conditions and contamination has been made with specific reference to the relevant National Policy Statements (NPS). These are the principal decision making documents for Nationally Significant Infrastructure Projects (NSIPs). Those relevant to the project are:

- Overarching 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).

11. The specific assessment requirements for ground conditions and contamination, as detailed in the NPSs, are summarised in Table 19.1, together with an indication of the paragraph numbers of the ES chapter where each is addressed.

Table 19.1 NPS assessment requirements relevant to ground conditions and contamination

NPS Requirement	NPS Reference	ES Reference
EN-1 Overarching NPS for Energy		
'Where the development is subject to EIA [Environmental Impact Assessment] the applicant should ensure that the ES (Environmental Statement) clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Infrastructure Planning Commission (IPC) consider thoroughly the potential effects of a proposed project.'	Section 5.3	Existing environment is discussed in section 19.6. Impacts are set out in sections 19.7 and 19.8.
EN-5 Electricity Networks Infrastructure		
'Where possible, applicants should follow the principles below in designing the route of their overhead line proposals and it will be for applicants to offer constructive proposals for additional mitigation of the proposed overhead line. While proposed, underground lines do not require development consent under the Planning Act 2008, wherever the nature or proposed route of an overhead line proposal makes it likely that its visual impact will be particularly significant, the applicant should have given appropriate consideration to the potential costs and benefits of other feasible means of connection or reinforcement, including underground and sub-sea cables where appropriate. The ES should set out details of how consideration has been given to undergrounding or sub-sea cables as a way of mitigating such impacts, including, where these have not been adopted on grounds of additional cost, how the costs of mitigation have been calculated.'	Section 2.8	Underground cables are discussed in section 19.7.
'The impacts and costs of both overhead and underground options vary considerably between individual projects (both in absolute and relative terms). Therefore, each project should be assessed individually on the basis of its specific circumstances and taking account of the fact that Government has not laid down any general rule about when an overhead line should be considered unacceptable. The IPC should, however only refuse consent for overhead line proposals in favour of an underground or sub-sea line if it is satisfied that the benefits from the non-overhead line alternative will clearly outweigh any extra economic, social and environmental impacts and the technical difficulties are surmountable. In this context it should consider: the environmental and archaeological consequences (undergrounding a 400kV line may mean disturbing a swathe of ground up to 40 metres across, which can disturb sensitive	Section 2.8.9	Impacts on geology are set out in sections 19.7 and 19.8. Soil resource is considered in Chapter 21 Land Use and Agriculture.

NPS Requirement	NPS Reference	ES Reference
habitats, have an impact on soils and geology, and damage heritage assets, in many cases more than an overhead line would).'		

12. The Environmental Protection Act 1990 makes provision for the improved control of pollution arising from certain industrial and other processes. Part 2A of the Act provides the regulatory basis for the identification, designation and remediation of Contaminated Land.

13. Contaminated land for the purpose of Part IIA is defined as 'any land which appears to the Local Authority in whose area it is situated to be in such condition, by reasons of substances in, on or under the land that:

- 'Significant harm is being caused or there is a significant possibility of such harm being caused'; or
- 'Significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused'.

14. Further detail on legislation and policy in relation to the wider project is provided in Chapter 3 Policy and Legislative Context.

19.2.2 Local Planning Policy

15. EN-1 states that the Planning Inspectorate will also consider Development Plan Documents or other documents in the Local Development Framework to be relevant to its decision making.

16. The onshore project area falls under the jurisdiction of Norfolk County Council and the following local authorities:

- Broadland District Council;
- North Norfolk District Council; and
- Breckland Council.

17. Appendix B (North Norfolk Ecological Network) of North Norfolk District Council's Policy EN 9 on Biodiversity emphasises the importance of the chalk rivers in the district.

18. Norfolk County Council has produced Mineral Safeguarding Guidance which outlines the measures needed to ensure that non-mineral development on Mineral Safeguarding Areas (MSAs) within Norfolk complies with adopted policy on the safeguarding of mineral resources.

19. Further advice in relation specifically to the project has been sought through consultation as detailed in section 19.3.

19.3 Consultation

20. Consultation is a key part of the EIA process and is an ongoing process throughout the lifecycle of the project, from the initial stages through to consent and post-consent. To date, consultation regarding ground conditions and contamination has been conducted through the Scoping Report (Royal HaskoningDHV, 2017) and the Evidence Plan Process (EPP), namely the Ground Conditions and Contamination Method Statement (Royal HaskoningDHV, 2018, unpublished) and the Preliminary Environmental Information Report (PEIR) (Norfolk Boreas Limited, 2018). Feedback received during the process to date has been incorporated into this ES.

21. As the majority of the onshore infrastructure for Norfolk Boreas and Norfolk Vanguard is co-located, the pre-application consultation undertaken for Norfolk Vanguard is relevant to both projects and has been used to inform the approach to this assessment. In addition, where possible any comment received as part of the Norfolk Vanguard examination process, up to Deadline 5 (20th March 2019) have also be considered. The Norfolk Vanguard responses considered are provided in Appendix 19.1.

22. Full details of the project consultation process are presented within the Consultation Report (document reference 5.1), which has been submitted with the Development Consent Order (DCO) application.

23. A summary of the consultation responses to date with respect to ground conditions and contamination is provided in Table 19.2.

Table 19.2 Norfolk Boreas Consultation Responses

Consultee	Date /Document	Comment	Response / where addressed in the ES
ETG (Norfolk County Council, Breckland Council, Broadland District Council, North Norfolk District Council)	January 2018 Norfolk Boreas Ground Conditions and Contamination Method Statement	No comments on the proposed methodology received.	No action required.
Secretary of State (SoS)	June 2017 Scoping Opinion	The ES should identify and assess potential impacts on the Mineral Safeguarding Areas underlying the onshore scoping area (see the comments of Norfolk County in Appendix 3 of this Opinion).	The MSAs are identified in section 19.6.2.6 and impacts are assessed in section 19.7.4.7.
SoS	June 2017 Scoping Opinion	The Scoping Report notes there is rapid cliff erosion on the coast of	The potential impacts of landfall

Consultee	Date /Document	Comment	Response / where addressed in the ES
		north east Norfolk. The potential impacts of landfall works on coastal processes, including erosion and deposition, should be addressed with appropriate cross reference to other technical reports including landscape and visual impacts. Reference to consideration of the Kelling to Lowestoft Ness Shoreline Management Plan at paragraph 887 of the Scoping Report is welcomed.	works on coastal processes are discussed in section 19.7.4.1.
SoS	June 2017 Scoping Opinion	The Scoping Report has scoped out all operational impacts on ground conditions and contamination at paragraph 907. The only justification for this is that operation and maintenance activities would follow standard procedures. Despite the limited justification provided, the SoS does not consider there would be any significant effects from operation and therefore agrees this can be scoped out.	See section 19.7.5.
SoS	June 2017 Scoping Opinion	The ES should justify the extent of the study areas used in the assessment in relation to the general 250m and 500m buffer zones around temporary and permanent infrastructure respectively used to define the onshore scoping area as described at paragraph 883 of the Scoping Report.	The study area is defined by the distance over which impacts on ground conditions and contamination from the project may be and by the location of any receptors that might be affected by those potential impacts see section 19.5.1. This has been established by professional judgement supported by a Preliminary Risk Assessment (PRA) undertaken for Norfolk Boreas.
Norfolk County Council - Mineral and Waste Planning	February 2018 Method Statement	Considers approach appropriate	N/A

Consultee	Date /Document	Comment	Response / where addressed in the ES
North Norfolk District Council	February 2018 Method Statement	NNDC is happy with the proposals presented and have no further comment to add regarding ground conditions	N/A
Anglian Water	February 2018 Method Statement	We would ask that you take account of the comments we have previously made in relation to Norfolk Vanguard relating to groundwater for the above project. These comments should be accessible.	Relevant consultation for Norfolk Vanguard has been incorporated and these are presented in Appendix 19.1
Breckland Council	October 2018 PEIR	In relation to the air plane crash: "Hydrazine and radioactive materials were reportedly present on the site. The location appears to be in a field near Ivy Todd Road, Necton, PE37 8JB, TF894100 which appears to be close to where you will be laying underground pipes/cables. We have now been advised that the impact point was 52.39.29 N 000.47.83 E on a heading of 089 degrees (from West towards the East)." It is recommended that the conceptual model specifically takes into account the possibility of hydrazine and radioactive materials being present. It is noted that the report recommends that the potential risk posed by the off-site sources is established and that further desk based assessment should be undertaken to establish the presence of this linkage.	Relevant information has been incorporated and these are presented in Appendix 19.1
Norfolk County Council	October 2018 PEIR	Norfolk County Council in its capacity as the Mineral and Waste Planning Authority has been involved in discussions with Vattenfall about the Wind Power Projects; regarding mineral and waste safeguarding, both of sites and resources. Throughout the project preparation information has been exchanged between the parties regarding these safeguarding issues. The Mineral Planning Authority welcomes the	Norfolk Boreas Limited acknowledge need for ongoing consultation with Norfolk County Council with regards to the mineral and waste planning issues. Potential impacts on mineral resources can be

Consultee	Date /Document	Comment	Response / where addressed in the ES
		recognition of mineral safeguarding issues, contained within the PEIR. It is felt that Vattenfall should continue to work closely with the County Council with regard to mineral and waste planning issues.	found in section 19.7.4.7.
North Norfolk District Council	October 2018 PEIR	This area of North Norfolk in particular has seen significant loss of cliff in recent years due to the effect of coastal processes with an increased risk to life and property including numerous buildings of heritage interest. It will therefore be important for Development Consent Order to give appropriate consideration to the potential for the project to be affected by and/or contribute to coastal change and to consider any public benefits that can be derived either as part of formal mitigation or as part of any wider community benefits to manage those adverse impacts in accordance with the adopted Shoreline Management Plan (SMP 6).	The potential impact of landfall works on the coastline are discussed in section 19.7.4.1. For coastal processes see Chapter 8 Marine Geology, Oceanography and Physical Processes.
Environment Agency	October 2018 PEIR	We agree if any works are proposed within or close to SPZ1 further ground investigation and associated risk assessments should be undertaken. Further ground investigation and risk assessments should also be undertaken in those areas identified as being potentially contaminated (as determined in the PRA). In those areas where piling is proposed, piling risk assessments will need to be undertaken to demonstrate the works will not have a detriment impact on groundwater quality.	Commitment has been added as a mitigation measure section 19.7.4.4.

19.4 Assessment Methodology

19.4.1 Impact Assessment Methodology

24. Chapter 6 EIA Methodology details the general impact assessment method, and the following sections describe more specifically the methodology used to assess the potential impacts of the project on onshore ground conditions and contamination, as

consulted on and agreed via the Scoping Report (Royal HaskoningDHV, 2017), the Ground Conditions and Contamination Method Statement (Royal HaskoningDHV, 2018, unpublished) and the PEIR (Norfolk Boreas Limited, 2018).

19.4.1.1 Sensitivity

25. The sensitivity of receptors is assessed according to the criteria set out in Table 19.3 and is based on the capacity of receptors to tolerate change and whether or not increased risks would be acceptable within the scope of the prevailing legislation and guidelines. The degree of change that is considered to be acceptable is dependent on the value of a receptor, which is discussed in section 19.4.1.2.

Table 19.3 Definitions of Sensitivity Levels for levels for ground conditions and contamination

Sensitivity	Definition
High	Has very limited or no capacity to accommodate physical or chemical changes. Increased risk of exposure / pollution would be unacceptable.
Medium	Has limited capacity to accommodate physical or chemical changes or influences. Increased risk of exposure/ pollution may be acceptable.
Low	Has moderate capacity to accommodate physical or chemical changes. Increased risk of exposure / pollution likely to be acceptable.
Negligible	Is generally tolerant of physical or chemical changes. Insensitive to increased risk of exposure / pollution.

26. Receptor sensitivity examples based on the above criteria are given in Table 19.4. It should be noted that some receptors may be assessed differently due to site-specific conditions.

27. The sensitivity criteria and examples for controlled waters receptors are aligned with those used in the assessment of water resources impacts in Chapter 20 Water Resources and Flood Risk.

Table 19.4 Receptor sensitivity assessment examples

Sensitivity / value	Examples
High	Human Health • Construction Workers; • Site Operatives; and • General Public (Off-site).
	Controlled Waters • Groundwater SPZ1 (Source Protection Zone) / 2 areas (inc. unpublished); • Principal Aquifer (resource potential); and • Surface water or groundwater supporting internationally designated or nationally important conservation site (e.g. Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar site / Sites of Special Scientific Interest (SSSI) or fishery).

Sensitivity / value	Examples
Medium	Controlled Waters • Secondary A (resource potential); • Groundwater SPZ areas Total Catchment; • Licenced groundwater / surface water abstractions; and • Surface water or groundwater supporting regionally important wildlife sites (Local Nature Reserves (LNR), Sites of Nature Conservation Interest (SNCI)) or commercial aquaculture.
	Mineral Resources • Mineral Safeguard Area (regionally important resource).
Low	Controlled Waters • Secondary Undifferentiated / Secondary B Aquifer (resource potential); • Unlicensed water supplies; and • Surface water or groundwater supporting locally important wildlife or amenity site.
Very Low	Controlled Waters • Unproductive Strata (resource potential).

19.4.1.2 Value

28. The sensitivity assessment for ground conditions and associated water and mineral resources takes into account how 'acceptable' changes to the availability or quality of a particular resource would be. This is dependent on the value of that resource, which is assessed based on its strategic or geographic importance (Table 19.5).

Table 19.5 Definitions of value levels for ground conditions and contamination

Value	Definition
High	Is an international or nationally important resource.
Medium	Is a regionally important resource.
Low	Is a locally important resource.
Negligible	Is of no significant resource value.

29. It should be noted that high value and high sensitivity are not necessarily linked within a particular impact. A receptor could be of high value (e.g. Groundwater SPZ1 areas) but have a low or negligible physical/ecological sensitivity to an effect – it is important not to inflate impact significance just because a feature is 'valued'. This is where the narrative behind the assessment is important; the value can be used where relevant as a modifier for the sensitivity assigned to the receptor.

19.4.1.3 Magnitude of Effect

30. Potential effects may be adverse, beneficial or neutral. The magnitude of an effect is assessed qualitatively, according to the criteria set out in Table 19.6.

31. The following definitions apply to time periods used in the magnitude assessment:

- Long term: Greater than 5 years;
- Medium term: 2 to 5 years; and

- Short term: Less than 2 years.

32. For human health, magnitude reflects the likely increase or decrease in exposure risk for a particular receptor. For controlled waters, magnitude represents the likely effect that an activity would have on resource usability or value, at the receptor. Magnitude is therefore affected by the distance and connectivity between an impact source and the receptor.

Table 19.6 Definitions of magnitude levels for ground conditions and contamination

Magnitude	Definition
High	Permanent or large scale change affecting usability, risk, value over a wide area, or certain to affect regulatory compliance.
Medium	Moderate permanent or long-term reversible change affecting usability, value, risk, over the medium-term or local area; possibly affecting regulatory compliance.
Low	Temporary change affecting usability, risk or value over the short-term or within the site boundary; measurable permanent change with minimal effect usability, risk or value; no effect on regulatory compliance.
Negligible	Minor permanent or temporary change, undiscernible over the medium- to long-term short-term, with no effect on usability, risk or value.

19.4.1.4 Impact significance

33. Following the identification of receptor sensitivity and value, and magnitude of the effect, it is possible to determine the significance of the impact. A matrix as presented in Table 19.7 will be used wherever relevant.

34. Where possible, impact significance is based upon quantitative and accepted criteria, together with the use of value judgement and expert interpretation to establish to what extent an impact is significant.

Table 19.7 Impact significance matrix

		Negative magnitude				Beneficial magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	*Major*	*Major*	*Moderate*	*Minor*	*Minor*	*Moderate*	*Major*	*Major*
	Medium	*Major*	*Moderate*	*Minor*	*Minor*	*Minor*	*Minor*	*Moderate*	*Major*
	Low	*Moderate*	*Minor*	*Minor*	*Negligible*	*Negligible*	*Minor*	*Minor*	*Moderate*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Minor*

35. As with the definitions of magnitude and sensitivity, the matrix used for a topic is clearly defined by the assessor within the context of that assessment. The impact significance categories are divided as shown in Table 19.8.

Table 19.8 Impact significance definitions

Impact Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or, could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No impact	No change, therefore no impact on receptor condition.

36. Note that for the purposes of this ES, major and moderate impacts are considered to be 'significant'. In addition, whilst minor impacts are not significant in their own right, it is important to distinguish these from other non-significant impacts as they may contribute to significant impacts cumulatively or through interactions.

37. Embedded mitigation is included in the initial assessment of impact. If the impact does not require additional mitigation (or none is possible) the residual impact would remain the same. If, however, additional mitigation is required there should be an assessment of the post-mitigation residual impact.

19.4.2 Cumulative Impact Assessment

38. Chapter 6 EIA Methodology provides a general methodology with regards to the CIA.

39. The potential for cumulative effects has been considered for the construction, operation and decommissioning of the onshore project area cumulatively with the offshore project area as well as with other onshore projects.

40. Cumulative impacts are discussed where the onshore project area has the potential to overlap with similar impacts arising from:

- Recent development, either built or under construction (which is not constructed as part of the baseline);
- Approved development, awaiting implementation; and
- Proposals awaiting determination within the planning process with design information in the public domain.

41. The CIA involves consideration of whether impacts on a receptor can occur on a cumulative basis between the project and other activities, projects and plans for which sufficient information regarding location and scale exist.

42. For further details of the methods used for the CIA for ground conditions and contamination, see section 19.8.

19.4.3 Transboundary Impact Assessment

43. There are no transboundary impacts with regards to ground conditions and contaminated land as the onshore project area is entirely within the UK and would not be sited in proximity to any international boundaries. Transboundary impacts are therefore scoped out of this assessment and will not be considered further.

19.5 Scope

19.5.1 Study Area

44. The onshore project area considered includes the following elements:

- Landfall, including landfall compound;
- Onshore cable route, accesses, trenchless crossing (e.g. Horizontal Directional Drilling (HDD)) zones and compounds, mobilisation zones and areas;
- Onshore project substation; and
- Extension to the Necton National Grid substation.

45. A full description of the above onshore infrastructure is provided in Chapter 5 Project Description.

46. The study area was consulted and agreed as part of the EPP namely the Ground Conditions and Contamination Method Statement (Royal HaskoningDHV, 2018, unpublished). It has been chosen to allow for the variance in final location and alignments and to identify any existing assets or infrastructure including landfills or contaminated land that might affect or be affected by the project.

47. The study area is defined by the distance over which impacts on ground conditions and contamination from the project may be and by the location of any receptors that might be affected by those potential impacts. This has been established by professional judgement supported by a PRA (Appendix 19.2).

48. For the landfall, National Grid Substation and onshore project substation, a 1km buffer was selected and a 250m buffer either side of the onshore cable route was also selected. The wider buffer size for the landfall, National Grid Substation and onshore project substation was primarily to allow for variance in final location of this infrastructure. The onshore assessment commences at Mean High Water Spring (MHWS) and does not consider the intertidal zone. The intertidal zone is discussed

in Chapter 8 Marine Geology, Oceanography and Physical Processes. The study area is shown in Figure 19.1.

19.5.2 Data Sources

49. This assessment has been informed by the findings from a desk-based exercise using information collected from July 2016 onwards. These data sets have been collected for different study areas depending upon the project information available at the time of collection. The data sources used to inform the ground conditions and contamination baseline are summarised in Table 19.9.

Table 19.9 Data sources

Data	Year	Notes
Geology	2018	British Geological Survey (BGS) online viewer: www.mapapps.bgs.ac.uk
	2017	Terra Consult (2017) Ground investigation reports
	2018	GHD (2018) Norfolk Vanguard and Norfolk Boreas Offshore Wind Farm Site Investigations Phase II
Hydrogeology: groundwater vulnerability, groundwater SPZ areas, abstractions	2017	Environmental Agency "What's in my back yard?" website: http://apps.environment-agency.gov.uk/wiyby/default.aspx
Landfills and mining		
Water Framework Directive (WFD) Classification	2018	Environmental Agency (2016) Catchment Data Explorer: www.environment.data.gov.uk /catchment-planning/
Private water supply	2017	Information obtained from District Councils
Contaminative land uses from historical maps	2017	Envirocheck Report (see Appendix 19.2)

50. The summary of baseline conditions only provides a broad guide to the conditions that are expected. Ground investigations were undertaken in 2017 by GHD and TerraConsult with local Norfolk subcontractor SI Drilling and in 2018 by GHD at key crossing locations (Figure 19.2) listed below as agreed with the Environment Agency and Anglian Water:

- **Crossing 1 – A47** The fieldwork was carried out between 28th July 2017 and 3rd August 2017 (TerraConsult, 2017a);
- **Crossing 2 – Mid-Norfolk Railway** The fieldwork was carried out between 18th July 2017 and 26th July 2017 (TerraConsult, 2017b);
- **Crossing 3 – River Wensum** The fieldwork was undertaken between 4th August 2017 and 14th August 2017 (TerraConsult, 2017c);
- **Crossing 4 – River Bure** The fieldwork was carried out between 4th August 2017 and 11th August 2017 (TerraConsult, 2017d);

- **Crossing 5 – A140** The fieldwork was carried out between 31st July 2017 and 3rd August 2017 (TerraConsult, 2017d);
- **Crossing 6 – A149**. The fieldwork was carried out between 13th July 2017 and 17th July 2017 (TerraConsult, 2017e);
- **Crossing 7– Norfolk Railway**. The fieldwork was carried out between 20th July 2017 and 28th July 2017 (TerraConsult, 2017e);
- **Happisburgh South landfall**. The fieldwork was undertaken between 3rd July 2017 and 19th July 2017 (TerraConsult, 2017f);
- **Wooded Copse**. The fieldwork was undertaken between 6th of November 2017 and 30th of January 2018 (GHD, 2018);
- **North Walsham and Dilham Canal**. The fieldwork was undertaken between 6th of November 2017 and 30th of January 2018 (GHD, 2018);
- **King's Beck**. The fieldwork was undertaken between 6th of November 2017 and 30th of January 2018 (GHD, 2018); and
- **Wendling Beck**. The fieldwork was undertaken between 6th of November 2017 and 30th of January 2018 (GHD, 2018).

19.5.3 Assumptions and Limitations

51. This assessment is based on a range of publicly available information and data from bodies such as the Environment Agency and Local Authorities. The direct assessments and judgements given in this chapter are limited by the finite data on which they are based. However, there is a level of uncertainty associated with extrapolation of site-specific data or non-site data to other locations within the study area, particularly where the study area is large as in the case of the project.

52. The acquisition of data is also constrained by both physical and economic factors and by definition is subject to the limitations imposed by the methods of investigations employed. In this instance the data has been obtained from borehole logs from mechanically drilled boreholes, which by their nature only provide spatially limited information.

53. Conditions at the site will change over time due to natural variations and may be affected by human activities. In particular, groundwater, surface water and soil gas conditions should be anticipated to change with diurnal, seasonal and meteorological variations.

19.6 Existing Environment

54. This section describes the existing environment in relation to ground conditions and contamination. It is based on a desk-top study of publicly available records and intrusive ground investigations identified in section 19.5.2 as a basis for the impact assessment.

19.6.1 Landfall

19.6.1.1 Geology

55. The cliffs at Happisburgh range in height from 6 – 10 metres (m) and are composed of a layer-cake sequence of several glacial tills, separated by beds of stratified silt, clay and sand. The basal unit within the stratigraphic succession at Happisburgh is the How Hill Member of the Wroxham Crag Formation. They consist of stratified brown sands and clays with sporadic quartzose-rich gravel seams.

56. The marine deposits are overlaid by a series of glacial lithologies deposited during several advances of glacier ice into the region during the Middle Pleistocene.

57. The Happisburgh Till crops-out at the base of the cliffs and its base is frequently obscured by modern beach material. The Happisburgh Till Member is a dark grey, highly consolidated till with a matrix composed of a largely massive clayey sand with occasional pebbles of local and far-travelled material.

58. Ground investigations were carried out in the landfall area between 3rd and 19th July 2017 and comprised nine boreholes (Figure 19.2). Sandy clay (Till Member) was found in most of the boreholes to depths between 2.7 and 10m below ground level (BGL). The sandy clay was underlain by sand up to depths of 18m BGL.

19.6.1.2 Designated geological sites

59. There is only one designated geological site within the study area. Happisburgh Cliffs SSSI is designated specifically for its geological interest (Figure 19.3). The cliffs are an important site for dating the Pleistocene succession in East Anglia, and display a range of marine, freshwater and glacial sediments which span five stages from the pre-Pastonian to the Anglian (Natural England, 1985). The SSSI is particularly important for several main features:

- Cliff exposures which uniquely show three glacial deposits;
- The Anglian-aged Cromer Tills, with intercalated water-deposited sediments; and
- The underlying Cromer Forest-bed Formation, which is exposed at the foreshore; and supports excellent development of pre-Pastonian and Pastonian deposits.

60. The SSSI is located approximately 600m from the landfall.

19.6.1.3 Coastal processes

61. The landfall is located within the East of Cromer to Happisburgh area of the Kelling to Lowestoft Ness Shoreline Management Plan (SMP). This is the most active length of coast within the SMP area and is the main provider of sediment for beaches throughout much of the SMP frontage.

62. There are numerous erosion prevention / flood defence assets in the areas of Bacton gas terminal, and the smaller settlements of Bacton, Walcott and Happisburgh. The SMP seeks to maintain present defences for a period with a long-term plan to gradually retreat and relocate, thus enabling a naturally functioning sustainable system to re-establish. The SMP will allow unabated erosion throughout much of this area in the longer term. To manage relocation, occasional measures to temporarily delay (but not halt) this erosion from time to time may be acceptable in some locations where there are larger concentrations of assets.

63. From Walcott to Happisburgh (encompassing the landfall area at Happisburgh South) sediment transport rates have been estimated at just over 500,000m^3/year between 1979 and 1994 (AECOM, 2012). The rate of transport at Happisburgh is thought to be the highest along the coastline and more sediment is leaving from the south than is entering from the north-west, due in part to the updrift coastal defences and the change in orientation of the coastline. The cliffs between Walcott and Happisburgh consist of fine sediment, containing a mixture of silt/clay and fine sand, and therefore contribute only small volumes of sediment to the beach system. The foreshore along this stretch of coast primarily relies on supply of sediment from the north-west.

64. The cliffs at Happisburgh South are eroding (see Appendix 4.5 Coastal Erosion Study of Chapter 4 Site Selection and Assessment of Alternatives). The shoreline has shown a history of net retreat and pre-defence maps (1900 – 1937) show the average erosion rate was between 0.4 and 2.1m/year. An analysis of post-defence erosion rates (1937 – 1999) concluded that erosion rates varied between 0.4 (north of the landfall site) and 0.8m/year. Since 1999, the shoreline has eroded at a higher rate of up to 10m/year along the landfall site; the existing defences have been overcome and no further investment into the existing or additional defences is proposed as is outlined in the Kelling to Lowestoft Ness SMP (AECOM, 2012). Cliff-top analysis in 2017 showed a negligible change in cliff top retreat, however this cannot be taken as a sign for retreat rates slowing down, but more that retreat is variable (Appendix 4.5).

65. Detailed information on coastal process in the landfall area can be found in Chapter 8 Marine Geology, Oceanography and Physical Processes.

19.6.1.4 Land Quality

66. Based on the desk based information and the findings of the site walkover, potential sources of contamination at the landfall have been identified. These are electrical substation facilities (shown on the historic map from 1970), and oil and petroleum tanks in Happisburgh village (shown on the historic map from 1892). These may be associated with a very wide range of contaminants including hydrocarbons and other organic compounds like polychlorinated biphenyls (PCBs) (see Figure 19.2.1 and

Figure 19.2.2 in Appendix 19.2). It is understood that these tanks are connected with the lighthouse.

19.6.1.5 Hydrology and surface drainage

67. The landfall is within the River Bure main surface water catchment, there are no surface waters within the landfall zone. The baseline hydrology is described in more detail in Chapter 20 Water Resources and Flood Risk.

19.6.2 Onshore cable route and onshore project substation

19.6.2.1 Geology

68. The BGS online viewer[1] shows that the solid geology beneath the study area (as shown in Figure 19.1 and Figure 19.2 and explained in more detail in Appendix 19.2) compromises White Chalk and Crag Group deposits which dip gently to the south east.

69. The Chalk is a white or grey limestone and is over 460m thick in Norfolk. It principally outcrops as a low, rolling plateau in west Norfolk, along the north Norfolk coast and near Norwich where the Rivers Yare and Wensum have cut down through overlying beds to expose it.

70. The Crag Group deposits are a sequence of sandy, marine deposits which outcrop in the eastern parts of the study area.

71. The solid deposits are overlain predominantly by glacial till dating from the Anglian glaciation, interspersed with sheets of glacial sands and gravels. Small isolated pockets or channels of superficial deposits exist over the Glacial Till Alluvium where watercourses are crossed.

72. Targeted ground investigations were undertaken along the onshore cable route in 2017 and 2018 (see Figure 19.2). The following ground conditions were encountered:

- Crossing 1: A47– the shallow geology is comprised of silty to gravely clay (Lowestoft Formation) with chalk and flint to a depth of 15.45m BGL;
- Crossing 2: Mid-Norfolk Railway - the shallow geology is comprised of silty to gravely clay (Till Formation) with chalk and flint interspersed with fine to medium sands to a depth of 20m BGL;
- Crossing 3: River Wensum - the shallow geology is comprised of fine to coarse gravels (Alluvium) interspersed with fine to coarse sands to a depth of 17m BGL. Small pockets of peat (of thickness up to 1.55 m) were encountered in this area.

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[1] www.bgs.ac.uk

- Crossing 4: River Bure - the shallow geology is comprised of sandy – gravelly clay (Alluvium) interspersed with clayey sands to a depth of between 4.2 to 7m BGL. The shallow geology was underlain by Chalk;
- Crossing 5: A140 - the shallow geology is comprised of fine to medium sand and clays (Brickearth) to a depth of approximately 4m BGL, underlain by fine to coarse flint gravels and sand (Wroxham Crag Formation) to a depth of approximately 12m BGL. The shallow geology was underlain by Chalk;
- Crossing 6: A149 - the shallow geology is comprised of fine to medium sands interspersed with sandy clay (Glaciofluvial deposits) to a depth of approximately 16m BGL;
- Crossing 7: Norfolk Railway - the shallow geology is comprised of fine to medium sands interspersed with sandy clay (Glaciofluvial deposits) to a depth of approximately 14m BGL, underlain by fine and medium sands interspersed with clay (Wroxham Crag formation) to depths 20m BGL;
- Wooded Copse – the shallow geology is comprised of medium dense sands interspersed with clay, encountered to a depth 10m BGL;
- North Walsham and Dilham Canal – the shallow geology is comprised of silty clay and clayey silt to a depth of 9.2m BGL, underlain by medium sands to a depth 10m BGL;
- Kings Beck – the shallow geology is comprised of loose sands and gravel to depth 10m BGL; and
- Wendling Beck – the shallow geology is comprised of gravels to a depth of 1.6m BGL, underlain by soft to firm clay to 3.5m BGL. The shallow deposits were underlain by Chalk deposits.

19.6.2.2 Hydrology and surface drainage

73. The project is located within three main surface water catchments (Figure 20.2).

74. The River Bure and several of its tributaries (most notably King's Beck and the North Walsham and Dilham Canal) would be crossed by the onshore cable route. The river rises near Briston, from where it flows in an easterly direction until it reaches Aylsham. From here, it continues to flow to the south east until it enters the sea at Great Yarmouth. The downstream reaches of the river include a wide range of wetland features, including Hoveton Great Broad and Marshes, Woodbastwick Fens and Marshes, Bure Marshes and the Norfolk Broads.

75. The River Wensum and several of its tributaries (most notably Wendling Beck and the Blackwater Drain) would be crossed by the onshore cable route. The river rises near Whissonsett, from where it flows north towards Fakenham before continuing in a broadly south easterly direction towards Norwich.

76. The River Wissey, the headwaters of which fall within the area for the National Grid substation extension. The Wissey rises to the south of Dereham, from where it drains in a westerly direction towards Necton before eventually joining the River Great Ouse at Denver Sluice, near Downham Market.

77. The baseline hydrology is described in more detail in Chapter 20 Water Resources and Flood Risk.

19.6.2.3 Hydrogeology

78. The Crag and the Chalk aquifers are classified as principal aquifers by the Environment Agency. The superficial deposits are classified as secondary A, B and undifferentiated aquifers (as shown on Figure 19.4).

79. The Water Framework Directive (2000/60/EC) (WFD) defines groundwater bodies as distinct volumes of groundwater within an aquifer or aquifers. It requires that groundwater bodies are designated as drinking water protected areas (DrWPAs) based on their use for human consumption.

80. All groundwater bodies in England are designated DrWPAs. The WFD aims to protect DrWPAs from over-abstraction and to prevent deterioration in quality that could increase the treatment of drinking water.

81. The Environment Agency groundwater vulnerability maps indicate the study area is located within an area of high groundwater vulnerability. This indicates soils which may be able to transmit a wide range of pollutants into any groundwater stored in the underlying strata.

82. The landfall and onshore cable route are mostly located on the Broadland Rivers Chalk and Crag groundwater body (GB40501G400300), as defined in the Anglian River Basin Management Plan (Environment Agency, 2015). The WFD status of the groundwater body has been classified by the Environment Agency as being of Poor Quantitative Status and Poor Chemical Status. The Poor Quantitative and Chemical Status is attributed to impacts from agriculture.

83. The onshore project substation is located within the Cam and Ely Ouse Chalk groundwater body (GB40501G400500) and the North West Norfolk Chalk (GB40501G400200) groundwater body, and the landfall is in the North Norfolk Chalk (GB40501G400100) groundwater body.

84. The detailed status of the water bodies is shown in Table 19.10 to Table 19.13. This information can be found on the Environment Agency's Catchment Data Explorer 2019 (the latest update was 15/10/18).

Table 19.10 Broadland Rivers Chalk and Crag groundwater body (GB40501G400300) status

Water body details	
Water body ID	GB40501G400300
Overall water body status	**Poor**
Quantitative	**Poor**
Quantitative Status element	Good
Quantitative GWDTEs test	*Poor*
Quantitative Saline Intrusion	*Good*
Quantitative Water Balance	*Good*
Chemical	**Poor**
Chemical Status element	Poor
Chemical Dependent Surface Water Body Status	*Good*
Chemical Drinking Water Protected Area	*Poor*
Chemical GWDTEs test	*Good*
Chemical Saline Intrusion	*Good*
General Chemical Test	*Good*
Supporting elements (Groundwater)	-
Prevent and Limit Objective	-
Trend Assessment	*Upward trend*

Table 19.11 Cam and Ely Ouse Chalk groundwater body (GB40501G400500) status

Water body details	
Water body ID	GB40501G400500
Overall water body status	**Poor**
Quantitative	**Poor**
Quantitative Status element	Poor
Quantitative GWDTEs test	*Poor*
Quantitative Saline Intrusion	*Good*
Quantitative Water Balance	*Poor*
Chemical	**Poor**
Chemical Status element	Poor
Chemical Dependent Surface Water Body Status	*Good*
Chemical Drinking Water Protected Area	*Poor*
Chemical GWDTEs test	*Good*
Chemical Saline Intrusion	*Good*
General Chemical Test	*Poor*

Water body details	
Supporting elements (Groundwater)	-
Prevent and Limit Objective	-
Trend Assessment	*Upward trend*

Table 19.12 North West Norfolk Chalk groundwater body (GB40501G400200) status

Water body details	
Water body ID	GB40501G400200
Overall water body status	**Poor**
Quantitative	**Poor**
Quantitative Status element	Poor
Quantitative GWDTEs test	*Good*
Quantitative Saline Intrusion	*Good*
Quantitative Water Balance	*Poor*
Chemical	**Poor**
Chemical Status element	Poor
Chemical Dependent Surface Water Body Status	*Good*
Chemical Drinking Water Protected Area	*Good*
Chemical GWDTEs test	*Good*
Chemical Saline Intrusion	*Good*
General Chemical Test	*Poor*
Supporting elements (Groundwater)	-
Prevent and Limit Objective	-
Trend Assessment	*No trend*

Table 19.13 North Norfolk Chalk groundwater body (GB40501G400100) status

Water body details	
Water body ID	GB40501G400100
Overall water body status	**Poor**
Quantitative	**Good**
Quantitative Status element	Good
Quantitative GWDTEs test	*Good*
Quantitative Saline Intrusion	*Good*
Quantitative Water Balance	*Good*
Chemical	**Poor**
Chemical Status element	Poor
Chemical Dependent Surface Water Body Status	*Good*

Water body details	
Chemical Drinking Water Protected Area	*Good*
Chemical GWDTEs test	*Good*
Chemical Saline Intrusion	*Good*
General Chemical Test	*Poor*
Supporting elements (Groundwater)	-
Prevent and Limit Objective	-
Trend Assessment	*Upward trend*

19.6.2.4 Groundwater abstractions

85. There are a number of licensed groundwater abstractions within the study area which are mostly associated with agricultural purposes. Broadland District Council, North Norfolk District Council and Breckland Council were contacted in May 2017 to obtain information regarding private water supplies located within the study area. There are 101 private water supplies within the study area in the areas administered by North Norfolk District Council, Breckland Council and South Holland Council. Broadland District Council does not hold records regarding private water supply and no information is available for this area.

86. There are a number of groundwater SPZ areas within the onshore project area (Figure 19.5). Currently, trenchless crossing techniques (e.g. HDD) are proposed in the following areas:

- SPZ3 in the area of Scarning;
- SPZ2 and SPZ3 north of Dereham;
- SPZ1 and SPZ2 in the area of North Walsham;
- SPZ3 under the River Wensum;
- SPZ2 and SPZ3 north of Aylsham;
- SPZ3 under the Cromer Road (A149); and
- SPZ3 south of Edingthorpe.

87. The study area does not cross any groundwater Safeguard Zones (SgZs). SgZs are non-statutory WFD designations by the Environment Agency for potable abstractions where the water quality is at risk of deterioration and where additional measures are needed to bring about improvement. SgZs are typically based on existing SPZ1 and SPZ2 areas. Designation means that there will be strict enforcement of existing measures for particular pollutants and activities, and possibly new voluntary measures.

19.6.2.5 Land Quality

88. The majority of the onshore cable route is located within an agricultural area, where significant contamination is not expected as the agricultural activities are usually not associated with major contamination. There is a small risk of encountering buried asbestos or agrochemical waste. One historical common clay and shale pit is present which has been infilled and may contain unknown and potentially contaminated fill material (see Figure 19.2.1 and Figure 19.2.2 in Appendix 19.2).

89. The dismantled railway lines south east of Themelthorpe and south east of Oulton are largely Made Ground (man-made deposits such as embankments and spoil heaps on the natural ground surface) and have the potential to contain elevated concentrations of contaminants such as petroleum and diesel hydrocarbons, heavy metals, PCBs and polyaromatic hydrocarbons (PAHs) see Figure 19.2.1 and Figure 19.2.2 in Appendix 19.2.

90. Clay bricks & tile manufacturers were historically located to the north and north east of North Walsham, which could be associated with heavy metals (e.g. hexavalent chromium) and inorganic compounds (arsenic compounds).

91. There is a graveyard north of North Walsham, which may be a source of contaminants such as metals, nutrients and pathogens (see Figure 19.2.1 and Figure 19.2.2 in Appendix 19.2).

92. There are several registered waste treatment sites and licensed waste facilities south of the onshore cable route in the area of North Walsham. These may be associated with a very wide range of contaminants, including Volatile Organic Compound (VOCs), Semivolatile Organic Compound (SVOCs), heavy metals, cyanides, ammonium, chlorides, sulphates and PAHs.

93. There is one Hazardous Substance Consent located approximately 200m north of the cable route in the area of Witton. The consent is associated with use of ammonium nitrate and ammonium nitrate compounds (see Figure 19.2.1 and Figure 19.2.2 in Appendix 19.2).

94. An historical landfill was identified adjacent to the onshore cable route south west of Witton and may be associated with a very wide range of contaminants, including VOCs, SVOCs, heavy metals, cyanides, ammonium, chlorides, sulphates and PAHs (see Figure 19.2.1 and Figure 19.2.2 in Appendix 19.2).

95. One minor pollution incident involving animal by-products occurred in the area of the River Bure in 1997 (see Figure 19.2.2 in Appendix 19.2). In addition, a military jet crash occurred in December 1996 in one of the fields in proximity to the onshore 400kV cable route. According to the environmental assessment report from the Royal Air Force (Royal Air Force Institute of Health and Medical Training, 2017) the

contaminates associated with plane crash included carbon fibre, hydrazine, oil products and fuel. Remediation works were undertaken, including the neutralisation of hydrazine and removal of contaminated soils, however there is the potential that some residual contamination may be present (see Appendix 19.2 for further details).

96. There are two former mineral workings present (one clay and shale, and the other sand and gravel) adjacent to the onshore project substation which have been infilled and may contain potentially contaminated fill material. These do not overlap with the footprint of the onshore project substation (see Figure 19.2.1 and Figure 19.2.2 in Appendix 19.2). However, the clay and shale pit lies within the 400kV cable route that connects the onshore project substation to the Necton National Grid substation. This is shown in Appendix 19.2 PRA Figure 19.2.2.

19.6.2.6 Minerals Safeguarding Area

97. The study area contains significant (177 ha) sand and gravel resources, associated with the glaciofluvial deposits (as shown in Figure 19.6). The onshore cable route crosses a number of Mineral Safeguard Areas (MSAs). These are mostly associated with glacial sand and gravel deposits. A MSA is an area designated by a Mineral Planning Authority (MPA) which covers known deposits of minerals which are desired to be kept safeguarded from unnecessary sterilisation by non-mineral development.

19.6.3 Anticipated Trends in Existing Environment

98. This section discusses the likely future evolution of the existing baseline environment according to known trends in the baseline condition without implementation of the project.

19.6.3.1 Geology and coastal processes

99. No major changes to the geology of the study area are anticipated. However, as discussed in section 19.6.1.3, the cliffs at Happisburgh South are eroding and the rate of erosion could potentially change in the future in response to changes in sea level and wave energy. This is discussed in more detailed in Chapter 4 Site Selection and Assessment of Alternatives, Appendix 4.5 Coastal Erosion Study.

19.6.3.2 Hydrogeology and Groundwater Abstractions

100. The WFD aims to protect and enhance water bodies in Europe by controlling inputs of chemical pollutants and reverse existing chemical contamination to achieve good status. The current status of the groundwater bodies is provided in section 19.6.2.3. It is evident from monitoring that the pressures of land use and permeability of soils in the study area have resulted in substantial leaching of nitrate to the groundwater. The majority of this comes from land use in the form of agriculture. All water bodies within the study area are characterised by upward or no trend. The increased

regulation of agricultural chemicals suggests that baseline groundwater quality could improve in the future. However, any improvements are likely to become apparent only gradually, over long timescales.

101. The Water Abstraction Plan (DEFRA, 2017) sets out how the government will reform water abstraction management over the coming years and how this will protect the environment and improve access to water. As part of the plan, the Environment Agency will review and amend existing abstraction licenses. As a result of the programme, it is anticipated that abstraction will decrease and approximately 90% of surface water bodies and 77% of groundwater bodies will meet the required standards by 2021 as detailed in the Water Abstraction Plan (DEFRA, 2017).

19.6.3.3 Hydrology

102. Information regarding anticipated trends associated with surface water is provided in Chapter 20 Water Resources and Flood.

19.6.3.4 Land Quality

103. The review of the historical information (see sections 19.6.1.4 and 19.6.2.5) suggests that the potential for significant contamination to be present within the study area is low. Land affected by contamination is managed and driven by UK and local legislation and policies. The current risk based approach to the investigation of contaminated land was introduced by Part 2A of the Environmental Protection Act, 1990 (EPA, 1990). Under the legislation, local authorities were given the duty of identifying contaminated land and addressing the risks which arise from it in accordance with statutory provisions. The regime does not consider future uses; however, these would require a specific grant of planning permission. In addition to planning controls there is a clear trend for emissions from commercial and industrial sources to be driven down in compliance with stricter emissions legislations. This means that it is unlikely that any areas of controlled contamination will be introduced. Consequently, in relation to the project and its immediate receiving environment it is reasonable to predict that no new sources of contaminated land would be introduced.

19.7 Potential Impacts

104. The EIA is being undertaken for the following two alternative scenarios, therefore 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.
- **Scenario 2** – Norfolk Vanguard does not proceed to construction and Norfolk Boreas project proceeds alone. Norfolk Boreas undertakes all works required as an independent project.

105. Where the assessment of the impact is different for Scenario 1 and Scenario 2 a separate assessment is presented under each impact heading. Where this is relevant, Scenario 2 is presented first as it would generally result in the more significant impacts.

106. This section details the impact assessment for the construction, operation and decommissioning phases of the project. It is based upon the interactions between the relevant worst case assumptions for the project and the embedded mitigation with regards to receptor sensitivity and value, and the magnitude of the potential effect (as detailed in section 19.4.1).

19.7.1 Embedded Mitigation

107. Norfolk Boreas Limited has committed to a number of techniques and engineering designs/modifications 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.

108. A range of different information sources has been considered as part of embedding mitigation into the design of the project (for further details see Chapter 5 Project Description, Chapter 4 Site Selection and Assessment of Alternatives and Chapter 7 Technical Consultation) including engineering requirement, feedback from community and landowners, ongoing discussions with stakeholders and regulators, commercial considerations and environmental best practice.

109. The following sections outline the key embedded mitigation measures relevant for this assessment. These measures are presented in Table 19.14. Where specific mitigation is required to reduce or eliminate a significant effect, this is referred to as mitigation and is presented in section 19.7.4.

Table 19.14 Embedded mitigation

Parameter	Mitigation measures embedded into the project design	Notes
Project Wide		
Commitment to High Voltage Direct Current (HVDC) technology	Commitment to HVDC technology minimises environmental impacts through the following design considerations; • HVDC requires fewer cables than the High Voltage Alternating Current (HVAC) solution. During the duct installation phase under Scenario 2 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	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.

Parameter	Mitigation measures embedded into the project design	Notes
	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).	
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 explanation see Chapter 4 Site Selection and Alternatives) for the onshore project substations and National Grid substation 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; • Avoiding other services (e.g. gas pipelines) but aiming to cross at close	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 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
	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 access to the beach for the public during construction. Norfolk Boreas Limited have also committed to not using 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 has been a project commitment from the outset of each project.
Scenario 2		
Duct installation strategy	The onshore cable duct installation strategy is proposed to be conducted in a sectionalised approach in order to minimise impacts. Construction teams would work on a short length (approximately 150m section) and once the cable ducts have been installed, the section would be back filled and the top soil replaced before moving onto the next section. This would minimise the amount of land being worked on at any one time and also minimise overall disruption.	This has been a very early project commitment. 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; • Wendling Carr County Wildlife Site; • Little Wood County Wildlife Site; • Land South of Dillington Carr County Wildlife Site;	A commitment to a number of trenchless crossings at certain 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.

Parameter	Mitigation measures embedded into the project design	Notes
	• Kerdiston proposed County Wildlife Site; • Marriott's Way County Wildlife Site / Public Right of Way; • 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.	

19.7.2 Worst Case

110. Chapter 5 Project Description details the parameters of the project using the Rochdale Envelope approach for the ES. This section identifies the worst case parameters during construction, operation and decommissioning relevant to potential impacts on ground conditions and contamination for each scenario.

111. The realistic worst case assumptions identified in this section are also applied to the CIA.

112. Table 19.15 summarises the worst case assumption for Scenario 1 and Table 19.16 summarise the worst case assumptions for Scenario 2 for ground conditions and contamination.

Table 19.15 Worst Case Assumptions for Scenario 1

Worst case assumptions			
Parameter	**Worst case criteria**	**Worst case definition**	**Notes**
Landfall			
Construction	Method Maximum drill length Maximum no. of drills	Trenchless technique (e.g. HDD) 1,000m 3	Any potential impacts on the SSSI are discussed in section 19.7.4.1 and in Chapter 8 Marine Geology, Oceanography and Physical Processes.

Worst case assumptions Parameter	Worst case criteria	Worst case definition	Notes
	Maximum drill diameter	750mm	
	Temporary works footprint	6,000m^2	
	Maximum temporary works duration	20 weeks	Based on 7am-7pm normal working hours. 7 Days a week.
	Excavated Material	1,325m^3	Excavated material based on maximum drill dimensions (1000m by 750mm) and 3 no. of drills.
Landfall compounds	Maximum number and maximum land take for temporary HDD compounds	Assumes 2 at 3,000m^2	Two compounds (50m x 60m) to support parallel drilling rigs
Onshore cable route			
Construction – cable pulling only	Method	Installation of cables in pre-installed ducts	Cables will be pulled through the ducts installed by Norfolk Vanguard.
	Installation maximum footprint	85,500m^2	Cable pulling footprints include the running track and jointing pits.
	Excavated material for running track	21,600m^3	
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.
Cable logistics area	Maximum number and required dimensions	Assumes one compound with an area of 4,190m^2	A cable logistics area has been identified for the storage of materials, welfare facilities, etc.
Construction programme	Cable pulling	2026-2027	
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 all temporary works area at the onshore project substation	95,000m^2	Substation compound 200m x 100m.
	Maximum land take for construction compound for onshore project substation	20,000m^2	Spicers Corner compound 100m x 100m.

Worst case assumptions Parameter	Worst case criteria	Worst case definition	Notes
	Maximum land take for temporary works area at Spicers Corner Maximum duration Substation foundations	$10,000m^2$ 30 months Piled	Indicative construction window 24 months. Assumes worst case there is piling as part of construction of foundations
Operation	Maximum land take for permanent footprint Maximum land take for access road.	$75,000m^2$ $1,800m^2$	Operational footprint 250m x 300m Dimensions 300m x 6m.
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 (WCS), 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	$75,000m^2$ 30 months	Compound 150m x 200m adjacent to eastern extension site and compound 300m x 150m adjacent to the Norfolk Vanguard Extension Indicative construction window 24 months.
Operation	Maximum land take for substation extension permanent footprint	$20,250m^2$	Permanent eastern extension footprint 135m x 150m

Table 19.16 Worst Case Assumptions for Scenario 2

Worst case assumptions Parameter	Worst case criteria	Worst case definition	Notes
Landfall			
Construction	Method Maximum drill length	Trenchless technique (e.g. HDD) 1,000m	Any potential impacts on the SSSI are discussed in section 19.7.4.1 and in Chapter 8 Marine Geology, Oceanography and Physical Processes.

Worst case assumptions			
Parameter	Worst case criteria	Worst case definition	Notes
	Maximum no. of drills Maximum drill diameter Indicative target depth of drill Temporary works footprint Maximum temporary works duration Excavated Material	3 750mm Up to 20m 6,000m^2 20 weeks 1,500m^2	Based on 7am-7pm normal working hours Two pits in total, one pit required per circuit. 10m x 15m x 5m deep
Landfall compounds	Maximum number and maximum land take for temporary HDD compounds	Assumes 2 at 3,000m^2	Two compounds (50m x 60m) to support parallel drilling rigs
Onshore cable route			
Construction	Method Maximum working width and length Onshore cable route maximum footprint Depth of trench Width of cable trench Trench excavated material Burial depth	Open cut trenching and trenchless crossing[2] methods 35m and 60km 2,100,000m^2 1.5m 1m 180,000m^3 Minimum 1.05m to top of ducts	Trenchless crossing methods (HDD, micro tunnelling or auger boring). Trench per circuit so two separate trenches of 1m width 1.05m 'normal' agricultural, 1.2m 'deep ploughing' agricultural to top of duct. Up to 20m at trenchless crossings.
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

[2] All crossing options will disturb ground materials and may disturb secondary aquifers, whereby surface water could hydraulically connect with groundwater in the secondary aquifer.

Worst case assumptions Parameter	Worst case criteria	Worst case definition	Notes
Trenchless launch and reception sites	Number of trenchless crossings Maximum number and maximum land take for trenchless launch and reception sites	16 Assumes 16 pairs at 7,500m^2 and 5,000m^2 respectively	 None
Construction programme	Total Pre-construction works Duct installation Cable pulling, jointing and commissioning	2021-2026 2021-2022 2023-2024 2025-2026	Pre-construction works would consist of road modifications, hedge and tree removal, ecological preparations, archaeological survey and pre-construction drainage.
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 all temporary works area at the onshore project substation Maximum land take for temporary construction compound for onshore project substation Maximum duration Substation foundations	95,000m^2 20,000m^2 30 months Piled	Operational area for Substation 250m x 300m= 75,000m^2 plus additional temporary construction compound 20,000m^2. Substation compound 200m x 100m. Indicative construction window 24 months. Assumes worst case there is piling as part of construction of foundations
Operation	Maximum land take for permanent footprint Maximum land take for access road.	75,000m^2 10,800m^2	Operational footprint 250m x 300m Dimensions 1.8km x 6m
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 WCS, impacts as for the construction phase are assumed.		

Worst case assumptions Parameter	Worst case criteria	Worst case definition	Notes
National Grid extension and overhead line modification			
Construction	Maximum land take for temporary works area – substation extension	67,500m^2	
	Maximum land take for temporary works area – overhead line	176,310m^2	
	Maximum duration	30 months	Indicative construction window 24 months.
	Tower foundations	Piled	4 piles required per tower
Operation	Maximum land take for substation extension permanent footprint	30,000m^2	Permanent western extension footprint approx. 200m length and 150m wide
	Maximum land take for overhead line permanent footprint	1,000m^2	Assumes two new permanent overhead line towers will be required.

113. Chapter 5 Project Description outlines the timings to be assessed in relation to the phasing of the works. In all cases for ground conditions and contamination; 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 receptors will be potentially impacted by the project.

19.7.3 Monitoring

114. The development of the detailed design and Code of Construction Practice (CoCP) will refine the worst-case impacts assessed in this EIA. It is recognised that monitoring is an important element in the management and verification of the actual project impacts. The requirement for and appropriate design and scope of monitoring will be agreed with the appropriate stakeholders and included within the CoCP and the Construction Method Statement (CMS) prior to construction works commencing.

19.7.4 Potential Impacts during Construction

19.7.4.1 Impact 1: Impacts to coastline, including designated geological sites

115. Any potential impacts to the coastline are associated with the work at the landfall. As the works at the landfall are the same under both scenarios the impact assessment detailed in 19.7.4.1.1 is applicable to both scenarios.

19.7.4.1.1 Scenario 1 and Scenario 2

Landfall

116. Within the Happisburgh Cliffs SSSI, the cliff and beach have been subject to visible erosion and in places they are very unstable. As this site is located approximately 570m north of the project landfall at its nearest point, no direct impacts (physical disturbance) are anticipated to arise from the construction of the project.

117. Impacts relating to offshore cable pulling are assessed in Chapter 8 Marine Geology, Oceanography and Physical Processes.

118. It has been assessed that due to the distance of the landfall from the Happisburgh Cliffs SSSI there is no mechanism for direct impact and therefore **no impact** was identified during the assessment.

119. The HDD will be secured beneath the surface of the shore platform and the base of the cliff, drilled from a location greater than 150m landward of the cliff edge. The material through which the HDD will pass, and through which the cables will ultimately be located, is consolidated and will have sufficient strength to maintain its integrity during the construction process. Also, the cable will be located at sufficient depth to account for shore platform steepening (downcutting) as cliff erosion progresses, and so will not become exposed during the design life of the project. Hence, the continued integrity of the geological materials and the continued depth of burial of the cables mean that they will have **no impact** on coastal erosion during construction.

120. The indirect impacts were assessed as **no impact**. Details of the assessment can be found in Chapter 8 Marine Geology, Oceanography and Physical Processes.

19.7.4.2 Impact 2: Contamination of secondary aquifers as a result of construction activities

19.7.4.2.1 Scenario 2

Onshore cable route, landfall, onshore project substation and National Grid substation extension

121. Direct impacts to the superficial deposits crossed by the project may occur due to the intrusive nature of trenching, and potential piling (at the onshore project substation if required), dependent on the depth of the aquifer unit in relation to the proposed depth of excavation. At the crossing locations where the secondary aquifer (A or B, or A and B undifferentiated) is present the receptor could be directly affected through disturbance.

122. During construction, surface layers will be excavated, allowing increased infiltration of rainwater and surface run-off to the subsurface. This could potentially mobilise

any residual contamination already present in overlying strata which could potentially migrate into the underlying secondary aquifer.

123. Potentially polluting substances and activities could be introduced during the construction works, for example as a result of concrete pouring, storage of fuels and chemicals, and leaks and spills of fuel and oil from construction plant. Any potential impacts will be minimised by the embedded mitigation measures presented in section 19.7.1.

124. However, any changes are predicted to be of local spatial extent within each aquifer unit, of short term duration (related to the working areas only) and of temporary occurrence. The magnitude of effect is therefore considered to be low.

125. The secondary aquifers which form part of the superficial deposits are considered to be of low to medium sensitivity.

126. Therefore, the overall significance of impact as a result of disturbance or contamination of secondary groundwater aquifers is considered to be **minor adverse**, based on the embedded mitigation measures set out in section 19.7.1.

127. Additional mitigation will include the CoCP (DCO Requirement 20), which will be adhered to during the construction. This will include the Environment Agency's Pollution Prevention Guidance (PPG1, PPG5, PPG6, PPG21 and PPG22 (although this has been withdrawn as regulatory guidance in England, it remains a good source of environmental best practice).

128. An Outline CoCP (OCoCP) has been produced and submitted with the DCO application, and sets out proposed management measures for any onshore construction works associated with the project including:

- Mobilisation areas within the onshore project area will comprise hardstanding of permeable gravel aggregate underlain by geotextile, or other suitable material;
- Concrete and cement mixing and washing areas will be situated at least 10m away from the nearest watercourse. These will incorporate settlement and recirculation systems to allow water to be re-used. All washing out of equipment will be undertaken in a contained area, and all water will be collected for off-site disposal;
- All fuels, oils, lubricants and other chemicals will be stored in an impermeable bund with at least 110% of the stored capacity. Damaged containers will be removed from site. All refuelling will take place in a dedicated impermeable area, using a bunded bowser. Biodegradable oils will be used where possible; and

- Spill kits will be available on site at all times. Sand bags or stop logs will also be available for deployment on the outlets from the site drainage system in case of emergency spillages.

129. After the application of the additional mitigation measures outlined, the residual impact is considered to be **negligible**, which is not significant in EIA terms.

19.7.4.2.2 Scenario 1

Onshore cable route, landfall, onshore project substation and National Grid substation extension

130. Under Scenario 1, onshore cable route construction works are limited to the pulling of the cables through pre-installed ducts, however localised excavations are required at the jointing pit locations (150 at 90m^2 each). As detailed for Scenario 2 there are potential direct impacts to the superficial deposits due to the construction works including excavation works, piling at the onshore project substation if required and limited reinstatement of running track.

131. The surface layers will also be excavated under this scenario in select locations, allowing increased infiltration of rainwater and surface run-off to the subsurface. This could potentially mobilise any residual contamination already present in overlying strata which could potentially migrate into the underlying superficial aquifer. Potentially polluting substances and activities could be introduced during the construction works.

132. Any changes are predicted to be of local spatial extent within each aquifer unit, of short term duration (related to the working areas only) and of temporary occurrence. The magnitude of effect is therefore considered to be low.

133. The secondary aquifers which form part of the superficial deposits are considered to be of low to medium sensitivity.

134. The overall significance of impact as a result of disturbance of contamination of secondary groundwater aquifers is considered to be **minor adverse** based on the embedded mitigation measures set out in section 19.7.1.

135. As detailed in Scenario 2, additional mitigation will be included within the CoCP which will be adhered to during construction and will set out proposed management measures for any onshore construction.

136. After the application of the additional mitigation measures outlined, the residual impact is considered to be **negligible**, which is not significant in EIA terms.

19.7.4.3 Impact 3: Impacts on groundwater quality in the principal aquifer (including SPZ areas and abstractions) as a result of shallow excavation construction activities

19.7.4.3.1 Scenario 2

Onshore cable route, landfall, onshore project substation and National Grid substation extension

137. The secondary aquifers are considered to be linked to the underlying principal aquifer. Leaching and groundwater transport may occur as a result of new vertical hydraulic connections between shallow perched groundwater and groundwater associated with the principal aquifer during any excavation works including trench construction. Any impacts are predicted to be of local spatial extent (in the area of the construction works only) and intermittent occurrence.

138. The principal aquifer which underlies the superficial deposits beneath the whole study area is considered to be of high vulnerability. The sensitivity of the receptor is therefore considered to be high. In SPZ1 and SPZ2 areas, the aquifer sensitivity can also be considered to be high.

139. Where works are necessary within or close to a SPZ1 areas (e.g. along the cable route at Crostwight, the North Walsham and Dilham Canal crossing point, Cawston and Dereham, and the substation north of Bradenham), then further ground investigation, an appropriate risk assessment (see section 19.7.1) and consultation with the Environment Agency and Anglian Water will be undertaken to ensure that any adverse effects are minimised. The magnitude of effect is therefore considered to be low.

140. The overall significance of the impact of disturbance of contamination on the principal groundwater aquifer is considered to be **moderate adverse**.

141. It is anticipated that after adopting additional mitigation measures to mitigate impacts on SPZ1 and 2 areas, including ensuring cable excavations would be designed to minimise groundwater disturbance and the use of best available techniques (BAT) in accordance with the Energy Network Association Guidance (available at http://www.energynetworks.org/electricity/she/environment/ena-fluid-filled-cables/resources.html), the magnitude of effect will be reduced to negligible, therefore the residual impact is expected to be **minor adverse**, which is not significant in EIA terms.

19.7.4.3.2 Scenario 1

Onshore cable route, landfall, onshore project substation and National Grid substation extension

142. Under Scenario 1 onshore cable route construction works are limited to the pulling of the cables through pre-installed ducts, however localised excavations are required at the jointing pit locations. Potential impacts could also occur from excavations associated with the onshore project substation (including National Grid substation extension).

143. Any impacts are predicted to be of local spatial extent (in the area of the construction works only) and intermittent occurrence. The magnitude of effect is therefore considered to be low.

144. The principal aquifer which underlies the superficial deposits beneath the whole study area is considered to be of high vulnerability. The sensitivity of the receptor is therefore considered to be high.

145. The overall significance of the impact as a result of disturbance of contamination on the principal groundwater aquifer is considered to be **moderate adverse**.

146. It is anticipated that after adopting mitigation measures to mitigate impacts as detailed in Scenario 2, the magnitude of effect will be reduced to negligible therefore the residual impact is expected to be **minor adverse**, which is not significant in EIA terms.

19.7.4.4 Impact 4: Impacts on groundwater quality in the principal aquifer (including SPZ areas) resulting from trenchless crossing techniques and piling

19.7.4.4.1 Scenario 2

Onshore cable route, onshore project substation, landfall and National Grid substation extension

147. Direct impacts to the principal aquifer may occur from deep ground workings related to trenchless drilling operations for duct installation beneath surface infrastructure and watercourses. There is potential for drilling fluid to leak along the drill path, or from the immediate area of the mud pits or tanks which could cause contamination of groundwater. The volume of drilling fluid that could be released is dependent on a number of factors, including the size of the fracture, the permeability of the geological material, the viscosity of the drilling fluid, and the pressure of the hydraulic drilling system.

148. In addition, there may be a need for piling to provide foundations for the onshore project substation. Piling has the potential to create preferential pathways through a low permeability layer allowing potential contamination of an underlying aquifer.

The National Grid substation extension foundations are anticipated to be of ground-bearing form with no requirement for piling.

149. The impacts are predicted to be of local spatial extent (occurring only at trenchless crossing locations and at the onshore project substation if piling is required) and of intermittent occurrence.

150. The magnitude of effect on public water supply from trenchless crossing techniques (e.g. HDD) within SPZ1 and SPZ2 areas is considered to be low as they are predicted to be of local spatial extent and minimal effect on the water supply usability.

151. The principal aquifer which underlies the superficial deposits beneath the whole of the onshore project area, and including SPZ1 and SPZ2, is considered to be of high vulnerability. The sensitivity of the receptor is considered to be high.

152. Without additional mitigation the magnitude of effect on the principal aquifer is considered to be medium and therefore the impact is considered to be **major adverse**.

153. In order to minimise impacts on the principal aquifer, additional mitigation measures are therefore proposed and consultation with the Environment Agency and Anglian Water will be undertaken to ensure that any adverse effects are minimised. Ground investigations and a hydrogeological risk assessment would be undertaken at each trenchless crossing (e.g. HDD) site and will be discussed with the Environment Agency and additional mitigation agreed if necessary.

154. Where works are proposed within any SPZ1 or SPZ2 areas, a more detailed hydrogeological risk assessment meeting the requirements of Groundwater Protection Principles and Practice (GP3) (Environment Agency, 2017), and in agreement with the Environment Agency and Anglian Water, would be undertaken.

155. The outcomes of the hydrogeological risk assessment will be discussed with the Environment Agency and additional mitigation agreed if necessary.

156. Additionally, for all areas where piling works are proposed a pilling risk assessment will be undertaken and discussed with the Environment Agency.

157. It is anticipated that, after adopting these additional mitigation measures, the magnitude of effect will be reduced to negligible therefore the residual impact is expected to be **minor adverse**, which is not significant in EIA terms.

19.7.4.4.2 Scenario 1

Onshore cable route

158. Under Scenario 1 the onshore cable route construction works are limited to the pulling of the cables through pre-installed ducts, deep ground workings are not

required. As such there would be no mechanism for impact during construction activities on the onshore cable route and therefore **no impact** was identified during the assessment under Scenario 1.

Landfall, onshore project substation and National Grid substation extension

159. Under Scenario 1 ducts are to be installed at the landfall using HDD (the same as Scenario 2). There is potential for drilling fluid to leak along the drill path, or from the immediate area of the mud pits or tanks which could cause contamination of groundwater.

160. At the onshore project substation there may be a need for piling for foundations. Piling has the potential to create preferential pathways through a low permeability layer allowing potential contamination of an underlying aquifer and disrupt groundwater flow. The National Grid substation extension foundations are anticipated to be of ground-bearing form with no requirement for piling.

161. The impacts are predicted to be of local spatial extent (occurring only at landfall and at the onshore project substation if piling is required) and of intermittent occurrence. Any impacts would be managed by embedded mitigation measures (see section 19.7.1). The magnitude of effect is therefore considered to be low.

162. The principal aquifer which underlies the superficial deposits beneath the whole of the site is considered to be of high vulnerability. The sensitivity of the receptor is considered to be high.

163. It is anticipated that after adopting mitigation measures presented in section 19.7.1 the magnitude of effect will be low and therefore the impact would be **moderate adverse**.

164. As detailed in Scenario 2 in order to minimise impacts, additional mitigation measures are therefore proposed including ground investigations and hydrogeological risk assessments.

165. It is anticipated that, after adopting these mitigation measures, the magnitude of effect will be reduced to negligible therefore the residual impact is expected to be **minor adverse**, which is not significant in EIA terms.

19.7.4.5 Impact 5: Impacts on the quality of surface waters fed by groundwater during construction

166. Any potential impact mechanisms on surface waters fed by groundwater are considered to be present under both scenarios therefore the impact assessment in section 19.7.4.5.1 applies to both scenarios.

19.7.4.5.1 Scenario 1 and Scenario 2

167. The presence of the Till in many locations throughout the study area will significantly delay the potential migration of any contaminants encountered or disturbed during any works associated with the project. However, leaching or groundwater transport of contaminants may occur as a result of hydraulic connections between surface waters and superficial aquifers affected by the construction works (excavations or pilling). The effect is predicted to be of local spatial extent, of intermittent occurrence and high reversibility. The magnitude of effect is therefore, considered to be low.

168. The ground investigations undertaken within the onshore cable route confirmed the presence of shallow groundwater in many areas along the onshore cable route and it is anticipated that surface watercourses are in hydraulic connectivity with groundwater contained within superficial deposits throughout the study area. The sensitivity of surface watercourses varies from low to high (the further information regarding the watercourse sensitivity is presented in section 19.4).

169. It is anticipated that the magnitude of effect will be negligible and therefore the impact would be **negligible** to **minor adverse** which is not significant in EIA terms. No further mitigation is therefore proposed.

19.7.4.6 Impact 6: Impacts to human health, including construction workers and general public during any excavations associated with construction

170. Any potential impact mechanisms to human health are the same under both scenarios therefore the below impact assessment in section 19.7.4.6.1 applies to both scenarios.

19.7.4.6.1 Scenario 1 and Scenario 2

Onshore cable route, landfall, onshore project substation and National Grid substation extension

171. A desk-based assessment of contamination risks has been undertaken for the project (Appendix 19.2). The majority of the study area crosses agricultural land where no significant contamination is expected. However, a number of localised potential sources of contamination have been identified within the study area, for example: a dismantled railway, historic military jet crash area, historical common clay and shale, sand and gravel pits, historic clay bricks and tile manufactures, graveyards and historic tanks (Figure 19.2.1 and 19.2.2 Appendix 19.2).

172. The desk-based assessment confirmed potential contaminants of concern (PCOC) could be present in the study area and could represent an unacceptable risk to construction workers, and potentially the public, if exposed during construction activities. Construction activities, particularly earthworks associated with the project

could potentially disturb and expose construction workers to localised made ground soils and potential soil and/or groundwater contamination associated with historical land uses within the study area. Construction activities could create pollutant linkages through ingestion, inhalation and direct dermal contact pathways. It is anticipated that general public will have no access to the construction site. However, measures will be implemented to minimise impacts on to off-site users.

173. In the event of exposing soils and stockpiling construction waste (including excavated materials), dust could be generated during dry and windy conditions. Under these conditions, construction workers and the general public, such as users of neighbouring sites and surrounding residents, could temporarily be exposed to contamination via the inhalation of potentially contaminated dust.

174. The short term risks to construction workers would be managed through the use of appropriate working practices and the use of Personal Protective Equipment (PPE). Construction workers will be made aware of the possibility of encountering contaminated soils in made ground through toolbox talks. Safe working procedures will be implemented, good standards of personal hygiene will be observed and appropriate levels of PPE and Respiratory Protective Equipment (RPE) will be provided and utilised as necessary, thereby minimising the risk of exposure to potentially contaminated soils, ground gas and groundwater.

175. The impacts are predicted to be of local spatial extent (localised potential sources of contamination within the work areas), of short term duration and of intermittent occurrence (occurring only during the works). The magnitude of effect is therefore, considered to be low.

176. Human health is of high importance, therefore the sensitivity of human health as a receptor (construction workers, site operatives and general public (off-site)) is considered to be high.

177. Based on the receptor sensitivity described above and the magnitude of effect, the impact significance is anticipated to be **moderate adverse**.

178. Additional mitigation will therefore be required, this will include ground investigations and further assessment of potential contaminated land at dismantled railway lines and historic military jet crash area (see Appendix 19.1). A written scheme (based on the Model procedures for the management of land contamination, CLR11) for the management of contamination will be submitted and approved by the local authority (DCO Requirement 20(2)(d)). The document will also provide procedures to follow in the event of encountering unexpected contamination and will include proposals to deal with any waste soils excavated during the works.

179. In addition an OCoCP has been produced and submitted with the DCO submission, and sets out proposed management measures to minimise the exposure of workers and the general public to potentially harmful substances. This includes:

- Site security and preventing public access;
- Personal hygiene, and washing and changing procedures; and
- Adoption of dust suppression methods, wheel washing facilities for vehicles leaving the site, covering of stockpiled materials and materials being transported to and from site.

180. A Site Waste Management Plan (SWMP) will also be produced to ensure that any waste arising is closely monitored and the appropriate waste management route will be confirmed following a waste hierarchy assessment.

181. Following the implementation of mitigation measures, the residual impact on all receptors identified above is predicted to be **minor adverse**, which is not significant in EIA terms.

182. An assessment of potential health effects is discussed in Chapter 27 Human Health.

19.7.4.7 Impact 7: Sterilisation of mineral resources.

19.7.4.7.1 Scenario 2

183. The onshore project area crosses numerous MSAs and the installation of cables within these areas would prevent future extraction of sand and gravels. There are 1.87km² of MSAs within the onshore project area, as a worst case it is assumed that this whole area would be sterilised. The ground investigation works undertaken for the project confirmed that the study area is underlain by sand deposits.

184. The impacts are predicted to be permanent and large scale. It is predicted that the impact would affect the receptor directly. The magnitude of effect is therefore considered to be high.

185. MSAs are considered to be of regional importance. The sensitivity of the receptor is considered to be medium.

186. The overall significance of the impact on mineral resources availability during the construction works is considered to be **major adverse** based on the worst case assumptions. Consultation with Norfolk County Council will be ongoing with regards to mineral resources and appropriate future works and mitigation measures (see section 19.7.4.7.3) will be agreed and documented in a Materials Management Plan (MMP), which will be developed post-consent. The contractor will have to comply with the MMP during construction. Following this, it is predicted that the magnitude of effect will be reduced to low; therefore, the impact would be **minor adverse**, which is not significant in EIA terms.

19.7.4.7.2 Scenario 1

187. Under Scenario 1 the onshore cable route construction works are limited to the pulling of the cables through pre-installed ducts and excavation at the jointing pit locations. As the locations of the jointing pits are not currently confirmed, to assess the worst case it is assumed all jointing pit excavations (13,500m^2) are within the mineral safe guarding areas.

188. The works at the onshore project substation and the National Grid substation extension will not result in the loss of any additional area available to future extraction of sand and gravels. However, the 400kV cable route between these locations does cross a safeguarded area resulting in a footprint of approximately 4,500m^2.

189. Assuming that all these areas would be impacted this would result in sterilisation of 0.018km^2 of the total 1.87km^2 of MSAs within the onshore project area, approximately 1.02%. Given the very small scale of potential impact this would result in a minimal effect on usability, therefore the magnitude is considered to be low.

190. MSAs are considered to be of regional importance. The sensitivity of the receptor is considered to be medium, resulting in a **minor adverse** impact.

191. As detailed in Scenario 2 consultation with Norfolk County Council will be ongoing with regards to mineral resources and appropriate future works and mitigation (see section 19.7.4.7.3) will be included in the MMP to further reduce the magnitude of the impact to negligible, resulting in a residual **minor adverse** impact, not significant in EIA terms.

19.7.4.7.3 Future works and mitigation

192. The estimated area of impact will be discussed with the MMP in the context of aggregate resources available in the local area and the cost effectiveness of pre-excavating and using the material for construction purposes within the project and reinstating the cable trench with imported backfill. Dependent on the outcome of consultation post-consent, further quantification of resource quality and value may be undertaken. The agreed construction approach will be set out in an MMP to be followed during construction, which would also deal with excavated waste management.

19.7.4.8 Impact 8: Impacts on shallow groundwater due to changes to the hydraulic regime as a result of changes to soil compaction along the cable route

19.7.4.8.1 Scenario 2

Onshore cable route

193. There is possibility that the hydraulic regime of the local area will be affected by the project. Backfilling the cable trench with less compacted soil could potentially influence the groundwater regime by altering porosity and creating preferential groundwater flow pathways. However, material used to infill trenches will be compacted to ensure that no preferential groundwater pathways are introduced along the cable route.

194. The shallow groundwater within the superficial deposits are considered to be of medium sensitivity. The impacts are predicted to be of local spatial extent (localised to the work areas) and of short term duration and of intermittent occurrence. magnitude is therefore considered to be low.

195. Due to the medium sensitivity of the receptor and the low magnitude of effect, the overall impact during the construction works is therefore considered to be of **minor adverse** significance. No further mitigation is therefore proposed.

19.7.4.8.2 Scenario 1

Onshore cable route

196. Under Scenario 1 the onshore cable route construction works are limited to the pulling of the cables through pre-installed ducts and excavations for jointing pits. The material used to infill jointing pits will be compacted to ensure that no changes to the hydraulic regime. The impacts are predicted to be of limited spatial extent (limited to the jointing pits only) and of short term duration. The magnitude of effect is therefore considered to be negligible.

197. Due to the medium sensitivity of the receptor and the negligible magnitude of effect, the overall impact during the construction works is therefore considered to be of **minor adverse** significance. No further mitigation is therefore proposed.

19.7.5 Potential Impacts during Operation

198. There are unlikely to be any significant additional impacts from the operation of the project. Routine Operation and Maintenance (O&M) activities will follow standard procedures therefore minimising any potential impacts. Non-routine maintenance will be subject to robust and effective planning and risk assessment procedures. As discussed previously, impacts during O&M are scoped out of the EIA in accordance with the Norfolk Boreas EIA Scoping Report (Royal HaskoningDHV, 2017), Ground

Conditions and Contamination Method Statement (Royal HaskoningDHV, 2018, unpublished) and PEIR (Norfolk Boreas Limited, 2018).

19.7.6 Potential Impacts during Decommissioning

199. This section describes the potential impacts of the decommissioning of the onshore infrastructure with regards to impacts on ground conditions and contamination. Further details are provided in Chapter 5 Project Description.

200. No decision has been made regarding the final decommissioning policy for the onshore cables, 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.

201. In relation to the onshore project substation, the programme for decommissioning is expected to be similar in duration to the construction phase. The detailed activities and methodology would be determined later within the project lifetime, but are expected to include:

- Dismantling and removal of outside electrical equipment from outside of the onshore project substation buildings;
- Removal of cabling from site;
- Dismantling and removal of electrical equipment from within the onshore project substation buildings;
- Removal of main onshore project substation building and minor services equipment;
- Demolition of the support buildings and removal of fencing; Landscaping and reinstatement of the site (including land drainage); and
- Removal of areas of hard standing.

202. Whilst details regarding the decommissioning of the onshore project substation are currently unknown, considering the WCS which would be the removal of project infrastructure and reinstatement of the current land use at the site, it is anticipated that the impacts would be similar or less than those during construction.

203. The decommissioning methodology would 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.

19.8 Cumulative Impacts

204. The assessment of cumulative impacts has been undertaken as a two stage process. Firstly, all the impacts from the previous sections have been assessed to determine

the potential for them to act cumulatively with other projects. This summary assessment is set out in Table 19.17.

Table 19.17 Potential cumulative impacts

Impact		Potential for cumulative impact	Rationale
Construction			
1	Impacts to coastline, including designated geological sites.	Yes	Impacts on designated sites may be exacerbated by other projects.
2	Contamination of secondary aquifers as a result of construction activities.	Yes	Impacts to secondary aquifers may be exacerbated by other projects.
3	Impacts on groundwater quality in the principal aquifer (including SPZ areas) as a result of shallow excavation construction activities.	Yes	Impacts to principal aquifer including SPZ areas may be exacerbated by other projects.
4	Impacts on groundwater quality in the principal aquifer (including SPZ areas) resulting from trenchless crossing techniques and piling (if required).	Yes	Impacts to principal aquifer including SPZ areas may be exacerbated by other projects.
5	Impacts on the quality of surface waters fed by groundwater during construction.	Yes	Impacts to surface water may be exacerbated by other projects.
6	Impacts to human health, including construction workers and general public during any excavations associated with construction.	Yes	Impacts to human health may be exacerbated by other projects in the unlikely event potential contamination migrates off-site.
7	Sterilisation of mineral resources.	Yes	Impacts to MSAs may be exacerbated by other projects.
8	Impacts on shallow groundwater due to changes to the hydraulic regime as a result of changes to soil compaction along the cable route	Yes	Impacts to groundwater may be exacerbated by other projects.
Operation			
As discussed previously, impacts during O&M are scoped out of the EIA as agreed during the scoping stage (see Table 19.2).			
Decommissioning			
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, cumulative impacts during the decommissioning stage are assumed to be the same as those identified during the construction stage.			

205. The second stage of the CIA is an assessment of whether there is spatial or temporal overlap between the extent of potential impacts of the onshore infrastructure and the potential impacts of other projects scoped into the CIA upon the same receptors. To identify whether this may occur, the potential nature and extent of effects arising from all projects scoped into the CIA have been identified above. Where there is an overlap, an assessment of the cumulative magnitude of impacts is provided.

206. Projects identified for potential cumulative impacts that were agreed as part of the Norfolk Boreas PEIR (Norfolk Boreas Limited, 2018) consultation. These projects, as well as any relevant development applications submitted since this consultation have been considered and their anticipated potential for cumulative impact are detailed in Table 19.18.

Table 19.18 Summary of Projects considered for the CIA in relation to the ground conditions and contamination.

Project	Status	Development period	[3]Distance from Norfolk Boreas (km)	Project definition	Project data status[4]	Included in CIA	Rationale
National Infrastructure Planning							
Norfolk Vanguard Offshore Wind Farm	Application submitted	Expected construction 2020 to 2025	0 – projects are co-located	Full ES available: https://infrastructure.planninginspectorate.gov.uk/proje	High	Yes	Overlapping proposed project boundaries may result in impacts of a direct and / or indirect nature on groundwater quality and resources during construction, as well as impacts on human health. The projects are located in the same bedrock principal aquifer. No cumulative impacts on surface water are anticipated.
Hornsea Project Three Offshore Wind Farm	Application submitted	Expected construction start date 2021. Duration 6 to 10 years dependent on phasing.	0 – cable intersects project 32km between substation locations	Full ES available: https://infrastructure.planninginspectorate.gov.uk/proje	High	Yes	The onshore export cable route will overlap the Norfolk Boreas onshore route around Reepham. The application was submitted to the Planning Inspectorate May 2018. Overlapping proposed project boundaries may result in impacts of a direct and / or indirect nature on groundwater quality and resources during construction, as well as impacts on human health. The projects are located in the same bedrock principal aquifer. No cumulative impacts on surface water are anticipated.

[3] Shortest distance between the considered project and Norfolk Boreas – unless specified otherwise.
[4] The level of data available for the project.

Project	Status	Development period	[3]Distance from Norfolk Boreas (km)	Project definition	Project data status[4]	Included in CIA	Rationale
Dudgeon Offshore Wind Farm	Commissioned	Constructed	0	http://dudgeonoffshorewind.co.uk/	High	No	No cumulative effects on onshore geology and ground conditions are likely, as the Dudgeon project is completed, and therefore there is no potential for construction-phase cumulative impacts to occur.
A47 corridor improvement programme – North Tuddenham to Easton	Pre-application (application due 2020)	Start works April 2021 Open May 2023	26.7	https://highwaysengland.co.uk/projects/a47-north-tuddenham-to-easton-improvement-scheme/	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
A47 corridor improvement programme – A47 Blofield to North Burlingham	Pre-application (application due 2019)	Start works 2021 Open 2022	25	https://highwaysengland.co.uk/projects/a47-blofield-to-north-burlingham/	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
A47 corridor improvement programme – A47 / A11 Thickthorn Junction	Pre-application (application due 2019)	Start works 2020 Open 2023	18	https://highwaysengland.co.uk/projects/a47-thickthorn-junction/	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
Norwich Western Link	Pre-application	Expected construction start late 2022	2.8	https://www.norfolk.gov.uk/roads-and-transport/major-projects-and-improvement-plans/norwich/norwich-western-link	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
Third River Crossing, Great Yarmouth	Pre-application (application due 2019)	Expected construction start in late 2020 Open early 2023	28	https://www.norfolk.gov.uk/roads-and-transport/major-projects-and-improvement-plans/great-	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.

Project	Status	Development period	[3]Distance from Norfolk Boreas (km)	Project definition	Project data status[4]	Included in CIA	Rationale
				yarmouth/third-river-crossing			
King’s Lynn B Power Station amendments	Approved	Expected construction start 2019 to 2022	28	https://www.kingslynnbccgt.co.uk/	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
North Norfolk District Council							
PF/17/1951 Erection of 43 dwellings and new access with associated landscaping, highways and external works	Approved	Anticipated Q2 2018.	0.7	Application available: https://idoxpa.north-norfolk.gov.uk/online-applications/applicationDetails.do?activeTab=summary&keyVal=_NNORF_DCAPR_92323	High	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
Bacton and Walcott Coastal Management Scheme	Approved	Expected construction start date Spring 2019	1.0	Public information leaflets available: https://www.north-norfolk.gov.uk/media/3371/bacton-to-walcott-public-information-booklet-july-2017.pdf	Medium	No	Due to the long HDD and there is no potential mechanism for impact, as the project will have no impact on costal erosion.
Coastal defence/protection work, Happisburgh PF/18/0751	Approved	Coastal protection over 10-year duration from August 2018	0.12	https://idoxpa.north-norfolk.gov.uk/online-applications/applicationDetails.do?activeTab=summary&keyVal=_NNORF_DCAPR_93543	Medium	No	Due to the long HDD and there is no potential mechanism for impact, as the project will have no impact on costal erosion.

Project	Status	Development period	[3]Distance from Norfolk Boreas (km)	Project definition	Project data status[4]	Included in CIA	Rationale
Breckland Council							
Erection of 85 Dwellings with Associated Open Space 3PL/2018/1246/F	Awaiting Decision	Application received 04/10/18.	1.26	http://planning.breckland.gov.uk/OcellaWeb/planningDetails?reference=3PL/2018/1246/F&from=planningSearch	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
Residential development of 40 No. units comprising a mix of housing types, accommodating open space and appropriate associated infrastructure with vehicle access via Hall Road 3PL/2018/0993/F	Approved	Application approved 11/02/19. Construction must begin within 2 years.	1.42	http://planning.breckland.gov.uk/OcellaWeb/planningDetails?reference=3PL/2018/0993/F&from=planningSearch	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.

207. In summary, the following projects will be assessed for potential direct cumulative impacts:

Scenario 1 only

- Norfolk Vanguard Offshore Wind Farm
- Hornsea Project Three Offshore Wind Farm

Scenario 2

- Hornsea Project Three Offshore Wind Farm

208. All of the above will include relevant mitigation measures embedded within their design. These measures should prevent significant adverse impacts on ground conditions or contamination occurring as a result.

19.8.1 Cumulative Impacts during Construction

19.8.1.1 Scenario 1

19.8.1.1.1 Norfolk Boreas, Norfolk Vanguard and Hornsea Project Three

209. Under Scenario 1 the onshore cable route construction works for Norfolk Boreas are limited to the installation of the cables in pre-installed ducts.

210. Norfolk Vanguard and Hornsea Project Three have potential to cause impacts to the superficial deposits due to the intrusive nature of trenching. However, trenching will be shallow and is unlikely to affect surface water and groundwater receptors. The simultaneous developments could lead to a larger land take and increased potential for impacts on water quality within the secondary aquifer.

211. However, the mitigation measures outlined in section 19.7 will prevent any significant adverse impacts on surface water and secondary aquifers resulting from Norfolk Boreas. Furthermore, Hornsea Project Three would adopt a similar suite of best practice mitigation measures to minimise impacts during construction. This would limit further impacts on surface waters and secondary aquifers to a negligible magnitude.

212. Leaching and groundwater transport may occur as a result of new vertical hydraulic connections between shallow perched groundwater and groundwater associated with the principal aquifer during any excavation works including trench construction. The principal aquifer is unlikely to be impacted cumulatively as Hornsea Project Three is unlikely to require deep piling to the principal aquifer through the superficial deposits (and hence there is no pathway). Furthermore, Hornsea Project Three would adopt a similar suite of best practice mitigation measures to minimise impacts during construction. This would limit further impacts on principal aquifer to a negligible magnitude.

213. It is considered unlikely that there would be any cumulative effects on human health associated with the listed projects as any impacts identified in the assessment are only related to the construction stage and will be minimised by the adoption of mitigation measures.

214. It has been assessed that due to the distance of the landfall from the Happisburgh Cliffs SSSI there is no mechanism for direct impact and therefore no impact was identified during the assessment. Therefore, no cumulative impact is anticipated.

19.8.1.2 Scenario 2

19.8.1.2.1 Norfolk Boreas and Hornsea Project Three

215. Hornsea Project Three have the potential to cause impacts to the superficial deposits due to the intrusive nature of trenching. However, trenching will be shallow and is unlikely to affect surface water and groundwater receptors. The simultaneous developments could lead to a larger land take and increased potential for impacts on water quality within the secondary aquifer

216. However, the mitigation measures outlined in section 19.7 will prevent any significant adverse impacts on surface water and secondary aquifers resulting from Norfolk Boreas. Furthermore, Hornsea Project Three have included best practice mitigation measures in their ES in order to minimise impacts during construction. This would limit further impacts on surface waters and secondary aquifers to a negligible magnitude.

217. Leaching and groundwater transport may occur as a result of new vertical hydraulic connections between shallow perched groundwater and groundwater associated with the principal aquifer during any excavation works including trench construction. The principal aquifer is unlikely to be impacted cumulatively as Hornsea Project Three is unlikely to require deep piling to the Chalk aquifer through the superficial deposits (and hence there is no pathway). Furthermore, Hornsea Project Three have included best practice mitigation measures in their ES, in order to minimise impacts during construction. This would limit further impacts on principal aquifer to a negligible magnitude.

218. It is considered unlikely that there would be any cumulative effects on human health associated with the listed projects as any impacts identified in the assessment are only related to the construction stage and will be minimised by adoption of mitigation measures.

219. The Hornsea Project Three area crosses numerous MSAs and the installation of cables within these areas would prevent future extraction of sand and gravels. Impacts to MSAs may be exacerbated by Hornsea Project Three. Norfolk Boreas will continue consultation with Norfolk County Council with regards to mineral resources

and appropriate future works and mitigation measures (see section 19.7.4.7.3) will be agreed and documented in a Materials Management Plan developed post-consent.

220. Furthermore, Hornsea Project Three would adopt a similar suite of best practice mitigation measures to minimise impacts during construction. This would limit further impacts on mineral resources to a negligible magnitude.

19.8.2 Cumulative Impacts during Operation

221. As discussed previously, impacts during O&M are scoped out of the EIA as agreed during the scoping stage (see Table 19.2).

19.8.2.1 Cumulative Impacts during Decommissioning

222. 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, cumulative impacts during the decommissioning stage are assumed to be the same as those identified during the construction stage.

19.9 Transboundary Impacts

223. No mechanism for transboundary impacts related to ground conditions and contamination has been identified as part of this assessment.

19.10 Inter-relationships

224. It should be noted that this chapter has the potential to interact with other chapters (Table 19.19).

Table 19.19 Chapter topic inter-relationships

Topic and description	Related Chapter	Section where addressed	Rationale
Impacts to coastline, including designated geological sites	Chapter 8 Marine Geology, Oceanography and Physical Processes	Section 19.7.4.1	The project could indirectly impact designated geological sites by affecting erosion and deposition processes.
Impacts to coastline, including designated geological sites	Chapter 9 Marine Water and Sediment Quality	Section 19.7.4.1	The project could indirectly impact designated geological sites by affecting erosion and deposition processes.
Impacts on the quality of surface waters fed by groundwater during construction	Chapter 20 Water Resources and Flood Risk	Section 19.7.4.5	Any project-related impacts on the quantity and quality of surface waters could impact upon hydrologically-connected groundwater.

Topic and description	Related Chapter	Section where addressed	Rationale
Impacts on human health, including construction workers and public during any excavations associated with construction	Chapter 27 Human Health	Section 19.7.4.6	The project could impact on human health if construction workers or public are exposed to PCOCs during construction activities.

19.10.1 Interactions

225. The impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts as a result of that interaction. The worst case impacts assessed within the chapter take these interactions into account and for the impact assessments are considered conservative and robust. For clarity the areas of interaction between impacts are presented in Table 19.20, along with an indication as to whether the interaction may give rise to synergistic impacts.

Table 19.20 Interaction between impacts

Potential interaction between impacts					
Construction	**1 Coastal erosion**	**2 Damage to designated geological sites**	**3 Drainage**	**4 Changes to quantity and quality of surface waters**	**5 Risk to human health**
1 Coastal erosion	-	Yes	Yes	Yes	No
2 Damage to designated geological sites	Yes	-	No	No	No
3 Drainage	Yes	No	-	Yes	No
4 Changes to quantity and quality of surface waters	Yes	No	Yes	-	No
5 Risk to human health from contaminated land	No	No	No	No	-
Operation					
Impacts during operation are scoped out of the ES in accordance with the Norfolk Boreas EIA Scoping Report (Royal HaskoningDHV, 2017).					
Decommissioning					
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.					

19.11 Summary

226. There are no designated sites of geological importance in close proximity to the landfall, onshore cable route, onshore project substation or National Grid substation extension.

227. Provided mitigation measures (both embedded and additional) are in place to prevent ground and groundwater pollution and interconnection of aquifer units in the footprint of the project, the project is predicted to have only **minor adverse** impacts in relation to ground conditions and contamination. A summary of the findings of the ES that have been completed for ground conditions and contamination are presented in Table 19.21 and Table 19.22, for Scenario 1 and Scenario 2 respectively.

Table 19.21 Potential impacts identified for ground conditions and contamination Scenario 1

	Potential impact	Receptor	Value/ sensitivity	Magnitude	Significance	Additional Mitigation	Residual impact
Construction							
1	Impacts to coastline, including designated geological sites	Coastline and designated geological sites	High	No change.	**No impact**	None needed.	**No impact**
2	Contamination of secondary aquifers as a result of construction activities	Secondary aquifers	Low to Medium	Low	**Minor adverse**	Section 19.7.4.2	**Negligible**
3	Impacts on groundwater quality in the principal aquifer (including SPZ areas) as a result of shallow excavation construction activities	Principal aquifer including at SPZ areas	High	Low	**Moderate adverse**	Section 19.7.4.3	**Minor adverse**
4	Impacts on groundwater quality in the principal aquifer (including SPZ areas), resulting from trenchless crossing techniques and piling.	Principal aquifer including at SPZ areas	High	Low	**Moderate adverse**	Section 19.7.4.4	**Minor adverse**
5	Impacts of construction may affect the quality of surface waters fed by groundwater	Surface water	Low to High	Negligible	**Negligible to Minor adverse**	None needed	**Negligible to Minor adverse**

Potential impact		Receptor	Value/ sensitivity	Magnitude	Significance	Additional Mitigation	Residual impact
6	Impacts to human health, including construction workers and general public during any excavations associated with construction.	Human health.	High	Low	**Moderate adverse**	Section 19.7.4.6	**Minor adverse**
7	Sterilisation of mineral resources.	Mineral safeguard areas.	Medium	Negligible	**Minor adverse**	Section 19.7.4.7.3	**Minor adverse**
8	Impacts on shallow groundwater due to changes to the hydraulic regime as a result of changes to soil compaction along the cable route	Shallow groundwater	Medium	Negligible	**Minor adverse**	None needed	**Minor adverse**
Operation							
Impacts during operation are scoped out of the EIA in accordance with the Norfolk Boreas EIA Scoping Report.							
Decommissioning							
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.							
Cumulative							
No cumulative effects on onshore ground conditions and contamination are likely as the project will meet all regulatory requirements in regards to protection of surface and groundwater (as discussed in section 19.8).							

Table 19.22 Potential impacts identified for ground conditions and contamination Scenario 2

	Potential impact	Receptor	Value/ sensitivity	Magnitude	Significance	Additional Mitigation	Residual impact
Construction							
1	Impacts to coastline, including designated geological sites	Coastline and designated geological sites	High	No change	**No impact**	None needed	**No impact**
2	Contamination of secondary aquifers as a result of construction activities	Secondary aquifers	Low to Medium	Low	**Minor adverse**	Section 19.7.4.2	**Negligible**
3	Impacts on groundwater quality in the principal aquifer (including SPZ areas) as a result of shallow excavation construction activities	Principal aquifer including at SPZ areas	High	Low	**Moderate adverse**	Section 19.7.4.3	**Minor adverse**
4	Impacts on groundwater quality in the principal aquifer (including SPZ areas), resulting from trenchless crossing techniques and piling.	Principal aquifer including at SPZ areas	High	Medium	**Major adverse**	Section 19.7.4.4	**Minor adverse**
5	Impacts of construction may affect the quantity and quality of surface waters fed by groundwater	Surface water	Low to High	Negligible	**Negligible to minor adverse**	None needed	**Negligible to minor adverse**

Potential impact		Receptor	Value/ sensitivity	Magnitude	Significance	Additional Mitigation	Residual impact
6	Impacts to human health, including construction workers and general public during any excavations associated with construction.	Human health.	High	Low	**Moderate adverse**	Section 19.7.4.6	**Minor adverse**
7	Sterilisation of mineral resources.	Mineral safeguard areas.	Medium	High	**Major adverse**	Section 19.7.4.7.3	**Minor adverse**
8	Impacts on shallow groundwater due to changes to the hydraulic regime as a result of changes to soil compaction along the cable route	Shallow groundwater	Medium	Low	**Minor adverse**	None needed	**Minor adverse**
Operation							
Impacts during operation are scoped out of the ES in accordance with the Norfolk Boreas EIA Scoping Report.							
Decommissioning							
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.							
Cumulative							
No cumulative effects on onshore ground conditions and contamination are likely as the project will meet all regulatory requirements in regards to protection of surface and groundwater (as discussed in section 19.8).							

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