Hornsea Project Four: Preliminary Environmental Information Report (PEIR)

Volume 3,
Chapter 1 : Geology and Ground Conditions

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Table of Contents

List of Tables

List of Figures

Annexes

Annex Number	Heading
1.1	Land Quality Preliminary Risk Assessment
1.2	Envirocheck Report

Glossary

Term	Definition
Code of Construction Practice (CoCP)	A document detailing the overarching principles of construction, contractor protocols, construction-related environmental management measures, pollution prevention measures, the selection of appropriate construction techniques and monitoring processes.
Commitment	A term used interchangeably with mitigation. Commitments are Embedded Mitigation Measures. Commitments are either Primary (Design) or Tertiary (Inherent) and embedded within the assessment at the relevant point in the EIA (e.g. at Scoping or PEIR). The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSE's), in EIA terms.
Cumulative effects	The combined effect of Hornsea Four in combination with the effects from a number of different projects, on the same single receptor/resource.
Cumulative impact	Impacts that result from changes caused by other past, present or reasonably foreseeable actions together with Hornsea Four.
Design Envelope	A description of the range of possible elements that make up the Hornsea Four design options under consideration, as set out in detail in the Volume 1, Chapter 4: Project Description. This envelope is used to define Hornsea Four for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
EIA Regulations	The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (the 'EIA Regulations').
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement.
Environmental Statement (ES)	A document reporting the findings of the EIA and produced in accordance with the EIA Directive as transposed into UK law by the EIA Regulations.
Export cable corridor (ECC) corridor	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Four array area to the Creyke Beck National Grid substation, within which the export cables will be located. The final ECC corridor will be located within the ECC corridor search area and will be defined via a site selection process considering technical, physical and environmental constraints.

Term	Definition
High Voltage Alternating Current (HVAC)	High voltage alternating current is the bulk transmission of electricity by alternating current (AC), whereby the flow of electric charge periodically reverses direction.
High Voltage Direct Current (HVDC)	High voltage direct current is the bulk transmission of electricity by direct current (DC), whereby the flow of electric charge is in one direction.
Made Ground	Land where natural and undisturbed soils have largely been replaced by man-made or artificial materials
Maintain	Includes inspect, upkeep, repair, adjust, and alter and further includes remove, reconstruct and replace, to the extent assessed in the environmental statement; and "maintenance" must be construed accordingly.
Maximum Design Scenario (MDS)	The maximum design parameters of each Hornsea Four. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g. at Scoping or PEIR).
Mitigation	A term used interchangeably with Commitment(s) by Hornsea Four. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g. at Scoping or PEIR).

Acronyms

Acronym	Definition
ACM	Asbestos Containing Material
Bgl	Below ground level
BGS	British Geological Survey
CEA	Cumulative Effects Assessment
CFA	Continuous Flight Auger
CoCP	Code of Construction Practice
CSM	Conceptual Site Model
DEFRA	Department for Environment Food and Rural Affairs
DCO	Development Consent Order
DWS	Drinking Water Standard
EEA	European Economic Area
EIA	Environmental Impact Assessment
EPA	Environmental Protection Act
ES	Environmental Statement
EQS	Environmental Quality Standard
GQA	General Quality Assessment
HDD	Horizontal Directional Drilling
HVDC	High Voltage Direct Current
HVAC	High Voltage Alternating Current
IDB	Internal Drainage Boards
JB	Joint Bay

Acronym	Definition
LB	Link Box
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
NPS	National Policy Statement
NPPF	National Planning Policy Framework
NSIP	Nationally Significant Infrastructure Project
O and M	Operation and Maintenance
Onshore ECC	Onshore Export Cable Corridor
OnSS	Onshore Substation
OS	Ordnance Survey
PCB	Polychlorinated biphenyls
PCoC	Potential Contaminants of Concern
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
PPE	Personal Protective Equipment
PRA	Preliminary Risk Assessment
PRoW	Public Right of Way
RSBP	Royal Society for the Protection of Birds
SPA	Special Protection Area
SPZ	Source Protection Zone
SSSI	Site of Special Scientific Interest
SUDS	Sustainable Urban Drainage
SVOC	Semi-Volatile Organic Compounds
UK	United Kingdom
VOC	Volatile Organic Compounds
WFD	Water Framework Directive

Units

Unit	Definition
kV	Kilovolt (electrical potential)

1.1 Introduction

1.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the results of the Environmental Impact Assessment (EIA) for the potential impacts of the Hornsea Four offshore wind farm (hereafter Hornsea Four) on geology and ground conditions. Specifically, this chapter considers the potential impact of Hornsea Four landward of Mean High Water Springs (MHWS) during its construction, operation and maintenance, and decommissioning phases. Details of impacts below MHWS on geology are included within **Volume 2, Chapter 1: Marine Geology, Oceanography and Physical Processes**.

1.1.1.2 Orsted Hornsea Project Four Limited (the Applicant) is proposing to develop Hornsea Four. Hornsea Four will include both offshore and onshore infrastructure including offshore generating stations (wind turbines), electrical export cables to landfall and on to a connection to the electricity transmission network at National Grid Creyke Beck substation (please see **Volume 1, Chapter 4: Project Description** for full details on the Project Design).

1.1.1.3 This chapter summarises information contained within the Land Quality Preliminary Risk Assessment (PRA) Technical Report, which is included at **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**.

1.2 Purpose

1.2.1.1 This PEIR presents the preliminary environmental information for Hornsea Four and sets out the findings of the EIA to date to support the pre-Development Consent Order (DCO) application consultation activities required under the Planning Act 2008.

1.2.1.2 The feedback from this consultation will be used to inform the final project design and the associated EIA (which will be reported in an Environmental Statement (ES)). The ES will accompany the DCO application to PINS.

1.2.1.3 This PEIR chapter:

- Presents the existing environmental baseline established from desk studies, and consultation;
- Presents the potential environmental effects on geology and ground conditions arising from Hornsea Four, based on the information gathered and the analysis and assessments undertaken to date;
- Identifies any assumptions and limitations encountered in compiling the environmental information; and
- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental effects identified in the EIA process.

1.3 Planning and Policy Context

1.3.1.1 Planning policy on offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to geology and ground conditions, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1; DECC, 2011).

1.3.1.2 EN-1 (DECC, 2011) includes guidance on what matters are to be considered in the assessment as summarised in **Table 1.1**:. The potential effects in relation to geological conservation importance are considered within this chapter. Note that potential effects on sites of importance for nature conservation are considered separately in **Chapter 3: Ecology and Nature Conservation**.

Table 1.1: Summary of NPS EN-1 provisions relevant to geology and ground conditions.

Summary of NPS EN-1	How and where considered in the PEIR
"*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 IPC consider thoroughly the potential effects of a proposed project'.* *The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests*" (EN-1, paragraph 5.3.3 and 5.3.4)	Designated sites (including geological) have been considered as part of the route planning and site selection process, outlined in **Volume 1, Chapter 3: Site Selection and Consideration of Alternatives**. This PEIR chapter provides an account of the potential impact of the proposed Hornsea Four project upon geological sites (**Sections 1.11** and **1.12** of this chapter). **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment** informs this PEIR chapter and includes a review of the available information with regards to internationally, nationally and locally designated sites of geological importance. Details and potential effects on international, nationally and locally designated sites of ecological conservation importance are addressed in **Chapter 3: Ecology and Nature Conservation**.

1.3.1.3 NPS EN-1 (DECC, 2011) also highlights several factors relating to the determination of an application and in relation to mitigation. These are summarised in **Table 1.2**.

Table 1.2: Summary of NPS EN-1 policy on decision making relevant to geology and ground conditions.

Summary of NPS EN-1 provisions	How and where considered in the PEIR
"*In having regard to the aim of the Government's biodiversity strategy the IPC should take account of the context of the challenge of climate change: failure to address this challenge will result in significant adverse impacts to biodiversity. The policy set out in the following sections recognises the need to protect the most important biodiversity and geological conservation interests. The benefits of nationally significant low carbon energy infrastructure development may include benefits may outweigh harm to these interests. The IPC may take account of any such net benefit in cases where it can be demonstrated.*" (EN-1, paragraph 5.3.6) "*[The] development should aim to avoid significant harm to biodiversity and geological conservation interests, including through mitigation and consideration of reasonable alternatives; where significant harm cannot be avoided, then appropriate compensation measures should be sought*" (EN-1, paragraph 5.3.7) "'*In taking decisions, the IPC should ensure that appropriate weight is attached to designated sites of international, national and local importance; protected species; habitats and other species of principal importance for the conservation of biodiversity; and to biodiversity and geological interests within the wider environment.*" (EN-1, paragraph 5.3.8) "*Applicants should safeguard any mineral resources on the proposed site as far as possible, taking into account the long-term potential of the land use after any future decommissioning has taken place*" (EN-1, paragraph 5.10.9)	Designated sites (including geological) have been considered as part of the route planning and site selection process, outlined in **Volume 1, Chapter 3: Site Selection and Consideration of Alternatives**. Full account has therefore been taken of reasonable alternatives and reported in their PEIR. **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment** informs this PEIR chapter and includes a review of the available information with regards to internationally, nationally and locally designated sites of geological importance. This PEIR chapter provides an account of the potential impact of the proposed Hornsea Four project upon geological sites (**Sections 1.11** and **1.12**). The minerals resources (specifically, Mineral Safeguarding Areas) have been identified as part of the baseline (see **Section 1.7**) and an assessment of operational phase impacts on these resources is set out in **Section 1.11.2**. Details and potential effects on international, nationally and locally designated sites of ecological conservation importance are addressed in **Chapter 3: Ecology and Nature Conservation**.

1.3.2 National Planning Policy Framework Guidance

1.3.2.1 The National Planning Policy Framework (NPPF) (Ministry of Housing, Communities and Local Government, updated 2019) and associated guidance provides guidance to planning authorities on how to assess planning applications. Sections relevant to this aspect of the PEIR are summarised below in **Table 1.3**.

Table 1.3: National Planning Policy Framework Guidance Relevant to Ground Conditions and Contamination.

NPPF Reference	NPPF Requirement	PEIR Reference
NPPF15-170	*"The planning system should contribute to and enhance the natural and local environment by:* • *protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils (in a manner commensurate with their statutory status or identified quality in the development plan);* • *preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans; and* • *remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate."*	Commitments (Co) made by the applicant with regards to protecting sites of geological value and the prevention of unacceptable risks are outlined in **Table 1.8** (Co2 & Co127). Potential effects as a result of Hornsea Four and subsequent mitigation measures are set out in **Section 1.11**.
NPPF15-179 and NPPF15-180	*"Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner.* *Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:* • *mitigate and reduce to a minimum potential adverse impact resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life;* • *identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason; and* • *limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation."*	The existing environment in relation to any sources of contaminated land is discussed in **Section 1.7.2**. **Figure 1.2** to **Figure 1.8** illustrate areas of potential contamination. Consideration any of cumulative effects id addressed in **Section 1.12**. The Outline Design Vision Statement (**Volume 4, Annex 4.6**) sets out Hornsea Fours aspirations for mitigating and reducing any impacts from noise and light pollution. Impacts are set out in **Sections 1.11** and **1.12**.

NPPF Reference	NPPF Requirement	PEIR Reference
NPPF15-178	*"Planning policies and decisions should ensure that:* • *a site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability and contamination. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation);* • *after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and* • *adequate site investigation information, prepared by a competent person, is available to inform these assessments."*	The existing environment for ground conditions, contamination, land stability including risks from land remediation is discussed in **Section 1.7**.and in **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**. Potential linkages and impacts arising from any remediation is discussed also discussed in **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**, and summarised in **Section 1.7**. Impacts are set out in **Sections 1.11** and **1.12**.
NPPF15-183	*"The focus of planning policies and decisions should be on whether proposed development is an acceptable use of land, rather than the control of processes or emissions (where these are subject to separate pollution control regimes). Planning decisions should assume that these regimes will operate effectively. Equally, where a planning decision has been made on a particular development, the planning issues should not be revisited through the permitting regimes operated by pollution control authorities."*	The existing environment and baseline in relation to the Hornsea Four PEIR boundary is addressed in **Section 1.7**. An assessment on any potential effects from Hornsea Four, along with proposed mitigation is given **Section 1.11.**

1.4 Consultation

1.4.1.1 Consultation is a key part of the DCO application process. Consultation regarding geology and ground conditions has been conducted through the Scoping Report (Ørsted, 2018) and as a part of the evidence plan process. An overview of the project consultation process are presented within **Volume 1, Chapter 6: Consultation**.

1.4.1.2 A summary of the key issues raised during consultation specific to geology and ground conditions is outlined below in **Table 1.4**, together with how these issues have been considered in the production of this PEIR. A summary of consultation specific to geology and ground conditions undertaken for the former Hornsea Zone, which are applicable to Hornsea Four, are also set out below.

Table 1.4: Consultation Responses.

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
PINS	23 November 2018, Scoping Report	*"Commitment no. 2 states that the "permanent project footprint will avoid SSSIs where practical". Table 7.4 states that two SSSIs have been identified and Figure 7.2 shows that they are both located within the landfall search area. Other SSSIs are shown on this figure; however, these are not identified as designated for their geological interest. Given the further refinements that will be made to the Proposed Development, it is not certain that these sites will be avoided by both the construction works and subsequently the Proposed Development. In addition, it is not apparent that indirect impacts have been considered.* *In light of the above, the Inspectorate considers impacts to geological SSSIs should be assessed where significant effects are likely to occur."*	A desk-based review of the existing environment in relation to the presence of geological SSSIs to inform this PEIR has been provided in **Section 1.7**. No assessment has been undertaken as no geological SSSIs are present within the Hornsea Four geology and ground conditions study area.
Natural England	23 November 2018, Scoping Report	*"Natural England notes that only SSSIs with geological features have been considered in the context of 'geology and ground conditions'. Natural England advises that impacts on designated sites with a biological interest that is linked to or dependent on the underlying geology and ground conditions (e.g. rivers) should also be considered. Consequently, Natural England does not agree that this section provides robust consideration of the impacts on designated sites."*	A desk-based review of the existing environment in relation to the presence of geological SSSIs to inform this PEIR has been provided in **Section 1.7**. No geological SSSIs fall within the 1 km Hornsea Four geology and grounds study area and therefore any potential impacts have been scoped out from further assessment. Consideration of impacts on designated site with a biological interest linked to the underlying geology and ground conditions has been provided in **Chapter 3: Ecology and Nature Conservation**, and **Chapter: 2 Hydrology and Flood Risk**.

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
		"Natural England does not consider it sufficient to rely on commitment no. 2 and the undertaking to 'where practical' avoid sensitive sites within the permanent footprint to scope out this impact at this stage. *Firstly, whilst they are likely outside of the proposed cable corridor and working area, the sites continue to fall within the 'red-line boundary'. Consequently, direct impacts cannot be fully excluded until the project plans are more detailed and have been subject to further refinement.* *Secondly, only the 'permanent project footprint' is referred to in this statement. This does not account for the fact that temporary works could lead to permanent or longer-term impacts on the site. All impacts on designated sites need to be considered, irrespective of their duration.* *Thirdly, only direct impacts on the geological sites are considered within the table and indirect impacts have been omitted from consideration completely. All impacts on designated sites need to be considered, both direct and indirect."*	A desk-based review of the existing environment has been undertaken to identify potential direct and/or indirect impacts to designated geological SSSIs. The findings of which is provided in **Section 1.7**. No geological SSSIs fall within the 1 km Hornsea Four geology and grounds study area and therefore any potential direct and/or indirect impacts have been scoped out from further assessment.
PINS	23 November 2018, Scoping Report	*"In the absence of the further information regarding contaminated land identified as required, uncertainty remains that the mitigation proposed will entirely remove the pathway for effect, as stated in the Scoping Report. The Inspectorate is therefore concerned that there is a risk of significant effects and therefore this matter cannot be scoped out the ES."*	A desk-based review in relation to potentially contaminated land and the identification of potential pathways and linkages has been assessed in **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment** and summarised in **Section 1.7.** Potential sources and pathways for contamination are discussed in **Section 1.7.2**. **Figure 1.2** to **Figure 1.8** illustrate areas of potential contamination. Human health is discussed within **paragraphs 1.7.2.3 and paragraph 1.7.2.4.** Related impacts assessments and proposed mitigation are provided in **Section 1.11** with impacts to

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
			construction workers discussed in paragraphs 1.11.1.3 to 1.11.1.12.
East Riding of Yorkshire Council (ERYC)	22 January 2019	*"At 7.1.7.4 (Construction workers exposure to contamination resulting in health risks) the potential for construction workers to be exposed to unknown sources of contamination is acknowledged, but the report proposes this can be scoped out of the assessment as embedded mitigation measures, including PPE, will create a necessary barrier and result in negligible impact. A variety of potential sources of contamination have been identified within the Hornsea Four PEIR boundary and it will not always be the case that visual and / or olfactory indicators of the presence of contamination will be apparent. Analysis of samples of soil, water and / or ground gas may be required to assess the contamination at individual sites. Buried organic matter will be of particular concern as it has the potential to generate methane and carbon dioxide, meaning sites located in the vicinity of refuse tips may be at risk from ground gases. Similarly, free fibres of asbestos cannot be seen, so the absence of visible asbestos containing material (ACM) does not necessarily mean that asbestos is not present in the soil. Sampling for asbestos is required, on all sites where a potential pollutant linkage has been identified, to ensure that it is not dispersed in the soil. If asbestos is identified it must be quantified.* *Sufficient information will be required in order to assess any risks to controlled waters. As part of the site investigation the observed levels of contaminants should be compared to water quality standards, for example environmental quality standards (EQS) or drinking water standards (DWS), and further risk assessment using the Environment Agency's Remedial Targets Methodology and / or remediation may be required.* *I would recommend, therefore, that rather than being scoped out of the Environmental*	A desk-based review in relation to potentially contaminated land and the identification of potential pathways and linkages has been assessed in **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment** and summarised in **Section 1.7.** Potential sources and pathways for contamination are discussed in **Section 1.7.2**. **Figure 1.2** to **Figure 1.8** illustrate areas of potential contamination. Human health is discussed within **paragraphs 1.7.2.3 and paragraph 1.7.2.4.** Human health is discussed within **paragraphs 1.7.2.3** and **paragraph 1.7.2.4**, and related impacts assessments and proposed mitigation are provided in **Section 1.11** with impacts to construction workers discussed in **paragraphs 1.11.1.3** to **1.11.1.12**.

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
		Statement (ES), all aspects of investigations into possible land contamination should follow the guidelines within CLR11 Model Procedures for the Management of Land Contamination (Environment Agency, 2004), in line with current best practice. "	
PINS	23 November 2018, Scoping Report	*"The Scoping Report proposes that accidental spills during construction and operation will be controlled through implementation of an outline Code of Construction Practice (CoCP) secured in the DCO. The Inspectorate is content that a suitably detailed and drafted CoCP is capable of avoiding likely significant effects in this regard. The Inspectorate agrees that a specific assessment in the ES is not necessary but requests that the ES includes appropriate cross reference to the specific measures relied upon in the CoCP (or equivalent)."*	The outline CoCP (Co124) (**Volume F2, Chapter 2**) provides further measures and mitigation in relation to controlling accidental spills during construction and operation. This is a live document and will continue to be developed.
PINS	23 November 2018, Scoping Report	*"The Scoping Report proposes to include assessment of the effects of construction of the substation in the ES. Given that decommissioning impacts are expected to be broadly similar and potentially less than outlined for the construction phase, the Inspectorate considers that effects in relation to the decommissioning of the substation should be assessed and presented in the ES where they have the potential to be significant. "*	The effects of decommissioning will be less than or equal to those associated with construction. At the OnSS all electrical infrastructure will be remove and any waste will be disposed of in accordance with the relevant regulations. Additionally, the same mitigation and commitments will also apply for decommissioning. A decommissioning plan will also be produced in line with the latest relevant guidance and to include details relevant to pollution prevention and avoidance of ground disturbance (Co127, **Table 1.8**). Further information on decommissioning is included in **Section 1.11.3**.
ERYC	22 January 2019	*"At 7.1.3.11 the scoping report acknowledges the potential areas of contamination within the study area and proposes that these will be further assessed during the PEIR upon review of environmental information. Later, at 7.1.8.1 (Proposed approach to the PEIR and ES), the report proposes a desk-based review of available environmental information followed*	A desk-based review of environmental information and a CSM has been provided in detail in **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment** and summarised in **Section 1.7.** Potential sources and pathways for contamination are discussed in **Section**

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
		with a site walkover of those areas where the desk-based study indicate this is necessary. No detailed assessment, such as intrusive ground investigation(s), is proposed; a Conceptual Site Model (CSM) is to be established to compare with the baseline environment and with the identified activities during construction, operation and decommissioning phases."	1.7.2. Figure 1.2 to Figure 1.8 illustrate areas of potential contamination. A contaminated land and groundwater scheme will be prepared to identify contamination and any remedial measures (Co77, Table 1.8). The approach to intrusive ground investigations has been proposed Section 1.11.
Environment Agency	18 April 2019	*"Groundwater Source Protection Zones (SPZs) have not been mentioned in the report and it would appear from the maps that the cable route may pass within the SPZ2 and / or SPZ3 near Beverley. This will need to be taken into account within the Environmental Statement as it increases the sensitivity of groundwater resources. "*	The locations of SPZs in relation to the Hornsea Four PEIR boundary and the 1 km Hornsea Four geology and ground conditions study area are illustrated in detail in Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment and within paragraph 1.7.1.10 of this chapter. Additional information is also included within Chapter 2: Hydrology and Flood Risk.

1.4.2 Hornsea Four Design Evolution – Stakeholder Consultation

1.4.2.1 As identified in Volume 1, Chapter 3: Site Selection and Consideration of Alternatives and Volume 1, Chapter 4: Project Description, the Hornsea Four design envelope has been refined significantly and is anticipated to be further refined for the DCO submission. This process is reliant upon stakeholder consultation feedback.

1.4.2.2 Design amendments of relevance to Geology and Ground Conditions comprise:

- Landfall – the Hornsea Four PEIR boundary currently comprises two landfall options (shown in Volume 1, Chapter 4: Project Description, Figure 4.13), which have been assessed in the respective PEIR receptor chapters A decision on the preferred landfall (A3 or A4) will be made post-PEIR and the Project Description and assessments updated for the ES and DCO for the preferred 40,000 m^2 compound within the landfall location.
- OnSS Operation and Maintenance Access - Hornsea Four are currently investigating the possibility of making the temporary construction access off the A1079 a permanent operational access.

- OnSS Design: The design of the Hornsea Four OnSS mitigation (inclusive of measures set out in **Volume 4, Annex 4.6: Outline Design Vision Statement**) will be further evolved based on the results of the PEIR assessments, in addition to stakeholder feedback and suggestions.

1.5 Study Area

1.5.1.1 Details of the location of Hornsea Four and the onshore elements of the project are delineated included within **Volume 1, Chapter 3 Site Selection and Consideration of Alternatives** and specifically consists of the following:

- Landfall search area: This includes the landfall, transition pit and cabling laydown and access. These components are located to the south of Bridlington;
- Hornsea Four onshore export cable corridor (onshore ECC): This is where the permanent onshore electrical cable infrastructure will be located. The onshore ECC will be approximately 40 km in length and travels from the landfall location to the OnSS; and
- Hornsea Four Onshore Substation (OnSS), including energy balancing infrastructure: This permanent infrastructure will allow electricity to be connected to the National Grid via the Creyke Beck substation.

1.5.1.2 A full description of the above infrastructure is provided in **Volume 1, Chapter 4 Project Description**.

1.5.1.3 The Hornsea Four geology and ground conditions study area, is defined by the distance over which impacts on geology and ground conditions from all of the Hornsea Four project elements (i.e. landfall, onshore ECC and OnSS) may occur and by the location of any receptors that may be affected by those potential impacts. This has been established using professional judgement and supported by **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment** (PRA).

1.5.1.4 The Hornsea Four geology and ground conditions study area includes the Hornsea Four PEIR boundary plus a 250 m buffer (hereafter the 250 m Hornsea Four geology and ground conditions study area) for direct impacts, and 1 km buffer (hereafter the 1 km Hornsea Four geology and ground conditions study area) for indirect impacts related to Hornsea Four (**Figure 1.1**).

1.5.1.5 Sources of contamination are considered within the 250 m Hornsea Four geology and ground conditions study area within the PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**). The risks associated with contamination sources at distances greater than 250 m are not considered as part of the PRA as it is anticipated that with increasing distance the risk from potential sources of contamination to the study area diminishes due to factors such as an absence of viable pathways. Within the PRA, both surface water and groundwater abstraction points have been considered within the 1 km Hornsea Four geology and ground conditions study area as these are considered to be sensitive receptors that may be indirectly impacted by the development within the Hornsea Four PEIR boundary due to

factors such as the potential for contaminants to travel greater distances via surface water and groundwater.

1.6 Methodology to inform baseline

1.6.1 Desktop Study

1.6.1.1 A desk-based study, in the form of a PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**), was undertaken to obtain and review information on geology and ground conditions within both the 1 km Hornsea Four geology and ground conditions study area (**Figure 1.1**).

1.6.1.2 The PRA provides an assessment of ground conditions for Hornsea Four (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) followed a phased risk-based approach including consideration of potential sources, pathways and receptors to identify potential pollutant linkages that may result in unacceptable risks to receptors from ground contamination. For a risk to exist, all three of the elements defined below must be present:

- Source: A potentially polluting activity or existing ground contamination;
- Pathway: A route or means by which a receptor could be exposed to or affected by contamination; and
- Receptor: Something that could be adversely affected by contamination.

1.6.1.3 The following sources of information in **Table 1.5** were consulted to inform the desk-based review.

Table 1.5: Key Sources of Geology and Ground Conditions Data.

Source	Summary	Coverage of Hornsea Four Hornsea Four 1 km Geology and Ground Conditions Study Area
BGS	BGS onshore GeoIndex map (http://mapapps2.bgs.ac.uk/geoindex/home.html)	All of the data sources used provide full coverage of the 1 km Hornsea Four geology and ground conditions study area (**Figure 1.1**)
DEFRA	MAGIC map (www.magic.defra.gov.uk)	
Coal Authority	Interactive online viewer (http://mapapps2.bgs.ac.uk/coalauthority/home.html)	
Public Health England	UK Radon Website (https://www.ukradon.org/information/ukmaps)	
Google Earth	Publicly available aerial imagery	
Envirocheck Report (Ref 201127462_1_1; 201127557_1_1; 201127555_1_1; 201127465_1_1; and 201127560_1_1.)	Historical maps, environmental sensitivity data and regulatory records.	

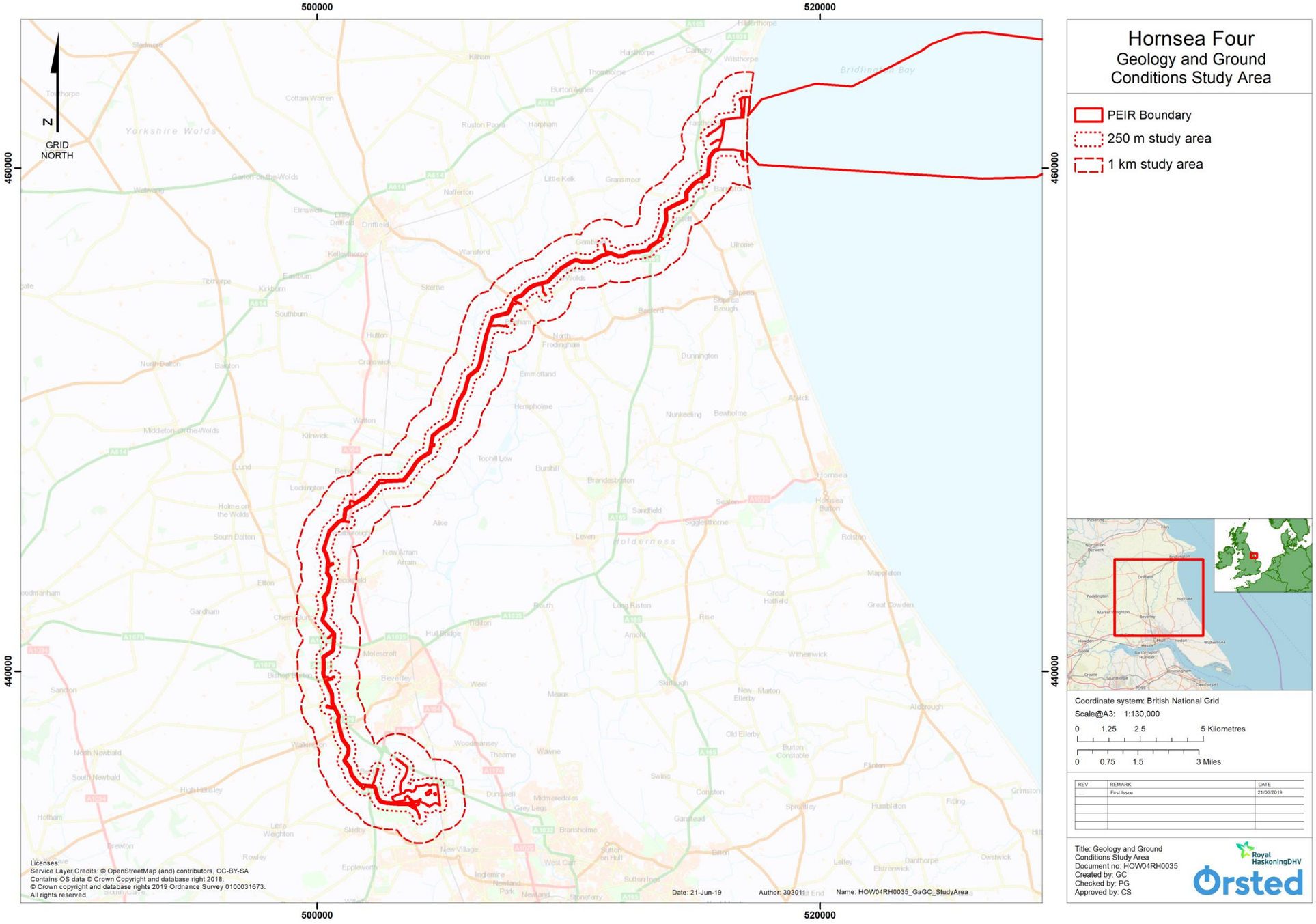


Figure 1.1: Study Area Relevant to Geology and Ground Conditions Study Area (Not to Scale).

1.7 Baseline environment

1.7.1 Existing baseline

1.7.1.1 This section describes the existing environment in relation to the geology and ground conditions associated with the Hornsea Four geology and ground conditions study area. It has been informed by a review of the sources listed in **Table 1.5** and the PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**).

Geology

1.7.1.2 Information on the geological conditions within the Hornsea Four 1 km geology and conditions study area has been collated from British Geological Survey (BGS) datasets including 1:50,000 scale geological mapping. The geological sequence within the 1 km Hornsea Four geology and ground conditions study area, as shown on the BGS online viewer, is outlined in **Table 1.6** below and illustrated in Figures 2 to 6 of the PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**).

Table 1.6: Geological sequence for the Hornsea Four 1 km geology and conditions study area.

Stratum	Unit	Description
Superficial Deposits	Till (Landfall, Onshore ECC and OnSS).	No description given.
	Glaciofluvial Deposits (Landfall, Onshore ECC and OnSS).	Sand and gravel.
	Alluvium (Landfall, Onshore ECC and OnSS).	Normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger desiccated surface zone may be present.
Bedrock	Rowe Chalk Formation (Landfall and Onshore ECC).	White, flint-bearing chalk with sporadic marl bands.
	Flamborough Chalk Formation (Landfall, Onshore ECC and OnSS).	White, well-bedded, flint free chalk with common marl seams (typically about one per metre). Common stylolitic surfaces and pyrite nodules.
	Burnham Chalk Formation (Onshore ECC and OnSS).	White, thinly-bedded chalk with common tabular and discontinuous flint bands; sporadic marl seams. Formal subdivision: none as defined here (BGS Lexicon), but there are many named marl and flint bands throughout the succession that are used to divide the formation. They are all of bed status.

1.7.1.3 Within the Hornsea Four PEIR boundary, pockets of Made Ground may be present. There are no designated geological sites within the 1 km Hornsea Four geology and ground conditions study area.

Hydrogeology

1.7.1.4 The baseline presented in the PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) indicates that the superficial Alluvium and Glaciofluvial Deposits within the Hornsea Four PEIR boundary are classified as Secondary A Aquifers, with some areas designated as Secondary B Aquifers (Figures 2 - 6, **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**).

1.7.1.5 Secondary A Aquifers are composed of permeable strata capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers. A Secondary B Aquifer comprises predominantly lower permeability strata which may in part have the ability to store and yield limited amounts of groundwater by virtue of localised features such as fissures, thin permeable horizons and weathering.

1.7.1.6 The superficial Till Deposits within the Hornsea Four PEIR boundary are classified as a Secondary Undifferentiated Aquifer, aquifers are given this classification when it has not been possible to attribute either category A or B to a rock type.

1.7.1.7 The Rowe Chalk Formation, Flamborough Chalk Formation and Burnham Chalk Formation within the Hornsea Four PEIR boundary are classified as Principal Aquifers. Aquifers within this classification are composed of geology that exhibits high permeability and/or provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.

1.7.1.8 The PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) indicates that the Hornsea Four PEIR boundary has been assigned, by the Environment Agency, a medium to high groundwater vulnerability risk for the Superficial Aquifers and a low to high vulnerability for the Principal Aquifers. A high groundwater vulnerability designation indicates that the soil is easily able to transmit pollution to groundwater, which is characterised by high leaching potential in soils and the absence of low permeability superficial deposits.

1.7.1.9 There are two groundwater abstractions within the Hornsea Four PEIR boundary (both relating to spray irrigation), and an additional 128 groundwater abstractions within the 1 km Hornsea Four geology and ground conditions study area (see Figures 2 - 6, **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**). Within the 1 km Hornsea Four geology and ground conditions study area, two records relate to potable water abstraction by Yorkshire Water Services Ltd.

1.7.1.10 Part of the onshore ECC and the OnSS are located within Source Protection Zones (SPZs) 1, 2 and 3 (see Figures 2 - 6, **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**). There are three SPZs located between Beverley and Cottingham, to the west of Leconfield and to the west of Hutton Cranswick. The OnSS is located to the north east of Bentley within the Inner Protection Zone (Zone 1). Approximately 4 km of the onshore ECC passes through the Outer Protection Zone (Zone 2), with approximately 6.9 km passing through the Total Catchment (Zone 3). These zones are associated with groundwater and abstraction for

public water supply, and therefore suggest that groundwater in this area is likely to be sensitive to change.

1.7.1.11 Regionally, the principal groundwater body underlying the Hornsea Four PEIR boundary is the Hull and East Riding Chalk groundwater body (Figure 2, **Volume 6, Annex 2.3: Water Framework Directive Compliance Assessment**), as defined by the Environment Agency under the Water Framework Directive (WFD) (water body ID: GB40401G700700). WFD classification data (Environment Agency, 2016) states that the groundwater status is poor both for quantitative and chemical quality elements. This is attributed by the Environment Agency to pressures from diffuse source pollution from agriculture and rural land management sources, and continuous point source sewage discharges from the water industry. In addition, there have been cases of saline intrusion as a result of industrial practices.

Hydrology and Surface Drainage

1.7.1.12 Information provided within the PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) indicates that the Hornsea Four PEIR boundary is located within the River Hull surface water catchment area. A total of 388 records of water bodies have been identified within the Hornsea Four PEIR boundary. Of these, 357 are rivers present at the ground surface and 27 are underground rivers. The inland rivers identified are comprised of both small streams and drainage ditches as well as larger water bodies over 1 km in length. Within the 250 m Hornsea Four geology and ground conditions study area, 430 additional waterbodies have been identified.

1.7.1.13 The Environment Agency's WFD water quality data for all surface waters in the Hornsea Four PEIR boundary, as presented on the Catchment Data Explorer (last updated January 2019) demonstrates that the water quality does not generally meet the required standards under the WFD and is under pressure from point source pollution from sewage and industrial discharges, and diffuse pollution from agriculture. As a result, concentrations of nutrients such as phosphate and ammonia, and contaminants such as metals are elevated within a large portion of the Hornsea Four PEIR boundary.

1.7.1.14 One surface water abstraction (for spray irrigation) has been identified within the Hornsea Four PEIR boundary, and there are an additional 85 surface water abstractions within the 1 km Hornsea Four geology and ground conditions study area (see Figures 2 – 6, **Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**), two of which are associated with water bottling from Blue Kell spring.

1.7.1.15 Further information with regards to hydrology is located within **Chapter 2: Hydrology and Flood Risk**.

1.7.2 Potential Sources of Contamination

1.7.2.1 The research undertaken to inform the PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) indicates that the Hornsea Four PEIR boundary is located predominantly in areas that have historically been utilised for (and continue to operate as) agricultural land. A review of historical Ordnance Survey (OS) maps has also confirmed the presence of a range of features (see **Figure 1.2 - Figure 1.8**) that may give rise to potential sources of contamination, as summarised below:

- Agricultural land use – from the earliest available maps (1850s), land within the Hornsea Four PEIR boundary has predominantly been used as agricultural land, resulting in the potential for both diffuse and point sources of pollution to be present;
- Railway and sidings – the York, Markey Weighton and Beverley railway were recorded as bisecting the onshore ECC on the 1891 – 1892 map, before being recorded as being dismantled by 1970. The Hull and Scarborough railway is recorded as being located adjacent to the OnSS from 1854 (see **Figure 1.5** to **Figure 1.8**);
- Electricity substations are recorded as being within the OnSS site from the 1970 map (see **Figure 1.5** to **Figure 1.8**);
- Electricity pylons are recorded as being within the OnSS site from the 1952 map and 100 m east of the Onshore ECC from 1982;
- A cemetery is recorded adjacent to the Onshore ECC (**Figure 1.7**);
- Lissett Airfield located within the Onshore ECC route from 1956 to 1984, at which point it was recorded as disused (**Figure 1.2** and **Figure 1.3**);
- A sewage works (Beverley Corporation) was recorded to the east of the Onshore ECC (0 m) from the 1954 – 1969 maps until 1993 (**Figure 1.6** and **Figure 1.7**).

1.7.2.2 These isolated potential sources of contamination within the Hornsea Four PEIR boundary may be associated with a wide range of contaminants including, but not limited to, herbicides, hydrocarbons, metals, polychlorinated biphenyl (PCBs), asbestos, volatile organic contaminants (VOCs) and semi-volatile organic contaminants (SVOCs). However, as **Figure 1.2 – Figure 1.8** illustrate, potential sources of contamination have been identified as being outside of the Hornsea Four PEIR boundary but within the 250 m Hornsea Four geology and ground conditions study area.

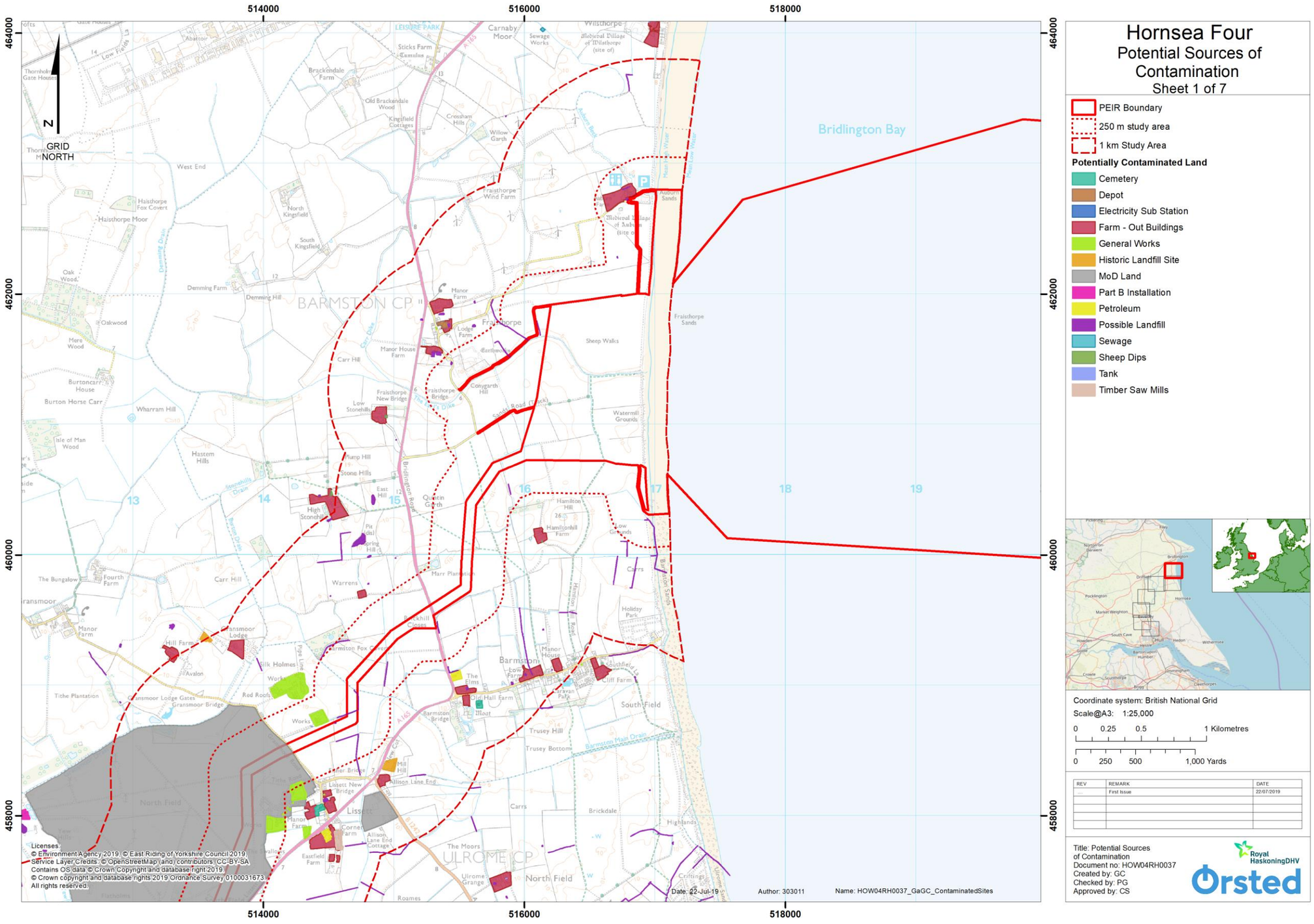


Figure 1.2: Potential Sources of Contamination within the Hornsea Four Geology and Ground Conditions Study Area (Not to Scale).

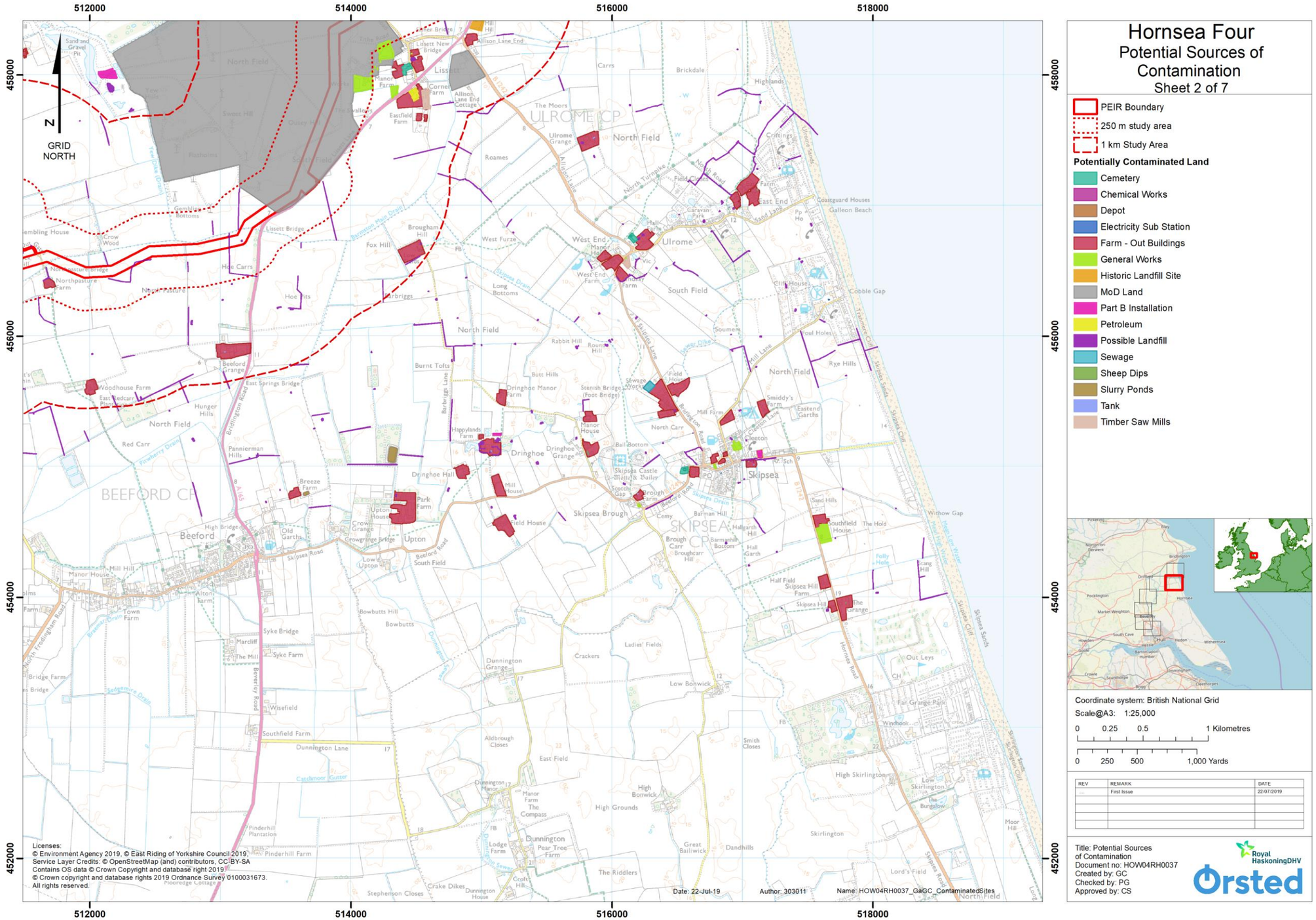
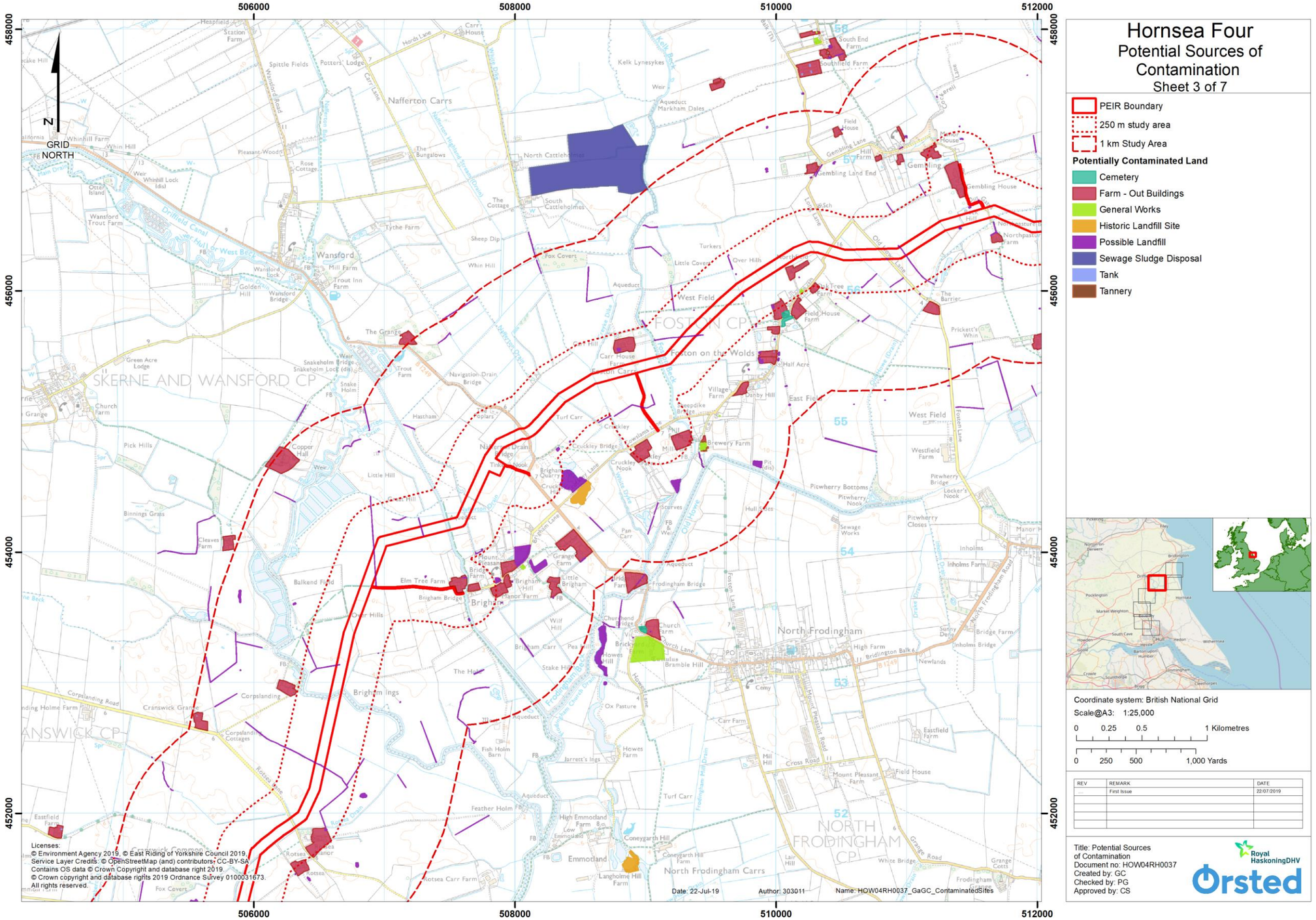


Figure 1.3: Potential Sources of Contamination within the Hornsea Four Geology and Ground Conditions Study Area (Not to Scale).



Hornsea Four
Potential Sources of Contamination
Sheet 3 of 7

- PEIR Boundary
- 250 m study area
- 1 km Study Area

Potentially Contaminated Land

- Cemetery
- Farm - Out Buildings
- General Works
- Historic Landfill Site
- Possible Landfill
- Sewage Sludge Disposal
- Tank
- Tannery

Coordinate system: British National Grid
Scale@A3: 1:25,000

0 0.25 0.5 1 Kilometres

0 250 500 1,000 Yards

REV	REMARK	DATE
	First Issue	22/07/2019

Title: Potential Sources of Contamination
Document no: HOW04RH0037
Created by: GC
Checked by: PG
Approved by: CS

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Figure 1.4: Potential Sources of Contamination within the Hornsea Four Geology and Ground Conditions Study Area (Not to Scale).

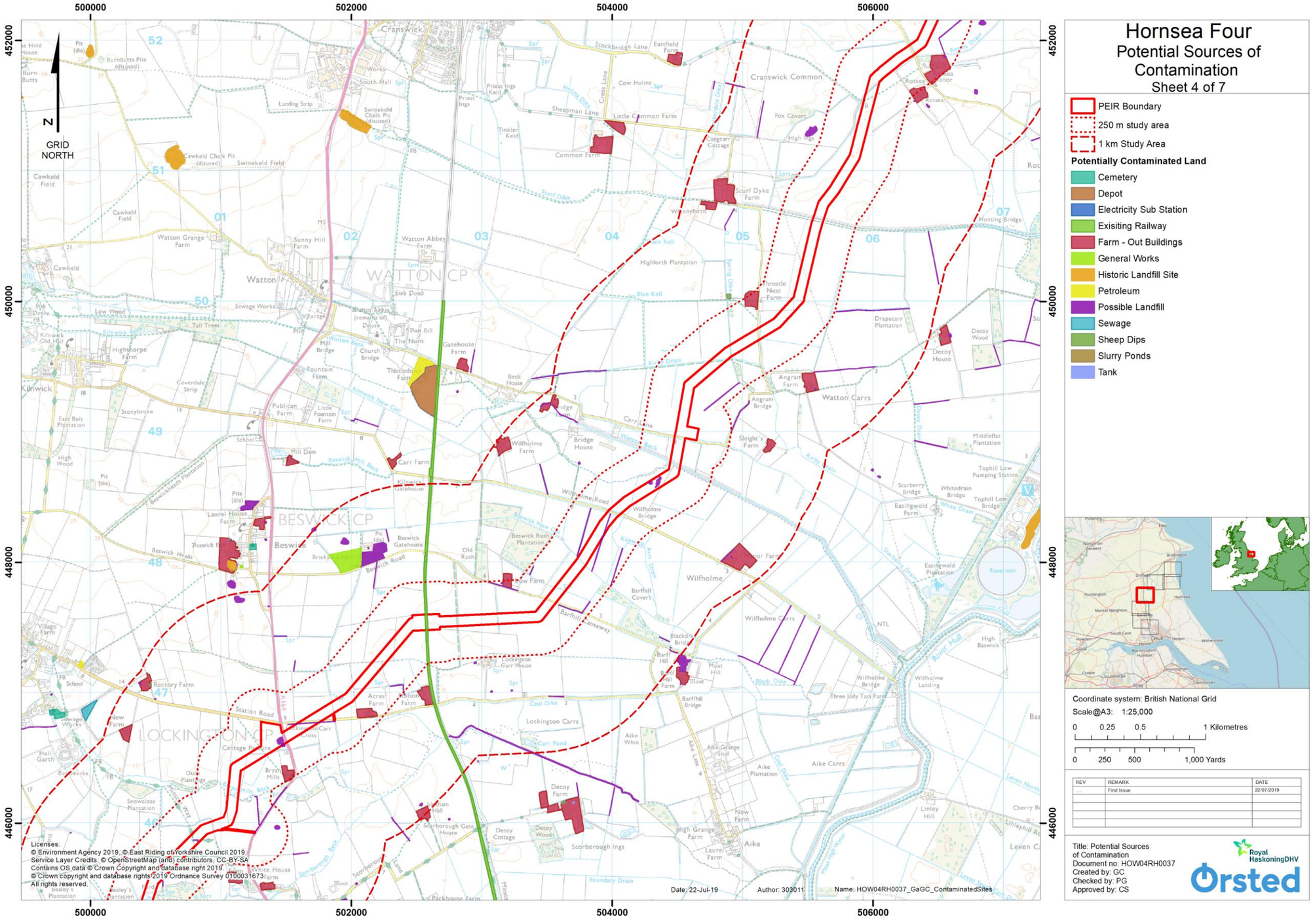


Figure 1.5: Potential Sources of Contamination within the Hornsea Four Geology and Ground Conditions Study Area (Not to Scale).

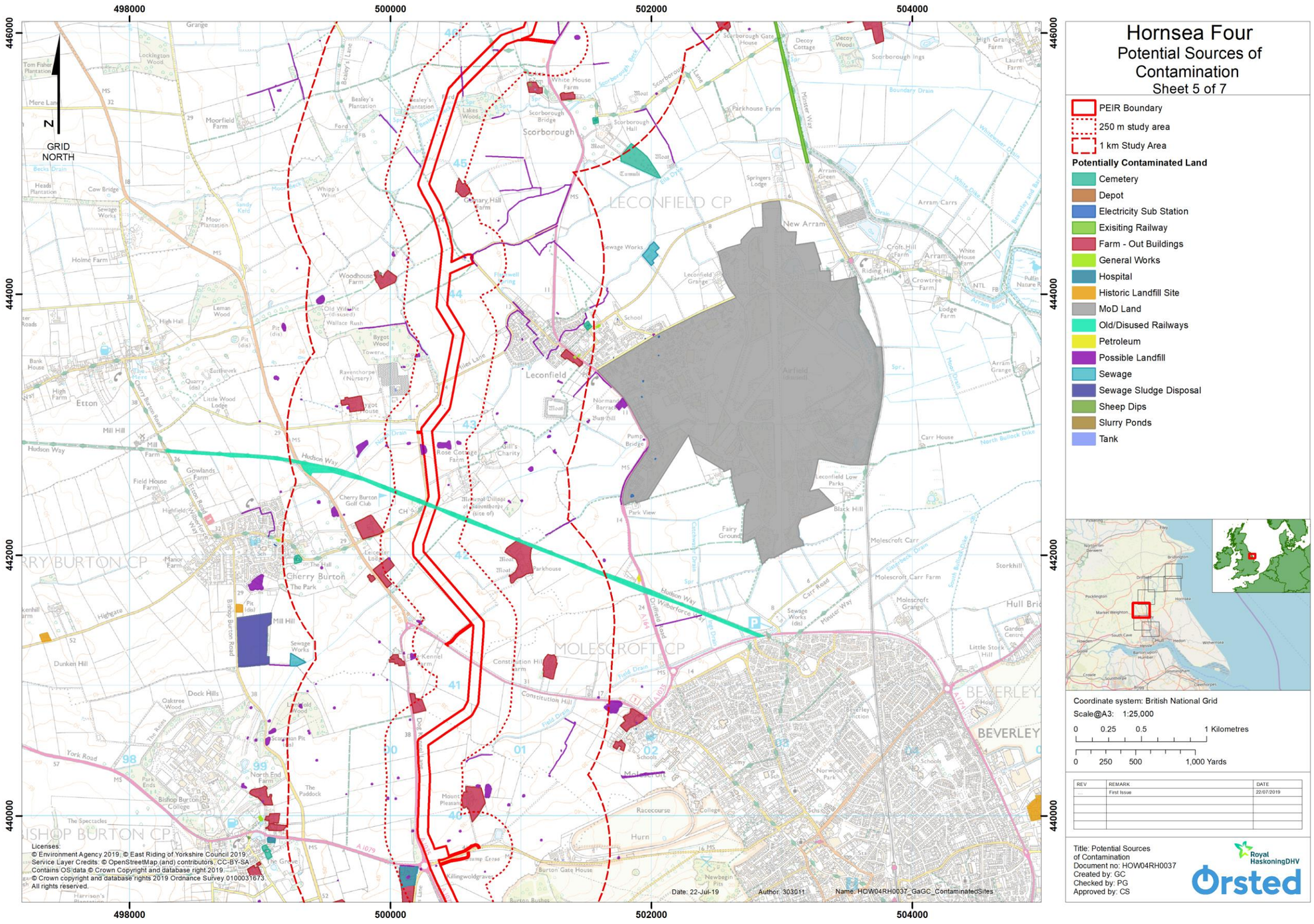
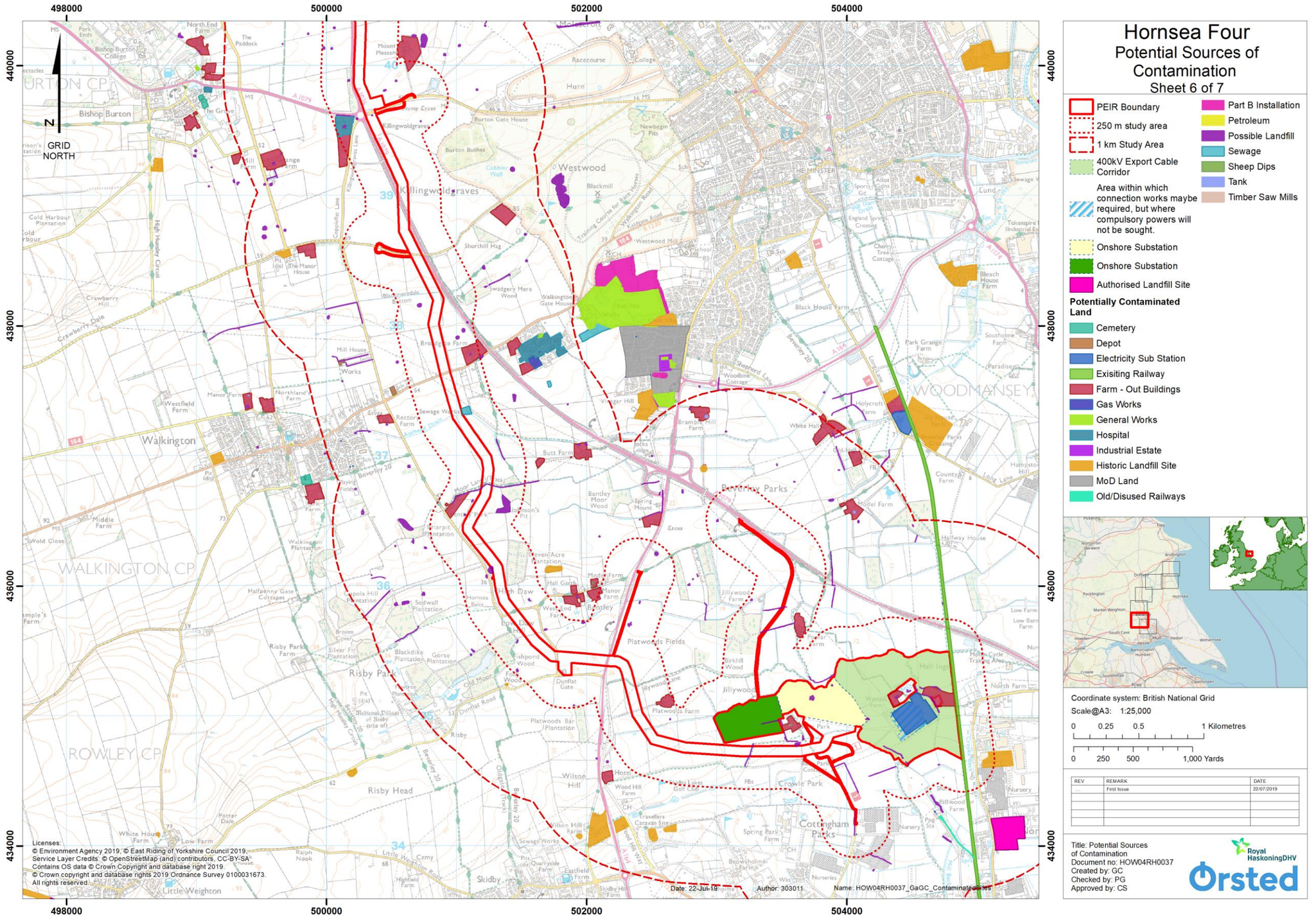


Figure 1.6: Potential Sources of Contamination within the Hornsea Four Geology and Ground Conditions Study Area (Not to Scale).



Hornsea Four
Potential Sources of Contamination
Sheet 6 of 7

- PEIR Boundary
- 250 m study area
- 1 km Study Area
- 400kV Export Cable Corridor
- Area within which connection works maybe required, but where compulsory powers will not be sought.
- Onshore Substation
- Onshore Substation
- Authorised Landfill Site

Potentially Contaminated Land

- Cemetery
- Depot
- Electricity Sub Station
- Exisiting Railway
- Farm - Out Buildings
- Gas Works
- General Works
- Hospital
- Industrial Estate
- Historic Landfill Site
- MoD Land
- Old/Disused Railways
- Part B Installation
- Petroleum
- Possible Landfill
- Sewage
- Sheep Dips
- Tank
- Timber Saw Mills

Coordinate system: British National Grid
Scale@A3: 1:25,000
0 0.25 0.5 1 Kilometres
0 250 500 1,000 Yards

REV	REMARK	DATE
...	First Issue	22/07/2019

Title: Potential Sources of Contamination
Document no: HOW04RH0037
Created by: GC
Checked by: PG
Approved by: CS

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Figure 1.7: Potential Sources of Contamination within the Hornsea Four Geology and Ground Conditions Study Area (Not to Scale).

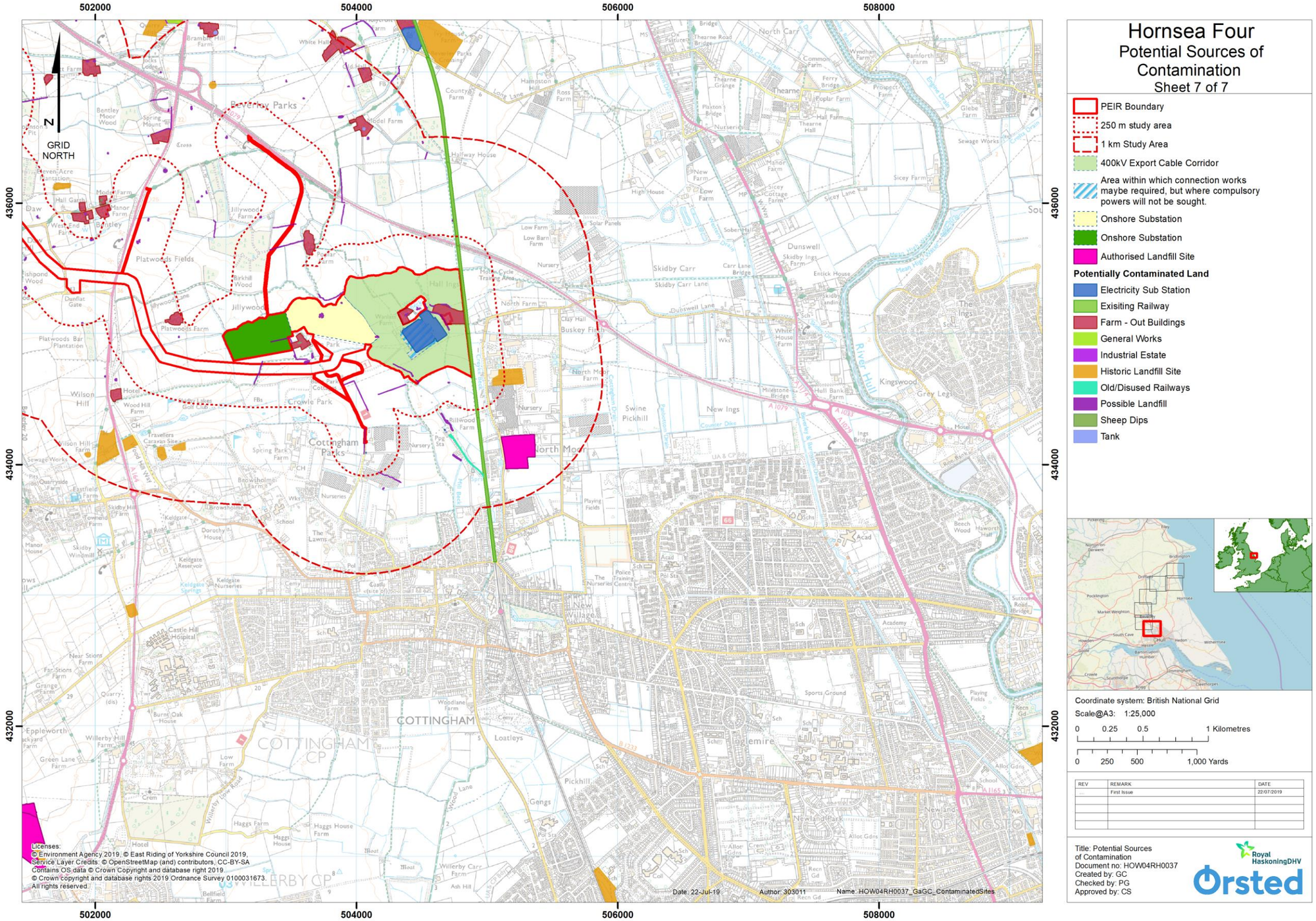

Figure 1.8: Potential Sources of Contamination within the Hornsea Four Geology and Ground Conditions Study Area (Not to Scale).

Human Health

1.7.2.3 The required onshore infrastructure comprises landfall works, onshore cable installation, onshore substation, electrical balancing infrastructure and grid connection as set out in **Volume 1, Chapter 4: Project Description**. Haul and temporary access roads will also be required during the construction period.

1.7.2.4 During the construction of the onshore infrastructure, the critical human health receptors are potentially those involved with construction activities, adjacent off-site residents (noting that route selection has avoided all villages and towns), nearby workers (e.g. agricultural workers) and visitors (e.g. where Public Rights of Way (PRoW) might be in use). During the operational phase of the project, the human health receptors will be site users as no operations are planned that would create contaminated fugitive dust during operation.

Sensitive Land Use

1.7.2.5 The River Hull Headwaters Sites of Special Scientific Interest (SSSI) is located within the Hornsea Four PEIR boundary (See Figures 7 - 11 within the PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**).

1.7.2.6 The River Hull Headwaters is afforded protection as a SSSI as the most northerly chalk stream system in Britain. The SSSI is currently undergoing river restoration works as 65% of the River Hull Headwaters were assessed as being in an unfavourable condition by Natural England in 2003. The designation of the River Hull Headwaters as a SSSI is in relation to its biological characteristics rather than for its geological qualities.

1.7.2.7 Bryan Mills Field SSSI is located within the 250 m Hornsea Four geology and ground conditions study area and comprises a tall fen community which occupies the centre of a small ungrazed field, the surrounding drier areas of which have been planted with trees.

1.7.2.8 Further information regarding designated sites can be found in **Chapter 3: Ecology and Nature Conservation**.

1.7.2.9 Parts of the Hornsea Four PEIR boundary are located within the following Nitrate Vulnerable Zones (NVZ):

- River Hull from Arram Bank to Humber NVZ (surface water);
- Yorkshire Chalk NVZ (groundwater);
- Barmston Sea Drain from Skipsea Drain to North Sea NVZ (surface water); and
- Earls Dyke from source to North Sea NVZ (surface water).

Minerals

1.7.2.10 A number of strategic mineral resources have been identified within the East Riding of Yorkshire (EYRC). These include for example, sand and gravel, chalk deposits, limestone, silica sand, brick clay and peat deposits. Within the 1 km Hornsea Four geology and ground conditions study area there are 20.84 km² of Mineral Safeguarding Areas (**Figure 1.10**). These are mostly associated with the sand and gravel deposits. However, directly within the Hornsea Four PEIR boundary there are 1.75 km² of Mineral Safeguarding Areas, which equates to 0.18% of the total recorded Mineral Safeguarding Areas within EYRC.

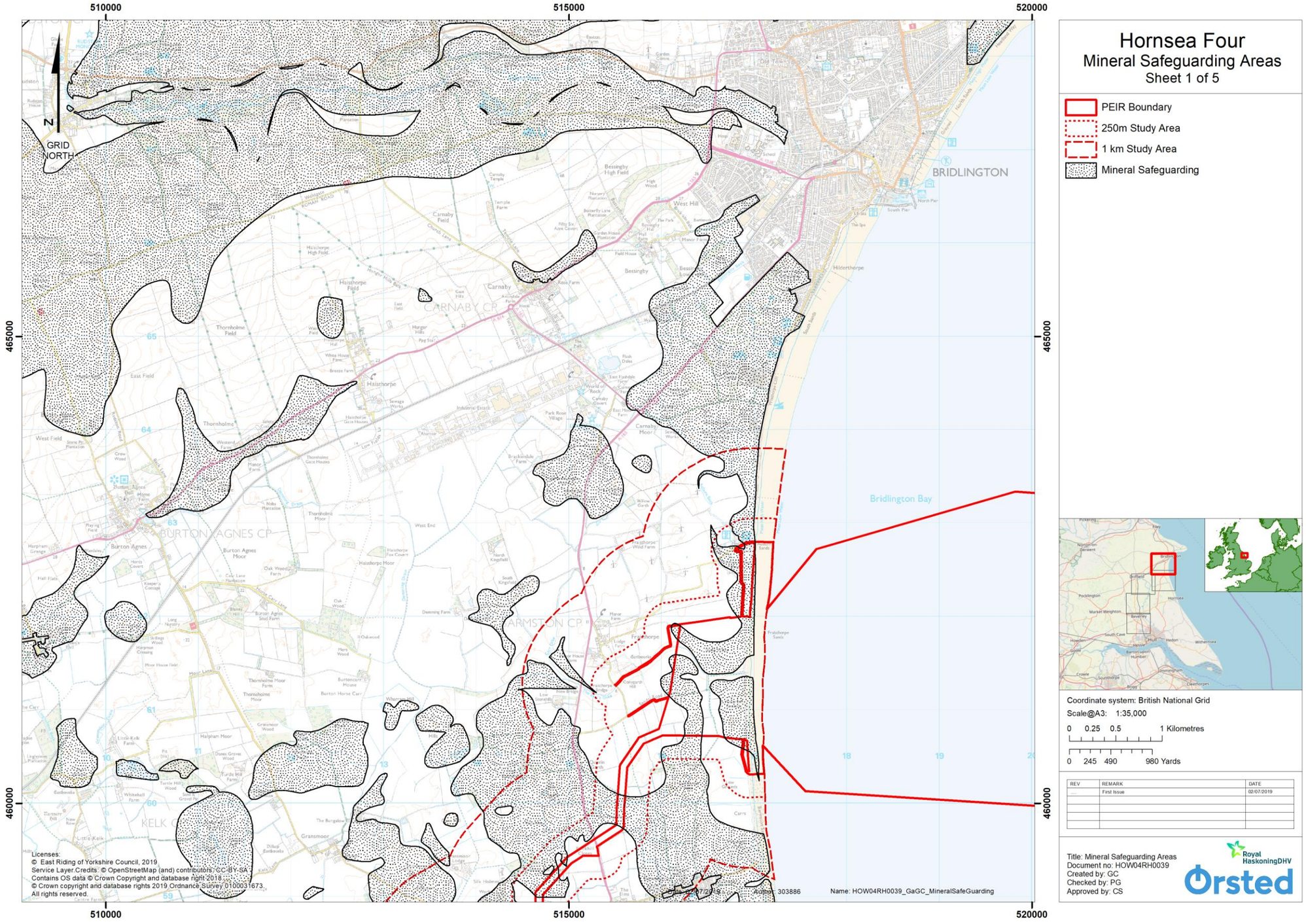

Figure 1.9: Mineral Safeguarding Areas (Landfall) (Not to Scale)

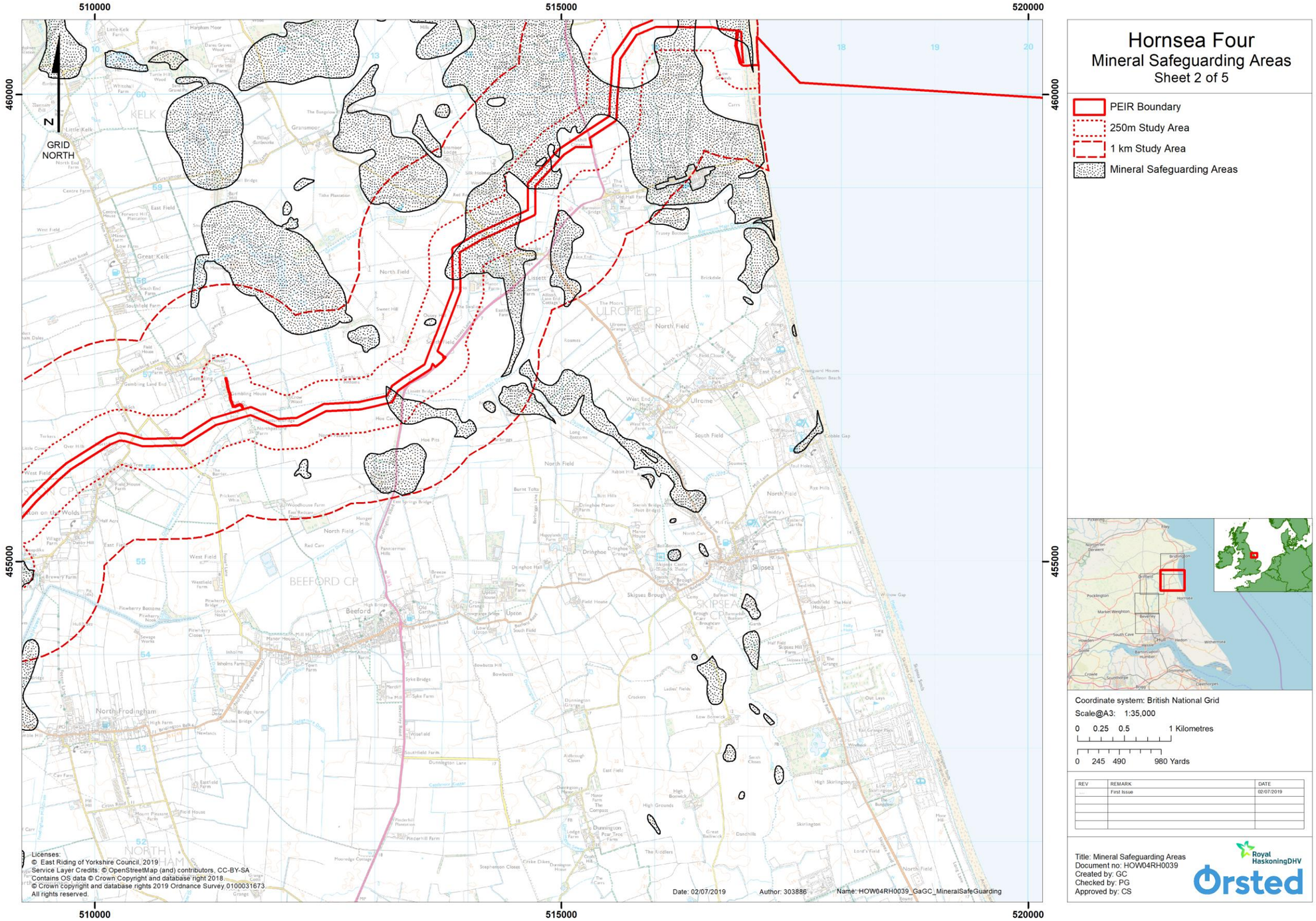

Figure 1.10: Mineral Safeguarding Areas (ECC) (Not to Scale).

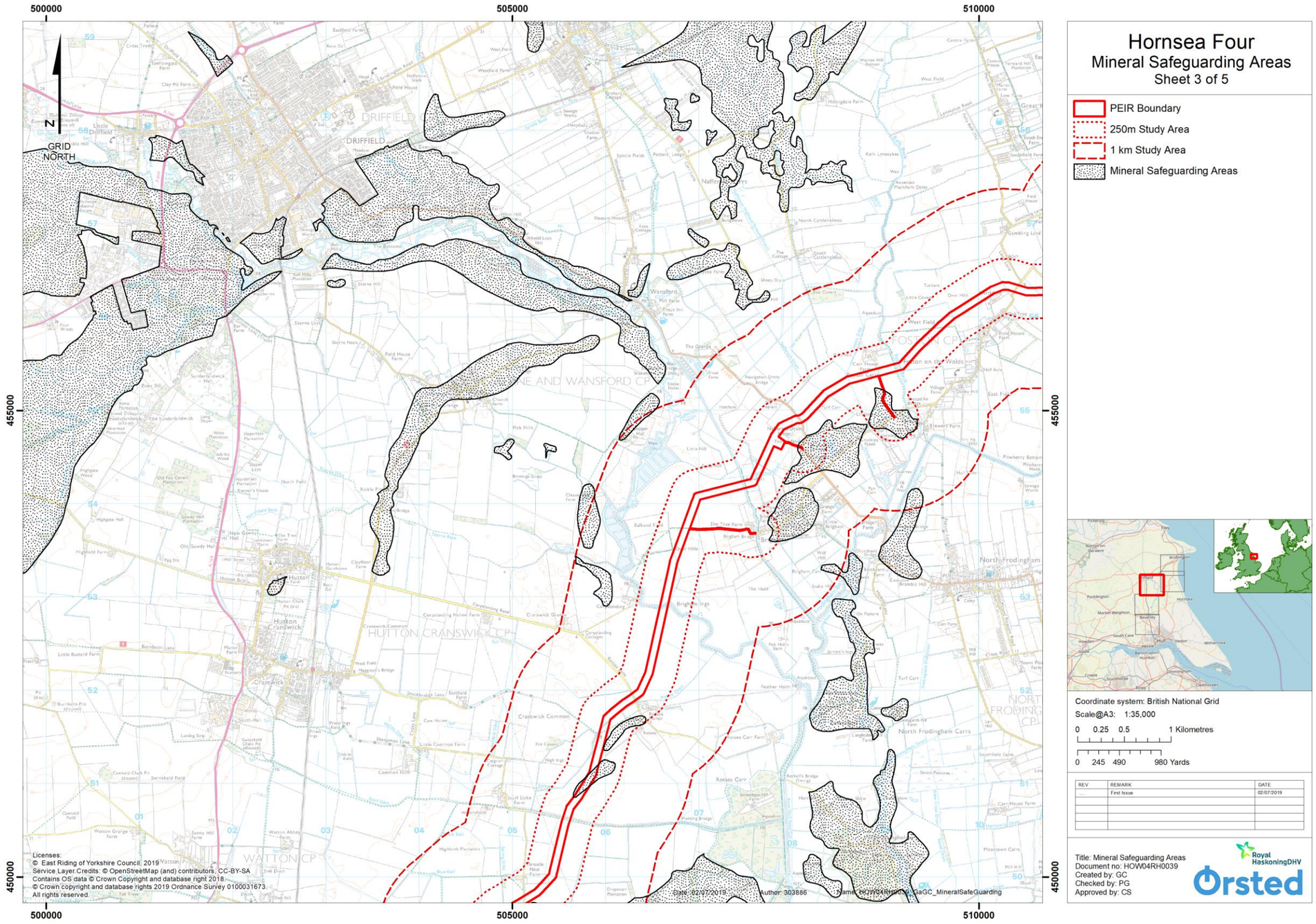

Figure 1.11: Mineral Safeguarding Areas (ECC 2) (Not to Scale)

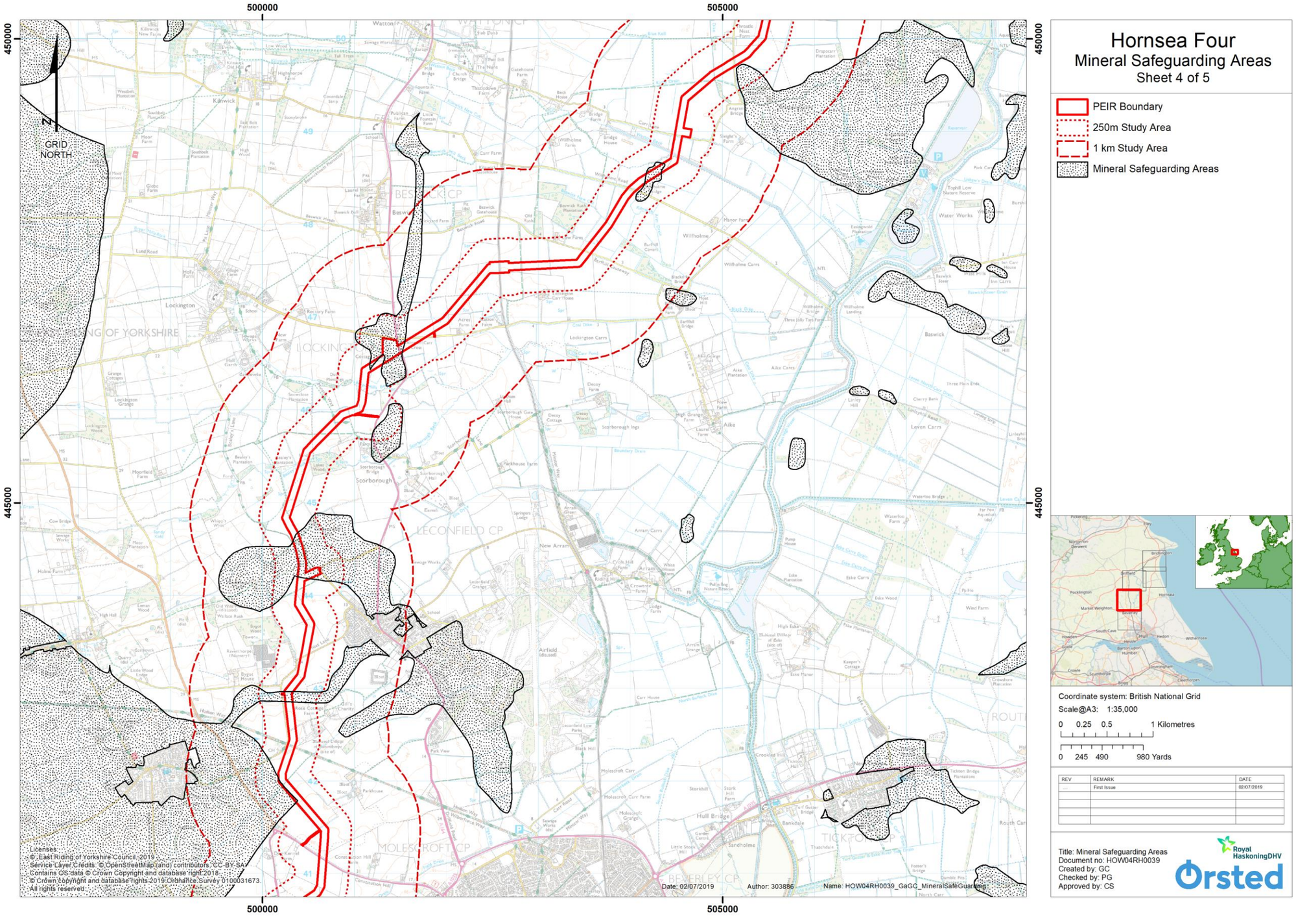

Figure 1.12: Mineral Safeguarding Areas (ECC 3) (Not to Scale).

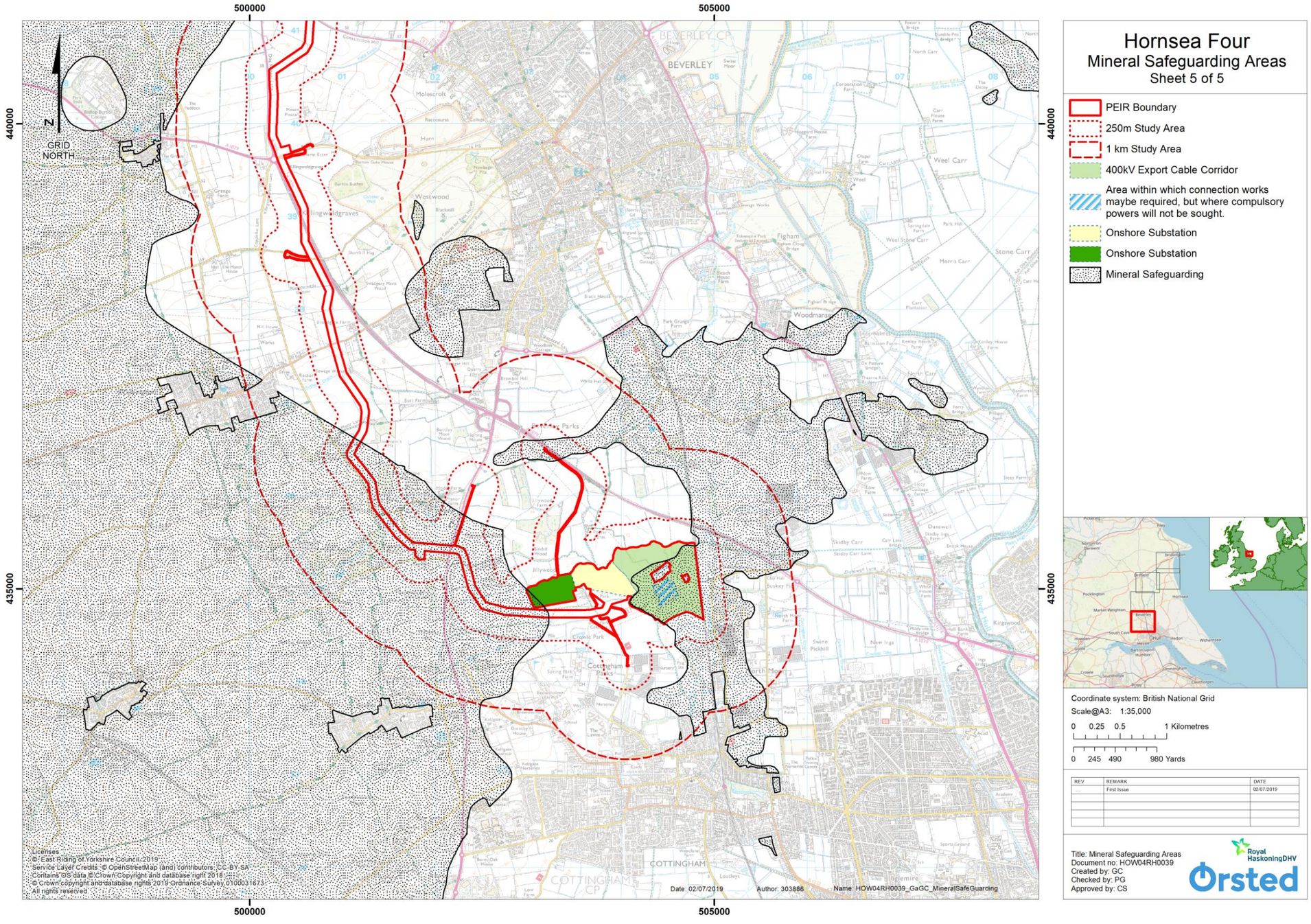

Figure 1.13: Mineral Safeguarding Areas (OnSS) (Not to Scale)

1.7.3 Predicted future baseline

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

Geology

1.7.3.2 Assuming that there are no significant changes to land uses within the Hornsea Four PEIR boundary, no major changes to geology are anticipated to occur in any location.

Hydrogeology and Groundwater Abstractions

1.7.3.3 The WFD aims to protect and enhance water bodies in Europe by controlling inputs of chemical pollutants and by reversing the effects of existing chemical contamination in order to achieve a good status. The current status of the groundwater bodies within the Hull and East Riding Chalk catchment is considered to have poor chemical quality elements (as classified by the Environment Agency, 2016). This is due to the pressure from diffuse pollution sources (e.g. agriculture) and point source pollution (e.g. sewage discharge from the water industry) in addition to saline intrusion. Further information is provided in detail within **Chapter 2: Hydrology and Flood Risk**. In the future, increased regulation of agricultural chemicals and catchment-wide initiatives to reduce pressures on groundwater to achieve compliance with the WFD suggest that the baseline groundwater quality is likely to improve over time. However, any improvements are likely to become apparent only over long timescales due to, for example, long residence times of chemical pollutants within the environment.

1.7.3.4 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 (DEFRA, 2017). Pressures on groundwater levels are therefore likely to decrease in the future.

Hydrology

1.7.3.5 Information regarding anticipated trends associated with surface water is provided in **Chapter 2: Hydrology and Flood Risk**. However, in summary it is predicted that the hydrology of the surface drainage network, which within the Hornsea Four PEIR boundary contains 388 water bodies (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) could change as a result of climate change with higher winter flows, lower summer flows and a greater number of storm related flood flows (refer to **Volume 6, Annex 2.2: Onshore Infrastructure Flood Risk Assessment** for further details on the assessment of climate change and its impacts with regards to surface water drainage).

Land Quality

1.7.3.6 Land affected by contamination is primarily managed in the UK by Part IIA of the Environmental Protection Act (EPA), 1990 (EPA, 1990) and the Town County Planning Act, 1990. Part IIA of the Environmental Protection Act requires local authorities to identify contaminated land and ensure potential risks are assessed and mitigated accordingly. The regime does not consider future uses. However, these would require a specific grant of planning permission and consideration of the potential for contamination to represent unacceptable risks to ensure the site is suitable for the proposed end use. Consequently, in relation to the project and its immediate receiving environment, it is reasonable to predict using professional judgement that no new sources of contaminated land would be introduced and that there would be a general improvement in land quality over time due to the natural breakdown of some contaminants that may be present in isolated areas.

1.7.4 Data Limitations

1.7.4.1 This desk-based assessment is based on a range of publicly available information and does not include site-specific intrusive, exploratory information. In the absence of such information the assessment adopts a precautionary approach i.e. if a potential pollutant linkage has been identified it is assumed to be present until further site-specific information is available to clarify whether a source-pathway-receptor linkage is present. The direct assessments and judgements given in this report are therefore limited in this regard but they do provide an adequate basis for the assessment, identifying areas of known contamination which may require further investigation through subsequent project phases, as well as the general level of contamination that may be expected in the various onshore project areas.

1.8 Project basis for assessment

1.8.1 Impact register and impacts "scoped out"

1.8.1.1 Based on the baseline environment, the project description outlined in **Volume 1, Chapter 4: Project Description** and the Commitments in **Volume 4, Annex 5.2: Commitments Register**, a number of impacts are "scoped out" of the PEIR assessment for geology and ground conditions. These impacts are outlined, together with a justification for scoping them out, in **Table 1.7**. Further detail is provided in the Impacts Register in **Volume 4, Annex 5.1: Impacts Register**.

1.8.1.2 Please note that the term "scoped out" relates to the Likely Significant Effect (LSE) in EIA terms and not "scoped out" of the EIA process *per se*. All impacts "scoped out" of LSE are assessed for magnitude, sensitivity of the receiving receptor and conclude an EIA significance in the Impacts Register (see **Volume 4, Annex 5.1**). This approach is aligned with the Hornsea Four Proportionate approach to EIA (see **Volume 1, Chapter 5: EIA Methodology**).

Table 1.7: Geology and Ground Conditions Impact Register.

Project activity and impact	Likely significance of effect	Approach to assessment	Justification
Damage to designated geological SSSIs: construction phase (GGC-C-1)	No likely significant effect	Scoped Out	No designated geological sites have been identified within the Hornsea Four geology and ground conditions Hornsea Four PEIR boundary. Given the lack of receptors there is no potential for a source-pathway-receptor linkage to exist and no significant effects are predicted. Co2 states that, sensitive sites will be avoided by the permanent project footprint. The Hornsea Four PEIR boundary is not located within geological SSSI areas, as such direct impacts to geological SSSIs have been scoped out of this assessment.
Indirect effects (damage) to designated geological SSSIs: construction phase (GGC-C-2)	No likely significant effect	Scoped Out	In line with the impact relating to the damage to designated geological SSSIs which is scoped out above, no geological SSSI exists within the Hornsea Four geology and ground conditions Hornsea Four PEIR boundary which extends to 1km from all site infrastructure/activity to allow for indirect effects. Therefore, given the lack of receptors there is no potential for a source-pathway-receptor linkage to exist and no significant effects are predicted. Co2 states that sensitive sites will be avoided by the permanent project footprint. The 1 km Hornsea Four

Project activity and impact	Likely significance of effect	Approach to assessment	Justification
			geology and ground conditions study area is not located within a geological SSSI area, as such indirect impacts to geological SSSIs have been scoped out of this assessment.
Soil Compaction: construction phase (GGC-C-6)	No likely significant effects	Scoped Out	Construction vehicle movements and the creation of haul routes could cause compaction of the subsoil, which would degrade soil quality. Soils will be protected during construction with reinstatement post construction. Co10 commits to re-instating the working areas to pre-existing conditions as far as reasonably practical in line with Defra guidance (or the latest available guidance). Co64 commits to storing topsoils and subsoils separately with contaminated soils separated, with Co8 committing to a maximum of 2 m high stockpiles to avoid compaction effects.
Accidental spills: construction and operation phases (GGC-C/O-9)	No likely significant effect	Scoped Out	Whilst there is the potential for contaminative sources introduced by the construction and operation of Hornsea Four through spillages and accidents, embedded tertiary mitigation will be in place to avoid significant effects. The Outline CoCP (Volume F2, Chapter 2: Outline Code of Construction Practice) will set out preventative measures and contingency plans.
Decommissioning (GGC-D-10)		Scoped out	Decommissioning of the onshore infrastructure for Hornsea Four will comprise the following activities: • Buried export cables left in situ, with cable ends cut, sealed and securely buried. Partial removal of cables at landfall occur for aluminium/steel recycling; • Joint Bays and Link boxes will typically be left in situ, or removed if environmentally feasible; and • The OnSS above ground electrical equipment and infrastructure will be removed, along with building foundations and security fencing. The site will be returned to its previous condition. Further details will be provided and secured within a Decommissioning Plan which will follow the latest relevant guidance (Co127).

Notes:
Grey - Potential impact is scoped out and both PINS and Hornsea Four agree.
Red – Potential impact is scoped out with no consensus between PINS and Hornsea Four at EIA Scoping.

1.8.2 Commitments

1.8.2.1 Hornsea Four has adopted commitments (primary design principles inherent as part of Hornsea Four, installation techniques and engineering designs/modifications) as part of their pre-application phase, to remove a number of impacts or reduce impacts as far as possible), these are outlined in **Volume 4, Annex 5.2 Commitments Register**. Further commitments (adoption of best practice guidance), referred to as tertiary commitments in **Table 1.8** below, are embedded as an inherent aspect of the EIA process.

1.8.2.2 The commitments adopted by Hornsea Four in relation to geology and ground conditions are presented in **Table 1.8**.

Table 1.8: Relevant Geology and Ground Conditions Commitments.

Commitment ID	Measure Proposed	How the measure will be secured
Co1	Primary: All main rivers, Internal Drainage Board (IDB) maintained drains, main roads and railways will be crossed by HDD or other trenchless technology as set out in the Onshore Crossing Schedule. Where HDD technologies are not practical, the crossing of ordinary watercourses may be undertaken by open cut methods. In such cases, temporary measures will be employed to maintain flow of water along the watercourse.	DCO requirement 16 (CoCP)
Co2	Primary: The following sensitive sites will be avoided by the permanent project footprint: Listed Buildings (580 sites), Registered Parks and Gardens (Thwaite Hall and Risby Hall), Scheduled Monuments (30 sites), Conservation Areas (19 sites), non-designated built heritage assets (368 sites) and Ancient Woodland (10 sites and TPOs). Please refer to PEIR Volume 6, Annex 6.5.1 Appendix B Designated Assets Gazetteer for detailed lists of designated heritage assets that are avoided by Hornsea Four. With the exception of River Hull Headwaters SSSI, sensitive sites have been avoided. Please refer to PEIR Volume 6, Annex 3.1: Extended Phase 1 Habitat Survey Report for details. Where possible, unprotected areas of woodland, mature, and protected trees (e.g. veteran trees) shall also be avoided or micro sited around.	DCO Works Plan - Onshore
Co4	Tertiary: A Pollution Prevention Plan (PPP) will be developed in accordance with the outline PPP and will include details of emergency spill procedures. Good practice guidance detailed in the Environment Agency's Pollution Prevention Guidance (PPG) notes (including PPG01, PPG05, PPG08 and PPG21) will be followed where appropriate, or the latest relevant available guidance.	DCO requirement 16 (CoCP)
Co6	Tertiary: During construction of piled foundations, the following guidance will be used: Piling and Penetrative Ground Improvement Methods on land Affected by Contamination: Guidance on Pollution Prevention (Environment Agency, 2001), or latest relevant available guidance.	DCO requirement 16 (CoCP)
Co7	Primary: The temporary work area associated with onshore export cable corridor will be 80 m working width to minimise the construction	DCO Works Plan - Onshore

Commitment ID	Measure Proposed	How the measure will be secured
	footprint, except the Network Rail Crossing near Beswick where the footprint is extended to 120 m to facilitate HDD of the railway line. The permanent onshore export cable corridor width will be 60 m except the Network Rail Crossing near Beswick where the footprint is extended to 120 m to facilitate HDD of the railway line.	
Co8	Tertiary: Stockpiles will be a maximum of 2 m high to avoid compaction from the weight, in line with DEFRA 2009 Construction Code of Practice for the Sustainable Use of Soils on Construction Sites PB13298 or the latest relevant available guidance.	DCO requirement 16 (CoCP)
Co10	Tertiary: Post-construction, the working area will be reinstated to pre-existing condition as far as reasonably practical in line with DEFRA 2009 Construction Code of Practice for the Sustainable Use of Soils on Construction Sites PB13298 or latest relevant available guidance.	DCO Requirement 16 (CoCP) DCO Requirement 19 (Restoration of land used temporarily for construction)
Co19	Tertiary: An Onshore Infrastructure Drainage Strategy will be developed for the permanent operational development along the onshore cable corridor and the onshore substation, and will include measures to ensure that existing land drainage is reinstated and maintained, and measures to limit discharge rates and attenuate flows such that pre-development run-off rates to surrounding land are retained. The Onshore Infrastructure Drainage Strategy will be developed in consultation with the Environment Agency, Lead Local Flood Authority and relevant Internal Drainage Board as appropriate.	DCO Requirement 12 (Surface and foul water drainage)
Co25	Primary: The onshore export cable corridor will be completely buried underground for its entire length. No overhead pylons will be installed as part of the consented works for Hornsea Four.	DCO Schedule 1, Part 1 Authorised Development
Co28	Primary: Joint Bays will be completely buried, with the land above reinstated except where access will be required from ground level, e.g. via link box chambers and manholes.	DCO Requirement 16 (CoCP); and; DCO Requirement 19 (Restoration of land used temporarily for construction)
Co30	Secondary: A Landscape Management Plan will be developed in accordance with the outline Landscape Management Plan. The plan will include details of mitigation planting at the onshore substation site, including number, location and species. Details of management and maintenance of planting will be provided. Where practical, landscape mitigation planting will be established as early as possible in the construction phase.	DCO Requirement 7 (Provision of landscaping)

Commitment ID	Measure Proposed	How the measure will be secured
Co33	Tertiary: All vegetation requiring removal will be undertaken outside of the bird breeding season. If this is not possible, the vegetation requiring removal will be subject to a nesting bird check by a suitably qualified ECoW. If nesting birds are present, the vegetation will not be removed until the young have fledged or the nest failed.	DCO Requirement 9 (Ecological Management Plan)
Co41	Primary: All HDD crossings will be undertaken by non-impact methods in order to minimise construction vibration beyond the immediate location of works.	DCO Requirement 16 (CoCP)
Co61	Secondary: Prior to the commencement of works, the contractor (or project appointed Agricultural Liaison Officer) will document information on existing agricultural management and soil/land conditions. This will include soil condition surveys and intrusive soil survey trial pits to identify and describe the physical and nutrient characteristics of the existing soil profiles.	DCO Requirement 16 (CoCP)
Co64	Tertiary: Topsoil and subsoil will be stored in separate stockpiles in line with DEFRA 2009 Construction Code of Practice for the Sustainable Use of Soils on Construction Sites PB13298 or the latest relevant available guidance. Any suspected or confirmed contaminated soils will be appropriately separated, contained and tested before removal (if required).	DCO Requirement 16 (CoCP) DCO Requirement 13 (Contaminated land and groundwater scheme)
Co68	Secondary: All logistics compounds will be removed and sites restored to their original condition when construction has been completed.	DCO Requirement 16 (CoCP) DCO Requirement 19 (Restoration of land used temporarily for construction)
Co76	Tertiary: Appropriate Personal Protective Equipment (PPE) will be used and relevant good working practices applied to avoid potential risk to human health from any potential ground contamination, in line with relevant available guidance.	DCO requirement 16 (CoCP)
Co77	Tertiary: A contaminated land and groundwater scheme will be prepared to identify any contamination and any remedial measures which may be required.	DCO requirement 13 (Contaminated land and groundwater scheme)
Co124	Tertiary: A Code of Construction Practice (CoCP) will be developed in accordance with the outline CoCP. The outline CoCP will include measures to reduce temporary disturbance to residential properties, recreational users and existing land users.	DCO requirement 16 (CoCP)
Co127	Tertiary: An Onshore Decommissioning Plan will be developed prior to decommissioning. The Onshore Decommissioning Plan will include provisions for the removal of all onshore above ground infrastructure and	DCO requirement 21 (onshore decommissioning).

Commitment ID	Measure Proposed	How the measure will be secured
	the decommissioning of below ground infrastructure and details relevant to pollution prevention and avoidance of ground disturbance. The Onshore Decommissioning Plan will be in line with the latest relevant available guidance.	
Co143	Secondary: The landfall site will avoid the Barmston Main Drain.	DCO Works Plan - Onshore

1.9 Maximum Design Scenarios

1.9.1.1 To inform the assessments, a range of parameters for each aspect of the project has been defined (the design envelope) with a Maximum Design Scenario (MDS) identified for each potential effect that has been assessed. Whilst the design envelope is broad enough to encompass the potential variations in design and other aspects of Hornsea Four, the MDS ensures that all assessments are based on a worst-case approach, specific to the effect being assessed. **Table 1.9** sets out the MDSs identified in relation to the potential effects on geology and ground conditions.

Table 1.9: Maximum design scenario for impacts on geology and ground conditions.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
Construction			
Exposure of workforce to health impacts (GGC-C-4) Construction activities (all project components), such as trenching, excavations and other earthworks could disturb contaminants, which could result in impacts on soil / land use; and pollution of groundwater.	Tertiary: Co76 Co77 Co124	**Landfall:** • Construction duration: 32 months• • Transition Joint Bays (located within Landfall compound area): Number: 6, Depth 6 m • HDD cable ducts: Number: 8, Diameter: 1 m, Length: 1.5 km • HDD Entry Pits: Area: 125 m^2 per entry pit, Depth: 6 m • HDD Exit Pits: Number: 8 m, Area: 900m^2 per exit pit, Depth: 5 m • HDD burial depth: Maximum: 40 m, Minimum: 5 m • Temporary intertidal exit pit working area: 1,600 m^2 per exit pit • HDD exit pit excavated material volume: 2500m^3 **Onshore Export Cable Corridor:** • Construction duration: 30 months • ECC (temporary and permanent): Length: 40 km (approximate), Width: 80 m, Area: 3,200,000 m^2 • Number of cable circuits (HVAC system): 6 • Number of cables (HVAC system): 18 • Diameter of cable: 220 mm per cable • Diameter of duct: 330 mm per cable • Joint Bays: Number: 240, Depth: 2.5 m, Width: 9 m, Length: 25 m per Joint Bay • Link Boxes: Number: 240, Depth: 2 m, Width: 3 m, Length: 3 m per Link Box • Cable trench: Depth of stabilised backfill: 1.5 m, Target burial depth: 1.2 m, Width at base: 1.5 m, Width at surface: 5 m	These parameters represent the maximum ground disturbance within the project area in which the potential disturbance of existing contamination could occur. They also represent the maximum construction duration which could affect human health.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
		Onshore substation: • Construction duration: 36 months • Permanent infrastructure area: 155,000 m^2 • Temporary works area: 130,000 m^2	
Encountering contamination during intrusive works (GGC-C-5) Construction activities (all project components), such as trenching, excavations and other earthworks could disturb contaminants, which could result in impacts on soils / land used; and pollution of groundwater.	Tertiary: Co64 Co77 Co124	**Landfall:** • Landfall compound: Number: 1, Total Area: 40,000 m^2 • Transition Joint Bays (located within Landfall compound area): Number: 6, Depth: 6 m • HDD cable ducts: Number: 8, Diameter: 1 m, Length: 1.5 km • HDD Entry Pits: Area: 125 m^2 per entry pit, Depth: 6 m • HDD burial depth: Maximum: 40 m, Minimum: 5 m • HDD Exit Pits: Number: 8, Area: 900 m^2 per exit pit, Depth: 5 m, Excavated material volume: 2, 500 m^3, Temporary onshore/intertidal working area: 1 600 m^2 • Temporary intertidal exit pit working area: 1,600 m^2 per exit pit **Onshore Export Cable Corridor:** • ECC: Length: 40 km (approximate), Max. Temporary Width: 80 m (excl. railway crossings), Area: 3,200,000 m^2 • Number of cable circuits (HVAC system): 6 • Number of cables (HVAC system): 18 • Diameter of cable: 220 mm per cable • Diameter of duct: 330 mm per cable • Cable trench: Number: 6, Depth: 1.5 m, Width at base: 1.5 m, Width at surface: 5 m, Depth of Stabilised backfill: 1.5 m • Cable Burial: Target Depth: 1.2 m • Distance between Joint Bay/ Link Box: Minimum: 750 m, Maximum: 3,000 m • Logistics compounds: Number: 8, Size of each: 140x140 m, Duration: 36 months	These parameters represent the maximum ground disturbance within the project area in which the potential disturbance of existing contamination could occur.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
		• HDDs: Number 112, HDD compounds (entry and exit): 56 x 70x70m compounds • Joint Bays (JB): Total area: 39 150 m^2, Spoil volume per JB: 563 m^3, Total Spoil volume 97 962 m^3 • Link Boxes (LB): Total area: 1 566 m2, Spoil volume per LB: 18 m^3, Total Spoil volume 3 132 m^3 **Onshore substation:** • • Permanent infrastructure area: 155,000 m^2	
Dewatering of trenches and excavations (GGC-C-7) If required, dewatering perched water or groundwater could reduce groundwater flow and affect water quality and base flow of local watercourses and abstractions	Tertiary: Co4 Co14 Co124	**Onshore Export Cable Corridor:** • ECC: Length: 40 km (approximate), Width: 80 m • Number of cable circuits (HVAC system): 6 • Number of cables (HVAC system): 18 • Diameter of cable: 220 mm per cable • Diameter of duct: 330 mm per cable • Cable trench: Depth: 1.5 m, Width at base: 1.5 m, Width at surface: 5 m, Target burial depth: 1.2 m • HDDs: Number: 112 • Number of crossings (HDD and Open Cut): 426	These parameters represent the maximum ground disturbance conditions within the ECC. With regards to damage to the coastline and impacts on coastal erosion during the construction phase, this impact has been assessed in Volume 2, Chapter 1: Marine Geology, Oceanography and Physical Processes.
Physical intrusion into groundwater resource (GGC-C-8)	Tertiary: Co4 Co14 Co76 Co77	**Landfall:** • Construction duration: 32 months• • Transition Joint Bays (located within Landfall compound area): Number: 6, Depth 6 m • HDD cable ducts: Number: 8, Diameter: 1 m, Length: 1.5 km	These parameters represent the maximum ground disturbance conditions both in terms

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
Installation of foundations, ground preparation, below ground works and associated activities could lead to potential contamination of underlying groundwater resources.	Co124	• HDD Entry Pits: Area: 125 m^2 per entry pit, Depth: 6 m • HDD Exit Pits: Number: 8 m, Area: 900m^2 per exit pit, Depth: 5 m • HDD burial depth: Maximum: 40 m, Minimum: 5 m • Temporary intertidal exit pit working area: 1,600 m^2 per exit pit • HDD exit pit excavated material volume: 2500m^3 **Onshore Export Cable Corridor:** • ECC: Length: 40 km (approximate), Max. Temporary Width: 80 m (excl. railway crossings), Area: 3,200,000 m^2 • Cable trench: Number: 6, Depth: 1.5 m, Width at base: 1.5 m, Width at surface: 5 m, Depth of Stabilised backfill: 1.5 m • Cable Burial: Target Depth: 1.2 m • Distance between Joint Bay/ Link Box: Minimum: 750 m, Maximum: 3,000 m • Joint Bays (JB): Total area: 39 150 m^2, Spoil volume per JB: 563 m^3, Total Spoil volume 97 962 m^3 • Link Boxes (LB): Total area: 1 566 m^2, Spoil volume per LB: 18 m^3, Total Spoil volume 3 132 m^3 **Onshore Substation:** Type of foundations not yet known - in the absence of a geotechnical investigation, worst case assessed is piling. • Permanent area of site for all infrastructure: 155,000m^2 • Maximum depth and extent of subsurface excavations or piling at OnSS: no geotechnical surveys have been carried out at this stage. Until these studies are complete the depth of any required piled foundations cannot be ascertained. • Maximum number of piles 500 (pre-cast or Continuous Flight Auger)	of potential area affected and in duration.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
Impacts on groundwater resources: Construction phase (GGC-C-11) Underground works along the cable route and at the project substation (e.g. HDD, deep excavations, piling) could introduce new contaminants into groundwater	Tertiary Co77	**Landfall:** • Construction duration: 32 months• • Transition Joint Bays (located within Landfall compound area): Number: 6, Depth 6 m • HDD cable ducts: Number: 8, Diameter: 1 m, Length: 1.5 km • HDD Entry Pits: Area: 125 m^2 per entry pit, Depth: 6 m • HDD Exit Pits: Number: 8 m, Area: 900m^2 per exit pit, Depth: 5 m • HDD burial depth: Maximum: 40 m, Minimum: 5 m • Temporary intertidal exit pit working area: 1,600 m^2 per exit pit • HDD exit pit excavated material volume: 2500m^3 **Onshore Export Cable Corridor:** • ECC: Length: 40 km (approximate), Max. Temporary Width: 80 m (excl. railway crossings), Area: 3,200,000 m^2 • Cable trench: Number: 6, Depth: 1.5 m, Width at base: 1.5 m, Width at surface: 5 m, Depth of Stabilised backfill: 1.5 m • Cable Burial: Target Depth: 1.2 m • Distance between Joint Bay/ Link Box: Minimum: 750 m, Maximum: 3,000 m • Joint Bays (JB): Total area: 39 150 m^2, Spoil volume per JB: 563 m^3, Total Spoil volume 97 962 m^3 • Link Boxes (LB): Total area: 1 566 m^2, Spoil volume per LB: 18 m^3, Total Spoil volume 3 132 m^3 **Onshore Substation** • Permanent infrastructure area: 155,000 m^2 • 500 pre-cast or Continuous Flight Auger (CFA) piles	These parameters represent the greatest number and depth of underground works associated with the cable and OnSS.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
Operation			
Sterilisation of future mineral resources (GGC-O-3) Where overlaps occur between the permanent ECC and regional geological sites and / or mineral safeguarding areas this could sterilise future resources.	Primary Co2 Tertiary Co7 Co10	**Landfall:** • Transition Joint Bays (located within Landfall compound area): Number: 6, Depth 6 m • HDD cable ducts: Number: 8, Diameter: 1 m, Length: 1.5 km • HDD Entry Pits: Area: 125 m^2 per entry pit, Depth: 6 m • HDD Exit Pits: Number: 8 m, Area: 900m^2 per exit pit, Depth: 5 m • HDD burial depth: Maximum: 40 m, Minimum: 5 m • Temporary intertidal exit pit working area: 1,600 m^2 per exit pit • HDD exit pit excavated material volume: 2500m^3 **Onshore Export Cable Corridor:** • ECC (temporary and permanent): Length: 40 km (approximate), Width: 80 m, Area: 3,200,000 m^2 • Number of cable circuits (HVAC system): 6 • Number of cables (HVAC system): 18 • Diameter of cable: 220 mm per cable • Diameter of duct: 330 mm per cable • Joint Bays: Number: 240, Depth: 2.5 m, Width: 9 m, Length: 25 m per Joint Bay • Link Boxes: Number: 240, Depth: 2 m, Width: 3 m, Length: 3 m per Link Box • Cable trench: Depth of stabilised backfill: 1.5 m, Target burial depth: 1.2 m, Width at base: 1.5 m, Width at surface: 5 m **Onshore substation:** • Permanent infrastructure area: 155,000 m^2	These parameters represent the maximum footprints, and therefore the maximum reduction in mineral resource areas, of onshore infrastructure during the operation of Hornsea Four.
Decommissioning			
Scoped out of assessment			

1.10 Assessment methodology

1.10.1.1 The assessment methodology for geology and ground conditions is presented as a variation of that included for soils and geology within Appendix C of the Scoping Report (Ørsted, 2018) with regards to sensitivity and value of receptors and the magnitude of effect upon the receptors assessed as part of this PEIR.

1.10.2 Impact assessment criteria

1.10.2.1 The criteria for determining the significance of effects is a two-stage process that involves defining the sensitivity of the receptors and the magnitude of the impacts. This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts. The terms used to define sensitivity and magnitude are based on those used in the DMRB methodology, which is described in further detail in **Volume 1, Chapter 5: Environmental Impact Assessment Methodology**.

1.10.3 Sensitivity

1.10.3.1 The sensitivity of receptors is assessed according to the criteria set out in **Table 1.10** 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 (e.g. CLR11, EA 2004). The degree of change that is considered to be acceptable is dependent on the value of a receptor, which is discussed below. It should be noted that human health is considered a high sensitivity receptor in all cases.

Table 1.10: Definition of Terms Relating to Receptor Sensitivity.

Sensitivity	Definition used in this chapter	Examples
Very High High	Very high importance and rarity, international scale and very limited potential for substitution High importance and rarity, national scale and limited potential for substitution	**Human Health** • Construction workers • Site operatives • General public (off-site) **Controlled Waters** • Groundwater SPZs 1 / 2 (including unpublished abstraction wells) • Surface Waters with WFD 'High' status objective • Surface water or groundwater supporting internationally designated or nationally important conservation sites (e.g. Special Areas of Conservation, Special Protection Area, Ramsar site / Site of Special Scientific Interest) or fisheries.
Medium	High or medium importance and rarity, regional scale, limited potential for substitution	**Controlled Waters** • Principal Aquifer (resource potential) • Groundwater SZ - total catchment. • Licenced groundwater / surface water abstractions • Surface waters with WFD Status / Potential objective 'Good'

Sensitivity	Definition used in this chapter	Examples
		• Surface water or groundwater supporting regionally important wildlife sites (Local Nature Reserves, Sites of Nature Conservation Interest) or commercial aquaculture. Mineral Resources • Mineral Safeguarding Area (regionally important resource)
Low	Low or medium importance and rarity, local scale	**Controlled Waters** • Secondary A / Undifferentiated Aquifer (resource potential) • Unlicensed water supplies • Surface waters with WFD Status / Potential objective 'Moderate' / 'Poor' • Surface water or groundwater supporting locally important wildlife or amenity site.
Negligible	Very low importance and rarity, local scale	**Controlled Waters** • Secondary B Aquifer / water-bearing Unproductive Strata (resource potential). • Surface waters with WFD Status / Potential objective 'Bad'.

1.10.4 Value

1.10.4.1 The sensitivity assessment 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 1.11.

Table 1.11: Definition of Value of 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

1.10.4.2 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 Source Protection Zone 1 areas) but have a low or negligible physical/ecological sensitivity to an effect.

1.10.5 Magnitude

1.10.5.1 Potential effects may be adverse, beneficial or neutral. The magnitude of an effect is assessed qualitatively, according to the criteria set out in **Table 1.12**. The following definitions apply to time periods used in the magnitude assessment:

- Long-term: >5 years;
- Medium-term: 1 to 5 years; and
- Short-term: <1 year.

1.10.5.2 For effects related to human health, magnitude reflects the likely increase or decrease in exposure risk for a 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.

1.10.5.3 The criteria for defining magnitude in this chapter are outlined in **Table 1.12**.

Table 1.12: Definition of Terms Relating to Magnitude of an Impact.

Magnitude of impact	Definition used in this chapter	
	Human Health Risk - Proposed Development or activity is likely to result in:	*Controlled Waters - Physical, biological or chemical effects on groundwater or surface water likely to result in:*
Major	• Permanent or major change to existing risk of exposure (Adverse / Beneficial). • Unacceptable risks to one or more receptors over the long-term or permanently (Adverse). • Prosecution e.g. under health and safety legislation (Adverse). • Remediation and *complete* source removal (Beneficial). • Construction workers at risk due to lack of appropriate personal protective equipment (Adverse).	• Permanent, long-term or wide scale effects on water quality or availability (Adverse / Beneficial). • Permanent loss or long-term derogation of a water supply source resulting in prosecution (Adverse). • Change in WFD water body status / potential or its ability to achieve WFD status objectives in the future (Adverse / Beneficial). • Permanent habitat creation or complete loss (Adverse / Beneficial). • Measurable habitat change that is sustainable / recoverable over the long-term (Adverse / Beneficial).
Moderate	• Medium-term or moderate change to existing risk of exposure (Adverse / Beneficial). • Unacceptable risks to one or more receptors over the medium-term (Adverse).	• Medium-term or local scale effects on water quality or availability (Adverse / Beneficial). • Medium-term derogation of a water supply source (Adverse).

Magnitude of impact	Definition used in this chapter	
	Human Health Risk - Proposed Development or activity is likely to result in:	*Controlled Waters - Physical, biological or chemical effects on groundwater or surface water likely to result in:*
	• Serious concerns or opposition from statutory consultees (Adverse).	• Observable habitat change that is sustainable / recoverable over the medium-term (Adverse / Beneficial). • Temporary change in status / potential of a WFD water body or its ability to meet objectives (Adverse / Beneficial).
Minor	• Short-term temporary or minor change to existing risk of exposure (Adverse / Beneficial). • Unacceptable risks to one or more receptors over the short-term (Adverse).	• Short-term or very localised effects on water quality or availability (Adverse / Beneficial). • Short-term derogation of a water supply source (Adverse). • Measurable permanent effects on a water supply source that do not impact on its operation (Adverse). • Observable habitat change that is sustainable / recoverable over the short-term (Adverse / Beneficial). • No change in status / potential of a WFD water body or its ability to meet objectives (Neutral).
Negligible	• Negligible change to existing risk of exposure. • Activity is *unlikely* to result in unacceptable risks to receptors (Neutral).	• Very minor or intermittent impact on local water quality or availability (Adverse / Beneficial). • Usability of a water supply source will be unaffected (Neutral). • Very slight local changes that have no observable impact on dependent receptors (Neutral). • No change in status / potential of a WFD water body or its ability to meet objectives (Neutral).

1.10.5.4 The significance of the effect upon geology and ground conditions is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The method employed for this assessment is presented in **Table 1.13**. Where a range for the significance of an effect is presented in **Table 1.13**, the final assessment for each effect is based upon expert judgement.

1.10.5.5 For the purposes of this assessment, any effects with a significance level of minor or less have been concluded to be not significant in terms of the EIA Regulations.

Table 1.13: Matrix used for the assessment of the significance of the effect.

		Magnitude of Impact/Degree of Change			
		Negligible	Minor	Moderate	Major
Value, Importance, Sensitivity	Low	Not Significant	Not Significant or Minor (Not Significant)	Minor (Not Significant)	Minor (Not Significant) or Moderate (Significant)
	Medium	Not Significant	Minor (Not Significant)	Moderate (Significant)	Moderate (Significant) or Major (Significant)
	High	Not Significant	Minor (Not Significant) or Moderate (Significant)	Moderate (Significant) or Major (Significant)	Major (Significant) or Substantial (Significant)
	Very High	Not Significant	Moderate (Significant) or Major (Significant)	Major (Significant) or Substantial (Significant)	Substantial (Significant)

1.11 Impact assessment

1.11.1 Construction

1.11.1.1 The impacts of the onshore construction of Hornsea Four have been assessed in relation to geology and ground conditions. The potential environmental impacts arising from the construction of Hornsea Four are listed in **Table 1.9** and **Table 1.9** details the maximum design scenario against which each potential construction phase impact has been assessed.

1.11.1.2 A description of the potential effect on geology and ground conditions receptors caused by each identified impact scoped in to the assessment is provided below (with relevant commitments incorporated within the determination of the impact magnitude). The PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) that has been used to inform the following impacts adopted a precautionary approach due to the absence of site-specific ground investigation data. As such the impacts described below also adopt a precautionary approach and therefore assumes there will be situations where potential contamination sources cannot be avoided.

Exposure of Workforce to Health Impacts (GGC-C-4).

1.11.1.3 The excavation of cable trenches, earthworks and piling (if required) and the movement and stockpiling of soils have the potential to mobilise existing ground contamination (where present), which could result in impacts to human health through dermal contact, inhalation and ingestion.

1.11.1.4 Potential Contaminants of Concern (PCOC) could be present in the Hornsea Four PEIR boundary and represent a risk to construction workers and the public (such as users of neighbouring sites and surrounding areas) if exposed during construction activities. Construction activities, particularly earthworks could disturb and expose construction workers to localised Made Ground soils and potential soil and/or groundwater contamination associated with historical and current land uses within the Hornsea Four PEIR boundary. Construction activities could create pollutant linkages through ingestion, inhalation and direct dermal contact pathways.

1.11.1.5 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 dusts.

1.11.1.6 The PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) showed that a large section of land within the Hornsea Four PEIR boundary crosses agricultural land where areas of significant contamination are not anticipated. The applicant has also committed to provide a contaminated land and groundwater scheme (Co77) to identify contamination and any required remedial measures, to be secured in the DCO by a CoCP (Co124) (**Volume F2, Chapter 2: Outline Code of Construction Practice**).

Magnitude of impact

1.11.1.7 With the inclusion of the embedded mitigation measures outlined as part of the project design, the impact is predicted to be of local spatial extent (localised to the work areas), of medium-term duration and temporary occurrence (only occurring during the works). It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **minor**.

Sensitivity of the receptor

1.11.1.8 Human health is deemed to be of high vulnerability, moderate recoverability and high value. The sensitivity of the receptor is therefore, considered to be **high**.

Significance of the effect

1.11.1.9 Overall, it is predicted that the sensitivity of the receptor is **high**, and the magnitude is **minor**. The effect is of **moderate adverse** significance due to the potential of encountering contaminated materials in areas that cannot be avoided.

Further mitigation

1.11.1.10 Where potential sources of contamination cannot be avoided, a targeted ground investigation shall be undertaken during the pre-construction stage of the project so that the potential risks can be identified, and appropriate mitigation measures put in place to protect key receptors (Co77).

1.11.1.11 Further mitigation (such as the implementation of appropriate Personal Protection Equipment (PPE) through Co76) may also be considered necessary if areas of unexpected contamination are encountered during construction works. This will involve the halting of works while a written statement on how the contamination will be dealt with, and by extension reduce the risk associated with the contamination, is produced and agreed with ERYC (Co77) and secured as part of the CoCP (**Volume F2, Chapter 2: Outline Code of Construction Practice**).

1.11.1.12 With the adoption of the additional mitigation measures the magnitude of impact will be **negligible** therefore the significance of effect is predicted to be **not significant**, which is not significant in EIA terms.

Encountering Contamination During Intrusive Works (GGC-C-5).

1.11.1.13 The PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) showed that a large section of land within the Hornsea Four PEIR boundary crosses agricultural land where areas of significant contamination are not anticipated. However, there is always the risk of encountering unforeseen contamination during construction works which could ultimately have detrimental impacts on sensitive receptors such as human health and controlled waters. The applicant has committed to prepare a contaminated land and groundwater scheme to identify any contamination and any remedial measures which may be required (Co77) and this will be secured in the DCO and embedded in the CoCP through the Outline CoCP (Co124) (**Volume F2, Chapter 2: Outline Code of Construction Practice**).

1.11.1.14 Sensitive receptors include construction workers and the public (such as users of neighbouring sites and surrounding areas), groundwater aquifers (Secondary A, B and Principal Aquifers) and associated abstractions, and surface waters specifically the River Hull headwaters which are designated as a SSSI.

Magnitude of impact

1.11.1.15 With the inclusion of the embedded mitigation measures, the impact is predicted to be of local spatial extent (localised to the work areas), of short-term duration and intermittent occurrence (only occurring during the works). It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **minor**.

Sensitivity of the receptor

1.11.1.16 The sensitivity of the human health and controlled waters receptors are considered to be **high**.

Significance of the effect

1.11.1.17 Overall, it is predicted that the sensitivity of receptors is **high** and the magnitude is minor. The effect is therefore of **moderate** adverse significance due to the potential of encountering contaminated materials.

Further mitigation

1.11.1.18 Where areas of unexpected contamination are encountered during construction works, the works will be halted whilst a written statement on how the contamination will be dealt with, and by extension reduce the risk associated with the contamination, is produced and agreed with EYRC (Co77) and secured through the Outline CoCP (**Volume F2, Chapter 2: Outline Code of Construction Practice**).

1.11.1.19 With the adoption of the further mitigation measures the magnitude of impact will be **negligible** therefore the significance of effect is predicted to be **not significant**, which is not significant in EIA terms.

Physical Intrusion into Groundwater Resource (GGC-C-8).

1.11.1.20 Note that this overarching impact relating to intrusion into groundwater resources is further delineated between differing aquifers and activities in the following sections to provide further clarity. The impact is divided into three assessment in this chapter, but retained as on line within **Volume 4, Annex 5.1: Impacts Register**.

Impacts on Groundwater Quality in the Superficial Secondary Aquifers During Earthwork Activities (GGC-C-8).

1.11.1.21 Direct impacts to the Secondary A, Secondary B and Secondary Undifferentiated Aquifers within the superficial deposits may occur due to the intrusive nature of trenching (typical burial depth of 1.2 m bgl). The significance of the disturbance will be dependent on the depth

of the aquifer unit in relation to the proposed depth of the excavation with superficial aquifers present at the surface at greater risk of direct impacts.

1.11.1.22 During construction, surface layers will be excavated, which could allow increased infiltration of rainwater and surface run-off to the subsurface. This could potentially mobilise any residual contamination already present in the overlying strata which could potentially migrate into the underlying shallow superficial aquifers. Whilst significant areas of contamination are not expected, there are parts of the proposed onshore infrastructure where crossing potentially contaminated land may be unavoidable.

Magnitude of impact

1.11.1.23 With the inclusion of the embedded mitigation measures outlined as part of the project design, the impact is predicted to be of local spatial extent (to the work areas), of medium-term duration and intermittent occurrence (only occurring during the works). It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **moderate.**

Sensitivity of the receptor

1.11.1.24 The superficial secondary aquifers are deemed to be of medium vulnerability, high recoverability and medium value. The secondary aquifers may be hydraulically connected to the deeper Principal Aquifer associated with the chalk deposits and the River Hull headwaters (SSSI). The sensitivity of the receptor is therefore, considered to be **high**.

Significance of the effect

1.11.1.25 Overall, it is predicted that the sensitivity of the receptor is **high** and the magnitude is **moderate**. The effect is therefore of **moderate adverse** significance.

Further mitigation

1.11.1.26 Where potential sources of contamination cannot be avoided, e.g. in close proximity to electricity substations (refer to **Section 1.7.1** for identified potential sources), a targeted ground investigation (Co77) shall be undertaken during the pre-construction stage of the project so that the potential risks can be identified, and appropriate mitigation measures put in place to protect key receptors e.g. the provision of appropriate PPE for construction workers (Co76) and by adopting appropriate working conditions. In addition, A PPP will be developed in accordance with the outline PPP and will include details of emergency spill procedures (Co4).

1.11.1.27 With the adoption of the additional mitigation measures the magnitude of impact would be **negligible** therefore the significance of effect is predicted to be **not significant** which is not significant in EIA terms.

Impacts on Groundwater Quality in the Principal Bedrock Aquifers Resulting from HDD (GGC-C-8).

1.11.1.28 Direct impacts to the Principal Aquifers of the Rowe Chalk Formation, Flamborough Chalk Formation and Burnham Chalk Formation may occur from deep ground workings related to horizontal drilling operations for cable installation beneath surface infrastructure (e.g. roads) and watercourses. There is potential for creating preferential pathways, for drilling mud/other contaminants to leak along the drill path, which could cause contamination of groundwater. The potential for other contaminants only being of concern in areas that cannot be avoided during the construction works. 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.

Magnitude of impact

1.11.1.29 With embedded mitigation measures included within the project design (e.g. Bentonite Break Out Plan secured through **Volume F2, Chapter 2: Outline Code of Construction Practice**), the impacts are predicted to be of local spatial extent, short term duration, intermittent and of high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **minor**.

Sensitivity of the receptor

1.11.1.30 The Principal Aquifer which underlies the superficial deposits beneath the Hornsea Four PEIR boundary is deemed to be of low vulnerability, high recoverability and medium value. There are a number of groundwater abstractions and groundwater source protection zones associated with the Principal Aquifer, and the groundwater body is also likely to be hydraulically connected to the River Hull headwaters (SSSI). The sensitivity of the receptor is therefore considered to be **high**.

Significance of the effect

1.11.1.31 Overall, it is predicted that the sensitivity of the receptor is **high** and the magnitude of impact is **minor**. The effect is of **moderate adverse** significance.

Further mitigation

1.11.1.32 Where potential sources of contamination cannot be avoided, targeted ground investigation (Co77) shall be undertaken during the pre-construction stage of the project so that the potential risks can be identified, and appropriate mitigation measures put in place

to protect key receptors e.g. the provision of appropriate PPE for construction workers and by adopting appropriate working conditions (Co76).

1.11.1.33 With the adoption of the additional mitigation measures the magnitude of impact would be **negligible** therefore the significance of effect is predicted to be **not significant**, which is not significant in EIA terms.

Impacts on Groundwater Quality in the Principal Aquifer (including SPZ areas and abstractions) Resulting from Piling (GGC-C-8).

1.11.1.34 Direct impacts to the Principal Aquifers of the Rowe Chalk Formation, Flamborough Chalk Formation and Burnham Chalk Formation may occur as a result of piling. Piling may be required to provide the foundations for the onshore substation. Piling has the potential to create preferential pathways through the superficial deposits allowing potential contamination of the underlying Principal Aquifers.

1.11.1.35 The Secondary Aquifers are considered to be linked to the underlying Principal Aquifers and the groundwater units are likely to be hydraulically connected with the River Hull headwaters (SSSI). 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.

1.11.1.36 The research undertaken to support the development of the PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) showed that a large section of land within the Hornsea Four PEIR boundary crosses agricultural land where areas of contamination are not anticipated. However, piling activities, if required, are anticipated to be undertaken in areas immediately adjacent to potential sources of contamination e.g. historic landfills at the OnSS site.

Magnitude of impact

1.11.1.37 With embedded mitigation measures (secured through the **Volume F2, Chapter 2: Outline Code of Construction Practice**) included within the project design, which include ground investigations at the OnSS to facilitate an understanding of the ground conditions and to inform potential mitigation measures (Co77), which will be agreed with the relevant stakeholders, and the adoption of Environment Agency guidance 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination (Environment Agency, 2001) (Co6) the impact is predicted to be of local spatial extent, short term duration, intermittent occurrence and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **negligible**.

1.11.1.38 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 1.13**; **Volume 1, Chapter 5: EIA Methodology**) and is not considered further in this assessment.

Impacts on Controlled Waters as a Result of Dewatering of Trenches and Excavations (GGC-C-7).

1.11.1.39 There is a 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 paths. However, the applicant has committed to installing drainage channels either side of the onshore ECC to ensure that direct impacts to the hydraulic regime within the Hornsea Four PEIR boundary and indirect impacts to the hydraulic regime within the 1 km Hornsea Four geology and ground conditions study area are not altered by construction activities (Co19).

Magnitude of impact

1.11.1.40 With the inclusion of the embedded mitigation measures outlined as part of the project design, the impact is predicted to be of local spatial extent, of short-term duration, intermittent occurrence and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **negligible**.

1.11.1.41 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 1.13**; **Volume 1, Chapter 5: EIA Methodology**) and is not considered further in this assessment.

Impacts on Groundwater Resources Through Introduction of Contamination via Deep Excavations (GGC-C-11).

1.11.1.42 Direct impacts to groundwater resources within the Secondary Aquifers associated with the superficial deposits and the Principal Aquifers associated with the Rowe Chalk Formation, Flamborough Chalk Formation and Burnham Chalk Formation may occur as a result of underground works along the onshore ECC and OnSS associated with HDD, deep excavations and/or piling. HDD, deep excavations and piling has the potential to create new preferential pathways through the superficial deposits allowing potential contamination of the underlying Principal Aquifers.

1.11.1.43 The Secondary Aquifers are considered to be linked to the underlying Principal Aquifers and the groundwater units. Leaching and groundwater transport may occur as a result of new hydraulic connections between shallow perched groundwater and groundwater associated with the Principal Aquifer thus potentially impacting groundwater resources.

1.11.1.44 The research undertaken to support the development of the PRA (**Volume 6, Annex 1.1: Land Quality Preliminary Risk Assessment**) showed that a large section of land within the Hornsea Four PEIR boundary crosses agricultural land where areas of contamination are not anticipated. There are parts of the proposed onshore infrastructures where crossing potentially contaminated land may be unavoidable and the applicant has committed to

developing a contaminated land and groundwater scheme to identify any such contamination and any remedial measures which may be required (Co77).

Magnitude of impact

1.11.1.45 With the inclusion of the embedded mitigation measures outlined (notably Co77) as part of the project design (secured through **Volume F2, Chapter 2: Outline Code of Construction Practice**), the impact of HDD, deep excavations and / or piling are predicted to be of local spatial extent, short term duration, intermittent occurrence and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **negligible**.

1.11.1.46 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 1.13**; **Volume 1, Chapter 5: EIA Methodology**) and is not considered further in this assessment.

Future monitoring

1.11.1.47 Where it is not possible to avoid areas previously identified as potential sources of contamination, targeted ground investigations are proposed during the pre-construction stage of the project (Co77). Within the CoCP (Co124) the requirement for ground gas and groundwater monitoring (Co77), which will allow for appropriate mitigation measures to be identified and / or for remediation to be undertaken, will also be detailed.

1.11.2 Operation and Maintenance

Sterilisation of Future Mineral Resources (GGC-O-3).

Magnitude of impact

1.11.2.1 The installation of cables within the onshore ECC and the permanent footprint of Landfall and OnSS infrastructure within areas identified as strategic Mineral Safeguarding Areas (see **Figure 1.9** to **Figure 1.13**) would prevent future extraction of resources within the permanent footprint of the project for the duration of the project's lifetime (35 years). Based on the MDS details presented in **Table 1.9** up to approximately 1.75 km^2 of Mineral Safeguarding Area is within the direct footprint of Hornsea Four, equating to 0.18 % of the total Mineral Safeguarding Area recorded within the ERYC area. The impacts are predicted to be permanent and would affect the receptor directly. Given the small proportion of the total safeguarded area within the local authority boundary that would effectively be sterilised permanently (or at least as long as Hornsea Four is operational) the magnitude of impact is considered to be **minor**.

Sensitivity of the receptor

1.11.2.2 Mineral Safeguarding Areas are considered to be of regional importance. The sensitivity of the receptor is, therefore considered to be **medium**.

Significant of the effect

1.11.2.3 The overall significance of impact on mineral resource availability during the operational phase of Hornsea Four is considered to be **minor adverse** which is not significant in EIA terms.

1.11.3 Decommissioning

1.11.3.1 It is expected that the detail and scope of the decommissioning works for the landfall, onshore ECC and OnSS will be determined by the relevant rules and regulations, as well as industry best practices at the time of decommissioning with an associated Decommissioning Plan being subsequently prepared (Co127).

1.11.3.2 It is considered that impacts associated with the decommissioning phase will be of equal and no more than those identified for the construction phase with no additional significant effects identified above those set out for the construction phase. The onshore export cables will be left in situ underground with the cable ends cut, sealed and securely buried. The external structures of the jointing pits and link boxes along the corridor will be removed only if it is feasible with minimal environmental disturbance. All relevant construction management, mitigation and project commitments are applicable to the decommissioning phase also.

1.11.3.3 Potential impacts arising from the decommissioning phase of Hornsea Four have been scoped out of further assessment following consultation with the Planning Inspectorate.

1.12 Cumulative effect assessment (CEA)

1.12.1.1 Cumulative effects can be defined as effects upon a single receptor from Hornsea Four when considered alongside other proposed and reasonably foreseeable projects and developments. This includes all projects that result in a comparative effect that is not intrinsically considered as part of the existing environment.

1.12.1.2 The overarching method followed in identifying and assessing potential cumulative effects in relation to the onshore environment is set out in **Volume 4, Annex 5.5: Onshore Cumulative Effects** and **Volume 4, Annex 5.6: Location of Onshore Cumulative Schemes**. The approach is based upon the Planning Inspectorate (PINS) Advice Note 17: Cumulative Effects Assessment (PINS, 2017). The approach to the CEA is intended to be specific to

Hornsea Four and takes account of the available knowledge of the environment and other activities around the Hornsea Four PEIR boundary.

1.12.1.3 The CEA has followed a four-stage approach developed from Advice Note 17. Each of the four stages is identified in **Table 1.14** along with commentary specifically relating to geology and ground conditions.

Table 1.14: Stages and activities involved in the CEA process.

CEA stage	Activity
Stage 1 – Establish the project's Zone of influence (ZoI) and establish a long-list of developments	Through consultation it has been identified that potential developments that need considering as part of the onshore CEA are restricted to those within the east Riding of Yorkshire Council (ERYC) area. To determine a 'long-list' of possible projects for inclusion in the CEA the following actions have been carried out: • Interrogation of the ERYC planning portal (latest review is May 2019); and • Discussion of potential projects for specific inclusion in the CEA at the Evidence Plan meetings. To date these processes have identified 17 potential projects which form the 'long-list'. In order to attribute an element of certainty to the assessment each project has been assigned a Tier reflecting their current status within the planning and development process. The full list of projects and relevant tiers assigned can be found in Appendix A of **Volume 4, Annex 5.5: Onshore Cumulative Effects**. The location of the projects is provided in **Volume 4, Annex 5.6: Location of Onshore Cumulative Schemes**.
Stage 2 – Screening of long list: Identify a shortlist of other developments for the CEA	With regards to the CEA the predicted effects predominantly relate to direct effects, a 1 km buffer was selected to ensure that the indirect impacts on geology and ground conditions were appropriately included. It is considered unlikely that significant effects greater than this distance would occur given the impacts under assessment. Impacts greater than this distance had also previously not been assessed as part of the PRA which has been used to inform the PEIR chapter.
Stage 3 – Information gathering	Where available information on the other developments within the shortlist generated at Stage 2 has been collated to inform the CEA. At this stage (PEIR) information is of high level unless explicitly discussed with ERYC. The information collected on each project is presented in **Volume 4, Annex 5.5: Onshore Cumulative Effects** and **Volume 4, Annex 5.6: Location of Onshore Cumulative Schemes**.
Stage 4 - Assessment	The CEA has been undertaken in two stages: • Each of the potential effects that are subject to assessment alone have been reviewed against the potential for cumulative effects to occur. • A CEA assessment of each of the other developments on the short-list has taken place for those effects where it is considered that potential cumulative impacts could occur.

CEA stage	Activity
	The assessment also includes, where relevant, consideration of any mitigation measures where adverse cumulative effects are identified and signposts to the relevant means of securing mitigation.

1.12.2 CEA Stage 2 Shortlist and Stage 3 Information Gathering

1.12.2.1 A short list of projects for CEA has been produced using the screening buffer/criteria set out in **Table 1.14**. Information regarding all projects is provided in **Volume 4, Annex 5.5: Onshore Cumulative Effects** and **Volume 4, Annex 5.6: Location of Onshore Cumulative Schemes**. Summary information on the short-list projects for geology and ground conditions is provided in **Table 1.15**.

1.12.2.2 Eight other projects have been identified for inclusion on the short-list of projects to be assessed cumulatively. The remaining nine projects have not been considered as resulting in likely cumulative significant effects as they are located in excess of 1 km from the Hornsea Four PEIR boundary. The eight projects can be summarised as:

- Four offshore wind farm projects that require the construction of an OnSS and associated onshore ECC elements projects;
- Alteration of agricultural buildings;
- An energy storage (battery) project;
- A highways improvement scheme; and
- A new business, general industry and storage/distribution facility.

1.12.3 CEA Stage 3 Assessment

1.12.3.1 As stated in the previous table the assessment is undertaken in two stages:

- **Table 1.15** sets out the potential impacts assessed in this chapter and identifies the potential for cumulative effects to arise, providing a rationale for such determinations; and
- **Table 1.16** sets out the CEA for each of the projects/developments that have been identified on the short-list of projects screened.

1.12.3.2 It should be noted that stage 2 is only undertaken if stage 1 identifies that cumulative effects are possible. This summary assessment is set out in **Table 1.15.**

Table 1.15: Potential Cumulative Effects.

Impact		Potential for Cumulative Effect?	Rationale
Construction			
1	Exposure of work force to health impacts.	Yes	Impact to both onsite and offsite human health receptors, e.g. via generation of dusts, which may be exacerbated by other projects.
2	Encountering contamination during intrusive works	No	The impacts will be confined to the work area.
3	Physical intrusion into groundwater resource - Impacts on groundwater quality in superficial secondary aquifers during earthworks activities.	Yes	Impacts to secondary aquifers may be exacerbated by other projects.
4	Physical intrusion into groundwater resource - Impacts on groundwater quality in principal bedrock aquifers resulting from HDD.	Yes	Impacts to principal aquifers may be exacerbated by other projects.
5	Physical intrusion into groundwater resource - Impacts on groundwater quality in principal bedrock aquifers resulting from piling.	Yes	Impacts to principal aquifers may be exacerbated by other projects.
6	Physical intrusion into groundwater resource - Impacts on controlled waters as a result of dewatering of trenches and excavations.	Yes	Impacts to groundwater may be exacerbated by other projects.
7	Impacts on groundwater resources - Underground works along the cable route and at the project substation (e.g. HDD, deep excavations, piling) could introduce new contaminants into groundwater	Yes	Impacts to groundwater resources may be exacerbated by other projects.
Operation			
8	Sterilisation of future mineral resources	No	The impacts will be confined to the work area.
There are unlikely to be any additional significant cumulative impacts from the operation of the project.			
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 (Co127). As such, cumulative impacts during the decommissioning stage are assumed to be the same as those identified during the construction stage. Additionally, PINS have stated in their Scoping Opinion that cumulative decommissioning effects are scoped out of the EIA.			

1.12.3.3 The second stage of the CEA is a project specific assessment of the potential for any significant cumulative effects to arise due to the construction and/or operation and maintenance of Hornsea Four. To identify whether this may occur each shortlisted project is discussed in **Table 1.16**.

1.12.3.4 The CEA has not identified impacts that are considered to be of any greater significance than those identified in isolation and no cumulative effects of significance are forecast.

Table 1.16: Project Screening for CEA for Geology and Ground Conditions.

Project	Description	Location Description (relative to Hornsea Project Four PEIR Boundary)	Discussion	Likelihood and Significance of Cumulative Effects
Bridge House Wind Farm – Associated Facilities	Erection of a substation building and underground electricity cable in association with previously approved wind turbine.	Located north-west of cable centreline, outside of the Hornsea Four boundary. Associated infrastructure including electricity cable will travel within the Hornsea Four boundary. 384m NW of PEIR Boundary	As the Bridge House Wind Farm substation (total floor area of only 24.23 m^2) has already been built and is considered to be operational, no cumulative impacts on any shared receptors identified are predicted.	No potential for significant cumulative effects.
Lawns Farm Park Battery Storage	Construction of a 49.5MW Battery Storage Facility (17 battery units) with associated infrastructure and landscaping.	Works are located east of OnSS within the Hornsea Four boundary.	As the battery storage facility is predicted to finish construction in 2021 and will potentially be operational during the construction period of Hornsea Four no cumulative impacts on any shared receptors identified are predicted. However, should there be any delays with the construction of the battery storage facility, the scale of the development (0.7 ha), the use of reinforced concrete foundations and the inclusion of appropriate mitigation measures (e.g. CoCP) into the design limit the potential for cumulative effects to occur.	No potential for significant cumulative effects.
Jocks Lodge Highway Scheme	EIA Screening Opinion - A164 and Jocks Lodge Highway Improvement Scheme	Works occurring on the A1079. 700 m north-west of Hornsea Four boundary access track.	Due to the proximity of the development to the project there is the potential for cumulative effects of a direct and / or indirect nature on the receptors identified. However, due to the nature of the development and the regulatory regime under which it will be constructed, it is	No potential for significant cumulative effects.

Project	Description	Location Description (relative to Hornsea Project Four PEIR Boundary)	Discussion	Likelihood and Significance of Cumulative Effects
			assumed (with high confidence) that appropriate mitigation measures are to be incorporated into the design thus limiting the potential for cumulative effects to occur.	
Dogger Bank – Creyke Beck A	The consent application submitted allows for up to 400 wind turbines in total, therefore currently being split across the two phases. Project Capacity 1000-1200MW.	Windfarm located 131km offshore. The converter station would be north of the A1709 between Beverley and Cottingham in the East Riding of Yorkshire. The cable route would then connect to the National Grid at the existing substation at Creyke Beck. Cable landing point is between Barmstone and Ulrome.	As Creyke Beck A is predicted to finish construction in 2022 and will potentially be operational during the construction period of Hornsea Four no cumulative impacts on any shared receptors identified are predicted. However, should there be any delays with the construction of the Creyke Beck A, the works will take place under a DCO and appropriate mitigation measures (e.g. CoCP and piling risk assessments etc.) will be incorporated into the design thus limiting the potential for cumulative effects to occur.	No potential for significant cumulative effects.
Dogger Bank – Creyke Beck B	The consent application submitted allows for up to 400 wind turbines in total, therefore currently being split across the two phases. Project Capacity 1000-1200MW.	Windfarm located 131km offshore. The converter station would be north of the A1709 between Beverley and Cottingham in the East Riding of Yorkshire. The cable route would then connect to the National Grid at the existing substation at Creyke Beck. Cable landing	As Creyke Beck B is predicted to finish construction in 2022 and will potentially be operational during the construction period of Hornsea Four no cumulative impacts on any shared receptors identified are predicted. However, should there be any delays with the construction of the Creyke Beck A, the works will take place under a DCO and appropriate mitigation measures (e.g. CoCP and piling risk assessments etc.) will be incorporated into the design thus limiting the potential for cumulative effects to occur.	No potential for significant cumulative effects.

Project	Description	Location Description (relative to Hornsea Project Four PEIR Boundary)	Discussion	Likelihood and Significance of Cumulative Effects
		point is between Barmstone and Ulrome.		
Teckno Developments Site	Erection of a building for Business (B1), General Industry (B2) and Storage/Distribution (B8) uses and erection of a boundary fence.	Located approximately 210 m west of the Hornsea Four boundary, south of the A1035.	As the site is due to finish construction in 2019 and will be operational during the construction of Hornsea Four, no cumulative impacts on any shared receptors identified are predicted. However, due to the nature of the development it is assumed (with high confidence) that appropriate mitigation measures are to be incorporated into the design thus limiting the potential for cumulative effects to occur.	No potential for significant cumulative effects.
Elm Tree Farm Substation and Access Track	Erection of a substation building and construction of an access track in connection with approved wind turbine	Substation is located approximately 196m from the Hornsea Four boundary. Construction access tracks due to extend west and north outside of the Hornsea Four boundary.	As the substation has already been built and is considered to be operational, no cumulative impacts on any shared receptors identified are predicted. However, due to the nature of the development it is assumed that appropriate mitigation measures are to be incorporated into the design thus limiting the potential for cumulative effects to occur.	No potential for significant cumulative effects.
Low Farm Dunswell Lane, Dunswell	Erection of glasshouses, automated bedding units and wind breaks to outdoor planting beds, external and internal alterations to redundant agricultural buildings to allow conversion to offices and stores, relocation of workers caravans, construction of reservoir with installation of	1.1km east of the Hornsea Four boundary.	Due to the nature of the development and the distance from the Hornsea Four PEIR boundary no cumulative effects on receptors identified are considered likely.	No potential for significant cumulative effects.

Project	Description	Location Description (relative to Hornsea Project Four PEIR Boundary)	Discussion	Likelihood and Significance of Cumulative Effects
	drainage infrastructure across the site and creation of access to Low Farm. 5 passing places along Long Lane and junction improvements onto the A1174 (Hull Road)			

1.13 Transboundary effects

1.13.1.1 A screening of transboundary impacts has been carried out and is presented in Appendix K of the Scoping Report (Ørsted, 2018). This screening exercise identified that there was no potential for significant transboundary effects regarding geology and ground conditions from Hornsea Four upon the interests of other EEA States and this is not discussed further.

1.14 Inter-related effects

1.14.1.1 Inter-related effects consider impacts from the construction, operation or decommissioning of Hornsea Four on the same receptor (or group). The potential inter-related effects that could arise in relation to geology and ground conditions are presented in **Table 1.17**. Such inter-related effects include both:

- Project lifetime effects: i.e. those arising throughout more than one phase of the project (construction, operation, and decommissioning) to interact to potentially create a more significant effect on a receptor than if just one phase were assessed in isolation; and
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor (or group). Receptor-led effects might be short term, temporary or transient effects, or incorporate longer term effects.

1.14.1.2 A description of the process to identify and assess these effects is presented in Section 2 of **Volume 1, Chapter 5: Environmental Impact Assessment Methodology**.

Table 1.17: Inter-related effects assessment for geology and ground conditions.

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
Project-lifetime effects			
There are no potential impacts that are scoped in to this assessment and could therefore constitute a cumulative project lifetime effect.			
Receptor-led effects			
Impacts on human health, including construction workers and members of the public during any excavations associated with construction, operation and decommissioning.		The greatest potential for impacts on human health will be during the construction phase of the project. There are unlikely to be significant additional impacts from the operation of the project as any maintenance work will follow standard procedures (e.g. Co4) thereby minimising potential impacts. Whilst details regarding the decommissioning are unknown, it is anticipated that, using a worst-case scenario, the impacts would be similar to those during construction. However, these two phases are significantly temporally separate that there will be no interaction between the two.	

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
Impacts on the quantity and quality of controlled waters fed during construction, operation and decommissioning.		The greatest potential for spatial and temporal interactions is likely to occur during construction. There are unlikely to be significant additional impacts from the operational phase of the project as any maintenance work will be conducted in accordance with standard procedures (e.g. Co4) thereby minimising potential impacts. Whilst details regarding the decommissioning are unknown, it is anticipated that, using a worst-case scenario, the impacts would be similar to those during construction. It is not anticipated that any inter-related effects will be produced that are of greater significance than those already identified.	
Mobilisation of soil contaminants to surface water via run-off		The greatest potential for spatial and temporal interactions is likely to occur if contamination is encountered during the intrusive works (i.e. during the construction phase). Impacts in relation to the mobilisation of soil contaminants to surface water via run-off have not been assessed within this chapter (refer to **Volume 4, Annex 5.1; Impacts Register** for further details) and have been scoped out of the Hydrology and Flood Risk chapter (**Volume 3, Chapter 2**). It is therefore not anticipated that any inter-related effects will be produced.	
Physical and chemical degradation of soils		The greatest potential for spatial and temporal interactions is likely to occur during earthwork activities (i.e. during the construction and decommissioning phases). The individual impacts in relation to ecology are yet to be assessed and therefore the inter-related effects have not been assessed within this PEIR chapter but will be included in the final Environmental Statement.	
Mobilisation of potentially contaminated dust		The greatest potential for spatial and temporal interactions is likely to occur during earthwork activities (i.e. during the construction phase). However, the effects of construction phase dust emissions were scoped out of the air quality assessment as a range of control measures will be implemented as part of the embedded mitigation, therefore the inter-related effects are considered insignificant.	

1.15 Conclusion and summary

1.15.1.1 A summary of the findings of the PEIR for geology and ground conditions is presented in **Table 1.18**. In accordance with the assessment methodology, this table should only be used in conjunction with the additional narrative explanations provided in **Section 1.11**. Through implementation of the mitigation measures identified (both embedded and additional) to prevent impacts on receptors from the project, potential impacts are anticipated to be not significant to minor adverse in relation to geology and ground conditions, and therefore non-significant in EIA terms for the all phases of development.

Table 1.18: Summary of potential impacts assessed for geology and ground conditions.

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
Construction				
Exposure of Workforce to Health Impacts (GGC-C-4)	Construction workers and site neighbours High sensitivity	Minor magnitude of impact, moderate adverse significance	Tertiary: Co76 Co77 Co124	Not significant
Encountering Contamination During Intrusive Works (GGC-C-5)	Construction workers and site neighbours; Secondary and Principal Aquifers, Abstractions and surface waters High sensitivity	Minor magnitude of impact, moderate adverse significance	Tertiary: Co64 Co77 Co124	Not significant
Physical Intrusion into Groundwater Resource (GGC-C-8) - Impacts on Groundwater Quality in the Superficial Secondary Aquifers During Earthwork Activities	Secondary A, B and Secondary Undifferentiated Aquifers, River Hull headwaters (SSSI) High sensitivity	Moderate magnitude of impact, moderate adverse significance	Tertiary: Co4 Co14 Co76 Co77 Co124	Not significant
Construction Impact Three: Physical Intrusion into Groundwater Resource (GGC-C-8) - Impacts on Groundwater Quality in the Principal Bedrock Aquifer Resulting from HDD	Principal Aquifer, groundwater abstractions, River Hull headwaters (SSSI) High sensitivity	Minor magnitude of impact, moderate adverse significance	Tertiary: Co4 Co14 Co77 Co124	Not significant
Construction Impact Three: Physical Intrusion into Groundwater Resource (GGC-C-8)- Impacts on Groundwater Quality in the Principal Aquifer (including SPZ	Principal Aquifer, groundwater abstractions, River Hull headwaters (SSSI) High sensitivity	Negligible magnitude of impact, minor adverse significance	Tertiary: Co4 Co6 Co14 Co77 Co124	Not significant

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
areas and abstractions) Resulting from Pilings				
Construction Impact Three: Physical Intrusion into Groundwater Resource (GGC-C-7) - Impacts on Controlled Waters as a result of Dewatering of Trenches and Excavations	River Hull headwaters (SSSI) High sensitivity	Negligible magnitude of impact, minor adverse significance	Tertiary: Co4 Co14 Co124	Not significant
Impacts on Groundwater Resources Through Introduction of Contamination via Deep Excavations (GGC-C-11)	Secondary A, B, Secondary Undifferentiated and Principal Aquifers High sensitivity	Negligible magnitude of impact, minor adverse significance	Tertiary: Co4 Co6 Co14 Co77 Co124	Not significant
Operation				
Sterilisation of future mineral resources (GGC-O-3)	Mineral Safeguarding Areas Medium sensitivity	Permanent sterilisation of 1.75 km2 (0.18% of total Mineral Safeguarding Areas within ERYC) is a minor adverse magnitude of impact, minor adverse significance	Primary: Co7 Tertiary: Co10	Minor adverse significance

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