Hornsea Project Four: Environmental Statement (ES)

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Volume 5, Annex 11.1: Offshore Installation Interfaces Part 1

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Hornsea Four Offshore Wind Development
Offshore Installations Interfaces


INTELLIGENT
ENGINEERING

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1 Executive Summary

1.1.1.1.1 Orsted Hornsea Project Four Ltd (hereafter the 'Applicant') is proposing to develop the Hornsea Project Four offshore wind farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 37 nm (69 kilometres (km)) east of the United Kingdom (UK) coast, at Flamborough Head, East Riding of Yorkshire. The project has an Agreement for Lease (AfL), granted by The Crown Estate, for an area of up to 868 km2.

1.1.1.1.2 Hornsea Four adopted a major site reduction from the array area presented at Scoping (868 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and Development Consent Order (DCO) application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the site boundaries is detailed in Volume A1, Chapter 3: Site Selection and Consideration of Alternatives and Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure. This concession is taken into account in the assessments conducted in this annex. The Hornsea Four offshore DCO limits are presented in Figure 3-1.

1.1.1.1.3 Hornsea Four is proximate to a number of Oil and Gas (O&G) operations resulting in important interactions.

1.1.1.1.4 EPConsult Energies Ltd. (EPEn) has been commissioned to undertake an Offshore Installations Interfaces (OII) study, specifically to address, from the perspective of additional safety impacts, all considerations associated with O&G operations as a result of interactions with Hornsea Four.

1.1.1.1.5 This OII report, which is an annex to ES Chapter (Volume A2, Chapter 11: Infrastructure and Other Users) presents potential hazards and associated additional safety risks to the existing operations as a result of implementation and operation of Hornsea Four. The report will enable readers interested in the safety impacts on O&G operations arising from the presence of Hornsea Four to find all key information in one place. Figure 2-1 provides an overview of the DCO application documents relevant for O&G and how they interlink.

1.1.1.1.6 The methodology applied follows and meets the regulatory requirements for UK continental offshore works, which is framed in the UK Offshore Safety Directive Regulator (OSDR) and supported by the statutory provisions such as the Health and Safety Executive Offshore Installations Safety Case Regulations (HSE-UK SCR) (HSE, 2015) among others. These Safety Case Regulations (SCRs) set out the way the OSDR assesses an O&G duty-holder's approach to identifying and managing adverse major events that may affect the health, safety and environment on O&G assets. The OSDR oversees oil and gas operations in external waters, that is, the territorial sea adjacent to Great Britain and any designated area within the United Kingdom Continental Shelf (UKCS). The SCRs apply to offshore operations and take account of the presence of any equipment/ operation beyond 500 m of assets on which the safety of the installation or the emergency response capability may depend.

1.1.1.1.7 The OII approach in assessing Hornsea Four's impact on O&G operations is considered appropriate by reference to standards applied in the O&G industry. The OII methodology was issued for comments to O&G operators prior to initiating the assessment. Details of the OII methodology and structure are presented in Section 5 and Section 6 of this report.

1.1.1.1.8 For the completeness of the OII in effectively assessing Hornsea Four's additional safety impact on O&G operations, hazards were identified based on consultation meetings with O&G operators. In addition, as a check-list approach, UK offshore safety guidelines were deployed to secure a comprehensive review of all potential hazards.

1.1.1.1.9 The continuous process of identification of Major Accident Hazards (MAHs), including those that can result in a Major Environmental Incident (MEI), is one of the requirements of the HSE-UK SCR (HSE, 2015). Compliance with this requirement is part of the demonstration of adequate management of MAHs. The HSE Inspectors SCR assessment/ inspection guidance approach has been applied in this OII assessment using Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006) as a baseline for the study. This ensures that the OII addresses potential safety issues that are in line with the HSE-UK SCR's topic areas of interest.

1.1.1.1.10 GASCET (HSE, 2006), provides a comprehensive list of topic areas that a duty holder for a typical offshore O&G installation in the UKCS should analyse in order to demonstrate compliance with the SCR. The OII assessment approach takes this framework and applies it for Hornsea Four construction and operations activities in order to assess the potential additional safety and asset risks to O&G operations. Details of GASCET (HSE, 2006) are presented in section 6.2.2 of this report.

1.1.1.1.11 Specialist reports were developed separately and fed into the assessments and conclusions derived in the OII. These reports focus on topic areas such as helicopter access, vessel detection (radar), vessel allision, route deviation and access risks, and a Simultaneous Operations (SIMOPS) workshop was also carried out. The reports constitute the OII appendices and include Appendix A: Helicopter Access Report; Appendix B: Rader Early Warning Technical Report, Appendix C: Allision Technical Report, Appendix D: Premier Oil – Hornsea Four SIMOPS Workshop (non-confidential version), and Appendix E: Hornsea Four Oil & Gas Consultation Standalone Report (see Figure 2-1).

1.1.1.1.12 In order to ensure that the interests of all relevant O&G stakeholders with operations proximate to Hornsea Four are considered, tier groupings (Tier 1, Tier 2, and Tier 3) are used to categorise each asset by distance from Hornsea Four. Each tier group is further divided into sub-groups (Platform, Platform Systems, and Associated Systems) to assist in the identification of hazards in a structured manner. Details of the tier groups and sub-groups are presented in sections 4.2 and 6.2.

1.1.1.1.13 Future developments are considered only if material documentation has been submitted to the relevant authority, is publicly available, or has been provided by the operator to Hornsea Four.

1.1.1.1.14 In summary, in this OII assessment of additional safety risks to O&G operations, it is revealed that while Hornsea Four will have some impact, additional safety risks were generally found to be negligible or acceptable.

1.1.1.1.15 In assessing the potential impact on O&G vessel operations, the assessment revealed that while Hornsea Four will have some impact due to vessel route changes and proximity of operations to Hornsea Four, additional safety risks were generally found to be negligible or acceptable, depending on asset location. It is observed that route deviations do not result in significant changes to the number of vessels moving closer to surface facilities. It should be noted that due to proximity of some operations to Hornsea Four, there may be an impact on access, however the impacts are not safety related. For example, Hornsea Four may impact operations such as decommissioning within the array. The extent of such impact will be dependent on the relevant stakeholder's cessation of production and decommissioning plans.

1.1.1.1.16 In assessing the potential impact on helicopter operations, considerations are given to Hornsea Four's obligation under the Civil Aviation Authority (CAA) publication, CAP 764, to undertake consultation when a development is within 9 nm of an offshore helicopter destination. CAP 764 implies that operations outside 9 nm of the helicopter's destination will not be impacted. Where the helicopter's offshore destination is within 9 nm of Hornsea Four, it is observed that the safety risks will remain unchanged, albeit with a slight reduction in access, as the approach and take-off will not be affected by the presence of Hornsea Four due to flight procedures and regulations taking account of all obstacles.

1.1.1.1.17 The OII also assesses the safety implications of Hornsea Four on other topic areas such as emergency response, non-process fires and explosions, impairment of radar and communication systems, human factors, loss of containment from pipelines (including fatigue/ vibration, dropped objects, seismic events, anchor snagging/dropping, etc.). These are presented in the relevant sections for each O&G stakeholder.

1.1.1.1.18 The assessment takes account of existing risk management controls such as Safety and Environmental Critical Elements (SECE), safety zones and marine safety management systems already in place in the UK North Sea. In addition, the risk assessment also considers the list of Commitments that Hornsea Four has established as part of progressing the DCO application. The commitments are all measures that will further reduce safety and asset risks during the construction and operations phase of Hornsea Four.

1.1.1.1.19 The findings and conclusions of the OII are presented in sections 7 to 19. It was found that the incremental additional risks to safety and asset risks are generally broadly acceptable.

1.1.1.1.20 An essential element of securing the relatively low interface risks while the project matures, is to maintain the consultation process on an ongoing basis and to progress co-existence plans between Hornsea Four and the different O&G operators.

1.1.1.1.21 In addition to these hazards and safety assessments, there are also a number of commercial impacts that need consideration. These are separate from the safety assessments in sections 7 to 19. For example, where a safety assessment has been concluded as "broadly acceptable", this means the risk to safety is considered low but there may still be commercial impacts e.g., related to access or lost production time. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation. These commercial considerations are addressed in **Section 20:** Commercial Considerations of this OII report.

2 Preliminaries

2.1 How to Navigate the Offshore Installations Interfaces Annex

2.1.1 Background

2.1.1.1.1 The Hornsea Project Four Offshore Wind Farm (hereafter Hornsea Four) is proximate to many Oil and Gas (O&G) installations and activities, resulting in complex interactions. This Offshore Installations Interfaces Annex (document reference 5.11.1) has been specifically created to cover all O&G considerations, enabling readers interested in O&G to find all key information in one place.

2.1.1.1.2 O&G interactions feature in several of the Environmental Impact Assessment (EIA) topic areas including Shipping and Navigation; Aviation and Radar; and Infrastructure and Other Users. However, the main assessments take place within this Annex, which focusses on the impacts on O&G assets and operations in their own right and using an assessment approach that is considered appropriate by reference to standards applied in the O&G industry.

2.1.1.1.3 Figure 2-1 provides an overview of the Development Consent Order (DCO) Application documents that are relevant for O&G and how they interlink. In addition to this Annex, other relevant EIA documents can be summarised as follows:

- Volume A2, Chapter 11: Infrastructure and Other Users forms part of the Environmental Statement (ES) which supports the DCO application for Hornsea Four under the Planning Act 2008. This chapter presents relevant policies, consultation undertaken to date, summarises the findings of the O&G assessments set out in this Offshore Installations Interfaces Annex and presents the results of the EIA for other infrastructure and seabed users;
- Volume A2, Chapter 7: Shipping and Navigation presents the results of the EIA for shipping and navigation receptors (i.e., passing vessel traffic) and vessel-to-vessel collision risk, with the effects on the O&G industry considered separately within Appendix C: Allision Technical Report of Volume A5, Annex 11.1: Offshore Installation Interfaces. Whilst the focus is on commercial shipping, O&G stakeholders may be interested in reference to O&G vessel activity gathered from vessel traffic surveys and the Hazard Workshops in which O&G operators participated; and
- Volume A2, Chapter 8: Aviation and Radar presents the results of the EIA for aviation and radar interests. Whilst the accompanying technical report (Volume A5, Annex 8.1: Aviation and Radar Technical Report) identifies Helicopter Main Routes (HMRs) and offshore O&G platforms with helidecks within the 9 nm consultation zone of Hornsea Four, the effects on the O&G industry are considered separately within Appendix A: Helicopter Access Report of Volume A5, Annex 11.1: Offshore Installation Interfaces.

2.1.1.1.4 It is anticipated that the documents described within Figure 2-1 will be reviewed by readers from varying disciplines. Intended readers are:

- O&G asset owners / operators;
- Health, Safety and Environment (HSE) managers and technical specialists;
- Commercial and legal representatives; and
- EIA and planning specialists.

2.1.1.1.5 As the area(s) of focus will be different for each readership group, the below sections highlight the sections that are likely to be most relevant for each discipline. Given the number and length of documents, the aim is to provide a user-friendly guide to navigate the reader and not to instruct stakeholders on how to review or provide a “to-do” list.

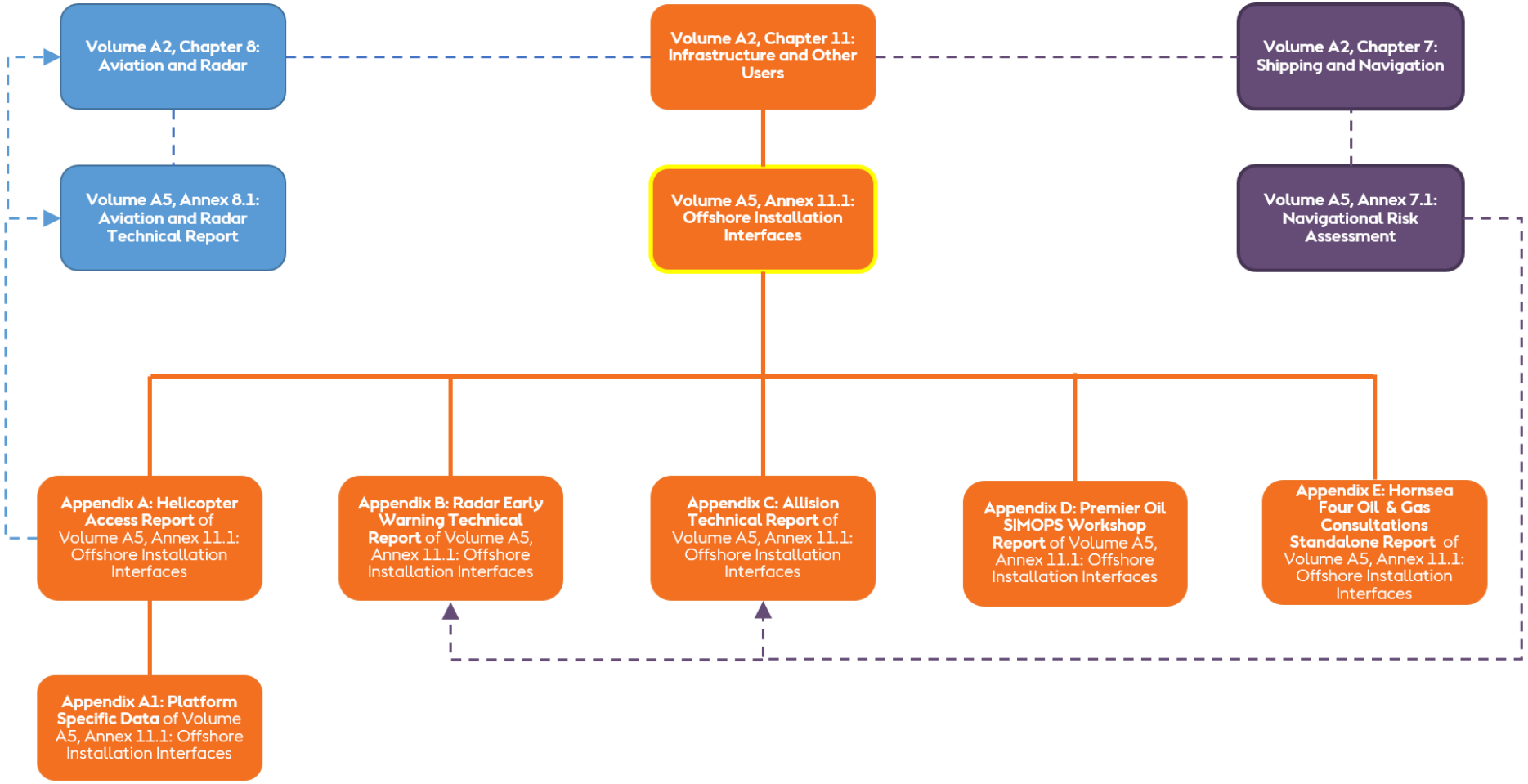


Figure 2-1: Overview of the Infrastructure and Other Users Chapter and Associated Reports

2.1.2 User Guide

2.1.2.1.1 The opening chapters of the Offshore Installation Interfaces Annex (Chapter 3: Introduction; Chapter 4: Facilities Descriptions; Chapter 5: Methodology and Chapter 6: Risk Assessment Structure) are relevant for all readership groups. These chapters provide background to Hornsea Four, an overview of O&G interests in the vicinity of the project, methodology for the assessment and the structure of the risk assessment; including the tier grouping, sub-grouping, hazard guidewords and risk significance criteria that will be utilised. Chapter 6 also features Table 6-2 which is a helpful overview of the main hazards and which hazards apply to each stakeholder.

2.1.2.1.2 Following the opening sections, there are then Chapters dedicated to each O&G stakeholder (Chapter 7 to Chapter 19). This means that O&G operators can jump straight to their specific chapter to review the assessment and its conclusions. During this review, O&G operators (and their HSE managers/technical specialists) may wish to jump to the relevant Appendices for more detail, where these are referenced. For example, for the assessment sections "Helicopter – Impaired Access…", further detail can be found in Appendix A: Helicopter Access Report of Volume A5, Annex 11.1: Offshore Installation Interfaces.

2.1.2.1.3 Readers with a commercial and planning/EIA background may wish to focus on the summary sections of each O&G stakeholder chapter, where a table summarising the hazard initiators and risk assessment conclusions can be found (e.g. Section 16.11 and Table 16-3).

2.1.2.1.4 Readers with a commercial and/or legal background are directed towards Chapter 20: Commercial Considerations. Whilst the stakeholder specific chapters assess the risk to safety only, Chapter 20 addresses the commercial impacts, that also need consideration, separately. Commercial readers may also want to review Appendices A – C which cover the technical aspects of some of the commercial issues.

2.1.2.1.5 For readers with a planning and/or EIA background, or for readers interested to see how this Annex feeds into the EIA, we suggest going on to read Volume A2, Chapter 11: Infrastructure and Other Users.

2.2 Appendices

2.2.1.1.1 The table below lists the documents included as appendices in this report.

Table 2-1: Appendices

Appendix	Heading
A	Helicopter Access Report: Assessment of the Impact of Hornsea Project Four on Helicopter Operations to Adjacent Gas Installations, Anatec Limited.
B	Radar Early Warning Technical Report, Manchester Advanced Radar Services.
C	Allision Technical Report: Assessment of the Impact of Hornsea Four on Offshore Oil and Gas Installations (Allision & Vessel/Rig Access), Anatec Limited.
D	Hornsea Four SIMOPS Workshop (non-confidential version), Premier Oil.
E	Hornsea Four Oil & Gas Consultations – Standalone Report, Orbis Energy Ltd.

2.3 Glossary

2.3.1.1.1 This section contains the definitions of terms used in this report.

Table 2-2: Terms and Definitions

Terms	Definitions
Allision	Allision has been used in this report to a moving vessel striking a stationary object such as an offshore installation.
Array Cables (inter-array cables)	Cables which connect the wind turbines to each other and to the offshore substation(s).

Terms	Definitions
Commitment	A term used interchangeably with mitigation. The purpose of a commitment is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment at the relevant point in the EIA (e.g., at Scoping, Preliminary Environmental Information Report (PEIR) or Environmental Statement (ES)). Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e., so that residual effects are acceptable.
Design Envelope	A description of the range of possible elements that make up the Hornsea Project Four design options under consideration, as set out in detail in the Volume A1, Chapter 4: Project Description. This envelope is used to define Hornsea Project 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.
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.
Export Cables	Cables that transfer power from the offshore substation(s) or the converter station(s) to shore and onwards to the Creyke Beck National Grid substation.
Export Cable Corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Project Four array area to the Creyke Beck National Grid substation, within which the export cables will be located.
Guidance for the topic assessment of the major accident hazard aspects of safety cases (GASCET) Guide Word - Diving	Where risk to diving operations is relevant, an assessment will be undertaken including hazard identification, consequence determination and consideration of risk management measures. The assessment will cover the impact on access for diving operations as a result of the presence of Hornsea Four in the area.
GASCET Guide Word - Emergency Response	As impairment or delay of emergency response arrangements could potentially lead to injury / fatality of personnel, this guide word focuses on the potential impact (impairment / delay) from Hornsea Four's presence in the area on the stakeholder's emergency response arrangements associated with their assets. The stakeholder's emergency response operations will typically include: Emergency Response Management, Alarms and Communication, Temporary Refuge and Muster Stations, Access / Egress Routes, Evacuation, Escape, Rescue and Recovery, Ship Collision, Emergency Lighting, Emergency Communications.
GASCET Guide Word - Helicopter Accident	The term helicopter accident covers the accident hazards associated with helicopters used for day-to-day transport and Search and Rescue (SAR) duties; impact risk due to potential changes in landing approach / take-off; and Helicopter Main Routes (HMRs) used by helicopters supporting Oil and Gas (O&G) operations.
GASCET Guide Word - Human Factor	This term considers the risk and measures associated with human reliability in an acute sense, where this constitutes a causal factor in the development of major accident scenarios.
GASCET Guide Word - Incorrect Installation	This term considers the risk of the incorrect installation of new infrastructure to existing assets in the vicinity.
GASCET Guide Word - Loss of Containment – Pipelines (Outboard Pipelines / Intra-field Pipelines)	According to GASCET (HSE, 2006), the relevant hazardous events with the potential for damage to the outboard / intra-field pipelines resulting in loss of containment could result from the following hazard initiators: fatigue or vibration, incorrect installation, violation of standards, operator error – inadequate training or competency, deficient (operational / maintenance) procedures, vessel impact, dropped objects (i.e. dropped cargo) or abnormal external load, seismic event, and anchor (snagging / dropping).
GASCET Guide Word - Loss of Maritime Integrity – Loss of Stability	Loss of stability is defined as any unplanned change in the floating stability of the installation. This may be caused by many factors including but not restricted to: collision with another vessel, failure of the watertight integrity, internal flooding from pipework, operation of installations drench and firefighting system, human errors in deck loading and ballast distribution, movement of deck-load, failure or unexpected loads on mooring line, excessive loads on derrick, or exceedance of design environmental parameters.
GASCET Guide Word - Loss of Maritime Integrity – Loss of Position	Position may be lost through either a failure of the mooring system, or a failure of the dynamic positioning system. Loss of position of a floating installation can lead to collision with an adjacent installation, or to the release of hydrocarbons from fractured drilling or well operations risers. Hence, loss of position is clearly a hazard 'with the potential to cause a major accident'.

Terms	Definitions
GASCET Guide Word - Seismic Survey	The term refers to impact on, or impairment of O&Gs seismic survey operations.
GASCET Guide Word - Seismic Events	This term refers to the accelerations, displacements, and relative deflections resulting from installation operations with the potential to impair O&G operations.
GASCET Guide Word - Vessel Impact	This term refers to the potential for increase in likelihood and significance of impact leading to collision or allision risks. As per GASCET (HSE, 2006), for vessel impact the following broad categories of Initiators are normally investigated: Positioning Failure, Navigational Failure, Procedural Failure, and Human Error.
GASCET Guide Word - Wells	Wells integrity compromise with the potential of blowout / spillage could arise from the following initiating operations: Vibration (i.e., from Piling / drilling of turbine foundations), Dropped objects from vessels, Anchor spread from vessels, e.g. work boats or Diving Support Vessel (DSV).
Hazard Initiators	These are events that precede / lead to the potential occurrence of a major hazardous event, for example. where vessel impact is potentially a major accident hazard, the source / initiator of this hazard can be any of the following: attendant and passing vessels with failures resulting from: positional, navigational, procedural, or human error
Helicopter Incident	An occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.
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.
Hornsea Project Four offshore wind farm	The term covers all elements of the project (i.e., both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Hornsea Four Array Area	This is where the offshore wind generating station will be located, which will include the turbines, array cables, offshore accommodation platforms and a range of offshore substations as well as offshore interconnector cables and export cables.
HVAC Booster Station(s)	Offshore HVAC booster station(s) are required in HVAC transmission systems only; they are not required in HVDC transmission systems. If required for Hornsea Four, they would be located entirely offshore.
Interconnector Cables	Cables that may be required to interconnect the offshore substations in order to provide redundancy in the case of cable failure elsewhere, or to connect to the offshore accommodation platforms in order to provide power for operation.
Offshore accommodation platform(s)	Used to accommodate multiple Operations and Maintenance (O&M) staff for a number of weeks at a time and to allow spares and tools to be stored within the array area.
Offshore substation(s)	One or more offshore substations to convert the power to higher voltages and/or to HVDC and transmit this power to shore.
Orsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Order Limits	The limits within which Hornsea Four may be carried out.
Safety Zones (Offshore Wind)	Pursuant to the Energy Act 2004 and the The Electricity (Offshore Generating Stations) (Safety Zones) (Applications Procedures and Control of Access) Regulations 2007 (SI No 2007/1948), safety zones can be established around offshore wind farm installations attached to the seabed that are used (or will be used) for purposes connected with the production of energy from wind. In practice, this includes both wind turbines, and wind farm platform structures such as OSS's and HVAC Booster Stations. During construction, these safety zones are typically 500m radius when a large vessel or jack-up is pulled-up alongside the wind turbine or platform, and 50m radius when the wind turbine or platform is not attended by a large vessel or jack-up. During operation, these safety zones are typically 500m. However, during operation these safety zones typically only apply when a large vessel or jack-up is pulled-up alongside the wind turbine or platform. Unless authorised, vessels are not permitted to enter these safety zones. Note - these safety zones are not applied along wind farm cables (inc. export cables and inter-array cables).
Safety Zones (Oil and Gas)	The Petroleum Act 1987 is the UK law which governs offshore oil and gas safety zones. Under this law there are two types of safety zone which can be created, HSE Safety Zones for surface installations, and Statutory Instrument (S.I.) safety zones for subsea structures. Pursuant to the Petroleum Act, 500m radius safety zones are established around oil and gas platforms,

Terms	Definitions
	MODU's, and some (but not necessarily all) producing subsea well heads/templates. Unless authorised, vessels are not permitted to enter these safety zones. Note - these safety zones are not applied along oil and gas pipelines.
Scour and cable protection	In order to prevent seabed scour around foundation structures and cables, cable protection may be placed on the seabed to protect from current and wave action.
Violation	Occurs when installations have not been designed and constructed, and / or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards.
Wind Turbine	All of the components of a wind turbine, including the tower, nacelle, and rotor
Wind Turbine Foundation	The wind turbines are attached to the seabed with a foundation structure typically fabricated from steel or concrete.

2.4 Acronyms

2.4.1.1.1 This section contains the acronyms used in this report.

Table 2-3: Acronyms and Definitions

Acronym	Definitions
AfL	Agreement for Lease
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
ARA	Airborne Radar Approach
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CAT	Commercial Air Transport
CBA	Cost Benefit Analysis
CFAR	Constant False Alarm Rate
CMAPP	Corporate Major Accident Prevention Policy
CPA	Closest Point of Approach
DCO	Development Consent Order
DP	Dynamically Positioned
DSV	Diving Support Vessel
EASA	European Aviation Safety Agency
EBI	Energy Balancing Infrastructure
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
ES	Environmental Statement
ESD	Emergency Shut Down
FARSI	Functionality. Availability, Reliability, Sustainability and Integrity
FDP	Field Development Plan
F&E	Fire and Explosion
FLiDAR	Floating Light Detection and Ranging
GASCET	Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases
GOMO	Guidelines for Offshore Marine Operations
GT	Gross Tonnage
HF	High Frequency

Acronym	Definitions
HMR	Helicopter Main Route
HSE	Health and Safety Executive
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
ISAR	Integrated Search and Rescue Consortium of oil companies who purchase commercial SAR services
LSE	Likely Significant Effect
MAH	Major Accident Hazard
MCA	Maritime and Coastguard Agency
MDS	Maximum Design Scenario
MEI	Major Environmental Incident
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MoD	Ministry of Defence
MODU	Mobile Offshore Drilling Unit
NEO	New European Offshore
NOGEPA	Nederlands Olie en Gas Exploratie en Productie Associatie
NRA	Navigational Risk Assessment
NtM	Notifications to Mariners
NUIs	Normally Unmanned Installations
OGA	Oil and Gas Authority
OII	Offshore Installations Interfaces
O&G	Oil and Gas
O&M	Operations and Maintenance
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSDR	Offshore Safety Directive Regulator
OSS	Offshore Substation
PEIR	Preliminary Environmental Information Report
PFEER	Prevention of Fire and Explosion, and Emergency Response
PLL	Potential Loss of Life
PS	Performance Standard
PTW	Permit to Work
REWS	Radar Early Warning System
ROV	Remotely Operated Vehicle
SAR	Search and Rescue
SBV	Stand-By Vessel
SCR	Safety Case Regulation
SEAL	Shearwater to Bacton pipeline
SECE	Safety and Environmental Critical Element
SIMOPS	Simultaneous Operations
SOAP	SBAS Offshore Approach Procedure
SOLAS	Safety of Life at Sea
SSIV	Sub-Sea Isolation Valves

Acronym	Definitions
TCPA	Time to Closest Point of Approach
TEMPSC	Totally Enclosed Motor Propelled Survival Craft
UKCS	United Kingdom Continental Shelf
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
WTG	Wind Turbine Generator

2.5 Units

2.5.1.1.1 This section contains the units used in this report.

Table 2-4: Units and Definitions

Units	Definition
GW	*Gigawatt (power)*
kV	*Kilovolt (electrical potential)*
kW	*Kilowatt (power)*
KJ	*Kilojoules (energy)*
GW	*Gigawatt (power)*
GT	*Gross Tonnage*
m	*Meters*
km	*Kilometres*
nm	*Nautical Mile*

3 Introduction

3.1 Project Background

3.1.1.1.1 Orsted Hornsea Project Four Limited (the 'Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 69 km offshore from the East Riding of Yorkshire coastline in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone (see Volume A1, Chapter 1: Introduction for further details on the former Hornsea Zone). Hornsea Four will include both offshore and onshore facilities including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network. The location of Hornsea Four is illustrated on Figure 3-1.

3.1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area is 868 km^2 and this represented the array area taken forward at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project gave due consideration to the size and location (within the AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes physical, biological and human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction. Hornsea Four adopted a major site reduction from the array area presented at Scoping (868 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the ES and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The offshore DCO Order Limits are presented in Figure 3-1. The evolution of the site boundaries is detailed in Volume A1, Chapter 3: Site Selection and Consideration of Alternatives and Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure.

3.1.1.1.3 The location of Hornsea Four is delineated on Figure 3-1 below and consists of the:

- Hornsea Four array area: This is where the offshore wind generating station will be located, which will include the turbines, array cables, offshore accommodation platforms and a range of offshore substations as well as offshore interconnector cables and export cables;
- Hornsea Four Offshore Export Cable Corridor (ECC): This is where the permanent offshore electrical infrastructure (offshore export cable(s), as well as the offshore High Voltage Alternating Current (HVAC) booster station(s) (if required), will be located;
- Hornsea Four intertidal area: This is the area between Mean High-Water Springs (MHWS) and Mean Low Water Springs (MLWS) through which all of the offshore export cables will be installed;
- Hornsea Four onshore export cable corridor: This is where the permanent onshore electrical cables will be located; and
- Hornsea Four onshore substation, including Energy Balancing Infrastructure (EBI). This is where the permanent onshore electrical substation infrastructure (onshore High Voltage Direct Current (HVDC) converter/HVAC substation, EBI and connections to the National Grid) will be located.

3.1.1.1.4 Refer to Volume A1, Chapter 4: Project Description for full details.

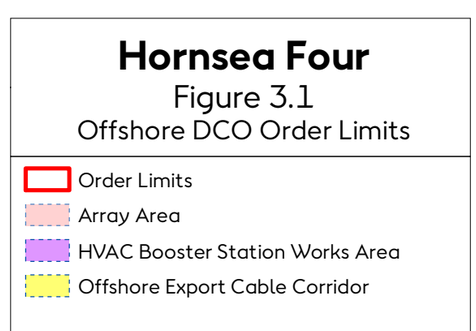
3.1.1.1.5 EPConsult Energies was commissioned to undertake an assessment of the interactions between Hornsea Four and proximate offshore oil and gas operations.

Hornsea Four

Figure 3.1

Offshore DCO Order Limits

- Order Limits
- Array Area
- HVAC Booster Station Works Area
- Offshore Export Cable Corridor



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometers

0 2.5 5 10 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	22/05/2019
A	Updated following PEIR consultations, for DCO	06/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Offshore DCO Order Limits
Document no: HOW040228
Created by: XDAOO
Checked by: JOHLE
Approved by: JULCA

Ørsted

Date: 18/08/2021 Author: XDAOO Name: HOW040228_OffshoreBoundaries_Figure_3-1_RevB_20210818

3.2 Aims and Objectives

3.2.1.1.1 The aim of this report is to assess the potential effects on the offshore installation interfaces likely to be impacted by the development of Hornsea Four.

3.2.1.1.2 They key objectives of the assessment are to:

- Study the additional hazards that may be introduced as a result of interaction between Hornsea Four and the existing offshore oil and gas operations in and around the footprint of the project;
- Assess the potential incremental additional risks that Hornsea Four imposes to the existing operations; and
- Where it is required, propose risk mitigation measures that will retain As Low As Reasonably Practicable (ALARP) or accomplish ALARP for oil and gas operations.

3.3 Report Structure

3.3.1.1.1 This report comprises the following sections:

- Section 1 - Executive Summary. This section summarises the basis for the assessment, methodology, criteria used, and key results;
- Section 2 - Preliminaries. In this section, the glossary, acronyms, and units used in this report are presented;
- Section 3 – Introduction. This section presents the background of the Hornsea Four project, the aim, and objectives of the assessment of Hornsea Four's impact on existing Oil and Gas (O&G) operations in the area, and the structure of this report;
- Section 4 – Facilities Descriptions. This section presents an overview of Hornsea Four, the list of the stakeholders with assets in and around the Hornsea Four area that have been assessed for potential impacts that Hornsea Four may have on their operations, and the asset tier grouping criteria;
- Section 5 – Methodology. This section presents the methodology adopted for assessing the interfaces between O&G companies' offshore operations, and Hornsea Four;
- Section 6 – Risk Assessment Structure. This section presents the structure of the assessment for the impact on O&G operations from interaction with Hornsea Four;
- Section 7 to Section 19 – Risk Assessment. This section presents the findings of the assessment conducted on existing O&G operations, e.g., platforms, pipelines, subsea facilities, the operations associated with operating and maintaining these facilities, and exploration operations including seismic surveys. The study will, as far as possible, consider existing protection measures associated with the O&G operations assessed. Where required, risk reduction measures will be studied and proposed for implementation to achieve ALARP;
- Section 20 – Commercial Considerations. This section highlights the commercial impacts that may arise as a result of Hornsea Four, over and above the safety risk assessments;
- Section 21 – References. The references used in this assessment are presented in this section;
- Appendix A – Helicopter Access Report. Attached in this appendix is the assessment performed for Helicopter access and deviation, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report;
- Appendix B – Radar Early Warning Technical Report. The Radar Early Warning System (REWS) Report, ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report provides the technical information and modelling results considering the impact of Hornsea Four;
- Appendix C – Allision Technical Report. The Allision Technical Report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report provides the assessment of the impact of Hornsea Four on offshore oil and gas operations, and includes allision and access to vessels and rigs);
- Appendix D – Premier Oil - Hornsea Four Simultaneous Operations (SIMOPS) Workshop (non-confidential version). Attached in this appendix is the report, ES Volume A5, Annex 11.1, Appendix D:

Premier Oil - Hornsea Four SIMOPS Workshop (non-confidential version), for the SIMOPS workshop at the Ørsted offices in Copenhagen on 10 December 2019; and

- Appendix E – Hornsea Four Oil & Gas Consultations Standalone Report. The standalone report, ES Volume A5, Annex 11.1, Appendix E: Hornsea Four Oil & Gas Consultations Standalone Report, is intended to inform the 'Infrastructure and Other Users' chapter of Hornsea Four's PEIR, by detailing the findings of the O&G consultation to date.

4 Facilities Descriptions

4.1 Project Infrastructure Overview

4.1.1.1.1 Hornsea Four will comprise of Wind Turbine Generators (WTGs) and all infrastructure required to transmit the power generated by the turbines to the Creyke Beck National Grid substation, which is located near Cottingham, Humberside. It will also comprise of any offshore infrastructure required to operate and maintain the wind farm, such as wave buoys and Floating Light Detection and Ranging (FLiDAR).

4.1.1.1.2 Hornsea Four will have a maximum of 180 WTGs. These will be connected to offshore substations via array cables, and the power will be transferred to the landfall via up to six offshore export cables. At landfall, the offshore export cables will be joined to onshore export cables at transition joint bays. There will be up to six onshore export cables buried in up to six trenches connecting to an onshore substation to allow the power to be transferred to the National Grid via the existing Creyke Beck National Grid substation.

4.1.1.1.3 Hornsea Four may use High Voltage Alternating Current (HVAC) or High Voltage Direct Current (HVDC) transmission or could use a combination of both technologies in separate electrical systems.

4.1.1.1.4 Hornsea Four is also applying for an Energy Balancing Infrastructure (EBI) in relation to the onshore HVDC converter or HVAC substation. The EBI would have the capability of energy balancing for the windfarm to buffer forecasted production with actual production and matching with consumption needs reducing the reliance on energy produced from gas-fired power plants that is currently the main source of balancing energy.

4.1.1.1.5 Table 4-1 lists the key components of Hornsea Four that will be utilised within this assessment. Further project details can be found in Volume A1, Chapter 4: Project Description.

Table 4-1: Relevant Components of Hornsea Four

Component	Maximum number / length / area
Wind turbine generators	180
Offshore transformer substations	6
Offshore HVAC booster station (HVAC only)	3
Offshore HVDC converter substation (HVDC only)	3
Offshore accommodation platform	1
Offshore HVDC converter substation(s) are mutually exclusive with HVAC booster station(s) in a single transmission system. Therefore, these two figures should not be combined in the total number. The maximum number of structures within the Hornsea Four array area is 190 (i.e., 180 turbines, one accommodation platform, 6 offshore transformer substations and 3 offshore HVDC converter substations).	
Array cables linking wind turbine generators to offshore transformer substations	600 km
Offshore interconnector cables(s)	90 km
Offshore export cables	654 km

4.2 Identification of Key Stakeholders

4.2.1.1.1 As per ES Volume A5, Annex 11.1, Appendix E: Hornsea Four Oil & Gas Consultations Standalone Report, a selection of predetermined criteria was first used to identify Oil and Gas (O&G) stakeholders that have the potential to affect or be affected by Hornsea Four.

4.2.1.1.2 The key stakeholders identified were the oil and gas companies with infrastructure, operations, and interests in and around the Hornsea Four array area and Export Cable Corridor (ECC). This comprised O&G stakeholders with interests in quadrants 42, 43, 47 and 48 of the UK Southern North Sea.

4.2.1.1.3 The operators that were found to have interests in the study area include:

- Bridge Petroleum Limited;
- Deltic Energy (previously Cluff Natural Resources);
- Painted Wolf Resources Limited (previously Actis Oil and Gas Ltd);
- RockRose Energy Ltd. (licence block previously owned by Speedwell Energy);
- Cornerstone Oil and Gas Ltd.;
- Holywell Resources Ltd.;
- Dana Petroleum (E&P) Ltd.;
- Gassco AS;
- Shell UK Ltd.;
- Perenco UK Ltd.;
- Harbour Energy (previously Premier Oil and Chrysaor Production Ltd. (Chrysaor licences previously owned by ConocoPhillips));
- Alpha Petroleum Resources Ltd.; and
- New European Offshore (NEO) Energy Ltd. (related asset previously operated by Spirit Energy).

4.2.1.1.4 The above operators have varying interests dependent on their type of asset (wells, subsea facilities, platforms, and pipeline infrastructure) and project phase (exploration & appraisal, pre-development, development, production operations and maintenance, production optimisation and decommissioning.

4.2.1.1.5 For all stakeholders and their varying field operations and interests, this study seeks to identify all potential hazards and analyse the associated risks. The assessment approach is presented in the Section 5: Methodology section and follows the Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006) guidelines, which is a Health and Safety Executive (HSE) framework for hazards and risk assessment in the UK North Sea.

4.2.1.1.6 Each asset was classified into one of three assessment tiers, defined in Table 4-2 below. The study area for each tier is presented in Figure 4-2 to illustrate the assets included within this assessment.

4.2.1.1.7 In order to structure the works of the risk assessment, the below tier groupings have been used in performing the works, which is aligned with other associated allision and collision assessment work, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report.

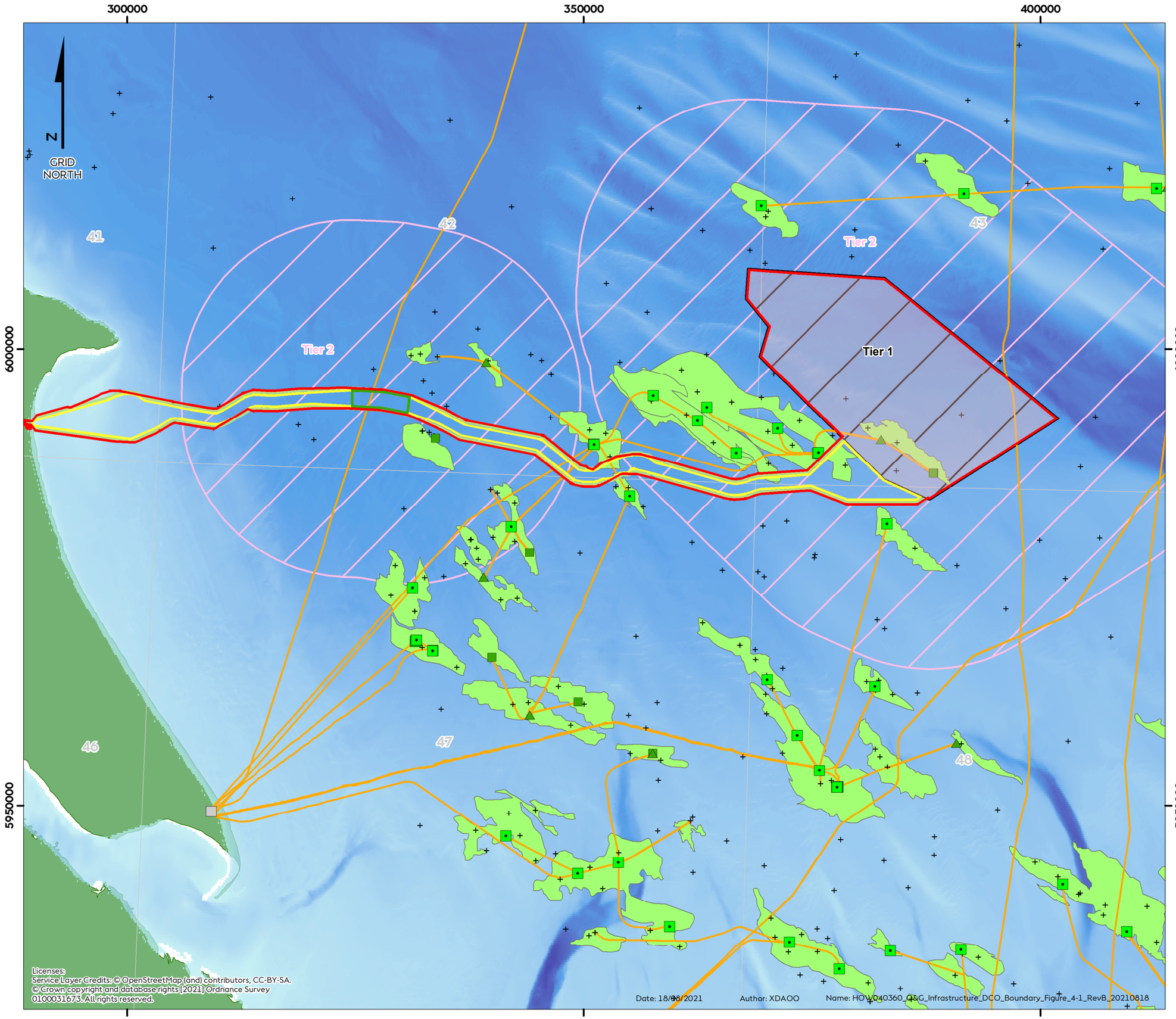
Table 4-2: Asset Tier Groups

Tier	Description
1	Pre-existing asset within Hornsea Four array area
2	Asset outside of Hornsea Four array area but within 10 nm; or asset within 10 nm of the HVAC booster station search area
3	Asset not within 10 nm but raised during consultation by a relevant stakeholder; or Asset not within 10 nm but route to asset will require deviation as a result of Hornsea Four array area.

Hornsea Four

Oil and Gas Infrastructure - DCO Order Limits

Figure 4.1



Surface Infrastructure

- Platform
- Terminal

Subsea Infrastructure

- Manifold
- Wellhead
- Wells
- Pipelines

Hydrocarbon Field

- Gas

Project Layers

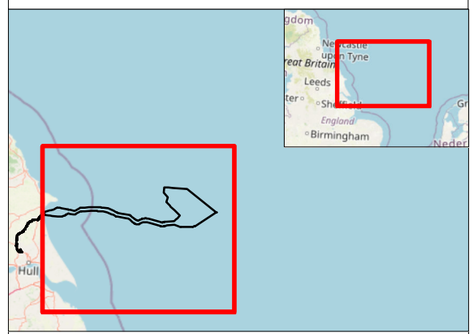
- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Tier Boundaries

- Tier 1 (Array Area)
- Tier 2 (10nm from Array Area / HVAC)
- Quadrants

Bathymetry (Below Sea Level)

- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	21/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Oil and Gas Infrastructure - DCO Order Limits
Document no: HOW040360
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

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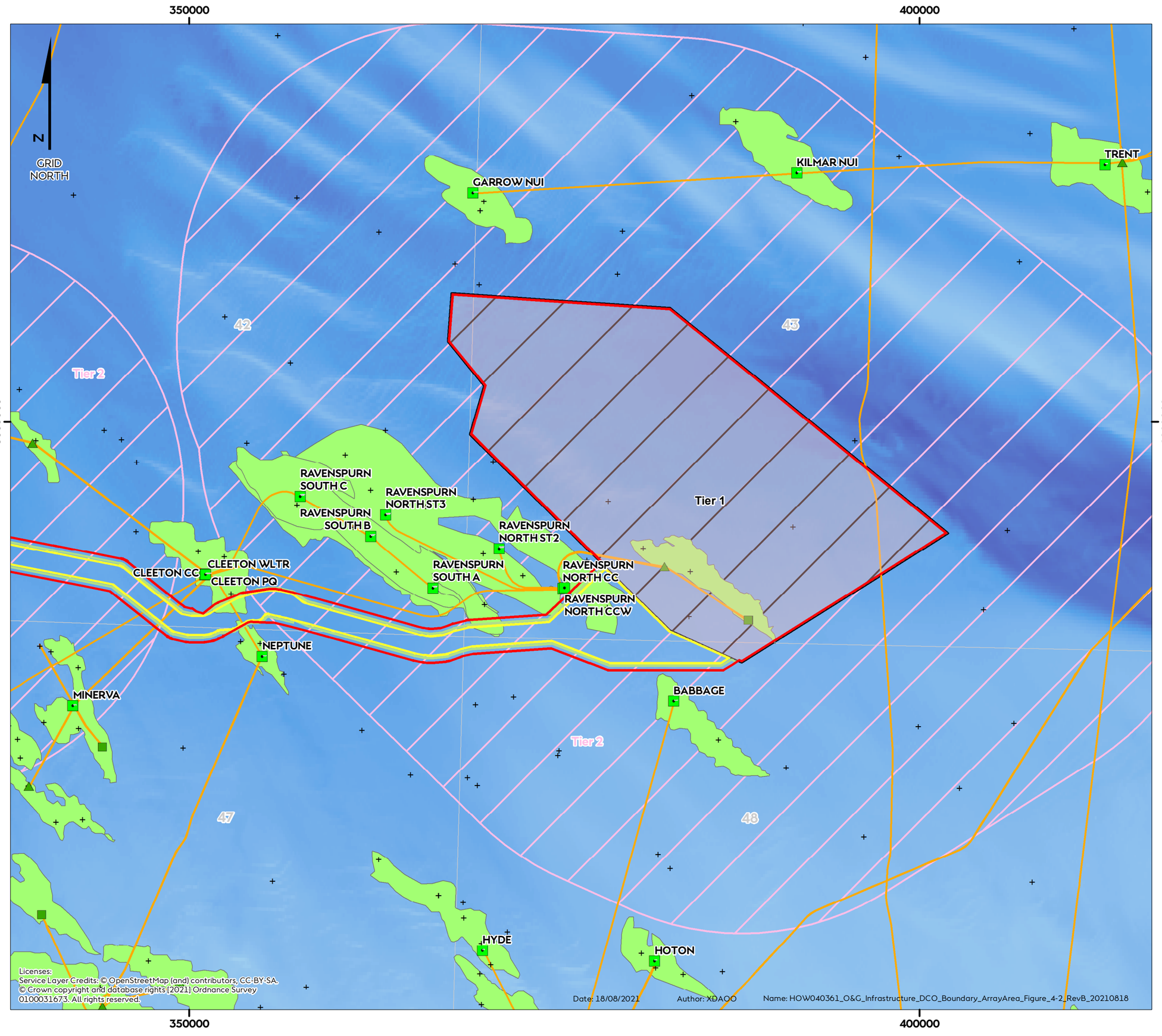
Hornsea Four

Oil and Gas Infrastructure - DCO Order Limits

Figure 4.2



Surface Infrastructure
- Platform
- Terminal

Subsea Infrastructure
- Manifold
- Wellhead
- Wells
- Pipelines

Hydrocarbon Field
- Gas

Project Layers
- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
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- Tier 1 (Array Area)
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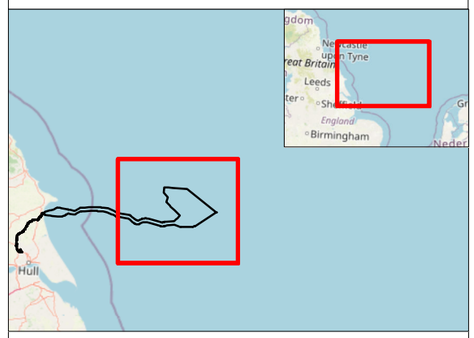

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:250,000

0 2.5 5 10 Kilometres

0 1.25 2.5 5 Nautical Miles

REV	REMARK	DATE
	First issue	21/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Oil and Gas Infrastructure - DCO Order Limits
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Created by: JOHLE
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Approved by: ELENI

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5 Methodology

5.1 Introduction

5.1.1.1.1 This section presents the methodology adopted for assessing the interfaces between Oil and Gas (O&G) companies offshore field infrastructure and operations, and the proposed Hornsea Four project. Full details of Hornsea Four's infrastructure is presented in Volume A1, Chapter 4: Project Description. See section 4.1 of this report for an overview of the project infrastructure.

5.1.1.1.2 The assessment covers the potential impacts on offshore O&G operations associated with the development, construction, operation, maintenance, and decommissioning phases of Hornsea Four.

5.1.1.1.3 The methodology follows the recommendations of Lord Cullen's report ["The Public Inquiry into the Piper Alpha Disaster – Cullen's Report" Department of Energy – UK 1990], which is framed in the UK Offshore Safety Directive Regulator (OSDR) and supported by the statutory provisions such as the Health and Safety Executive (HSE) Offshore Installations Safety Case Regulations (HSE-UK SCR) (HSE, 2015) among others. These Safety Case Regulations set out the way the OSDR assesses an O&G duty-holder's approach to identifying and managing adverse major events that may affect the health, safety and environment on O&G assets HSE-UK SCR (HSE, 2015), Schedule 6, Regs17(1)). The OSDR oversees oil and gas operations in external waters, that is, the territorial sea adjacent to Great Britain and any designated area within the United Kingdom Continental Shelf (UKCS).

5.1.1.1.4 The Safety Case Regulations (SCRs) referenced above apply to offshore operations and also take account of the presence of any equipment/operations beyond 500 metres of each asset, such as Sub-Sea Isolation Valves and pipeline pressure control devices, on which the safety of the installation or the emergency response capability (following a major accident), may depend.

5.1.1.1.5 The primary aim of the Safety Case Regulations is to reduce the risks posed by Major Accident Hazards (MAH) to the health and safety of the workforce employed on offshore operations. The regulations also aim to increase the protection of the marine environment and coastal economies, for example against pollution and by ensuring improved response mechanisms in the event of incidents.

5.1.1.1.6 The assessment presented herein draws on the Corporate Major Accident Prevention Policies (CMAPPs) that are produced by all O&G companies active on the UKCS. These CMAPPs establish an O&G duty holder's overall method for managing and controlling potential MAHs, and also set out how those aims are to be achieved and how arrangements are to be put into effect by the officers of the duty holder.

5.1.1.1.7 The continuous process of identification of Major Accident Hazards (MAHs), including those that can result in a Major Environmental Incident (MEI), is one of the requirements of the HSE-UK SCR (HSE, 2015). Compliance with this requirement is part of the demonstration of adequate management of MAHs. The HSE Inspectors SCR assessment/ inspection guidance approach has been applied in this Offshore Installations Interfaces (OII) assessment using Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006) as a baseline for the study. This assures that the OII addresses potential safety issues that are in line with the HSE-UK SCR's topic areas of interest.

5.1.1.1.8 GASCET (HSE, 2006), provides a comprehensive list of topic areas that a duty holder for a typical offshore O&G installation in the UK Continental Shelf should analyse in order to demonstrate compliance with the SCR. The OII assessment approach takes this framework and applies it for Hornsea Four construction and operations activities in order to assess the potential incremental additional safety and asset risks to O&G operations. Details of GASCET (HSE, 2006) are presented in section 6.2.2 of this report.

5.1.1.1.9 The assessment presented herein is based on reviewing the incremental additional risks that the development of Hornsea Four may pose for existing O&G field infrastructure and operations, e.g., surveys, maintenance, etc. Future plans and developments will be considered only if material documentation has been submitted to the relevant authority, is publicly available or has been provided by the operator to Hornsea Four.

5.1.1.1.10 Hazards which may be potentially developed from the Hornsea Four operations and that can cause a major accident, affecting the O&G facilities, will be identified and their risks evaluated through the assessment

of likelihood and consequences. The assessment will determine if the protections in place are suitable and adequate according to requirements of the relevant Statutory Provisions and offshore Codes, Standards and Guidelines as per Figure 5-1.

5.1.1.1.11 Commercial considerations are addressed separately to major accident hazards in Chapter 20 of this report and are being addressed through engagement with each relevant stakeholder.

5.1.1.1.12 As stated in ES Volume A5, Annex 11.1, Appendix E: Hornsea Four Oil & Gas Consultations Standalone Report, input to the assessment has been provided through a number of meetings with the operators of nearby O&G facilities during which a range of key issues (potential impacts) have been discussed. Other input to the assessment includes specialist reports on the subjects of allision, helicopter transport, and Radar Early Warning Systems (REWS) and microwave communication.

5.1.1.1.13 The assessment methodology is presented in Figure 5-1.

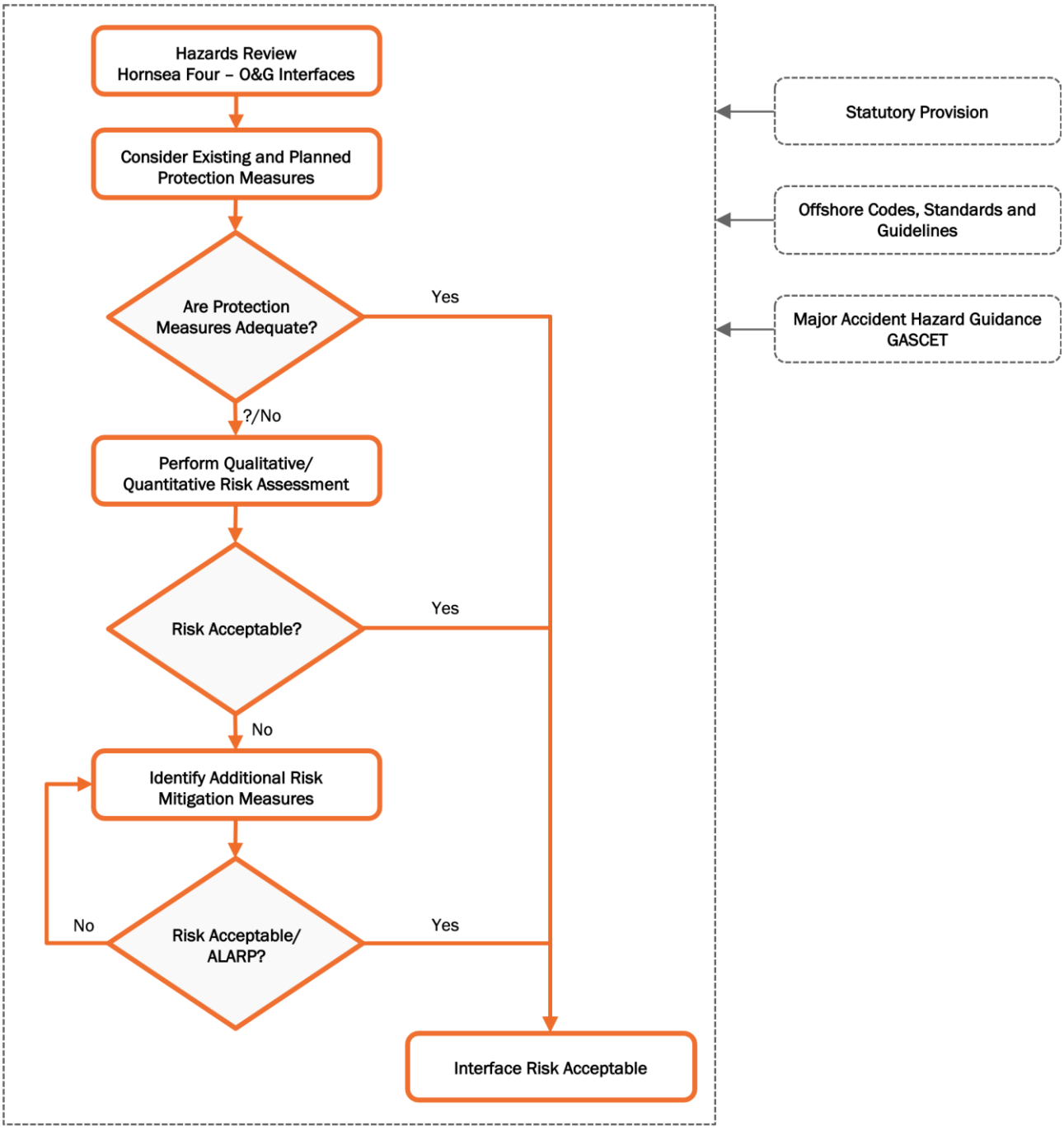


Figure 5-1: Assessment Methodology

5.2 Hazard Identification

5.2.1.1.1 Hazard identification has been informed through consultation with relevant O&G operators (including through formal consultation under the Planning Act 2008 process (referred to as Section 42) which was informed by the Preliminary Environmental Information Report (PEIR); this identified a number of potential hazards that would be considered by this assessment and associated planned protection measures (or mitigation)). In addition, other identified hazards that have the potential to cause a major accident are also subject to assessment.

5.2.1.1.2 The continuous process of identification of major accident hazards, including those that could result in a Major Environmental Incident (MEI), is one of the requirements of the HSE-UK SCR (HSE, 2015). Compliance with this requirement is part of the demonstration of adequate management of MAHs. The HSE Inspectors SCR assessment/ inspection guidance approach has been used throughout the assessment. Using the Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) as a baseline for the study assures that the assessment is in line with the HSE-UK SCR.

5.2.1.1.3 As per the HSE-UK SCR (HSE, 2015), major accident hazards are classified as:

a. An event involving a fire, explosion, loss of well control or the release of a dangerous substance causing, or with a significant potential to cause, death or serious personal injury to persons on the installation or engaged in an operation on or in connection with it;

b. An event involving major damage to the structure of the installation or plant affixed to it or any loss in the stability of the installation causing, or with a significant potential to cause, death or serious personal injury to persons on the installation or engaged in an operation on or in connection with it;

c. The failure of life support systems for diving operations in connection with the installation, the detachment of a diving bell used for such operations or the trapping of a diver in a diving bell or other subsea chamber used for such operations;

d. Any other event arising from a work activity involving death or serious personal injury to five or more persons on the installation or engaged in an operation on or in connection with it; or

e. Any MEI resulting from any event referred to in paragraph (a), (b) or (d), and for the purposes of determining whether an event constitutes a major accident under paragraph (a), (b) or (e), an installation that is normally unattended is to be treated as if it were attended.

5.2.1.1.4 The GASCET (HSE, 2006), provides a comprehensive list of aspects that a duty holder for a typical offshore O&G installation in the UKCS should analyse, in order to demonstrate compliance with the Safety Case Regulations: "to protect the Health and Safety of the workforce; and the protection of the marine environment and coastal economies against pollution". Guidance will also be taken from the HSE Inspectors SCR assessment/ inspection guidance.

5.2.1.1.5 The following list summarises the major accident hazards recognised in GASCET (HSE, 2006) associated with offshore O&G operations:

- Platforms:
  - Structural Integrity;
  - Stability Maritime Integrity;
  - Position Keeping System Failures; and
  - Vessel Impact.
- Platform Systems:
  - Loss of Containment – Process;
  - Loss of Containment – Pipelines;
  - Loss of Containment – Fire & Explosion; and
  - Emergency Response.
- Associated Topics:
  - Wells Risk Evaluation;
  - Diving Operation;
  - Occupational Health;
  - Helicopter Risk;
  - Human & Organisational Factors; and
  - Non-Process Fire and Explosion (F&E).

5.2.1.1.6 GASCET (HSE, 2006) also presents possible measures and reference to specific standards, models and methodologies, representing good practice that the duty-holder may adopt to demonstrate that major accident hazards are satisfactorily managed.

5.2.1.1.7 Using the above structure, an initial screening of the extensive hazards/hazard initiators as presented in GASCET (HSE, 2006), was conducted to produce a short list of the hazards that are considered of relevance for interfaces between O&G operators and Hornsea Four.

5.2.1.1.8 The assets for each stakeholder are grouped into Platforms, Platform Systems, and Associated Systems, as listed above, and the hazards/hazard guide words obtained from GASCET (HSE, 2006), are assessed against each asset group.

5.2.1.1.9 Hornsea Four has engaged with all O&G stakeholders to discuss the key issues with potential to impact their operations in and around the Hornsea Four array area. An initial overview of the hazards which may affect each stakeholder is provided in Table 6-2.

5.2.1.1.10 To enable better understanding of the structure, a section of the report is dedicated to each stakeholder to ensure it is clearly presented and easy to read.

5.2.1.1.11 The prevention, detection, controls and mitigation of each of the hazards identified reflects the principles provided in the HSE-UK SCR (HSE, 2015) and other applicable Statutory Provisions, codes and good practices. The latter states that, if guidance is followed, the duty holders should be able to demonstrate that hazards are properly managed.

5.2.1.1.12 SCR 2015 will be followed in conjunction with the following UK Regulations, offshore codes and practices, which are relevant for supply vessels and Mobile Offshore Drilling Units (MODUs):

- The International Convention for Safety of Life at Sea (SOLAS) for the construction, equipment and operation of structures compatible with their safety;
- MODU Code (NeRF, 2015) covers construction, subdivision and stability, machinery and electricals for main propulsion and auxiliary machinery, fire safety, lifesaving appliances, radio communications, lifting devices, helicopter facilities and operational procedures and pollution preventions;
- UK HSE, for administration of the management of the health and safety at work and the removal of personnel from the offshore environment;
- Offshore Installations and Pipeline Works (Management and Administration) Regulations SI 1995/728 and associated operations notices; and
- Prevention of Fire and Explosion and Emergency Regulations SI 1995/743.

5.3 Existing and Planned Protective Measures

5.3.1.1.1 This step will review the effectiveness of the following two safeguards:

- The existing Safety and Environmental Critical Elements (SECE); and
- The planned protection measures, i.e., Hornsea Four Commitments.

5.3.1.1.2 It is likely that most of the interface hazards identified between Hornsea Four and O&G operators will be adequately managed based on existing SECEs and Hornsea Four Commitments.

5.3.1.1.3 O&G safety protection measures are in general referred to as SECE. SECEs are the key means for managing and keeping in check major accidental hazards and where applicable, MEIs.

5.3.1.1.4 SECEs have performance requirements, known as Performance Standards (PS), that are assured through inspection, examination, and verification processes.

5.3.1.1.5 Since SECEs and their associated PSs are a key element in demonstrating that duty holders can achieve compliance with Statutory Provisions, SECEs and PS must be incorporated in the Safety Case which duty holders submit to the OSDR.

5.3.1.1.6 The assessment presented herein will review the adequacy and suitability of the duty holder's SECEs that are applicable during the construction, commissioning, operation, and maintenance of Hornsea Four. The assessment will be performed in accordance with the HSE guideline for a structured and systematic review of the Statutory Provisions, standards and codes, recognised by the authorities as good practice.

5.3.1.1.7 The identified interface hazards (MAH) will be screened against the existing SECEs effectiveness at keeping the MAH in check. Where incremental additional risk is observed as a result of Hornsea Four, an assessment of standards and codes, as per GASCET (HSE, 2006), will be conducted to review if detection, prevention, control, mitigation and/or recovery can be re-assessed and existing SECEs can meet or be upgraded to achieve the required protection. This may involve amendments to the associated PSs and written schemes of verification.

5.3.1.1.8 A technical discussion will determine whether the potentially hazardous effects may increase the chance (likelihood) of occurrence of a major accident or deteriorate the protection level of the safety measure (SECEs) in the event of an accident occurring (magnifying consequences).

5.3.1.1.9 Existing SECEs or planned protective measures will be taken into account to show how relevant good practice and judgement based on sound engineering may demonstrate that those major events are manageable to make the risk acceptable. If detailed demonstration is still required a more detailed semi-quantitative or quantitative risk assessment will be performed, as presented in the next section.

5.3.1.1.10 In addition to assessing the impact of the hazards on the overall risk, the assessment presented herein will also review how Hornsea Four may impair the effectiveness of existing SECEs. Examples of this include, how the turbine array may impact REWS or how microwave communication may be impaired by the array.

5.4 Risk Assessment

5.4.1 Introduction

5.4.1.1.1 This section presents the steps taken in the case where interface MAHs are found not to be kept in "check" by the existing and planned safeguards, and where upgrades or modifications to these safeguards may be required.

5.4.2 Risk Assessment

5.4.2.1.1 The risk assessment exercise is a systematic method of assessing operations, considering hazards and reviewing suitability of the control measures. These control measures are designed to eliminate, reduce or minimize the risks of loss, damage or injury. There are six major steps in performing a risk assessment:

- Identifying hazardous events (MAH);
- Establish the likelihood of MAH events;
- Evaluating the associated consequence;
- Establish the risk level and review if the risk is acceptable;
- If the risk is not acceptable, identify risk reduction measures; and
- Implement risk reduction measures to the point where risks are As Low As Reasonably Practicable (ALARP).

5.4.2.1.2 The estimated frequency (likelihood) of a MAH event and the associated anticipated consequence (severity) of the event will be assessed qualitatively or quantitatively.

5.4.2.1.3 The risk assessment will analyse the incremental additional risk to O&G facilities because of Hornsea Four. Existing and planned protective measures will be assessed and identified to keep MAHs in check. The assessment will involve reviewing the ability and effectiveness of the protective measures to prevent, detect, control, mitigate, and enable recovery.

5.4.2.1.4 The risk assessment will be performed in accordance with the HSE information sheet, Guidance on Risk Assessment for Offshore Installations: Offshore Information Sheet No. 3/2006 (HSE, 2006).

5.4.2.1.5 For qualitative and semi-quantitative approaches, a risk matrix is convenient for presenting the results. The quantitative risk assessment is performed by reviewing the variation in availability/reliability of the SECEs of the O&G facilities due to Hornsea Four. The resultant risk level will be compared against risk acceptance criteria.

5.4.2.1.6 It is expected that some of the key risks with the potential to impair asset integrity and existing operations will be dependent on distances between Hornsea Four and the O&G infrastructures.

5.4.2.1.7 For selected potential interface MAH the risk assessment will take into consideration the SECEs that O&G facilities must have implemented to demonstrate compliance with relevant UK Statutory Provisions.

5.4.3 Risk Acceptability

5.4.3.1.1 The risk acceptance criteria of O&G companies are broadly consistent and are in line with the Guidance on Risk Assessment for Offshore Installations: Offshore Information Sheet No. 3/2006 (HSE, 2006).

5.4.3.1.2 On the basis of the performed risk assessment, the results will be compared against the risk acceptance criteria in order to review the potential requirement for additional risk mitigation.

5.4.3.1.3 Risk tolerability will be performed by reviewing the O&G risk acceptance criteria which is likely to be presented in a risk matrix and/or as specific numeric thresholds that define acceptability limits for individual risks and Potential Loss of Life (PLL). There will typically also be thresholds for asset risk and production loss.

Potential Severity of Event			Potential Likelihood				
			Very Unlikely	Unlikely	Possible	Likely	Very Likely
Level	Safety Impact	Asset Damage	Never Heard of in the Industry	Heard of in the Industry	Has Happened in company or more than once per year in the Industry	Has Happened in location or more than once per year across company	Has Happened in location or more than once per year in BU
1	Slight	Slight Damage					
2	Minor	Minor Damage					
3	Moderate	Local Damage					
4	Serious	Major Damage					
5	Major	Extensive Damage					

Figure 5-2: Typical UKCS Risk Matrix for OII Study

5.4.4 Risk Mitigation and ALARP

5.4.4.1.1 Where risks are found not to be acceptable, different risk mitigation measures will be identified and assessed against their effectiveness in bringing down the risk.

5.4.4.1.2 Risk reduction measures are required to be implemented to the point where the incremental additional risk reduction is considered disproportionate to the cost of the reduction measure. This is the industry

approach for reducing a risk to ALARP. Cost Benefit Analysis (CBA) may be used to determine the point at which no further risk reduction is justified.

5.4.4.1.3 For Hornsea Four and the associated interface risks with O&G operators, it may be that despite reducing a risk to ALARP, some commercial risks may remain. These residual risks will be managed separately through individual commercial discussions, should they be deemed necessary, with each O&G Company affected. They may benefit from a joint coexistence approach as a practical way forward considering the current national importance of uninterrupted supply of both fossil-based energy and renewable energy. Paragraph 3.6.1 of National Policy Statement for Energy (EN-1) states that "fossil fuel power stations... will continue to play an important role in our energy mix as the UK makes the transition to a low carbon economy".

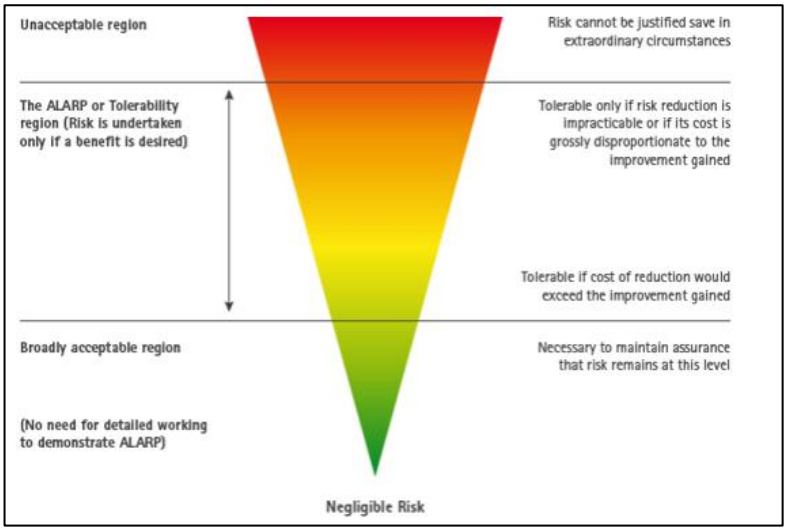


Figure 5-3: ALARP Concept Diagram

6 Risk Assessment Structure

6.1 Introduction

6.1.1 Risk Evaluation

6.1.1.1.1 In this chapter changes in risk profiles are assessed due to new risks and changes in risks, due to the implementation and operation of Hornsea Four.

6.1.1.1.2 Hornsea Four is in the early development phase where the design specifics associated with precise location of turbines, cables and size of turbines are not fixed. In addition, where risks are found to be high or acceptable with mitigation, this will highlight areas of improvement for developers and designers and provide support in scoping the co-existence procedure between Hornsea Four and Oil and Gas (O&G) operators.

6.1.1.1.3 The table below is based on the methodology presented earlier in Section 5 and will be used in evaluating risk for the interfaces between Hornsea Four and O&G operator assets and operations.

Table 6-1: Risk Significance

Risk Significance	Description
Broadly Acceptable	These are considered low risks and by their nature are ALARP.
Tolerable with Mitigation	These are risks in the "ALARP" region, that can become acceptable with adequate risk reducing measures implemented.
Un-acceptable risk level	High risks that are un-acceptable that require to be eliminated/ designed out or re-engineered to make them acceptable.

6.1.2 Risk Management Measures

6.1.2.1.1 Over and above the Methodology, which is described in section 5, this section presents the risk management measures which will be applied in the assessment of interface risks between O&G operators and Hornsea Four.

6.1.2.1.2 To assist the hazard identification and risk assessment process, the adequacy of risk management measures is being considered. Such measures can be classified as barriers. These may be one or more of engineering, procedural or human. By priority the barriers are categorised as:

- Inherent Safety - an inherent safe design seeks to "design out" hazards rather than controlling hazards. Where hazards cannot fully be "designed out", the design will seek to mitigate the potential consequence where a hazard results in an incident. Inherent safe design makes use of best practices in performing the design;
- Prevention - e.g., not allowing diving operation whilst driving or drilling piles;
- Detection - e.g., automated vessel detection devices such as Radar Early Warning System (REWS), or fire and gas detectors that may shut safety valves such as Emergency Shut Down valves (ESD) or Sub-Sea Isolation Valves (SSIV);
- Control - e.g., making use of offshore marine shippers' guidelines, planning tools, etc.; and
- Mitigation - additional risk reduction measures, e.g., concrete mattress to provide impact protection for pipelines, against dropped objects.

6.1.2.1.3 Safety and Environmental Critical Elements (SECE) are put in place to support an installation in meeting adequate safety standards and thereby reducing potential risks to acceptable levels. Associated Performance Standards (PS) secure that SECE are inspected, tested, and maintained to adequate

standards in accordance with the principles of: Functionality, Availability, Reliability, Sustainability and Integrity (FARSI).

6.1.2.1.4 In addition, Hornsea Four is also progressing the project and working to managing interface risks with oil and gas operators and operations, through consultation and associated:

- Promulgation;
- Co-existence planning; and
- Commitments.

6.1.2.1.5 Hornsea Four has adopted a number of Commitments as part of the Environmental Impact Assessment (EIA) process in order to avoid or reduce impacts where possible. All Commitments that are taken forward within the ES are detailed in Volume A4, Annex 5.2: Commitment Register, which also provides details as to how the Commitments are secured. These commitments in themselves are a mix of standard offshore practices that the project will adhere to and specific risk reduction measures, that reduce interface risks between O&G operators and Hornsea Four.

6.1.2.1.6 The Commitments that are relevant to reducing interface risks with O&G operators are as follows:

- Co57: Where offshore export cables must cross third party infrastructure, such as existing cables and pipelines, both the third-party asset and the installed cables will be protected;
- Co81: Where scour protection is required, MGN 654 (or latest relevant available guidance) will be adhered to with respect to changes greater than 5 % to the under-keel clearance in consultation with the Maritime and Coastguard Agency (MCA);
- Co89: Advance warning and accurate location details of construction, maintenance and decommissioning operations, associated Safety Zones and advisory passing distances will be given via Notifications to Mariners and Kingfisher Bulletins;
- Co93: Aids to navigation and aviation warning lights (marking and lighting) will be deployed in accordance with the latest relevant available standard industry guidance and as advised by Trinity House, MCA, Civil Aviation Authority (CAA), and Ministry of Defence (MoD) as appropriate. This will include a buoyed construction area around the array area and the High Voltage Alternating Current (HVAC) booster station in consultation with Trinity House;
- Co94: The United Kingdom Hydrographic Office will be notified of both the commencement (within two weeks), progress and completion of offshore construction works (within two weeks) to allow marking of all installed infrastructure on nautical charts;
- Co96: The project commits to agree layout principles with the Marine Management Organisation (MMO), in consultation with the MCA and Trinity House;
- Co98: Monitoring and annual reporting of vessel traffic for the duration of the construction period;
- Co99: Hornsea Four will ensure compliance with MGN 654 where appropriate;
- Co102: The Defence Infrastructure Organisation and the Civil Aviation Authority (CAA) will be informed of the locations, heights and lighting status of the wind turbines, including estimated and actual dates of construction and the maximum height of any construction equipment to be used, prior to the start of construction, to allow inclusion on Aviation Charts;
- Co107: Crossing and proximity agreements with known existing pipeline and cables operators will be sought;
- Co139: Safety zones of up to 500 m will be applied during construction, maintenance, and decommissioning phases. Where defined by risk assessment, guard vessels will also be used to ensure adherence with Safety Zones or advisory passing distances to mitigate impacts which pose a risk to surface navigation during construction, maintenance, and decommissioning phases; and
- Co181: An Offshore Decommissioning Plan will be developed prior to decommissioning.

6.2 Hazard Identification

6.2.1 Introduction

6.2.1.1.1 This section presents the structure of the assessment performed for each stakeholder. The structure supports the assessment by making use of the guide words and hazard initiators taken from Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006) and considered relevant for this study. These hazard/hazard guide words have also been expanded to take into account impacts from Hornsea Four on certain operations specific to each stakeholder, as detailed in Table 6-2, i.e. impact upon helicopter access, impact upon access to pipelines, impairment of REWS system, etc.

6.2.1.1.2 For each Tier Group there is a further "sub-grouping" which is applied in performing the assessment. This sub-grouping assist in the identification of hazards in a structured manner, and are as follows:

- 'Platform' - the platform installation considered as the structure only;
- 'Platform System' - all the systems of the platform, e.g., risers, processing and production system, safety systems, etc.; and
- 'Associated Systems' - production infrastructure and operations away from the platform.

6.2.1.1.3 Hence, for each O&G operator, the assessment will consider Tier group and the above three systems per Tier Group.

6.2.1.1.4 The guide words considered in assessing the potential hazards resulting from presence of Hornsea Four in the area are listed below.

- Platforms:
  - Structural Integrity:
    - Seismic Event;
    - Vessel Impact - Allision risk due to vessels being deviated from existing route;
    - Helicopter Impact - Impact risk due to potential changes in landing approach / take-off as a result of Hornsea Four; and
  - Loss of Maritime Integrity - Loss of Stability / Loss of Position; and
  - Vessel Impact – Access risks associated with O&G vessels being deviated from existing route during construction, Operations and Maintenance (O&M) phase of Hornsea Four,.
- Platform System:
  - Loss of Containment - Process and Pipelines;
  - Loss of Containment - Fire & Explosion; and
  - Emergency Response.
- Associated Systems
  - Wells, including those abandoned;
  - Diving – Platforms, Pipelines;
  - Human Factor;
  - Helicopter Impact (CAT and SAR) - Impaired Access to O&G platforms, including impairment from proximity of tall structures and obstacles; wind turbulence; navigational and communications failure; and human error;
  - Seismic Survey Activities - Conflicts with O&G seismic survey activity within array area;
  - Drilling (Array or Export Cable Corridor (ECC)) Activities - Restriction on O&G drilling due to infrastructure in array or ECC;
  - Construction (Array or ECC) Activities - Restriction on O&G construction activities in array or ECC;

- Loss of Containment - Outboard Pipelines / Intra-field Pipelines:
  - Fatigue / Vibration;
  - Incorrect Installation;
  - Operator Error – Inadequate Training;
  - Violation;
  - Deficient Procedures – Operational and Maintenance;
  - Vessel Impact;
  - Dropped Objects;
  - Seismic Event; and
  - Anchor – Snagging / Dropping.
- Others:
  - Non-Process Fires & Explosions – i.e., potential electrical fire on HVAC booster station platform and array area substations;
  - Communication / Control Impairment - Interference with microwave telecommunication links;
  - REWS Impairment - Interference with the performance of REWS located on O&G platforms; and
  - CPA Alarms - Change in Closest Point of Approach (CPA) alarms on O&G platforms protected by REWS due to vessels deviating around wind farm.

6.2.2 GASCET

6.2.2.1.1 GASCET (HSE, 2006), 'Guidance for the topic assessment of the major accident hazard aspects of safety cases' provides a framework of topic assessment principles and guidance in respect of the assessment of the MAH (Major Accident Hazards) aspects of offshore safety cases. GASCET is a commonly used by North Sea O&G operators as a guide for the identification of Major Accident Hazards (MAH) for O&G operations. GASCET is typically used to identify hazards when preparing Safety Case documentation or when operators plan for changes or modification to projects and want to re-assess the existing or potential new hazards.

6.2.2.1.2 To assist in the assessment process GASCET provides prompt check lists that have been developed based on the experience of HSE personnel and these are documented in a categorisation table in each of the major accident sections of GASCET. Each section that deals with a hazard has a categorisation table having sub-sections that provide supporting information: Source of Hazard; Initiators; Risk Evaluation; Risk Management Measures: Inherent Safety; Prevention; Detection; Control; and Mitigation. Additionally, there are standalone sections for Emergency Response, Human Factors, and Human Vulnerability.

6.2.2.1.3 At the time of drafting the OII Report and preparing the methodology for the OII report it was decided to use GASCET as a guide and checklist for screening any new hazards and reviewing any incremental additional risk which Hornsea Four could initiate, over and above the existing risks that O&G operators are already exposed to.

6.2.2.1.4 After having performed the interface risk assessment of this report, the UK HSE withdrew the GASCET, with effect of September 2020. The previous content of the GASCET is being reviewed by the UK HSE with relevant information being incorporated into individual Safety Case Topic Assessment Guides (TAGs) which are currently being drafted. Although the GASCET has been withdrawn and will be replaced with the new TAGs to make it more readily accessible and easier to navigate, the information contained within GASCET has not been cancelled and is still valid as a hazard management guide until the more detailed TAGs will be available. This is as informed by the UK HSE.

6.3 Hornsea Four Hazard Overview

6.3.1.1.1 In general, GASCET (HSE, 2006) served as the reference for the relevant guide words used in the assessment of additional hazards to existing O&G assets from the presence of Hornsea Four.

6.3.1.1.2 Prior to this exercise, consultation meetings / workshops between Hornsea Four and the O&G stakeholders listed in section 4.2 were conducted (see Table 12.2 of Volume A2, Chapter 11: Infrastructure and Other Users for a log of the consultation meetings that have taken place). The findings, in terms of areas where there are impacts in the interface, are presented in Table 6-2 below. This has also been considered in the current study.

Table 6-2: Hornsea Four Potential Impact Overview by Stakeholders

Potential Impact			Receptors																
	Painted Wolf Resources	**Deltic Energy**	**Gassco**	**Dana Petroleum**	**Shell**	**RockRose Energy**	**Alpha Petroleum**	**Perenco**					**Harbour Energy**			**Bridge Petroleum**	**NEO**	**Corner-stone O&G**	**Holywell Resources**
	UKCS Blocks 42/20a, 43/16, 43/17a, 43/23, 43/24b, 47/2d, 47/3f, 47/7a & 47/8d	UKCS Block 47/10d, 48/6c, 42/22, 42/23, 42/17, 42/18, 42/19 and 42/20b	Langeled Pipeline	UKCS Blocks 42/29a, 47/5b, 47/5c, 48/1a, 42/27, 47/2b, 47/3g and Platypus Pipeline	SEAL P/L	UKCS Block 43/21b	UKCS Blocks 42/25a & 43/21a & 43/22a including Kilmar & Garrow platforms	UKCS Blocks 47/3c, 47/3b & 47/4a, including the Minerva platform	UKCS Block 43/24a, including the Trent platform	UKCS Block 47/5a including Hyde platform, and 48/7b including Hoton platform, & West Sole Hub	UKCS Blocks 43/26a & 42/30a, including Ravenspurn Hub	UKCS Block 42/29a, including Cleeton & 47/4b including Neptune	UKCS Blocks 42/28c & 42/28d including Tolmount platform & wells	UKCS Blocks 43/26a & 43/27a including Johnston wells	Pipeline south-east of Hornsea Four	UKCS Blocks 42/30d & 43/26c	UKCS Block 48/2a including Babbage Platform	UKCS Block 47/3i	UKCS Blocks 43/25, 43/29a, 43/30a, 48/4a, and 48/5a
Allision risk due to vessels being deviated from existing route							■	■	■	■	■	■	■				■		
Collision risk with O&G vessels and vessels being deviated from existing route							■	■	■	■	■	■	■	■			■		
Helicopter access to platforms (CAT and SAR)							■		■		■	■	■				■		
Helicopter access to nearby O&G vessels (CAT and SAR)							■		■		■	■	■	■			■		
Disruption to HMRs used by helicopters supporting O&G operations							■	■	■		■	■	■	■			■		
Interference with microwave telecommunication links							■		■		■						■		
Interference with the performance of REWS located on O&G platforms							■	■	■	■	■	■					■		
Change in CPA alarms on O&G platforms protected by REWS due to vessels deviating around wind farm							■	■	■	■	■	■	■	■	■	■	■		
Conflicts with O&G seismic survey operations within array area							■	■	■	■	■	■	■	■	■	■	■		
Conflicts with O&G seismic survey operations within ECC							■	■	■	■	■	■	■	■	■	■	■		
Acoustic interference with O&G seismic survey operations due to piling of wind turbines and substation foundations							■	■	■	■	■	■	■	■	■	■	■		
Restriction on O&G drilling due to infrastructure in array							■	■	■	■	■	■	■	■	■	■	■		
Restriction on O&G drilling due to infrastructure in ECC							■	■	■	■	■	■	■	■	■	■	■		
Restriction on O&G decommissioning operations in array area							■	■	■	■	■	■	■	■	■	■	■		
Restriction on O&G construction operations in array area							■	■	■	■	■	■	■	■	■	■	■		
Restriction on O&G construction operations in ECC							■	■	■	■	■	■	■	■	■	■	■		
Disruption of vessel access to O&G platforms and subsurface infrastructure			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Pipelines - temporary impact upon access for repair/maintenance			■	■	■		■	■			■	■	■	■			■		
Impact of piling on O&G diving operations			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		

Note: Orange fields have potential hazards that require analysis.

7 Bridge Petroleum Limited

7.1.1.1.1 Bridge Petroleum is the sole equity holder (100 %) of United Kingdom Continental Shelf (UKCS) Blocks 42/30d & 43/26c (P2426) (licence was acquired by Bridge Petroleum in October 2018), located in the Southern North Sea within the north-western extent of the proposed Hornsea Four array area (Figure 7-1).

7.1.1.1.2 The Blocks 42/30d and 43/26c contain a known field (Kumatage). Bridge Petroleum plans to develop the gas reservoir either through a platform or subsea development and associated pipeline, however the development plans are still in the conceptual engineering phase. As the required details are not currently available, Bridge is not considered further.

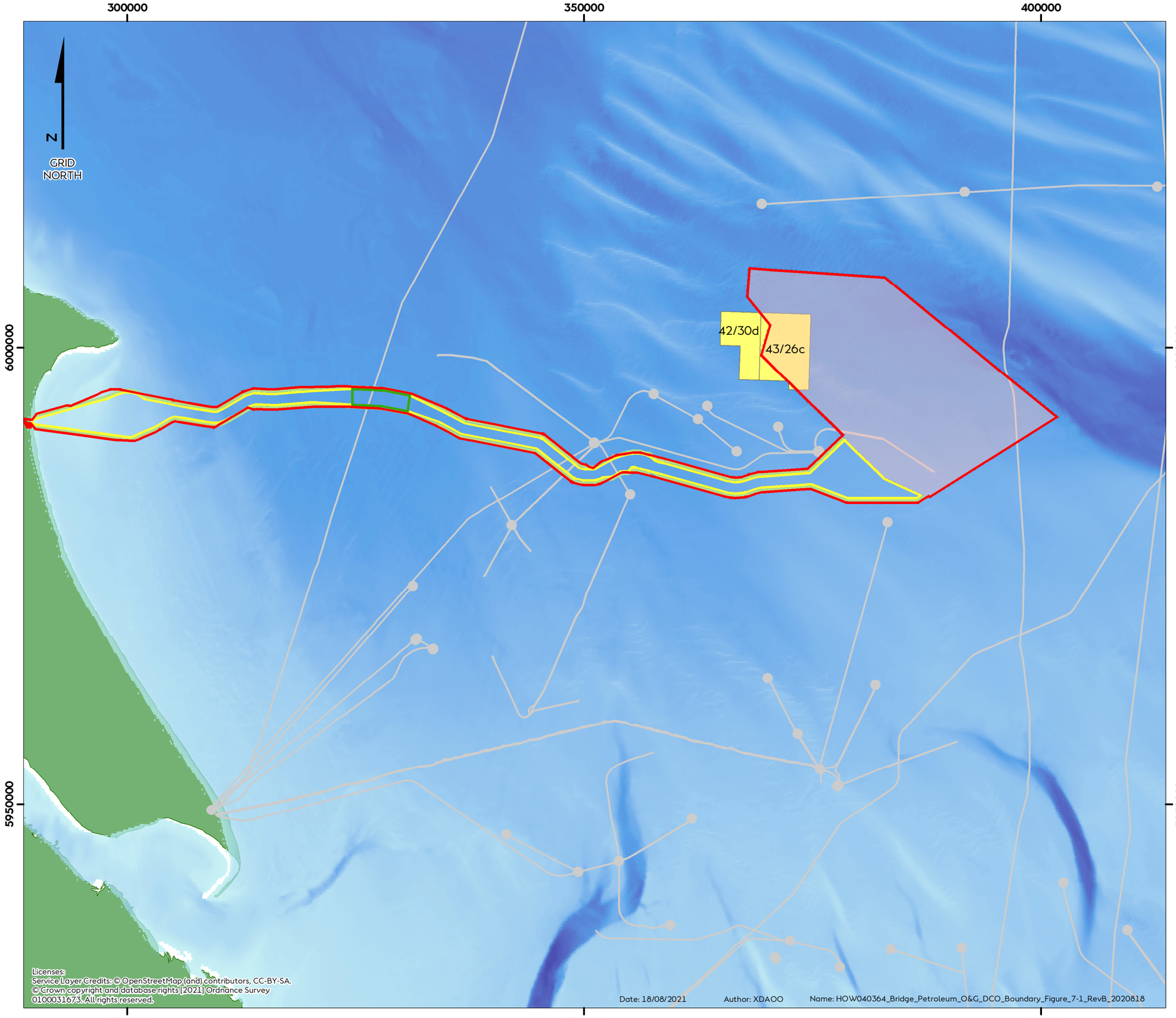
7.1.1.1.3 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

7.1.1.1.4 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

7.1.1.1.5 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. To make a meaningful assessment, once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

Hornsea Four

Bridge Petroleum Ltd Assets -
DCO Order Limits
Figure 7.1



Bridge Petroleum Licenses

Oil and Gas Infrastructure

- Other Operators
- Other Operators

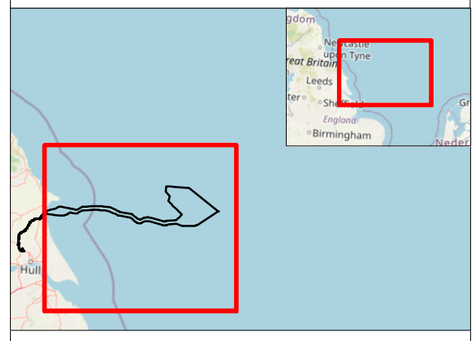
Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)

High : 0

Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	21/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Bridge Petroleum Ltd Assets - DCO Order Limits
Document no: HOW040364
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

8 Deltic Energy (formerly Cluff Natural Resources)

8.1.1.1.1 Deltic Energy is licence holder of United Kingdom Continental Shelf (UKCS) Block 48/08b (P2437), 47/10d and 48/6c (P2435) located to the south of the Development Consent Order (DCO) Order Limits, and 42/22 and 42/23 (P2562), 42/17 and 42/18 (P2560), 42/19 and 42/20b (P2561) located to the north of the DCO (Figure 8-1).

8.1.1.1.2 Based on the location of the block, the interaction between 48/8b and the Hornsea Four array area is negligible since the separation distance between the two areas is around 13 km (7 nm). Similarly, 47/10d, and to the north of the DCO - P2562 (42/22 and 42/23), P2560 (42/17 and 42/18), and P2561 (42/19 and 42/20b) have separation distances resulting in negligible interaction.

8.1.1.1.3 Given that there is a considerable separation distance and because these blocks are not operational, Deltic Energy is not considered further.

8.1.1.1.4 Hornsea Four undertook a consultation exercise with Cluff Natural Resources Plc (now Deltic Energy). Following this, Cluff Natural Resources Plc (now Deltic Energy) confirmed in a Letter of No Objection that after having reviewed the information provided by Hornsea Four, they have no principle objection to the development of Hornsea Four. Cluff Natural Resources Plc (now Deltic Energy) also confirmed that they do not intend to object to the future development of Hornsea Project Four.

8.1.1.1.5 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

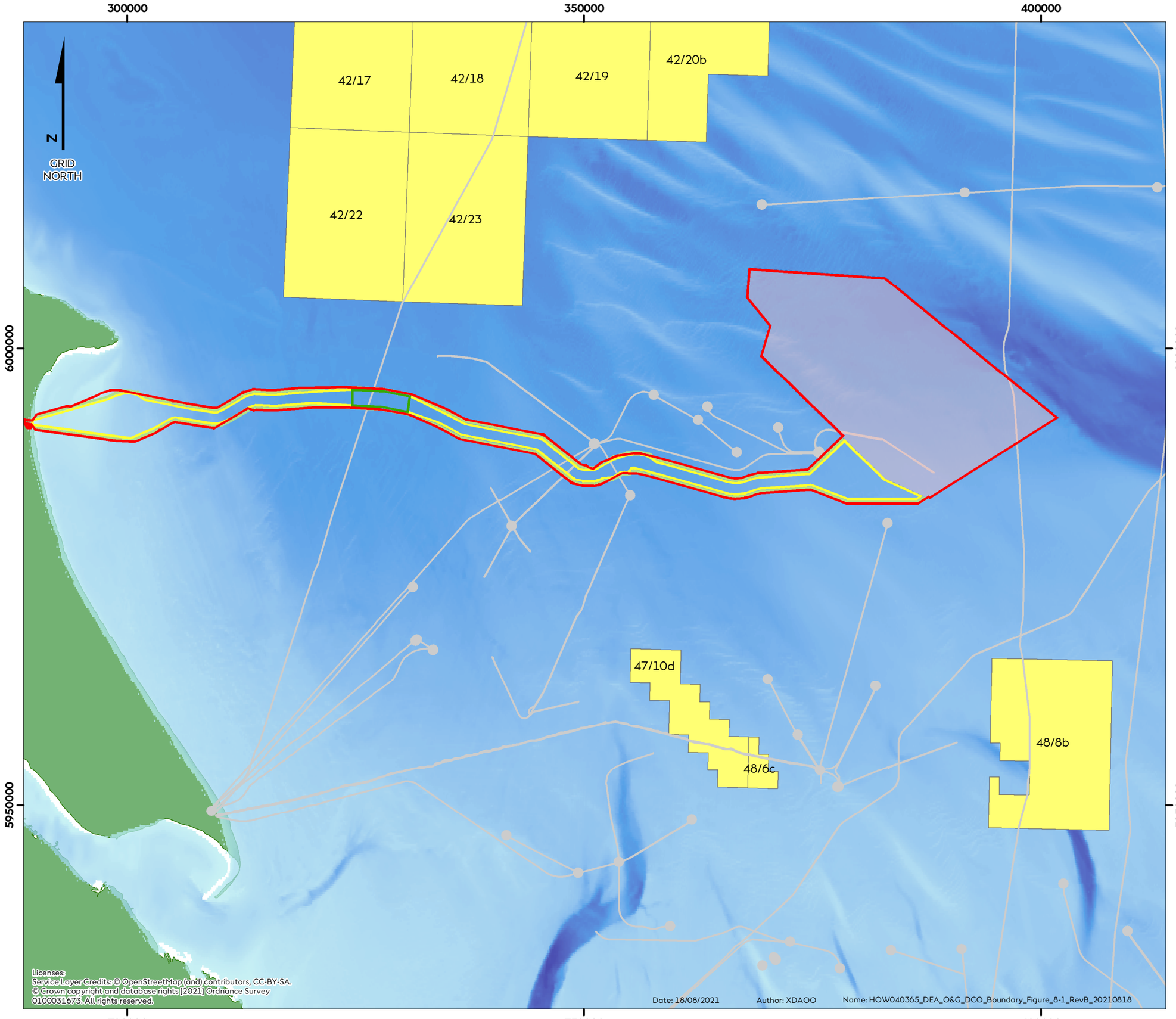
8.1.1.1.6 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

8.1.1.1.7 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

Hornsea Four

Deltic Energy Assets - DCO Order Limits

Figure 8.1



Deltic Energy Assets Licenses

Oil and Gas Infrastructure

Other Operators

Pipelines

Other Operators

Project Layers

DCO Order Limits

Offshore Export Cable

Hornsea 4 Array Area

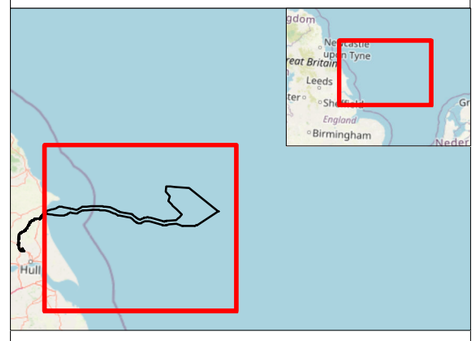
HVAC Booster Stations

Offshore Temporary Works Area

Bathymetry (Below Sea Level)

High : 0

Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	24/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Deltic Energy Assets - DCO Order Limits
Document no: HOW040365
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

Date: 18/08/2021 Author: XDAOO Name: HOW040365_DEA_O&G_DCO_Boundary_Figure_8-1_RevB_20210818

9 Painted Wolf Resources Limited

9.1.1.1.1 Painted Wolf Resources (formerly Actis Oil & Gas) is the sole equity holder of United Kingdom Continental Shelf (UKCS) Blocks 43/23 & 43/24b (P2431) located to the northeast boundary of the array area and 47/2d, 47/3f, 47/7a and 47/8d (P2433), as shown in Figure 9-1. Painted Wolf Resources is also licence holder of 42/20a, 43/16 and 43/17a (P2425) all located north of the Hornsea Four array area.

9.1.1.1.2 Based on the description of current operations, the interface between the blocks of this stakeholder and Hornsea Four is very limited.

9.1.1.1.3 Hornsea Four undertook a consultation exercise with Painted Wolf Resources. Following this, Painted Wolf Resources confirmed in a Letter of No Objection that after having reviewed the information provided by Hornsea Four, they have no principle objection to the development of Hornsea Four. Painted Wolf Resources also confirmed that they do not intend to object to the future development of Hornsea Project Four.

9.1.1.1.4 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

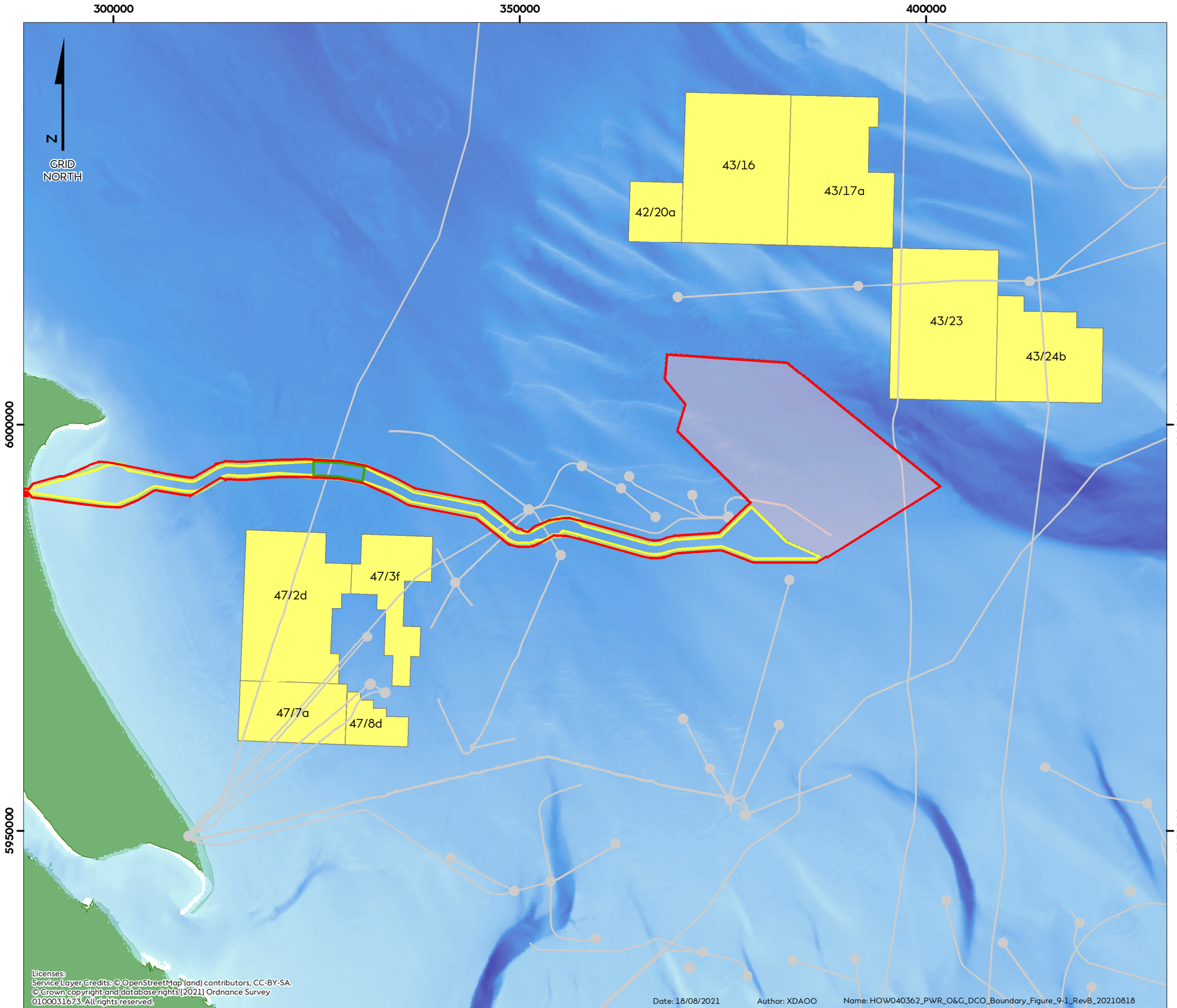
9.1.1.1.5 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

9.1.1.1.6 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

Hornsea Four

Painted Wolf Resources Ltd Assets - DCO Order Limits

Figure 9.1



- Painted Wolf Resources Licenses

Oil and Gas Infrastructure

- Other Operators
- Other Operators

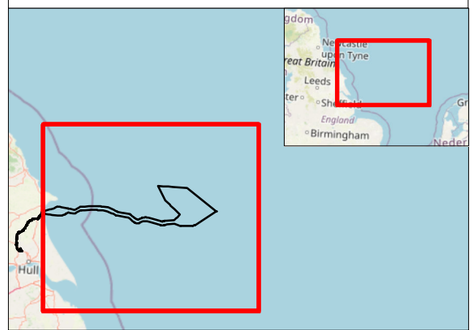
Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)

High : 0

Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:450,000

0 5 10 20 Kilometres

0 2.5 5 10 Nautical Miles

REV	REMARK	DATE
	First issue	25/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Painted Wolf Resources Ltd Assets - DCO Order Limits
Document no: HOW040362
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

Date: 18/08/2021 Author: XDAOO Name: HOW040362_PWR_O&G_DCO_Boundary_Figure_9-1_RevB_20210818

10 RockRose Energy Limited

10.1.1.1.1 At the time of writing the Offshore Installation Interface (OII) report, RockRose Energy was the licence operator of United Kingdom Continental Shelf (UKCS) Block 43/21b (P2341), located approximately 2.8 km (1.5 nm) to the north of the proposed Hornsea Four array area (Figure 10-1).

10.1.1.1.2 RockRose Energy have subsequently submitted a relinquishment application with the OGA, for the Cotton Licence P2341. The application is now approved.

10.1.1.1.3 Prior to the application for relinquishment, consultation meetings were held. During a consultation meeting in March 2019, Speedwell Energy (the previous owner of the block) indicated plans for a pipeline routing survey with the following operations under consideration:

- Drilling of two wells from the same drilling centre close to the existing 5z well north of the array; and
- Trenching and installation of a new 8" pipeline and control umbilical straight to Ravenspurn North in Block 42/30a.

10.1.1.1.4 Draft Field Development Plans and ES were submitted to Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) (by Speedwell Energy, the previous owner of the licence block). However the stakeholder was not performing operations directly in the licence block 43/21b, and therefore it was not possible to anticipate the full extent of the interaction between both projects. Based on the description of current operations, the interface between operations in Block 43/21b and Hornsea Four was considered limited.

10.1.1.1.5 During further consultation meetings in 2020, RockRose Energy confirmed that potential plans for a pipeline were still under consideration, but as the required details are not currently available, they have not been considered in this assessment.

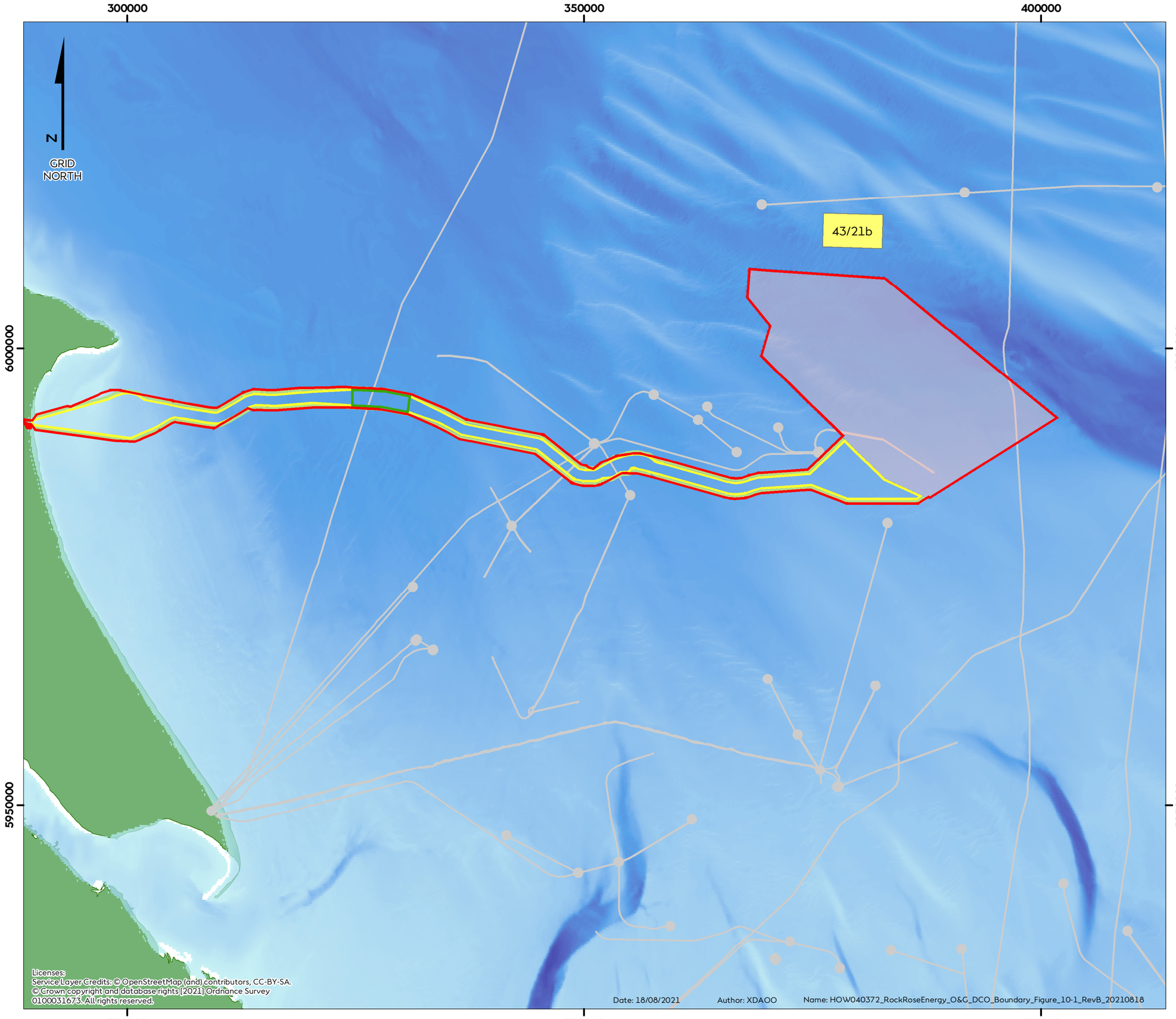
10.1.1.1.6 The stakeholder anticipates that helicopter and vessel transportation will be required for the field during drilling. If exercised and depending on the route agreed between the helicopter service provider, RockRose Energy, and the aviation and maritime and coastguard authorities, a further assessment will be required to analyse potential interferences of Hornsea Four on the access to this block.

10.1.1.1.7 The OII Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

10.1.1.1.8 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

Hornsea Four

RockRose Energy Ltd Assets -
DCO Order Limits
Figure 10.1



RockRose Energy Licenses

Oil and Gas Infrastructure

- Other Operators
- Other Operators

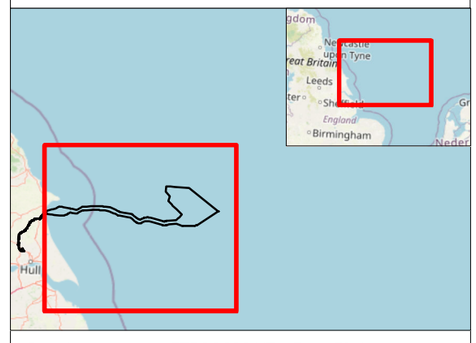
Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)

High : 0

Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	25/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

RockRose Energy Ltd Assets - DCO Order Limits
Document no: HOW040372
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

11 Cornerstone Oil and Gas Ltd

11.1.1.1.1 Cornerstone Oil and Gas Ltd. is the licence administrator of United Kingdom Continental Shelf (UKCS) Block 47/3i located south of the midway point of the Export Cable Corridor (ECC) and southwest of the Hornsea Four array area (Figure 11-1).

11.1.1.1.2 Based on the location of the block, the interaction between Block 47/3i and the Hornsea Four array area is negligible since the separation distance between the two areas is around 35 km. Given that there is a considerable separation distance and because this block is not operational, Cornerstone is not considered further.

11.1.1.1.3 Hornsea Four undertook a consultation exercise with Cornerstone Oil and Gas Ltd. Following this, Cornerstone Oil and Gas Ltd. confirmed in a Letter of No Objection that after having reviewed the information provided by Hornsea Four, they have no principle objection to the development of Hornsea Four. Cornerstone Oil and Gas Ltd. also confirmed that they do not intend to object to the future development of Hornsea Project Four.

11.1.1.1.4 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

11.1.1.1.5 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

11.1.1.1.6 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

300000
350000
400000
6000000
5950000
N
GRID NORTH
47/3i

Hornsea Four

Cornerstone Oil and Gas Ltd Assets - DCO Order Limits

Figure 11.1

32nd Round Provisional Awards

- CORNERSTONE OIL AND GAS LTD

Oil and Gas Infrastructure

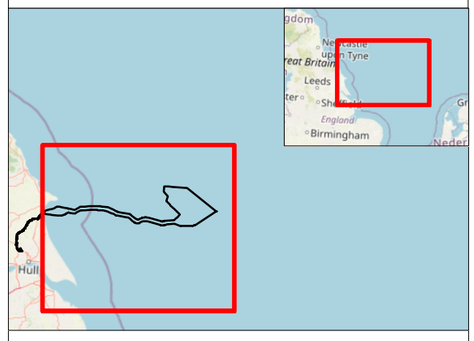
- Other Operators
- Other Operators

Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)

- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	11/11/2020
A	Reduced Array Area in northwest corner	18/08/2021

Cornerstone Oil and Gas Ltd Assets - DCO Order Limits
Document no: HOW040438
Created by: XDAOO
Checked by: JOHLE
Approved by: ELENI

Ørsted

Date: 18/08/2021 Author: XDAOO Name: HOW040438_Cornerstone_O&G_DCO_Boundary_Figure_11-1_20210818

12 Holywell Resources Ltd

12.1.1.1.1 At the time of writing the Offshore Installation Interfaces (OII) annex, Holywell Resources Ltd. is the licence administrator of United Kingdom Continental Shelf (UKCS) Blocks 43/25, 43/29a, 43/30a, 48/4a, and 48/5a located east of the Development Consent Order (DCO) Order Limits (Figure 12-1).

12.1.1.1.2 Based on the location of the block, the interaction between Blocks 43/25, 43/29a, 43/30a, 48/4a, and 48/5a and the Hornsea Four array area is considered. Given the location and because these blocks are not operational, Holywell Resources is not considered further.

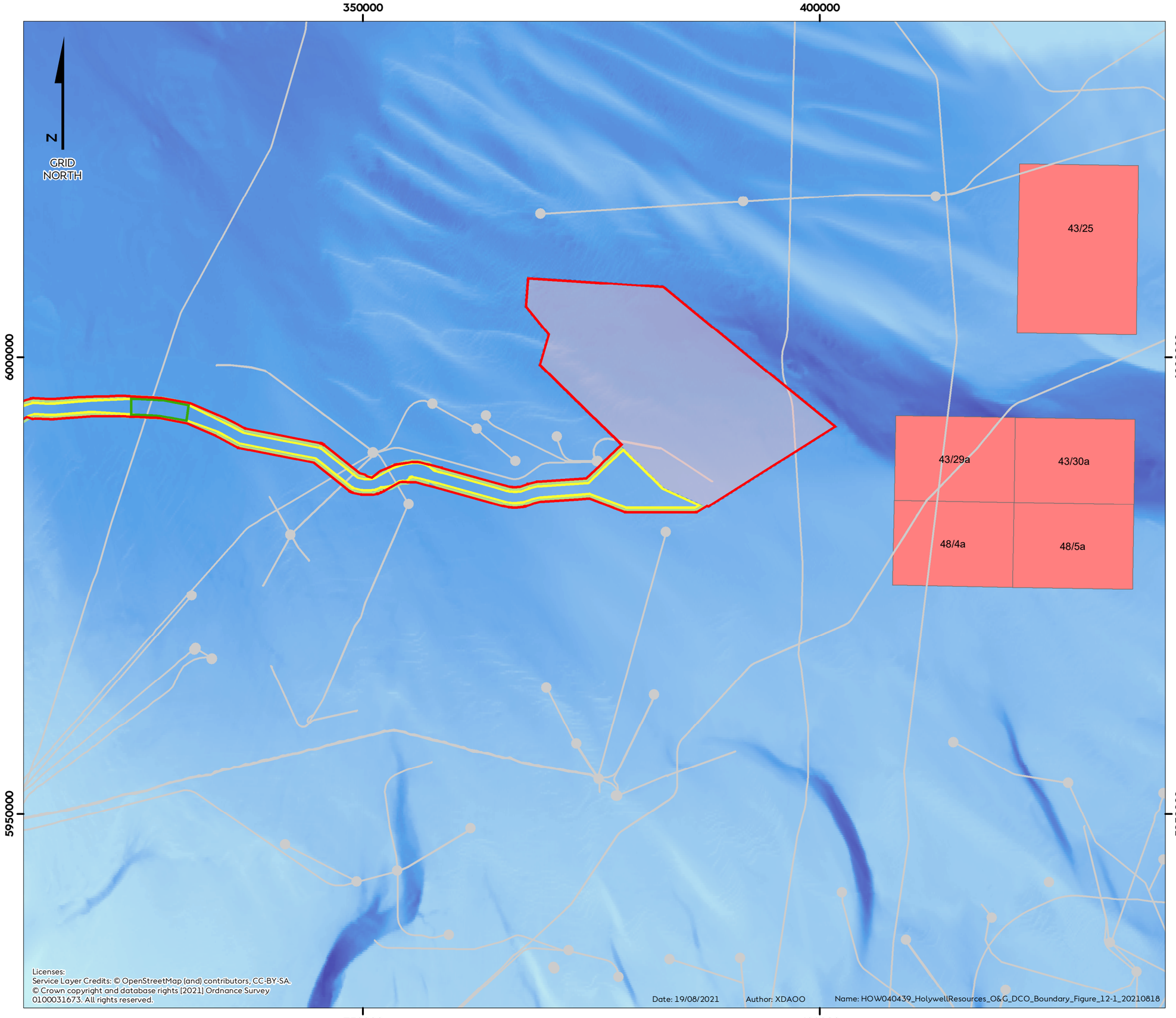
12.1.1.1.3 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

12.1.1.1.4 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

12.1.1.1.5 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

Hornsea Four

Holywell Resources Ltd Assets - DCO Order Limits
Figure 12.1



32nd Round Provisional Awards

- HOLYWELL RESOURCES LIMITED

Oil and Gas Infrastructure

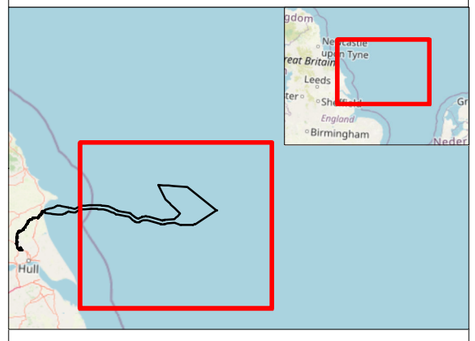
- Other Operators
- Other Operators

Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)

- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	11/11/2020
A	Reduced Array Area in northwest corner	18/08/2021

Holywell Resources Ltd Assets - DCO Order Limits
Document no: HOW040439
Created by: XDAOO
Checked by: JOHLE
Approved by: ELENI

Ørsted

13 Dana Petroleum (E&P) Limited

13.1 Introduction

13.1.1.1.1 Dana Petroleum is the licenced operator of United Kingdom Continental Shelf (UKCS) Blocks 42/29a which traverses the proposed Export Cable Corridor (ECC); and 47/5c located in close vicinity to the south boundary of the Hornsea Four cable corridor (Figure 13-1). Dana Petroleum was awarded licence blocks 42/27, 47/2b and 47/3g, as part of the Oil and Gas Authority's 32nd Offshore Licensing Round and have indicated preliminary development plans for these areas through consultation meetings. As details are not currently available, licence blocks 42/27, 47/2b and 47/3g are not considered further within the assessment.

13.1.1.1.2 At the early development stages of the Offshore Installation Interfaces (OII) annex, Dana Petroleum was the license holder for the blocks 47/5b and 48/1a located to the south of the cable corridor and to the southwest boundary of the Hornsea Four array area respectively; and also the operator of the planned Platypus Pipeline, which will cross the Hornsea Four ECC once constructed.

13.1.1.1.3 Dana Petroleum have now withdrawn from the Platypus license P1242, including blocks 47/5b and 48/1a. As it is perceived that there will be a new license holder and operator for the Platypus license, the following subsections addressing Hornsea Four's potential safety impact on the Platypus pipeline have been retained.

13.1.1.1.4 The Platypus pipeline will link the 47/5b and 48/1a wells located to the south of the cable corridor to the Cleeton CC/PQ/WLTR. The pipeline will cross the ECC at approximately 18 km from the array area and approximately 25 km from the High Voltage Alternating Current (HVAC) booster station search area. It is assumed that the pipeline will be less than 16" diameter and buried. It is assumed that the pipeline will be installed prior to the Hornsea Four export cables.

13.1.1.1.5 Dana Petroleum have previously confirmed in a Letter of No Objection that after having reviewed the information provided by Hornsea Four, Dana Petroleum have no principal objection to the development of Hornsea Four. Dana Petroleum also confirmed that they do not intend to object to the future development of Hornsea Project Four.

13.1.1.1.6 It is expected that the Operator will also sign a Letter of No Objection as plans for Platypus have not changed.

13.1.1.1.7 The OII Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

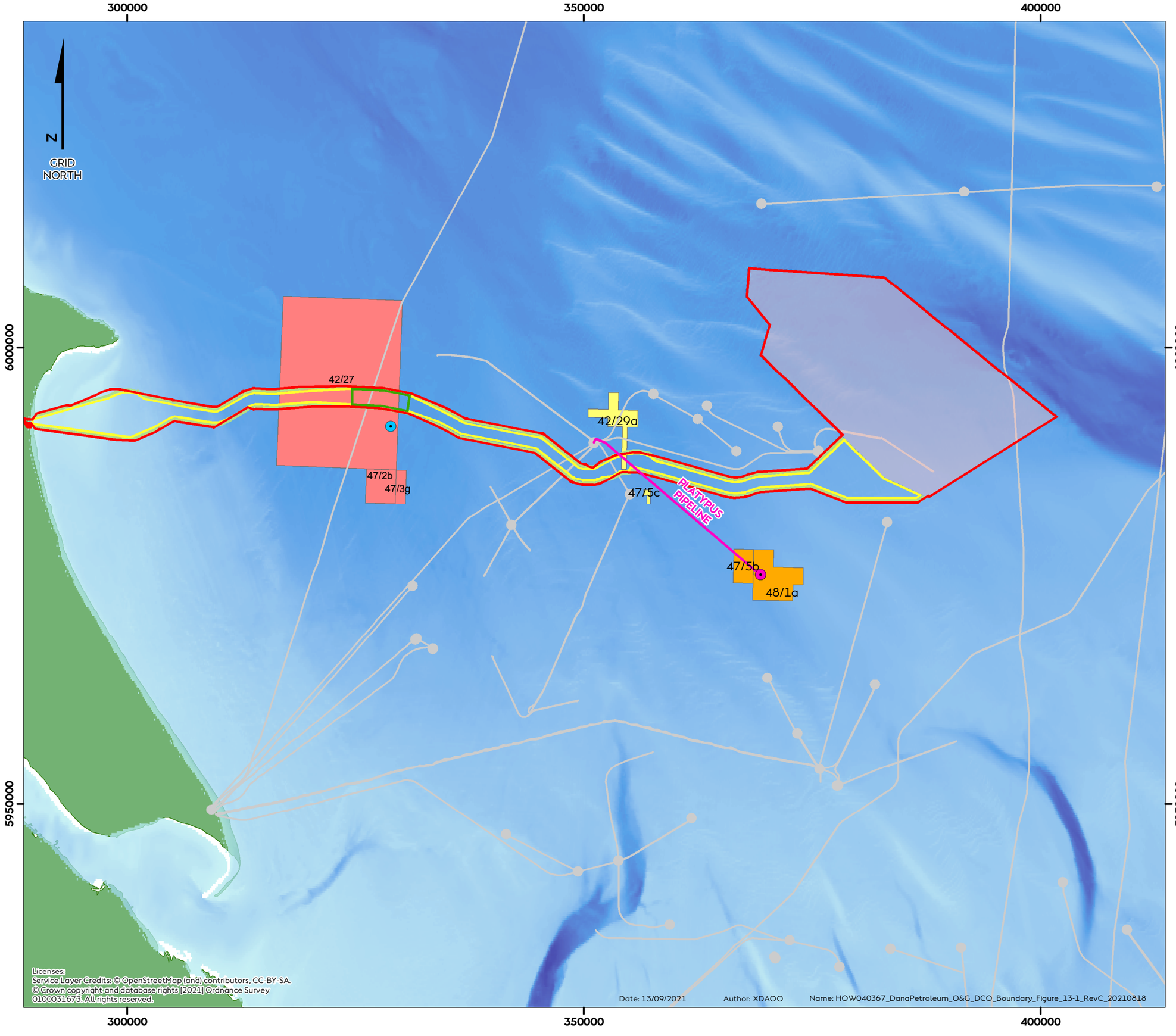
13.1.1.1.8 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

13.1.1.1.9 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

Hornsea Four

Dana Petroleum EP Ltd Assets - DCO Order Limits

Figure 13.1



- Existing Dana Petroleum Licenses
- New Operator(s) Platypus Licenses

32nd Round Provisional Awards

- DANA PETROLEUM (E&P) LIMITED
- Dana Petroleum Wellhead
- Platypus Wellhead
- Platypus Pipeline

Oil and Gas Infrastructure

- Other Operators
- Other Operators

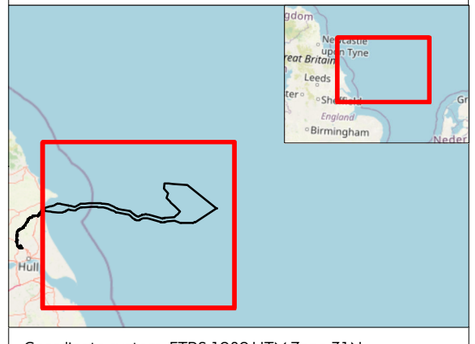
Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)

High : 0

Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	25/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	32nd round licenses included	11/11/2020
C	Reduced Array Area in northwest corner	18/08/2021

Dana Petroleum EP Ltd Assets - DCO Order Limits
Document no: HOW040367
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

Date: 13/09/2021 Author: XDAOO Name: HOW040367_DanaPetroleum_O&G_DCO_Boundary_Figure_13-1_RevC_20210818

13.2 Pipelines – Loss of Containment

13.2.1.1.1 According to Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006), the relevant potential hazardous events with the potential for damage to the pipeline resulting in loss of containment could result from the following hazard initiators:

- Fatigue / Vibration;
- Incorrect Installation / Inadequate Design / Incorrect Material Specification;
- Operator Error – Inadequate Training / Competency;
- Violation;
- Deficient Procedures – Operational / Maintenance;
- Vessel Impact;
- Dropped Objects (i.e., dropped cargo) / Abnormal External Load;
- Seismic Event; and
- Anchor – Snagging / Dropping.

13.2.2 Fatigue / Vibration

13.2.2.1.1 Operations associated with installation of the HVAC Booster Station(s) and foundations for the Wind Turbine Generators (WTGs) and Offshore Substations (OSS) could involve piling or drilling dependent on the selected foundation method which is also dependent on ground conditions.

Potential Consequences

13.2.2.1.2 Loss of containment due to flowline vibration triggered by drilling / piling.

Existing Safeguards / Controls

- Inherent safety (including fully rated pipelines, inherent impact resistance, pipe burial and trenching, where applicable);
- 500 m safety zone;
- Good procedures and competent personnel associated with installation and operation of Hornsea Four;
- Isolation and Permit to Work (PTW) controls; and
- Pre-operation strength and leak testing.

Analysis of Risk

13.2.2.1.3 If the HVAC technologies are progressed, and as documented in Volume A1, Chapter 4: Project Description, the Maximum Design Scenario (MDS) strike energy for piling within the offshore ECC is 5,000 kJ. It is expected that there will be three (3) HVAC Booster Stations. For HVAC stations on monopiles, there will be a 4-hour piling duration with a total duration of 1.2 days per monopile. For HVAC booster stations on piled jackets, the jackets will have a total of 72 pins with each jacket having 6 legs and 4 piles per leg. Although piling will not be a continuous operation, the duration of HVAC Booster Station(s) foundation installation would be less than two months for each platform. The durations of the impact piling component of the HVAC Booster Station(s) installation campaign is expected to be a maximum of 12 months.

13.2.2.1.4 The MDS strike energy for piling of the foundations in the array area is 3,000 kJ to 5,000 kJ. For WTGs, substations, and accommodation platform on monopiles, there will be a 4-hour piling duration and 1.2 days per monopile, with a total duration of 106 to 216 piling days depending on the number of vessels. For WTGs, substations, and accommodation platform on piled jackets, the jackets will have a piling duration of 1.5 days per jacket foundation and a total of 135 to 270 piling days depending on the number

of vessels. The durations of the impact piling component of the installation campaign is expected to be a maximum of 12 months.

13.2.2.1.5 The ground shaking from the HVAC booster station search area and the array area, is not expected to impact the operation of the Platypus pipeline. The expected ground shaking will not be significant and will dissipate over the distance from where the piling would take place (crossing location is approximately 18 km from the array area and approximately 25 km from the HVAC booster station search area). The structural integrity of the pipeline is also not expected to be impaired.

13.2.2.1.6 Considering the distance between the locations of drilling/piling and the pipelines, the potential ground shaking and associated vibration in the surrounding area is expected to dissipate before reaching the pipeline, and as such, there will be negligible impact to the pipeline. The risk is therefore considered to be broadly acceptable.

13.2.3 Incorrect Installation

13.2.3.1.1 Incorrect installation of Hornsea Four cable crossings has the potential to impact the pipelines at their crossing points within the ECC due to incremental additional risks over and above the pipeline design criteria.

Potential Consequences

13.2.3.1.2 Loss of containment due to incorrect installation of cable crossings.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel;
- Monitoring and Audit systems; and
- Crossing protection mattresses, where assessed to be applicable.

Analysis of Risk

13.2.3.1.3 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four export cables, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the Platypus pipeline is considered negligible, and therefore broadly acceptable.

13.2.3.1.4 Also, the pipeline crossings will be designed and engineered in accordance with standard approaches and be subject to crossing agreement, as per Co107 (see Volume A4, Annex 5.2: Commitment Register). This would typically include the provision for a representative of the Operator to be in attendance on the vessel and monitor the works.

13.2.4 Operator Error – Inadequate Training / Competency

13.2.4.1.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

13.2.4.1.2 For the analysis of the Platypus pipeline the most relevant subject is navigation, station holding and/or the potential of drifting close to or around the route of the pipeline, due to vessel operations associated with cable installation, cable inspection or maintenance.

13.2.4.1.3 Human errors can occur in any phase of a project. Human errors, that have the potential to result in a Major Accident Hazards (MAH), in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

13.2.4.1.4 Loss of containment due to incidents caused by personnel incompetency / lack of experience.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

13.2.4.1.5 According to GASCET (HSE, 2006), the O&G asset holder should have a procedure in place for the selection, competence assessment, and training of operations and maintenance personnel. The O&G asset holder's procedure should be designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

13.2.4.1.6 The Health and Safety Executive (HSE) standards and codes of practices are referenced to show that in order to operate in the UK Continental Shelf, the O&G asset holders are expected to follow certain requirements.

13.2.4.1.7 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016). Risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel will be employed during the installation, operations, and maintenance of the Hornsea Four infrastructure. Incremental additional risk to the pipeline from this potential initiator is considered negligible.

13.2.4.1.8 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the risk of impact from human factors is considered broadly acceptable.

13.2.5 Violation

13.2.5.1.1 Human factors involved in the earlier conceptual design stages of the installation lifecycle can influence the likelihood of the occurrence of hazardous events. When installations have not been designed and constructed, and / or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice, or code of practice for accidental hazards, a violation is said to have occurred.

Potential Consequences

13.2.5.1.2 Loss of containment due to not following procedure and guidelines.

Existing Safeguards / Controls

- Good procedures; and
- Competent personnel.

Analysis of Risk

13.2.5.1.3 As stated in section 13.2.4, human errors can occur in all phases of a project. Human errors, that have the potential to result in MAHs, in the earlier conceptual design stages, can also be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

13.2.5.1.4 The impact of violation is considered similar to 'operator error' and considering that risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel are being applied to the design of the Hornsea Four infrastructure, the introduction of additional risk to the pipeline from this potential initiator is considered negligible, and therefore, the risk is broadly acceptable.

13.2.6 Deficient Procedures

13.2.6.1.1 If deficient procedures are applied during the installation, operations, and maintenance of Hornsea Four cables, there is potential that pipelines with crossings will be affected due to additional hazards over and above the pipeline design tolerance.

Potential Consequences

13.2.6.1.2 Loss of containment due to inadequate quality assurance during procedures development.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring & Audit systems.

Analysis of Risk

13.2.6.1.3 The impact of deficient procedures is considered similar to incorrect installation and operator error which are assessed in sections 13.2.3 and 13.2.4, and considering that risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel are being employed in the design of the Hornsea Four, the introduction of incremental additional risk to the pipelines from this potential initiator is considered negligible. The risk is therefore considered to be broadly acceptable.

13.2.7 Inadequate Design

13.2.7.1.1 The impact of inadequate design is considered similar to 'incorrect installation' (see section 13.2.3 above).

13.2.7.1.2 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four export cables, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the Platypus pipeline is considered negligible, and therefore broadly acceptable.

13.2.8 Incorrect Material Specification

13.2.8.1.1 The impact of incorrect material specification is considered similar to 'incorrect installation' (see section 13.2.3 above).

13.2.8.1.2 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four export cables, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the Platypus pipeline is considered negligible, and therefore broadly acceptable.

13.2.9 Vessel Impact

13.2.9.1.1 Vessel impact concerns the potential additional hazards associated with vessel movements in and around the pipeline corridor, due to the presence of Hornsea Four construction and operation. This may include the following types of vessels: standby vessels, supply vessels, diving support vessels, survey vessels, barges, and cable installation vessels.

13.2.9.1.2 For a major accident to be realised, these hazard sources need an initiator, for vessel collisions, the following broad categories of initiators are present:

- Positioning Failure;
- Navigational Failure;
- Procedural Failure; and
- Human Error.

13.2.9.1.3 The usual measures employed in controlling the hazards include:

- Inherent safety in design and operation;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection (visual & radar, platform mounted radar, automated systems);
- Control through quality assurance, operating envelope, procedures, and barriers; and
- Mitigation through physical protection and robust structure.

13.2.9.1.4 According to section 5.2.HS0 of GASCET (HSE, 2006), the pipeline should be protected from third party and/or construction damage by vessel anchors and mooring wires and chains, by pipe lay abandon and retrieval wires, and by support vessels installing subsea facilities (e.g., HVAC cables or umbilical); also considering the anchoring procedures for standby vessels, supply vessels, diving support vessels, heavy lift crane vessels, flotels, drilling rigs, etc.

13.2.9.1.5 In addition, the pipeline will be marked on the local field admiralty charts and Hornsea Four intends to interface with the operator closer to the installation time in order to arrange for a Simultaneous Operations (SIMOPS) review, prior to commencement of cable installation.

13.2.9.1.6 The interaction between vessels and pipelines will potentially result from dropped objects and/ or anchor snagging. Dropped object and anchor snagging risks are addressed in section 13.2.10 and 13.2.12 of the report.

13.2.9.1.7 A vessel allision study, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, was performed duly considering assets close to Hornsea Four, including Cleeton and Neptune which are in the vicinity of where the platypus pipeline and the ECC interact. Both deviations to routine support vessel routeing and spacing / proximity issues relative to the Hornsea Four were considered.

13.2.9.1.8 As per proximity assessments conducted and presented in section 7.4 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, no notable changes/ effect in vessel numbers predicted within 2 nm of the platform assets in the vicinity of the pipeline, the risk of impact from Hornsea Four on these assets were considered broadly acceptable.

13.2.9.1.9 As the relevant UK Continental Shelf Procedures, Legislation, and Guidelines will be adhered to and maintained in designing and installation of the cables, it is considered that all design, prevention and control measures will be adhered to; therefore it is not perceived that potential additional hazards initiated as a result of Hornsea Four in the array area will surpass those for which the Platypus pipeline should be designed to withstand; and so the introduction of additional risks from this potential initiator is considered negligible. The risk is therefore considered to be broadly acceptable.

13.2.10 Dropped Objects

13.2.10.1.1 This involves the potential incremental additional risk to the Platypus pipeline as a result of abnormal external load / dropped objects from vessels associated with Hornsea Four. Major damage risks can come from dropped objects during installation or maintenance of Hornsea Four's export cables.

13.2.10.1.2 According to the Offshore Technology Report 2001/013 (HSE, 2002), the principal categories of load are: dead loads, imposed (operational) loads, environmental loads, deformation loads - loads associated with imposed deformations and imposed strains; and accidental loads, results from accidental events, such as collision, dropped objects, fire and explosion and other abnormal events.

13.2.10.1.3 For the interaction between Hornsea Four and the Platypus pipeline, dropped object accidental loads are the only relevant potential hazards that could arise from this interaction.

Potential Consequences

13.2.10.1.4 Loss of containment from rupture of flowlines due to dropped objects from Hornsea Four construction (cable crossings, cable lay vessels, and other construction works) and supply / support vessels during installation and maintenance of Hornsea Four.

Existing Safeguards / Controls

13.2.10.1.5 As per Offshore Technology Report (2001/013) (HSE, 2002), the pipeline installation should be so designed and, if necessary, protected so that the consequences of damage are acceptable and that an adequate margin of safety is maintained.

13.2.10.1.6 As with the hazards associated with collision, the usual measures employed in controlling the hazards from dropped objects include:

- Inherent safety in design and operation;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection (visual & radar, platform mounted radar, automated systems);
- Control through quality assurance, operating envelope, procedures, and barriers;
- Mitigation through: Physical protection and robust structure; and
- The subsea infrastructure will be marked in sea charts and other layout drawings.

Analysis of Risk

13.2.10.1.7 According to section 3.G16 of GASCET (HSE, 2006), the pipeline should have been designed and constructed, and/or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards. General requirements for accidental hazards are found in:

- Loads, Offshore Technology Report – OTO 2001/013 (HSE, 2002);
- Petroleum and Natural Gas Industries – Fixed Steel Offshore Structures – ISO 19902 (ISO, 2011);
- Technical Safety – S-001 (NORSOK, 2008);
- Documentation for Operation – Z-001 (NORSOK, 1998);
- Risk and Emergency Preparedness Analysis – Z-013 (NORSOK, 2001); and
- Explosion Resistant Design for Offshore Structures – Technical Note No 4 (SCI, 1996).

13.2.10.1.8 Other requirements are found in DNV RPF-107 – RP Risk Assessment of Pipeline Protection (DNV, 2010).

13.2.10.1.9 Also, the relevant Legislation, ACOP and Guidance that apply includes:

- Offshore Installations Safety Case Regulations – HSE-UK SCR (HSE, 2015);
- Offshore Installations and Wells (Design and Construction, etc) Regulations (HSE, 2008); and

- Assessment Principles for Offshore Safety Cases [APOSC] (HSE, 2016).

13.2.10.1.10 As the relevant UK Continental Shelf Procedures, Legislation, and Guidelines will be adhered to and maintained in designing and installation of the export cables, it is considered that all design, prevention and control measures for cable installation in the UK Continental Shelf will be adhered to; therefore it is not perceived that potential additional hazards initiated as a result of Hornsea Four will surpass those which the Platypus pipeline should be designed to withstand; and so the introduction of additional risks is considered negligible. The risk is therefore considered to be broadly acceptable.

13.2.10.1.11 As part of Hornsea Four's commitment Co107 (see Volume A4, Annex 5.2: Commitment Register), crossing and proximity agreements with known existing pipeline and cables operators will be sought.

13.2.10.1.12 Note that consideration will be given to providing mattress protections in vulnerable areas of interference.

13.2.11 Seismic Event

13.2.11.1.1 Hornsea Four will not induce / trigger any seismic events. It will however induce ground shaking and associated vibration during the piling/drilling of HVAC Booster Station(s) and WTG foundations.

13.2.11.1.2 Details of the duration of piling operations in the HVAC booster station search area and the array area are documented in section 13.2.2.

13.2.11.1.3 The hazard of a natural seismic event is not perceived relevant in relation to Hornsea Four, however ground-shaking and/or acoustic vibration may be induced because of construction operations. This is however, considered to be short term and have a minor effect to pipeline.

13.2.11.1.4 Note that the crossing location is approximately 18 km from the array area and approximately 25 km from the HVAC booster station search area and therefore chances of ground shaking having any impact are negligible. The risk is therefore considered to be broadly acceptable.

13.2.12 Anchor – Snagging / Dropping

13.2.12.1.1 Ships may anchor under various circumstances including the following:

- Normal anchoring:
  - when waiting on berths or for permission to use a controlled channel;
  - when necessary to aid manoeuvring in restricted areas;
  - when performing survey or construction operations; and
  - when performing repairs during the operation and maintenance phase.
- Emergency anchoring:
  - following mechanical breakdown of the propulsion or steering system;
  - following an accident such as major fire or a collision; and
  - to slow down the ship in order to avert a possible collision or ramming or grounding.

13.2.12.1.2 Hazards to pipelines can arise either at the time of anchoring or subsequently if the ship should drag its anchor due to the effects of wind, wave and/or current. A hazard can also arise when the ship tries to retrieve the anchor.

13.2.12.1.3 In normal anchoring, there should be minimal risk to the pipelines, which are shown on charts and may be protected by anchoring exclusion zones. Initially, DNV guidelines shall be adhered to with respect the minimum distance between any existing subsea asset and the placement of any Hornsea Four anchors. These distances shall be discussed and agreed with the subsea asset owner.

13.2.12.1.4 At the time of anchoring, the risk to the pipeline is either that the anchor is dropped onto the pipeline or that the anchor is dragged across the pipeline. If the anchor hooks the pipeline but does not cause immediate damage, there will be a further risk of damage when the ship comes to try to haul the anchor back in.

13.2.12.1.5 Good seamanship will avert impact from emergency anchoring. Good seamanship involves anchoring well away from pipelines, in water of an appropriate depth (neither too shallow nor too deep) and in an area where the seabed is known to have good anchor holding properties. In addition, under weather conditions when dragging might occur, it is normal good practice to keep engines on standby and to make regular checks on position. Sometimes ships will leave their anchorages if dragging is anticipated.

13.2.12.1.6 The cause of anchors dropping accidentally is mainly due to failure of the brake systems when anchors are made ready for use, i.e., when mechanical securing systems are removed. The risk to the pipeline due to dropping anchors at sea is considered negligible, because the anchors should not be made ready for use and should be secured.

13.2.12.1.7 The Hornsea Four export cable installation operations may include, but not be limited to, survey vessels, clearance vessels, cable installation vessels, cable burial vessels, remedial works vessels and post installation survey vessels, none of which are expected to make use of anchors or anchor spreads but may be required in shallow waters (less than 15 m) or where difficult conditions dictate. The Hornsea Four operations and maintenance operations associated with the export cables will involve mainly external inspection survey vessels, possibly accompanied by Remotely Operated Vehicle (ROV). Remedial protection replenishment may also be required. Such vessels are unlikely to make use of anchors or anchor spreads but may do so should conditions dictate. Should cable inspections, or cable testing identify a need for repair operations, a repair vessel, and associated support vessels will be required, which could involve anchorage. Initially, DNV guidelines shall be adhered to with respect the minimum distance between any existing subsea asset and the placement of any anchors. These distances shall be discussed and agreed with the subsea asset owner.

13.2.12.1.8 Considering the types of vessels that Hornsea Four intends to make use of during installation and maintenance of the export cables, the likelihood of anchor incidents leading to snagging, hooking or dropping is considered negligible, and therefore the incremental additional risk over and above the existing risk is therefore considered to be broadly acceptable.

13.3 Platypus Pipeline Summary

13.3.1.1.1 The table below presents the assessment summary of the impact from interaction of the Platypus pipeline with Hornsea Four.

13.3.1.1.2 It is noted that the Hornsea Four design envelope currently includes both HVAC and High Voltage Direct Current (HVDC) transmission technologies to allow a necessary degree of flexibility. Hornsea Four may use HVAC or HVDC transmission or could use a combination of both technologies in separate electrical systems. If HVDC technologies are chosen, there will be no HVAC Booster Station present within the offshore ECC. Therefore, in the event that HVAC technologies are not taken forward, the impact on the Platypus pipeline, herein will no longer be relevant.

Table 13-1: Hazards and Risk Summary – Platypus Pipeline

Tier	Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
TIER 1						
			N/A			
TIER 2						
TIER 2 – ASSOCIATED SYSTEMS						
	Loss of Containment - Outboard Pipelines / Intra-field Pipelines	Fatigue / Vibration	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Incorrect Installation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Operator Error – Inadequate Training / Competency	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Violation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Deficient Procedures – Operational / Maintenance	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Inadequate Design	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Incorrect Material Specification	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Vessel Impact	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Dropped Objects	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Anchor – Snagging / Dropping	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
TIER 3						
	TIER 3 – PLATFORMS		N/A			

14 Gassco AS

14.1 Introduction

14.1.1.1.1 Gassco is the operator of the Langeled pipeline (PL2071) that crosses the High Voltage Alternating Current (HVAC) Booster Station search area within the Export Cable Corridor (ECC) (Figure 14-1). The southern leg of Langeled is a 44-inch pipeline from the Sleipner East hub to the receiving terminal at Easington on the English east coast.

14.1.1.1.2 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

14.1.1.1.3 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

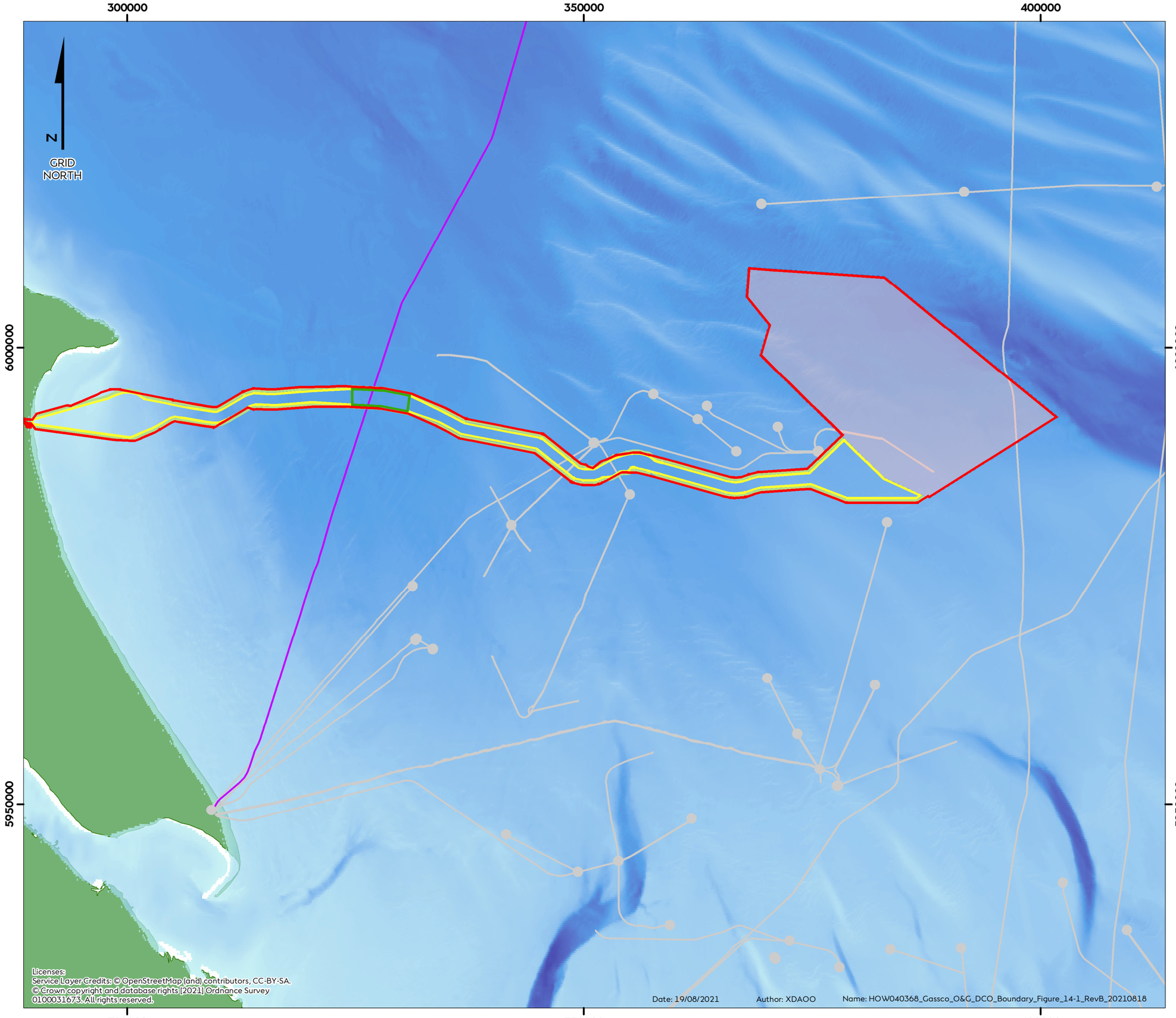
14.1.1.1.4 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

14.1.1.1.5 Potential hazards resulting from interaction of the Gassco assets with Hornsea Four include:

- Vessel access;
- Oil and Gas (O&G) diving operations;
- Pipelines - temporary impact upon access for repair/maintenance; and
- Pipelines - Loss of Containment.

Hornsea Four

Gassco Assets -
DCO Order Limits
Figure 14.1



Oil and Gas Infrastructure

- Other Operators

Pipelines

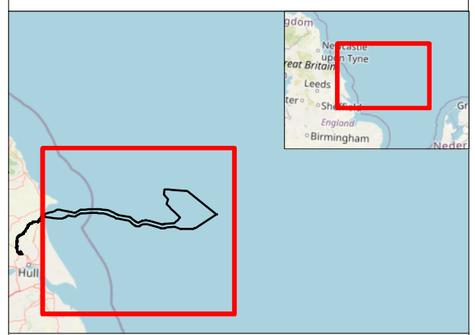
- Gassco
- Other Operators

Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)

- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	25/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Gassco Assets - DCO Order Limits
Document no: HOW040368
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

14.2 Pipelines - Temporary Impact Upon Access for Repair/Maintenance

14.2.1.1.1 As the Gassco Langeled pipeline crosses the ECC, and in particular the HVAC Booster Station search area of the ECC, the interaction between the two assets can potentially result in temporary impact upon Gassco's access to the pipeline. These impacts will take the form of:

- Temporary Impact upon Vessel Access; and
- Temporary Loss to Diving Operations.

14.2.2 Vessel Access

14.2.2.1.1 Interaction between Gassco's Langeled pipeline and Hornsea Four could potentially result in disruption of vessel access to the section of the pipeline that crosses the HVAC booster station search area.

14.2.2.1.2 As part of the repair and maintenance operations, access to the pipeline section running through/close to the HVAC booster station search area will be required. This is typically an infrequent operation with visual inspections by maintenance vessel/ 'flying' a Remotely Operated Vehicle (ROV) over the pipeline occurring approximately every 12 months. This operation will be well planned in accordance with a coexistence arrangement, and a Simultaneous Operations (SIMOPS) workshop will be performed where required.

14.2.2.1.3 It is anticipated that the only disruption to pipeline access by vessel may occur during installation of the Hornsea Four export cables. During this phase, and through detailed discussions, planning, and scheduling by both parties (Hornsea Four and Gassco), an arrangement can be made such that disruptions can be completely avoided or kept to a minimum.

14.2.2.1.4 During installation of the HVAC Booster Station(s) (incl. temporary piling / drilling operations), it is not anticipated that there will be temporary impact upon vessel access to the pipeline. This is due to the presence of a safety / buffer zone of at least 500 m that will be in place between the HVAC Booster Station(s) and the pipeline.

14.2.2.1.5 During the operational phases of Hornsea Four, it is not anticipated that there will disruption to or impact upon vessel access to the pipeline. This is due to the presence of a safety / buffer zone of at least 500 m that will be in place between the HVAC Booster Station(s) and the pipeline. The incremental additional risk to safety is therefore considered to be broadly acceptable.

14.2.2.1.6 As part of Hornsea Four's commitment Co107 (see Volume A4, Annex 5.2: Commitment Register), crossing and proximity agreements with known existing pipeline and cables operators will be sought.

14.2.2.1.7 Note that consideration will be given to providing mattress protections in vulnerable areas of interference.

14.2.3 Diving Operations

14.2.3.1.1 This section focuses on potential impact on Gassco's diving operations (temporary impact upon access for pipeline repair / maintenance, etc.) from interaction between Gassco's pipeline asset and Hornsea Four.

14.2.3.1.2 It is anticipated that the only temporary losses to diving operations for maintenance / repair may occur during installation of the Hornsea Four cables and HVAC Booster Station(s) (via piling / drilling). During this phase, and through detailed discussions, planning, and scheduling by both parties, an arrangement can be made such that temporary disruption to access can be managed and mitigated.

14.2.3.1.3 During the operational phases of Hornsea Four, it is not anticipated that there will be disruption to or impact upon access to the pipeline. Note that a an safety zone / buffer zone of at least 500 m will be in place between the HVAC Booster Stations(s) and the pipeline. The risk is therefore considered to be broadly acceptable.

14.3 Pipelines – Loss of Containment

14.3.1.1.1 According to Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006), the relevant potential hazardous events with the potential for damage to the pipeline resulting in loss of containment could result from the following hazard initiators:

- Fatigue / Vibration;
- Incorrect Installation / Inadequate Design / Incorrect Material Specification;
- Operator Error – Inadequate Training / Competency;
- Violation;
- Deficient Procedures – Operational / Maintenance;
- Vessel Impact;
- Dropped Objects (i.e., dropped cargo) / Abnormal External Load;
- Seismic Event; and
- Anchor – Snagging / Dropping.

14.3.2 Fatigue / Vibration

14.3.2.1.1 Fatigue and vibration of the pipeline could be induced as a result of operations associated with installation of the foundations for the HVAC Booster Station(s). This could involve piling or drilling, depending on the selected foundation method which is also dependent on ground conditions.

Potential Consequences

14.3.2.1.2 Loss of containment due to flowline vibration triggered by drilling / piling.

Existing Safeguards / Controls

- Inherent safety (including fully rated pipelines, inherent impact resistance, pipe burial and trenching (where applicable);
- HVAC Booster Station positions will also be set back 500 m from active pipelines;
- Good procedures and competent personnel associated with installation and operation of Hornsea Four;
- Isolation and Permit to Work (PTW) controls; and
- Pre-operation strength and leak testing.

Analysis of Risk

14.3.2.1.3 If the HVAC technologies are progressed, and as documented in Volume A1, Chapter 4: Project Description, the Maximum Design Scenario (MDS) strike energy for piling within the offshore ECC is 5,000 kJ. It is expected that there will be three (3) HVAC Booster Stations. For HVAC stations on monopiles, there will be a 4-hour piling duration with a total duration of 1.2 days per monopile. For HVAC booster stations on piled jackets, the jackets will have a total of 72 pins with each jacket having 6 legs and 4 piles per leg. Although piling will not be a continuous operation, the duration of HVAC Booster Station(s) foundation installation would be less than two months for each platform. The durations of the impact piling component of the HVAC Booster Station(s) installation campaign is expected to be a maximum of 12 months.

14.3.2.1.4 The potential ground shaking and associated vibration in the surrounding area is expected to dissipate before reaching the Langeled pipeline, and as such, there will be negligible impact to the pipeline. Note that an safety zone / buffer zone of at least 500 m will be in place between the HVAC Booster Station(s) and the Langeled pipeline.

14.3.2.1.5 The timing and execution of these foundation installation operations will be planned in consultation between Gassco and Hornsea Four, and these operations will be performed in accordance with good engineering practice.

14.3.2.1.6 The temporary piling / drilling operations associated with the HVAC Booster Station(s) installation could also lead to acoustic vibrations which could have an adverse effect on diving, while diving near the pipeline should be avoided during such operations. This will be managed via standard site installation communication between interested parties, and as a result is considered to have a negligible impact on the pipeline operation. The incremental additional risk is therefore considered to be broadly acceptable.

14.3.3 Incorrect Installation

14.3.3.1.1 Incorrect installation of the Hornsea Four export cables along the ECC has the potential to impact the pipeline due to incremental additional hazards over and above the pipeline design criteria.

Potential Consequences

14.3.3.1.2 Loss of containment due to incorrect installation of cable crossings.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel;
- 500 m safety zone;
- Monitoring and Audit systems; and
- Crossing protection mattresses where assessed to be applicable.

Analysis of Risk

14.3.3.1.3 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four export cables, and will include considerations for risk preventive measures such as: design practices, good installation practices and procedures, and the use of competent personnel; the introduction of additional risk to the Langeled pipeline is considered negligible. The risk is therefore considered to be broadly acceptable.

14.3.3.1.4 Also, the pipeline crossings will be designed and engineered in accordance with standard approaches and be subject to crossing agreement, as per Co107 (see Volume A4, Annex 5.2: Commitment Register). This would typically include the provision for a representative of Gassco to be in attendance on the vessel and monitor the works.

14.3.4 Operator Error – Inadequate Training / Competency

14.3.4.1.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

14.3.4.1.2 For the analysis of the Langeled pipeline the most relevant subject is Hornsea Four navigation, station holding and/or the potential of drifting close to or around the route of the pipeline, due to vessels operations associated with HVAC Booster Station and cable installation, inspection or maintenance.

14.3.4.1.3 Human errors can occur both in the conceptual and design phases as well as operational phases of a project. Human errors, that have the potential to result in a Major Accident Hazard (MAH), in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

14.3.4.1.4 Loss of containment due to incidents caused by personnel incompetency / lack of experience.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

14.3.4.1.5 According to the GASCET (HSE, 2006), the O&G asset holder should have a procedure in place for the selection, competence assessment, and training of operations and maintenance personnel. The O&G asset holder's procedure should be designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

14.3.4.1.6 The Health and Safety Executive (HSE) standards and codes of practices are referenced to show that in order to operate in the United Kingdom Continental Shelf (UKCS), the O&G asset holders are expected to follow certain requirements.

14.3.4.1.7 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016). Risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel will be employed during the installation, operations, and maintenance of the Hornsea Four infrastructure. Therefore, the introduction of additional risk to the pipeline from this potential initiator is considered negligible. Note that a safety / buffer distance of at least 500 m is planned between the HVAC Booster Station(s) and the Langeled pipeline.

14.3.4.1.8 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the risk of impact from human factors is considered broadly acceptable.

14.3.5 Violation

14.3.5.1.1 Human factors involved in the earlier conceptual design stages of the installation lifecycle can influence the likelihood of the occurrence of hazardous events. When installations have not been designed and constructed, and / or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards, a violation is said to have occurred.

Potential Consequences

14.3.5.1.2 Loss of containment due to not following procedure and guidelines.

Existing Safeguards / Controls

- Good procedures; and

Competent personnel.Analysis of Risk

14.3.5.1.3 As stated in 14.3.4, human errors can occur in all phases of a project. Human errors, that have the potential to result in MAHs, in the earlier conceptual design stages, can also be initiated from pressures

and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

14.3.5.1.4 The impact of violation is considered similar to 'operator error' and considering that risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel are being applied to the design of Hornsea Four, the introduction of additional risk to the pipeline from this potential initiator is considered negligible. Therefore, the risk is broadly acceptable.

14.3.6 Deficient Procedures

14.3.6.1.1 If deficient procedures are applied during the installation, operations, and maintenance of Hornsea Four cables, there is potential that pipelines with crossings will be affected due to additional hazards over and above the pipeline design tolerance.

Potential Consequences

14.3.6.1.2 Loss of containment due to inadequate quality assurance during procedures development.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring & Audit systems.

Analysis of Risk

14.3.6.1.3 The impact of deficient procedure is considered similar in consequences and safeguards to 'incorrect installation' and 'operator error' which are assessed in sections 14.3.3 and 14.3.4.

14.3.6.1.4 As the relevant UK Continental Shelf Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four infrastructure, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the pipeline is considered negligible, and therefore broadly acceptable.

14.3.7 Inadequate Design

14.3.7.1.1 The impact of inadequate design is considered similar to 'incorrect installation' (see section 14.3.3 above).

14.3.7.1.2 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four export cables, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the pipeline is considered negligible, and therefore broadly acceptable.

14.3.8 Incorrect Material Specification

14.3.8.1.1 The impact of incorrect material specification is considered similar to 'incorrect installation' (see section 14.3.3 above).

14.3.8.1.2 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four export cables, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the pipeline is considered negligible, and therefore broadly acceptable.

14.3.9 Vessel Impact

14.3.9.1.1 Vessel impact concerns the potential additional hazards associated with vessel movements in and around the Langeled pipeline corridor, due to Hornsea Four.

14.3.9.1.2 For a major accident to be realised, these hazard sources need an initiator. For vessel collisions, the following broad categories of Initiators are present:

- Positioning Failure;
- Navigational Failure;
- Procedural Failure; and
- Human Error.

14.3.9.1.3 The usual measures employed in controlling the hazards include:

- Inherent safety in design and operation;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection;
- Control through quality assurance, operating envelope, procedures, and barriers; and
- Mitigation through physical protection and robust structure.

14.3.9.1.4 According to section 5.2.HS0 of GASCET (HSE, 2006), the pipeline should be protected from third party and/or construction damage by vessel anchors and mooring wires and chains, by pipe lay abandon and retrieval wires, and by support vessels installing subsea facilities (e.g., HVAC cables or umbilical); also considering the anchoring procedures for standby vessels, supply vessels, diving support vessels, heavy lift crane vessels, flotels, drilling rigs, etc.

14.3.9.1.5 In addition, the Langeled pipeline will be marked on admiralty charts and Hornsea Four intends to interface with Gassco closer to the export cable and HVAC Booster Station installation time in order to arrange for a SIMOPS review, prior to commencement of cable installation.

14.3.9.1.6 A buffer distance of at least 500 m is planned between the HVAC booster station and the pipeline.

14.3.9.1.7 The interaction between vessels and pipelines will potentially result from dropped objects and/ or anchor snagging. Dropped object and anchor snagging risks are addressed in section 14.3.10 and 14.3.12 of the report.

14.3.9.1.8 As the relevant UK Continental Shelf Procedures, Legislation, and Guidelines will have been adhered to and maintained during the design and installation of the cables, it is considered that relevant design, prevention and control measures for pipelines installed on the UK Continental Shelf will have been adhered to; therefore it is not perceived that potential additional hazards initiated as a result of the Hornsea Four export cables and potential HVAC Booster Station Station(s) will surpass those for which the Langeled pipeline should be designed to withstand; and so the introduction of additional risks from this potential initiator is considered negligible. The risk is therefore considered to be broadly acceptable.

14.3.10 Dropped Objects

14.3.10.1.1 This involves the potential incremental additional exposure to the Langeled pipeline as a result of abnormal external load / dropped objects from vessels associated with Hornsea Four.

14.3.10.1.2 Major damage risks can come from dropped objects during installation or maintenance of the Hornsea Four export cables, and also during installation and maintenance of the HVAC Booster Station(s).

14.3.10.1.3 According to the Offshore Technology Report 2001/013 (HSE, 2002), the principal categories of load are: dead loads, imposed (operational) loads, environmental loads, deformation loads - loads associated with imposed deformations and imposed strains; and accidental loads, results from accidental events, such as collision, dropped objects, fire and explosion and other abnormal events.

14.3.10.1.4 For the interaction between Hornsea Four and the Gassco Langeled pipeline, dropped object accidental loads are the only relevant potential hazards that could arise from this interaction.

Potential Consequences

14.3.10.1.5 Loss of containment from rupture of flowlines due to dropped objects from Hornsea Four construction (cable crossings, cable lay vessels, and other construction works) and vessels during installation and maintenance of Hornsea Four.

Existing Safeguards / Controls

14.3.10.1.6 As per Offshore Technology Report (2001/013) (HSE, 2002), the pipeline installation should be so designed and, if necessary, protected so that the consequences of damage are acceptable and that an adequate margin of safety is maintained.

14.3.10.1.7 As with the hazards associated with collision, the usual measures employed in controlling the hazards from dropped objects include:

- Inherent safety in design and operation - HVAC booster station(s) will be separated from the pipeline by a safety zone / buffer zone of at least 500 m;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection;
- Control through quality assurance, operating envelope, procedures and barriers;
- Mitigation through: Physical protection and robust structure; and
- The subsea infrastructure will be marked in sea charts and other layout drawings.

Analysis of Risk

14.3.10.1.8 According to section 3.G16 of GASCET (HSE, 2006), the pipeline should have been designed and constructed, and/or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards. General requirements for accidental hazards are found in:

- Loads, Offshore Technology Report – OTO 2001/013 (HSE, 2002);
- Petroleum and Natural Gas Industries – Fixed Steel Offshore Structures – ISO 19902 (ISO, 2011);
- Technical Safety – S-001 (NORSOK, 2008);
- Documentation for Operation – Z-001 (NORSOK, 1998);
- Risk and Emergency Preparedness Analysis – Z-013 (NORSOK, 2001); and
- Explosion Resistant Design for Offshore Structures – Technical Note No 4 (SCI, 1996).

14.3.10.1.9 Other requirements are found in DNV RPF-107 – RP Risk Assessment of Pipeline Protection (DNV, 2010).

14.3.10.1.10 Also, the relevant Legislation, ACOP and Guidance that apply includes:

- Offshore Installations Safety Case Regulations – HSE-UK SCR (HSE, 2015);
- Offshore Installations and Wells (Design and Construction, etc) Regulations (HSE, 2008); and
- Assessment Principles for Offshore Safety Cases [APOSC] (HSE, 2016).

14.3.10.1.11 On the basis of the above considerations and the main windows within which accidental dropped objects may occur, i.e. during HVAC booster station and cable installation, and during the maintenance operations of the cables, it is considered that these hazardous operations are standard offshore operations that need standard good practice management via more detailed assessment in the next phase of engineering and offshore communications planning including crossing agreement at the time of installation. It is therefore considered that the additional hazards introduced as a result of the installation of the ECC cables and potential HVAC booster station are manageable via adequate design, installation methods and crossing

agreement, and so the introduction of additional risks from this potential initiator is considered negligible, and considered to be broadly acceptable.

14.3.10.1.12 As part of Hornsea Four's commitment Co107 (see Volume A4, Annex 5.2: Commitment Register), crossing and proximity agreements with known existing pipeline and cables operators will be sought.

14.3.10.1.13 Note that consideration will be given to providing mattress protections in vulnerable areas of interference.

14.3.11 Seismic Event

14.3.11.1.1 Hornsea Four will not induce / trigger any seismic events. It will however induce ground shaking and associated vibration during the piling/drilling of HVAC Booster Station(s) foundations.

14.3.11.1.2 Details of the duration of piling operations in the HVAC booster station search area are documented in section 14.3.2 above.

14.3.11.1.3 The hazard of a natural seismic event is not perceived relevant in relation to Hornsea Four, however ground-shaking and/or acoustic vibration may be induced because of construction operations. This is however, considered to be short term and have a minor effect to pipeline. The risk is considered negligible, and therefore broadly acceptable.

14.3.11.1.4 The timing and execution of these foundation operations will be planned in consultation between Gassco and Hornsea Four, and these operations will be performed in accordance with good practice.

14.3.12 Anchor – Snagging / Dropping

14.3.12.1.1 The cause of anchors dropping accidentally is mainly due to failure of the brake systems when anchors are made ready for use, i.e., when mechanical securing systems are removed. The risk to the pipeline due to dropping anchors at sea is considered negligible, because the anchors should not be made ready for use and should be secured.

14.3.12.1.2 The Hornsea Four export cable installation operations may include, but not be limited to, survey vessels, clearance vessels, cable installation vessels, cable burial vessels, remedial works vessels and post installation survey vessels, none of which are expected to make use of anchors or anchor spreads but may be required in shallow waters (less than 15 m) or where difficult conditions dictate. The Hornsea Four operations and maintenance operations associated with the export cables will involve mainly external inspection survey vessels, possibly accompanied by ROV. Remedial protection replenishment may also be required. Such vessels are unlikely to make use of anchors or anchor spreads but may do so should conditions dictate. Should cable inspections, or cable testing identify a need for repair operations, a repair vessel, and associated support vessels will be required, which could involve anchorage. Initially, DNV guidelines shall be adhered to with respect the minimum distance between the Langeled pipeline and the placement of any anchors. These distances shall be discussed and agreed with the subsea asset owner.

14.3.12.1.3 Considering the types of vessels that Hornsea Four intends to make use of during installation and maintenance operations, the likelihood of anchor incidents leading to snagging, hooking or dropping is considered negligible, and therefore broadly acceptable.

14.4 Gassco Summary

14.4.1.1.1 The table below presents the assessment summary of the impact from interaction of Gassco's Langeled pipeline with Hornsea Four.

14.4.1.1.2 It should be noted that the Hornsea Four design envelope currently includes both HVAC and High Voltage Direct Current (HVDC) transmission technologies to allow a necessary degree of flexibility. Hornsea Four may use HVAC or HVDC transmission or could use a combination of both technologies in separate

electrical systems. If HVDC technologies are chosen, there will be no Offshore Substation(s) (OSS) present within the offshore ECC. Therefore, in the event that HVAC technologies are not taken forward, the impact on the Langeled pipeline, assessed herein will no longer be relevant.

14.4.1.1.3 Gassco have confirmed in a Letter of No Objection that after having reviewed the information provided by Hornsea Four, Gassco have no principle objection to the development of Hornsea Four. Gassco also confirmed that they do not intend to object to the future development of Hornsea Project Four.

Table 14-1: Hazards and Risk Summary – Gassco AS

Tier	Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
TIER 1						
	N/A					
TIER 2						
TIER 2 – ASSOCIATED SYSTEMS						
	Pipelines	Temporary Impact Upon Access for Repair/ Maintenance - Vessel Access	All Assets	Unlikely	Slight Damage	Broadly Acceptable
		Temporary Impact Upon Access for Repair/ Maintenance - Diving Operations	All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
	Loss of Containment - Outboard Pipelines / Intra-field Pipelines	Fatigue / Vibration	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Incorrect Installation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Operator Error – Inadequate Training / Competency	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Violation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Deficient Procedures – Operational / Maintenance	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Inadequate Design	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Incorrect Material Specification	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Vessel Impact	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Dropped Objects	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Anchor – Snagging / Dropping	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
TIER 3						
	TIER 3 – PLATFORMS	N/A				

15 Shell UK Limited

15.1 Introduction

15.1.1.1.1 Shell is the operator of the Shearwater to Bacton (SEAL) pipeline that traverses the eastern section of the array area (Figure 15-1). SEAL is a 34-inch, active pipeline that transports gas from the Shearwater and Elgin Franklin platforms (Block 22/30) to the Bacton Terminal on the northeast Norfolk coast. Shell also holds 50 % equity on the licence for the block 48/8b (P2437).

15.1.1.1.2 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

15.1.1.1.3 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

15.1.1.1.4 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

15.1.1.1.5 Potential hazards resulting from interaction of Shell's pipeline asset with Hornsea Four include:

- Vessel access;
- Oil and Gas (O&G) diving operations;
- Pipelines - temporary impact upon access for repair/maintenance; and
- Pipelines - Loss of Containment.

Hornsea Four

Shell Assets -
DCO Order Limits
Figure 15.1

300000 350000 400000

6000000

5950000

N
GRID NORTH

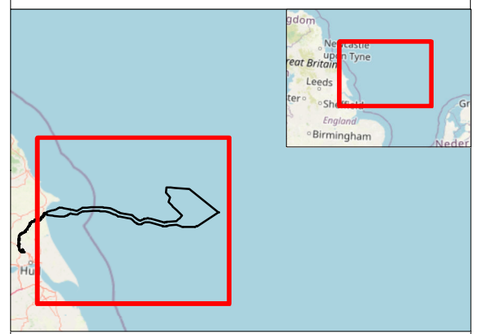
48/8b

Project Layers
- License Blocks
- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Oil and Gas Infrastructure
- Other Operators

Pipelines
- Shell
- Other Operators

Bathymetry (Below Sea Level)
- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	25/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Shell Assets - DCO Order Limits
Document no: HOW040371
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

Date: 19/08/2021 Author: XDAOO Name: HOW040371_Shell_O&G_DCO_Boundary_Figure_15-1_RevB_20210818

15.2 Pipelines - Temporary Impact Upon Access for Repair/Maintenance

15.2.1.1.1 As the SEAL pipeline crosses the array area, the interaction between the two assets can potentially result in temporary impact upon Shell's access to the SEAL pipeline. These impacts will take the form of:

- Temporary Impact upon Vessel Access; and
- Temporary Loss to Diving Operations.

15.2.2 Vessel Access

15.2.2.1.1 This section assesses the potential impacts in relation to access to Oil and Gas (O&G) assets that may arise as a result of the construction and operation of Hornsea Four.

15.2.2.1.2 A vessel access impairment study was performed, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, for assets close to Hornsea Four. The assets within 10 nm were screened to identify which may be affected in terms of access. Proximity and deviations to offshore routine support vessel (e.g., supply and standby) routeing relative to the Hornsea Four structures were considered.

15.2.2.1.3 It should be considered that given the Tier 1 assets are subsea, "routine" visits are unlikely to be as frequent as for the surface assets within the other tiers. However, it is considered that access to SEAL pipeline may be necessary. Therefore, surface routeing has still been considered.

15.2.2.1.4 The pipeline will be required to accommodate various O&G operations requiring vessel access, including inspections, maintenance interventions, and emergency repairs.

Potential Consequences

- Impairment of vessel access; and
- Allision and collision due to changes in traffic patterns.

Existing Safeguards / Controls

- The existing safeguards / controls for allision risks listed in the safeguards / controls for allision risk – section 15.3.9.

Analysis of Risk

15.2.2.1.5 Given that the SEAL pipeline is within the Hornsea Four array area, it will be necessary for vessels associated with the asset to enter into the array, and on this basis, there will be no route deviation as such. However, the presence of the structures and Hornsea Four vessels may impact upon O&G support vessels ability to access the areas needed to undertake any operations associated with the pipeline.

15.2.2.1.6 O&G vessels accessing the asset from the south would experience minimum access issues given the location of the assets near the southern periphery, and it is noted that no Hornsea Four works would enter into the 500 m safety zones (except in an emergency situation). However, vessels approaching from the north or west would either need to navigate within the array or deviate to access via the south (it is considered unlikely that vessels would seek access from the east).

15.2.2.1.7 Spacing limitations are of primary concern as this can potentially increase the risk of allision / collision, noting that certain operations will require additional sea room beyond the 500 m threshold of the safety zones (e.g., where support tugs are required, anchor spreads etc). As noted in section 8.3.1 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, the minimum spacing under consideration between the centre points of Wind Turbine Generators (WTGs) is 810 m, however actual spacing may be higher.

15.2.2.1.8 Experience at other wind farms that have been constructed within close proximity to O&G assets shows that Heavy Lift Vessel (HLV) activities associated with wind farm construction can still occur within limited sea-room. An example would be the Stanislav Yudin HLV (with anchor spread) which has carried out operations in the Dudgeon and Beatrice Wind Farms, as well as O&G decommissioning operations where

there are other platforms in proximity. These operations are able to be undertaken noting the available industry experience and guidance, such as the Guidelines for Offshore Marine Operations (GOMO) (2020). This guidance facilitates effective planning of these types of operations, taking into account restrictions, to help ensure safe and efficient operations even when searoom is limited.

15.2.2.1.9 While re-routeing may be necessary, details of Hornsea Four would be promulgated in advance via the usual means (e.g., Notifications to Mariners (NtM)), including directly to Shell UK This will facilitate advanced passage planning, ensuring any deviations are minimal, and will allow the locations of completed or partially completed structures to be accounted for.

15.2.2.1.10 It is considered that due to the standard offshore operations and communication protocols that will be deployed, the incremental additional safety risk associated with vessel access within the array is considered negligible. The safety risk associated with vessels within the array is not considered to change. The risk is therefore considered to be broadly acceptable.

15.2.2.1.11 It is however noted that the identified potential implications / consequences of vessel access as a result of proximity to the array area may be commercial. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation. These are addressed in Section 20: Commercial Considerations of this report.

15.2.3 Diving Operations

15.2.3.1.1 This section focuses on potential impact on Shell's diving operations (temporary impact upon access for pipeline repair / maintenance, etc.) from interaction between the SEAL pipeline and Hornsea Four.

15.2.3.1.2 It is anticipated that the only temporary losses to diving operations for maintenance / repair may occur during the installation of Hornsea Four, due to piling/drilling operations when installing the turbine and/or offshore substation foundations. These operations may trigger underwater acoustic vibration and diving should be avoided during this period. At a later project stage, the periods at which these operations will take place will be planned via ongoing consultations with Shell with the objective of minimising the impact on Shell's maintenance diving operations. Considering that maintenance diving for the pipeline is relatively rare and that the diving operation cannot take place while drilling/piling operations will be ongoing; the safety risk is considered negligible. The risk is therefore considered to be broadly acceptable.

15.3 Pipelines – Loss of Containment

15.3.1.1.1 According to Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006), the relevant potential hazardous events with the potential for damage to the SEAL pipeline resulting in loss of containment could result from the following hazard initiators:

- Fatigue / Vibration;
- Incorrect Installation / Inadequate Design / Incorrect Material Specification;
- Operator Error – Inadequate Training / Competency;
- Violation;
- Deficient Procedures – Operational / Maintenance;
- Vessel Impact;
- Dropped Objects (i.e., dropped cargo) / Abnormal External Load;
- Seismic Event; and
- Anchor – Snagging / Dropping.

15.3.2 Fatigue / Vibration

15.3.2.1.1 Fatigue and vibration of the intra-field pipeline could be introduced as a result of operations associated with foundation installation for the WTGs which could involve piling or drilling, and this will be dependent on the selected foundation method which is also dependent on ground conditions.

Potential Consequences

15.3.2.1.2 Loss of containment due to flowline vibration triggered by drilling / piling.

Existing Safeguards / Controls

- Inherent safety (including fully rated pipelines, inherent impact resistance, pipe burial and trenching (where applicable);
- Turbine positions will also be set back 500 m from active pipelines;
- Good procedures and competent personnel associated with installation and operation of Hornsea Four;
- Isolation and Permit to Work (PTW) controls; and
- Pre-operation strength and leak testing.

Analysis of Risk

15.3.2.1.3 As documented in Volume A1, Chapter 4: Project Description, the Maximum Design Scenario (MDS) strike energy for piling of the foundations in the array area is 3,000 kJ to 5,000 kJ. For WTGs, substations, and accommodation platform on monopiles, there will be a 4-hour piling duration and 1.2 days per monopile, with a total duration of 106 to 216 piling days depending on the number of vessels. For WTGs, substations, and accommodation platform on piled jackets, the jackets will have a piling duration of 1.5 days per jacket foundation and a total of 135 to 270 piling days depending on the number of vessels. The duration of the impact piling component of the installation campaign is expected to be a maximum of 12 months.

15.3.2.1.4 The timing and execution of these foundation operations will be planned in consultation between Shell and Hornsea Four, and these operations will be performed in accordance with good engineering practice.

15.3.2.1.5 Considering the piling operation is temporary, the ground shaking that may be introduced will be minor, the energy generated is expected to dissipate, and the pipeline is free to move on the seabed, the potential impact to the pipeline is therefore considered negligible.

15.3.2.1.6 The risk associated with potential impact of ground shaking is considered to be **broadly acceptable**.

15.3.3 Incorrect Installation

15.3.3.1.1 Incorrect installation of the Hornsea Four cables crossing the SEAL pipeline has the potential to impact the pipeline due to incremental additional risks over and above the pipeline design criteria.

Potential Consequences

15.3.3.1.2 Loss of containment due to incorrect installation of cable crossings.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel;
- Turbine positions will be set back at least 500 m from pipelines;
- Monitoring and Audit systems; and
- Crossing protection mattresses where assessed to be applicable.

Analysis of Risk

15.3.3.1.3 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four array cables and will include considerations for risk preventive measures such as: design practices, good installation practices and procedures, and the use of competent personnel; the introduction of additional risk to the SEAL pipeline is considered negligible. The risk is therefore considered to be broadly acceptable.

15.3.3.1.4 Also, the pipeline crossings will be designed and engineered in accordance with standard approaches and be subject to crossing agreement, as per Co107 (see Volume A4, Annex 5.2: Commitment Register).

15.3.4 Operator Error – Inadequate Training / Competency

15.3.4.1.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

15.3.4.1.2 For the analysis of the SEAL pipeline the most relevant subjects are navigation, station holding and/or the potential of drifting close to or around the route of the pipeline, due to vessel operations associated with cable installation, cable inspection or maintenance.

15.3.4.1.3 Human errors can occur in all phases of a project. Human errors, that have the potential to result in a Major Accident Hazard (MAH), in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

15.3.4.1.4 Loss of containment due to incidents caused by personnel incompetency / lack of experience.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

15.3.4.1.5 According to GASCET (HSE, 2006), the O&G asset holder should have a procedure in place for the selection, competence assessment, and training of operations and maintenance personnel. The O&G asset holder's procedure should be designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

15.3.4.1.6 The Health and Safety Executive (HSE) standards and codes of practices are referenced to show that in order to operate in the UK Continental Shelf, the O&G asset holders are expected to follow certain requirements.

15.3.4.1.7 As Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016); considerations for risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel during installation, operations and maintenance of the Hornsea Four cables, the introduction of

additional risk to the pipeline from this potential initiator is considered negligible. Note that a safety / buffer distance of at least 500 m is planned between the Hornsea Four assets and the pipeline.

15.3.4.1.8 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the risk of impact from human factors is considered broadly acceptable.

15.3.5 Violation

15.3.5.1.1 Human factors involved in the earlier conceptual design stages of the installation lifecycle can influence the likelihood of the occurrence of hazardous events. When installations have not been designed and constructed, and / or re-assessed, maintained, and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards, a violation is said to have occurred.

Potential Consequences

15.3.5.1.2 Loss of containment due to not following procedure and guidelines.

Existing Safeguards / Controls

- Good procedures; and
- Competent personnel.

Analysis of Risk

15.3.5.1.3 As stated in section 15.3.4, human errors can occur in all phases of a project. Human errors, that have the potential to result in MAHs, in the earlier conceptual design stages, can also be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

15.3.5.1.4 The impact of violation is considered similar to 'operator error' and considering that risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel are being applied to the design of Hornsea Four, the introduction of additional risk to the pipelines from this potential initiator is considered negligible. The risk is therefore considered to be broadly acceptable.

15.3.6 Deficient Procedures

15.3.6.1.1 If deficient procedures are applied during the installation, operations, and maintenance of Hornsea Four cables, there is potential that pipelines with crossings will be affected due to additional hazards over and above the pipeline design tolerance.

15.3.6.1.2 The impact of deficient procedure is considered similar in consequences and safeguards to 'incorrect installation' and 'operator error' which are assessed in sections 15.3.3 and 15.3.4.

15.3.6.1.3 As the relevant UK Continental Shelf Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four infrastructure, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the pipeline is considered negligible, and therefore broadly acceptable.

15.3.7 Inadequate Design

15.3.7.1.1 The impact of inadequate design is considered similar to 'incorrect installation' (see section 15.3.3).

15.3.7.1.2 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four export cables, including risk preventive measures, good work

practices and procedures, and the use of competent personnel; the introduction of additional risk to the pipeline is considered negligible, and therefore broadly acceptable.

15.3.8 Incorrect Material Specification

15.3.8.1.1 The impact of incorrect material specification is considered similar to 'incorrect installation' (see section 15.3.3 above.

15.3.8.1.2 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four export cables, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the pipeline is considered negligible, and therefore broadly acceptable.

15.3.9 Vessel Impact

15.3.9.1.1 Vessel impact concerns the potential additional hazards associated with vessel movements in and around the SEAL pipeline corridor, due to the presence of Hornsea Four construction and operation. This may include the following types of vessels: standby vessels, supply vessels, diving support vessels, survey vessels, barges, and cable installation vessels.

15.3.9.1.2 A vessel allision study, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, was performed duly considering assets close to Hornsea Four in terms of potential changes in allision risk, considering deviations to both routine support vessel routeing and third-party traffic. Spacing / proximity issues relative to the Hornsea Four structures were also considered.

15.3.9.1.3 It should be noted that proximity between offshore assets and passing traffic is a primary factor affecting allision risk. On this basis, the assessment of allision risk undertaken has focused on changes to traffic patterns passing within 2 nm of the relevant asset as a result of Hornsea Four's presence.

15.3.9.1.4 As stated in section 7.5.1 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, assets within the array are at no risk of allision as they are subsea, however it should be considered that rigs used for any associated operations are at risk of allision when stationed on site over the assets (and supporting vessels at risk of collision).

15.3.9.1.5 The interaction between vessels and the pipeline can potentially result from dropped objects and/ or anchor snagging. Dropped object and anchor snagging risks are addressed in section 15.3.10 and 15.3.12 of the report.

Potential Consequences

- Allision risk due to changes to traffic patterns passing within 2 nm of the SEAL pipeline.

Existing Safeguards / Controls

- Inherent safety in design and operation;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection (visual & radar, platform mounted radar, automated systems);
- Control through quality assurance, operating envelope, procedures and barriers; and
- Mitigation through: Physical Protection and Robust Structure.

15.3.9.1.6 According to section 5.2.HS0 of GASCET (HSE, 2006), the pipeline should be protected from third party and/or construction damage by vessel anchors and mooring wires and chains, by pipe lay abandon and retrieval wires, and by support vessels installing subsea facilities (e.g., array cables or umbilical); also considering the anchoring procedures for standby vessels, supply vessels, diving support vessels, heavy lift crane vessels, flotels, drilling rigs, etc.

Analysis of Risk

15.3.9.1.7 From proximity assessments conducted and presented in section 7.4 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and based on the Navigational Risk Assessment (NRA) (see **Volume A5, Annex 7.1: Navigational Risk Assessment**) deviations, it is estimated that there will be no change in vessel numbers per day within 2 nm of the section of SEAL pipeline within the array area. It should be considered that while there is no increase in traffic within 2nm of the section of SEAL pipeline within the Hornsea Four array area, traffic will be concentrated over the section of SEAL pipeline in between Hornsea Two and Hornsea Four, and as such any associated pipeline maintenance operations in this area would need to account for the passing traffic. However, the likelihood of a need for such an operation is considered low, noting that as per the NRA consultation (**Volume A5, Annex 7.1: Navigational Risk Assessment**), vessel operators have indicated that any anchoring between Hornsea Two and Hornsea Four (and by extension any potential for pipeline interaction / damage) would be an extremely unlikely occurrence.

15.3.9.1.8 With regards smaller vessels (e.g., fishing, recreation) that may still choose to transit through the Hornsea Four array area, and as such may still pose risk to vessels associated with operations, sections 6.5 and 6.6 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, show that the levels are low and as such any associated risk is likely to be low. No clear active fishing (i.e., vessels considered likely as having gear deployed) was observed over subsea infrastructure within the array. It should be considered that the summer survey period is AIS only, and as such fishing vessel activity may be underrepresented (however it is considered unlikely that smaller non AIS fishing vessels would transit this far offshore on a regular basis). Fishing vessel levels would be expected to reduce during periods of less favourable weather conditions.

15.3.9.1.9 It should be noted that the wind farm support vessels within the Hornsea Four array area during the construction and operational phases are also an allision / collision risk to the operations associated with the Tier 1 asset. However, such vessels will likely be more aware of associated Tier 1 works than passing third party traffic, and it should also be considered that they also provide additional response resources in the event of an emergency within or near the wind farm.

15.3.9.1.10 Details of the construction and maintenance of Hornsea Four will be promulgated to the relevant operators (including Shell UK) to ensure they are aware of the ongoing works and any periods / locations where project vessel activity may be increased.

15.3.9.1.11 In addition, the pipeline is marked on admiralty charts and Hornsea Four intends to interface with Shell closer to the installation time in order to arrange for a SIMOPS review, prior to commencement of cable installation.

15.3.9.1.12 As the relevant UK Continental Shelf Procedures, Legislation, and Guidelines will be adhered to and maintained in designing and installation of the cables, it is considered that all design, prevention and control measures will be adhered to; therefore it is perceived that potential additional hazards initiated as a result of Hornsea Four in the array area will not surpass those for which the SEAL pipeline should be designed to withstand; and so the introduction of additional risks from this potential initiator is considered negligible.

15.3.9.1.13 Given that the vessel traffic around the SEAL pipeline remains unchanged, the rerouting of commercial traffic from the area, and noting that Hornsea Four will have appropriate vessel management procedures in place to ensure risk from project vessels is minimised, it is considered that the incremental additional safety risk associated with vessel impact is negligible. The risk is therefore considered to be broadly acceptable.

15.3.10 Dropped Objects

15.3.10.1.1 This involves additional hazards to the SEAL pipeline as a result of abnormal external load / dropped objects from vessels associated with Hornsea Four.

15.3.10.1.2 Major damage risks can come from dropped objects during installation or maintenance of the Hornsea Four array cables.

15.3.10.1.3 According to the Offshore Technology Report 2001/013 (HSE, 2002), the principal categories of load are: dead loads, imposed (operational) loads, environmental loads, deformation loads - loads associated with imposed deformations and imposed strains; and accidental loads, results from accidental events, such as collision, dropped objects, fire and explosion and other abnormal events.

15.3.10.1.4 For the interaction between Hornsea Four and the Shell's SEAL pipeline, dropped object accidental loads are the only relevant potential hazards that could arise from this interaction.

Potential Consequences

15.3.10.1.5 Loss of containment from rupture of flowlines due to dropped objects from Hornsea Four construction (cable crossings, cable lay vessels, and other construction works) and supply / support vessels during installation and maintenance of Hornsea Four.

Existing Safeguards / Controls

15.3.10.1.6 As per Offshore Technology Report 2001/013 (HSE, 2002), the pipeline installation should be so designed and, if necessary, protected that the consequences of damage are acceptable and that an adequate margin of safety is maintained.

15.3.10.1.7 As with the hazards associated with collision, the usual measures employed in controlling the hazards from dropped objects include:

- Inherent safety in design and operation, i.e., safety zone of at least 500 m;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection;
- Control through quality assurance, operating envelope, procedures and barriers;
- Mitigation through: Physical protection and robust structure; and
- The subsea infrastructure will be marked in sea charts and other layout drawings.

Analysis of Risk

15.3.10.1.8 According to section 3.G16 of GASCET (HSE, 2006), the pipeline should have been designed and constructed, and/or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards. General requirements for accidental hazards are found in:

- Loads, Offshore Technology Report – OTO 2001/013 (HSE, 2002);
- Petroleum and Natural Gas Industries – Fixed Steel Offshore Structures – ISO 19902 (ISO, 2011);
- Technical Safety – S-001 (NORSOK, 2008);
- Documentation for Operation – Z-001 (NORSOK, 1998);
- Risk and Emergency Preparedness Analysis – Z-013 (NORSOK, 2001); and
- Explosion Resistant Design for Offshore Structures – Technical Note No 4 (SCI, 1996).

15.3.10.1.9 Other requirements are found in DNV RPF-107 – RP Risk Assessment of Pipeline Protection (DNV, 2010).

15.3.10.1.10 Also, the relevant Legislation, ACOP and Guidance that apply includes:

- Offshore Installations Safety Case Regulations – HSE-UK SCR (HSE, 2015);
- Offshore Installations and Wells (Design and Construction, etc) Regulations (HSE, 2008); and
- Assessment Principles for Offshore Safety Cases [APOSC] (HSE, 2016).

15.3.10.1.11 As the relevant UK Continental Shelf Procedures, Legislation, and Guidelines will be adhered to and maintained in designing and installation of the cables, it is considered that all design, prevention and control measures for cable installation in the UK Continental Shelf will be adhered to; therefore it is not perceived that potential additional hazards initiated as a result of Hornsea Four will surpass those for

which the SEAL pipeline should be designed to withstand; and so the introduction of additional risks from this potential initiator is considered negligible. The risk is therefore considered to be broadly acceptable.

15.3.10.1.12 As part of Hornsea Four's commitment Co107 (see Volume A4, Annex 5.2: Commitment Register), crossing and proximity agreements with known existing pipeline and cables operators will be sought.

15.3.10.1.13 Note that consideration will be given to providing mattress protections in vulnerable areas of interference.

15.3.11 Seismic Event

15.3.11.1.1 Hornsea Four will not induce / trigger any seismic events. It will however in and around the array area induce a degree of ground shaking during the installation of foundations due to drilling or piling.

15.3.11.1.2 Details of the duration of piling operations in the array area are documented in section 15.3.2.

15.3.11.1.3 The hazard of a natural seismic event is not perceived relevant in relation to Hornsea Four, however ground-shaking and/or acoustic vibration may be induced because of construction operations. This is however, considered to be short term and have a minor effect to pipeline.

15.3.11.1.4 Around the array area, the ground shaking is not expected to impact the operation of the SEAL pipeline, as the expected ground shaking will not be significant.

15.3.11.1.5 The timing and execution of these foundation operations will be planned in consultation between Shell and Hornsea Four, and these operations will be performed in accordance with good practice. The risk is negligible and therefore considered to be broadly acceptable.

15.3.12 Anchor – Snagging / Dropping

15.3.12.1.1 Ships may anchor under various circumstances including the following:

- Normal anchoring:
  - when waiting on berths or for permission to use a controlled channel;
  - when necessary to aid manoeuvring in restricted areas;
  - when performing survey or construction operations; and
  - when performing repairs during the operation and maintenance phase.
- Emergency anchoring:
  - following mechanical breakdown of the propulsion or steering system;
  - following an accident such as major fire or a collision; and
  - to slow down the ship in order to avert a possible collision or ramming or grounding.

15.3.12.1.2 Hazards to pipelines can arise either at the time of anchoring or subsequently if the ship should drag its anchor due to the effects of wind, wave and/or current. A hazard can also arise when the ship tries to retrieve the anchor.

15.3.12.1.3 In normal anchoring, there should be minimal risk to the pipelines, which are shown on charts and may be protected by anchoring exclusion zones. Initially, DNV guidelines shall be adhered in to with respect the minimum distance between any existing subsea asset and the placement of any Hornsea Four anchors. These distances shall be discussed and agreed with the subsea asset owner.

15.3.12.1.4 At the time of anchoring, the risk to the pipeline is either that the anchor is dropped onto the pipeline or that the anchor is dragged across the pipeline. If the anchor hooks the pipeline but does not cause immediate damage, there will be a further risk of damage when the ship comes to try to haul the anchor back in.

15.3.12.1.5 Good seamanship will avert impact from emergency anchoring. Good seamanship involves anchoring well away from pipelines, in water of an appropriate depth (neither too shallow nor too deep) and in an area where the seabed is known to have good anchor holding properties. In addition, under weather conditions when dragging might occur, it is normal good practice to keep engines on standby and to make regular checks on position. Sometimes ships will leave their anchorages if dragging is anticipated.

15.3.12.1.6 The cause of anchors dropping accidentally is mainly due to failure of the brake systems when anchors are made ready for use, i.e., when mechanical securing systems are removed. The risk to the pipeline due to dropping anchors at sea is considered negligible, because the anchors should not be made ready for use and should be secured.

15.3.12.1.7 The Hornsea Four installation operations will involve survey vessels, cable installation vessels, cable crossing installation vessels and post installation survey vessels, none of which are expected to make use of anchors or anchor spreads. The Hornsea Four operations and maintenance operations will involve mainly external inspection survey vessels, possibly accompanied by Remotely Operated Vehicle (ROV) and are unlikely to make use of anchors or anchor spreads. Should cable inspection also involve repair operations, a diving support vessel may be required, which could involve anchorage in and around the crossing area of the cable. In which case such operation would be subject to standard marine operations including SIMOPS review.

15.3.12.1.8 Considering the types of vessels that Hornsea Four intends to make use of during installation and maintenance operations, the likelihood of anchor incidents leading to snagging, hooking, or dropping is considered negligible. The risk is there considered to be broadly acceptable.

15.4 Shell Summary

15.4.1.1.1 The table below presents the assessment summary of the impact from interaction of Shell's SEAL pipeline with Hornsea Four.

Table 15-1: Hazards and Risk Summary – Shell UK Ltd.

Tier	Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
TIER 1						
TIER 1 – ASSOCIATED SYSTEMS						
	Pipelines	Temporary Impact Upon Access for Repair/ Maintenance - Vessel Access	All Assets	Unlikely	Slight Damage	Broadly Acceptable
		Temporary Impact Upon Access for Repair/ Maintenance - Diving Operations	All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
	Loss of Containment - Outboard Pipelines / Intra-field Pipelines	Fatigue / Vibration	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Incorrect Installation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Operator Error – Inadequate Training / Competency	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Violation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Deficient Procedures – Operational / Maintenance	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Inadequate Design	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Incorrect Material Specification	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Vessel Impact	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Dropped Objects	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Anchor – Snagging / Dropping	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
TIER 2						
			N/A			
TIER 3						
			N/A			

16 Perenco UK Limited

16.1 Introduction

16.1.1.1.1 Perenco UK Limited (Perenco) is the operator of various licence blocks and infrastructure in the southern North Sea, many of which are located in the vicinity of both the array area and Export Cable Corridor (ECC) (Figure 16-1). Current licences to the west of the Hornsea Four array area include: P16 (United Kingdom Continental Shelf (UKCS) Block 42/28a); P606 (UKCS Block 42/28b); P1 (UKCS Blocks 42/29a & 42/30a); P302 (UKCS Block 47/4b); P380 (UKCS Block 43/26a). Perenco is also the licence holder of 43/24a (P685) located northeast of the Hornsea Four array. Further licence blocks to the south of the ECC are illustrated in Figure 16-1. Perenco's infrastructure includes: 4 Manned Platforms (Cleeton CC, Cleeton PQ, Ravenspurn North CC & Ravenspurn North CCW), 10 Unmanned Platforms (Cleeton WLTR, Minerva, Neptune, Ravenspurn North ST2, Ravenspurn North ST3, Ravenspurn South A, Ravenspurn South B, Ravenspurn South C, and Trent) and various associated pipelines.

16.1.1.1.2 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

16.1.1.1.3 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

16.1.1.1.4 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

16.1.1.1.5 The table below presents the structure of the assessment conducted on the potential impacts resulting from interaction of Perenco assets with Hornsea Four. The subsections where each topic area is addressed is shown in the table. Refer to sections 4.2 and 6.2 for details of Tier groups and sub-groupings.

Table 16-1: Perenco Assessment Structure

TIER		Hazards	Sub-Group	Report Section
TIER 1				
	N/A	N/A	N/A	N/A
TIER 2				16.3
	TIER 2 – PLATFORMS			16.4
		Structural Integrity		16.4.2
			Seismic Event	16.4.2.2
			Vessel Impact	16.4.2.3
			Helicopter Impact	16.4.2.4
		Loss of Maritime Integrity - Loss of Stability		16.4.3
		Loss of Maritime Integrity - Loss of Position		16.4.4
		Vessel Access (Deviation) - Construction and Operations		16.4.5
		Vessel Access (Proximity) - Construction and Operations		16.4.6
				16.5
		Loss of Containment - Process		16.5.2

TIER		Hazards	Sub-Group	Report Section
	TIER 2 – PLATFORM SYSTEMS	Loss of Containment - Pipelines		16.5.3
		Loss of Containment - Fire & Explosion		16.5.4
		Emergency Response		16.5.5
	TIER 2 – ASSOCIATED SYSTEMS			16.6
		Wells		16.6.2
		Diving		16.6.3
		Human Factor		16.6.4
		Helicopter - Impaired Access to O&G Platforms (CAT)		16.6.5
		Helicopter - Impaired Access to O&G Platforms (SAR)		16.6.6
		Helicopter - Impaired Access to O&G Vessels (CAT)		16.6.7
		Helicopter - Impaired Access to O&G Vessels (SAR)		16.6.8
		Seismic Survey Activities		16.6.9
		Drilling (Array Area) Activities		16.6.10
		Drilling (ECC Area) Activities		16.6.11
		Construction (Array Area) Activities		16.6.12
		Construction (ECC Area) Activities		16.6.13
		Non-Process Fires & Explosions		16.6.14
		Microwave Communication		16.6.15
		Radar Early Warning Systems (REWS)		16.6.16
		CPA Alarms		16.6.17
		Loss of Containment - Outboard Pipelines / Intra-field Pipelines		16.6.18
			Fatigue / Vibration	16.6.18.2
			Incorrect Installation	16.6.18.3
			Operator Error – Inadequate Training / Competency	16.6.18.4
			Violation	16.6.18.5
			Deficient Procedures – Operational / Maintenance	16.6.18.6
			Vessel Impact	16.6.18.7
			Dropped Objects	16.6.18.8
			Seismic Event	16.6.18.9
			Anchor – Snagging / Dropping	16.6.18.10
TIER 3				16.7
	TIER 3 – PLATFORMS			16.8
		Structural Integrity		16.8.2
			Seismic Event	16.8.2.2
			Vessel Impact	16.8.2.3
			Helicopter Impact	16.8.2.4

TIER	Hazards	Sub-Group	Report Section
	Loss of Maritime Integrity - Loss of Stability		16.8.3
	Loss of Maritime Integrity - Loss of Position		16.8.4
	Vessel Access (Deviation) - Construction and Operations		16.8.5
	Vessel Access (Proximity) - Construction and Operations		16.8.6
TIER 3 – PLATFORM SYSTEMS			16.9
	Loss of Containment - Process		16.9.2
	Loss of Containment - Pipelines		16.9.3
	Loss of Containment - Fire & Explosion		16.9.4
	Emergency Response		16.9.5
TIER 3 – ASSOCIATED SYSTEMS			16.10
	Wells		16.10.2
	Diving		16.10.3
	Human Factor		16.10.4
	Helicopter - Impaired Access to O&G Platforms (CAT)		16.10.5
	Helicopter - Impaired Access to O&G Platforms (SAR)		16.10.6
	Helicopter - Impaired Access to O&G Vessels (CAT)		16.10.7
	Helicopter - Impaired Access to O&G Vessels (SAR)		16.10.8
	Seismic Survey Activities		16.10.9
	Drilling Activities		16.10.10
	Construction Activities		16.10.11
	Non-Process Fires & Explosions		16.10.12
	Microwave Communication		16.10.13
	Radar Early Warning Systems (REWS) / CPA Alarms		16.10.14
	CPA and TCPA Alarms		16.10.15
	Loss of Containment - Outboard Pipelines / Intra-field Pipelines		16.10.16
		Fatigue / Vibration	16.10.16.2
		Incorrect Installation	16.10.16.3
		Operator Error – Inadequate Training / Competency	16.10.16.4
		Violation	16.10.16.5
		Deficient Procedures – Operational / Maintenance	16.10.16.6
		Vessel Impact	16.10.16.7
		Dropped Objects	16.10.16.8
		Seismic Event	16.10.16.9
		Anchor – Snagging / Dropping	16.10.16.10

Hornsea Four

Perenco UK Ltd Assets -
DCO Order Limits
Figure 16.1

300000 350000 400000

6000000 5950000

N
GRID NORTH

KILMAR NUI
TRENT
43/24a
42/28a
42/28b
42/29a
42/30a
RAVENSPURN SOUTH C
RAVENSPURN NORTH ST3
RAVENSPURN SOUTH B
RAVENSPURN NORTH ST2
RAVENSPURN SOUTH A
RAVENSPURN NORTH CC
CLEETON PQ, CC & WLTR
NEPTUNE
47/3c
47/4b
MINERVA
43/26a
47/3b
47/4a
47/5a
HYDE
HOTON
48/7b
47/10b
47/9b
WEST SOLE C
WEST SOLE B
WEST SOLE A (8 LEG)
WEST SOLE SP
48/7a
48/6a
WEST SOLE A (6 LEG)
AMETHYST C1D
AMETHYST A1D
AMETHYST A2D
48/11a
AMETHYST B1D
PICKERILL A
PICKERILL B
MALORY
GALAHAD
48/17a
48/18a
EXCALIBER EA
GUINEVERE A
LANCELOT A

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Date: 19/08/2021 Author: XDAOO Name: HOW040369_Perenco_O&G_DCO_Boundary_Figure_16-1_RevB_20210818

300000 350000 400000

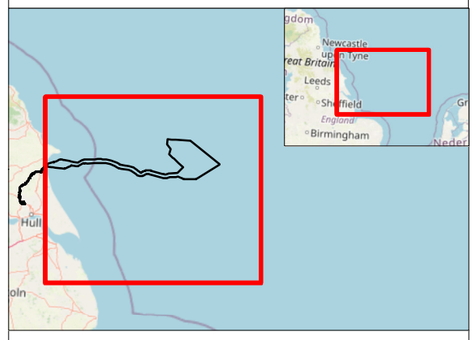
Perenco Licenses

Oil and Gas Infrastructure
- Perenco Platform
- Perenco Terminal
- Perenco Subsea
- Other Operators

Pipelines
- Perenco
- Other Operators

Project Layers
- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)
- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:450,000

0 5 10 20 Kilometres
0 2.5 5 10 Nautical Miles

REV	REMARK	DATE
	First issue	25/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Perenco UK Ltd Assets - DCO Order Limits
Document no: HOW040369
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

16.2 TIER 1

16.2.1.1.1 As per the tier grouping, Tier 1 assets are defined as those assets contained within the array area. As all Perenco assets are outside the array area, Tier 1 assessments have not been conducted for Perenco.

16.3 TIER 2

16.3.1.1.1 Based on the asset screening process, Tier 2 (as defined in Section 4.2, Table 4-2) assets are those assets that are either within 10 nm of the Hornsea Four array area or within 10 nm of the High Voltage Alternating Current (HVAC) booster station search area.

16.3.1.1.2 The platforms within 10 nm of the Hornsea Four array area are shown in Figure 16-2. These are:

- Ravenspurn North (CC and CCW platforms, ST2 platform, and ST3 platform); and
- Ravenspurn South (A, B, and C).

Hornsea Four

Perenco UK Ltd Assets -
Tier 2
Figure 16.2

350000 400000

6050000 6000000 5950000

N
GRID NORTH

Tier 2
Tier 2
Tier 1

KILMAR NUI

42/28a
42/28b
42/30a
42/29a
43/26a
47/3c
47/3b
47/4a

RAVENSPURN SOUTH C
RAVENSPURN NORTH ST3
RAVENSPURN SOUTH B
RAVENSPURN NORTH ST2
RAVENSPURN SOUTH A
RAVENSPURN NORTH CC
RAVENSPURN NORTH CCW

MINERVA

- Perenco Licenses

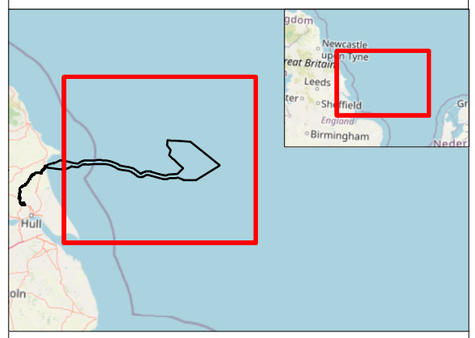
Oil and Gas Infrastructure
- Perenco Platform
- Perenco Terminal
- Other Operators

Pipelines
- Perenco
- Other Operators

Project Layers
- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Tier Boundaries
- Tier 1 (Array Area)
- Tier 2 (10nm from Array Area / HVAC)

Bathymetry (Below Sea Level)
- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 5 10 20 Kilometres
0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	25/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Perenco UK Ltd Assets - Tier 2
Document no: HOW040409
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

Date: 19/08/2021 Author: XDAOO Name: HOW040409_Perenco_O&G_DCO_Tier_2_Figure_16-2_RevA_20210818

16.4 TIER 2 Assessment - Platforms

16.4.1.1.1 This section focuses on the potential impacts on Perenco's platforms as a result of Hornsea Four's presence in the area.

16.4.2 Structural Integrity

16.4.2.1.1 This section assesses the impact on the structural integrity of Perenco platforms from interaction with Hornsea Four. Structural integrity issues can arise from the following: seismic events, vessel impact (allision), and helicopter impact (risk due to potential changes in landing approach / take-off as a result of Hornsea Four).

16.4.2.2 Seismic Event

16.4.2.2.1 Hornsea Four will not induce any seismic events. Piling or drilling operations associated with foundation installation for the HVAC Booster Station(s), Wind Turbine Generators (WTGs), and array platforms may induce ground shaking.

16.4.2.2.2 If the HVAC technologies are progressed, and as documented in section 4.8.4 of Volume A1, Chapter 4: Project Description, the Maximum Design Scenario (MDS) strike energy for piling within the offshore Export Cable Corridor (ECC) is 5,000 kJ. It is expected that there will be three (3) HVAC Booster Stations. For HVAC stations on monopiles, there will be a 4-hour piling duration with a total duration of 1.2 days per monopile. For HVAC booster stations on piled jackets, the jackets will have a total of 72 pins with each jacket having 6 legs and 4 piles per leg. Although piling will not be a continuous operation, the duration of HVAC Booster Station(s) foundation installation would be less than two months for each platform. The duration of the impact piling component of the HVAC Booster Station(s) installation campaign is expected to be a maximum of 12 months.

16.4.2.2.3 The MDS strike energy for piling of the foundations in the array area is 3,000 kJ to 5,000 kJ. For the WTGs, substations, and accommodation platform on monopiles), there will be a 4-hour piling duration and 1.2 days per monopile, with a total duration of 106 to 216 piling days depending on the number of vessels. For WTGs, substations, and accommodation platform on piled jackets, the jackets will have a piling duration of 1.5 days per jacket foundation and a total of 135 to 270 piling days depending on the number of vessels. The durations of the impact piling component of the installation campaign are expected to be a maximum of 12 months.

16.4.2.2.4 Ravenspurn North CC complex which is 3 km from, and the closest Tier 2 platform to, the array area is not expected to experience significant ground shaking from piling, and the structural integrity is not expected to be impaired. From the array area, the ground shaking is also not expected to impact the operation of the other Perencos Tier 2 assets, as the expected ground shaking will not be significant and will dissipate over the distance from where the piling would take place.

16.4.2.2.5 The timing and execution of these foundation operations will be planned in consultation between Perenco and Hornsea Four, and these operations will be performed in accordance with good engineering practice.

16.4.2.2.6 The potential safety related impact of ground shaking on Tier 2 platforms within 10 nm of the Hornsea Four array area is considered broadly acceptable.

16.4.2.3 Vessel Impact

16.4.2.3.1 As some vessel routes may be changed, and the vessels taking these routes are deviated due to the presence of Hornsea Four, allision risks as a result of these deviations can potentially increase the risk of structural damage to platform assets.

16.4.2.3.2 A vessel allision study, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, was performed duly considering assets close to Hornsea Four in terms of potential changes in allision risk, resulting from deviations to both routine support vessel routeing and third-party traffic. Spacing / proximity issues relative to the Hornsea Four structures were also considered.

16.4.2.3.3 It should be noted that proximity between offshore installations and passing traffic is a primary factor affecting allision risk. On this basis, the assessment of allision risk undertaken has focused on changes to traffic patterns passing within 2 nm of the relevant assets as a result of Hornsea Four.

Potential Consequences

- Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage and reduced remaining platform life.

Existing Safeguards / Controls

- 500 m safety zone;
- Inherent safety (best design practice);
- Suitable safety factors (fatigue, applied loading, etc);
- Control measures (management/ structural);
- Visual and radar;
- Platform mounted radar - Radar Early Warning System (REWS) uses the radar returns to monitor and track vessels within the detection region; and
- Stand-By Vessels (SBVs), communications and procedures (including vessel contracting and suitability, inspections, marine operations, and combined operations).

Analysis of Risk

Hornsea Four - Array Area:

16.4.2.3.4 As stated in section 7.3.2 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, noting the presence of Hornsea One and Two, and from pre- and post-Hornsea Four analysis, the majority of commercial vessels on affected routes will pass between Hornsea Four and Hornsea Two – see Figure 16-3 below. Hornsea One and Two are located south of the Hornsea Four array area.

16.4.2.3.5 From proximity assessments conducted and presented in section 7.4 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and based on the Navigational Risk Assessment (NRA) (see **Volume A5, Annex 7.1: Navigational Risk Assessment**) deviations, it is predicted that vessel numbers within 2 nm of assets that are within 10 nm of the Hornsea Four array area will not increase for most of the platforms following the construction of Hornsea Four.

16.4.2.3.6 The only changes in vessel numbers were to the Ravenspurn North ST2 (one (1) additional vessel per day) and the Ravenspurn South A platform (one (1) additional vessel per day). No changes in vessel numbers were observed for Ravenspurn North Complex, Ravenspurn North ST3, Ravenspurn South B, and Ravenspurn South C.

HVAC Booster Station Search Area:

16.4.2.3.7 As per section 7.3.2 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, it was observed that the only routes requiring deviation are routes 6 and 9, which are predicted to shift to the west to avoid the likely HVAC booster station locations – see Figure 16-4 below.

16.4.2.3.8 As per proximity assessments in section 7.4 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, vessel numbers within 2 nm of the Tier 2 assets are not anticipated to change following the installation of the HVAC booster stations (no change for Minerva).

16.4.2.3.9 It is important to note that these are based on the worst-case deviations assessed within the NRA (see **Volume A5, Annex 7.1: Navigational Risk Assessment**), and as such in reality vessels may choose alternate

routes, including passing further from the assets given there is sea-room available to do so. Given the relatively low scale of these changes, additional risk of allision to the platforms is considered **broadly acceptable.**

16.4.2.3.10 It should be noted that the Hornsea Four design envelope currently includes both HVAC and High Voltage Direct Current (HVDC) transmission technologies to allow a necessary degree of flexibility. Hornsea Four may use HVAC or HVDC transmission or could use a combination of both technologies in separate electrical systems. If HVDC technologies are chosen, there will be no Offshore Substation(s) (OSS) present within the offshore ECC. Therefore, in the event that HVAC technologies are not taken forward, the interface with the Minerva asset herein will no longer be relevant.

16.4.2.3.11 Also, for the duration of the construction period, Hornsea Four will monitor and report annually, vessel traffic as per Co98 (see Volume A4, Annex 5.2: Commitment Register).

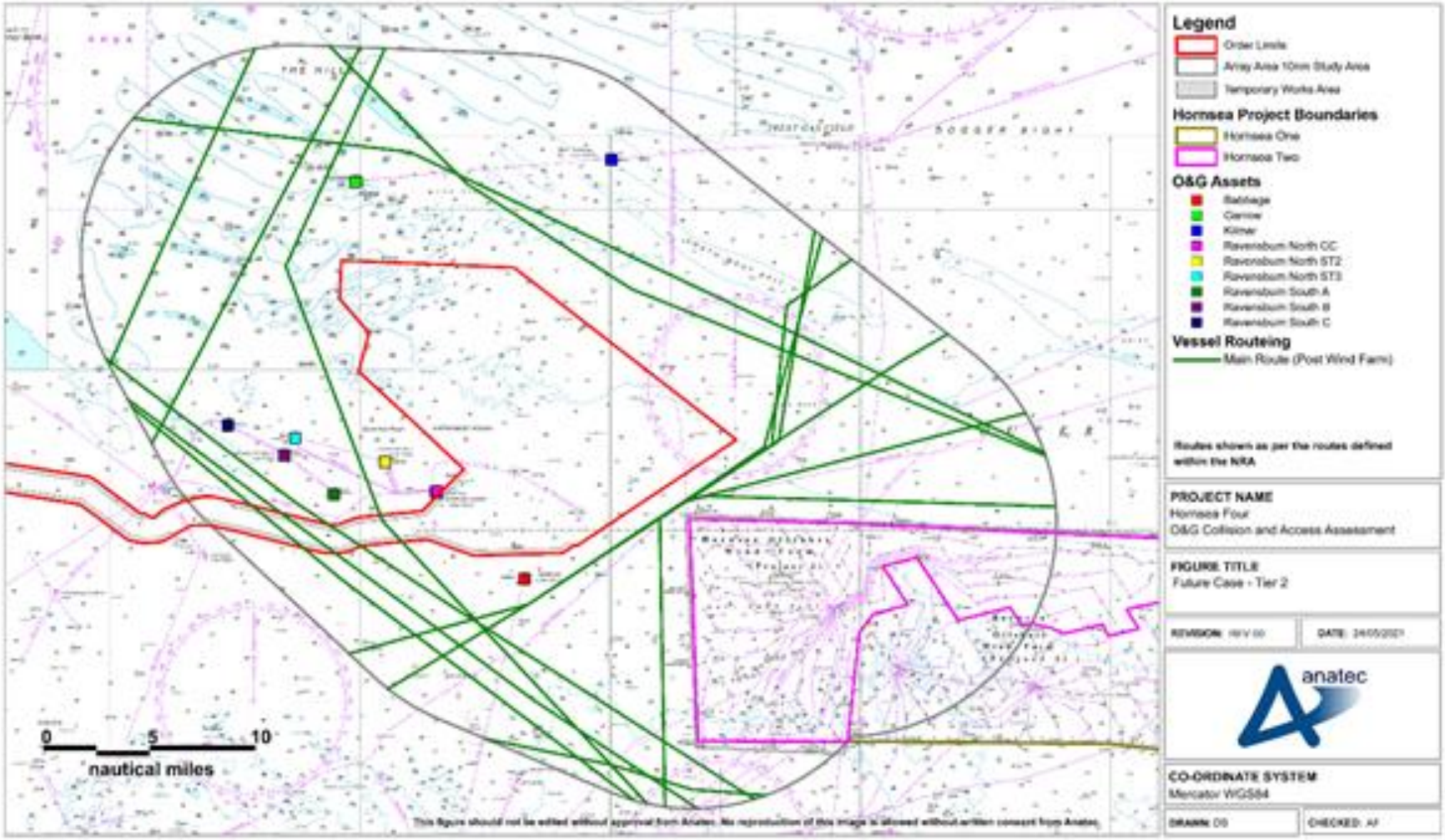


Figure 16-3: Future Case – Tier 2 Assets

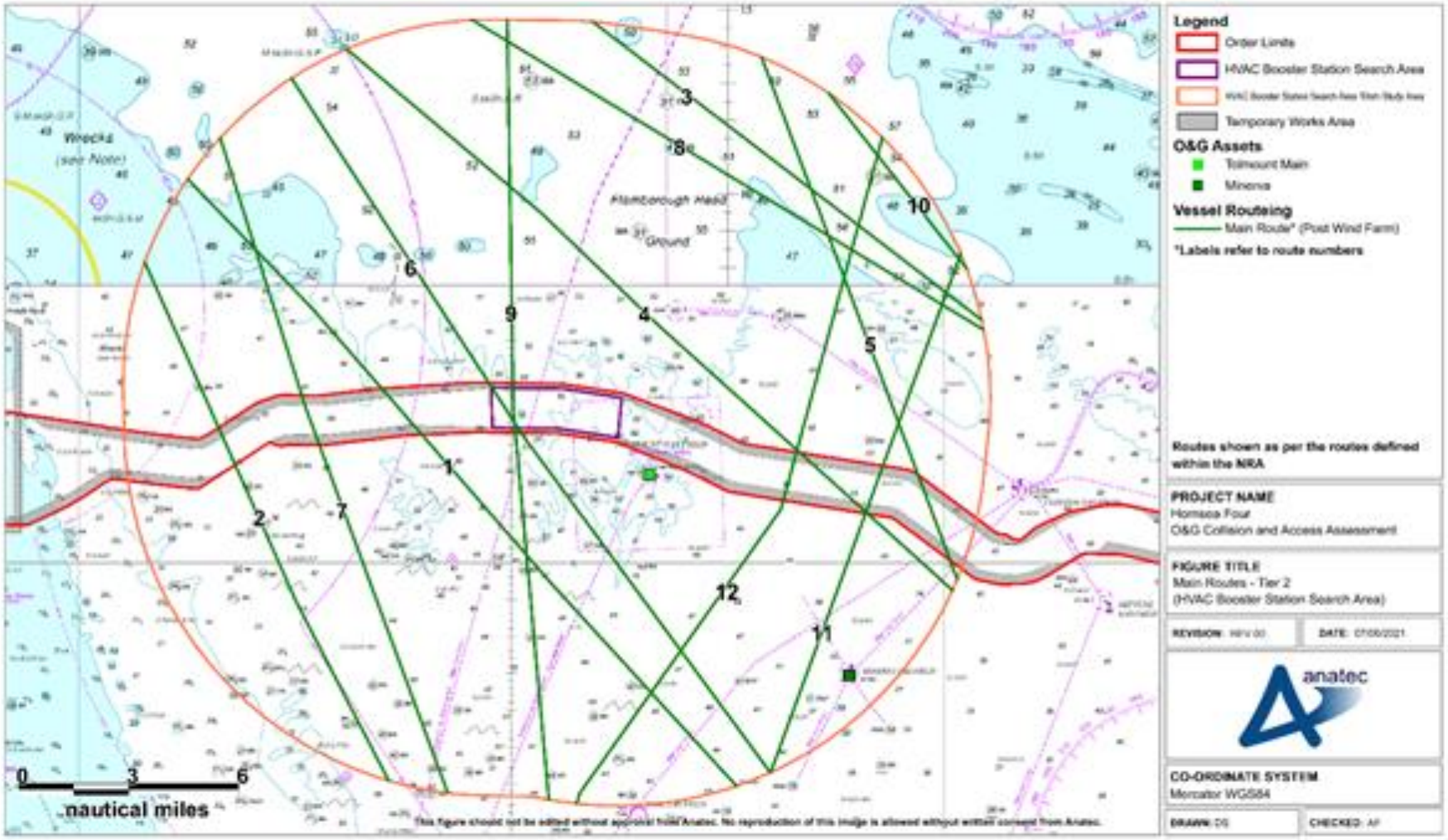


Figure 16-4: Future Case – Tier 2 (within 10nm of HVAC Booster Station Search Area)

16.4.2.4 Helicopter Impact

16.4.2.4.1 This subsection addresses the potential for CAT helicopter impact with Tier 2 assets, resulting in structural damage / integrity issues.

Potential Consequences

16.4.2.4.2 Impact risk due to potential changes in landing approach / take-off as a result of Hornsea Four.

Existing Safeguards / Controls

- Safety and Environmental Critical Element (SECE) Verification (European Aviation Safety Agency (EASA)/ Civil Aviation Authority (CAA) Regulations also apply);
- No flying during unsafe conditions;
- Company transportation policy / procedures;
- Correct operational procedures;
- Competent personnel / training;
- Helicopter monitoring; and
- Communications.

Analysis of Risk

16.4.2.4.3 It is anticipated that helicopter impacts are more likely to occur if landing is attempted in unsafe conditions. As helicopter landing during unsafe conditions is not permitted, it is considered that there will be no incremental additional risk to structural integrity as a result of helicopter transport.

16.4.2.4.4 As addressed in ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, the helicopter approach and take-off will not be affected as a result of the presence of Hornsea Four due to flight procedures and regulations taking account of all obstacles. The severity and probability of helicopter impact remain unchanged. The risk is therefore assessed to be broadly acceptable.

16.4.2.4.5 Note that in the case of an emergency, Hornsea Four will not restrict Search and Rescue (SAR) aircraft access to nearby platforms.

16.4.3 Loss of Maritime Integrity - Loss of Stability

16.4.3.1.1 As there are no floating Perenco platforms in the Tier 2 grouping this impact is not considered applicable.

16.4.4 Loss of Maritime Integrity - Loss of Position

16.4.4.1.1 As there are no floating Perenco platforms in the Tier 2 grouping this impact is not considered applicable.

16.4.5 Vessel Access (Deviation) - Construction and Operations

16.4.5.1.1 This section assesses the potential safety impacts in relation to access to Oil and Gas (O&G) assets that may arise as a result of the construction and operation of Hornsea Four.

16.4.5.1.2 A vessel access impairment study was performed, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, for assets close to Hornsea Four. The assets within 10 nm were screened to identify which may be affected in terms of access to the structures. Deviations to offshore routine support vessel (e.g., supply and standby) routeing relative to the Hornsea Four structures were considered.

16.4.5.1.3 During construction of Hornsea Four, a number of vessels will be required within the array area. This combined with vessel route changes and vessel deviations, means that the potential for impaired access during this period may increase.

Potential Consequences

- Impairment of vessel access to platforms; and
- Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage.

Existing Safeguards / Controls

- The existing safeguards / controls for allision risks listed in the safeguards / controls for allision risks – section 16.4.2.3; and
- Existing routeing for support vessels - majority of the support vessels making routine visits will originate from either Great Yarmouth or Lowestoft.

Analysis of Risk

Hornsea Four - Array Area:

16.4.5.1.4 As noted in section 8.3.2 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and based on consultation and a review of the destination information transmitted within the marine traffic data studied, the majority of O&G vessels visiting the Perenco's Tier 2 assets within 10 nm of the Hornsea Four array area do so from Lowestoft or Great Yarmouth, and as such will approach from the south.

16.4.5.1.5 Details of Hornsea Four operations would be promulgated in advance via the usual means (e.g., Notifications to Mariners (NtM)), including directly to the relevant operators as identified within the allision study and consulted with to date. This will facilitate advanced passage planning, ensuring any deviations are minimal, and will allow the locations of completed or partially completed structures to be accounted for.

HVAC Booster Station Search Area:

16.4.5.1.6 As per section 8.3.2 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, the majority of vessels visiting the Tier 2 assets within 10 nm of the HVAC booster station search area do so from Lowestoft or Great Yarmouth, and as such will approach from the south. On this basis, no notable deviations are likely for routine routeing to Minerva.

16.4.5.1.7 Given the deviations required, only vessels associated with platforms north of the array will be affected by the construction of Hornsea Four in terms of access. Given the potential for a limited impact to any vessels visiting from ports other than Lowestoft or Great Yarmouth, additional risks to the Perenco Tier 2 assets is considered negligible, and therefore broadly acceptable.

16.4.5.1.8 Also, advance warning and accurate location details of construction, maintenance, and decommissioning operations, associated Safety Zones and advisory passing distances will be given as per Co89 (see Volume A4, Annex 5.2: Commitment Register).

16.4.6 Vessel Access (Proximity) - Construction and Operations

16.4.6.1.1 This section assesses the potential safety impacts in relation to access to O&G assets that may arise as a result of the construction and operation of Hornsea Four.

16.4.6.1.2 A vessel access impairment study was performed, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, for assets close to Hornsea Four. The assets within 10 nm were screened to identify which may be affected in terms of access to the structures. Spacing / proximity issues relative to Hornsea Four structures were considered.

16.4.6.1.3 During construction of Hornsea Four, a number of vessels will be required within the array area. This combined with vessel route changes and proximity of wind turbines and associated works may restrict / hamper access to O&G platforms and subsurface infrastructure during certain periods (e.g., allowable weather).

Potential Consequences

- Impairment of vessel access to platforms due to proximity of wind turbines and associated works; and
- Allision risk due to proximity of vessels being deviated from existing route resulting in the potential for structural damage.

Existing Safeguards / Controls

- The existing safeguards / controls for allision risks are listed in the safeguards / controls section 16.4.2.3.

Analysis of Risk

Hornsea Four - Array Area:

16.4.6.1.4 The closest Tier 2 platform is the Ravenspurn North complex, located 1.6 nm (3 km) to the south of Hornsea Four array area. All other Tier 2 platforms are in excess of 2 nm from Hornsea Four array area. Note that large scale operations associated with O&G assets can be undertaken in proximity to wind farm structures, including in smaller spaces than is available in this instance. As noted in section 8.3.2 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and based on the marine traffic data studied, the majority of O&G vessel operation associated with the Ravenspurn assets remain outside of the Hornsea Four array area. Regardless, noting that Perenco queried how simultaneous operations would be managed, ongoing liaison would be necessary to ensure cooperation particularly during the construction phase. This includes consideration of works associated with export cable installation noting that the offshore cable corridor is in close proximity to the Ravenspurn North CC platform (within 0.5 nm).

HVAC Booster Station Search Area:

16.4.6.1.5 In terms of proximity from the HVAC Booster Station, there is no perceived impact on operations associated with Minerva.

16.4.6.1.6 Given the location of Minerva, it is not considered that there would be additional safety impact from Hornsea Four's presence. Vessels attending to the asset will do so from Lowestoft or Great Yarmouth, and as such will approach from the south. This will not change and as such the associated safety risks will remain unchanged.

16.4.6.1.7 Considering that all operations associated with Ravenspurn assets remain outside the array area, The incremental additional safety risk associated with access to these assets is considered to be negligible, and therefore **broadly acceptable**.

16.4.6.1.8 The identified potential implications / consequences of vessel access as a result of proximity to the array area may be commercial. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation. These considerations are addressed in Section 20: Commercial Considerations of this report.

16.4.6.1.9 Also, advance warning and accurate location details of construction and maintenance operations, associated Safety Zones and advisory passing distances will be given as per Co89 (see Volume A4, Annex 5.2: Commitment Register).

16.5 TIER 2 Assessment - Platform Systems

16.5.1.1.1 This section focuses on the potential impacts on Perenco's Tier 2 platform systems as a result of Hornsea Four's presence in the area.

16.5.1.1.2 Hazard guide words have been employed and were developed from Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006) and extended to incorporate specific operational concerns. These are: loss of containment – process; loss of containment – pipelines; loss of containment – fire & explosion; and emergency response.

16.5.2 Loss of Containment - Process

16.5.2.1.1 This section addresses loss of containment from process plant and process operations. According to GASCET (HSE, 2006) hazard sources for process systems include process equipment such as pressure vessels, heat exchangers, pipeline risers, flexible hoses, etc.

16.5.2.1.2 Process systems are the primary responsibility of the duty holder and constrained to within the 500 m safety zone, the presence of Hornsea Four will not result in loss of containment from process systems, as all Hornsea Four operations remain outside these safety zones. The risk is therefore not considered applicable.

16.5.3 Loss of Containment - Pipelines

16.5.3.1.1 This section addresses loss of containment from pipelines and piping systems associated with the platform systems and constrained within 500 m of the platform. According to GASCET (HSE, 2006) hazard sources for the platform pipeline systems include fixed and flexible risers, emergency shutdown valves, and subsea isolation systems, etc.

16.5.3.1.2 These pipeline systems are the primary responsibility of the duty holder and constrained within the 500 m safety zone. The impact of Hornsea Four potentially resulting in loss of containment from platform systems is not considered applicable, as all Hornsea Four operations remain outside these safety zones. However, the impact of Hornsea Four's presence on associated pipeline systems (outboard and intra-field pipelines) is addressed in section 16.6.18 of this report.

16.5.4 Loss of Containment - Fire & Explosion

16.5.4.1.1 With the 500 m safety zone, Hornsea Four will have no impact on process hazards leading to fire and explosions on Perenco platform systems.

16.5.4.1.2 The potential for loss of containment for outboard pipelines leading to fires and explosions is addressed for associated systems in section 16.6.18 below.

16.5.5 Emergency Response

16.5.5.1.1 This section focuses on the impact (impairment / delay) Hornsea Four's presence in the area may have on Perenco's emergency response arrangements associated with their Tier 2 assets. Perenco's emergency response arrangements will include the following:

- Emergency Response Management;
- Alarms and Communication;
- Temporary Refuge and Muster Stations;
- Access / Egress Routes;
- Evacuation;
- Escape;
- Rescue and Recovery;

- Emergency Lighting; and
- Emergency Communications.

16.5.5.1.2 The Health and Safety Executive (HSE) UK, Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations (HSE, 2016) and associated Schedules contain specific requirements for emergency response to major accident hazards on installations. It is assumed that Perenco's current emergency response arrangements comply with the relevant statutory provisions governing the operations listed above.

Potential Consequences

16.5.5.1.3 Impairment or delay of emergency response arrangement could potentially lead to injury / fatality of personnel.

Analysis of Risk

16.5.5.1.4 It is not considered that Hornsea Four will have any impact on emergency response systems on the Tier 2 facilities, i.e., access / egress, alarms, and communication (including emergency communications), escape, emergency lighting on installations, temporary refuge and muster stations.

16.5.5.1.5 Other emergency responses would typically include provision of primary and secondary means of evacuation and escape from these installations, e.g., helicopter, Totally Enclosed Motor Propelled Survival Craft (TEMPSC), sea transfer and bridge-link, some necessitating arrangements with others.

16.5.5.1.6 As stated in section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, for emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by Commercial Air Transport (CAT) Regulations as these rely on the Coastguard SAR Aircraft operating under the Civil Aviation Publication (CAP), CAP 999. The Coastguard helicopters are operated as State Aircraft under National Regulations and are not constrained by EASA Regulations. As Coastguard SAR Operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to nearby installations.

16.5.5.1.7 As the preferred means of evacuation from the offshore Tier 2 asset area are helicopter and via sea transfer, details of the impact of Hornsea Four on access via vessel and helicopter are discussed in the following sections:

- Vessels – sections 16.4.2.3 and 16.4.5; and
- Helicopter – sections 16.6.5 to 16.6.8

16.5.5.1.8 In considering the assessment of vessel and helicopter access for emergency response purposes there will be no risk of delay or impairment of emergency response systems required around Tier 2 assets. Note that, as per Prevention of Fire and Explosion, and Emergency Response (PFEER) Regulation 17, other response systems (TEMPSC, etc.) must always be present. The risk is considered negligible and is therefore broadly acceptable.

16.6 TIER 2 Assessment - Associated Systems

16.6.1.1.1 This section focuses on the potential impact on Perenco's Tier 2 assets as a result of Hornsea Four's presence in the area. Associated systems comprise other equipment and operations that are associated with but not part of the platform and platform systems.

16.6.1.1.2 Hazard guide words have been employed, and were obtained from GASCET (HSE, 2006) and extended to incorporate specific operational concerns (as shown in Table 6-2). The guide words employed are: wells; diving; human factor; helicopter - impaired access to O&G platforms and to O&G vessels; helicopter - deferred access to support O&G operations; seismic survey operations; drilling (array and ECC) operations; construction (array and ECC) operations; non-process fires & explosions; communication / control (microwave); REWS impairment; closest point of approach alarms; and loss of containment - outboard pipelines / intra-field pipelines.

16.6.2 Wells

16.6.2.1.1 Hazards to the Tier 2 wells could arise from the following initiators:

- Vibration (i.e., from Piling / drilling of turbine foundations);
- Dropped objects from vessels; and
- Anchor spread from vessels, e.g., work boats or Diving Support Vessel (DSV).

Potential Consequences

16.6.2.1.2 Wells integrity compromise with the potential of blowout / spillage.

Existing Safeguards / Controls

- Subsea protection structure;
- Inherent Safety practices;
- Competent personnel;
- Control measures via existing marine procedures, e.g., NtM;
- SIMOPS will be performed prior to Hornsea Four field operations; and
- 500 m safety zone around assets.

Analysis of Risk

16.6.2.1.3 Considering the relative footprint of the closest Perenco Ravenspurn wells (i.e., 43/26a-F16) compared to that of Hornsea Four's operation, the likelihood of a dropped object strike is considered negligible.

16.6.2.1.4 Anchor spread for vessels supporting the construction and operations in Hornsea Four will be controlled by SIMOPS, expected works will be published in NtM; Given that wellheads are generally not found close to shore (water depths less than 15 m), the use of anchor spreads is not expected. However, they may be required for cable jointing or repair works, or to assist construction vessels where conditions dictate.

16.6.2.1.5 Also considering the distance of the closest wells in the Tier 2 area (i.e., at least 1.6 nm) from the Hornsea Four turbine foundations, there is little risk of Hornsea Four interfering with the existing wells in the Ravenspurn field.

16.6.2.1.6 The likelihood of compromising well integrity is considered remote given the above listed existing safeguards and controls. Hence, the incremental additional risk of compromise to the Tier 2 wells is considered **broadly acceptable**.

16.6.3 Diving

16.6.3.1.1 This section focuses on potential impact on Perenco's diving operations (temporary impact upon access for pipeline repair / maintenance, etc.) due to the implementation and operation of Hornsea Four.

Potential Consequences

- The safety of divers is compromised due to Hornsea Four construction / operations; and
- Delay in diving maintenance, including inspection and repair operations.

Existing Safeguards / Controls

- No diving operations in unsafe conditions; and
- Co-existence procedures.

Analysis of Risk

16.6.3.1.2 It is anticipated that temporary restrictions to diving operations for maintenance / repair may occur during installation of Hornsea Four. Through detailed discussions, planning, and good SIMOPS practices by both parties, these potential access restrictions can be avoided.

16.6.3.1.3 The temporary piling / drilling operations associated with the array area could lead to acoustic vibrations which may have an impact on diving operations. Diving near subsea assets associated with the Tier 2 platforms should be avoided during such operations. This will be managed via standard site installation communication between interested parties.

16.6.3.1.4 Given the management of operations via communication and consultation between Hornsea Four and Perenco, it is considered that the safety risks associated with diving operations for Tier 2 assets remain unchanged and therefore considered to be **broadly acceptable**.

16.6.4 Human Factor

16.6.4.1.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

16.6.4.1.2 This section addresses human factors associated with Hornsea Four construction and operations that may have a hazardous impact on Perenco's Tier 2 operations.

16.6.4.1.3 For the analysis of Perenco's Tier 2 operations the most relevant subjects are Hornsea Four navigation, station holding and/or the potential of drifting close to or around the route of the pipeline and platforms, due to operations associated with installation, inspection or maintenance.

16.6.4.1.4 Human errors can occur both in the conceptual and design phases as well as construction and operational phases of a project. Human errors, that have the potential to result in a Major Accident Hazard (MAH), in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

16.6.4.1.5 Loss of containment due to incidents caused by personnel incompetency / lack of experience / stress.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

16.6.4.1.6 According to GASCET (HSE, 2006), the stakeholder should have a procedure in place for the selection, competence assessment, and training of operations and maintenance personnel and that it is designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

16.6.4.1.7 The HSE standards and codes of practices are referenced to show that in order to operate in the UK Continental Shelf, the O&G asset holders are expected to follow certain requirements.

16.6.4.1.8 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016). Risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel will be employed during the installation, operations and maintenance of the Hornsea Four infrastructure. Therefore, the introduction of incremental additional risk from this potential initiator is considered negligible.

16.6.4.1.9 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the incremental additional risk of impact from human factors is considered broadly acceptable.

16.6.5 Helicopter - Impaired Access to O&G Platforms (CAT)

16.6.5.1.1 This subsection addresses the potential impaired access of CAT operated helicopters to Perenco's Tier 2 platforms, and the associated additional safety impact.

16.6.5.1.2 In assessing this potential impact, a study on Helicopter access, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, was performed and applied the CAT weather limits, as a series of filters, to the meteorological data provided by Perenco in order to understand the potential operational impact on the installations. The report considered relevant CAA and industry guidance and was written to ensure that Hornsea Four accounts for the associated obligations. This includes an obligation under CAP 764 to undertake consultation when a development is within 9 nm of an offshore helicopter destination. Ravenspurn North was used as an illustrative case, as it is located 3 km (1.6 nm) from the Hornsea Four array area (see Figure 16-2) and is a permanently manned platform. The assessment focused on identifying reduced access when operating under CAT Regulations, but access under SAR Regulations was also considered.

16.6.5.1.3 The helicopter access data for other Ravenspurn platforms are presented in sections 6 to 10 of Appendix A1 (Platform Specific Data for Helicopter ARA to Gas Installations Adjacent to Hornsea Project Four) of the report, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

16.6.5.1.4 The potential for impaired access to O&G platforms could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Reduction of access to platform;
- Helicopter incident; and
- Potential restriction to flying due to other restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training; and
- For emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as state aircraft under national regulations and are not constrained by EASA Regulations. As Coastguard SAR operations are not restricted by CAT

Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to nearby installations – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

Analysis of Risk

Hornsea Four – Array Area (Ravenspurn North Case Study):

- Approach limitations – in assessing (with the application of meteorological limits) the potential additional limitations in helicopter approach to platforms that could be imposed on installations as a result of Hornsea Four's presence, the findings from section 4.2 Helicopter access and deviation, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report show:
  - En-Route Descent – on average an en-route descent could be made on 89 % of occasions by day and 83 % of occasions by night. Under these conditions no approach limitations whatsoever will be imposed on gas installations adjacent to Hornsea Four;
  - Shuttling Permitted - The data indicates that on average the option of flying a shuttle flight, where the helicopter would fly an instrument approach to an initial installation (often without landing) and then transit to its destination, would be available 93 % by day and 90 % by night. Shuttling procedures can be used if the destination is within 10 nm of the initial installation approached. Thus, shuttling would provide an alternative approach profile within the Ravenspurn Field. Below shuttling meteorological conditions, an ARA would be required;
  - ARA Required - When the weather conditions are below those permitting an en-route descent or a shuttle flight, an ARA must be flown;

    ARA is required 7 % of occasions by day and 10 % by night. These figures are the difference between when shuttling can be used subtracted from 100 %. However, in order to assess the worst case and ensure a conservative approach, the evaluation assumed that an ARA will be required whenever an en-route descent is not permitted, except for in no-fly conditions.
  - No Fly Conditions - No Fly conditions exist for an average of 6 % of occasions by day and 5 % of occasions by night. No fly conditions will be higher for some Normally Unmanned Installations (NUIs) where additional restrictions are in place, such as a 30 kt wind deck limit, for example the Ravenspurn North ST2 platform.

    The gap between when a flight can be made under Visual Flight Rules (VFR) and when the weather conditions preclude a flight can be quite small. For example, the gap between when an en-route descent can be made (89 % by day) and when a flight is prohibited (6 % by day) results in only a small reduction in capability (100 % - 89 % - 6 % = 5 %). If an ARA has to be flown but is not obstructed by the wind farm due to the wind direction, the resulting restrictions may not be as large as initially assumed.
- As per section 5.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, vantage data for the Ravenspurn North platform did not show any significant seasonal variation in flights. However, it did show a steady decline in flights since 2015, resulting in a reduced impact from Hornsea Four. As a decline in flights has occurred, it is important to identify future trends and if this decline will continue or stabilise. If greater use is made of walk-to-work vessels and /or the number of flights remain at a low level, then the impact of Hornsea Four is likely to be reduced compared to the historic level of access required. Although the analysis assumes no increase in flights above those flown in 2018/19, Perenco has stated during consultation meetings in January 2020 that flights may increase in future years, although no evidence was provided to support this statement.
- Section 2, Appendix A1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report shows that for Ravenspurn North, it was assessed that the largest impact on access will occur when an ARA is required due to low cloud and/or poor visibility and the wind direction is between 180° and 260°. The data indicates that an ARA will be obstructed for up to 1.16 % (102 hours) to 2.07 % (181.5 hours) of the year, using complete data sets collected from 2013 to 2018. Note that the affected hours are spread out through the years studied, and delays occur for a matter of hours as opposed to

days. A summary of all the results from the assessment is presented in Table 6.1 in Section 6 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

16.6.5.1.5 Sections 6 to 10 of Appendix A1 in ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report presents the data for the other platforms in the Ravenspurn field, Ravenspurn North ST2, Ravenspurn North ST3, Ravenspurn South A, Ravenspurn South B, and Ravenspurn South C respectively. The analysis of the other platforms indicates that the impact of Hornsea Four on their access will be even lower than the impact on Ravenspurn North.

16.6.5.1.6 In terms of navigational failure as a result of Hornsea Four, consideration of helicopter systems is already built into the procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required as a result of the presence of Hornsea Four.

16.6.5.1.7 On the basis of the above assessment, helicopter transport will not take place should there be any risk brought about by a combination of meteorological conditions and the presence of the Hornsea Four array. Therefore, the additional safety risk associated with helicopter transport to and from platforms in Tier 2 will remain unchanged and therefore is considered to be broadly acceptable.

16.6.5.1.8 ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report shows that the implications of impaired access are not safety related, but commercial only. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation. These are considered in Section 20: Commercial Considerations of this report.

16.6.5.1.9 Also, as per Co102 (see Volume A4, Annex 5.2: Commitment Register), the Defence Infrastructure Organisation and the CAA, Maritime and Coastguard Agency (MCA) and operators will be informed of the locations, heights, and lighting status of the wind turbines, including estimated and actual dates of construction and the maximum height of any construction equipment to be used, prior to the start of construction, to allow inclusion on Aviation Charts.

16.6.6 Helicopter - Impaired Access to O&G Platforms (SAR)

16.6.6.1.1 This subsection addresses the potential for impaired access by SAR operated helicopters to Perenco Tier 2 platforms, and the associated additional safety impact.

16.6.6.1.2 In assessing this potential impact, a study on Helicopter access, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report , was performed. Ravenspurn North was used as an illustrative case, as it is located 3 km (1.6 nm) from the Hornsea Four array area (see Figure 16-2) and is a permanently manned platform. In the assessment access under SAR Regulations was considered.

16.6.6.1.3 The potential for impaired access to O&G platforms could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Reduction of access to platform;
- Helicopter incident; and
- Potential restriction to flying due to other restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training;

- For emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as state aircraft under national regulations and are not constrained by EASA Regulations. As Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to nearby installations – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report; and
- MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training are more advanced than that available to CAT helicopters.

Analysis of Risk

- Take-off limitations – there are no take off limitations on SAR operated helicopter flights imposed by the presence of Hornsea Four; and
- Approach limitations – there are no approach limitations on SAR operated helicopter flights imposed by the presence of Hornsea Four.

16.6.6.1.4 On the basis of the above assessment, and as Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, the presence of Hornsea Four will not impose any restrictions on SAR aircraft access to nearby installations. The safety risk remains unchanged and is considered broadly acceptable.

16.6.7 Helicopter - Impaired Access to O&G Vessels (CAT)

16.6.7.1.1 This subsection addresses the potential for impaired access of CAT operated helicopters to O&G vessels associated with Tier 2 operations, and the associated additional safety impact.

16.6.7.1.2 The potential for impaired access to O&G vessels associated with Tier 2 operations could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions

Potential Consequences

- Helicopter incident; and
- Potential restriction to flying due to restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication; and
- Operational procedures / personnel training.

Analysis of Risk

16.6.7.1.3 In terms of navigational failure as a result of Hornsea Four, consideration of helicopter systems is already built into the procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

16.6.7.1.4 In consideration of extreme weather / environmental conditions, the operational regulations already include weather limits, and these will not change with the presence of Hornsea Four.

16.6.7.1.5 As stated in section 4.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, it was observed that under stated conditions, O&G platforms adjacent to Hornsea Four will not be subject to approach limitations. Consequently, it is considered that the vessels associated with these platforms will also not be subject to approach limitations.

16.6.7.1.6 On the basis of the above assessment, there will be no additional risk to safety brought about by the presence of Hornsea Four. Therefore the incremental additional safety risk associated with helicopter transport to and from vessels in Tier 2 will remain unchanged and so is considered broadly acceptable.

16.6.7.1.7 ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report shows that the implications of impaired access are not safety related. The identified potential implications/ consequences of impaired access are commercial only. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation - these are considered in Section 20: Commercial Considerations of this report.

16.6.8 Helicopter - Impaired Access to O&G Vessels (SAR)

16.6.8.1.1 This subsection addresses the potential for impaired access of SAR operated helicopters to O&G vessels associated with Tier 2 operations, and the associated additional safety impact.

16.6.8.1.2 The potential for impaired access to O&G vessels associated with Tier 2 operations could arise from the following initiators:

- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter incident; and
- Potential restriction to flying due to restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training;
- For emergency conditions, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as state aircraft under national regulations and are not constrained by EASA Regulations. As Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to vessels attending Perenco's nearby facilities – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report; and
- MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training are more advanced than that available to CAT helicopters.

Analysis of Risk

16.6.8.1.3 In terms of navigational failure, this consideration is already built into the helicopter systems procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

16.6.8.1.4 In consideration of extreme weather / environmental conditions, the operational regulations already include weather limits, and these will not change with the presence of Hornsea Four.

16.6.8.1.5 As stated in section 4.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, it was observed that under stated conditions, O&G platforms adjacent to Hornsea Four will not be subject to approach limitations.. Consequently, it is considered that the vessels associated with these platforms will also not be subject to approach limitations.

16.6.8.1.6 On the basis of the above assessment, there will be no additional risk to safety brought about by the presence of Hornsea Four. Therefore, the safety risk associated with helicopter transport to and from vessels in Tier 2 will remain unchanged and so is considered broadly acceptable.

16.6.9 Seismic Survey Activities

16.6.9.1.1 Seismic surveillance activities may be required in the future, around the Hornsea Four array. At the time of such activity, it is proposed that a co-existence plan will develop how the performance of such activity will be implemented without undue risk in the interfaces.

16.6.9.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

16.6.10 Drilling (Array Area) Activities

16.6.10.1.1 Exploration and appraisal drilling may be required around the Hornsea Four array area. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

16.6.10.1.2 There have been recent drilling campaigns in the Irish Sea taking place in and around existing offshore wind farms. This presents an example that with adequate planning offshore wind and O&G infrastructures can coexist.

16.6.10.1.3 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

16.6.11 Drilling (ECC Area) Activities

16.6.11.1.1 As shown in Figure 16-1 and Figure 16-2, parts of license block 42/29a crosses the Hornsea Four ECC. Exploration and appraisal drilling may be required around the Hornsea Four ECC. At the time of such activity, it is proposed that a co-existence plan will develop how the performance of such activity will be implemented without undue risk in the interfaces.

16.6.11.1.2 There have been recent drilling campaigns in the Irish Sea taking place in and around existing offshore wind farms. This presents an example that with adequate planning offshore wind and O&G infrastructures can coexist.

16.6.11.1.3 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

16.6.12 Construction (Array Area) Activities

16.6.12.1.1 Perenco may want to construct new production facilities around the Hornsea Four array area. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

16.6.12.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

16.6.13 Construction (ECC Area) Activities

16.6.13.1.1 Perenco may want to construct new production facilities in the field around the ECC. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

16.6.13.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

16.6.14 Non-Process Fires & Explosions

16.6.14.1.1 Non-process fires and explosions are typically associated with non-process plants. In the case of Hornsea Four, this could be electrical fires associated with the HVAC booster station platform, and the offshore substations within the array.

16.6.14.1.2 Considering the distance of the closest Tier 2 surface asset (Minerva) to the HVAC booster station is more than 12 km, and the distance of the closest Tier 2 asset (Ravenspurn North CC) to the array area is 3 km, it is considered that the impact of electrical fires on Perenco's Tier 2 assets are negligible, and therefore broadly acceptable.

16.6.15 Microwave Communication

16.6.15.1.1 This subsection considers the potential effect of Hornsea Four on the operation of microwave telecommunication links.

16.6.15.1.2 It is envisaged that the presence of Hornsea Four has the potential to obstruct or interfere with a number of microwave links operated by Perenco – see Figure 16-8 below.

16.6.15.1.3 The links which need to be taken into account are:

- Ravenspurn North to Trent;
- Ravenspurn North to Kilmar; and
- Ravenspurn North to Garrow.

Potential Consequences

- Interference with microwave telecommunication links leading to potential loss of, or interruptions in direct communications between Ravenspurn North and Trent, Kilmar, and Garrow platforms.

Existing Safeguards / Controls

16.6.15.1.4 None.

Analysis of Risk

16.6.15.1.5 Microwave links are communication mechanisms used for high-speed data and voice communication, e.g. interconnection of measurement channels and terrestrial voice radio transmission. Microwave links are not used for essential communication relating to safety management. Interference with microwave links will therefore not in itself introduce additional safety risk. On this basis it is considered that the potential of interference with microwave communication will not result in additional safety risk, and is therefore considered broadly acceptable.

16.6.15.1.6 Note that the identified potential implications/ consequences of interference of microwave links may be commercial. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation - these considerations are presented in Section 20: Commercial Considerations of this report.

16.6.15.1.7 It should be noted that there are microwave communication links in operation, successfully running through windfarms without obstruction or interference from the windfarm.

16.6.15.1.8 Some examples, shown in Figure 16-8 below, are Spirit Energy's:

- North Morecambe DPPA to Barrow terminals; and
- South Morecambe CPP to Barrow terminals (via Dalton-in-Furness).

16.6.15.1.9 Both links are operational in the Irish Sea and run across the West of Duddon Sands (WoDs) offshore wind farm which was fully commissioned in October 2014.

16.6.15.1.10 Spirit Energy have confirmed that with these microwave links, they have not experienced any interferences or obstructions from the WoDs offshore wind farm.

16.6.15.1.11 If it is established that Hornsea Four will interfere with the performance of the microwave links, to minimise the impact of the new turbines on the microwave links, two options are considered:

- Establish exclusion zones around the affected microwave links to mitigate the detrimental effects on the link performance which may be caused by the presence of the wind-turbines; and
- Identify alternative routes for the traffic currently being carried over some of the affected links.

16.6.15.1.12 In addition, the communication may be obtained via alternative communication means e.g., satellite communication.

Option 1 - Exclusion Zones

16.6.15.1.13 With regards to establishment of exclusion zones an assessment was performed. The calculation methodology applied is based on a paper by D F Bacon (2002) which also forms the basis of current Ofcom guidelines; and includes Near-Field, Diffraction, and Reflection calculations for the links.

16.6.15.1.14 In consideration of near-field interferences, it is noted that wind turbines should be excluded from the near-field of any microwave antennas since it is not possible to calculate the effect they will have on the performance of the antenna. This is generally quite a small area and is unlikely to be a significant factor in the placement of wind-turbines.

16.6.15.1.15 In consideration of diffraction, it is noted that to avoid unwanted diffraction effects, it is recommended that turbines be excluded from an elliptical area equivalent to the area bounded by the 2nd Fresnel Zone as illustrated in the figures below.

16.6.15.1.16 In consideration of signal reflection, it is noted that signals reflected from the wind-turbine represent an interferer at the radio receiver.

16.6.15.1.17 In the exclusion zone calculations, an assumed value (45 dBm2) is used for the Radar Cross-Section (RCS). To illustrate the sensitivity to RCS in the calculations, the (worst-case) reflection exclusion zone has also been calculated specifically for the Ravenspurn North to Trent link using RCS values of 50 dBm^2, 55 dBm^2, 60 dBm^2 and 65 dBm^2.

Exclusion Zones - Ravenspurn North to Trent

16.6.15.1.18 The following figures were used in the calculations: Hop Length - 47.2 km; Frequency - 7.5 GHz; Antenna Size - 1.2 m; and Turbine RCS: 45 dBm². The calculated near-field distance is 62 m, and the maximum radius of the 2nd Fresnel zone is 31 m.

16.6.15.1.19 The worst-case calculated offset distance Ds is 45 m at approximately 1.3 km from Trent or from Ravenspurn North. The reflection exclusion zone falls to below the Fresnel radius at approximately 2.3 km from either Ravenspurn North or Trent.

Exclusion Zones - Ravenspurn North to Kilmar

16.6.15.1.20 The following figures were used in the calculations: Hop Length - 32.8 km; Frequency - 7.5 GHz; Antenna Size - 0.6 m; and Turbine RCS – 45 dBm². The calculated near-field distance is 16 m, and the maximum radius of the 2nd Fresnel zone is 26 m.

16.6.15.1.21 The worst-case calculated offset distance Ds is approximately 90 m at 1.8 km from Kilmar or from Ravenspurn North. The reflection exclusion zone falls to below the Fresnel radius at approximately 2.6 km from either Ravenspurn North or Kilmar.

Exclusion Zones - Ravenspurn North to Garrow

16.6.15.1.22 The following figures were used in the calculations: Hop Length - 28 km; Frequency - 7.5 GHz; Antenna Size - 0.6 m; and Turbine RCS – 45 dBm². The calculated near-field distance is 16 m, and the maximum radius of the 2nd Fresnel zone is 24 m.

16.6.15.1.23 The worst-case calculated offset distance Ds is 90 m at 1.3 km from Garrow or from Ravenspurn North. The reflection exclusion zone falls to below the Fresnel radius at a distance of approximately 2.6 km from either Ravenspurn North or Garrow.

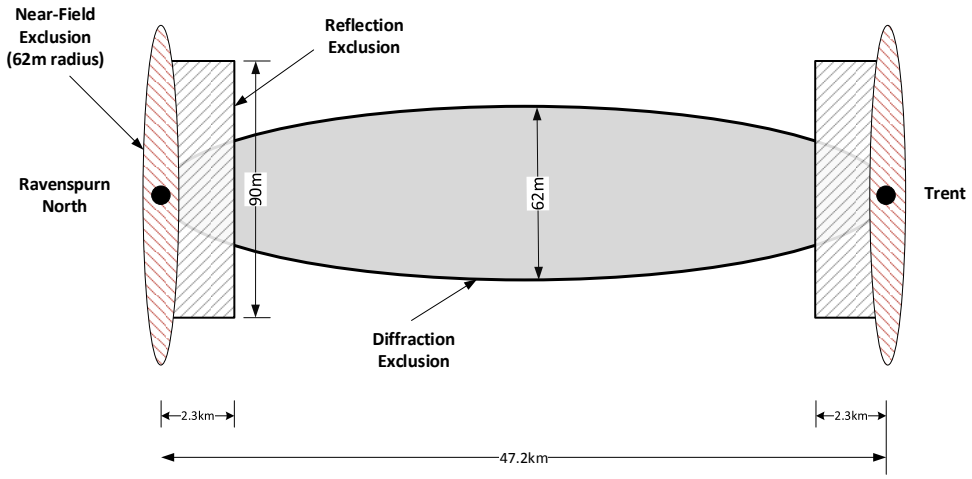


Figure 16-5: Schematic for Ravenspurn North to Trent Exclusion Zone

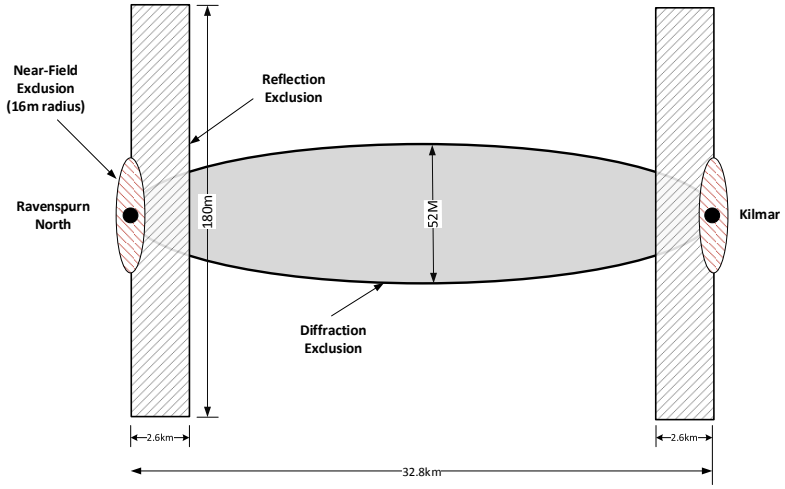


Figure 16-6: Schematic for Ravenspurn North to Kilmar Exclusion Zone

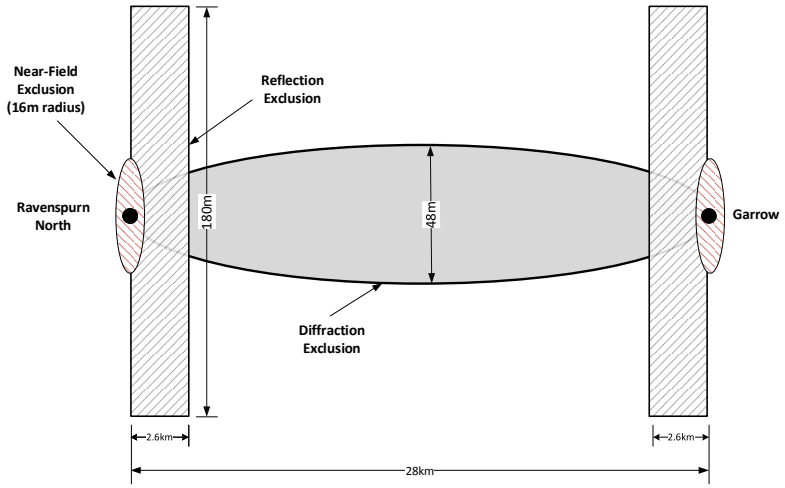


Figure 16-7: Schematic for Ravenspurn North to Garrow Exclusion Zone

Option 2 - Alternative Routes

16.6.15.1.24 In identifying alternative routes for the data currently being carried over some of the affected links, It is understood that the link from Ravenspurn North to Trent is important to Perenco operations and it would be difficult to re-route the signal. However, as an alternative to the direct routes indicated in Figure 16-9, links to Kilmar and Garrow could be routed via Cleeton and Trent as shown in the figure Figure 16-10.

Hornsea Four

Spirit Energy Resources Ltd Assets -
West of Duddon Sands Microwave Links
Figure 16.8

450000 500000

6000000

5950000

N
GRID NORTH

40m separation from turbine tower

10m separation from turbine tower

Walney 1
Walney Extension 4
West of Duddon Sands
Walney Extension 3
Walney Extension 4
RHYL NORTH WELLHEAD 113/27B-J
Walney 2
Ormonde
RHYL SUBSEA WELL (NORTH)
RHYL SUBSEA WELL
RHYL WELLHEAD 113/27B-L
RHYL SUBSEA WELL 2
WHITEHAVEN WELLHEAD 113/27B-K
MILLOM WEST PLATFORM
MILLOM WEST
MILLOM PLEM
MILLOM EAST PLEM
MILLOM WELLHEAD PROTECTION STRUCTURE - Q1
MILLOM WELLHEAD PROTECTION STRUCTURE - Q2
NORTH MORECAMBE PLATFORM
NORTH MORECAMBE DPPA
WELL NO 110/2A-12
DALTON WELLHEAD PROTECTION STRUCTURE - R1
DALTON PLEM
DALTON WELLHEAD PROTECTION STRUCTURE - R2
SOUTH MORECAMBE DP8
SOUTH MORECAMBE DP6
SOUTH MORECAMBE DP4
SOUTH MORECAMBE FL1
SOUTH MORECAMBE DP1
SOUTH MORECAMBE CPP1
CALDER
SOUTH MORECAMBE DP3
BAINS WELLHEAD PROTECTION STRUCTURE
West of Duddon Sands
Barrow
DALTON-IN-FURNESS
BARROW-IN-FURNESS GAS TERMINAL

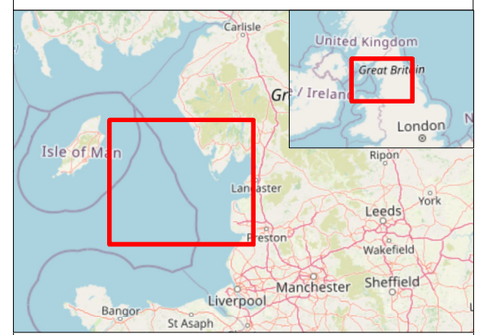
Spirit Energy Mircrowave Fixed Link Tx Rx Locations
Microwave Fixed Links
Wind Turbine

Oil and Gas Infrastructure

- Spirit Energy Platform
- Spirit Energy Terminal
- Spirit Energy Subsea

Pipelines

- Spirit Energy Pipelines
- Other Operators



Coordinate system: WGS 1984 UTM Zone 30N
Scale@A3: 1:300,000

0 2.5 5 10 Kilometres
0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	17/02/2021
A	Removed turbine positions	12/07/2021

Spirit Energy Resources Ltd Assets -
West of Duddon Sands Microwave Links
Document no: HOW040456
Created by: XDAOO
Checked by: JOHLE
Approved by: ELEAN

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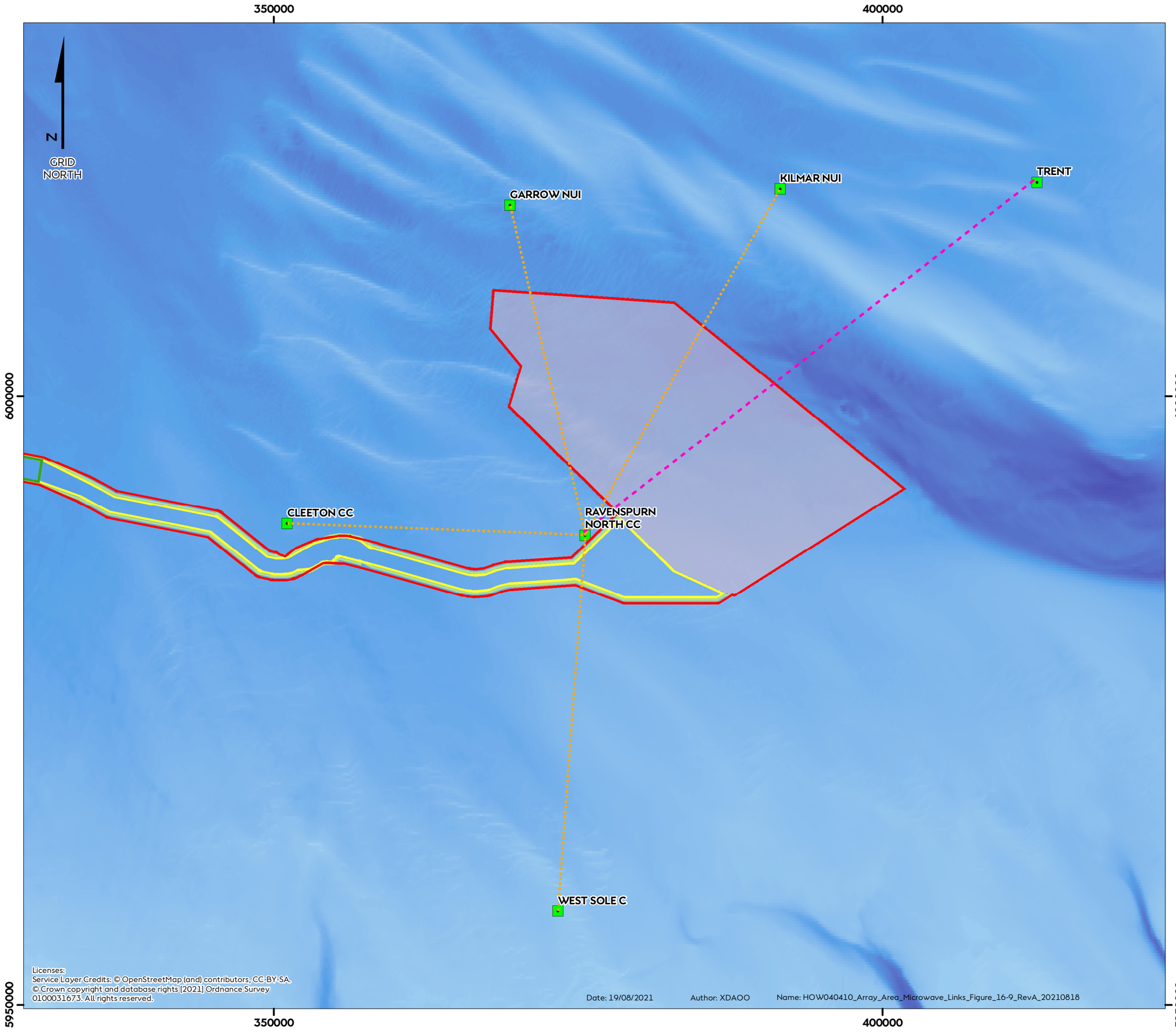
Date: 24/08/2021 Author: XDAOO Name: HOW040456_SpiritEnergy_O&G_MicrowaveLinks_Figure_16-8_RevA_20210818

Hornsea Four

Microwave Routes
Figure 16.9

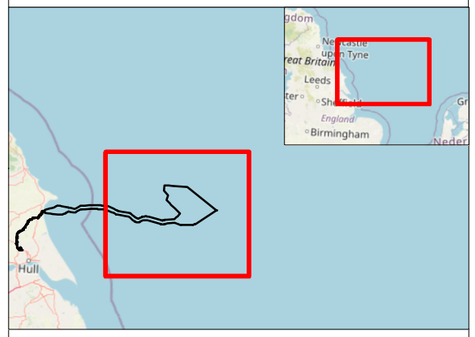


Microwave Routes
- Existing Ravenspurn North to Trent Link
- Proposed Microwave Routes

Surface Infrastructure
- Platform
- Terminal

Project Layers
- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)
- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:300,000

0 2.5 5 10 Kilometres

0 1.25 2.5 5 Nautical Miles

REV	REMARK	DATE
	First issue	24/07/2020
A	Reduced Array Area in northwest corner	18/08/2021

Microwave Routes
Document no: HOW040410
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

350000

400000

6000000

5950000

N

GRID NORTH

GARROW NUI

KILMAR NUI

TRENT

CLEETON CC

RAVENSPURN NORTH CC

WEST SOLE C

Date: 19/08/2021 Author: XDAOO Name: HOW040410_Array_Area_Alt_Microwave_Links_Figure_16-10_RevA_20210818

Hornsea Four

Alternative Microwave Routes
Figure 16.10

Microwave Routes

- Alternative Microwave Routes

Surface Infrastructure

- Platform
- Terminal

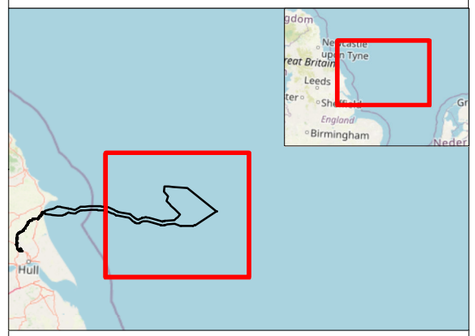
Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)

High : 0

Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:300,000

0 2.5 5 10 Kilometres

0 1.25 2.5 5 Nautical Miles

REV	REMARK	DATE
	First issue	24/07/2020
A	Reduced Array Area in northwest corner	18/08/2021

Alternative Microwave Routes
Document no: HOW040410
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

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16.6.16 Radar Early Warning Systems (REWS)

16.6.16.1.1 This subsection considers the potential effect of the operation and maintenance phase of Hornsea Four on REWS located on offshore O&G platforms. Special focus is on the effects of Hornsea Four on the REWS' ability to detect vessels within the vicinity of the wind farm.

16.6.16.1.2 REWS uses radar returns to monitor and track vessels within the detection region and alert the operator when a proximity violation or an allision threat is detected.

16.6.16.1.3 An assessment was conducted and documented in the REWS Report, ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report. The report provides the technical information and modelling results considering the cumulative impact of Hornsea Four and other projects and plans, specifically other projects within the Hornsea Zone. The assessment considers the MDS for the operation and maintenance phase of Hornsea Four.

16.6.16.1.4 The assessment in ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report uses a number of modelling techniques developed at the University of Manchester to model and predict the impact of turbines and associated offshore structures on radar systems. These models have been verified and were compared against real-life radar and RCS measurements and it is noted that the modelling results showed very good correlation with measurements.

16.6.16.1.5 Two Perenco platforms (Ravenspurn North CC and Ravenspurn South B) where a REWS is installed and which are in close proximity (1.6 nm and 5.2 nm respectively) to the Hornsea Four array area, were considered. These two REWS installations along with the REWS installation on the Cleeton CC platform provide radar coverage and protection for several other nearby Perenco offshore platforms (i.e., Ravenspurn North ST2, Ravenspurn North ST3, Ravenspurn South A, Ravenspurn South C, Neptune, Hoton, Hyde, Trent, A1D).

16.6.16.1.6 As per section 7 of ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report, the presence of turbines is expected to affect the REWS by introducing shadow regions and increasing the detection threshold around the turbines which will reduce the REWS' ability to detect and track targets within the affected area.

16.6.16.1.7 As stated in section 7 of ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report, some of the assumptions considered within the turbine RCS and shadow modelling are expected to overestimate the effects of turbines on REWS. Measurements show that the radar shadows from turbines diminish gradually with range due to the diffraction effects. Additionally, turbine materials, exact geometry, manufacturing tolerances, and external effects such as blade and tower bending due to wind loading are expected to effect and reduce the RCS of the turbines. The REWS report considers the worst-case scenario using the MDS parameters for the Hornsea Four array area and turbines.

16.6.16.1.8 The extent and length of the shadow region cast by a turbine depends on the size of the turbine, the distance to the radar antenna, the height of the radar and the height of the target of interest. The severity of the shadow will also depend on the distance of the target from the turbine. This is illustrated in Figure 16-11 below.

16.6.16.1.9 In the turbine shadow modelling described in section 3.5 of ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report, one thousand Gross Tonnage (GT) plus vessels (which are the main safety concern to offshore platforms) vary in size and typical vessel lengths are between 15 m and 60 m. The shadows from the turbines are relatively narrow and are typically between 4 m and 20 m in width. This indicates that a large 1,000 GT vessel will be partially shadowed by the turbine as it moves through the shadow regions (as shown in Figure 16-12).

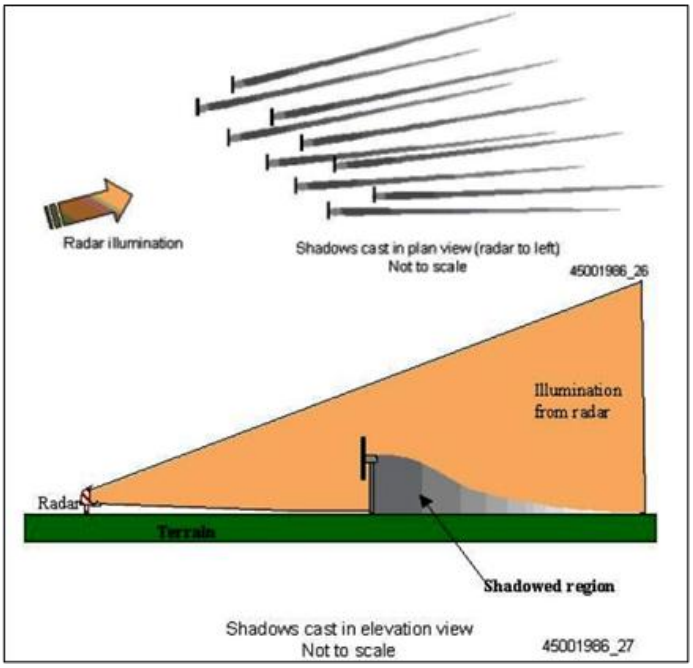


Figure 16-11: Illustration of Radar Shadowing with Diffraction Effects

16.6.16.1.10 Figure 16-11 is obtained from section 2.2 of the REWS report ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report.

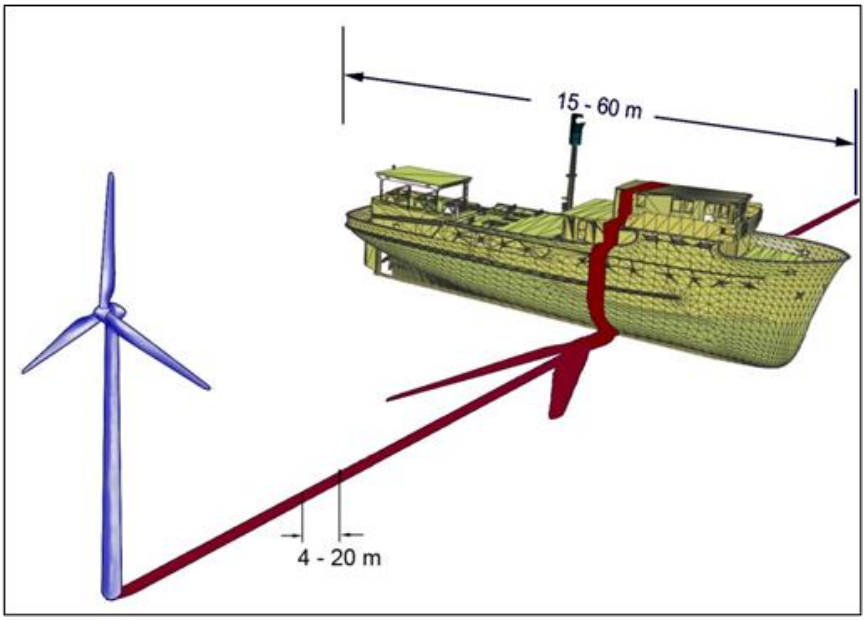


Figure 16-12: Optical Blockage and Partial Shadowing

16.6.16.1.11 Figure 16-12 is an excerpt from section 3.5 of ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report.

16.6.16.1.12 The main hazard is:

- Partial impairment of the REWS performance on O&G platforms.

Potential Consequences

- Potential loss of detection and monitoring of vessel movements within the region due to Target Masking and Shadowing Effects, ultimately leading to potential for allision.

Existing Safeguards / Controls

- Ships are required to have a passage plan, taking into account all hazards;
- It is illegal for a Master to navigate vessels within 500 m of an installation except in special circumstances, e.g., distress. Normally, the Master will plan to pass a minimum 1 nm from a platform;
- Automatic Identification System (AIS) data is integrated into the REWS tracker. This provides the REWS a reliable source of data as AIS transponders are largely unaffected by the presence of wind turbines;
- In terms of tracking vessels within the wind farm, the tracker software is expected to compensate for most of the detection losses of the vessels;
- REWS stations are equipped with High Frequency (HF) radio communications, which can be used to contact vessels in the area if a potential threat is detected or expected; and
- Visual (lights) and audio (horns) alarms can be used to alert vessels close to the platform.

Analysis of Risk

16.6.16.1.13 The results from the assessment of impairment of the effectiveness of REWS, indicates that the raw, single scan detection performance of the REWS due to the presence of Hornsea Four in isolation and cumulatively with Hornsea One and Hornsea Two is affected adversely within the wind farm regions. Radar detection of vessels travelling within the modelled Hornsea Projects may be lost temporarily as they move close to the modelled turbines located within the radar range. The loss of detection is mainly caused by the elevated threshold levels due to the presence of the turbines while a small number of losses are expected to occur due to shadowing.

16.6.16.1.14 The density of turbines, causing shadowing, decreases as vessels are approaching platforms from the array area. Hence, REWS detectability will increase and the likelihood of REWS picking up the signal increases as the vessel approaches the O&G platforms.

16.6.16.1.15 Larger vessels, with larger potential impact damage, approaching the Ravenspurn field from the array area East and North-East, will typically have their routes diverted due to the wind farm array. Other vessels from East / North-East, with lesser potential impact damage may still choose to transit through the array area.

16.6.16.1.16 In addition, the likelihood of allision risk is very low even with no REWS detection system because sea going vessels have trained captains and ships have AIS mounted navigation systems. It should also be noted that the locations of some O&G platforms are available to ships via AIS. Newer installations tend to be fitted with AIS as an Aid to Navigation; and older platforms (or jackets) undergoing decommissioning tend to be retrofitted with AIS when they enter the cold stack (or lighthouse) phase prior to removal for up to ~3 years, such as LOGGS, CMS, Viking, Pickerill, etc.

16.6.16.1.17 Furthermore O&G offshore platforms are marked on Admiralty charts. REWS is considered an additional layer of safety protection, SECE, only.

16.6.16.1.18 REWS is equipped with an intelligent tracking software which is installed by the supplier as part of the REWS package. Typically, in terms of tracking vessels within the wind farm, the tracker software is expected to compensate for most of the detection losses of the vessels. Additionally, the integration of AIS data with the REWS will provide an alternative source of vessel information and location which can complement the data when temporary radar losses are experienced.

16.6.16.1.19 Note that if the situation requires, the tracker software can be modified to address specific issues depending on the operator's demands, environment and clutter in the region. However, in the case of wind farm shadows and turbine radar masking, the standard tracker (along with the AIS transceiver) is effective at compensating for the temporary losses.

16.6.16.1.20 A number of studies have attempted to determine the RCS of turbines through measurements of the power received by a radar in the region. ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report refers to a study undertaken by Terma within Hornsea Project One (Terma 2021) which highlights the difference between measured and theoretical RCS values of turbines obtained from computational modelling. The turbines deployed at Hornsea Project One have a rotor diameter of 154 m and a hub height of 117.9 m AMSL. Although these turbines are smaller than the MDS turbines considered for Hornsea Four, they are still considered to be very large structures for radars. The results of the study show that the power received from turbines within the Hornsea Project One are within reasonable levels and the radar is able to detect a vessel travelling within the array area.

16.6.16.1.21 On the basis of the above listed existing safeguards and analysis, it is considered that the incremental additional safety risk to platform allision due to REWS partial impairment is broadly acceptable.

16.6.16.1.22 The identified potential implications/ consequences of partial impairment of REWS may be commercial, Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation. These are addressed in Section 20: Commercial Considerations of this report.

16.6.17 CPA and TCPA Alarms

16.6.17.1.1 This subsection considers the potential effect during the operation and maintenance phase of Hornsea Four on REWS located on offshore oil and gas platforms, with special focus on the impact on the REWS alarm rates due to rerouted traffic. This is further described in section 6.4 of ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report.

16.6.17.1.2 The manned and normally unmanned platforms to the South-West of the array area have REWS alarm settings, Closest Point of Approach (CPA) and Time to Closest Point of Approach (TCPA), as per the below table.

Table 16-2: REWS Alarm Settings

Installation Type	Signal (Alarm) Type	
	Closest Point of Approach (CPA)	Time to CPA (TCPA)
Manned Installation	Amber @ < 1nm	Amber @ 40 min
	Red @ 0.27 nm	Red @ 30 min
Normally Unmanned Installation (NUI)	Amber @ < 1nm	Amber @ 25 min
	Red @ 0.27 nm	Red @ 15 min

Potential Consequences

16.6.17.1.3 The consequence of the increased vessel density in and around the Ravenspurn platforms is a potential increase in alarms being triggered, and in the ultimate event, allision could happen if the alarm malfunctions or does not trigger action.

Existing Safeguards / Controls

- The existing safeguard is the detection measures, i.e., REWS with alarm setting as per above table;
- AIS data is integrated into the REWS tracker, which provide additional layer of safety protection;
- VHF radio can be used to contact vessels that may trigger REWS alarms to investigate their status / heading;
- ERRV and/or daughter craft may approach the vessel to alert it if it is close to the platform/complex;
- Visual (lights) and audio (horns) alarms can be used to alert vessels close to the platform; and
- The ultimate action in case a vessel cannot be diverted and is on a collision course with the installation is emergency response.

Analysis of Risk

16.6.17.1.4 As stated in section 7.3.1.2 of ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report, the modelled routes and reroutes were chosen based on their general direction and close proximity to Perenco's operated Ravenspurn North CC, Ravenspurn South B, Ravenspurn North ST2, Ravenspurn North ST3, Ravenspurn South A, and Ravenspurn South C platforms. The routes were chosen for their proximity for CPA alarms assessment and for their general heading vectors for TCPA alarms assessment.

16.6.17.1.5 Once Hornsea Four is constructed, some routes may remain unchanged relative to the assessed platforms while others might result in further spacing from, or closer proximity to, the platforms.

16.6.17.1.6 The modelling results indicate that while some platforms will not experience any change in the probability of alarms, other platforms are expected to see an increase of alarm rates due to the displacement of traffic around the Hornsea Four array area. This will bring some of the existing routes closer to some of the platforms and change their general heading in some route sections. The rerouting of traffic was shown to increase the alarm rates for certain platforms (North ST2, North ST3, South A, South B, South C, Hoton and Trent).

16.6.17.1.7 Vessels on these rerouted lanes may trigger TCPA alarms as they travel along some segments with travel vectors in the direction of the platforms. In theory, the triggering of alarms along most of the routes can be avoided if the ship's captain ensures that the heading of the ship along the affected segments is not along a vector heading towards the platform. However, in practice this might be impractical and will depend on other factors that are considered outside the scope of this work and is subject to discussion with the operators of the REWS and the vessels.

16.6.17.1.8 The alarm modelling results are presented in section 6.6 of ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report, and show the estimated difference in yearly alarm rates for each platform. The results are presented to show the 'Change in Yearly Alarm Rates Considering Hornsea Four in Isolation' and 'Change in Yearly Alarm Rates Considering Hornsea Four Cumulatively'. The cause of this increase in alarm rates comes as a result of rerouting Route 6: Grangemouth (UK) to Rotterdam (Netherlands).

16.6.17.1.9 Route 6 is predicted to be rerouted between some of the Ravenspurn platforms in the future (Ravenspurn North CC, North ST2, South A and South B). Although it maintains a good distance from the platforms along most of the route, it comes close to the Ravenspurn North ST2 platform in some cases (minimum modelled case 0.30 nm). However, the main reason of alarms being generated is not due to the proximity of the traffic to the platforms but due to the heading/direction of the route along some segments. These segments are shown in Figure 45 of ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report, where the travel vector of the vessels appears to be heading towards North ST2, North ST3, South A, South B and South C. Vessels travelling along these vectors will trigger TCPA alarms on these platforms.

16.6.17.1.10 It should be noted that when considering Hornsea Four cumulatively, the majority of the platforms show no changes in Red TCPA trigger rates. Ravenspurn South A and C show Red TCPA alarm rate increases, over a year, of 18 and 40 respectively. Ravenspurn North ST3 shows an increase of 114.

16.6.17.1.11 For the Amber TCPA when considering Hornsea Four cumulatively, two platforms (the manned Ravenspurn North CC platform and Hyde) show a reduction in Amber TCPA rates. Ravenspurn ST2, Trent, Hoton, and Ravenspurn ST3 show yearly rate increases of 13, 16, 48, and 58 respectively. Ravenspurn South A and Ravenspurn South C show the largest increases in yearly Amber TCPA rates, 208 and 249 respectively.

16.6.17.1.12 Note that these rate increases are over a year, and the largest increase in alarm rates is for Ravenspurn South C and approximates to less than one additional alarm (Amber TCPA) per day. In total for all the affected platforms, this translates to approximately 2 – 3 additional alarms (Amber and Red TCPA) per day.

16.6.17.1.13 Whilst the REWS alarms are an indication of potential for allision, it should be noted that there are additional tools (layers of protection) that complement the REWS, including AIS data (information on

vessels approaching), VHF radio used to contact vessels that may trigger REWS alarms to investigate their status / heading, visual (lights) and audio (horns) alarms used to alert vessels, as well as the field ERRV when available etc.

16.6.17.1.14 From proximity assessments conducted and presented in section 7.4 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and based on the Navigational Risk Assessment (NRA) route deviations (see Volume A5, Annex 7.1: Navigational Risk Assessment), it is predicted that, following the construction of Hornsea Four, vessel numbers within 2 nm of assets that are Tier 2 (within 10 nm of the Hornsea Four array area) will not increase for most of the platforms.

16.6.17.1.15 The only changes in vessel numbers were to the Ravenspurn North ST2 (one (1) additional vessel per day) and the Ravenspurn South A platform (one (1) additional vessel per day). No changes in vessel numbers were observed for Ravenspurn North CC, Ravenspurn North ST3, Ravenspurn South B, and Ravenspurn South C.

16.6.17.1.16 Vessels proximate to shipping routes which have been diverted due to Hornsea Four will have radar, visual watchkeeping, etc., to support good practice navigation, including avoidance of allision i.e., compliance with COLREGS. In addition, the platform installations are marked on Admiralty charts which mariners make use of in passage planning their routes as well as all having the required Aids to Navigation (lights and foghorns). Mariners are also required by law to stay 500 m clear of O&G installation and typically stay 1 nm clear of installations.

16.6.17.1.17 The REWS along with the alarms are detection methods only and lead to actions that might avoid potential allisions such as using radio, lights, horns, etc. The REWS will not in itself prevent a potential allision threat. Alarms are considered an extra layer of protection and are also classified as SECE. SECEs are subject to the Functionality, Availability, Reliability, Sustainability and Integrity (FARSI) approach which aim to keep the SECE as reliable and available as prescribed. Hence, in order to ensure that detectability of a potential vessel on allision course with a platform is optimised, adhering to existing Performance Standard (PS) to maintain availability and reliability of the REWS, is essential.

16.6.17.1.18 In the extreme case where an allision is unavoidable, which is a rare event in the UK Southern North Sea, adequate Emergency Response is the ultimate safety feature.

16.6.17.1.19 Considering the expected increase in alarms, the existing procedures, and Collison Risk Management Plan should be reviewed with the objective to tailor for more alarms. Also, given the expected increase of demand requirement for the alarms (REWS), which is considered a SECE, the PS and associated written scheme of verifications should be reviewed.

16.6.17.1.20 It is noted that route changes as a result of the presence of Hornsea Four will lead to vessels having a vector in the direction of platforms and in some cases will result in an increase in alarm rates. Note that these vessels should change directions as they maintain their vessel routes.

16.6.17.1.21 On the basis of the above analysis, the direct impact from increases in alarms as a result of route changes will be on the management of the alarms as described above. It is not considered that there will be a significant increase in safety risk to the affected Tier 2 platforms due to the predicted increase in alarms. The risk is therefore considered to be broadly acceptable.

16.6.17.1.22 The identified potential implications/ consequences of increase in alarms may be commercial, Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation. These are addressed in Section 20: Commercial Considerations of this report.

16.6.18 Loss of Containment - Outboard Pipelines / Intra-field Pipelines

16.6.18.1.1 According to GASCET (HSE, 2006), the relevant hazardous events with the potential for damage to the outboard / intra-field pipelines resulting in loss of containment could result from the following hazard initiators: fatigue / vibration; incorrect installation; violation; operator error – inadequate training / competency; deficient procedures – operational / maintenance; vessel impact; dropped objects (i.e. dropped cargo) / abnormal external load; seismic event; and anchor – snagging / dropping.

16.6.18.2 Fatigue / Vibration

16.6.18.2.1 Operations associated with installation of the HVAC Booster Station(s) and foundations of the WTGs and offshore substations could involve piling or drilling dependent on the selected foundation method which is also dependent on ground conditions.

Potential Consequences

16.6.18.2.2 Loss of containment due to flowline vibration triggered by drilling / piling induced vibration.

Existing Safeguards / Controls

- Inherent safety (including fully rated pipelines, inherent impact resistance, pipe burial and trenching (where applicable);
- Good procedures and competent personnel associated with installation and operation of Hornsea Four;
- Isolation and Permit to Work (PTW) controls; and
- Pre-operation strength and leak testing.

Analysis of Risk

16.6.18.2.3 Based on previous experience the expected strike energy for piling would typically be 3,000 kJ and could increase to 5,000 kJ. Details of the duration of piling operations in the HVAC booster station search area and the array area are documented in section 16.4.2.2.

16.6.18.2.4 The timing and execution of these foundation operations will be planned in consultation between Perenco and Hornsea Four, and these operations will be performed in accordance with good engineering practice.

16.6.18.2.5 Considering the distance (approximately 1.6 nm (3 km)) between the locations of drilling/piling and the pipelines (i.e., Ravenspurn in-field and export lines), the potential ground shaking and associated vibration in the surrounding area is expected to dissipate before reaching the pipeline, and as such, there will be negligible impact to the pipeline. The risk is therefore considered to be broadly acceptable.

16.6.18.2.6 The temporary piling / drilling operations associated with the HVAC Booster Station(s) and array installations could also lead to acoustic vibrations which could have an adverse effect on diving, so diving near the pipeline should be avoided during such operations. This will be managed via standard site installation communication between interested parties.

16.6.18.3 Incorrect Installation

16.6.18.3.1 Incorrect installation of the Hornsea Four export cables has the potential to impact the pipelines at their crossing points within the ECC due to the introduction of incremental additional risk, over and above the pipeline design criteria.

Potential Consequences

16.6.18.3.2 Loss of containment due to incorrect installation of cable crossings.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel;
- Monitoring and Audit systems; and
- Crossing protection mattresses where assessed to be applicable.

Analysis of Risk

16.6.18.3.3 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four export cables, including risk preventive measures, good work

practices and procedures, and the use of competent personnel; the introduction of additional risk to the Perenco pipelines is considered negligible, and therefore broadly acceptable.

16.6.18.3.4 Also, the pipeline crossings will be designed and engineered in accordance with standard approaches and be subject to crossing agreement, as per Co107 (see Volume A4, Annex 5.2: Commitment Register). This would typically include the provision for a representative of Perenco to be in attendance on the vessel and monitor the works.

16.6.18.4 Operator Error – Inadequate Training / Competency

16.6.18.4.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

16.6.18.4.2 For the analysis of Perenco's pipelines the most relevant subjects are navigation, station holding and/or the potential of drifting close to or around the route of the pipeline, due to vessel operations associated with cable installation, cable inspection or maintenance

16.6.18.4.3 Human errors can occur in any phase of a project. Human errors, that have the potential to result in MAHs, in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

16.6.18.4.4 Loss of containment due to incidents caused by personnel incompetency / lack of experience.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

16.6.18.4.5 According to GASCET (HSE, 2006), the O&G asset holder should have a procedure in place for the selection, competence assessment, and training of operations and maintenance personnel. The O&G asset holder's procedure should be designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

16.6.18.4.6 The HSE standards and codes of practices are referenced to show that in order to operate in the UK Continental Shelf, the O&G asset holders are expected to follow certain requirements.

16.6.18.4.7 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016). Risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel will be employed during the installation, operations, and maintenance of the Hornsea Four infrastructure. Incremental additional risk to the pipelines from this potential initiator is considered negligible.

16.6.18.4.8 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the risk of impact from human factors is considered broadly acceptable.

16.6.18.5 Violation

16.6.18.5.1 Human factors involved in the earlier conceptual design stages of the installation lifecycle can influence the likelihood of the occurrence of hazardous events. When installations have not been designed and constructed, and / or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards, a violation is said to have occurred.

Potential Consequences

16.6.18.5.2 Loss of containment due to not following procedure and guidelines.

Existing Safeguards / Controls

- Good procedures; and
- Competent personnel.

Analysis of Risk

16.6.18.5.3 As stated in section 16.6.18.4, human errors can occur in all phases of a project. Human errors, that have the potential to result in MAHs, in the earlier conceptual design stages, can also be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

16.6.18.5.4 The impact of violation is considered similar to 'operator error' and considering that risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel are being applied to the design of the Hornsea Four infrastructure, the introduction of additional risk to the pipelines from this potential initiator is considered negligible, and therefore broadly acceptable.

16.6.18.6 Deficient Procedures

16.6.18.6.1 If deficient procedures are applied during the installation, operations, and maintenance of Hornsea Four cables, there is potential that pipelines with crossings will be affected due to additional hazards over and above the pipeline design tolerance.

16.6.18.6.2 The impact of deficient procedure is considered similar in consequences and safeguards to 'incorrect installation' which is assessed in section 16.6.18.3 above.

16.6.18.6.3 As the relevant UK Continental Shelf Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four infrastructure, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the pipeline is considered negligible, and therefore broadly acceptable.

16.6.18.7 Vessel Impact

16.6.18.7.1 Vessel impact concerns the potential additional hazards associated with vessel movements in and around the pipeline corridor, due to the presence of Hornsea Four construction and operation. This may include the following types of vessels: standby vessels, supply vessels, DSVs, survey vessels, barges, and cable installation vessels.

16.6.18.7.2 The interaction between vessels and pipelines will potentially result from dropped objects and/ or anchor snagging.

16.6.18.7.3 Dropped object risks are addressed in section 16.6.18.8 of the report.

16.6.18.7.4 Anchor snagging risks are addressed in section 16.6.18.10 of the report.

16.6.18.8 Dropped Objects

16.6.18.8.1 This involves the potential incremental additional exposure to Perenco's pipelines as a result of abnormal external load / dropped objects from vessels associated with Hornsea Four installation and maintenance.

16.6.18.8.2 According to the Offshore Technology Report 2001/013 (HSE, 2002), the principal categories of load are: dead loads, imposed (operational) loads, environmental loads, deformation loads - loads associated with imposed deformations and imposed strains; and accidental loads, results from accidental events, such as collision, dropped objects, fire and explosion and other abnormal events.

16.6.18.8.3 For the interaction between Hornsea Four and the Perenco pipelines, dropped object accidental loads are the only relevant potential hazards that could arise from this interaction.

Potential Consequences

16.6.18.8.4 Loss of containment from rupture of flowlines due to dropped objects from Hornsea Four construction (cable crossings, cable lay vessels, and other construction works) and supply / support vessels during installation and maintenance of Hornsea Four.

Existing Safeguards / Controls

16.6.18.8.5 As per Offshore Technology Report 2001/013 (HSE, 2002), the pipeline installation should be so designed and, if necessary, protected that the consequences of damage are acceptable and that an adequate margin of safety is maintained.

16.6.18.8.6 As with the hazards associated with collision, the usual measures employed in controlling the hazards from dropped objects include:

- Inherent Safety in design and operation;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection;
- Control through quality assurance, operating envelope, procedures, and barriers;
- Mitigation through physical protection and robust structure; and
- The subsea infrastructure will be marked in sea charts and other layout drawings.

Analysis of Risk

16.6.18.8.7 According to section 3.G16 of GASCET (HSE, 2006), the pipeline should have been designed and constructed, and/or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards. General requirements for accidental hazards are found in:

- Loads, Offshore Technology Report – OTO 2001/013 (HSE, 2002);
- Petroleum and Natural Gas Industries – Fixed Steel Offshore Structures – ISO 19902 (ISO, 2011);
- Technical Safety – S-001 (NORSOK, 2008);
- Documentation for Operation – Z-001 (NORSOK, 1998);
- Risk and Emergency Preparedness Analysis – Z-013 (NORSOK, 2001); and
- Explosion Resistant Design for Offshore Structures – Technical Note No 4 (SCI, 1996).

16.6.18.8.8 Other requirements are found in DNV RPF-107 – RP Risk Assessment of Pipeline Protection (DNV, 2010).

16.6.18.8.9 Also, the relevant Legislation, ACOP and Guidance that apply includes:

- Offshore Installations Safety Case Regulations – HSE-UK SCR (HSE, 2015);
- Offshore Installations and Wells (Design and Construction, etc) Regulations (HSE, 2008) and
- Assessment Principles for Offshore Safety Cases [APOSC] (HSE, 2016).

16.6.18.8.10 As the relevant UK Continental Shelf Procedures, Legislation, and Guidelines will be adhered to and maintained in designing and installation of the cables, it is considered that all design, prevention and control measures for pipelines installed in the UK Continental Shelf will be adhered to. Therefore, it is not perceived that potential additional risks initiated as a result of Hornsea Four will surpass those for which

the pipelines should be designed to withstand. As a result, the introduction of additional risks from this potential initiator is negligible and considered to be broadly acceptable.

16.6.18.8.11 As part of Hornsea Four's commitment Co107 (see Volume A4, Annex 5.2: Commitment Register), crossing and proximity agreements with known existing pipeline and cables operators will be sought.

16.6.18.8.12 Note that consideration will be given to providing mattress protections in vulnerable areas of interference.

16.6.18.9 Seismic Event

16.6.18.9.1 Hornsea Four will not induce / trigger any seismic events. It will however in and around the array area and the HVAC Booster Station(s) induce a degree of ground shaking during the installation of foundations due to drilling or piling.

16.6.18.9.2 Details of the duration of piling operations in the HVAC booster station search area and the array area are documented in section 16.4.2.2.

16.6.18.9.3 The hazard of a natural seismic event is not perceived relevant in relation to Hornsea Four, however ground-shaking and/or acoustic vibration may be induced because of construction operations. This is however, considered to be short term and have a minor effect to pipeline.

16.6.18.9.4 The timing and execution of these foundation operations will be planned in consultation between Perenco and Hornsea Four, and these operations will be performed in accordance with good engineering practice.. The risk is negligible and therefore considered to be broadly acceptable.

16.6.18.10 Anchor – Snagging / Dropping

16.6.18.10.1 Ships may anchor under various circumstances including the following:

- Normal anchoring:
  - when waiting on berths or for permission to use a controlled channel;
  - when necessary to aid manoeuvring in restricted areas;
  - when performing survey or construction operations; and
  - when performing repairs during the operation and maintenance phase.
- Emergency anchoring:
  - following mechanical breakdown of the propulsion or steering system;
  - following an accident such as major fire or a collision; and
  - to slow down the ship in order to avert a possible collision or ramming or grounding.

16.6.18.10.2 Hazards to pipelines can arise either at the time of anchoring or subsequently if the ship should drag its anchor due to the effects of wind, wave and/or current. A hazard can also arise when the ship tries to retrieve the anchor.

16.6.18.10.3 In normal anchoring, there should be minimal risk to the pipelines, which are shown on charts and may be protected by anchoring exclusion zones. Initially, DNV guidelines shall be adhered to with respect the minimum distance between any existing subsea asset and the placement of any Hornsea Four anchors. These distances shall be discussed and agreed with the subsea asset owner.

16.6.18.10.4 At the time of anchoring, the risk to the pipeline is either that the anchor is dropped onto the pipeline or that the anchor is dragged across the pipeline. If the anchor hooks the pipeline but does not cause immediate damage, there will be a further risk of damage when the ship comes to haul the anchor back in.

16.6.18.10.5 Good seamanship will avert impact from emergency anchoring. Good seamanship involves anchoring well away from pipelines, in water of an appropriate depth (neither too shallow nor too deep) and in an area where the seabed is known to have good anchor holding properties. In addition, under weather conditions

when dragging might occur, it is normal good practice to keep engines on standby and to make regular checks on position. Sometimes ships will leave their anchorages if dragging is anticipated.

16.6.18.10.6 The cause of anchors dropping accidentally is mainly due to failure of the brake systems when anchors are made ready for use, i.e., when mechanical securing systems are removed. The risk to the pipeline due to dropping anchors at sea is considered negligible, because the anchors should not be made ready for use and should be secured.

16.6.18.10.7 The Hornsea Four export cable installation operations may include, but not be limited to, survey vessels, clearance vessels, cable installation vessels, cable burial vessels, remedial works vessels and post installation survey vessels, none of which are expected to make use of anchors or anchor spreads but may be required in shallow waters (less than 15 m) or where difficult conditions dictate. The Hornsea Four operations and maintenance operations associated with the export cables will involve mainly external inspection survey vessels, possibly accompanied by Remotely Operated Vehicle (ROV). Remedial protection replenishment may also be required. Such vessels are unlikely to make use of anchors or anchor spreads but may do so should conditions dictate. Should cable inspections, or cable testing identify a need for repair operations, a repair vessel, and associated support vessels will be required, which could involve anchorage. Initially, DNV guidelines shall be adhered to with respect the minimum distance between any existing subsea asset and the placement of any anchors. These distances shall be discussed and agreed with the subsea asset owner.

16.6.18.10.8 Considering the types of vessels that Hornsea Four intends to make use of during installation and maintenance operations, the likelihood of anchor incidents leading to snagging, hooking or dropping is considered negligible, and therefore the incremental additional risk over and above the existing risk is therefore considered to be broadly acceptable.

16.7 TIER 3

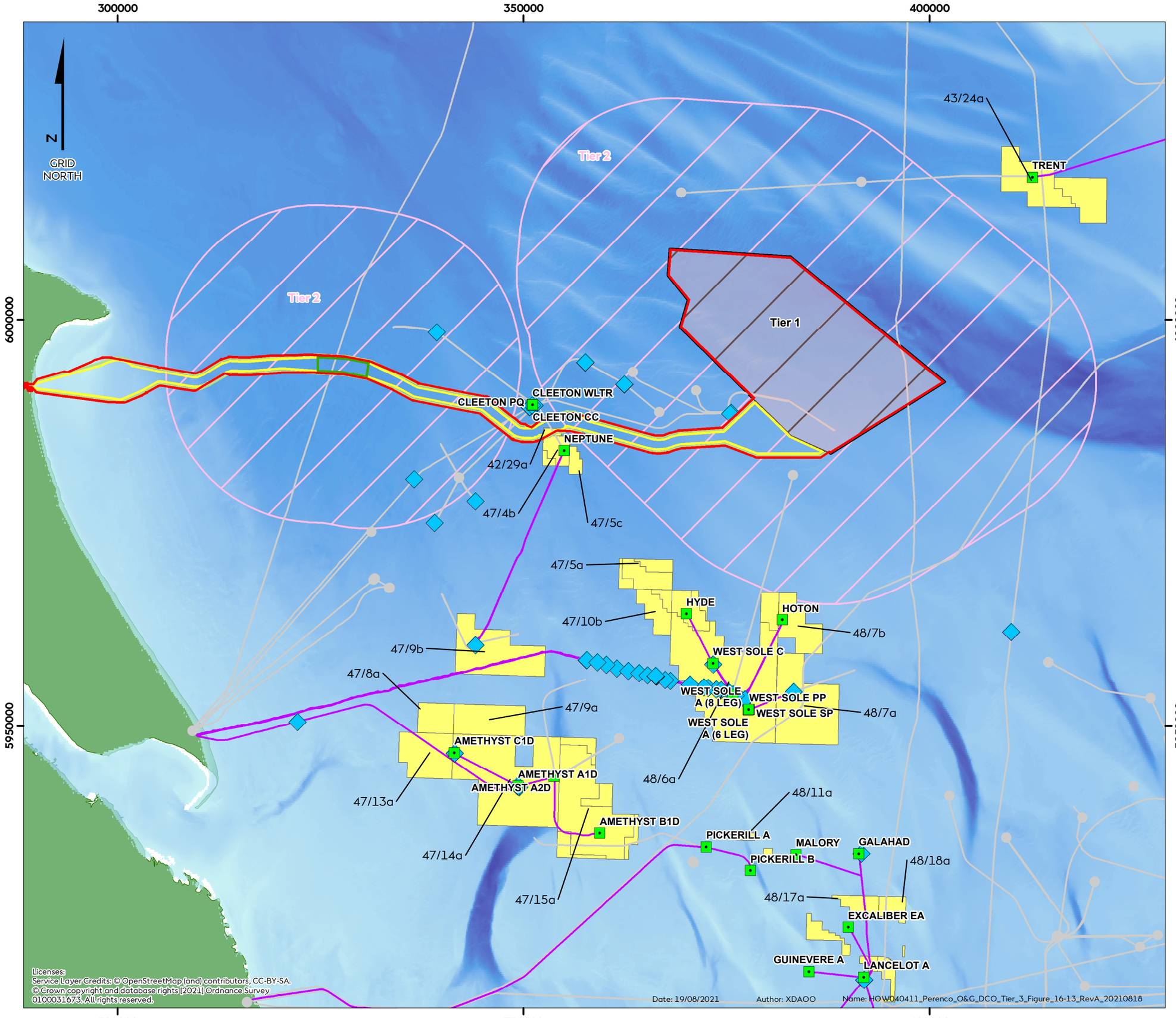
16.7.1.1.1 Based on the asset screening process, Tier 3 assets are primarily located in excess of 10 nm from the Hornsea Four array area and shown below in Figure 16-13. These include:

- Trent;
- Cleeton;
- Hoton;
- Hyde;
- Neptune; and
- West Sole (A complex, B, and C).

Hornsea Four

Perenco UK Ltd Assets - Tier 3

Figure 16.13



- Perenco Licenses

Oil and Gas Infrastructure

- Perenco Platform
- Perenco Terminal
- Perenco Subsea
- Other Operators

Pipelines

- Perenco
- Other Operators

Project Layers

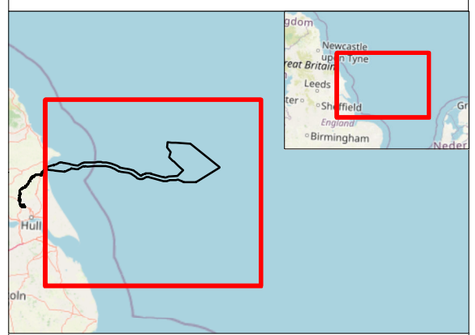
- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Tier Boundaries

- Tier 1 (Array Area)
- Tier 2 (10nm from Array Area / HVAC)

Bathymetry (Below Sea Level)

- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:450,000

0 5 10 20 Kilometres

0 2.5 5 10 Nautical Miles

REV	REMARK	DATE
	First issue	25/07/2020
A	Reduced Array Area in northwest corner	18/08/2021

Perenco UK Ltd Assets - Tier 3
Document no: HOW040411
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

16.8 TIER 3 Assessment - Platforms

16.8.1.1.1 This section focuses on the potential impacts on Perenco's Tier 3 platform assets as a result of Hornsea Four's presence in the area.

16.8.2 Structural Integrity

16.8.2.1.1 This section assesses the impact on the structural integrity of Perenco platform assets from interaction with Hornsea Four. Structural integrity issues can potentially arise from the following: seismic events, vessel impact (allision), and helicopter impact (risk due to potential changes in landing approach / take-off as a result of Hornsea Four)

16.8.2.2 Seismic Event

16.8.2.2.1 Piling or drilling operations associated with foundation installation for HVAC Booster Station(s) and foundations for the WTGs may induce ground shaking.

16.8.2.2.2 Around both array area and the HVAC booster station areas, the ground shaking is not expected to impact the operation of the Perenco's Tier 3 assets, as the expected ground shaking will not be significant (refer to section 16.4.2.2 for details of piling strike energy and duration of operation). The ground shaking would have dissipated before reaching the Cleeton and Neptune assets approximately 18 km and 25 km away, respectively.

16.8.2.2.3 The timing and execution of these foundation operations will be planned in consultation between Perenco and Hornsea Four, and these operations will be performed in accordance with good practice. Therefore, chances of ground shaking having additional impact are negligible; and the potential risk is considered broadly acceptable.

16.8.2.3 Vessel Impact

16.8.2.3.1 As some vessel routes may be changed, and the vessels taking these routes deviated due to the presence of Hornsea Four, allision risks due to these deviations from existing routes can potentially increase the risk of structural damage to Perenco's Tier 3 assets.

16.8.2.3.2 A vessel allision study, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, was performed duly considering assets close to Hornsea Four. With regards, allision with structures, both deviations to routine support vessel routeing and spacing / proximity issues relative to the Hornsea Four structures were considered.

16.8.2.3.3 It should be noted that proximity between offshore installations and passing traffic is a primary factor affecting allision risk. On this basis, the assessment of allision risk undertaken has focused on changes to traffic patterns passing within 2 nm of the relevant assets as a result of Hornsea Four.

Potential Consequences

16.8.2.3.4 Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage, and reduction in remaining asset life.

Existing Safeguards / Controls

- 500 m safety zone;
- Inherent safety (best design practice);
- Suitable safety factors (fatigue, applied loading, etc);
- Control measures (management/structural);
- Visual and radar;

- Platform mounted radar - REWS uses the radar returns to monitor and track vessels within the detection region; and
- SBVs, communications and procedures (including vessel contracting and suitability, inspections, marine operations and combined operations).

Analysis of Risk

16.8.2.3.5 As per section 7.3.3 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, it was observed from pre- and post-Hornsea Four wind farm analysis deemed relevant to Tier 3 assets, that there is to be an increase in vessels passing south east of the Hornsea Four array area, between the Hornsea Four array area and Hornsea Two – see Figure 16-14 below. It is also noted that, based on the NRA deviations, vessels utilising the route to the Trent platform (Route 12) will deviate between Hornsea Four and Hornsea Two, before accessing the platform.

16.8.2.3.6 From proximity assessments conducted and presented in section 7.4 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, based on the worse case deviations assessed within the NRA (see **Volume A5, Annex 7.1: Navigational Risk Assessment**), vessel numbers will not change for the Tier 3 assets as a result of the construction and operation of Hornsea Four. It is important to note that in reality vessels may choose alternate routes, including considerations to pass further from O&G assets than has been assessed.

16.8.2.3.7 As per proximity assessments conducted and presented in section 7.4 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and given no notable changes/ effect in vessel numbers predicted within 2 nm of the Tier 3 assets, the risk of impact from Hornsea Four on all Tier 3 assets is considered to be **broadly acceptable**.

16.8.2.3.8 Also, for the duration of the construction period, Hornsea Four will monitor and report annually, vessel traffic as per Co98 (see Volume A4, Annex 5.2: Commitment Register).

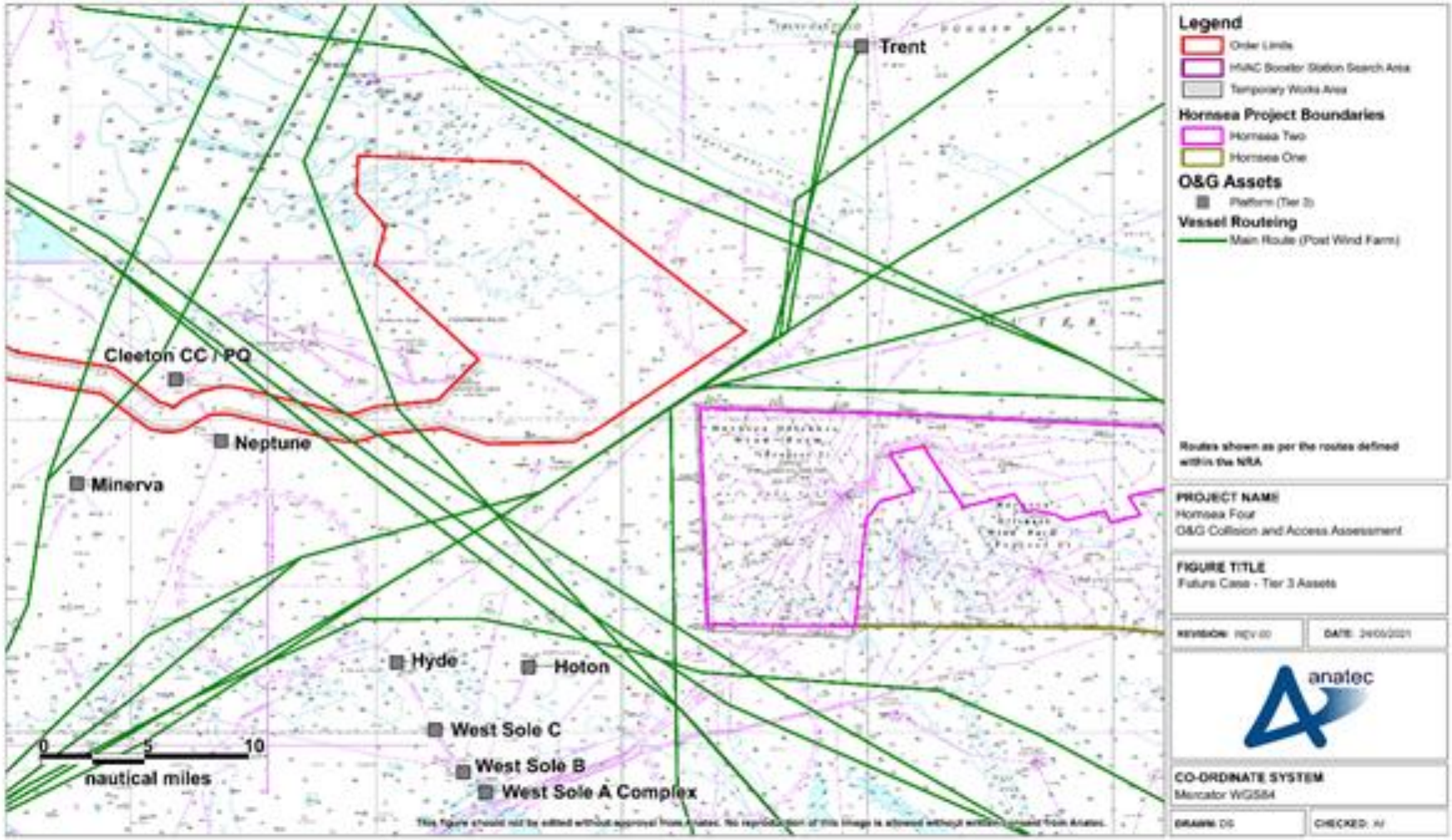


Figure 16-14: Future Case – Tier 3 Assets

16.8.2.4 Helicopter Impact

16.8.2.4.1 This subsection addresses the potential for CAT helicopter impact with Tier 3 assets, resulting in structural damage / integrity issues.

16.8.2.4.2 As addressed in Section 3.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, the Tier 3 assets are not within 10 nm of Hornsea Four, and are located outside the CAA's CAP 764 (CAA, 2016) 9 nm helicopter consultation requirement. This implies that the presence of Hornsea Four will not have an impact on the helicopter landing approach or take-off at Perenco's Tier 3 platforms.

16.8.2.4.3 As helicopter landing and take-off remain unchanged due to the presence of Hornsea Four, the additional safety risk to structural integrity as a result of helicopter transport is negligible, and therefore assessed to be broadly acceptable.

16.8.3 Loss of Maritime Integrity - Loss of Stability

16.8.3.1.1 As there are no floating Perenco platforms in the Tier 3 grouping this impact is not considered applicable.

16.8.4 Loss of Maritime Integrity - Loss of Position

16.8.4.1.1 As there are no floating Perenco platforms in the Tier 3 grouping this impact is not considered applicable.

16.8.5 Vessel Access (Deviation) – Construction and Operations

16.8.5.1.1 This section assesses the potential safety impacts in relation to access to O&G assets that may arise as a result of the construction and operation of Hornsea Four.

16.8.5.1.2 A vessel access impairment study was performed, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report for assets close to Hornsea Four. The assets outside 10 nm of Hornsea Four were screened to identify which may be affected in terms of access to the structures. Deviations to offshore routine support vessel (e.g., supply and standby) routeing relative to the Hornsea Four structures were considered.

Potential Consequences

- Impairment of vessel access to platforms; and
- Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage.

Existing Safeguards / Controls

- The existing safeguards / controls for allision risks are listed in the safeguards / controls for allision risk – section 16.8.2.3; and
- Existing routeing for support vessels - majority of the support vessels making routine visits will originate from either Great Yarmouth or Lowestoft.

Analysis of Risk

16.8.5.1.3 The only Tier 3 asset which will require a deviation in terms of routine supply visits is the Trent platform, given it is located north of the Hornsea Four array area. Based on the NRA deviations (see Figure 16-14), it is likely that vessels visiting the Trent platform will pass between Hornsea Four and Hornsea Two. This is estimated to result in a journey increase of 1.0 nm, which represents a 1 % increase over the pre-wind farm route.

16.8.5.1.4 It should be considered that the Trent platform is a NUI, and as such will be less frequently visited than manned assets.

16.8.5.1.5 As noted in the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, section 8.3.3 states that where applicable details of Hornsea Four would be promulgated in advance via the usual means (including directly with Perenco). This will facilitate advanced passage planning, ensuring any deviations are minimal, and will allow the locations of completed or partially completed structures to be accounted for.

16.8.5.1.6 Given the above assessment, the safety impact to the Tier 3 assets is considered to be **broadly acceptable**, given only minor deviations required in the case of Trent, and noting the potential for a limited impact to any vessels visiting from ports other than Lowestoft or Great Yarmouth.

16.8.5.1.7 Advance warning and accurate location details of construction, maintenance, and decommissioning operations associated Safety Zones, and advisory passing distances will be given as per Co89 (see Volume A4, Annex 5.2: Commitment Register).

16.8.6 Vessel Access (Proximity) – Construction and Operations

16.8.6.1.1 This section assesses the potential impacts in relation to access to O&G assets that may arise as a result of the construction and operation of Hornsea Four.

16.8.6.1.2 A vessel access impairment study was performed, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report for assets close to Hornsea Four. The assets outside 10 nm of Hornsea Four were screened to identify which may be affected in terms of access to the structures. Spacing / proximity issues relative to the Hornsea Four structures were considered.

16.8.6.1.3 As noted in the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, section 8.3.3, given all Tier 3 assets are in excess of 10 nm from the Hornsea Four array area and HVAC booster station search area, there is considered to be no impact in terms of proximity. The incremental additional risk in terms of safety is considered to be **broadly acceptable**.

16.9 TIER 3 Assessment - Platform Systems

16.9.1.1.1 This section focuses on the potential impact on Perenco's Tier 3 platform systems as a result of Hornsea Four's presence in the area.

16.9.1.1.2 Hazard guide words have been employed, and were developed from GASCET (HSE, 2006) and extended to incorporate specific operational concerns. These are: loss of containment – process; loss of containment – pipelines; loss of containment - fire & explosion; and emergency response.

16.9.2 Loss of Containment - Process

16.9.2.1.1 The Tier 3 assets comprise: Cleeton, Horton, Hyde, Neptune, and West Sole platforms, intra-field pipelines, and surface and subsea infrastructure located more than 10 nm from the array area and the HVAC Booster Station(s) Search area.

16.9.2.1.2 This section addresses loss of containment from process plant and process operations. According to GASCET (HSE, 2006) hazard sources for process systems include process equipment such as Pressure Vessels, Heat Exchangers, Pipeline Risers, Flexible hoses, etc.

16.9.2.1.3 Process systems are the primary responsibility of the duty holder and constrained to within the 500 m safety zone, the presence of Hornsea Four will not result in loss of containment from process systems, as all Hornsea Four operations remain outside these safety zones. The risk is therefore not considered applicable.

16.9.3 Loss of Containment - Pipelines

16.9.3.1.1 This section addresses loss of containment from pipelines and piping systems associated with the platform systems and constrained within 500 m of the platform. According to GASCET (HSE, 2006) hazard sources for the platform pipeline systems include fixed and flexible risers, emergency shutdown valves, and subsea isolation systems, etc.

16.9.3.1.2 These systems are the primary responsibility of the duty holder and constrained to within the 500 m safety zone. The impact of Hornsea Four potentially resulting in loss of containment from platform systems is not considered applicable, as all Hornsea Four operations remain outside these safety zones from Perenco's surface facilities.

16.9.3.1.3 However, the impact of Hornsea Four's presence on associated pipeline systems (outboard and intra-field pipelines) is addressed in section 16.10.16 of this report.

16.9.4 Loss of Containment - Fire & Explosion

16.9.4.1.1 With the 500m safety zone, Hornsea Four will have no impact on process hazards leading to fire and explosions on Perenco platform systems.

16.9.4.1.2 The potential for loss of containment leading to fires and explosions is addressed for associated systems in section 16.10.16 below.

16.9.5 Emergency Response

16.9.5.1.1 This section focuses on the impact (impairment / delay) Hornsea Four's presence in the area may have on Perenco's emergency response arrangements associated with their Tier 3 assets. Perenco's emergency response operations will include the following:

- Emergency Response Management;
- Alarms and Communication;
- Temporary Refuge and Muster Stations;
- Access / Egress Routes;
- Evacuation;
- Escape;
- Rescue and Recovery;
- Emergency Lighting; and
- Emergency Communications.

16.9.5.1.2 The HSE UK, Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations (HSE, 2016) and associated Schedules contain specific requirements for emergency response to major accident hazards on installations. It is assumed that Perenco's current emergency response arrangements comply with the relevant statutory provisions governing the operations listed above.

Potential Consequences

16.9.5.1.3 Impairment or delay of emergency response arrangement could potentially lead to injury / death of personnel.

Analysis of Risk

16.9.5.1.4 It is not considered that Hornsea Four will have any impact on emergency response systems on the Tier 3 installations, i.e., access / egress, alarms and communication (including emergency communications), escape, emergency lighting on installations, temporary refuge and muster stations.

16.9.5.1.5 Other emergency responses would typically include provision of primary and secondary means of evacuation and escape from these installations, e.g., helicopter, TEMPSC, sea transfer and bridge-link, some necessitating arrangements with others.

16.9.5.1.6 As stated in section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, for emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as State Aircraft under National Regulations and are not constrained by EASA Regulations. As Coastguard SAR Operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to nearby installations.

16.9.5.1.7 As the preferred means of evacuation from the offshore Tier 3 asset area are helicopter and via sea transfer, details of the impact of Hornsea Four on access via vessel and helicopter are discussed in the following sections:

- Vessels – sections 16.8.2.3 and 16.8.5.
- Helicopter – sections 16.10.5 and 16.10.7.

16.9.5.1.8 In considering the assessment of vessel and helicopter access for emergency response purposes there will be no risk of delay or impairment of emergency response systems required around Tier 3 assets. Note that, as per PFEER Regulation 17, other response systems (TEMPSC, etc.) must always be present. The risk is considered negligible and is therefore broadly acceptable.

16.10 TIER 3 Assessment - Associated Systems

16.10.1.1.1 This section focuses on the potential impact on Perenco's Tier 3 assets as a result of Hornsea Four's presence in the area. Associated systems comprise other equipment and operations associated with but not part of the installations and platform systems.

16.10.1.1.2 Hazard guide words have been employed, and were obtained from GASCET (HSE, 2006) and extended to incorporate specific operational concerns. The guide words employed are: wells; diving; human factor; helicopter - impaired access to O&G platforms and to O&G vessels; helicopter - deferred access to support O&G operations; seismic survey operations; drilling (array and ECC) operations; construction (array and ECC) operations; non-process fires & explosions; communication / control (microwave); REWS impairment; CPA alarms; and loss of containment - outboard pipelines / intra-field pipelines.

16.10.2 Wells

16.10.2.1.1 Hazards to the Tier 3 wells could arise from the following initiators:

- Vibration (i.e., from Piling / drilling of turbine foundations);
- Dropped objects from vessels; and
- Anchor spread from vessels, e.g., work boats or DSV.

Potential Consequences

16.10.2.1.2 Well integrity compromised with the potential of blowout / spillage.

Existing Safeguards / Controls

- Subsea protection structure;
- Inherent safety practices;
- Competent personnel;
- Control measures via existing marine procedures, e.g., NtM; and
- SIMOPS will be performed prior to Hornsea Four field operations.

Analysis of Risk

16.10.2.1.3 Considering the relative footprint of the well compared to that of Hornsea Four's operation, the likelihood of a dropped object strike is considered negligible.

16.10.2.1.4 It is not anticipated that vessels will be parking alongside or close to Tier 3 assets, however anchor spread for vessels supporting the construction and operations in Hornsea Four will be controlled by SIMOPS and expected works will be published in NtM.

16.10.2.1.5 Also considering that wells in the Tier 3 area are located well over 10 nm from the Hornsea Four turbine, substations, and HVAC booster station foundations, there is less risk of Hornsea Four interfering with existing Tier 3 wells.

16.10.2.1.6 The likelihood of compromising well integrity is considered remote given the above listed existing safeguards and controls. Hence, the incremental additional risk of compromise to the Tier 3 wells is considered **broadly acceptable**.

16.10.3 Diving

16.10.3.1.1 This section focuses on potential impact on Perenco's diving operations (temporary impact upon access for pipeline repair / maintenance, etc.) due to the implementation and operation of Hornsea Four.

Potential Consequences

- The safety of divers is compromised due to Hornsea Four construction / operations; and
- Delay in diving maintenance, including inspection and repair operations.

Existing Safeguards / Controls

- No diving operations in unsafe conditions; and
- Co-existing procedures.

Analysis of Risk

16.10.3.1.2 It is anticipated that temporary restrictions to diving operations for maintenance / repair may occur during installation of the Hornsea Four. Through detailed discussions, planning, and good SIMOPS practices by both parties, these potential losses to access restrictions can be avoided.

16.10.3.1.3 The temporary piling / drilling operations associated with the array installations could lead to acoustic vibrations which could have an impact on diving operations. Diving near the well should be avoided during such operations. This will be managed via standard site installation communication between interested parties.

16.10.3.1.4 Given the management of operations via communication and consultation between Hornsea Four and Perenco, and that Tier 3 operations will occur in excess of 10 nm from the array or HVAC booster station areas, it is considered that the safety risks associated with diving operations for Tier 3 assets remain unchanged and therefore considered to be **broadly acceptable**.

16.10.4 Human Factor

16.10.4.1.1 The impact of human factors is the same for all Perenco assets regardless of Tier grouping and is addressed in section 16.6.4 of this report.

16.10.4.1.2 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the incremental additional risk of impact from human factors is considered broadly acceptable.

16.10.5 Helicopter - Impaired Access to O&G platforms (CAT)

16.10.5.1.1 This subsection addresses the potential for impaired access by CAT operated helicopters to Perenco's Tier 3 platforms.

16.10.5.1.2 In assessing this potential impact, a study on Helicopter access, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, was performed and applied the CAT weather limits, as a series of filters, to the meteorological data provided by Perenco in order to understand the potential operational impact on the installations. Ravenspurn North, a Tier 2 installation, was used as an illustrative case, as it is located 3 km from the Hornsea Four array area and would be the most impacted by the presence of Hornsea Four. The assessment focused on identifying reduced access when operating under CAT Regulations, but access under SAR Regulations was also considered.

16.10.5.1.3 The helicopter access data for other Ravenspurn platforms is presented in sections 6 to 10 of Appendix A1 (Platform Specific Data for Helicopter ARA to Gas Installations Adjacent to Hornsea Project Four) of the study report, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

16.10.5.1.4 The potential for impaired access to O&G platforms could arise from the following initiators:

- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Reduction of access to platform;
- Helicopter incident as a result of Hornsea Four; and
- Potential restriction to flying due to other restrictions given by Hornsea Four.

16.10.5.1.5 As shown above, it is considered that the safeguards for the Tier 3 assets are similar to those discussed for Tier 2 assets in section 16.6.5 of this report.

16.10.5.1.6 However, as per section 3.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, it is considered that there will be no additional impact on helicopter access to Tier 3 platforms as a result of the presence of Hornsea Four. This is due to the distance of these assets (further than 10 nm) from the Hornsea Four array area. Furthermore, the assets are outside the 9 nm consultation zone guidance required by CAP 764 (CAA, 2016). The array will have negligible impact on approach, en-route decent, or ARA requirement as a result of proximity to tall structures.

16.10.5.1.7 On the basis of the above assessment, there will be no additional risk to safety. Therefore, the risk associated with helicopter transport to and from platforms in Tier 3 remain unchanged and is considered broadly acceptable.

16.10.5.1.8 Note that as per Co102 (see Volume A4, Annex 5.2: Commitment Register), the Defence Infrastructure Organisation and the CAA, MCA and operators will be informed of the locations, heights, and lighting status of the wind turbines, including estimated and actual dates of construction and the maximum height of any construction equipment to be used, prior to the start of construction, to allow inclusion on Aviation Charts.

16.10.6 Helicopter - Impaired Access to O&G platforms (SAR)

16.10.6.1.1 This subsection addresses the potential for impaired access by SAR operated helicopters to Perenco Tier 3 platforms.

16.10.6.1.2 In assessing this potential impact, a study on Helicopter access and deviation, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, was performed. Ravenspurn North, a Tier 2 installation, was used as an illustrative case, as it is located 3 km (1.6 nm) from the Hornsea Four array area. In the assessment access under SAR Regulations was considered.

16.10.6.1.3 The potential for impaired access to O&G platforms could arise from the following initiators:

- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Reduction of access to platform; and
- Potential restriction to flying due to other restrictions given by Hornsea Four.

16.10.6.1.4 As shown above, it is considered that the safeguards for the Tier 3 assets are similar to those discussed for Tier 2 assets in section 16.6.6 of this report, except for the impact of proximity to tall structures.

16.10.6.1.5 MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training is more advanced than that available to CAT helicopters.

16.10.6.1.6 On the basis of the above assessment, and as Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, the presence of Hornsea Four will not impose any restrictions on SAR aircraft access to Tier 3 installations. The risk is therefore considered broadly acceptable.

16.10.7 Helicopter - Impaired Access to O&G Vessels (CAT)

16.10.7.1.1 This subsection addresses the potential for impaired access of CAT operated helicopters to O&G vessels associated with Tier 3 operations.

16.10.7.1.2 The potential for impaired access to O&G vessels associated with Tier 3 operations could arise from the following initiators:

- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter incident as a result of Hornsea Four; and
- Potential restriction to flying due to restrictions given by Hornsea Four.

16.10.7.1.3 As shown above, it is considered that the consequences and safeguards for the vessels associated with Tier 3 assets are similar to those discussed for Tier 2 in section 16.6.7 of this report.

16.10.7.1.4 It is considered that there will be no additional impact on helicopter access to Tier 3 platforms as a result of the presence of Hornsea Four due to the distance of these assets from the Hornsea Four array. Consequently, it is considered that the vessels associated with these O&G platforms will also not be subject to approach limitations from Hornsea Four.

16.10.7.1.5 On the basis of the above assessment, there will be no additional risk to safety brought about by the presence of the Hornsea Four. The safety risk associated with helicopter transport to and from vessels in Tier 3 will remain unchanged and is considered broadly acceptable.

16.10.8 Helicopter - Impaired Access to O&G Vessels (SAR)

16.10.8.1.1 This subsection addresses the potential for impaired access of SAR operated helicopters to O&G vessels associated with Tier 3 operations.

16.10.8.1.2 The potential for impaired access to O&G vessels associated with Tier 3 operations could arise from the following initiators:

- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter incident; and
- Potential restriction to flying due to restrictions given by Hornsea Four.

16.10.8.1.3 As shown above, it is considered that the consequences and safeguards for the vessels associated with Tier 3 assets are similar to those discussed for Tier 2 in section 16.6.8 of this report.

16.10.8.1.4 MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training are more advanced than that available to CAT helicopters.

16.10.8.1.5 It is considered that there will be no additional impact on helicopter access to Tier 3 platforms as a result of the presence of Hornsea Four due to the distance of these assets from the Hornsea Four array. Consequently, it is considered that the vessels associated with these O&G platforms will also not be subject to approach limitations from Hornsea Four.

16.10.8.1.6 On the basis of the above assessment, and as Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, there will be no additional risk to safety brought about by the presence of the Hornsea Four. The risk associated with helicopter transport to and from vessels in Tier 3 will remain unchanged and is considered broadly acceptable.

16.10.9 Seismic Survey Activities

16.10.9.1.1 Seismic surveillance activities may be required in the future, around the Hornsea Four array. At the time of such activity, it is proposed that a co-existence plan will develop how the performance of such activity will be implemented without undue risk in the interfaces.

16.10.9.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

16.10.10 Drilling Activities

16.10.10.1.1 Exploration and appraisal drilling may be required around the Hornsea Four array area and ECC area. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

16.10.10.1.2 There have been recent drilling campaigns in the Irish Sea taking place in and around existing offshore wind farms. This presents an example that with adequate planning offshore wind and O&G infrastructures can coexist.

16.10.10.1.3 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

16.10.11 Construction Activities

16.10.11.1.1 Perenco may want to construct new production facilities in and around the Hornsea Four array area and ECC area. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

16.10.11.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

16.10.12 Non-Process Fires & Explosions

16.10.12.1.1 Non-process fires and explosions are typically associated with non-process plants. In the case of Hornsea Four, this could be electrical fires associated with the HVAC booster station platform and offshore substations within the array area.

16.10.12.1.2 Considering the distance (over 10 nm) of the HVAC booster station from the Tier 3 assets and array area, it is considered that the impact of electrical fires on Perenco's Tier 3 assets are negligible, therefore considered broadly acceptable.

16.10.13 Microwave Communication

16.10.13.1.1 It is envisaged that the presence of Hornsea Four may have the potential to obstruct or interfere with a number of microwave links operated by Perenco.

16.10.13.1.2 The links which need to be taken into account are: Ravenspurn North to Trent; Ravenspurn North to Kilmar; and Ravenspurn North to Garrow.

16.10.13.1.3 As there are no Perenco platform installations / assets in the Tier 3 grouping that require microwave communication, this impact is not considered applicable.

16.10.14 Radar Early Warning Systems (REWS)

16.10.14.1.1 It is envisaged that the presence of Hornsea Four will potentially obstruct or interfere with a number of REWS mounted installations operated by Perenco.

16.10.14.1.2 The two platforms, operated by Perenco, where REWS are installed that are in close proximity to the Hornsea Four array area, are Ravenspurn North CC and Ravenspurn South B. These two REWS installations along with the REWS site on the Cleeton CC platform provide radar coverage and protection for a number of other nearby Perenco offshore platforms (i.e., Ravenspurn North ST2, Ravenspurn North ST3, Ravenspurn South A, Ravenspurn South C, Neptune, Hoton, Hyde, Trent, A1D).

16.10.14.1.3 On the basis of the assessment conducted in section 16.6.16 for the Tier 2 REWS installations, and considering that the Cleeton CC installation is further away from the array area, it is considered that the safety risk to platform allision due to partial impairment of the Cleeton CC REWS system remains unchanged and so is considered broadly acceptable.

16.10.15 CPA and TCPA Alarms

16.10.15.1.1 This subsection considers the potential effect of Hornsea Four, during the operation and maintenance phase, on REWS alarm rates due to rerouted traffic close to Perenco's Tier 3 assets. This is further described in section 6.4 of the REWS Report, ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report .

16.10.15.1.2 The alarm settings, potential consequences of increase vessel density, and the existing safeguards / controls are similar for the Tier 2 assets and discussed in section 16.6.17 of this report.

Analysis of Risk

16.10.15.1.3 As stated in section 7.3.1.2 of the REWS Report, ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report , the modelled routes and reroutes were chosen based on their general direction and close proximity to Perenco's operated Cleeton CC, Neptune, Hoton, Hyde, and Trent platforms. The routes were chosen for their proximity for CPA alarms assessment and for their general heading vectors for TCPA alarms assessment.

16.10.15.1.4 Once Hornsea Four is constructed, some routes may remain unchanged relative to the assessed platforms while others might result in further spacing from, or closer proximity to, the platforms.

16.10.15.1.5 The modelling results indicate that while some platforms will not experience any change in the probability of alarms, Hyde is expected to see an decrease of alarm rates due to the displacement of traffic around the Hornsea Four array area. The alarm modelling results are presented in section 6.6 of the REWS Report, ES Volume A5, Annex 11.1, Appendix B: Radar Early Warning Technical Report, and show the estimated difference in yearly alarm rates for each platform.

16.10.15.1.6 The modelling results also indicated that Perenco's Trent platform will see an increase in annual alarm rates by approximately 12 Amber TCPA alarms per year when considering the impact of Hornsea Four in isolation, and 16 Amber TCPA alarms per year when considering the impact of Hornsea Four cumulatively. However, Perenco's Trent platform has limited radar coverage from the REWS installations in the region. The rerouted traffic due to the presence of Hornsea Four may result in vessels passing closer to the platform and hence increase the alarm rates. Using AIS coverage in the region or more comprehensive radar coverage in the area may help in resolving any related concerns.

16.10.15.1.7 A detailed analysis of risk is performed for the Tier 2 assets and discussed in section 16.6.17 of this report. It is considered that this is similar for the Tier 3 assets.

16.10.15.1.8 On the basis of the analysis performed, the direct impact from increases in alarms as a result of route changes will be on the management of the alarms as described above. It is not considered that there will be a significant increase in safety risk to the affected Tier 2 platforms due to the predicted increase in alarms. The risk is therefore considered to be broadly acceptable.

16.10.15.1.9 The identified potential implications/ consequences of increase in alarms may be commercial, Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation. These are addressed in Section 20: Commercial Considerations of this report.

16.10.16 Loss of Containment - Outboard Pipelines / Intra-field Pipelines

16.10.16.1.1 According to GASCET (HSE, 2006), the relevant hazardous events with the potential for damage to the outboard / intra-field pipelines resulting in loss of containment could result from the following hazard

initiators: fatigue / vibration; incorrect installation; violation; operator error – inadequate training / competency; deficient procedures – operational / maintenance; vessel impact; dropped objects (i.e. dropped cargo) / abnormal external load; seismic event; and anchor – snagging / dropping.

16.10.16.2 Fatigue / Vibration

16.10.16.2.1 Operations associated with installation of the HVAC Booster Station(s) and turbine foundations could involve piling or drilling dependent on the selected foundation method which is also dependent on ground conditions.

Potential Consequences

16.10.16.2.2 Loss of containment due to flowline vibration triggered by drilling / piling.

Existing Safeguards / Controls

- Inherent Safety (including fully rated pipelines, inherent impact resistance, pipe burial and trenching (where applicable);
- Good procedures and Competent personnel associated with installation and operation of Hornsea Four;
- Isolation and PTW controls; and
- Pre-operation strength and leak testing.

Analysis of Risk

16.10.16.2.3 Operations associated with installation of the HVAC Booster Station(s) and array could potentially induce vibration in the surrounding area. The impact of drilling and piling operations on the pipeline is assessed in section 16.6.18.2 for Tier 2 assets, and is considered to have significantly less impact on Tier 3 assets considering the distance (over 10 nm) of these assets from the HVAC booster station search area and the array area. The risk is therefore considered to be broadly acceptable.

16.10.16.3 Incorrect Installation

16.10.16.3.1 Incorrect installation of the Hornsea Four export cables has the potential to impact the pipelines at their crossing points within the ECC due to additional hazards over and above the pipeline design criteria.

16.10.16.3.2 Incorrect installation of the Hornsea Four cables is addressed in section 16.6.18.3 for Tier 2 assets. As there are no Tier 3 intra-field pipeline-ECC crossings, this impact of is not considered applicable.

16.10.16.4 Operator Error – Inadequate Training / Competency

16.10.16.4.1 The consequences of human error, as well as the existing safeguards and impact is discussed in section 16.6.18.4 for Tier 2 assets and is considered similar for Tier 3 assets.

16.10.16.4.2 Based on the discussion presented, the introduction of additional safety risk to the pipelines is considered negligible. The risk is therefore considered to be broadly acceptable.

16.10.16.5 Violation

16.10.16.5.1 The consequences of violation, as well as the existing safeguards and impact is discussed in section 16.6.18.5 for Tier 2 assets and is considered similar for Tier 3 assets.

16.10.16.5.2 Based on the discussion presented, the introduction of additional risk to the pipelines from this potential initiator is considered negligible. The risk is there considered to be broadly acceptable.

16.10.16.6 Deficient Procedures – Operational / Maintenance

16.10.16.6.1 If deficient procedures are applied during the installation, operations, and maintenance of Hornsea Four (offshore interconnector and array cables), there is potential that pipelines with crossings will be affected due to additional hazards over and above the pipeline design tolerance.

16.10.16.6.2 The impact of deficient procedure is considered similar to 'incorrect installation' (see section 16.10.16.3 above). As there are no Tier 3 intra-field pipeline-ECC crossings, this impact of is not considered applicable.

16.10.16.7 Vessel Impact

16.10.16.7.1 Vessel impact concerns the potential additional hazards associated with vessel movements in and around the pipeline corridor, due to the presence of Hornsea Four construction and operation. This may include the following types of vessels: standby vessels, supply vessels, DSVs, survey vessels, barges, and cable installation vessels.

16.10.16.7.2 The interaction between vessels and pipelines will potentially result from dropped objects and/ or anchor snagging.

16.10.16.7.3 Dropped object risks are addressed in section 16.10.16.8 of the report.

16.10.16.7.4 Anchor snagging risks are addressed in section 16.10.16.10 of the report.

16.10.16.8 Dropped Objects

16.10.16.8.1 This involves additional hazards to the pipelines as a result of abnormal external load / dropped objects from vessels associated with Hornsea Four.

16.10.16.8.2 The consequences of dropped objects, as well as the existing safeguards and impact is discussed in section 16.6.18.8 for Tier 2 assets and is considered similar for Tier 3 assets.

16.10.16.8.3 Based on the discussion presented, the introduction of additional safety risks to the pipelines from this potential initiator is considered negligible. The risk is therefore considered to be broadly acceptable.

16.10.16.9 Seismic Event

16.10.16.9.1 Hornsea Four will not induce / trigger any seismic events. It will however in and around the array area and the HVAC Booster Station(s) induce a degree of ground shaking during the installation of foundations due to drilling or piling.

16.10.16.9.2 Details of the duration of piling operations in the HVAC booster station search area and the array area are documented in section 16.4.2.2.

16.10.16.9.3 The timing and execution of these foundation operations will be planned in consultation between Perenco and Hornsea Four, and these operations will be performed in accordance with good practice.

16.10.16.9.4 Operations associated with installation of the HVAC Booster Station(s) and array could potentially induce vibration in the surrounding area. The impact of drilling and piling operations on the pipeline is assessed in section 16.6.18.2 for Tier 2 assets, and is considered to have significantly less impact on Tier 3 assets considering the distance of these assets from the HVAC booster station search area and the array area. The risk is therefore considered to be broadly acceptable.

16.10.16.10 Anchor – Snagging / Dropping

16.10.16.10.1 This involves additional hazards to the pipelines as a result of anchor snagging / dropping from vessels associated with Hornsea Four.

16.10.16.10.2 The consequences of anchor snagging / dropping, as well as the existing safeguards and impact is discussed in section 16.6.18.10 for Tier 2 assets and is considered similar for Tier 3 assets.

16.10.16.10.3 Considering the types of vessels that Hornsea Four intends to make use of during installation and maintenance operations, the likelihood of anchor incidents leading to snagging, hooking or dropping is considered negligible, and therefore the incremental additional risk over and above the existing risk is there considered to be broadly acceptable.

16.11 Perenco Summary

16.11.1.1.1 The table below presents the risk summary for the assessment performed for the Perenco assets. The structure of the table is in line with the Tier grouping and order in which the hazards were assessed.

Table 16-3: Hazards and Risk Summary - Perenco

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
TIER 1							
	N/A	N/A	N/A	N/A			N/A
TIER 2							
	TIER 2 – PLATFORMS						
		Structural Integrity	Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Vessel Impact	All Assets	Unlikely	Slight Damage	Broadly Acceptable
			Helicopter Impact	All Assets	Very Unlikely	Local Damage	Broadly Acceptable
		Loss of Maritime Integrity - Loss of Stability		All Assets			Not Considered Further
		Loss of Maritime Integrity - Loss of Position		All Assets			Not Considered Further
		Vessel Access (Deviation) - Construction and Operations		All Assets	Unlikely	Slight Damage	Broadly Acceptable
		Vessel Access (Proximity) - Construction and Operations		Ravenspurn North Complex	Unlikely	Slight Damage	Broadly Acceptable
	TIER 2 – PLATFORMS SYSTEMS						
		Loss of Containment - Process		All Assets			Not Considered Further
		Loss of Containment - Pipelines		All Assets			Not Considered Further
		Loss of Containment - Fire & Explosion		All Assets			Not Considered Further
		Emergency Response		All Assets	Very Unlikely	Slight Impact	Broadly Acceptable
	TIER 2 – ASSOCIATED SYSTEMS						
		Wells		All Assets	Unlikely	Minor Damage	Broadly Acceptable
		Diving		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Human Factor		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Non-Process Fires & Explosions		All Assets	Very Unlikely	Local Damage	Broadly Acceptable

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
		Microwave Communication		Ravenspurn North to Cleeton	Very Unlikely	Slight Damage	Broadly Acceptable
				Ravenspurn North to Others	Very Unlikely	Slight Damage	Broadly Acceptable
		Radar Early Warning Systems (REWS)		REWS Installations	Unlikely	Slight Damage	Broadly Acceptable
		CPA and TCPA Alarms		All Assets	Unlikely	Slight Damage	Broadly Acceptable
		Loss of Containment - Outboard Pipelines / Intra-field Pipelines	Fatigue / Vibration	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Incorrect Installation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Operator Error – Inadequate Training / Competency	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Violation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Deficient Procedures – Operational / Maintenance	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Vessel Impact	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Dropped Objects	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Anchor – Snagging / Dropping	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
TIER 3							
	TIER 3 – PLATFORMS						
		Structural Integrity	Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Vessel Impact	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Helicopter Impact	All Assets	Very Unlikely	Local Damage	Broadly Acceptable
		Loss of Maritime Integrity - Loss of Stability		All Assets			Not Considered Further
		Loss of Maritime Integrity - Loss of Position		All Assets			Not Considered Further
		Vessel Access (Deviation) - Construction and Operations		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
		Vessel Access (Proximity) - Construction and Operations		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
	TIER 3 – PLATFORMS SYSTEMS						
		Loss of Containment - Process		All Assets			Not Considered Further
		Loss of Containment - Pipelines		All Assets			Not Considered Further
		Loss of Containment - Fire & Explosion		All Assets			Not Considered Further
		Emergency Response		All Assets	Very Unlikely	Slight Impact	Broadly Acceptable
	TIER 3 – ASSOCIATED SYSTEMS						
		Wells		All Assets	Unlikely	Minor Damage	Broadly Acceptable
		Diving - Pipelines		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Human Factor		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Non-Process Fires & Explosions		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Microwave Communication		All Assets			Not Considered Further
		Radar Early Warning Systems (REWS)		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		CPA and TCPA Alarms		Hyde	Unlikely	Slight Damage	Broadly Acceptable
				OTHERS	Very Unlikely	Slight Damage	Broadly Acceptable
		Loss of Containment - Outboard Pipelines / Intra-field Pipelines	Fatigue / Vibration	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Incorrect Installation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Operator Error – Inadequate Training / Competency	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Violation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
			Deficient Procedures – Operational / Maintenance	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Vessel Impact	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Dropped Objects	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Anchor – Snagging / Dropping	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable

17 Harbour Energy Limited

17.1 Introduction

17.1.1.1.1 Harbour Energy (formerly Premier Oil and Chrysaor Production Ltd.) is the licence holder of United Kingdom Continental Shelf (UKCS) Blocks 43/27a (P686), located within the array area, 43/26a (P380), located to the west and overlapping with the array area and Export Cable Corridor (ECC) and 42/28c & 42/28d (P2305/P1330) which overlaps with the ECC (Figure 17-1). Premier Oil was also recently awarded licence blocks 42/28e and 42/29b as part of the Oil and Gas Authority's 32nd Offshore Licensing Round and have indicated preliminary plans for these areas through consultation meetings. As details are not currently available, licence blocks 42/28e and 42/29b are not considered further within the assessment.

17.1.1.1.2 Harbour Energy's assets include subsea infrastructure (Johnston manifold & Johnston J4 and J5 wellheads), the Tolmount Platform, a Normally Unmanned Installation (NUI) (construction completed in 2020), and various pipelines both currently active and proposed. Harbour Energy is the operator of the Theddlethorpe to Murdoch gas and methanol pipelines.

17.1.1.1.3 There is no planned physical overlay of the pipeline, and a distance of at least 12 km between the pipeline and the Hornsea Four array area. Based on this distance, it is not anticipated that there will be any interactions between both assets.

17.1.1.1.4 Harbour Energy, then Chrysaor, have confirmed that there are no concerns as no specific interfaces between the pipeline and Hornsea Four have been identified, therefore no assessments will take place.

17.1.1.1.5 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

17.1.1.1.6 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

17.1.1.1.7 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

17.2 Meetings

17.2.1.1.1 As part of the consultation process, a number of meetings (consultation meetings are detailed in Table 11.3 of Volume A2, Chapter 11: Infrastructure and Other Users) were held with Premier Oil (now Harbour Energy) to review the timing and interface hazards associated with the implementation of Hornsea Four, in particular regarding the Johnston decommissioning scope and Tolmount operations.

17.2.1.1.2 On 10th December 2019, a Simultaneous Operations (SIMOPS) workshop was held where particularly the Johnston de-commissioning timing and hazardous operations were discussed.

17.2.1.1.3 During the brainstorming exercise a large field layout plan, illustrating Hornsea Four and Johnston infrastructures was used to better visualise the relative proportions, sizes and distances to/from platforms, pipelines, vessels and the wind-turbines. Model size vessels were used to obtain appreciation of size, distances and gaps.

17.2.1.1.4 The findings from the workshop and arrangements regarding co-existence and collaboration are presented in ES Volume A5, Annex 11.1, Appendix D: Premier Oil - Hornsea Four SIMOPS Workshop (non-confidential version), dated 23rd December 2019, and used in the following assessment.

17.3 Assessment Structure

17.3.1.1.1 The table below presents the structure of the assessment conducted on the potential hazards resulting from interaction of Harbour Energy assets with Hornsea Four. The subsections where each hazard is addressed is also shown in the table.

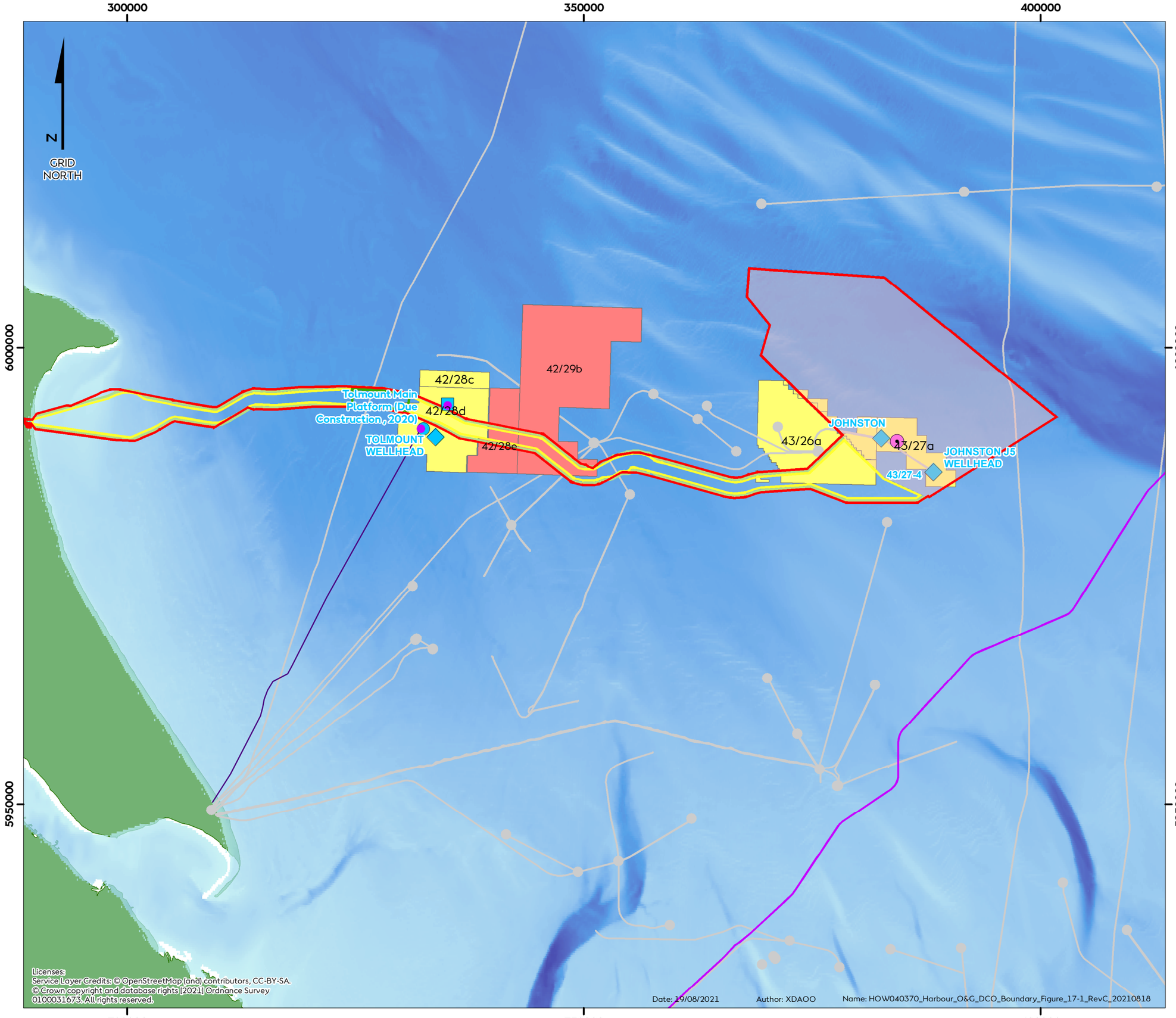
Table 17-1: Harbour Energy Assessment Structure

TIER	Hazards	Sub-Group	Report Section
TIER 1			17.4
TIER 1 – PLATFORMS	N/A		N/A
TIER 1 – PLATFORM SYSTEMS	N/A		N/A
TIER 1 – ASSOCIATED SYSTEMS			17.7
	Wells		17.7.2
	Diving		17.7.3
	Human Factor		17.7.4
	Helicopter - Impaired Access to O&G Platforms		17.7.5
	Helicopter - Impaired Access to O&G Vessels (CAT)		17.7.6
	Helicopter - Impaired Access to O&G Vessels (SAR)		17.7.7
	Emergency Response		17.7.8
	Seismic Survey Activities		17.7.9
	Drilling (Array Area) Activities		17.7.10
	Construction (Array Area) Activities		17.7.11
	Non-Process Fires & Explosions		17.7.12
	Loss of Containment - Outboard Pipelines / Intra-field Pipelines		17.7.13
		Fatigue / Vibration	17.7.13.2
		Incorrect Installation	17.7.13.3
		Operator Error – Inadequate Training / Competency	17.7.13.4
		Violation	17.7.13.5
		Deficient Procedures – Operational / Maintenance	17.7.13.6
		Vessel Impact	17.7.13.7
		Decommissioning Access	17.7.13.8
		Dropped Objects	17.7.13.9
		Seismic Event	17.7.13.10
		Anchor – Snagging / Dropping	17.7.13.11
TIER 2			17.8
TIER 2 – PLATFORMS			17.9
	Structural Integrity		17.9.2
		Seismic Event	17.9.2.2
		Vessel Impact	17.9.2.3

TIER	Hazards	Sub-Group	Report Section
		Helicopter Impact	17.9.2.4
	Loss of Maritime Integrity - Loss of Stability		17.9.3
	Loss of Maritime Integrity - Loss of Position		17.9.4
	Vessel Access (Deviation) - Construction and Operations		17.9.5
	Vessel Access (Proximity) - Construction and Operations		17.9.6
TIER 2 – PLATFORM SYSTEMS			17.10
	Loss of Containment - Process		17.10.2
	Loss of Containment - Pipelines		17.10.3
	Loss of Containment - Fire & Explosion		17.10.4
	Emergency Response		17.10.5
TIER 2 – ASSOCIATED SYSTEMS			17.11
	Wells		17.11.2
	Diving		17.11.3
	Human Factor		17.11.4
	Helicopter - Impaired Access to O&G Platforms (CAT)		17.11.5
	Helicopter - Impaired Access to O&G Platforms (SAR)		17.11.6
	Helicopter - Impaired Access to O&G Vessels (CAT)		17.11.7
	Helicopter - Impaired Access to O&G Vessels (SAR)		17.11.8
	Seismic Survey Activities		17.11.9
	Drilling (Array Area) Activities		17.11.10
	Drilling (ECC Area) Activities		17.11.11
	Construction (Array Area) Activities		17.11.12
	Construction (ECC Area) Activities		17.11.13
	Non-Process Fires & Explosions		17.11.14
	Loss of Containment - Outboard Pipelines / Intra-field Pipelines		17.11.15
		Fatigue / Vibration	17.11.15.2
		Incorrect Installation	17.11.15.3
		Operator Error – Inadequate Training / Competency	17.11.15.4
		Violation	17.11.15.5
		Deficient Procedures – Operational / Maintenance	17.11.15.6
		Vessel Impact	17.11.15.7
		Dropped Objects	17.11.15.8
		Seismic Event	17.11.15.9
		Anchor – Snagging / Dropping	17.11.15.10
TIER 3			
N/A	N/A	N/A	N/A

Hornsea Four

Harbour Energy Assets -
DCO Order Limits
Figure 17.1



Harbour Energy Licenses

32nd Round Provisional Awards

HARBOUR ENERGY

Tolmount MFP

Tolmount Pipeline Route

Oil and Gas Infrastructure

Harbour Energy Subsea

Other Operators

Platform

Proposed Wellhead

Well

Harbour Energy, Additional Wellhead

Pipelines

Harbour Energy

Other Operators

Project Layers

DCO Order Limits

Offshore Export Cable

Hornsea 4 Array Area

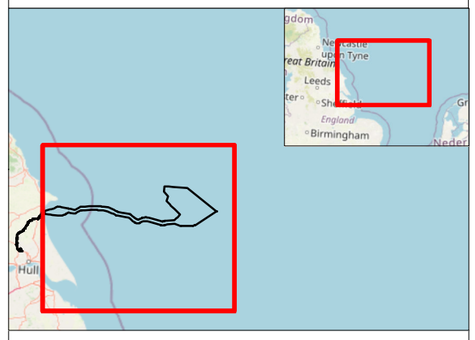
HVAC Booster Stations

Offshore Temporary Works Area

Bathymetry (Below Sea Level)

High : 0

Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometres

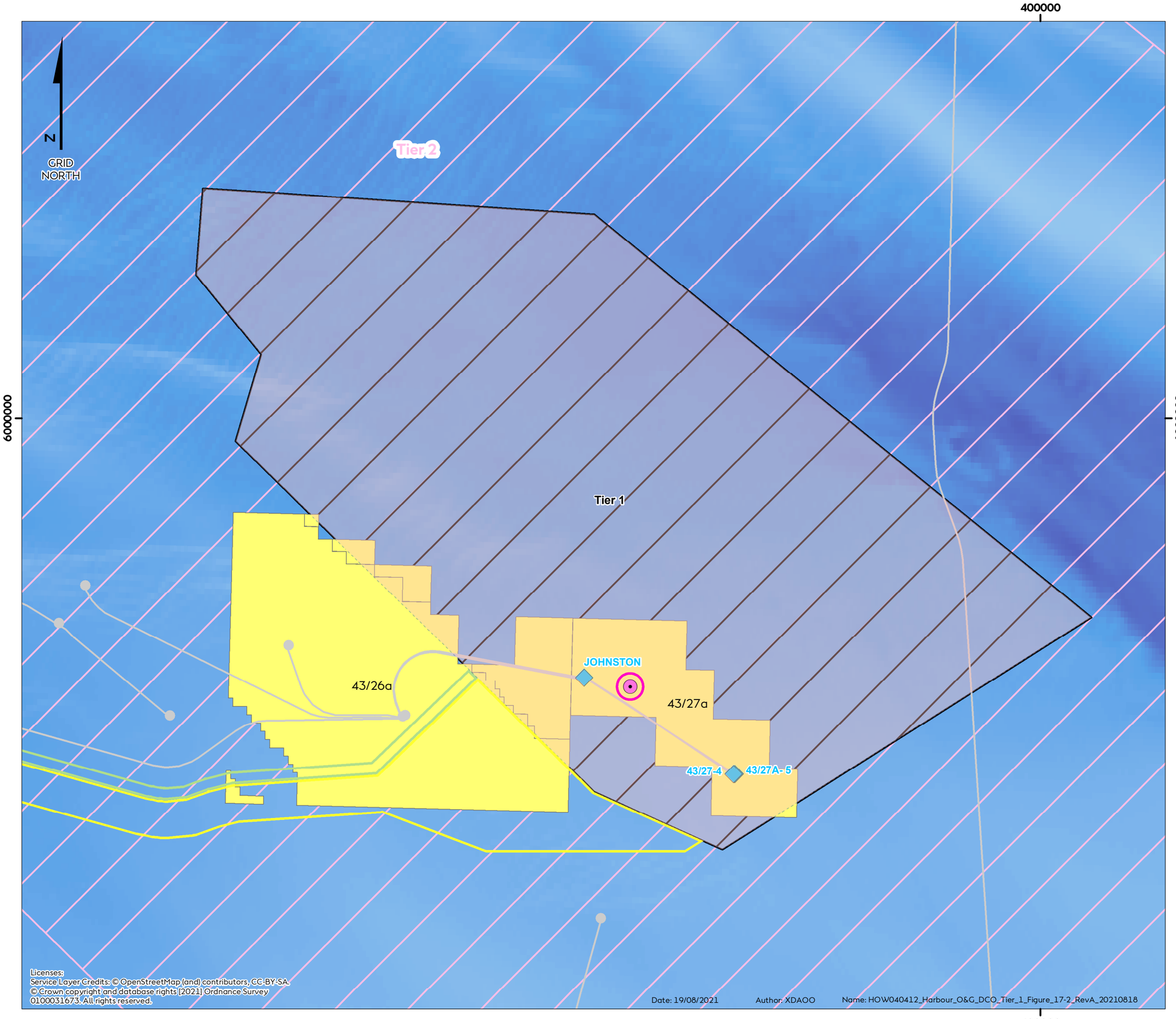
0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	25/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Included Round 32 Licences	14/10/2020
C	Reduced Array Area in northwest corner	18/08/2021

Harbour Energy Assets - DCO Order Limits
Document no: HOW040370
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

Date: 19/08/2021 Author: XDAOO Name: HOW040370_Harbour_O&G_DCO_Boundary_Figure_17-1_RevC_20210818



Hornsea Four

Harbour Energy Assets - Tier 1
Figure 17.2

- Harbour Energy Licenses

Oil and Gas Infrastructure

- Harbour Energy Subsea
- Harbour Energy, Additional Wellhead
- Wellhead 500m Buffer
- Other Operators
- Other Operators

Project Layers

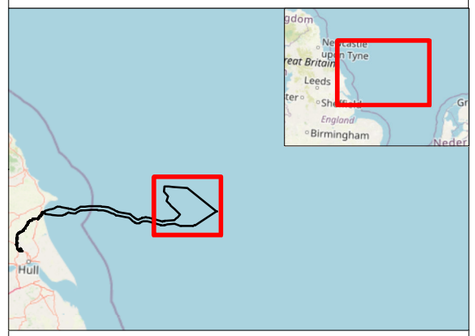
- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Tier Boundaries

- Tier 1 (Array Area)
- Tier 2 (10nm from Array Area / HVAC)

Bathymetry (Below Sea Level)

- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:140,000

0 1.5 3 6 Kilometres

0 0.5 1 2 Nautical Miles

REV	REMARK	DATE
	First issue	24/07/2020
A	Reduced Array Area in northwest corner	18/08/2021

Harbour Energy Assets - Tier 1
Document no: HOW040412
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

17.4 TIER 1

17.4.1.1.1 Based on the asset screening process, Tier 1 assets (as defined in Section 4.2, Table 4-2) are shown relative to the Hornsea Four array area in Figure 17-2. In summary, Tier 1 assets are comprised of the subsea infrastructure associated with the Johnston Field, all of which are operated by Harbour Energy (then Premier Oil). These include:

- Six wells divided between two locations (J1, J2, J3 & J6 at the Johnston manifold template, and J4 & J5 at a separate step out location);
- One abandoned appraisal well;
- Rigid pipeline between Johnston template and Ravenspurn North (assessment only includes section within the Hornsea Four array area); and
- Flexible pipeline and umbilical between the J4 & J5 step out and the Template.

17.5 TIER 1 Assessment - Platforms

17.5.1.1.1 As there are no oil and gas platforms within the Tier 1 area, this section does not apply.

17.6 TIER 1 Assessment - Platform Systems

17.6.1.1.1 As there are no oil and gas platforms within the Tier 1 area, this section does not apply.

17.7 TIER 1 Assessment - Associated Systems

17.7.1.1.1 Associated systems comprise other equipment and operations associated with but not part of the installations and platform systems.

17.7.1.1.2 Hazard guide words have been employed and were obtained from Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006) and extended to incorporate specific operational concerns (as shown in Table 6-2). The guide words employed are wells; diving; human factor; helicopter - impaired access to Oil and Gas (O&G) infrastructure and de-commissioning vessels; helicopter - deferred access to support O&G operations; seismic survey operations; drilling operations; construction operations; non-process fires & explosions; and loss of containment - outboard pipelines / intra-field pipelines.

17.7.1.1.3 The Johnston subsea infrastructure is within the Tier 1 area of the Hornsea Four array area. Cessation of production is likely to occur in the 2020s, with decommissioning at some point in the future, not necessarily immediately after cessation of production.

17.7.1.1.4 Considering Hornsea Four's offshore installation campaign is currently planned for 2027, the cessation of production of the Johnston subsea infrastructure would significantly reduce the interface risks between Hornsea Four construction and Harbour Energy production operations.

17.7.1.1.5 Whilst the Johnston de-commissioning campaign is still unknown, there are clear advantages to decommission ahead of the Hornsea Four construction 'window' to manage risk exposures relating to construction overlaps.

17.7.1.1.6 Nevertheless, the below assessment is performed based on a conservative approach, assuming Harbour Energy may decommission the Johnston infrastructure during Hornsea Four construction.

17.7.2 Wells

17.7.2.1.1 Hazards to the Tier 1 wells could arise from the following initiators:

- Premier vessel access for operations/decommissioning;
- Hornsea Four installation vessels proximity;
- Vibration (i.e., from piling / drilling of turbine foundations);
- Dropped objects from vessels; and
- Anchor spread from vessels, e.g., work boats or Diving Support Vessel (DSV).

Potential Consequences

- Wells access compromised; and
- Wells integrity compromise with the potential of blowout / spillage.

Existing Safeguards / Controls

- Access corridor / spacing agreed in principle with Harbour Energy (then Premier Oil), following post-SIMOPS workshop communications, with exception, see below analysis;
- Subsea protection structure;
- Inherent Safety practices;
- Competent personnel;
- Control measures via existing marine procedures, e.g., Notifications to Mariners (NtM);
- SIMOPS will be performed prior to Hornsea Four field operations; and
- 500 m safety zone around assets.

Analysis of Risk

17.7.2.1.2 All wells in the Johnston field are in the planning stage for decommissioning. The wells will be decommissioned making use of the well-established plug and abandon method. Vessels for wells decommissioning will involve Jack-up Rig with associated support vessels.

17.7.2.1.3 Depending on the Cessation of Production (CoP) / well abandonment status, the potential hazards associated with piling of wind turbine foundations may pose a risk to the integrity of wellheads and subsea manifolds, due to ground shaking induced pressure waves. Given the distance between foundations and subsea infrastructure, such pressure waves are expected to have dissipated over the distance and only result in minimal impact. In addition, the existing subsea infrastructure is designed with safety factors allowing for external hydrodynamic loads.

17.7.2.1.4 Considering the relative footprint of the Johnston wells (i.e., 43/27-4) compared to that of Hornsea Four's operation, the likelihood of a dropped object strike is considered negligible.

17.7.2.1.5 Anchor spread for vessels supporting the construction and operations in Hornsea Four will be controlled by SIMOPS, expected works will be published in NtM; Given that wellheads are generally not found close to shore (water depths less than 15 m), the use of anchor spreads is not expected. However, they may be required for cable jointing or repair works, or to assist construction vessels where conditions dictate.

17.7.2.1.6 The likelihood of compromising the well integrity is considered remote given the above listed existing safeguards and controls.

17.7.2.1.7 Proposed access corridors are adequate for all wells considering planned operations, maintenance, and de-commissioning operations. The Hornsea Four turbine layout has been adapted to accommodate jack-up rig access to the Johnston wellheads. Harbour Energy (then Premier Oil) confirmed via consultation that they are in agreement with the spacing between the turbine array and Johnston well locations from the perspective of marine & rig access (see Table 11.3 of Volume A2, Chapter 11: Infrastructure and Other Users).

17.7.2.1.8 In conclusion, all aspects associated with hazards and risks to the Tier 1 wells are broadly acceptable.

17.7.3 Diving

17.7.3.1.1 This section focuses on potential impact on Harbour Energy's diving operations (temporary impact upon access for pipeline repair / maintenance, etc.) due to the implementation and operation of Hornsea Four.

Potential Consequences

- The safety of divers is compromised due to Hornsea Four construction / operations; and
- Delay in diving maintenance, including inspection and repair operations.

Existing Safeguards / Controls

- No diving operations in unsafe conditions; and
- Co-existence procedures.

Analysis of Risk

17.7.3.1.2 It is anticipated that temporary restrictions to diving operations for maintenance / repair may occur during installation of Hornsea Four. Through detailed discussions, planning, and good SIMOPS practices by both parties, significant access restrictions can be avoided.

17.7.3.1.3 The temporary piling / drilling operations associated with the array area could lead to acoustic vibrations which could have an impact on diving operations. Diving near subsea assets should be avoided during such operations. This will be managed via standard site installation communication between interested parties.

17.7.3.1.4 Given the management of operations via communication and consultation between Hornsea Four and Harbour Energy, it is considered that the safety risks associated with diving operations for Tier 1 assets remain unchanged and therefore considered to be **broadly acceptable**.

17.7.4 Human Factor

17.7.4.1.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

17.7.4.1.2 This section addresses human factors associated with Hornsea Four construction and operations that have the potential to impact Harbour Energy's Tier 1 operations.

17.7.4.1.3 For the analysis of Harbour Energy's Tier 1 assets the most relevant subjects are Hornsea Four navigation, station holding and/or the potential of drifting close to or around the route of the subsea infrastructure, due to operations associated with installation, inspection or maintenance.

17.7.4.1.4 Human errors can occur both in the conceptual and design phases as well as construction, operational and de-commissioning phases of a project. Human errors, that have the potential to result in a Major Accident Hazard (MAH), in the operational or de-commissioning phase, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

17.7.4.1.5 Loss of containment due to incidents caused by personnel incompetency / lack of experience / stress.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and

- Monitoring and Audit systems.

Analysis of Risk

17.7.4.1.6 According to GASCET (HSE, 2006), a procedure should be in place for the selection, competence assessment, and training of operations and maintenance personnel and that it is designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

17.7.4.1.7 The Health and Safety Executive (HSE) standards and codes of practices are referenced to show that in order to operate in the UK Continental Shelf, the O&G asset holders are expected to follow certain requirements.

17.7.4.1.8 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016 - Ref. 8). Risk mitigating measures, such as good work practices and procedures, training, and the use of competent personnel will be employed during the installation, operations and maintenance of the Hornsea Four infrastructure. Therefore, the introduction of incremental additional risk to the operations/decommissioning of Harbour Energy's subsea infrastructure, from this potential initiator is considered negligible.

17.7.4.1.9 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the incremental additional risk of impact from human factors is considered broadly acceptable.

17.7.5 Helicopter - Impaired Access to O&G Platforms

17.7.5.1.1 As there are no Harbour Energy platform installations in the Tier 1 grouping, this is not considered applicable.

17.7.6 Helicopter - Impaired Access to O&G Vessels (CAT)

17.7.6.1.1 This subsection addresses the potential for impaired access of Commercial Air Transport (CAT) operated helicopters to helideck-equipped O&G vessels and/or helideck-equipped jack-up vessels associated with Tier 1 operations during de-commissioning of Johnston subsea infrastructure; and the associated additional safety impact.

17.7.6.1.2 The potential for impaired access to O&G vessels, likely to be Jack-Up and DSV vessels, could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter incident; and

- Potential restriction to flying due to other restrictions given by Hornsea Four.

Existing Safeguards / Controls

- All CAT Tier 1 operations must be operated under VFR (Visual Flight Rules);
- Awareness of flying restrictions;
- Communication; and
- Operational procedures / personnel training.

Analysis of Risk

17.7.6.1.3 IMC is prevalent for an estimated circa 10 % of the daytime for the years there is data. This is expected to be spread throughout the year and with few events of more than a few hours on a given day. This would only be relevant for the relatively short duration of the decommissioning period.

17.7.6.1.4 In terms of navigational failure as a result of Hornsea Four, consideration of helicopter systems is already built into the procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

17.7.6.1.5 In consideration of extreme weather / environmental conditions, the operational regulations already include weather limits, and these will not change with the presence of Hornsea Four.

17.7.6.1.6 On the basis of the above assessment, the incremental additional risk to safety brought about by the presence of Hornsea Four is considered negligible. The safety risk associated with impaired helicopter access to and from Harbour Energy's decommissioning vessels is considered **broadly acceptable**.

17.7.6.1.7 Consideration of the following measures will enhance access:

- Agree suitable clearances to accommodate Visual Meteorological Conditions (VMC) approaches and departures;
- Also, Harbour Energy is considering decommissioning prior to start of array construction.

17.7.6.1.8 ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report shows that the implications of impaired access are not safety related. The identified potential implications/ consequences of impaired access are commercial only. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation – these are considered in Section 20: Commercial Considerations of this report.

17.7.6.1.9 Also, as per Co102 (see Volume A4, Annex 5.2: Commitment Register), the Defence Infrastructure Organisation and the Civil Aviation Authority (CAA), Maritime and Coastguard Agency (MCA) and operators will be informed of the locations, heights, and lighting status of the wind turbines, including estimated and actual dates of construction and the maximum height of any construction equipment to be used, prior to the start of construction, to allow inclusion on Aviation Charts.

17.7.7 Helicopter – Impaired Access to O&G Vessels (SAR)

17.7.7.1.1 This subsection addresses the potential for impaired access of Search and Rescue (SAR) operated helicopters to helideck equipped O&G vessels and/or helideck-equipped jack-up vessels associated with Tier 1 operations during de-commissioning of Johnston subsea infrastructure; and the associated additional safety impact.

17.7.7.1.2 The potential for impaired access to O&G vessels, likely to be Jack-Up and DSV vessels, could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;

- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter incident;
- Potential restriction to flying due to other restrictions given by Hornsea Four.

Existing Safeguards / Controls

- All CAT Tier 1 operations must be VFR;
- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training;
- For emergency conditions, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under the Civil Aviation Publication (CAP), CAP 999. The Coastguard helicopters are operated as state aircraft under national regulations and are not constrained by European Aviation Safety Agency (EASA) Regulations. As Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to vessels attending Harbour Energy's nearby subsea facilities – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report; and
- MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training are more advanced than that available to CAT helicopters.

Analysis of Risk

17.7.7.1.3 In terms of navigational failure, this consideration is already built into the helicopter systems procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

17.7.7.1.4 In consideration of extreme weather / environmental conditions, the operational regulations already include weather limits, and these will not change with the presence of Hornsea Four.

17.7.7.1.5 On this basis and considering that helicopter transport will not take place should there be any risk brought about by a combination of meteorological conditions and the presence of the Hornsea Four array, the risk associated with impaired helicopter access to and from Harbour Energy's decommissioning vessels will remain unchanged and so is considered broadly acceptable.

17.7.8 Emergency Response

17.7.8.1.1 This section focuses on the impact (impairment / delay) Hornsea Four's presence in the area may have on Harbour Energy's emergency response arrangements associated with their Tier 1 assets, and in particular associated with the decommissioning of the Johnston subsea infrastructure.

17.7.8.1.2 Harbour Energy's emergency response arrangements include the following:

- Emergency Response Management;
- Alarms and Communication;
- Temporary Refuge and Muster Stations;
- Access / Egress Routes;
- Evacuation;

- Escape;
- Rescue and Recovery;
- Emergency Lighting; and
- Emergency Communications.

17.7.8.1.3 The HSE UK, Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations (HSE, 2016) and associated Schedules contain specific requirements for emergency response to major accident hazards on installations. It is assumed that Harbour Energy's current emergency response arrangements comply with the relevant statutory provisions governing the operations listed above.

Potential Consequences

17.7.8.1.4 Impairment or delay of emergency response arrangement could potentially lead to injury / fatality of personnel.

Analysis of Risk

17.7.8.1.5 It is not considered that Hornsea Four will have any impact on emergency response systems on the Tier 1 decommissioning vessels (Jack-Up and DSV), i.e., access / egress, alarms, and communication (including emergency communications), escape, emergency lighting, temporary refuge and muster stations.

17.7.8.1.6 Other emergency responses would typically include provision of primary and secondary means of evacuation and escape from the vessels, e.g., helicopter, Totally Enclosed Motor Propelled Survival Craft (TEMPSC), sea transfer and bridge-link; some necessitating arrangements with others.

17.7.8.1.7 It is considered that these primary and secondary means of evacuation and escape from decommissioning vessels will not be impaired. As stated in section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, for emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as State Aircraft under National Regulations and are not constrained by EASA Regulations. Also, commercial SAR can be flown with some alleviations from CAT Regulations. Such SAR arrangements have existed in the United Kingdom (UK), Norway and the Netherlands for decades and include SAR coverage provided by the Integrated Search and Rescue (ISAR) Consortium in Aberdeen (formerly Jigsaw Aviation), SAR helicopters based in the Ekofisk Field, and SAR helicopters under contract to Nederlands Olie en Gas Exploratie en Productie Associatie (NOGEPA), the Dutch equivalent of Oil & Gas UK.

17.7.8.1.8 As Coastguard SAR Operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to nearby installations. The potential risk of delay or impairment of emergency response systems required around Tier 1 will remain unchanged.

17.7.8.1.9 Note that Hornsea Four is willing to explore emergency response synergies with Harbour Energy.

17.7.8.1.10 In considering the assessment of the potential impairment of emergency response arrangements, there will be no risk of delay or impairment of emergency response and evacuation systems for the Tier 1 decommissioning vessels. The risk is considered negligible and is therefore broadly acceptable.

17.7.9 Seismic Survey Activities

17.7.9.1.1 As Harbour Energy is planning the decommissioning of the Johnston subsea infrastructure, seismic survey activities are not considered applicable.

17.7.10 Drilling Activities

17.7.10.1.1 As Harbour Energy is planning the decommissioning of the Johnston subsea infrastructure, drilling activities are not considered applicable.

17.7.11 Construction (Array) Activities

17.7.11.1.1 Harbour Energy will be de-commissioning its Tier 1 subsea oil and gas infrastructure. This may be performed concurrently to the construction of Hornsea Four. The hazard interface management and associated risk evaluation, in the event that Harbour Energy's decommissioning operations and Hornsea Four construction operations take place at the same time, have been assessed in the different sub-sections of this section 17.

17.7.12 Non-Process Fires & Explosions

17.7.12.1.1 Non-process fires and explosions are typically associated with non-process plants. In the case of Hornsea Four, this could be electrical fires associated with the High Voltage Alternating Current (HVAC) booster station(s) or offshore substation platforms in the array area.

17.7.12.1.2 Considering that Hornsea Four will apply a safety zone of up to 500 m between Hornsea Four assets and Harbour Energy Tier 1 assets, it is considered that the impact of electrical fires is negligible. The risk is therefore considered to be **broadly acceptable**.

17.7.13 Loss of Containment – Outboard Pipelines / Intra-field Pipelines

17.7.13.1.1 According to GASCET (HSE, 2006), the relevant hazardous events with the potential for damage to the outboard / intra-field pipelines resulting in loss of containment could result from fatigue / vibration,; incorrect installation, violation, operator error – inadequate training / competency, deficient procedures – operational / maintenance, vessel impact; dropped objects (i.e. dropped cargo) / abnormal external load, seismic event, and anchor – snagging / dropping.

17.7.13.1.2 In the following sub-sections, the Harbour Energy subsea infrastructure that is considered includes the production flowlines connecting the wells J1, J2, J3, J6, and the wells J4 and J5, the methanol pipeline, electro-hydraulic umbilicals, the subsea template, jumpers and spools. Wells are covered in section 17.7.2.

17.7.13.2 Fatigue / Vibration

17.7.13.2.1 Fatigue and vibration of Harbour Energy's intra-field pipelines could be introduced as a result of operations associated with foundation installation of the Wind Turbine Generators (WTGs) and Offshore Sub-stations (OSS), dependent on ground conditions.

Potential Consequences

17.7.13.2.2 Loss of containment due to flowline or pipeline vibration triggered by drilling / piling induced vibration.

Existing Safeguards / Controls

- Inherent Safety (including fully rated pipelines, inherent impact resistance, pipe burial and trenching (where applicable);
- Turbine positions will also be set back at least 500 m from pipelines and other Harbour Energy assets;
- Good procedures and Competent personnel associated with installation and operation of Hornsea Four;
- Isolation and Permit to Work (PTW) controls; and

- Pre-operation strength and leak testing.

Analysis of Risk

17.7.13.2.3 As documented in Volume A1, Chapter 4: Project Description, the Maximum Design Scenario (MDS) strike energy for piling of the foundations in the array area is 3,000 kJ to 5,000 kJ. For the WTGs, substations, and accommodation platform on monopiles, there will be a 4-hour piling duration and 1.2 days per monopile, with a total duration of 106 to 216 piling days depending on the number of vessels. For WTGs, substations, and accommodation platform on piled jackets, the jackets will have a piling duration of 1.5 days per jacket foundation and a total of 135 to 270 piling days depending on the number of vessels. The durations of the impact piling component of the installation campaign is expected to be a maximum of 12 months.

17.7.13.2.4 The timing and execution of these foundation operations will be planned in consultation between Harbour Energy and Hornsea Four, and these operations will be performed in accordance with good practice.

17.7.13.2.5 Considering the above, and in particular that the Harbour Energy pipelines are buried, the potential safety impact of ground shaking is considered **broadly acceptable**.

17.7.13.3 Incorrect Installation

17.7.13.3.1 Incorrect installation of the Hornsea Four offshore interconnector and array cables within the array has the potential to impact the pipeline crossings due to additional hazards over and above the pipeline design tolerance.

Potential Consequences

17.7.13.3.2 Loss of containment due to incorrect installation of cable crossings.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel;
- Monitoring and Audit systems; and
- Crossing protection mattresses where assessed to be applicable.

Analysis of Risk

17.7.13.3.3 As the relevant Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four offshore interconnector and array cables, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the pipeline is considered negligible, and therefore broadly acceptable.

17.7.13.3.4 Also, the pipeline crossings will be designed and engineered in accordance with standard approaches and be subject to crossing agreement, as per Co107 (see Volume A4, Annex 5.2: Commitment Register). This would typically include the provision for a representative of Harbour Energy to be in attendance on the vessel and monitor the works.

17.7.13.4 Operator Error – Inadequate Training / Competency

17.7.13.4.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

17.7.13.4.2 For the analysis of Harbour Energy's pipelines / subsea infrastructure in Tier 1 area, the most relevant subjects are navigation, station holding and/or the potential of drifting close to or around the route of the pipeline, due to vessels operations associated with cable installation, cable inspection or maintenance.

17.7.13.4.3 Human errors can occur in all phases of a project. Human errors, that have the potential to result in MAHs, in the operational scenario, can be initiated from pressures and influences on the individual brought by

organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

17.7.13.4.4 Loss of containment due to incidents caused by personnel incompetency / lack of experience.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

17.7.13.4.5 According to GASCET (HSE, 2006), the O&G asset holder should have a procedure in place for the selection, competence assessment, and training of operations and maintenance personnel. The O&G asset holder's procedure should be designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

17.7.13.4.6 The HSE standards and codes of practices are referenced to show that in order to operate in the UK Continental Shelf, the O&G asset holders are expected to follow certain requirements.

17.7.13.4.7 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016). Risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel will be employed during installation, operations, and maintenance of the Hornsea Four infrastructure. Incremental additional risk to the pipelines from this potential initiator is considered negligible.

17.7.13.4.8 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the risk of impact from human factors is considered broadly acceptable.

17.7.13.5 Violation

17.7.13.5.1 Human factors involved in the earlier conceptual design stages of the installation lifecycle can influence the likelihood of the occurrence of hazardous event. When installations have not been designed and constructed, and / or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards, a violation is said to have occurred.

Potential Consequences

17.7.13.5.2 Loss of containment due to not following procedure and guidelines.

Existing Safeguards / Controls

- Good procedures; and
- Competent personnel.

Analysis of Risk

17.7.13.5.3 As stated in section 17.7.13.4, human errors can occur in all phases of a project. Human errors, that have the potential to result in MAHs, in the earlier conceptual design stages, can also be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

17.7.13.5.4 The impact of violation is considered similar to 'operator error' and considering that risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel is being employed in the design of the Hornsea Four infrastructure, the introduction of additional risk to the pipelines from this potential initiator is considered negligible, and therefore broadly acceptable.

17.7.13.6 Deficient Procedures

17.7.13.6.1 If deficient procedures are applied during the installation, operations, and maintenance of Hornsea Four (offshore interconnector and array cables) within the array, there is potential that pipelines with crossings will be affected due to additional hazards over and above the pipeline design tolerance.

17.7.13.6.2 The impact of deficient procedure is considered similar in consequences and safeguards to 'incorrect installation' which is assessed in section 17.7.13.3 above.

17.7.13.6.3 As the relevant UK Continental Shelf Procedures, Legislation, and Guidance will be adhered to and maintained in designing and during installation of the Hornsea Four infrastructure, including risk preventive measures, good work practices and procedures, and the use of competent personnel; the introduction of additional risk to the pipeline is considered negligible, and therefore broadly acceptable.

17.7.13.7 Vessel Impact

17.7.13.7.1 Vessel impact concerns the potential additional hazards associated with vessel movements in and around the Johnston' subsea facilities corridor, due to Hornsea Four's implementation and presence.

17.7.13.7.2 During construction and operations of Hornsea Four, a number of vessels will be required within the array area, and possibly close to the existing subsea infrastructure. These may interfere with Harbour Energy's de-commissioning vessels.

17.7.13.7.3 Also, during construction and operation of Hornsea Four, existing shipping vessels and fishing vessels may change their routes.

17.7.13.7.4 The potential for collision hazards could arise from the following hazard initiators:

- Attendant and Passing Vessels;
- Failures – Positional;
- Failures – Navigational;
- Failures – Procedural; and
- Failures – Human Error.

Potential Consequences

- Collision risks between Harbour Energy decommissioning vessels and Hornsea Four construction/operations vessels; and
- Collision risks between Harbour Energy decommissioning vessels and shipping/fishing vessels.

Existing Safeguards / Controls

17.7.13.7.5 The existing safeguards / controls for collision risk include the following:

- Inherent safety, e.g., Automatic Identification System (AIS).;
- Stand-by Vessels;
- Agreed space and access corridor;

- Communications and Procedures (including vessel contracting and suitability, inspections, marine operations and combined operations); and
- Visual & Radar.

Analysis of Risk

17.7.13.7.6 As per section 6.5 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, fishing vessels were observed during a study period to be present within the proposed Hornsea Four array area. No clear active fishing (i.e., vessels considered as having gear deployed) was observed over subsea infrastructure. It should be considered that the summer survey period is AIS only, and as such fishing vessel activity may be underrepresented (however it is considered unlikely that smaller non AIS fishing vessels would transit this far offshore on a regular basis). Fishing vessel levels would be expected to reduce during periods of less favourable weather conditions.

17.7.13.7.7 It was noted that the recreational vessels recorded during the study period were observed to be limited, which is to be expected given the distance offshore of the Hornsea Four array area.

17.7.13.7.8 For future case shipping, it should be considered that while larger commercial vessels have been rerouted away from the Hornsea Four infrastructure, smaller vessels (e.g., fishing and recreation) may still choose to transit through. However, baseline transits of such vessels within the study area were low.

17.7.13.7.9 From proximity assessments conducted and presented in section 7.4 ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, it is predicted that vessel numbers within 2 nm of the Johnston assets within the Hornsea Four array area are expected to decrease by between one (1) to two (2) vessels per day, following the construction of Hornsea Four. Note that following the implementation of Hornsea Four the shipping routes are expected to be in excess of 2 nm from the Johnston assets.

17.7.13.7.10 Experience of other projects (including Hornsea Project One) shows that the majority of commercial vessels will begin to deviate once the construction buoyage is in place, and as such allision / collision risk to vessels associated with the Tier 1 assets from routed third party traffic will also decrease.

17.7.13.7.11 Given a reduction in Hornsea Four support vessel operations during operations, the rerouting of commercial traffic from the area, and noting that fishing vessel levels are expected to reduce during periods of less favourable weather conditions, it is considered that the additional safety risk associated with vessels in the Tier 1 area is **broadly acceptable.**

17.7.13.8 Decommissioning Access

17.7.13.8.1 Hazards due to access for Harbour Energy to perform Johnston decommissioning could arise from the following initiators:

- Insufficient access / space to allow multiple decommissioning vessels in the field; and
- Hornsea Four installation vessels proximity.

Potential Consequences

- Access and safety distances compromised leading to infield collision between Harbour Energy vessels and Hornsea Four vessels; and
- Delays due to infield proximity issues between vessels.

Existing Safeguards / Controls

- Access corridor / spacing agreed in principle with Harbour Energy, following post-SIMOPS workshop communications;
- Inherent safety practices;
- Competent personnel;
- Control measures via existing marine procedures, e.g., NtM; and
- Detailed SIMOPS review will be performed prior to Hornsea Four field operations.

Analysis of Risk

17.7.13.8.2 The likely decommissioning plan for flowlines will involve only cutting the ends of the flowlines and leave in-situ the buried sections of the flowlines. This will minimise the de-commissioning vessel activities and reduce the risks of vessel interactions.

17.7.13.8.3 Given the up to 500 m safety zone between Hornsea Four operations and Harbour Energy's decommissioning operations (see Co139 in section 6.1.2), along with the above listed existing safeguards and controls, and a planned coexistence procedure, the risk associated with access during Harbour Energy's planned decommissioning is assessed as broadly acceptable.

17.7.13.8.4 Note that cessation of production is likely to occur in the 2020s, with decommissioning at some point in the future, not necessarily immediately after cessation of production (see paragraph 11.7.1.22 of Volume A2, Chapter 11: Infrastructure and Other Users).

17.7.13.9 Dropped Objects

17.7.13.9.1 This involves the potential incremental additional exposure to Harbour Energy's pipelines as a result of abnormal external load / dropped objects from vessels associated with Hornsea Four.

17.7.13.9.2 Major damage risks can come from dropped objects during installation or maintenance of Hornsea Four cables.

17.7.13.9.3 According to the Offshore Technology Report 2001/013 (HSE, 2002), the principal categories of load are: dead loads, imposed (operational) loads, environmental loads, deformation loads - loads associated with imposed deformations and imposed strains; and accidental loads, results from accidental events, such as collision, dropped objects, fire and explosion and other abnormal events.

17.7.13.9.4 For the interaction between Hornsea Four and the pipelines, dropped object accidental loads are the only relevant potential hazards that could arise from this interaction.

Potential Consequences

17.7.13.9.5 Loss of containment from rupture of flowlines due to dropped objects from Hornsea Four construction (cable crossings, cable lay vessels, and other construction works) and supply / support vessels during installation and maintenance of Hornsea Four.

Existing Safeguards / Controls

17.7.13.9.6 As per Offshore Technology Report 2001/013 (HSE, 2002), the pipeline installation should be so designed and, if necessary, protected so that the consequences of damage are acceptable and that an adequate margin of safety is maintained.

17.7.13.9.7 As with the hazards associated with collision, the usual measures employed in controlling the hazards from dropped objects include:

- Inherent safety in design and operation;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection;
- Control through quality assurance, operating envelope, procedures, and barriers;
- Mitigation through: Physical protection and robust structure; and
- The subsea infrastructure will be marked in sea charts and other layout drawings.

Analysis of Risk

17.7.13.9.8 According to section 3.G16 of GASCET (HSE, 2006), the pipeline installation should have been designed and constructed, and/or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards. General requirements for accidental hazards are found in:

- Loads, Offshore Technology Report – OTO 2001/013 (HSE, 2002);
- Petroleum and Natural Gas Industries – Fixed Steel Offshore Structures – ISO 19902 (ISO, 2011);
- Technical Safety – S-001 (NORSOK, 2008);
- Documentation for Operation – Z-001 (NORSOK, 1998);
- Risk and Emergency Preparedness Analysis – Z-013 (NORSOK, 2001); and
- Explosion Resistant Design for Offshore Structures – Technical Note No 4 (SCI, 1996).

17.7.13.9.9 Other requirements are found in DNV RPF-107 – RP Risk Assessment of Pipeline Protection (DNV, 2010).

17.7.13.9.10 Also, the relevant Legislation, ACOP and Guidance that apply includes:

- Offshore Installations Safety Case Regulations – HSE-UK SCR (HSE, 2015);
- Offshore Installations and Wells (Design and Construction, etc) Regulations (HSE, 2008); and
- Assessment Principles for Offshore Safety Cases [APOSC] (HSE, 2016).

17.7.13.9.11 As the relevant UK Continental Shelf Procedures, Legislation, and Guidelines will be adhered to and maintained in designing and installation of the pipeline, it is assumed that all design, prevention and control measures for pipelines installed in the UK Continental Shelf will be adhered to. Therefore, it is not perceived that potential additional risks initiated as a result of Hornsea Four will surpass those for which the pipelines should be designed to withstand. As a result, the introduction of additional risks from this potential initiator is negligible and considered to be broadly acceptable.

17.7.13.9.12 As part of Hornsea Four's commitment Co107 (see Volume A4, Annex 5.2: Commitment Register), crossing and proximity agreements with known existing pipeline and cables operators will be sought.

17.7.13.9.13 Note that consideration will be given to providing mattress protections in vulnerable areas of interference.

17.7.13.10 Seismic Event

17.7.13.10.1 Hornsea Four will not induce / trigger any seismic events. It will however in and around the array area induce a degree of ground shaking during the installation of foundations due to drilling or piling.

17.7.13.10.2 Details of the duration of piling operations in the array area are documented in section 17.7.13.2.

17.7.13.10.3 Around the array area, the ground shaking is not expected to impact the operation of the Harbour Energy's Tier 1 assets, as the expected ground shaking will not be significant.

17.7.13.10.4 The timing and execution of these foundation operations will be planned in consultation between Harbour Energy and Hornsea Four, and these operations will be performed in accordance with good engineering practice. The risk is negligible and therefore considered to be broadly acceptable.

17.7.13.11 Anchor – Snagging / Dropping

17.7.13.11.1 Ships may anchor under various circumstances including the following:

- Normal anchoring:
  - when waiting on berths or for permission to use a controlled channel;
  - when necessary to aid manoeuvring in restricted areas;
  - when performing survey or construction operations; and
  - when performing repairs during the operation and maintenance phase.
- Emergency anchoring:
  - following mechanical breakdown of the propulsion or steering system;
  - following an accident such as major fire or a collision; and
  - to slow down the ship in order to avert a possible collision or ramming or grounding.

17.7.13.11.2 Hazards to pipelines can arise either at the time of anchoring or subsequently if the ship should drag its anchor due to the effects of wind, wave and/or current. A hazard can also arise when the ship tries to retrieve the anchor.

17.7.13.11.3 In normal anchoring, there should be minimal risk to the pipelines, which are shown on charts and may be protected by anchoring exclusion zones. Initially, DNV guidelines shall be adhered to with respect the minimum distance between any existing subsea asset and the placement of any Hornsea Four anchors. These distances shall be discussed and agreed with the subsea asset owner.

17.7.13.11.4 At the time of anchoring, the risk to the pipeline is either that the anchor is dropped onto the pipeline or that the anchor is dragged across the pipeline. If the anchor hooks the pipeline but does not cause immediate damage, there will be a further risk of damage when the ship comes to haul the anchor back in.

17.7.13.11.5 Good seamanship will avert impact from emergency anchoring. Good seamanship involves anchoring well away from pipelines, in water of an appropriate depth (neither too shallow nor too deep) and in an area where the seabed is known to have good anchor holding properties. In addition, under weather conditions when dragging might occur, it is normal good practice to keep engines on standby and to make regular checks on position. Sometimes ships will leave their anchorages if dragging is anticipated.

17.7.13.11.6 The cause of anchors dropping accidentally is mainly due to failure of the brake systems when anchors are made ready for use, i.e., when mechanical securing systems are removed. The risk to the pipeline due to dropping anchors at sea is considered negligible, because the anchors should not be made ready for use and should be secured.

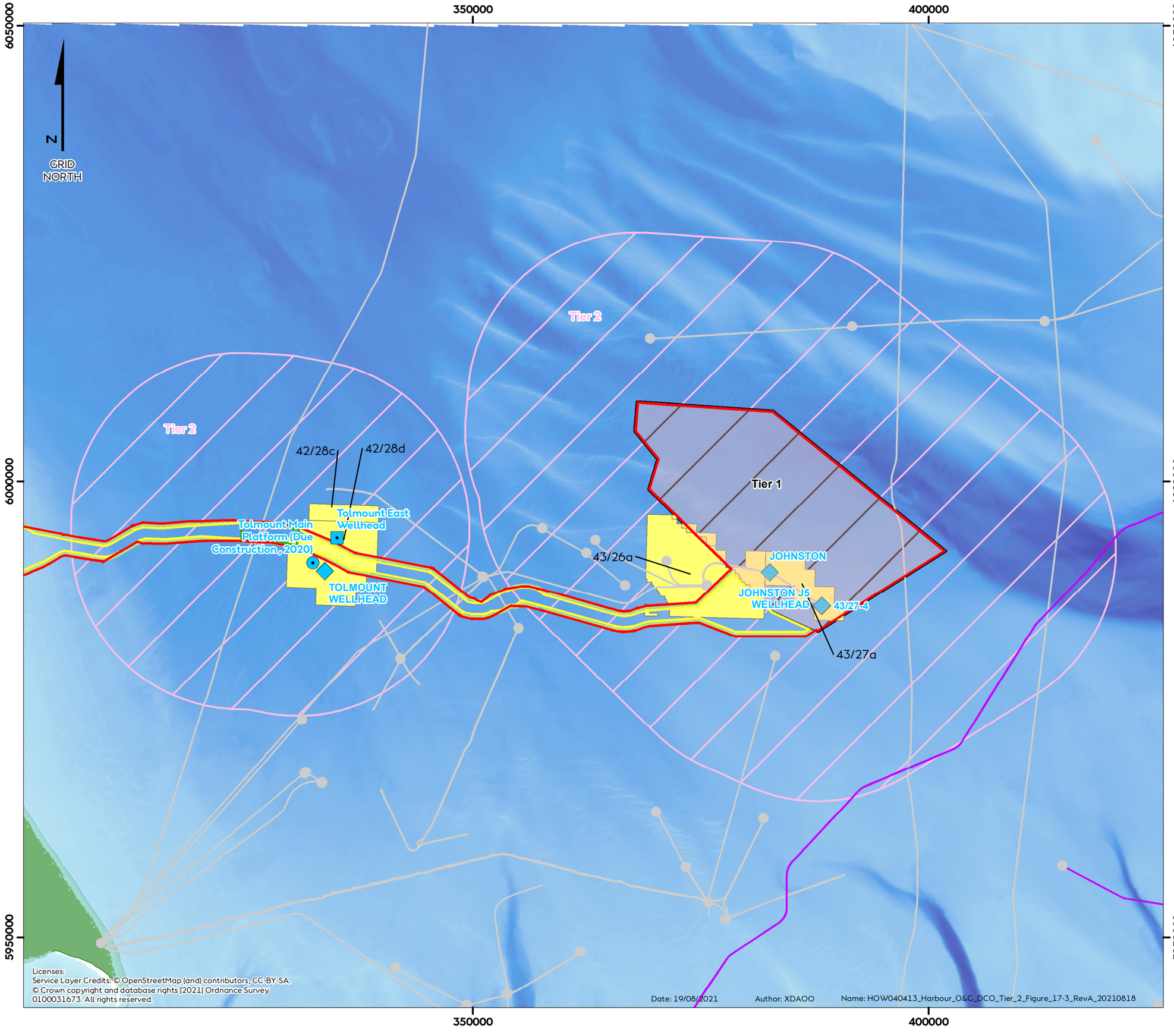
17.7.13.11.7 The Hornsea Four installation operations may include, but not be limited to, survey vessels, clearance vessels, cable installation vessels, cable burial vessels, remedial works vessels and post installation survey vessels, none of which are expected to make use of anchors or anchor spreads but may be required in shallow waters (less than 15 m) or where difficult conditions dictate. The Hornsea Four operations and maintenance operations associated with the export cables will involve mainly external inspection survey vessels, possibly accompanied by Remotely Operated Vehicle (ROV). Remedial protection replenishment may also be required. Such vessels are unlikely to make use of anchors or anchor spreads but may do so should conditions dictate. Should cable inspections, or cable testing identify a need for repair operations, a repair vessel, and associated support vessels will be required, which could involve anchorage. Initially, DNV guidelines shall be adhered to with respect the minimum distance between any existing subsea asset and the placement of any anchors. These distances shall be discussed and agreed with the subsea asset owner..

17.7.13.11.8 Considering the types of vessels that Hornsea Four intends to make use of during installation and maintenance operations, the likelihood of anchor incidents leading to snagging, hooking, or dropping is considered negligible, and therefore the incremental additional risk over and above the existing risk is there considered to be broadly acceptable.

17.8 TIER 2

17.8.1.1.1 Based on the asset screening process, Tier 2 (as defined in Section 4.2, Table 4-2) assets are those that are either within 10 nm of the array area or within 10 nm of the HVAC booster station search area.

17.8.1.1.2 The Harbour Energy Tier 2 assets comprise the locations within 10 nm of the HVAC booster station search area, which includes the Tolmount Main Platform, a NUI constructed in 2020.. This location is shown relative to the HVAC booster station search area in Figure 17-3 and Figure 17-4.



Hornsea Four

Harbour Energy Assets - Tier 2
Figure 17.3

- Harbour Energy Licenses

Oil and Gas Infrastructure

- Platform
- Proposed Wellhead
- Well
- Harbour Energy Subsea
- Other Operators

Pipelines

- Harbour Energy
- Other Operators

Project Layers

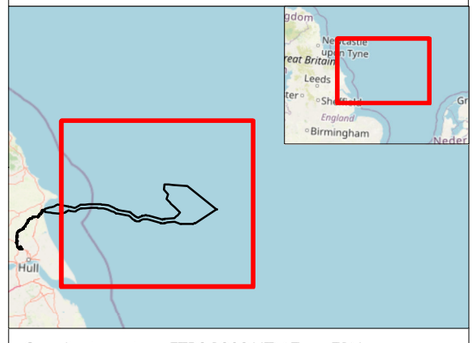
- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Tier Boundaries

- Tier 1 (Array Area)
- Tier 2 (10nm from Array Area / HVAC)

Bathymetry (Below Sea Level)

- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	28/01/2021
A	Reduced Array Area in northwest corner	18/08/2021

Harbour Energy Assets - Tier 2
Document no: HOW040413
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

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17.9 TIER 2 Assessment – Platforms

17.9.1.1.1 This section focuses on the potential impacts on Harbour Energy's Tier 2 assets as a result of Hornsea Four's presence in the area.

17.9.2 Structural Integrity

17.9.2.1.1 This section assesses the impact from interaction between Harbour Energy assets and Hornsea Four on the structural integrity of these Harbour Energy assets. Potential structural integrity issues can arise from the following: seismic events, vessel impact (allision), and helicopter impact (risk due to potential changes in landing approach / take-off as a result of Hornsea Four).

17.9.2.2 Seismic Event

17.9.2.2.1 Hornsea Four will not induce any seismic events. Piling or drilling operations associated with foundation installation for HVAC Booster Station(s) may induce ground shaking.

17.9.2.2.2 If the HVAC technologies are progressed, and as documented in section 4.8.4 of Volume A1, Chapter 4: Project Description, the MDS strike energy for piling within the offshore ECC is 5,000 kJ. It is expected that there will be three (3) HVAC Booster Stations. For HVAC stations on monopiles, there will be a 4-hour piling duration with a total duration of 1.2 days per monopile. For HVAC booster stations on piled jackets, the jackets will have a total of 72 pins with each jacket having 6 legs and 4 piles per leg. Although piling will not be a continuous operation, the duration of HVAC Booster Station(s) foundation installation would be less than two months for each platform. The duration of the impact piling component of the HVAC Booster Station(s) installation campaign is expected to be a maximum of 12 months.

17.9.2.2.3 The ground shaking is not expected to impact the integrity of the Tolmount facilities (main platform and surface or subsurface infrastructure).

17.9.2.2.4 The timing and execution of these foundation operations will be planned in consultation between Harbour Energy and Hornsea Four, and these operations will be performed in accordance with good practice.

17.9.2.2.5 As the Tolmount NUI is more than 500 m from the Hornsea Four Order Limits, it is not anticipated that the cable installation operation will compromise the assets operations, including vessel access, as the proximity from the platform will be taken into consideration.

17.9.2.2.6 The potential for impact from seismic events on Tier 2 platform within 10 nm of the HVAC Booster Station(s) search area is considered **broadly acceptable**.

17.9.2.3 Vessel Impact

17.9.2.3.1 As some vessel routes may be changed, and the vessels taking these routes deviated due to the presence of Hornsea Four, allision risks due to these deviations from existing routes can potentially increase the risk of structural damage to the Harbour Energy Tier 2 platform.

17.9.2.3.2 A vessel allision study, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report was performed for assets close to Hornsea Four in terms of potential changes in allision risk, considering deviations to both routine support vessel routeing and third-party traffic. Spacing / proximity issues relative to the Hornsea Four structures were also considered.

17.9.2.3.3 It should be considered that proximity between offshore installations and passing traffic is a primary factor affecting allision risk. On this basis, the assessment of allision risk undertaken has focused on changes to traffic patterns passing within 2 nm of the relevant assets as a result of Hornsea Four.

Potential Consequences

17.9.2.3.4 Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage and reduced remaining platform life.

Existing Safeguards / Controls

- 500 m safety zone;
- Inherent safety (best design practice);
- Suitable safety factors (fatigue, applied loading, etc);
- Control measures (management/structural);
- Visual and radar;
- Platform mounted radar – Radar Early Warning System (REWS) uses the radar returns to monitor and track vessels within the detection region; and
- Stand-By Vessels (SBVs), communications and procedures (Including vessel contracting and suitability, inspections, marine operations and combined operations).

Analysis of Risk

17.9.2.3.5 As stated in section 7.3.2 of the of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, it was observed that the only routes requiring deviation are routes 6 and 9, which are predicted to shift to the west to avoid the likely HVAC booster station locations, which results in traffic moving away from the Tolmount NUI.

17.9.2.3.6 As per proximity assessments conducted and presented in section 7.4 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, vessel numbers within 2 nm of the Tolmount NUI are anticipated to decrease by one (1) vessel per day following the installation of the HVAC booster stations.

17.9.2.3.7 Based on the worst-case assessment routeing of the Navigational Risk Assessment (NRA) (see **Volume A5, Annex 7.1: Navigational Risk Assessment**), it is anticipated that vessels currently intersecting the HVAC booster station search area will generally pass further to the west as a result of the booster stations, if a HVAC transmission option is selected. This would still represent a reduction in allision risk overall, given vessels will be passing further from the assets. The risk is therefore assessed to be **broadly acceptable**.

17.9.2.3.8 It is noted that the Hornsea Four design envelope currently includes both HVAC and High Voltage Direct Current (HVDC) transmission technologies to allow a necessary degree of flexibility. Hornsea Four may use HVAC or HVDC transmission or could use a combination of both technologies in separate electrical systems. If HVDC technologies are chosen, there will be no Offshore Substation(s) (OSS) present within the offshore ECC. Therefore, in the event that HVAC technologies are not taken forward, the interface with the Tolmount NUI presented in this sub-section will no longer be relevant.

17.9.2.3.9 Also, for the duration of the construction period, Hornsea Four will monitor and report annually, vessel traffic as per Co98 (see Volume A4, Annex 5.2: Commitment Register).

17.9.2.4 Helicopter Impact

17.9.2.4.1 This subsection addresses the potential for CAT helicopter impact with Tier 2 assets, resulting in structural damage / integrity issues.

17.9.2.4.2 As a result of the presence of Hornsea Four, the helicopter impact risk with the potential for structural damage can result from changes in landing approach or take-off.

Potential Consequences

17.9.2.4.3 Impact risk due to potential changes in landing approach / take-off as a result of Hornsea Four.

Existing Safeguards / Controls

- Safety and Environmental Critical Element (SECE) Verification (EASA/ CAA Regulations also apply);
- No flying during unsafe conditions;
- Company transportation policy / procedures;
- Correct operational procedures;
- Competent personnel;
- Helicopter monitoring; and
- Communications.

Analysis of Risk

17.9.2.4.4 It is anticipated that helicopter impacts are more likely to occur if landing is attempted in unsafe conditions. As helicopter landing during unsafe conditions is not permitted, it is considered that there will be no incremental additional risk to structural integrity as a result of helicopter transport.

17.9.2.4.5 As addressed in ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, the helicopter approach and take-off will not be affected as a result of the presence of Hornsea Four due to flight procedures and regulations taking account of all obstacles, so the severity and probability of helicopter impact remains unchanged. The risk to safety is therefore assessed to be broadly acceptable. Note that in the case of an emergency, Hornsea Four will not restrict SAR aircraft access to nearby installations.

17.9.2.4.6 The potential impacts to access for helicopters supporting O&G operations in proximity of Hornsea Four are addressed in section 17.11.5 and 17.11.7 of this report.

17.9.3 Loss of Maritime Integrity – Loss of Stability

17.9.3.1.1 As there are no floating Harbour Energy platform installations in the Tier 2 grouping this impact is not considered applicable.

17.9.4 Loss of Maritime Integrity – Loss of Position

17.9.4.1.1 As there are no floating Harbour Energy platform installations in the Tier 2 grouping this impact is not considered applicable.

17.9.5 Vessel Access (Deviation) – Construction and Operations

17.9.5.1.1 This section assesses the potential impacts in relation to access to O&G assets that may arise as a result of the construction and operation of Hornsea Four.

17.9.5.1.2 A vessel access impairment study was performed, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report for assets close to Hornsea Four. The assets within 10 nm were screened to identify which may be affected in terms of access to the structures. Deviations to offshore routine support vessel (e.g., supply and standby) routeing relative to the Hornsea Four structures were considered.

17.9.5.1.3 During construction of Hornsea Four, a number of vessel types, including installation, cable laying, supply / support vessels, will be required within the ECC and HVAC search area. This combined with vessel route changes and vessel deviations, means that the potential for impaired access during this period may increase.

Potential Consequences

- Impairment of vessel access to platforms; and

- Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage .

Existing Safeguards / Controls

- The existing safeguards / controls for allision risks are listed in the safeguards / controls for allision risk – section 17.9.2.3; and
- Existing routeing for support vessels – majority of the support vessels making routine visits will originate from either Great Yarmouth or Lowestoft.

Analysis of Risk

HVAC Booster Station Search Area:

17.9.5.1.4 As per section 8.3.2 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report , the majority of vessels visiting the Tier 2 assets within 10 nm of the HVAC booster station search area do so from Lowestoft or Great Yarmouth, and as such will approach from the south. On this basis, no notable deviations are likely for routine routeing to the Tolmount NUI.

17.9.5.1.5 Given that there are no deviations for assets within 10 nm of the HVAC booster station search area, the safety risks associated with access to the Tolmount NUI will remain unchanged as a result of Hornsea Four and is considered to be of **broadly acceptable**.

17.9.5.1.6 Also, advance warning and accurate location details of construction, maintenance, and decommissioning operations, associated Safety Zones and advisory passing distances will be given as per Co89 (see Volume A4, Annex 5.2: Commitment Register).

17.9.6 Vessel Access (Proximity) – Construction and Operations

17.9.6.1.1 This section assesses the potential impacts in relation to access to O&G assets that may arise as a result of the construction and operation of Hornsea Four.

17.9.6.1.2 A vessel access impairment study was performed, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report for assets close to Hornsea Four. The assets within 10 nm were screened to identify which may be affected in terms of access to the structures. Spacing / proximity issues relative to Hornsea Four structures were considered.

17.9.6.1.3 During construction of Hornsea Four, a number of vessels, including installation, cable laying, supply / support vessels, will be required within the array area. This combined with vessel route changes and proximity of HVAC booster station and associated works may restrict access to O&G platforms and subsurface infrastructure during certain periods (e.g., allowable weather).

Potential Consequences

- Impairment of vessel access to platforms due to proximity of wind turbines and associated works; and
- Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage and reduced remaining life.

Existing Safeguards / Controls

- The existing safeguards / controls for allision risks are listed in the safeguards / controls section 17.9.2.3; and
- Existing routeing for support vessels – majority of the support vessels making routine visits will originate from either Great Yarmouth or Lowestoft.

Analysis of Risk

HVAC Booster Station Search Area:

17.9.6.1.4 As noted in section 8.3.2 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, in terms of the Tolmount NUI, following responses to the Section 42 consultation, both the offshore ECC and the HVAC booster station search area were refined between the Preliminary Environmental Information Report (PEIR) and Environmental Statement (ES) stages, as captured in Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure, to increase spacing available. This represents a material change resultant of consultation, and further discussions with Harbour Energy (then Premier Oil) indicated that the refined areas are considered suitable in terms of proximity, assuming ongoing discussions to ensure effective coexistence. The Tolmount NUI is to be positioned 1.3 nm from the HVAC booster station search area, however it should be considered that this is a worst-case distance, noting that if HVAC booster stations are utilised then they could be positioned anywhere within the search area.

17.9.6.1.5 Based on the statement above, and in terms of proximity from the HVAC Booster Station, it is perceived that safety risks associated with Tolmount NUI will remain unchanged.

17.9.6.1.6 The safety risk associated with proximity between Hornsea Four HVAC booster station search area and the Tolmount NUI is considered to be of **broadly acceptable**.

17.9.6.1.7 Also, advance warning and accurate location details of construction and maintenance operations, associated Safety Zones and advisory passing distances will be given as per Co89 (see Volume A4, Annex 5.2: Commitment Register).

17.10 TIER 2 Assessment – Platform Systems

17.10.1.1.1 This section focuses on the potential impacts on Harbour Energy's Tier 2 platform system as a result of Hornsea Four's presence in the area.

17.10.1.1.2 Hazard guide words have been employed, and were developed from GASCET (HSE, 2006) and extended to incorporate specific operational concerns. These are: loss of containment – process; loss of containment – pipelines; loss of containment – fire & explosion; and emergency response.

17.10.2 Loss of Containment – Process

17.10.2.1.1 The Tier 2 assets comprise surface and subsea infrastructure within 10 nm of the array area or the HVAC Booster Station(s) Search area.

17.10.2.1.2 This section addresses loss of containment from process plant and process operations. According to GASCET (HSE, 2006) hazard sources for process systems include process equipment such as pressure vessels, heat exchangers, pipeline risers, flexible hoses, etc.

17.10.2.1.3 Process systems are the primary responsibility of the duty holder and constrained to within the 500 m safety zone. The presence of Hornsea Four will not result in loss of containment from process systems, as all Hornsea Four operations and operations remain outside these safety zones. The risk is therefore not considered applicable.

17.10.3 Loss of Containment – Pipelines

17.10.3.1.1 This section addresses loss of containment from pipelines and piping systems associated with the platform systems and constrained within 500 m of the platform. According to GASCET (HSE, 2006) hazard sources for the platform pipeline systems include fixed and flexible risers, emergency shutdown valves, and subsea isolation systems, etc.

17.10.3.1.2 These systems are the primary responsibility of the duty holder and constrained to within the 500 m safety zone. The presence of Hornsea Four will not result in loss of containment from process systems, as all Hornsea Four operations and operations remain outside these safety zones. The risk is therefore **not considered applicable**.

17.10.3.1.3 However, the impact of Hornsea Four's presence on associated pipeline systems (outboard and intra-field pipelines) is addressed in section 17.11.15 of this report.

17.10.4 Loss of Containment – Fire & Explosion

17.10.4.1.1 With the 500 m safety zone, Hornsea Four will have no impact on process hazards leading to fire and explosions on Harbour Energy platform systems.

17.10.4.1.2 The potential for loss of containment leading to fires and explosions is addressed for associated systems in section 17.11.15 below.

17.10.5 Emergency Response

17.10.5.1.1 This section focuses on the impact (impairment / delay) Hornsea Four's presence in the area may have on Harbour Energy's emergency response arrangements associated with their Tier 2 assets. Harbour Energy's emergency response arrangements will include the following:

- Emergency Response Management;
- Alarms and Communication;
- Temporary Refuge and Muster Stations;
- Access / Egress Routes;
- Evacuation;
- Escape;
- Rescue and Recovery;
- Emergency Lighting; and
- Emergency Communications.

17.10.5.1.2 The HSE UK, Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations (HSE, 2016) and associated Schedules contain specific requirements for emergency response to major accident hazards on installations. It is assumed that Harbour Energy's current emergency response arrangements comply with the relevant statutory provisions governing the operations listed above.

Potential Consequences

17.10.5.1.3 Impairment or delay of emergency response arrangement could potentially lead to injury / fatality of personnel.

Analysis of Risk

17.10.5.1.4 It is not considered that Hornsea Four will have any impact on emergency response systems on the Tier 2 installations, i.e., access / egress, alarms and communication (including emergency communications), escape, emergency lighting on installations, temporary refuge and muster stations.

17.10.5.1.5 Other emergency responses would typically include provision of primary and secondary means of evacuation and escape from these installations, e.g., helicopter, TEMPSC, sea transfer and bridge-link; some necessitating arrangements with others.

17.10.5.1.6 It is considered that these primary and secondary means of evacuation and escape from Tier 2 installations will not be impaired. As stated in section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, for emergency conditions, i.e. down manning of any installation, critical Medivacs and SAR are generally flown by the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as State Aircraft under National Regulations and are not constrained by EASA Regulations.

17.10.5.1.7 As the preferred means of evacuation from the offshore Tier 2 asset area are helicopter and via sea transfer, details of the impact of Hornsea Four on access via vessel and helicopter are discussed in the following sections:

- Vessels – sections 17.9.2.3 and 17.9.5; and
- Helicopter – sections 17.11.5 and 17.11.7.

17.10.5.1.8 In considering the assessment of vessel and helicopter access for emergency response purposes there will be no risk of delay or impairment of emergency response systems required around Tier 2 assets. Note that, as per Prevention of Fire and Explosion, and Emergency Response (PFEER) Regulation 17, other response systems (TEMPSC, etc.) must always be present. The incremental additional risk is considered negligible and is therefore broadly acceptable.

17.11 TIER 2 Assessment – Associated Systems

17.11.1.1.1 This section focuses on the impact on Harbour Energy's Tier 2 assets as a result of Hornsea Four's presence in the area. Associated systems comprise other equipment and operations that are associated with, but not part of, the installations and platform systems.

17.11.1.1.2 Hazard guide words have been employed, and were obtained from GASCET (HSE, 2006) and extended to incorporate specific operational concerns. The guide words employed are: wells; diving; human factor; helicopter – impaired access to O&G platforms and to O&G vessels; helicopter – deferred access to support O&G operations; seismic survey operations; drilling (array and ECC) operations; construction (array and ECC) operations; non-process fires & explosions; communication / control (microwave); REWS impairment; closest point of approach alarms; and loss of containment – outboard pipelines / intra-field pipelines.

17.11.2 Wells

17.11.2.1.1 Hazards to the Tier 2 wells could arise from the following initiators:

- Vibration (i.e., from Piling / drilling of HVAC Booster Station foundations);
- Dropped objects from vessels;
- Anchor spread from vessels, e.g., work boats or DSV; and
- Interaction between plough and wellhead.

Potential Consequences

17.11.2.1.2 Well integrity compromise with the potential of blowout / spillage.

Existing Safeguards / Controls

- Subsea protection structure;
- Inherent Safety Practices;
- Competent Personnel;
- Control Measures via existing marine procedures, e.g., NtM;

- SIMOPS will be performed prior to Hornsea Four field operations; and
- 500 m safety zone around assets.

Analysis of Risk

17.11.2.1.3 Considering the relative footprint of the Harbour Energy wellhead compared to that of Hornsea Four's operation, the likelihood of a dropped object strike is considered negligible.

17.11.2.1.4 Anchor spread for vessels supporting the construction and operations in Hornsea Four will be controlled by SIMOPS, expected works will be published in NtM; Given that wellheads are generally not found close to shore (water depths less than 15 m), the use of anchor spreads is not expected. However, they may be required for cable jointing or repair works, or to assist construction vessels where conditions dictate.

17.11.2.1.5 Also considering the distance of the wellhead (i.e., over 4 km, approximately) from the Hornsea Four HVAC Booster Station foundations, there is less risk of Hornsea Four interfering with the existing wells in the Tolmount gas field.

17.11.2.1.6 Given the existing operational procedures, installation methods, and SIMOPS methods, the likelihood of a strike between a trenching plough and a well head is considered negligible.

17.11.2.1.7 The likelihood of compromising well integrity is considered remote given the above listed existing safeguards and controls. Hence, the incremental additional risk of compromise to the Tier 2 asset is considered **broadly acceptable**.

17.11.3 Diving

17.11.3.1.1 This section focuses on potential impact on Harbour Energy's diving operations (temporary impact upon access for pipeline repair / maintenance, etc.) due to the implementation and operation of Hornsea Four.

Potential Consequences

- The safety of divers is compromised due to Hornsea Four construction / operations; and
- Delay in diving maintenance, including inspection and repair operations.

Existing Safeguards / Controls

- No diving operations in unsafe conditions; and
- Co-existence procedures.

Analysis of Risk

17.11.3.1.2 It is anticipated that temporary restrictions to diving operations for maintenance / repair may occur during installation of Hornsea Four. Through detailed discussions, planning, and good SIMOPS practices by both parties, these potential access restrictions can be avoided.

17.11.3.1.3 The temporary piling / drilling operations associated with the HVAC Booster Station installation could lead to acoustic vibrations which may have an impact on diving operations. Diving near subsea assets associated with the Tolmount assets should be avoided during such operations. This will be managed via standard site installation communication between interested parties.

17.11.3.1.4 Given the management of operations via communication and in consultation between Hornsea Four and Harbour Energy, it is considered that the incremental additional safety risks associated with diving operations for the Tolmount assets is negligible, and therefore considered to be **broadly acceptable**.

17.11.4 Human Factor

17.11.4.1.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

17.11.4.1.2 This section addresses human factors associated with Hornsea Four construction and operations that may pose a hazardous impact Harbour Energy's Tier 2 operations.

17.11.4.1.3 For the analysis of Harbour Energy's Tier 2 operations the most relevant subjects are Hornsea Four navigation, station holding and/or the potential of drifting close to or around the route of the platform, due to operations associated with installation, inspection or maintenance.

17.11.4.1.4 Human errors can occur both in the conceptual and design phases as well as operational phases of a project. Human errors, that have the potential to result in MAHs, in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

17.11.4.1.5 The impact of human factors is the same for all Harbour Energy assets regardless of Tier grouping and is addressed in section 17.7.4 of this report.

17.11.4.1.6 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the risk of impact from human factors is considered broadly acceptable.

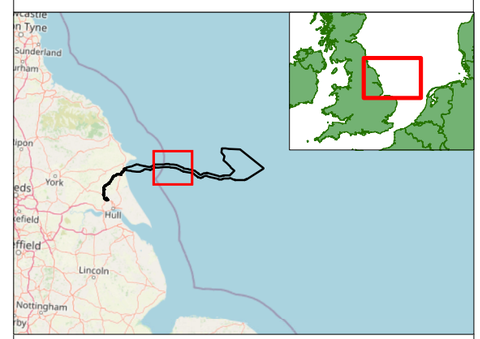
Hornsea Four

HVAC Booster Station Search Area
Design Evolution relative to Tolmount
Figure 17.4

- Order Limits
- HVAC Booster Station Search Area (DCO)
- HVAC Booster Station Search Area (PEIR)
- Offshore Export Cable Corridor
- Offshore Temporary Works Area

Tolmount Layers

- Platform
- Proposed Wellhead
- Tolmount Pipeline Route



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:100,000

0 1.25 2.5 5 Kilometers

0 0.5 1 2 Nautical Miles

REV	REMARK	DATE
	First Issue	28/01/2021
A	Reduced Array Area in northwest corner	18/08/2021

HVAC Booster Station Search Area
Design Evolution relative to Tolmount
Document no: HOW040417
Created by: JOHLE
Checked by: XDAOO
Approved by: ELEAN

Ørsted

Date: 19/08/2021 Author: XDAOO Name: HOW040417_HVAC_Booster_Station_Search_Area_Evolution_Tolmount_Main_Figure_17-4_RevA_20210818

17.11.5 Helicopter – Impaired Access to O&G Platforms (CAT)

17.11.5.1.1 This subsection addresses the potential for impaired access by CAT operated helicopter to Harbour Energy's Tier 2 platform, and the associated additional safety impact.

17.11.5.1.2 In assessing this potential impact, a study on Helicopter access, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, was performed and applied the CAT weather limits, as a series of filters, to the meteorological data provided by a duty holder with platform assets close to the array area and ECC, in order to understand the potential operational impact on the installations. The assessment focused on identifying reduced access when operating under CAT Regulations, but access under SAR Regulations was also considered.

17.11.5.1.3 The helicopter access data for the platforms assessed is presented in Appendix A1 (Platform Specific Data) of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

17.11.5.1.4 The potential for impaired access to O&G platforms could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Reduction of access to platform;
- Helicopter incident; and
- Potential restriction to flying due to other restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication; and
- Operational procedures / personnel training.
- For emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The coastguard helicopters are operated as state aircraft under national regulations and are not constrained by EASA Regulations. As Coastguard SAR Operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, the wind farm will not restrict SAR aircraft access to nearby installations – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

Analysis of Risk

17.11.5.1.5 As per section 3.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, assets at distances greater than 10 nm from the Hornsea Four array area will not be impacted or restricted by the installation of Hornsea Four. Furthermore, they are outside the 9 nm consultation zone guidance required by CAP 764 (CAA, 2016)..

17.11.5.1.6 Considering the distance (greater than 35 km) between Harbour Energy's Tier 2 platform and the array area, it is considered that the presence of Hornsea Four WTGs will have no impact on helicopter access for Harbour Energy.

17.11.5.1.7 Following responses to consultation with Premier Oil – see Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure, in order to increase spacing between Hornsea Four HVAC booster station area and Tolmount NUI, both the offshore ECC and the HVAC booster station search area have been refined between the PEIR and Development Consent Order (DCO) application stages – see Figure 17-4.

17.11.5.1.8 On the basis of the above assessment, there will be no additional risk to safety brought about by the presence of Hornsea Four. Therefore, the safety risk associated with helicopter transport to and from the Tolmount NUI will remain unchanged and therefore considered to be broadly acceptable.

17.11.5.1.9 Also, as per Co102 (see Volume A4, Annex 5.2: Commitment Register), the Defence Infrastructure Organisation and the CAA, MCA and operators will be informed of the locations, heights, and lighting status of the Hornsea Four infrastructure, including estimated and actual dates of construction and the maximum height of any construction equipment to be used, prior to the start of construction, to allow inclusion on Aviation Charts.

17.11.6 Helicopter – Impaired Access to O&G Platforms (SAR)

17.11.6.1.1 This subsection addresses the potential for impaired access by SAR operated helicopter to Harbour Energy's Tier 2 platform, and the associated additional safety impact.

17.11.6.1.2 In assessing this potential impact on helicopter transport, a study was performed on Helicopter access and deviation, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report. In the assessment access under SAR Regulations was considered.

17.11.6.1.3 The potential for impaired access to O&G platforms could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Reduction of access to platform;
- Helicopter incident; and
- Potential restriction to flying due to other restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training;
- For emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The coastguard helicopters are operated as state aircraft under national regulations and are not constrained by EASA Regulations. As Coastguard SAR Operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to nearby installations – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report; and
- MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training are more advanced than that available to CAT helicopters.

Analysis of Risk

- Take-off limitations – there are no take off limitations on SAR operated helicopter flights imposed by the presence of Hornsea Four; and
- Approach limitations – there are no approach limitations on SAR operated helicopter flights imposed by the presence of Hornsea Four.

17.11.6.1.4 On the basis of the above assessment, the presence of Hornsea Four will not impose any restrictions on SAR aircraft access to nearby installations. The risk is considered broadly acceptable.

17.11.7 Helicopter – Impaired Access to O&G Vessels (CAT)

17.11.7.1.1 This subsection addresses the potential for impaired access of CAT operated helicopter to O&G vessels associated with Tier 2 operations, and the associated additional safety impact.

17.11.7.1.2 The potential for impaired access to O&G vessels associated with Tier 2 operations could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter incident; and
- Potential restriction to flying due to restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication; and
- Operational procedures / personnel training.

Analysis of Risk

17.11.7.1.3 In terms of navigational failure, this consideration is already built into the helicopter systems procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

17.11.7.1.4 In consideration of extreme weather / environmental conditions, the operational regulations already include weather limits, and these will not change with the presence of Hornsea Four.

17.11.7.1.5 As stated in section 4.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, it was observed that under stated conditions, O&G platforms adjacent to Hornsea Four will not be subject to approach limitations. Helicopter approach and take-off will not be affected due to flight procedures and regulations taking account of all obstacles. This will also apply for O&G platforms like Tolmount NUI which are much further away from Hornsea Four array area. Consequently, it is considered that the vessels associated with the O&G platform will also not be subject to approach limitations.

17.11.7.1.6 On the basis of the above assessment, there will be no additional risk to safety brought about by the presence of Hornsea Four. Therefore the safety risk associated with helicopter transport to and from vessels in Tier 2 will remain unchanged and so is considered broadly acceptable.

17.11.8 Helicopter – Impaired Access to O&G Vessels (SAR)

17.11.8.1.1 This subsection addresses the potential for impaired access of SAR operated helicopters to O&G vessels associated with Tier 2 operations, and the associated additional safety impact.

17.11.8.1.2 The potential for impaired access to O&G vessels associated with Tier 2 operations could arise from the following initiators:

- Proximity of tall structures / obstacles leading to wind turbulence;

- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter incident; and
- Potential restriction to flying due to restrictions given by Hornsea Four

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training;
- For emergency conditions, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as state aircraft under national regulations and are not constrained by EASA Regulations. As Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to vessels attending Harbour Energy's nearby facilities; and
- MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training are more advanced than that available to CAT helicopters.

Analysis of Risk

17.11.8.1.3 In terms of navigational failure, this consideration is already built into the helicopter systems procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

17.11.8.1.4 In consideration of extreme weather / environmental conditions, the operational regulations already include weather limits, and these will not change with the presence of Hornsea Four.

17.11.8.1.5 As stated in section 4.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, it was observed that Hornsea Four's presence will not impose on installations adjacent to Hornsea Four. Consequently, it is considered that the vessels associated with the O&G platform will also not be subject to imposition / effects from Hornsea Four.

17.11.8.1.6 On the basis of the above assessment, there will be no additional risk to safety brought about by the presence of Hornsea Four. Therefore, the safety risk associated with helicopter transport to and from vessels in Tier 2 will remain unchanged and so is considered broadly acceptable.

17.11.9 Seismic Survey Activities

17.11.9.1.1 Seismic surveillance activities may be required in the future, around the Hornsea Four array. At the time of such activity, it is proposed that a co-existence plan will develop how the performance of such activity will be implemented without undue risk in the interfaces.

17.11.9.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

17.11.10 Drilling (Array Area) Activities

17.11.10.1.1 Exploration and appraisal drilling may be required around the Hornsea Four array area. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

17.11.10.1.2 There have been recent drilling campaigns in the Irish Sea taking place in and around existing offshore wind farms. This presents an example that with adequate planning offshore wind and O&G infrastructures can coexist.

17.11.10.1.3 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

17.11.11 Drilling (ECC Area) Activities

17.11.11.1.1 Exploration and appraisal drilling may be required around the ECC area, including within close proximity to the HVAC Booster Station Search Area. At the time of such activity, it is proposed that a co-existence plan will develop how the performance of such activity will be implemented without undue risk in the interfaces.

17.11.11.1.2 There have been recent drilling campaigns in the Irish Sea taking place in and around existing offshore wind farms. This presents an example that with adequate planning offshore wind and O&G infrastructures can coexist.

17.11.11.1.3 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable

17.11.12 Construction (Array Area) Activities

17.11.12.1.1 Harbour Energy may want to construct new production facilities around the Hornsea Four array area. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

17.11.12.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

17.11.13 Construction (ECC Array) Activities

17.11.13.1.1 Harbour Energy may want to construct new production facilities in the field around the ECC. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

17.11.13.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

17.11.14 Non-Process Fires & Explosions

17.11.14.1.1 Non-process fires and explosions are typically associated with non-process plants. In the case of Hornsea Four, this could be electrical fires associated with the HVAC booster station platform, and the offshore substations within the array.

17.11.14.1.2 Considering the HVAC booster station is more than 2 km from the nearest Tier 2 assets, it is considered that the impact of electrical fires on Harbour Energy's Tier 2 assets are negligible, and therefore broadly acceptable.

17.11.15 Loss of Containment – Outboard Pipelines / Intra-field Pipelines

17.11.15.1.1 At the time of conducting this assessment, the Tolmount to Easington pipeline is under construction. The analysis conducted below takes into consideration the potential hazards associated with the outboard pipelines.

17.11.15.1.2 It is understood that Harbour Energy plans to construct a pipeline between Tolmount East and the Tolmount Main NUI. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

17.11.15.1.3 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

17.11.15.1.4 According to GASCET (HSE, 2006), the relevant hazardous events with the potential for damage to the outboard / intra-field pipelines resulting in loss of containment could result from the following hazard initiators: fatigue / vibration; incorrect installation; violation; operator error – inadequate training / competency; deficient procedures – operational / maintenance; vessel impact; dropped objects (i.e. dropped cargo) / abnormal external load; seismic event; and anchor – snagging / dropping.

17.11.15.2 Fatigue / Vibration

17.11.15.2.1 Operations associated with installation of the HVAC Booster Station foundations could involve piling or drilling dependent on the selected foundation method which is also dependent on ground conditions.

Potential Consequences

17.11.15.2.2 Loss of containment due to flowline vibration triggered by drilling / piling.

Existing Safeguards / Controls

- Inherent Safety (including fully rated pipelines, inherent impact resistance, pipe burial and trenching (where applicable);
- Good procedures and Competent personnel associated with installation and operation of Hornsea Four;
- Isolation and PTW controls; and
- Pre-operation strength and leak testing.

Analysis of Risk

17.11.15.2.3 Based on previous experience the expected strike energy for piling would typically be 3,000 kJ and could increase to 5,000 kJ. Details of the duration of piling operations in the HVAC booster station search area and the array area are documented in section 17.9.2.2.

17.11.15.2.4 The timing and execution of these foundation operations will be planned in consultation between Harbour Energy and Hornsea Four, and these operations will be performed in accordance with good practice.

17.11.15.2.5 Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the PEIR boundary, with a further reduction adopted for the ES and DCO application due to the results of the PEIR, technical considerations and stakeholder feedback. This concession is considered in the assessment.

17.11.15.2.6 Considering the distance of the drilling and piling areas to the pipeline (over 2.5 km to the HVAC booster station search area), the potential ground shaking and associated vibration in the surrounding area is expected to dissipate before reaching the pipeline, and as such, there will be negligible impact to the pipeline. The risk is therefore considered to be broadly acceptable.

17.11.15.2.7 The temporary piling / drilling operations associated with the HVAC Booster Station(s) and array installations could also lead to acoustic vibrations which could have an adverse effect on diving. Diving near the pipeline should be avoided during such operations. This will be managed via standard site installation communication between interested parties.

17.11.15.3 Incorrect Installation

17.11.15.3.1 Incorrect installation of the Hornsea Four export cables has the potential to impact the pipelines at their crossing points within the ECC due to additional hazards over and above the pipeline design criteria.

17.11.15.3.2 As there are no intra-field pipeline-ECC crossings, this impact is not considered applicable.

17.11.15.4 Operator Error – Inadequate Training / Competency

17.11.15.4.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

17.11.15.4.2 For the analysis of the Harbour Energy Tolmount NUI to Easington pipeline the most relevant subjects are Hornsea Four navigation, station holding and/or the potential of drifting close to or around the route of the pipeline, due to vessels operations associated with cable installation, cable inspection or Hornsea Four maintenance.

17.11.15.4.3 Human errors can occur in any phase of a project. Human errors, that have the potential to result in MAHs, in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

17.11.15.4.4 Loss of containment due to incidents caused by personnel incompetency / lack of experience.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

17.11.15.4.5 According to the UK HSE, the O&G asset holder should have a procedure in place for the selection, competence assessment, and training of operations and maintenance personnel and that it is designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

17.11.15.4.6 The HSE standards and codes of practices are referenced to show that in order to operate in the UK Continental Shelf, the O&G asset holders are expected to follow certain requirements.

17.11.15.4.7 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016). Risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel will be employed during the installation, operations and maintenance of the Hornsea Four infrastructure. Incremental additional risk to the pipelines from this potential initiator is considered negligible.

17.11.15.4.8 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the risk of impact from human factors is considered broadly acceptable.

17.11.15.5 Violation

17.11.15.5.1 Human factors involved in the earlier conceptual design stages of the installation lifecycle can influence the likelihood of the occurrence of hazardous event. When installations have not been designed and constructed, and / or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards, a violation is said to have occurred.

Potential Consequences

17.11.15.5.2 Loss of containment due to not following procedure and guidelines.

Existing Safeguards / Controls

- Good procedures; and
- Competent personnel.

Analysis of Risk

17.11.15.5.3 As stated above in section 17.11.15.4 above, human errors can occur in all phases of a project. Human errors, that have the potential to result in MAHs, in the earlier conceptual design stages, can also be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

17.11.15.5.4 The impact of violation is considered similar to 'operator error' and considering that risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel is being employed in the design of the Hornsea Four infrastructure, the introduction of additional risk to the pipelines from this potential initiator is considered negligible. The risk is considered to be broadly acceptable.

17.11.15.6 Deficient Procedures – Operational / Maintenance

17.11.15.6.1 If deficient procedures are applied during the installation, operations, and maintenance of Hornsea Four export cables, there is potential that pipelines with crossings will be affected due to additional hazards over and above the pipeline design tolerance.

17.11.15.6.2 As there are no intra-field pipeline-ECC crossings, this impact is not considered applicable.

17.11.15.7 Vessel Impact

17.11.15.7.1 Vessel impact concerns the potential additional hazards associated with vessel movements in and around the pipeline corridor, due to the presence of Hornsea Four construction and operation. This may include the following types of vessels: standby vessels, supply vessels, DSVs, survey vessels, barges, and cable installation vessels.

17.11.15.7.2 The interaction between vessels and pipelines will potentially result from dropped objects and/ or anchor snagging.

17.11.15.7.3 Dropped object risks are addressed in section 17.11.15.8 of the report.

17.11.15.7.4 Anchor snagging risks are addressed in section 17.11.15.10 of the report.

17.11.15.8 Dropped Objects

17.11.15.8.1 This involves additional hazards to the Tolmount NUI to Easington pipeline as a result of abnormal external load / dropped objects from vessels associated with Hornsea Four.

17.11.15.8.2 According to the Offshore Technology Report 2001/013 (HSE, 2002), the principal categories of load are: dead loads, imposed (operational) loads, environmental loads, deformation loads - loads associated with imposed deformations and imposed strains; and accidental loads, results from accidental events, such as collision, dropped objects, fire and explosion and other abnormal events.

17.11.15.8.3 For the interaction between Hornsea Four and the pipeline, accidental loads are the only relevant potential hazards that could arise from this interaction.

Potential Consequences

17.11.15.8.4 Loss of containment from rupture of flowlines due to dropped objects from Hornsea Four vessels during installation and maintenance of Hornsea Four.

Existing Safeguards / Controls

17.11.15.8.5 As per Offshore Technology Report 2001/013 (HSE, 2002), the pipeline installation should be so designed and, if necessary, protected that the consequences of damage are acceptable and that an adequate margin of safety is maintained.

17.11.15.8.6 As with the hazards associated with collision, the usual measures employed in controlling the hazards from dropped objects include:

- Inherent Safety in design and operation;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection;
- Control through quality assurance, operating envelope, procedures, and barriers; and
- Mitigation through physical protection and robust structure.

Analysis of Risk

17.11.15.8.7 According to section 3.G16 of GASCET (HSE, 2006), the pipeline should have been designed and constructed, and/or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards. General requirements for accidental hazards are found in:

- Loads, Offshore Technology Report – OTO 2001/013 (HSE, 2002);
- Petroleum and Natural Gas Industries – Fixed Steel Offshore Structures – ISO 19902 (ISO, 2011);
- Technical Safety – S-001 (NORSOK, 2008);
- Documentation for Operation – Z-001 (NORSOK, 1998);
- Risk and Emergency Preparedness Analysis – Z-013 (NORSOK, 2001); and
- Explosion Resistant Design for Offshore Structures – Technical Note No 4 (SCI, 1996).

17.11.15.8.8 Other requirements are found in DNV RPF-107 – RP Risk Assessment of Pipeline Protection (DNV, 2010).

17.11.15.8.9 Also, the relevant Legislation, ACOP and Guidance that apply includes:

- Offshore Installations Safety Case Regulations – HSE-UK SCR (HSE, 2015);
- Offshore Installations and Wells (Design and Construction, etc) Regulations (HSE, 2008); and
- Assessment Principles for Offshore Safety Cases [APOSC] (HSE, 2016).

17.11.15.8.10 As the relevant UK Continental Shelf Procedures, Legislation, and Guidelines will be adhered to and maintained in designing and installation of the pipeline, it is assumed that all design, prevention and control measures for pipelines installed in the UK Continental Shelf will be adhered to. Therefore, it is not perceived that potential additional risks initiated as a result of Hornsea Four will surpass those for which the pipelines should be designed to withstand. As a result, the introduction of additional risks from this potential initiator is negligible and considered to be broadly acceptable.

17.11.15.9 Seismic Event

17.11.15.9.1 Hornsea Four will not induce / trigger any seismic events. It will however in and around the HVAC Booster Station(s) induce a degree of ground shaking during the installation of foundations due to drilling or piling.

17.11.15.9.2 Details of the duration of piling operations in the HVAC booster station search area are documented in section 17.9.2.2.

17.11.15.9.3 The timing and execution of these foundation operations will be planned in consultation between Harbour Energy and Hornsea Four, and these operations will be performed in accordance with good engineering practice. The risk is negligible and are considered to be broadly acceptable.

17.11.15.10 Anchor – Snagging / Dropping

17.11.15.10.1 Ships may anchor under various circumstances including the following:

- Normal anchoring:
  - when waiting on berths or for permission to use a controlled channel;
  - when necessary to aid manoeuvring in restricted areas;
  - when performing survey or construction operations; and
  - when performing repairs during the operation and maintenance phase.
- Emergency anchoring:
  - following mechanical breakdown of the propulsion or steering system;
  - following an accident such as major fire or a collision; and
  - to slow down the ship in order to avert a possible collision or ramming or grounding.

17.11.15.10.2 Hazards to pipelines can arise either at the time of anchoring or subsequently if the ship should drag its anchor due to the effects of wind, wave and/or current. A hazard can also arise when the ship tries to retrieve the anchor.

17.11.15.10.3 In normal anchoring, there should be minimal risk to the pipelines, which are shown on charts and protected by anchoring safety zones. The anchor safety zones typically extend at least 0.5 nautical miles to either side of the pipelines.

17.11.15.10.4 At the time of anchoring, the risk to the pipeline is either that the anchor is dropped onto the pipeline or that the anchor is dragged across the pipeline. If the anchor hooks the pipeline but does not cause immediate damage, there will be a further risk of damage when the ship comes to try to haul the anchor back in.

17.11.15.10.5 Good seamanship will avert impact from emergency anchoring. Good seamanship involves anchoring well away from pipelines, in water of an appropriate depth (neither too shallow nor too deep) and in an area where the seabed is known to have good anchor holding properties. In addition, under weather conditions when dragging might occur, it is normal good practice to keep engines on standby and to make regular checks on position. Sometimes ships will leave their anchorages if dragging is anticipated.

17.11.15.10.6 The cause of anchors dropping accidentally is mainly due to failure of the brake systems when anchors are made ready for use, i.e., when mechanical securing systems are removed. The risk to the pipeline due to dropping anchors at sea is considered negligible, because the anchors should not be made ready for use and should be secured.

17.11.15.10.7 The Hornsea Four export cable installation operations may include, but not be limited to, survey vessels, clearance vessels, cable installation vessels, cable burial vessels, remedial works vessels and post installation survey vessels, none of which are expected to make use of anchors or anchor spreads but may be required in shallow waters (less than 15 m) or where difficult conditions dictate. The Hornsea Four operations and maintenance operations associated with the export cables will involve mainly external inspection survey vessels, possibly accompanied by ROV. Remedial protection replenishment may also be required. Such vessels are unlikely to make use of anchors or anchor spreads but may do so should conditions dictate. Should cable inspections, or cable testing identify a need for repair operations, a repair vessel, and associated support vessels will be required, which could involve anchorage. Initially, DNV guidelines shall be adhered to with respect the minimum distance between any existing subsea asset and the placement of any anchors. These distances shall be discussed and agreed with the subsea asset owner.

17.11.15.10.8 It is not envisaged that Hornsea Four vessels will be stationed around the Tolmount NUI to Easington pipeline, and considering the types of vessels that Hornsea Four intends to make use of, the likelihood of anchor incidents leading to snagging, hooking or dropping is considered negligible, and therefore broadly acceptable.

17.12 TIER 3

17.12.1.1.1 As per the tier grouping (as defined in Section 4.2, Table 4-2), Tier 3 assets are defined as those assets not within 10 nm but raised during consultation by a relevant stakeholder; or assets not within 10 nm but where the route to the asset will require deviation as a result of Hornsea Four array area. As a result of this, no Tier 3 assessments have been conducted for Harbour Energy.

17.13 Harbour Energy Summary

17.13.1.1.1 The table below presents the risk summary for the assessment performed for the Harbour Energy assets. The structure of the table is in line with the Tier grouping and order in which the hazards were assessed.

Table 17-2: Hazards and Risk Summary – Harbour Energy

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
TIER 1							
	TIER 1 – PLATFORMS						
							Not Considered Further
	TIER 1 – PLATFORMS SYSTEMS						
							Not Considered Further
	TIER 1 – ASSOCIATED SYSTEMS						
		Wells		All Assets	Unlikely	Minor Damage	Broadly Acceptable
		Diving		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Human Factor		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms		All Assets			Not Considered Further
		Helicopter - Impaired Access to O&G Vessels (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Emergency Response		All Assets	Very Unlikely	Slight Impact	Broadly Acceptable
		Non-Process Fires & Explosions		All Assets	Very Unlikely	Local Damage	Broadly Acceptable
		Loss of Containment - Outboard Pipelines / Intra-field Pipelines	Fatigue / Vibration	All Assets	Unlikely	Slight Damage	Broadly Acceptable
			Incorrect Installation	All Assets	Unlikely	Minor Damage	Broadly Acceptable
			Operator Error – Inadequate Training / Competency	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Violation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Deficient Procedures – Operational / Maintenance	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Vessel Impact	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Decommissioning Access	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Dropped Objects	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
			Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Anchor – Snagging / Dropping	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
TIER 2							
	TIER 2 – PLATFORMS						
		Structural Integrity	Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Vessel Impact	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Helicopter Impact	All Assets	Very Unlikely	Local Damage	Broadly Acceptable
		Loss of Maritime Integrity - Loss of Stability		All Assets			Not Considered Further
		Loss of Maritime Integrity - Loss of Position		All Assets			Not Considered Further
		Vessel Access (Deviation) - Construction and Operations		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Vessel Access (Proximity) - Construction and Operations		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
	TIER 2 – PLATFORMS SYSTEMS						
		Loss of Containment - Process		All Assets			Not Considered Further
		Loss of Containment - Pipelines		All Assets			Not Considered Further
		Loss of Containment - Fire & Explosion		All Assets			Not Considered Further
		Emergency Response		All Assets	Very Unlikely	Slight Impact	Broadly Acceptable
	TIER 2 – ASSOCIATED SYSTEMS						
		Wells		All Assets	Unlikely	Minor Damage	Broadly Acceptable
		Diving		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Human Factor		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Non-Process Fires & Explosions		All Assets	Very Unlikely	Local Damage	Broadly Acceptable

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
		Microwave Communication		All Assets			Not Considered Further
		Loss of Containment - Outboard Pipelines / Intra-field Pipelines	Fatigue / Vibration	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Incorrect Installation	All Assets			Not Considered Further
			Operator Error – Inadequate Training / Competency	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Violation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Deficient Procedures – Operational / Maintenance	All Assets			Not Considered Further
			Vessel Impact	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Dropped Objects	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Anchor – Snagging / Dropping	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
TIER 3							
	N/A	N/A	N/A	N/A			N/A

18 Alpha Petroleum Resources Limited

18.1 Introduction

18.1.1.1.1 Alpha Petroleum is the licence holder of United Kingdom Continental Shelf (UKCS) Blocks 42/25a and 43/21a (P1034), located north of the Development Consent Order (DCO) Order Limits, and Block 43/22a (P683) located to the northeast of the DCO Order Limits on the east side of the array (Figure 18-1). Assets within these licence blocks and owned by Alpha Petroleum are the Garrow and Kilmar Normally Unmanned Installations (NUIs), and various pipelines.

18.1.1.1.2 Alpha Petroleum is considering the following potential future plans:

- Pipeline construction from Kilmar NUI to an as yet undecided host platform to the south of the array; or
- Decommissioning programme for Kilmar and Garrow.

18.1.1.1.3 Note that if Alpha Petroleum does not proceed with the construction of the pipeline, the NUI's will be decommissioned.

18.1.1.1.4 Hornsea Four is aware that potential plans for a pipeline are currently under consideration, but as the required details are not currently available, they have not been considered in this assessment.

18.1.1.1.5 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

18.1.1.1.6 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

18.1.1.1.7 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

18.1.1.1.8 The table below presents the structure of the assessment conducted on the potential hazards resulting from interaction of Alpha Petroleum assets with Hornsea Four. The subsections where each hazard is addressed is also shown in the table.

Table 18-1: Alpha Petroleum Assessment Structure

TIER		Hazards	Sub-Group	Report Section
TIER 1				
	N/A	N/A	N/A	N/A
TIER 2				18.3
	TIER 2 – PLATFORMS			18.4
		Structural Integrity		18.4.2
			Seismic Event	18.4.2.2
			Vessel Impact	18.4.2.3
			Helicopter Impact	18.4.2.4
		Loss of Maritime Integrity – Loss of Stability		18.4.3
		Loss of Maritime Integrity – Loss of Position		18.4.4
		Vessel Access (Deviation) – Construction and Operations		18.4.5

TIER		Hazards	Sub-Group	Report Section
		Vessel Access (Proximity) – Construction and Operations		18.4.6
	TIER 2 – PLATFORM SYSTEMS			18.5
		Loss of Containment – Process		18.5.2
		Loss of Containment – Pipelines		18.5.3
		Loss of Containment – Fire & Explosion		18.5.4
		Emergency Response		18.5.5
	TIER 2 – ASSOCIATED SYSTEMS			18.6
		Wells		18.6.2
		Diving		18.6.3
		Human Factor		18.6.4
		Helicopter – Impaired Access to O&G Platforms (CAT)		18.6.5
		Helicopter – Impaired Access to O&G Platforms (SAR)		18.6.6
		Helicopter – Impaired Access to O&G Vessels (CAT)		18.6.7
		Helicopter – Impaired Access to O&G Vessels (SAR)		18.6.8
		Seismic Survey Activities		18.6.9
		Drilling Activities		18.6.10
		Construction Activities		18.6.11
		Non-Process Fires & Explosions		18.6.12
		Microwave Communication		18.6.13
		Loss of Containment – Outboard Pipelines / Intra-field Pipelines		18.6.14
			Fatigue / Vibration	18.6.14.2
			Incorrect Installation	18.6.14.3
			Operator Error – Inadequate Training / Competency	18.6.14.4
			Violation	18.6.14.5
			Vessel Impact	18.6.14.6
			Dropped Objects	18.6.14.7
			Seismic Event	18.6.14.8
			Anchor – Snagging / Dropping	18.6.14.9
TIER 3				
	N/A	N/A	N/A	N/A

Hornsea Four

Alpha Petroleum Resources Ltd
Assets - DCO Order Limits
Figure 18.1

350000

400000

6000000

N
GRID NORTH

42/25a

GARROW NUI

43/21a

43/22a

KILMAR/SEAL PIPELINE CROSSING

KIMAR NUI

Alpha Petroleum Licenses

Oil and Gas Infrastructure

- Alpha Petroleum Platform
- Alpha Petroleum Terminal
- Alpha Petroleum Subsea
- Other Operators

Pipelines

- Alpha Petroleum
- Other Operators

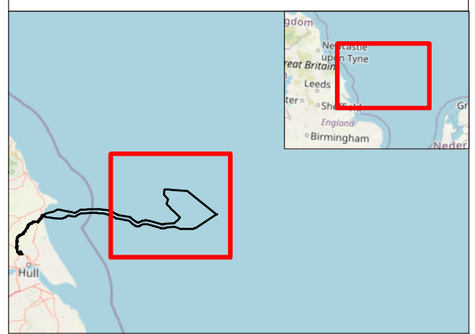
Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)

High : 0

Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:250,000

0 2.5 5 10 Kilometres

0 1.25 2.5 5 Nautical Miles

REV	REMARK	DATE
	First issue	21/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

Alpha Petroleum Assets - DCO Order Limits
Document no: HOW040363
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

Date: 19/08/2021 Author: XDAOO Name: HOW040363_Alpha_Petroleum_O&G_DCO_Boundary_Figure_18-1_RevB_20210818

18.2 TIER 1

18.2.1.1.1 As per the tier grouping, Tier 1 assets are defined as those assets contained within the array area. As all Alpha Petroleum assets are outside the array area, Tier 1 assessments have not been conducted for Alpha Petroleum.

18.3 TIER 2

18.3.1.1.1 Based on the asset screening process, Tier 2 assets (as defined in Section 4.2, Table 4-2) are those that are outside the Hornsea 4 array area but within 10 nm of the Hornsea Four array area.

18.3.1.1.2 The assets within 10 nm of the Hornsea Four array area are shown in Figure 18-2. These are:

- Garrow NUI; and
- Kilmar NUI.

The Garrow NUI is located 7.0 km (3.8 nm) from the Hornsea Four array are, and the Kilmar NUI is located 12.9 km (7.0 nm) from the Hornsea Four array area.

Hornsea Four

Alpha Petroleum Resources Ltd
Assets - Tier 2
Figure 18.2

350000
400000
6050000
6000000
5950000

N
GRID NORTH

GARROW NUI
KILMAR NUI
KILMAR/SEAL PIPELINE CROSSING
42/25a
43/22a
43/21a
Tier 1
Tier 2
Tier 2

Alpha Petroleum Licenses

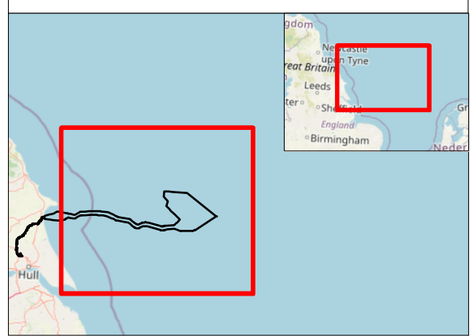
Oil and Gas Infrastructure
- Alpha Petroleum Platform
- Alpha Petroleum Terminal
- Alpha Petroleum Subsea
- Other Operators

Pipelines
- Alpha Petroleum
- Other Operators

Project Layers
- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Tier Boundaries
- Tier 1 (Array Area)
- Tier 2 (10nm from Array Area / HVAC)

Bathymetry (Below Sea Level)
- High : 0
- Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 5 10 20 Kilometres
0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	28/01/2021
A	Reduced Array Area in northwest corner	18/08/2021

Alpha Petroleum Assets - Tier 2
Document no: HOW040414
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

Date: 24/08/2021 Author: XDAOO Name: HOW040414_Alpha_Petroleum_O&G_DCO_Tier_2_Figure_18-2_RevA_20210818

18.4 TIER 2 Assessment – Platforms

18.4.1.1.1 This section focuses on the potential impacts on Alpha Petroleum's assets as a result of Hornsea Four's presence in the area.

18.4.2 Structural Integrity

18.4.2.1.1 This section assesses the impact on the structural integrity of Alpha Petroleum assets from interaction with Hornsea Four. Structural integrity issues can arise from the following: seismic events, vessel impact (allision), and helicopter impact (risk due to potential changes in landing approach / take-off as a result of Hornsea Four).

18.4.2.2 Seismic Event

18.4.2.2.1 Hornsea Four will not induce any seismic events. Piling or drilling operations associated with foundation installation of the Wind Turbine Generators (WTGs) may induce ground shaking.

18.4.2.2.2 As documented in section 4.8.4 of Volume A1, Chapter 4: Project Description, the Maximum Design Scenario (MDS) strike energy for piling of the foundations in the array area is 3,000 kJ to 5,000 kJ. For WTGs, substations, and accommodation platform on monopiles, there will be a 4-hour piling duration and 1.2 days per monopile, with a total duration of 106 to 216 piling days depending on the number of vessels. For WTGs, substations, and accommodation platform on piled jackets, the jackets will have a piling duration of 1.5 days per jacket foundation and a total of 135 to 270 piling days depending on the number of vessels. The combined durations of the impact piling component of the installation campaign is expected to be a maximum of 12 months.

18.4.2.2.3 From the array area and considering the distances (approximately 7.5 km from Garrow NUI and 12. 5 km from the Kilmar crossing), the ground shaking is not expected to impact the operation on and around Kilmar and Garrow, as the expected ground shaking will not be significant enough with the potential to impact the structural integrity of these assets and will dissipate over the distance from where the piling would take place.

18.4.2.2.4 The timing and execution of these foundation operations will be planned in consultation between Alpha Petroleum and Hornsea Four, and these operations will be performed in accordance with good practice.

18.4.2.2.5 The potential impact of seismic events on Tier 2 platforms within 10 nm of the Hornsea Four array area is considered **broadly acceptable**.

18.4.2.3 Vessel Impact

18.4.2.3.1 As some vessel routes may be changed, and the vessels taking these routes are deviated due to the presence of Hornsea Four, allision risks due to these deviations from existing routes can potentially increase the risk of structural damage to Alpha Petroleum Tier 2 NUIs.

18.4.2.3.2 A vessel allision study, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report was performed duly considering assets close to Hornsea Four in terms of potential changes in allision risk, considering deviations to both routine support vessel routeing and third-party traffic. Spacing / proximity issues relative to the Hornsea Four structures were also considered.

18.4.2.3.3 It should be considered that proximity between offshore installations and passing traffic is a primary factor affecting allision risk. On this basis, the assessment of allision risk undertaken has focused on changes to traffic patterns passing within 2 nm of the relevant assets as a result of Hornsea Four.

Potential Consequences

18.4.2.3.4 Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage, reducing remaining platform life.

Existing Safeguards / Controls

- 500 m safety zone;
- Inherent safety (best design practice);
- Suitable safety factors (fatigue, applied loading, etc);
- Control measures [management/structural];
- Visual and radar; and
- Stand-By Vessels (SBVs), communications and procedures (including vessel contracting and suitability, inspections, marine operations and combined operations).

Analysis of Risk

18.4.2.3.5 As stated in section 7.3.2 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and noting the presence of Hornsea One and Two, it was observed from pre- and post-Hornsea Four analysis that the majority of commercial vessels on affected routes will pass between Hornsea Four and Hornsea Two. Hornsea One and Two are located south of the Hornsea Four array area.

18.4.2.3.6 From proximity assessments conducted and presented in section 7.4 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and based on the Navigational Risk Assessment (NRA) (see **Volume A5, Annex 7.1: Navigational Risk Assessment**) deviations, it is predicted that vessel numbers within 2 nm of the Garrow NUI will increase by two (2) vessels per day following the construction of Hornsea Four. There will be no increase in vessel numbers within 2 nm of the Kilmar NUI.

18.4.2.3.7 It is important to note that these are based on the worst-case deviations assessed within the NRA (see **Volume A5, Annex 7.1: Navigational Risk Assessment**), and as such in reality vessels may choose alternate routes, including passing further from the assets given there is sea room available to do so. On this basis, and given the relatively low scale of this change, allision risk to the Kilmar and Garrow NUI's is considered to be broadly acceptable.

18.4.2.3.8 Also, for the duration of the construction period, Hornsea Four will monitor and report annually, vessel traffic as per Co98 (see Volume A4, Annex 5.2: Commitment Register).

18.4.2.4 Helicopter Impact

18.4.2.4.1 This subsection addresses the potential for CAT helicopter impact with the Garrow and Kilmar NUIs, resulting in structural damage / integrity issues.

Potential Consequences

18.4.2.4.2 Impact risk due to potential changes in landing approach / take-off as a result of Hornsea Four.

Existing Safeguards / Controls

- Safety and Environmental Critical Element (SECE) Verification (European Aviation Safety Agency (EASA)/ Civil Aviation Authority (CAA) Regulations also apply);
- No flying during unsafe conditions;
- Company transportation policy / procedures;
- Correct operational procedures;
- Competent personnel;

- Helicopter Monitoring; and
- Communications.

Analysis of Risk

18.4.2.4.3 It is anticipated that helicopter impacts are more likely to occur if landing is attempted in unsafe conditions. As helicopter landing during unsafe conditions is not permitted, it is considered that there will be no incremental additional risk to structural integrity as a result of helicopter transport.

18.4.2.4.4 As addressed in ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, the helicopter approach and take-off will not be affected as a result of the presence of Hornsea Four due to flight procedures and regulations taking account of all obstacles. The severity and probability of helicopter impact remain unchanged. The risk is therefore assessed to be broadly acceptable. Note that in the case of an emergency, Hornsea Four will not restrict Search and Rescue (SAR) aircraft access to nearby installations.

18.4.3 Loss of Maritime Integrity – Loss of Stability

18.4.3.1.1 As there are no floating Alpha Petroleum platforms in the Tier 2 grouping this impact is not considered applicable.

18.4.4 Loss of Maritime Integrity – Loss of Position

18.4.4.1.1 As there are no floating Alpha Petroleum platforms in the Tier 2 grouping this impact is not considered applicable.

18.4.5 Vessel Access (Deviation) – Construction and Operations

18.4.5.1.1 This section assesses the potential impacts in relation to access to Oil and Gas (O&G) assets that may arise as a result of the construction and operation of Hornsea Four.

18.4.5.1.2 A vessel access impairment study, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report was performed for assets close to Hornsea Four. The assets within 10 nm were screened to identify which may be affected in terms of access to the structures. Deviations to offshore routine support vessel (e.g., supply and standby) routeing relative to the Hornsea Four structures were considered.

18.4.5.1.3 It was observed that during construction of Hornsea Four, a number of vessels will be required within the array area. This combined with vessel route changes and vessel deviations, means that the potential for impaired access during this period may increase.

18.4.5.1.4 The potential for access and deviation hazards could arise from the following hazard initiators:

- Attendant and Passing Vessels;
- Failures – Positional;
- Failures – Navigational;
- Failures – Procedural; and
- Failures – Human Error.

Potential Consequences

- Impairment of vessel access to platforms; and
- Allision risk due to vessels being deviated from existing route, resulting in the potential for structural damage and reduced remaining life.

Existing Safeguards / Controls

- The existing safeguards / controls for allision risks are listed in the safeguards / controls for allision risk – section 18.4.2.3.

Analysis of Risk

18.4.5.1.5 As noted in section 8.3.2 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and based on consultation, the majority of O&G vessels visiting Tier 2 assets within 10 nm of the Hornsea Four array area do so from Lowestoft or Great Yarmouth, and as such will approach from the south. On this basis, vessels associated with Kilmar or Garrow will be affected by the construction of Hornsea Four in terms of access, given that these assets are located north of the array area.

18.4.5.1.6 Based on an internal routeing database, and applying the approach detailed in ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report in terms of rerouting, it is considered likely that vessels accessing Kilmar will choose to transit between Hornsea Two and Hornsea Four, whereas vessels accessing Garrow may pass west of the site – see Figure 18-3. It should be considered that both Kilmar and Garrow are NUI's, and as such will be less frequently visited than manned assets.

18.4.5.1.7 Details of Hornsea Four would be promulgated in advance via the usual means (e.g., Notifications to Mariners (NtM)), including directly to the relevant operators as identified within this study and consulted with to date. This will facilitate advanced passage planning, ensuring any deviations are minimal, and will allow the locations of completed or partially completed structures to be accounted for.

18.4.5.1.8 Given that only minor deviations will be required for the Garrow and Kilmar platforms, it is not anticipated that there will be an increase in the risk to safety. Safety risks will remain unchanged, and therefore considered to be broadly acceptable.

18.4.5.1.9 The identified potential implications / consequences of vessel access may be commercial. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation. These are addressed in Section 20: Commercial Considerations of this report.

18.4.5.1.10 Also, advance warning and accurate location details of construction, maintenance, and decommissioning operations, associated Safety Zones and advisory passing distances will be given as per Co89 (see Volume A4, Annex 5.2: Commitment Register).

18.4.6 Vessel Access (Proximity) – Construction and Operations

18.4.6.1.1 This section assesses the potential impacts in relation to access to O&G assets that may arise as a result of the construction and operation of Hornsea Four.

18.4.6.1.2 Vessel impact can be categorised as allision or collision – this section addresses vessel collision risks. Allision risks have been addressed above in section 18.4.2.3.

18.4.6.1.3 A vessel access impairment study was performed, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, for assets close to Hornsea Four. The assets within 10 nm were screened to identify which may be affected in terms of access to the structures. Spacing / proximity issues relative to Hornsea Four structures were considered.

18.4.6.1.4 During construction of Hornsea Four, a number of vessels will be required within the array area. This combined with vessel route changes and proximity of wind turbines and associated works may restrict / hamper access to O&G platforms and subsurface infrastructure during certain periods (e.g., allowable weather).

Potential Consequences

- Impairment of vessel access to platforms due to proximity of wind turbines and associated works; and

- Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage, reduced remaining life.

Existing Safeguards / Controls

- The existing safeguards / controls for allision risks are listed in the safeguards / controls section 18.4.2.3.

Analysis of Risk

18.4.6.1.5 As noted in section 8.3.2 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, large scale operations associated with O&G assets are able to be undertaken in proximity to wind farm structures, including with lower space than is available in this instance.

18.4.6.1.6 Section 8.3.2 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, notes that Garrow and Kilmar NUIs, which are 3.8 nm and 6.8 nm minimum potential distance respectively from Hornsea Four structures, will not be affected by proximity issues as a result of the presence of Hornsea Four.

18.4.6.1.7 Based on the statement above, and in terms of proximity from Hornsea Four array area, it is perceived that safety risks associated with Kilmar and Garrow NUIs will remain unchanged.

18.4.6.1.8 The safety risk associated with proximity between Hornsea Four array area and the Kilmar and Garrow NUIs is considered to be of **broadly acceptable**.

18.4.6.1.9 Also, advance warning and accurate location details of construction, maintenance, and decommissioning operations, associated Safety Zones and advisory passing distances will be given as per Co89 (see Volume A4, Annex 5.2: Commitment Register).

Hornsea Four

Route Deviations Tier 2 - Array
Figure 18.3

Project Layers

- DCO Order Limits
- Offshore Temporary Works Area

Hornsea Project Boundaries

- Hornsea Project One
- Hornsea Project Two

O & G Assets

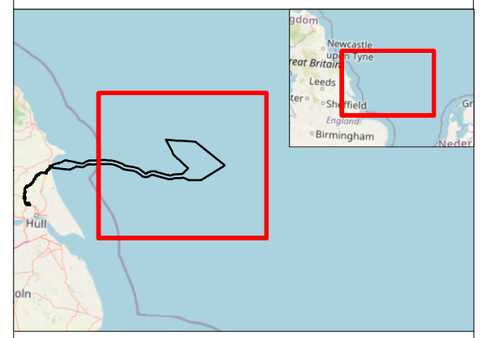
- Babbage
- Garrow NUI
- Kilmar NUI
- Ravenspurn North CC
- Ravenspurn North CCW
- Ravenspurn North ST2
- Ravenspurn North ST3
- Ravenspurn South A
- Ravenspurn South B
- Ravenspurn South C

Vessel Routing

- Post Wind Farm Route

Datasets provided by Anatec Ltd.

anatec
Anatec Limited
Risk based decision making



Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:350,000

0 2.5 5 10 Kilometres

0 1.25 2.5 5 Nautical Miles

REV	REMARK	DATE
	First issue	21/09/2020
A	Reduced Array Area in northwest corner	18/08/2021

Route Deviations Tier 2 - Array
Document no: HOW040430
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

Date: 19/08/2021 Author: XDAOO Name: HOW040430_Anatec_Route_Deviations_Figure_18-3_RevA_20210818

350000 400000 6000000 5950000

18.5 TIER 2 Assessment – Platform Systems

18.5.1.1.1 This section focuses on the potential impacts on Alpha Petroleum's Tier 2 platform systems as a result of Hornsea Four's presence in the area.

18.5.1.1.2 Hazard guide words have been employed and were developed from Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006) and extended to incorporate specific operational concerns. These are: loss of containment – process; loss of containment – pipelines; loss of containment – fire & explosion; and emergency response.

18.5.2 Loss of Containment – Process

18.5.2.1.1 The Tier 2 assets comprise: Garrow and Kilmar NUIs, intra-field pipelines, and surface and subsea infrastructure.

18.5.2.1.2 This section addresses loss of containment from process plant and process operations. According to GASCET (HSE, 2006) hazard sources for process systems include process equipment such as pressure vessels, heat exchangers, pipeline risers, flexible hoses, etc.

18.5.2.1.3 Process systems are the primary responsibility of the duty holder and constrained to within the 500 m safety zone, the presence of Hornsea Four will not result in loss of containment from process systems. The risk is therefore **not considered applicable**.

18.5.3 Loss of Containment – Pipelines

18.5.3.1.1 This section addresses loss of containment from pipelines and piping systems associated with the platform systems and constrained within 500 m of the platform. According to GASCET (HSE, 2006) hazard sources for the platform pipeline systems include fixed and flexible risers, emergency shutdown valves, and subsea isolation systems, etc.

18.5.3.1.2 These systems are the primary responsibility of the duty holder and constrained to within the 500 m safety zone. The impact of Hornsea Four potentially resulting in loss of containment from platform systems is not considered applicable, as all Hornsea Four operations remain outside these safety zones from Alpha Petroleum's surface facilities.

18.5.3.1.3 However, the impact of Hornsea Four's presence on associated pipeline systems (outboard and intra-field pipelines) is addressed in section 18.6.14 of this report.

18.5.4 Loss of Containment – Fire & Explosion

18.5.4.1.1 With the 500 m safety zone, Hornsea Four will have no impact on process hazards leading to fire and explosions on any Alpha Petroleum platform system.

18.5.4.1.2 The potential for loss of containment for outboard pipelines leading to fires and explosions is addressed for associated systems in section 18.6.14 below.

18.5.5 Emergency Response

18.5.5.1.1 This section focuses on the impact (impairment / delay) Hornsea Four's presence in the area may have on Alpha Petroleum's emergency response arrangements associated with their Tier 2 assets. Alpha Petroleum's emergency response arrangements will include the following:

- Emergency Response Management;

- Alarms and Communication;
- Temporary Refuge and Muster Stations;
- Access / Egress Routes;
- Evacuation;
- Escape;
- Rescue and Recovery;
- Emergency Lighting; and
- Emergency Communications.

18.5.5.1.2 The Health and Safety Executive (HSE) UK, Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations (HSE, 2016) and associated Schedules contain specific requirements for emergency response to major accident hazards on installations. It is assumed that Alpha Petroleum's current emergency response arrangements comply with the relevant statutory provisions governing the operations listed above.

Potential Consequences

18.5.5.1.3 Impairment or delay of emergency response arrangement could potentially lead to injury / fatality of personnel.

Analysis of Risk

18.5.5.1.4 It is not considered that Hornsea Four will have any impact on emergency response systems on the Tier 2 installations, i.e., access / egress, alarms and communication (including emergency communications), escape, emergency lighting on installations, temporary refuge and muster stations.

18.5.5.1.5 Other emergency responses would typically include provision of primary and secondary means of evacuation and escape from these installations, e.g., helicopter, Totally Enclosed Motor Propelled Survival Craft (TEMPSC), sea transfer and bridge-link; some necessitating arrangements with others.

18.5.5.1.6 It is considered that these primary and secondary means of evacuation and escape from Tier 2 installations will not be impaired. As stated in section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, for emergency conditions, i.e. down manning of any installation, critical Medivacs and SAR are not constrained by Commercial Air Transport (CAT) Regulations as these rely on the Coastguard SAR Aircraft operating under the Civil Aviation Publication (CAP), CAP 999. The Coastguard helicopters are operated as State Aircraft under National Regulations and are not constrained by EASA Regulations. As Coastguard SAR Operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to nearby installations.

18.5.5.1.7 As the preferred means of evacuation from the offshore Tier 2 asset area are helicopter and via sea transfer, details of the impact of Hornsea Four on access via vessel and helicopter are discussed in the following sections:

- Vessels – sections 18.4.2.3 and 18.4.5; and
- Helicopter – sections 18.6.5 and 18.6.7.

18.5.5.1.8 In considering the assessment of vessel and helicopter access for emergency response purposes there will be no risk of delay or impairment of emergency response systems required around Tier 2 assets. Note that, as per Prevention of Fire and Explosion, and Emergency Response (PFEER) Regulation 17, other response systems (TEMPSC, etc.) must always be present. The incremental additional risk is considered negligible and is therefore broadly acceptable.

18.6 TIER 2 Assessment – Associated Systems

18.6.1.1.1 This section focuses on the potential impact on Alpha Petroleum's Tier 2 assets as a result of Hornsea Four's presence in the area. Associated systems comprise other equipment and operations that are associated with but not part of the installations and platform systems.

18.6.1.1.2 Hazard guide words have been employed, and were obtained from GASCET (HSE, 2006) and extended to incorporate specific operational concerns. The guide words employed are: wells; diving; human factor; helicopter – impaired access to O&G platforms and to O&G vessels; helicopter – deferred access to support O&G operations; seismic survey operations; drilling operations; construction operations; non-process fires & explosions; and loss of containment – outboard pipelines / intra-field pipelines.

18.6.2 Wells

18.6.2.1.1 Hazards to the Tier 2 wells could arise from the following initiators:

- Vibration (i.e., from Piling / drilling of turbine foundations);
- Dropped objects from vessels; and
- Anchor spread from vessels, e.g., work boats or Diving Support Vessel (DSV).

Potential Consequences

18.6.2.1.2 Wells integrity compromise with the potential of blowout / spillage.

Existing Safeguards / Controls

- Subsea protection structure;
- Inherent Safety Practices;
- Competent Personnel;
- Control Measures via existing marine procedures, e.g., NtM;
- Simultaneous Operations (SIMOPS) will be performed prior to Hornsea Four field operations; and
- 500 m safety zone around assets.

Analysis of Risk

18.6.2.1.3 Considering the relative footprint of the Alpha Petroleum wells (42/25a-G1Z and 43/22a-K1Y) compared to that of Hornsea Four's operation, the likelihood of a dropped object strike is considered negligible.

18.6.2.1.4 Anchor spread for vessels supporting the construction and operations in Hornsea Four will be controlled by SIMOPS, expected works will be published in NtM; Given that wellheads are generally not found close to shore (water depths less than 15 m), the use of anchor spreads is not expected. However, they may be required for cable jointing or repair works, or to assist construction vessels where conditions dictate.

18.6.2.1.5 Also considering the distance of the wells in the Tier 2 area (i.e., over 3.8 nm) from the Hornsea Four turbine foundations there is less risk of Hornsea Four interference.

18.6.2.1.6 The likelihood of compromising well integrity is considered remote given the above listed existing safeguards and controls. Hence, the incremental additional risk to the Tier 2 wells is considered broadly acceptable.

18.6.3 Diving

18.6.3.1.1 This section focuses on potential impact on Alpha Petroleum's diving operations (temporary impact upon access for pipeline repair / maintenance, etc.) due to the implementation and operation of Hornsea Four.

Potential Consequences

- The safety of divers is compromised due to Hornsea Four construction / operations; and
- Delay in diving maintenance, including inspection and repair operations.

Existing Safeguards / Controls

- No diving operations in unsafe conditions; and
- Co-existence procedures.

Analysis of Risk

18.6.3.1.2 It is anticipated that temporary restrictions to Alpha Petroleum diving operations for maintenance / repair may occur during installation of the Hornsea Four. Through detailed discussions, planning, and good SIMOPS practices by both parties, these potential access restrictions can be avoided.

18.6.3.1.3 The temporary piling / drilling operations associated with the array area installations could lead to acoustic vibrations which in turn could impact diving operations. Diving near subsea assets associated with Kilmar and Garrow NUIs should be avoided during such operations. This will be managed via standard site installation communication between interested parties.

18.6.3.1.4 Given the distances of Kilmar and Garrow (approximately 12.5 km and 7 km respectively) from the array area, and the management of operations via communication and consultation between Hornsea Four and Alpha Petroleum, it is considered that the safety risks associated diving operations for Tier 2 assets remain unchanged and therefore considered to be **broadly acceptable**.

18.6.4 Human Factor

18.6.4.1.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

18.6.4.1.2 This section addresses human factors associated with Hornsea Four construction and operations that have the potential to impact Alpha Petroleum's Tier 2 operations.

18.6.4.1.3 For the analysis of Alpha Petroleum's assets, the most relevant subjects are Hornsea Four navigation, station holding and/or the potential of drifting close to or around the route of the subsea infrastructure, due to operations associated with installation, inspection or maintenance.

18.6.4.1.4 Human errors can occur both in the conceptual and design phases as well as construction and operational phases of a project. Human errors, that have the potential to result in a Major Accident Hazard (MAH), in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

18.6.4.1.5 Loss of containment due to incidents caused by personnel incompetency / lack of experience.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

18.6.4.1.6 According to GASCET (HSE, 2006), a procedure should be in place for the selection, competence assessment, and training of operations and maintenance personnel and that it is designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

18.6.4.1.7 The HSE standards and codes of practices are referenced to show that in order to operate in the UK Continental Shelf, the O&G asset holders are expected to follow certain requirements.

18.6.4.1.8 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016). Risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel will be employed during the installation, operations and maintenance of the Hornsea Four infrastructure. Therefore, the introduction of incremental additional risk from this potential initiator is considered negligible.

18.6.4.1.9 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the incremental additional risk of impact from human factors is considered broadly acceptable.

18.6.5 Helicopter – Impaired Access to O&G Platforms (CAT)

18.6.5.1.1 This subsection addresses the potential for impaired access by CAT operated helicopter to Alpha Petroleum's platforms.

18.6.5.1.2 In assessing this potential impact, a study Helicopter access, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, was performed and applied the CAT weather limits, as a series of filters, to the meteorological data provided by a duty holder with platform assets close to the array area, in order to understand the potential operational impact on the installations. The report considered all relevant CAA and industry guidance and was written to ensure that Hornsea Four accounts for all associated legal obligations. This includes an obligation under CAP 764 to undertake consultation when a development is within 9 nm of an offshore helicopter destination (which includes Garrow and Kilmar in the case of Hornsea Four). The platform used as an illustrative case is located 3 km from the Hornsea Four array area. The assessment focused on identifying reduced access when operating under CAT Regulations, but access under SAR Regulations was also considered.

18.6.5.1.3 The helicopter access data for the platforms assessed (including Kilmar and Garrow) is presented in Appendix A1 (Platform Specific Data) of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

18.6.5.1.4 The potential for impaired access to O&G platforms could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Reduction of access to platform;
- Helicopter incident; and
- Potential restriction to flying due to other restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training; and
- For emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as state aircraft under national regulations and are not constrained by EASA Regulations. As Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, the wind farm will not restrict SAR aircraft access to nearby installations – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

Analysis of Risk

18.6.5.1.5 In section 4.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, it was observed that under stated conditions, O&G platforms adjacent to Hornsea Four will not be subject to approach limitations. Helicopter approach and take-off will not be affected due to flight procedures and regulations taking account of all obstacles. The impact on ARA when required is not considered significant. The approach and take-off will not be affected by the presence of Hornsea Four due to flight procedures and regulations taking account of all obstacles.

18.6.5.1.6 Section 4, Appendix A1 of the ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report shows that for Garrow, it was assessed that the largest impact will occur when an ARA is required due to low cloud and/or poor visibility and the wind direction is between 330° and 010°. The data indicates that an ARA will be impacted by up to 0.3 % (28.5 hours) to 0.5 % (42 hours) of the year, using complete data sets collected from 2013 to 2018.

18.6.5.1.7 Section 5, Appendix A1 of the ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report shows that for Kilmar, it was assessed that the largest impact will occur when an ARA is required due to low cloud and/or poor visibility and the wind direction is between 20° and 30°. The data indicates that an ARA will be impacted by up to 0.1 % (8 hours) to 0.3 % (28.7 hours) of the year, using complete data sets collected from 2013 to 2018. Note that the affected hours are spread out through the years studied, and delays occur in a matter of hours as opposed to days..

18.6.5.1.8 A summary of all the results from the assessment is presented in Table 6.1 in Section 6 of the ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

18.6.5.1.9 The data shows that the duration of time when an ARA was obstructed was low and so there were unlikely to be any long periods of time when CAT helicopter operations were inhibited.

18.6.5.1.10 On the basis of the above assessment, helicopter transport will not take place should there be any risk brought about by a combination of meteorological conditions and the presence of the Hornsea Four array. Therefore, the safety risk associated with helicopter transport to and from platforms in Tier 2 will remain unchanged and so is considered broadly acceptable.

18.6.5.1.11 Note that the potential implications of impaired access are not safety related, but may be commercial. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation. These are considered in Section 20: Commercial Considerations of this report.

18.6.5.1.12 Also, as per Co102 (see Volume A4, Annex 5.2: Commitment Register), the Defence Infrastructure Organisation and the CAA, Maritime and Coastguard Agency (MCA) and operators will be informed of the locations, heights, and lighting status of the wind turbines, including estimated and actual dates of construction and the maximum height of any construction equipment to be used, prior to the start of construction, to allow inclusion on Aviation Charts.

18.6.6 Helicopter – Impaired Access to O&G Platforms (SAR)

18.6.6.1.1 This subsection addresses the potential for impaired access by SAR operated helicopter to Alpha Petroleum platforms, and the associated additional safety impact.

18.6.6.1.2 In assessing this potential impact, a study Helicopter access, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report was performed. In the assessment access under SAR Regulations was considered.

18.6.6.1.3 The potential for impaired access to O&G platforms could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Reduction of access to platform;
- Helicopter incident; and
- Potential restriction to flying due to other restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training;
- For emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as state aircraft under national regulations and are not constrained by EASA Regulations. As Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, the wind farm will not restrict SAR aircraft access to nearby installations – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report; and
- MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training is more advanced than that available to CAT helicopters.

Analysis of Risk

Hornsea Four – Array Area:

- Take-off limitations – there are no take off limitations on SAR operated helicopter flights imposed by the presence of Hornsea Four; and
- Approach limitations – there are no approach limitations on SAR operated helicopter flights imposed by the presence of Hornsea Four.

18.6.6.1.4 On the basis of the above assessment, and as Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, the presence of Hornsea Four will not impose any restrictions on SAR aircraft access to nearby installations. The safety risk remains unchanged and is considered broadly acceptable.

18.6.7 Helicopter – Impaired Access to O&G Vessels (CAT)

18.6.7.1.1 This subsection addresses the potential for impaired access of CAT operated helicopters to O&G vessels and associated with Tier 2 operations.

18.6.7.1.2 The potential for impaired access to O&G vessels associated with Tier 2 operations could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter incident; and
- Potential restriction to flying due to restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication; and
- Operational procedures / personnel training.

Analysis of Risk

18.6.7.1.3 In terms of navigational failure as a result of Hornsea Four, consideration of helicopter systems is already built into the procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

18.6.7.1.4 In consideration of extreme weather / environmental conditions, the operational regulations already include weather limits, and these will not change with the presence of Hornsea Four.

18.6.7.1.5 As stated in section 4.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, it was observed that under stated conditions, O&G platforms adjacent to Hornsea Four will not be subject to approach limitations. Helicopter approach and take-off will not be affected due to flight procedures and regulations taking account of all obstacles. Consequently, it is considered that the vessels associated with these O&G platforms will also not be subject to approach limitations.

18.6.7.1.6 On the basis of the above assessment, there will be no additional risk to safety brought about by the presence of Hornsea Four. Therefore the safety risk associated with helicopter transport to and from vessels in Tier 2 will remain unchanged and so is considered broadly acceptable.

18.6.7.1.7 Note that the identified potential implications/ consequences of impaired access may be commercial, Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation – these are considered in Section 20: Commercial Considerations of this report.

18.6.8 Helicopter – Impaired Access to O&G Vessels (SAR)

18.6.8.1.1 This subsection addresses the potential for impaired access of SAR operated helicopters to O&G vessels associated with Tier 2 operations.

18.6.8.1.2 The potential for impaired access to O&G vessels associated with Tier 2 operations could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter incident; and
- Potential restriction to flying due to restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training;
- For emergency conditions, i.e., critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as state aircraft under national regulations and are not constrained by EASA Regulations. As Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to vessels associated with nearby installations; and
- MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training are more advanced than that available to CAT helicopters.

Analysis of Risk

18.6.8.1.3 In terms of navigational failure, this consideration is already built into the helicopter systems procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

18.6.8.1.4 In consideration of extreme weather / environmental conditions, the operational regulations already include weather limits, and these will not change with the presence of Hornsea Four.

18.6.8.1.5 As stated in section 4.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, it was observed that under stated conditions, O&G platforms adjacent to Hornsea Four will not be subject to approach limitations. Helicopter approach and take-off will not be affected due to flight procedures and regulations taking account of all obstacles. Consequently, it is considered that the vessels associated with these O&G platforms will also not be subject approach limitations, however, this will also be dependent on vessel location and height of decent or approach.

18.6.8.1.6 On the basis of the above assessment, there will be no additional risk to safety brought about by the presence of Hornsea Four. Therefore, the safety risk associated with helicopter transport to and from vessels in Tier 2 will remain unchanged and so is considered broadly acceptable.

18.6.9 Seismic Survey Activities

18.6.9.1.1 Seismic surveillance activities may be required in the future, around the Hornsea Four array. At the time of such activity, it is proposed that a co-existence plan will develop how the performance of such activity will be implemented without undue risk in the interfaces.

18.6.9.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

18.6.10 Drilling Activities

18.6.10.1.1 Exploration and appraisal drilling may be required around the Hornsea Four array area. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

18.6.10.1.2 There have been recent drilling campaigns in the Irish Sea taking place in and around existing offshore wind farms. This presents an example that with adequate planning offshore wind and O&G infrastructures can coexist.

18.6.10.1.3 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

18.6.11 Construction Activities

18.6.11.1.1 Alpha Petroleum may want to construct new production facilities around the Hornsea Four array area. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

18.6.11.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

18.6.12 Non-Process Fires & Explosions

18.6.12.1.1 Non-process fires and explosions are typically associated with non-process plants. In the case of Hornsea Four, this could be electrical fires associated with the High Voltage Alternating Current (HVAC) booster station(s) or offshore substations in the array area.

18.6.12.1.2 Considering the closest distance of the of a Tier 2 asset to the array area is at least 7.5 km, it is considered that the impact of electrical fires on Alpha Petroleum's Tier 2 assets are negligible, and therefore considered to be broadly acceptable.

18.6.13 Microwave Communication

18.6.13.1.1 This subsection considers the potential effect of Hornsea Four on the operation of microwave telecommunication links to Alpha Petroleum's Kilmar and Garrow platforms. Special focus is on the impact of Hornsea Four on the use of the microwave links for remote control purposes.

18.6.13.1.2 It is envisaged that the presence of Hornsea Four may have the potential to obstruct or interfere with a number of microwave links operated by Perenco and connecting to Alpha Petroleum platforms. The links which need to be taken into account are:

- Ravenspurn North to Kilmar; and
- Ravenspurn North to Garrow.

18.6.13.1.3 In this report two options for mitigating against impairment are considered:

- Establish safety zones around the affected microwave links to mitigate the detrimental effects on the link performance which may be caused by the presence of the wind turbines; and
- Identify alternative routes for the traffic currently being carried over some of the affected links.

18.6.13.1.4 As Ravenspurn North is the main hub connected via microwave to Garrow and Kilmar, the consequences, existing controls and analysis of the risk have been addressed in section 16.6.15.

18.6.13.1.5 In addition, the communication may be obtained via alternative communication means like satellite communication.

18.6.13.1.6 On the basis of the assessment performed, it is considered that the safety risk associated with microwave communication is considered broadly acceptable.

18.6.13.1.7 Note that the identified potential implications/ consequences of interference of microwave links may commercial, Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation – these are considered in Section 20: Commercial Considerations of this report.

18.6.14 Loss of Containment – Outboard Pipelines / Intra-field Pipelines

18.6.14.1.1 According to GASCET (HSE, 2006), the relevant hazardous events with the potential for damage to the outboard / intra-field pipelines resulting in loss of containment could result from the following hazard initiators: fatigue / vibration; incorrect installation; violation; operator error – inadequate training / competency; deficient procedures – operational / maintenance; vessel impact; dropped objects (i.e. dropped cargo) / abnormal external load; seismic event; and anchor – snagging / dropping.

18.6.14.2 Fatigue / Vibration

18.6.14.2.1 Operations associated with installation of the towers for the WTGs could involve piling or drilling dependent on the selected foundation method which is also dependent on ground conditions.

Potential Consequences

18.6.14.2.2 Loss of containment due to flowline vibration triggered by drilling / piling.

Existing Safeguards / Controls

- Inherent Safety (including fully rated pipelines, inherent impact resistance, pipe burial and trenching (where applicable);
- Good procedures and Competent personnel associated with installation and operation of Hornsea Four;
- Isolation and Permit to Work (PTW) controls; and
- Pre-operation strength and leak testing.

Analysis of Risk

18.6.14.2.3 Based on previous experience the expected strike energy for piling would typically be 2,500 kJ and could increase to 5,000 kJ. Details of the duration of piling operations in the array area are documented in section 18.4.2.2.

18.6.14.2.4 The timing and execution of these foundation operations will be planned in consultation between Alpha Petroleum and Hornsea Four, and these operations will be performed in accordance with good practice.

18.6.14.2.5 Considering the distance of the drilling and piling areas to the pipeline, the potential ground shaking and associated vibration in the surrounding area is expected to dissipate before reaching the pipeline, and as such, there will be negligible impact to the pipeline. The risk is therefore considered to be broadly acceptable.

18.6.14.2.6 The temporary piling / drilling operations associated with the array installations could also lead to acoustic vibrations which could have an adverse effect on diving, why diving near the pipeline should be avoided during such operations. This will be managed via standard site installation communication between interested parties.

18.6.14.3 Incorrect Installation

18.6.14.3.1 Incorrect installation of the Hornsea Four export cables has the potential to impact the pipelines at their crossing points within the ECC due to additional hazards over and above the pipeline design criteria.

18.6.14.3.2 As there are no intra-field pipeline-ECC crossings, this impact of is not considered applicable.

18.6.14.4 Operator Error – Inadequate Training / Competency

18.6.14.4.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

18.6.14.4.2 For the analysis of the Alpha Petroleum's pipelines the most relevant subjects are navigation, station holding and/or the potential of drifting close to or around the route of the pipeline, due to vessels operations associated with cable installation, cable inspection or maintenance.

18.6.14.4.3 Human errors can occur in any phase of a project. Human errors, that have the potential to result in MAHs, in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

18.6.14.4.4 Loss of containment due to incidents caused by personnel incompetency / lack of experience.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

18.6.14.4.5 According to GASCET (HSE, 2006), the O&G asset holder should have a procedure in place for the selection, competence assessment, and training of operations and maintenance personnel and that it is designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

18.6.14.4.6 The HSE standards and codes of practices are referenced to show that in order to operate in the UK Continental Shelf, the O&G asset holders are expected to follow certain requirements.

18.6.14.4.7 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016). Risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel will be employed during the installation, operations and maintenance of the Hornsea Four infrastructure. Incremental additional risk to the pipelines from this potential initiator is considered negligible.

18.6.14.4.8 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the risk of impact from human factors is considered broadly acceptable.

18.6.14.5 Violation

18.6.14.5.1 Human factors involved in the earlier conceptual design stages of the installation lifecycle can influence the likelihood of the occurrence of hazardous event. When installations have not been designed and

constructed, and / or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards, a violation is said to have occurred.

Potential Consequences

18.6.14.5.2 Loss of containment due to not following procedure and guidelines.

Existing Safeguards / Controls

- Good procedures; and
- Competent personnel.

Analysis of Risk

18.6.14.5.3 As stated above in section 18.6.14.4 above, human errors can occur in all phases of a project. Human errors, that have the potential to result in MAHs, in the earlier conceptual design stages, can also be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

18.6.14.5.4 The impact of violation is considered similar to 'operator error' and considering that risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel is being employed in the design of the Hornsea Four infrastructure, the introduction of additional risk to the pipelines from this potential initiator is considered negligible. The risk is considered to be broadly acceptable.

18.6.14.6 Vessel Impact

18.6.14.6.1 Vessel impact concerns the potential additional hazards associated with vessel movements in and around the pipeline corridor, due to the presence of Hornsea Four construction and operation. This may include the following types of vessels: standby vessels, supply vessels, DSVs, survey vessels, barges, and cable installation vessels.

18.6.14.6.2 The interaction between vessels and pipelines will potentially result from dropped objects and/ or anchor snagging.

18.6.14.6.3 Dropped object risks are addressed in section 18.6.14.7 of the report.

18.6.14.6.4 Anchor snagging risks are addressed in section 18.6.14.9 of the report.

18.6.14.7 Dropped Objects

18.6.14.7.1 This involves additional hazards to the pipelines as a result of abnormal external load / dropped objects from vessels associated with Hornsea Four.

18.6.14.7.2 According to the Offshore Technology Report 2001/013 (HSE, 2002), the principal categories of load are: dead loads, imposed (operational) loads, environmental loads, deformation loads - loads associated with imposed deformations and imposed strains; and accidental loads, results from accidental events, such as collision, dropped objects, fire and explosion and other abnormal events.

18.6.14.7.3 For the interaction between Hornsea Four and the pipeline, accidental loads are the only relevant potential hazards that could arise from this interaction.

Potential Consequences

18.6.14.7.4 Loss of containment from rupture of flowlines due to dropped objects from Hornsea Four vessels during installation and maintenance of Hornsea Four.

Existing Safeguards / Controls

18.6.14.7.5 As per Offshore Technology Report 2001/013 (HSE, 2002), the pipeline installation should be so designed and, if necessary, protected that the consequences of damage are acceptable and that an adequate margin of safety is maintained.

18.6.14.7.6 As with the hazards associated with collision, the usual measures employed in controlling the hazards from dropped objects include:

- Inherent safety in design and operation;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection;
- Control through quality assurance, operating envelope, procedures, and barriers; and
- Mitigation through physical protection and robust structure.

Analysis of Risk

18.6.14.7.7 Considering the distance of the intra-field pipeline between Kilmar and Garrow, the risk of dropped object from installation and operation of Hornsea Four is considered not applicable.

18.6.14.8 Seismic Event

18.6.14.8.1 Hornsea Four will not induce / trigger any seismic events. It will however in and around the array area induce a degree of ground shaking during the installation of foundations due to drilling or piling.

18.6.14.8.2 Around the array area, the ground shaking is not expected to impact the operation of the Alpha Petroleum's Tier 2 assets, as the expected ground shaking will not be significant enough to impact its structural integrity. Details of the duration of piling operations in the array area are documented in section 18.6.14.2.

18.6.14.8.3 The timing and execution of these foundation operations will be planned in consultation between Alpha Petroleum and Hornsea Four, and these operations will be performed in accordance with good engineering practice. The risk is negligible and therefore considered to be broadly acceptable.

18.6.14.9 Anchor – Snagging / Dropping

18.6.14.9.1 Ships may anchor under various circumstances including the following:

- Normal anchoring:
  - when waiting on berths or for permission to use a controlled channel;
  - when necessary to aid manoeuvring in restricted areas;
  - when performing survey or construction operations; and
  - when performing repairs during the operation and maintenance phase.
- Emergency anchoring:
  - following mechanical breakdown of the propulsion or steering system;
  - following an accident such as major fire or a collision; and
  - to slow down the ship in order to avert a possible collision or ramming or grounding.

18.6.14.9.2 Hazards to pipelines can arise either at the time of anchoring or subsequently if the ship should drag its anchor due to the effects of wind, wave and/or current. A hazard can also arise when the ship tries to retrieve the anchor.

18.6.14.9.3 In normal anchoring, there should be minimal risk to the pipelines, which are shown on charts and protected by anchoring safety zones. The anchor safety zones typically extend at least 0.5 nautical miles to either side of the pipelines.

18.6.14.9.4 At the time of anchoring, the risk to the pipeline is either that the anchor is dropped onto the pipeline or that the anchor is dragged across the pipeline. If the anchor hooks the pipeline but does not cause

immediate damage, there will be a further risk of damage when the ship comes to try to haul the anchor back in.

18.6.14.9.5 Good seamanship will avert impact from emergency anchoring. Good seamanship involves anchoring well away from pipelines, in water of an appropriate depth (neither too shallow nor too deep) and in an area where the seabed is known to have good anchor holding properties. In addition, under weather conditions when dragging might occur, it is normal good practice to keep engines on standby and to make regular checks on position. Sometimes ships will leave their anchorages if dragging is anticipated.

18.6.14.9.6 The cause of anchors dropping accidentally is mainly due to failure of the brake systems when anchors are made ready for use, i.e., when mechanical securing systems are removed. The risk to the pipeline due to dropping anchors at sea is considered negligible, because the anchors should not be made ready for use and should be secured.

18.6.14.9.7 The Hornsea Four export cable installation operations may include, but not be limited to, survey vessels, clearance vessels, cable installation vessels, cable burial vessels, remedial works vessels and post installation survey vessels, none of which are expected to make use of anchors or anchor spreads but may be required in shallow waters (less than 15 m) or where difficult conditions dictate. The Hornsea Four operations and maintenance operations associated with the export cables will involve mainly external inspection survey vessels, possibly accompanied by Remotely Operated Vehicle (ROV). Remedial protection replenishment may also be required. Such vessels are unlikely to make use of anchors or anchor spreads but may do so should conditions dictate. Should cable inspections, or cable testing identify a need for repair operations, a repair vessel, and associated support vessels will be required, which could involve anchorage. Initially, DNV guidelines shall be adhered to with respect the minimum distance between any existing subsea asset and the placement of any anchors. These distances shall be discussed and agreed with the subsea asset owner.

18.6.14.9.8 Considering the closest distance of the intra-field pipeline between Kilmar and Garrow the array is approximately 7.5 km, and the types of vessels that Hornsea Four intends to make use of during installation and maintenance of the cable, the likelihood of anchor incidents leading to snagging, hooking or dropping is considered negligible, and therefore broadly acceptable.

18.7 TIER 3

18.7.1.1.1 As per the tier grouping (as defined in Section 4.2, Table 4-2), Tier 3 assets are defined as those assets not within 10 nm but raised during consultation by a relevant stakeholder; or assets not within 10 nm but where the route to the asset will require deviation as a result of Hornsea Four array area. As a result of this, no Tier 3 assessments have been conducted for Alpha Petroleum.

18.8 Alpha Petroleum Summary

18.8.1.1.1 The table below presents the risk summary for the assessment performed for the Alpha Petroleum assets. The structure of the table is in line with the Tier grouping and order in which the hazards were assessed.

Table 18-2: Hazards and Risk Summary – Alpha Petroleum

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
TIER 1							
	N/A	N/A	N/A	N/A			N/A
TIER 2							
	TIER 2 – PLATFORMS						
		Structural Integrity	Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Vessel Impact	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Helicopter Impact	All Assets	Very Unlikely	Local Damage	Broadly Acceptable
		Loss of Maritime Integrity - Loss of Stability		All Assets			Not Considered Further
		Loss of Maritime Integrity - Loss of Position		All Assets			Not Considered Further
		Vessel Access (Deviation) - Construction and Operations		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Vessel Access (Proximity) - Construction and Operations		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
	TIER 2 – PLATFORMS SYSTEMS						
		Loss of Containment - Process		All Assets			Not Considered Further
		Loss of Containment - Pipelines		All Assets			Not Considered Further
		Loss of Containment - Fire & Explosion		All Assets			Not Considered Further
		Emergency Response		All Assets	Very Unlikely	Slight Impact	Broadly Acceptable
	TIER 2 – ASSOCIATED SYSTEMS						
		Wells		All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
		Diving		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Human Factor		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Non-Process Fires & Explosions		All Assets	Very Unlikely	Local Damage	Broadly Acceptable

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
		Microwave Communication		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Loss of Containment - Outboard Pipelines / Intra-field Pipelines	Fatigue / Vibration	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Incorrect Installation	All Assets			Not Considered Further
			Operator Error – Inadequate Training / Competency	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Violation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Deficient Procedures – Operational / Maintenance	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Vessel Impact	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Dropped Objects	All Assets			Not Considered Further
			Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Anchor – Snagging / Dropping	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
TIER 3							
	N/A	N/A	N/A	N/A			N/A

19 NEO Energy (SNS) Limited

19.1 Introduction

19.1.1.1.1 NEO is the operator of various licences and infrastructure in the southern North Sea, including United Kingdom Continental Shelf (UKCS) Blocks 48/2a (P456), which overlaps with the Hornsea Four Development Consent Order (DCO) Order Limits (Figure 19-1).

19.1.1.1.2 Infrastructure includes the Babbage platform; wells (B1, B2, B3, B4, and B5); and a 28 km 12" gas export pipeline.

19.1.1.1.3 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

19.1.1.1.4 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

19.1.1.1.5 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or a FDP is made, then an assessment will take place and the annex will be updated accordingly.

19.1.1.1.6 The table below presents the structure of the assessment conducted on the potential hazards resulting from interaction of NEO Energy assets with Hornsea Four. The subsections where each hazard is addressed is also shown in the table.

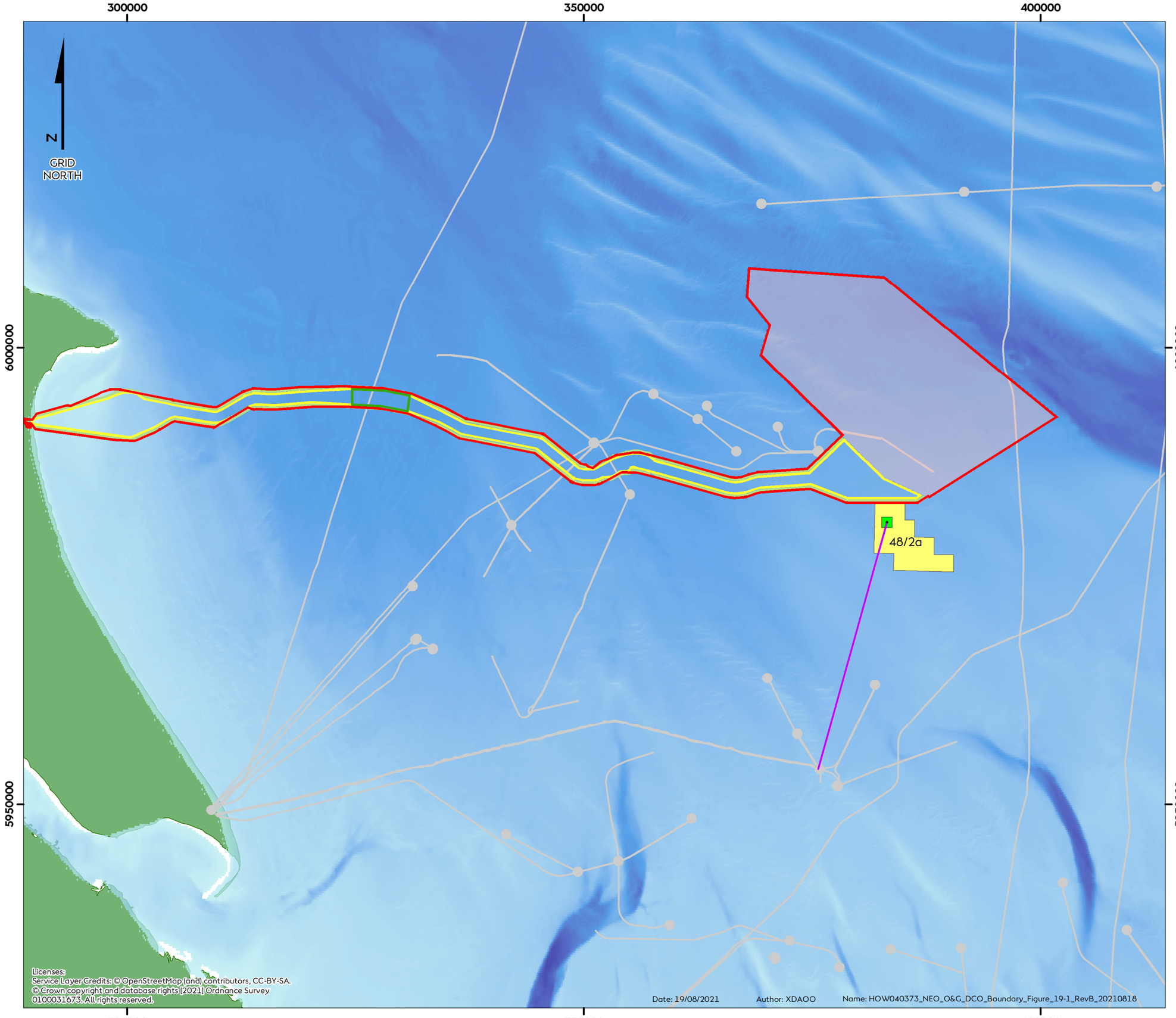
Table 19-1: NEO Energy Assessment Structure

TIER		Hazards	Sub-Group	Report Section
TIER 1				
	N/A	N/A	N/A	N/A
TIER 2				19.3
	TIER 2 – PLATFORMS			19.4
		Structural Integrity		19.4.2
			Seismic Event	19.4.2.2
			Vessel Impact	19.4.2.3
			Helicopter Impact	19.4.2.4
		Loss of Maritime Integrity – Loss of Stability		19.4.3
		Loss of Maritime Integrity – Loss of Position		19.4.4
		Vessel Access (Deviation) – Construction and Operations		19.4.5
		Vessel Access (Proximity) – Construction and Operations		19.4.6
	TIER 2 – PLATFORM SYSTEMS			19.5
		Loss of Containment – Process		19.5.2
		Loss of Containment – Pipelines		19.5.3
		Loss of Containment – Fire & Explosion		19.5.4
		Emergency Response		19.5.5
				19.6

TIER		Hazards	Sub-Group	Report Section
	TIER 2 – ASSOCIATED SYSTEMS	Wells		19.6.2
		Diving		19.6.3
		Human Factor		19.6.4
		Helicopter – Impaired Access to O&G Platforms (CAT)		19.6.5
		Helicopter – Impaired Access to O&G Platforms (CAT)		19.6.6
		Helicopter – Impaired Access to O&G Vessels (CAT)		19.6.7
		Helicopter – Impaired Access to O&G Vessels (CAT)		19.6.8
		Seismic Survey Activities		19.6.9
		Drilling Activities		19.6.10
		Construction Activities		19.6.11
		Non-Process Fires & Explosions		19.6.12
		Loss of Containment – Outboard Pipelines / Intra-field Pipelines		19.6.13
			Fatigue / Vibration	19.6.13.2
			Incorrect Installation	19.6.13.3
			Operator Error – Inadequate Training / Competency	19.6.13.4
			Violation	19.6.13.5
			Deficient Procedures – Operational / Maintenance	19.6.13.6
			Vessel Impact	19.6.13.7
			Dropped Objects	19.6.13.8
			Seismic Event	19.6.13.9
			Anchor – Snagging / Dropping	19.6.13.10
TIER 3				
	N/A	N/A	N/A	N/A

Hornsea Four

NEO Energy (SNS) Ltd Assets -
DCO Order Limits
Figure 19.1



- NEO Energy (SNS) Ltd Licences

Oil and Gas Infrastructure

- NEO Energy (SNS) Ltd Platform
- NEO Energy (SNS) Ltd Terminal
- Other Operators

Pipelines

- NEO Energy (SNS) Ltd
- Other Operators

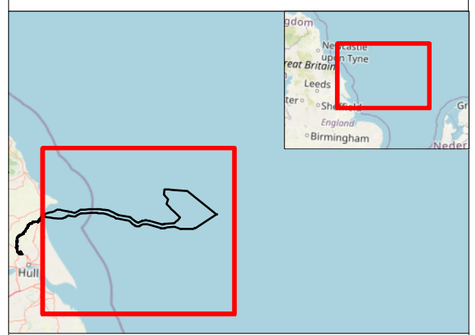
Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

Bathymetry (Below Sea Level)

High : 0

Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	25/02/2020
A	Updated following PEIR consultations, for DCO	20/07/2020
B	Reduced Array Area in northwest corner	18/08/2021

NEO Energy (SNS) Ltd Assets - DCO Order Limits
Document no: HOW040373
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

19.2 TIER 1

19.2.1.1.1 As per the tier grouping, Tier 1 assets are defined as those assets contained within the array area. As all NEO's assets are outside the array area, Tier 1 assessments have not been conducted for NEO.

19.3 TIER 2

19.3.1.1.1 Based on the asset screening process, Tier 2 (as defined in Section 4.2, Table 4-2) assets are those that are either within 10 nm of the Hornsea Four array area or within 10 nm of the High Voltage Alternating Current (HVAC) booster station search area.

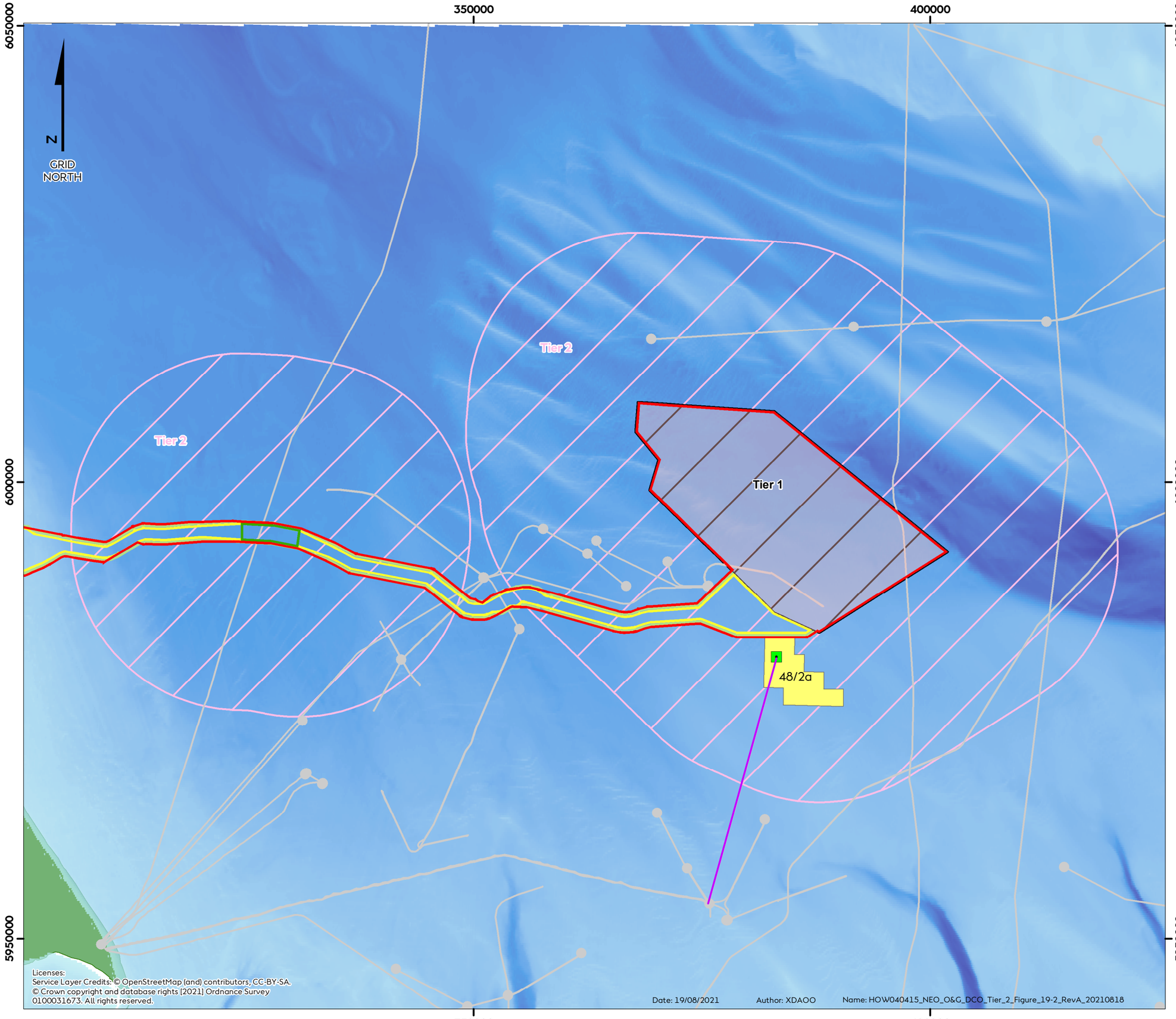
19.3.1.1.2 The platforms within 10 nm of the Hornsea Four array area are shown in Figure 16-2. These are:

- Babbage Plaform;
- Babbage Platform wells B1, B2, B3, B4, & B5; and
- 28 km 12" gas export pipeline.

Hornsea Four

NEO Energy (SNS) Ltd Assets - Tier 2

Figure 19.2



NEO Energy (SNS) Ltd Licences

Oil and Gas Infrastructure

- NEO Energy (SNS) Ltd Platform
- NEO Energy (SNS) Ltd Terminal
- Other Operators

Pipelines

- NEO Energy (SNS) Ltd
- Other Operators

Project Layers

- DCO Order Limits
- Offshore Export Cable
- Hornsea 4 Array Area
- HVAC Booster Stations
- Offshore Temporary Works Area

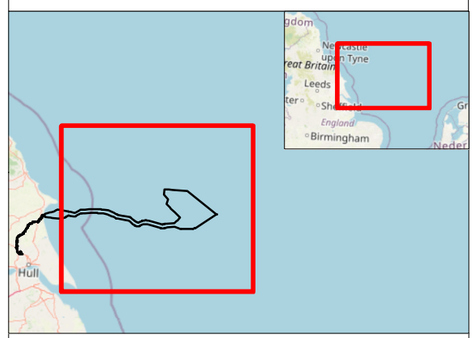
Tier Boundaries

- Tier 1 (Array Area)
- Tier 2 (10nm from Array Area / HVAC)

Bathymetry (Below Sea Level)

High : 0

Low : -100



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometres

0 2 4 8 Nautical Miles

REV	REMARK	DATE
	First issue	24/07/2020
A	Reduced Array Area in northwest corner	18/08/2021

NEO Energy (SNS) Ltd Assets - Tier 2
Document no: HOW040415
Created by: JOHLE
Checked by: XDAOO
Approved by: ELENI

Ørsted

19.4 TIER 2 Assessment – Platforms

19.4.1.1.1 This section focuses on the potential impacts on NEO's platform asset as a result of Hornsea Four's presence in the area.

19.4.2 Structural Integrity

19.4.2.1.1 This section assesses the impact on the structural integrity of NEO's Babbage platform asset from interaction with Hornsea Four. Structural integrity issues can arise from the following: seismic events, vessel impact (allision), and helicopter impact (risk due to potential changes in landing approach / take-off as a result of Hornsea Four).

19.4.2.2 Seismic Event

19.4.2.2.1 Piling or drilling operations associated with foundation installation of foundations for Wind Turbine Generators (WTGs) and array platforms may induce ground shaking.

19.4.2.2.2 As documented in Volume A1, Chapter 4: Project Description, the Maximum Design Scenario (MDS) strike energy for piling of the foundations in the array area is 3,000 kJ to 5,000 kJ. For WTGs, substations, and accommodation platform on monopiles, there will be a 4-hour piling duration and 1.2 days per monopile, with a total duration of 106 to 216 piling days depending on the number of vessels. For WTGs, substations, and accommodation platform on piled jackets, the jackets will have a piling duration of 1.5 days per jacket foundation and a total of 135 to 270 piling days depending on the number of vessels. The duration of the impact piling component of the installation campaign is expected to be a maximum of 12 months.

19.4.2.2.3 Considering that the distance from the closest point of the array area to the platform is over 4 km, the vibration is not expected to impact the operation of the NEO's Tier 2 asset over the distance from where the piling would take place. Babbage platform is not expected to experience ground shaking from piling significant enough to impair the structural integrity of the platform.

19.4.2.2.4 The timing and execution of these foundation operations will be planned in consultation between NEO and Hornsea Four, and these operations will be performed in accordance with good practice.

19.4.2.2.5 The potential impact of seismic events on Tier 2 platforms within 10 nm of the Hornsea Four array area is considered **broadly acceptable**.

19.4.2.3 Vessel Impact

19.4.2.3.1 As some vessel routes may be changed, and the vessels taking these routes are deviated due to the presence of Hornsea Four, there is potential for an increase in vessel numbers passing within 2 nm of Babbage. This may potentially increase the risk of allision and impairment of structural integrity.

19.4.2.3.2 A vessel allision study, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, was performed duly considering assets close to Hornsea Four in terms of potential changes in allision risk. The study considered deviations to both routine support vessel routeing and third-party traffic. Spacing / proximity issues relative to the Hornsea Four structures were also considered.

19.4.2.3.3 Proximity between offshore installations and passing traffic is a primary factor affecting allision risk. On this basis, the assessment of allision risk undertaken has focused on changes to traffic patterns passing within 2 nm of the relevant asset as a result of Hornsea Four.

Potential Consequences

- Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage and reduced remaining platform life.

Existing Safeguards / Controls

- 500 m safety zone;
- Inherent safety (best design practice);
- Suitable safety factors (fatigue, applied loading, etc);
- Control measures (management/structural);
- Visual and radar; and
- Stand-By Vessels (SBVs), communications and procedures (including vessel contracting and suitability, inspections, marine operations and combined operations).

Analysis of Risk

19.4.2.3.4 As stated in section 7.3.2 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, noting the presence of Hornsea One and Two, and from pre- and post-Hornsea Four analysis, the majority of commercial vessels on affected routes will pass between Hornsea Four and Hornsea Two, Hornsea One and Two arrays are located south of the Hornsea Four array area.

19.4.2.3.5 From proximity assessments conducted and presented in section 7.4 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and based on the Navigational Risk Assessment (NRA) (see **Volume A5, Annex 7.1: Navigational Risk Assessment**) deviations, it is predicted that vessel numbers within 2 nm of assets that are within 10 nm of the Hornsea Four array area will not increase for most of the platforms following the construction of Hornsea Four. However, in the proximity assessment, it is predicted that vessel numbers within 2 nm of Babbage will increase by (approximately) one (1) vessels per day.

19.4.2.3.6 It is important to note that this is based on the worst-case deviations assessed within the NRA, and as such in reality vessels may choose alternate routes, including passing further from the assets given there is sea room available to do so.

19.4.2.3.7 It should be noted that during consultation, particular concern was raised over a potential rise in allision risk associated with deviated vessels passing between the Babbage platform. However, it is noted that based upon the worst case NRA deviations, no deviated routes are expected to make passage between Babbage and the Hornsea Four array area. There would also be no restrictions on vessels taking such passage. However, such transits are considered to be an extremely unlikely occurrence, noting the presence of the Hornsea One and Two sites to the east, making it more likely that any vessels not passing between Hornsea Four and Hornsea Two will pass south of the Hornsea projects altogether. This is discussed further in Section 7.3 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and is considered to be beneficial in terms of reduction in potential allision risk to the Babbage platform.

19.4.2.3.8 As presented in Table 7.2 in section 7.4 of ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, across the Hornsea Four area, changes in daily vessel numbers are relatively low, with many showing reductions in vessel numbers. Given at most low increases in vessel numbers predicted within 2 nm, significance in terms of allision for all Tier 2 platforms within 10 nm of the Hornsea Four array area is considered to be broadly acceptable.

19.4.2.3.9 Based on the above findings from the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, it is considered that the incremental additional safety risks associated with allision will be minimal and therefore **broadly acceptable**.

19.4.2.3.10 Also, for the duration of the construction period, Hornsea Four will monitor and report annually, vessel traffic as per Co98 (see Volume A4, Annex 5.2: Commitment Register).

19.4.2.4 Helicopter Impact

19.4.2.4.1 This subsection addresses the potential for CAT helicopter impact with Tier 2 assets, resulting in structural damage / integrity issues.

Potential Consequences

19.4.2.4.2 Impact risk due to potential changes in landing approach / take-off as a result of Hornsea Four.

Existing Safeguards / Controls

- Safety and Environmental Critical Element (SECE) Verification (European Aviation Safety Agency (EASA)/ Civil Aviation Authority (CAA) Regulations also apply);
- No flying during unsafe conditions;
- Company transportation policy / procedures;
- Correct operational procedures;
- Competent personnel / training;
- Helicopter monitoring; and
- Communications.

Analysis of Risk

19.4.2.4.3 It is anticipated that helicopter impacts are more likely to occur if landing is attempted in unsafe conditions. As helicopter landing during unsafe conditions is not permitted, it is considered that there will be no incremental additional risk to structural integrity as a result of helicopter transport.

19.4.2.4.4 As addressed in ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, the helicopter approach and take-off will not be affected as a result of the presence of Hornsea Four due to flight procedures and regulations taking account of all obstacles, the severity and probability of helicopter impact remain unchanged. The risk is therefore assessed to be broadly acceptable. Note that in the case of an emergency, Hornsea Four will not restrict Search and Rescue (SAR) aircraft access to nearby installations.

19.4.3 Loss of Maritime Integrity – Loss of Stability

19.4.3.1.1 As there are no floating NEO platform installations in the Tier 2 grouping this impact is not considered applicable.

19.4.4 Loss of Maritime Integrity – Loss of Position

19.4.4.1.1 As there are no floating NEO platform installations in the Tier 2 grouping this impact is not considered applicable.

19.4.5 Vessel Access (Deviation) – Construction and Operations

19.4.5.1.1 This section assesses the potential impacts in relation to access to Oil and Gas (O&G) assets that may arise as a result of the construction and operation of Hornsea Four.

19.4.5.1.2 A vessel access impairment study was performed, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report for assets close to Hornsea Four. The assets within 10 nm were screened to identify which may be affected in terms of access to the structures. Deviations to offshore routine support vessel (e.g., supply and standby) routeing relative to the Hornsea Four structures were considered.

19.4.5.1.3 During construction of Hornsea Four, a number of vessels will be required within the array area. This combined with vessel route changes and vessel deviations, mean that the potential for impaired access during this period may increase.

19.4.5.1.4 The potential for access and deviation hazards could arise from the following hazard initiators:

- Attendant and Passing Vessels;
- Failures – Positional;
- Failures – Navigational;
- Failures – Procedural; and
- Failures – Human Error.

Potential Consequences

- Impairment of vessel access to platform; and
- Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage.

Existing Safeguards / Controls

- The existing safeguards / controls for allision risks listed in the safeguards / controls for allision risk – section 19.4.2.3; and
- Existing routeing for support vessels – the majority of the support vessels making routine visits will originate from either Great Yarmouth or Lowestoft.

Analysis of Risk

19.4.5.1.5 As noted in section 8.3.2 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, and based on consultation and a review of the destination information transmitted within the marine traffic data studied, the majority of vessels visiting the Tier 2 assets within 10 nm of the Hornsea Four array area do so from Lowestoft or Great Yarmouth, and as such will approach from the south. On this basis, vessels associated with Babbage are unlikely to be affected by the construction of Hornsea Four in terms of access, given that the asset is located south of the array area.

19.4.5.1.6 Details of Hornsea Four would be promulgated in advance via the usual means (e.g., Notifications to Mariners (NtM)), including directly to the relevant operators as identified within the allision study and consulted with to date. This will facilitate advanced passage planning, ensuring any deviations are minimal.

19.4.5.1.7 Considering that majority of vessels visiting the Tier 2 assets within 10 nm of the Hornsea Four array area do so from Lowestoft or Great Yarmouth, and as such will approach from the south, the impact on safety associated with routine supply access to NEO's Tier 2 assets will remain unchanged. The risk is therefore considered to be **broadly acceptable**.

19.4.5.1.8 Also, advance warning and accurate location details of construction, maintenance, and decommissioning operations, associated Safety Zones and advisory passing distances will be given as per Co89 (see Volume A4, Annex 5.2: Commitment Register).

19.4.6 Vessel Access (Proximity) – Construction and Operations

19.4.6.1.1 This section assesses the potential impacts in relation to access to O&G assets that may arise as a result of the construction and operation of Hornsea Four.

19.4.6.1.2 A vessel access impairment study was performed, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, for assets close to Hornsea Four. The assets within 10 nm were screened to identify which may be affected in terms of access to the structures. Spacing / proximity issues relative to Hornsea Four structures were considered.

19.4.6.1.3 During construction of Hornsea Four, a number of vessels will be required within the array area. This combined with vessel route changes and proximity of wind turbines and associated works may restrict / hamper access to O&G platforms and subsurface infrastructure during certain periods (e.g., allowable weather).

Potential Consequences

- Impairment of vessel access to platforms due to proximity of wind turbines and associated works; and
- Allision risk due to vessels being deviated from existing route resulting in the potential for structural damage.

Existing Safeguards / Controls

- The existing safeguards / controls for allision risks listed in the safeguards / controls for allision risk – section 19.4.2.3; and
- Existing routeing for support vessels – the majority of the support vessels making routine visits will originate from either Great Yarmouth or Lowestoft.

Analysis of Risk

19.4.6.1.4 As per section 8.3.2 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report, the majority of Tier 2 platforms (including Babbage) are in excess of 2 nm in proximity to the array area, and large-scale operations associated with O&G assets are able to be undertaken in proximity to wind farm structures, including with lower space than is available in this instance.

19.4.6.1.5 It is noted that access to the Babbage platform has been discussed with NEO Energy as part of consultation (see Table 2.1 of the Allision report, ES Volume A5, Annex 11.1, Appendix C: Allision Technical Report), with the platform being located approximately 2.3 nm from the Hornsea Four array area. Discussions around marine access are ongoing with the relevant operator, and it is noted that based on marine traffic analysis, operations associated with the Babbage platform remained outside of the Hornsea Four array area. Regardless, ongoing liaison would be necessary to ensure cooperation in terms of simultaneous operations particularly in relation to works associated with export cable installation, noting that the offshore cable corridor is in proximity to the Babbage platform (approximately 1.35 nm). Appropriate protocols should therefore be agreed.

19.4.6.1.6 The incremental additional safety risk as a result of proximity with Hornsea Four is considered negligible, and therefore **broadly acceptable**, given the following:

- Vessel operations associated with Babbage remain outside the Hornsea Four array area;
- Majority of the support vessels making routine visits will originate from either Great Yarmouth or Lowestoft;
- Majority of commercial vessels on affected routes will pass between Hornsea Four and Hornsea Two, and in reality, vessels may choose alternate routes, including passing further from the assets given there is sea room available to do so;
- Small increase of one (1) vessel per day as a result of route changes; and
- Ongoing liaison to ensure cooperation between Hornsea Four and NEO Energy.

19.4.6.1.7 The identified potential implications / consequences of vessel access due to proximity may be commercial. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation. These are addressed in Section 20: Commercial Considerations of this report.

19.4.6.1.8 Also, advance warning and accurate location details of construction, maintenance, and decommissioning operations, associated Safety Zones and advisory passing distances will be given as per Co89 (see Volume A4, Annex 5.2: Commitment Register).

19.5 TIER 2 Assessment – Platform Systems

19.5.1.1.1 This section focuses on the potential impacts on NEO's Tier 2 platform systems as a result of Hornsea Four's presence in the area.

19.5.1.1.2 Hazard guide words have been employed and were developed from Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006) and extended to incorporate specific operational concerns. These are: loss of containment – process; loss of containment – pipelines; loss of containment – fire & explosion; and emergency response.

19.5.2 Loss of Containment – Process

19.5.2.1.1 The Tier 2 assets comprise: NEO's Babbage platform, intra-field pipelines, and surface and subsea infrastructure which are over 3 km from the array area.

19.5.2.1.2 This section addresses loss of containment from process plant and process operations. According to GASCET (HSE, 2006) hazard sources for process systems include process equipment such as pressure vessels, heat exchangers, pipeline risers, flexible hoses, etc.

19.5.2.1.3 Process systems are the primary responsibility of the duty holder and constrained to within the 500 m safety zone, the presence of Hornsea Four will not result in loss of containment from process systems, as all Hornsea Four operations and operations remain outside these safety zones. The risk is therefore not considered applicable.

19.5.3 Loss of Containment – Pipelines

19.5.3.1.1 This section addresses loss of containment from pipelines and piping systems associated with the platform systems and constrained within 500 m of the platform. According to GASCET (HSE, 2006) hazard sources for the platform pipeline systems include fixed and flexible risers, emergency shutdown valves, and subsea isolation systems, etc.

19.5.3.1.2 These systems are the primary responsibility of the duty holder and constrained to within the 500 m safety zone. The impact of Hornsea Four potentially resulting in loss of containment from platform systems is not considered applicable, as all Hornsea Four operations remain outside these safety zones from NEO's surface facilities.

19.5.3.1.3 However, the impact of Hornsea Four's presence on associated pipeline systems (outboard and intra-field pipelines) is addressed in section 19.6.13 of this report.

19.5.4 Loss of Containment – Fire & Explosion

19.5.4.1.1 With the 500 m safety zone, Hornsea Four will have no impact on process hazards leading to fire and explosions on NEO's platform systems.

19.5.4.1.2 The potential for loss of containment leading to fires and explosions is addressed for associated systems in section 19.6.13 below.

19.5.5 Emergency Response

19.5.5.1.1 This section focuses on the impact (impairment / delay) Hornsea Four's presence in the area may have on NEO's emergency response arrangements associated with the Tier 2 assets. NEO's emergency response arrangements will include the following:

- Emergency Response Management;
- Alarms and Communication;
- Temporary Refuge and Muster Stations;
- Access / Egress Routes;

- Evacuation;
- Escape;
- Rescue and Recovery;
- Emergency Lighting; and
- Emergency Communications.

19.5.5.1.2 The Health and Safety Executive (HSE) UK, Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations (HSE, 2016) and associated Schedules contain specific requirements for emergency response to major accident hazards on installations. It is assumed that NEO's current emergency response arrangements comply with the relevant statutory provisions governing the operations listed above.

Potential Consequences

19.5.5.1.3 Impairment or delay of emergency response arrangement could potentially lead to injury / fatality of personnel.

Analysis of Risk

19.5.5.1.4 It is not considered that Hornsea Four have any impact on emergency response systems on the Tier 2 installations, i.e., access / egress, alarms and communication (including emergency communications), escape, emergency lighting on installations, temporary refuge and muster stations.

19.5.5.1.5 Other emergency responses would typically include provision of primary and secondary means of evacuation and escape from these installations, e.g., helicopter, Totally Enclosed Motor Propelled Survival Craft (TEMPSC), sea transfer and bridge-link; some necessitating arrangements with others.

19.5.5.1.6 It is considered these primary and secondary means of evacuation and escape from Tier 2 installations will not be impaired. As stated in section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, for emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by Commercial Air Transport (CAT) Regulations as these rely on the Coastguard SAR Aircraft operating under the Civil Aviation Publication (CAP), CAP 999. The Coastguard helicopters are operated as State Aircraft under National Regulations and are not constrained by EASA Regulations. As Coastguard SAR Operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to nearby installations – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

19.5.5.1.7 As the preferred means of evacuation from the offshore Tier 2 asset area are helicopter and via sea transfer, details of the impact of Hornsea Four on access via vessel and helicopter are discussed in the following sections:

- Vessels – sections 19.4.2.3 and 19.4.5; and
- Helicopter – sections 19.6.5 and 19.6.7.

19.5.5.1.8 In considering the assessment of vessel and helicopter access for emergency response purposes there will be no risk of delay or impairment of emergency response systems required around the Tier 2 asset. Note that, as per Prevention of Fire and Explosion, and Emergency Response (PFEER) Regulation 17, other response systems (TEMPSC, etc.) must always be present. The risk is considered negligible and is therefore broadly acceptable.

19.6 TIER 2 Assessment - Associated Systems

19.6.1.1.1 This section focuses on the potential impacts on NEO's Tier 2 assets as a result of Hornsea Four's presence in the area. Associated systems comprise other equipment and operations associated with but not part of the installations and platform systems.

19.6.1.1.2 Hazard guide words have been employed, and were obtained from GASCET (HSE, 2006) and extended to incorporate specific operational concerns. The guide words employed are: wells; diving; human factor; helicopter - impaired access to O&G platforms and to O&G vessels; helicopter - deferred access to support O&G operations; seismic survey operations; drilling operations; construction operations; non-process fires & explosions; and loss of containment - outboard pipelines / intra-field pipelines.

19.6.2 Wells

19.6.2.1.1 Hazards to the Tier 2 wells could arise from the following initiators:

- Vibration (i.e., from Piling / drilling of turbine foundations);
- Dropped objects from vessels; and
- Anchor spread from vessels, e.g., work boats or Diving Support Vessel (DSV).

Potential Consequences

19.6.2.1.2 Wells integrity compromise with the potential of blowout / spillage.

Existing Safeguards / Controls

- Subsea protection structure;
- Inherent Safety Practices;
- Competent Personnel;
- Control Measures via existing marine procedures, e.g., NtM;
- Simultaneous Operations (SIMOPS) will be performed prior to Hornsea Four field operations; and
- 500 m safety zone around assets.

Analysis of Risk

19.6.2.1.3 Considering the relative footprint of the wells (i.e., 48/02a-B5Y) compared to that of Hornsea Four's operation, the likelihood of a dropped object strike is considered negligible.

19.6.2.1.4 Anchor spread for vessels supporting the construction and operations in Hornsea Four will be controlled by SIMOPS, expected works will be published in NtM; Given that wellheads are generally not found close to shore (water depths less than 15 m), the use of anchor spreads is not expected. However, they may be required for cable jointing or repair works, or to assist construction vessels where conditions dictate.

19.6.2.1.5 Also considering the distance of wells in the Tier 2 area (i.e., 2.3 nm) from the Hornsea Four turbine foundations, there is less risk of Hornsea Four interfering with the existing wells in the Babbage field.

19.6.2.1.6 The likelihood of compromising well integrity is considered remote given the above listed existing safeguards and controls. Hence, the incremental additional risk to the Tier 2 wells is considered **broadly acceptable**.

19.6.3 Diving

19.6.3.1.1 This section focuses on potential impact on NEO's diving operations (temporary impact upon access for pipeline repair / maintenance, etc.) due to the implementation and operation of Hornsea Four.

Potential Consequences

- The safety of divers is compromised due to Hornsea Four construction / operations; and
- Delay in diving maintenance, including inspection and repair operations.

Existing Safeguards / Controls

- No diving operations in unsafe conditions; and
- Co-existence procedures.

Analysis of Risk

19.6.3.1.2 It is anticipated that temporary restrictions to diving operations for maintenance / repair may occur during installation of Hornsea Four. Through detailed discussions, planning, and good SIMOPS practices by both parties, these potential access restrictions can be avoided.

19.6.3.1.3 The temporary piling / drilling operations associated with the array area installations could lead to acoustic vibrations which may have an impact on diving operations. Diving near the subsea assets associated with the Tier 2 platforms should be avoided during such operations. This will be managed via standard site installation communication between interested parties.

19.6.3.1.4 Given the management of operations via communication and consultation between Hornsea Four and NEO, it is considered that the safety risks associated with diving operations for Tier 2 assets remain unchanged and therefore considered to be **broadly acceptable**.

19.6.4 Human Factor

19.6.4.1.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

19.6.4.1.2 This section addresses human factors associated with Hornsea Four construction and operations that have the potential to impact NEO's Tier 2 operations.

19.6.4.1.3 For the analysis of NEO's Tier 2 assets the most relevant subjects are navigation, station holding and/or the potential of drifting close to or around the route of the pipeline and platforms, due to operations associated with installation, inspection or maintenance.

19.6.4.1.4 Human errors can occur in any phase of a project. Human errors, that have the potential to result in a Major Accident Hazard (MAH), in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

19.6.4.1.5 Loss of containment due to incidents caused by personnel incompetency / lack of experience.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

19.6.4.1.6 According to the GASCET (HSE, 2006), the stakeholder should have a procedure in place for the selection, competence assessment, and training of operations and maintenance personnel and that it is designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

19.6.4.1.7 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016). Risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel will be employed during the installation, operations and maintenance of the Hornsea Four infrastructure. Therefore, the introduction of incremental additional risk from this potential initiator is considered negligible.

19.6.4.1.8 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the risk of impact from human factors is considered broadly acceptable.

19.6.5 Helicopter - Impaired Access to O&G Platforms (CAT)

19.6.5.1.1 This subsection addresses the potential for impaired access by helicopter to NEO's Tier 2 Babbage platform, located 4.3 km (2.3 nm) from the Hornsea Four array area.

19.6.5.1.2 In assessing this potential impact, a study of Helicopter access, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, was performed and applied the CAT weather limits, as a series of filters, to the meteorological data provided by a duty holder with platform assets close to the array area and Export Cable Corridor (ECC), in order to understand the potential operational impact on the installations. The report considered all relevant CAA and industry guidance and was written to ensure that Hornsea Four accounts for the associated obligations. This includes an obligation under CAP 764 to undertake consultation when a development is within 9 nm of an offshore helicopter destination (which includes Babbage in the case of Hornsea Four). The assessment focused on identifying reduced access when operating under CAT Regulations, but access under SAR Regulations was also considered.

19.6.5.1.3 The helicopter access data for Babbage is presented in section 3 of Appendix A1: Platform Specific Data of the report, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report; the data for other platforms assessed is also presented the study report.

19.6.5.1.4 The potential for impaired access to O&G platforms could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Reduction of access to platform;
- Helicopter incident; and
- Potential restriction to flying due to other restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training; and
- For emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as State Aircraft under National Regulations and are not constrained by EASA Regulations. As Coastguard SAR Operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, the wind farm will not restrict SAR aircraft access to nearby installations – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

Analysis of Risk

19.6.5.1.5 In the assessment shown in section 4.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report , it was observed that Hornsea Four's presence will not impose on installations adjacent to Hornsea Four. As a result of this, limitations to route decent, and impact on ARA when required are not significant.

19.6.5.1.6 Section 3, Appendix A1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report shows that for Babbage, it was assessed that the largest impact will occur when an ARA is required due to low cloud and/or poor visibility and the wind direction is between 170° and 270°. The data indicates that an ARA will be impacted by up to 1.3 % (117.3 hours) to 2.3 % (198.5 hours) of the year, using complete data sets collected from 2013 to 2018. Note that the affected hours are spread out through the years studied, and delays occur for a matter of hours as opposed to days.

19.6.5.1.7 A summary of all the results from the assessment is presented in Table 6.1 in Section 6 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report.

19.6.5.1.8 The data shows that the duration of time when an ARA was obstructed was low and so there were unlikely to be any long periods of time when CAT helicopter operations were inhibited.

19.6.5.1.9 The data also showed that the duration of time when an ARA was obstructed was low and so there were unlikely to be any long periods of time when CAT helicopter operations were inhibited.

19.6.5.1.10 In terms of navigational failure as a result of Hornsea Four, consideration of helicopter systems is already built into the procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

19.6.5.1.11 On the basis of the above assessment, helicopter transport will not take place should there be any risk brought about by a combination of meteorological conditions and the presence of the Hornsea Four array. Therefore, the safety risk associated with helicopter transport to and from platforms in Tier 2 will remain unchanged and so is considered broadly acceptable.

19.6.5.1.12 Note that the potential implications of impaired access are not safety related but may be commercial. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation - these are considered in Section 20: Commercial Considerations of this report.

19.6.5.1.13 Note that as per Co102 (see Volume A4, Annex 5.2: Commitment Register), the Defence Infrastructure Organisation and the CAA, Maritime and Coastguard Agency (MCA) and operators will be informed of the locations, heights, and lighting status of the wind turbines, including estimated and actual dates of construction and the maximum height of any construction equipment to be used, prior to the start of construction, to allow inclusion on Aviation Charts.

19.6.6 Helicopter - Impaired Access to O&G Platforms (SAR)

19.6.6.1.1 This subsection addresses the potential for impaired access by SAR operated helicopters to NEO's Tier 2 Babbage platform, located 4.3 km (2.3 nm) from the Hornsea Four array area.

19.6.6.1.2 In assessing this potential impact, a study of Helicopter access, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, was performed. In the assessment access under SAR Regulations was considered.

19.6.6.1.3 The potential for impaired access to O&G platforms could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Reduction of access to platform;
- Helicopter incident; and
- Potential restriction to flying due to other restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training;
- For emergency conditions, i.e., down manning of any installation, critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as State Aircraft under National Regulations and are not constrained by EASA Regulations. As Coastguard SAR Operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, the wind farm will not restrict SAR aircraft access to nearby installations – see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report; and
- MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training is more advanced than that available to CAT helicopters.

Analysis of Risk

- Take-off limitations – there are no take off limitations on SAR operated helicopter flights imposed by the presence of Hornsea Four; and
- Approach limitations – there are no approach limitations on SAR operated helicopter flights imposed by the presence of Hornsea Four.

19.6.6.1.4 On the basis of the above assessment, and as Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, the presence of Hornsea Four will not impose any restrictions on SAR aircraft access to nearby installations. The safety risk remains unchanged and is considered broadly acceptable.

19.6.7 Helicopter - Impaired Access to O&G Vessels (CAT)

19.6.7.1.1 This subsection addresses the potential for impaired access of CAT operated helicopters to O&G vessels associated with Tier 2 operations.

19.6.7.1.2 The potential for impaired access to O&G vessels associated with Tier 2 operations could arise from the following initiators:

- Proximity of tall structures / obstacles;
- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter incident; and
- Potential restriction to flying due to restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;

- Communication; and
- Operational procedures / personnel training.

Analysis of Risk

19.6.7.1.3 In terms of navigational failure as a result of Hornsea Four, consideration of helicopter systems is already built into the procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

19.6.7.1.4 In consideration of extreme weather / environmental conditions, the operational regulations already include weather limits, and these will not change with the presence of Hornsea Four.

19.6.7.1.5 As stated in section 4.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, it was observed that under stated conditions, O&G platforms adjacent to Hornsea Four will not be subject to approach limitations. Helicopter approach and take-off will not be affected due to flight procedures and regulations taking account of all obstacles. Consequently, it is considered that the vessels associated with these O&G platforms will also not be subject to approach limitations, however, this will also be dependent on vessel location and height of decent or approach.

19.6.7.1.6 On this basis and considering that helicopter transport will not take place should there be any risk brought about by a combination of meteorological conditions and the presence of the Hornsea Four array, the safety risk associated with helicopter transport to and from vessels in Tier 2 will remain unchanged and so is considered broadly acceptable.

19.6.7.1.7 Note that, ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report shows that the implications of impaired access are not safety related, but commercial only. Hornsea Four acknowledges this and are in discussions with the relevant operators via continued consultation - these are considered in Section 20: Commercial Considerations of this report.

19.6.8 Helicopter - Impaired Access to O&G Vessels (SAR)

19.6.8.1.1 This subsection addresses the potential for impaired access of SAR operated helicopter to O&G vessels associated with Tier 2 operations.

19.6.8.1.2 The potential for impaired access to O&G vessels associated with Tier 2 operations could arise from the following initiators:

- Proximity of tall structures / obstacles leading to wind turbulence;
- Navigational failure; and
- Extreme weather / environmental conditions.

Potential Consequences

- Helicopter restrictions to flying as a result of Hornsea Four; and
- Potential restriction to flying due to restrictions given by Hornsea Four.

Existing Safeguards / Controls

- Awareness of flying restrictions;
- Communication;
- Operational procedures / personnel training;
- For emergency conditions, i.e., critical Medivacs and SAR are not constrained by CAT Regulations as these rely on the Coastguard SAR Aircraft operating under CAP 999. The Coastguard helicopters are operated as state aircraft under national regulations and are not constrained by EASA Regulations. As Coastguard SAR operations are not restricted by CAT Regulations and are conducted as a State Activity under CAP 999, Hornsea Four will not restrict SAR aircraft access to vessels NEO's nearby installation– see section 7.1 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report; and

- MCA SAR helicopters have advanced autopilot features and crew training which will enable an approach in extreme conditions. This equipment and training is more advanced than that available to CAT helicopters.

Analysis of Risk

19.6.8.1.3 In terms of navigational failure, this consideration is already built into the helicopter systems procedures. Hornsea Four will not introduce any additional requirements. New flight procedures will not be required with the presence of Hornsea Four.

19.6.8.1.4 In consideration of extreme weather / environmental conditions, the operational regulations already include weather limits, and these will not change with the presence of Hornsea Four.

19.6.8.1.5 As stated in section 4.2 of ES Volume A5, Annex 11.1, Appendix A: Helicopter Access Report, it was observed that under stated conditions, O&G platforms adjacent to Hornsea Four will not be subject to approach limitations. Helicopter approach and take-off will not be affected due to flight procedures and regulations taking account of all obstacles. Consequently, it is considered that the vessels associated with these O&G platforms will also not be subject to approach limitations, however, this will be dependent on vessel location and height of decent or approach.

19.6.8.1.6 On this basis and considering that helicopter transport will not take place should there be any risk brought about by a combination of meteorological conditions and the presence of the Hornsea Four array, the risk associated with helicopter transport to and from vessels in Tier 2 will remain unchanged and so is considered broadly acceptable.

19.6.9 Seismic Survey Activities

19.6.9.1.1 Seismic surveillance activities may be required in the future, around the Hornsea Four array. At the time of such activity, it is proposed that a co-existence plan will develop how the performance of such activity will be implemented without undue risk in the interfaces.

19.6.9.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

19.6.10 Drilling Activities

19.6.10.1.1 Exploration and appraisal drilling may be required around the Hornsea Four array area and ECC area. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

19.6.10.1.2 There have been recent drilling campaigns in the Irish Sea taking place in and around existing offshore wind farms. This presents an example that with adequate planning offshore wind and O&G infrastructures can coexist.

19.6.10.1.3 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

19.6.11 Construction (ECC and Array Area) Activities

19.6.11.1.1 NEO may want to construct new production facilities in and around the Hornsea Four array area and ECC area. At the time of such activity, it is proposed that a co-existence plan will develop how the communication including SIMOPS activity for such plans would take place.

19.6.11.1.2 If such activity will be required in the future it will be adequately planned and analysed in line with regulatory requirements, good engineering practice and the safe operability regime existing on the UK continental shelf. As such the activity would only proceed once identified risks would have been demonstrated to be acceptable.

19.6.12 Non-Process Fires & Explosions

19.6.12.1.1 Non-process fires and explosions are typically associated with non-process plants. In the case of Hornsea Four, this could be electrical fires associated with the High Voltage Alternating Current (HVAC) booster station platform, and the offshore substations within the array.

19.6.12.1.2 Considering the distances of the Tier 2 asset from the HVAC booster station search area (over 10 nm) and array area (over 2.3 nm), it is considered that the impact of electrical fires on NEO's Tier 2 assets are negligible, and therefore broadly acceptable.

19.6.13 Loss of Containment - Outboard Pipelines / Intra-field Pipelines

19.6.13.1.1 According to GASCET (HSE, 2006), the relevant hazardous events with the potential for damage to the outboard / intra-field pipelines resulting in loss of containment could result from the following hazard initiators: fatigue / vibration; incorrect installation; violation; operator error – inadequate training / competency; deficient procedures – operational / maintenance; vessel impact; dropped objects (i.e. dropped cargo) / abnormal external load; seismic event; and anchor – snagging / dropping.

19.6.13.2 Fatigue / Vibration

19.6.13.2.1 Operations associated with installation of the towers for the WTGs could involve piling or drilling dependent on the selected foundation method which is also dependent on ground conditions.

Potential Consequences

19.6.13.2.2 Loss of containment due to flowline vibration triggered by drilling / piling.

Existing Safeguards / Controls

- Inherent Safety (including fully rated pipelines, inherent impact resistance, pipe burial and trenching (where applicable);
- Good procedures and Competent personnel associated with installation and operation of Hornsea Four;
- Isolation and Permit to Work (PTW) controls; and
- Pre-operation strength and leak testing.

Analysis of Risk

19.6.13.2.3 Based on previous experience the expected strike energy for piling would typically be 3,000 kJ and could increase to 5,000 kJ. Details of the duration of piling operations in the HVAC booster station search area and the array area are documented in section 19.4.2.2.

19.6.13.2.4 The timing and execution of these foundation operations will be planned in consultation between NEO and Hornsea Four, and these operations will be performed in accordance with good practice.

19.6.13.2.5 Considering the distances of the drilling and piling areas to the pipeline (over 4 km to the array area), the potential ground shaking and associated vibration in the surrounding area is expected to dissipate before reaching the pipeline, and as such, there will be negligible impact to the pipeline. The risk is therefore considered to be broadly acceptable.

19.6.13.2.6 The temporary piling / drilling operations associated with the array could also lead to acoustic vibrations which could have an adverse effect on diving. Diving near the pipeline should be avoided during such operations. This will be managed via standard site installation communication between interested parties.

19.6.13.3 Incorrect Installation

19.6.13.3.1 Incorrect installation of the Hornsea Four export cables has the potential to impact the pipelines at their crossing points within the ECC due to additional hazards over and above the pipeline design criteria.

19.6.13.3.2 As there are no intra-field pipeline-ECC crossings, this impact of is not considered applicable.

19.6.13.4 Operator Error – Inadequate Training / Competency

19.6.13.4.1 The topic area of Human Factors covers three broad areas: human error; procedural integrity; and organisational integrity.

19.6.13.4.2 For the analysis of NEO's pipelines the most relevant subjects are Hornsea Four navigation, station holding and/ or the potential of drifting close to or around the route of the pipeline, due to vessel operations associated with cable installation, cable inspection or maintenance.

19.6.13.4.3 Human errors can occur both in the conceptual and design phases as well as operational phases of a project. Human errors, that have the potential to result in MAHs, in the operational scenario, can be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

Potential Consequences

19.6.13.4.4 Loss of containment due to incidents caused by personnel incompetency / lack of experience.

Existing Safeguards / Controls

- Good procedures;
- Competent personnel; and
- Monitoring and Audit systems.

Analysis of Risk

19.6.13.4.5 According to the UK HSE, the O&G asset holder should have a procedure in place for the selection, competence assessment, and training of operations and maintenance personnel and that it is designed in accordance with a recognised standard or code of practice. Recognised current standards/codes of practice would include:

- Competence Assessment for the Hazardous Industries, Research Report 086 (HSE, 2003);
- Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092 (HSE, 2000); and
- Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053 (HSE, 2001).

19.6.13.4.6 The HSE standards and codes of practices are referenced to show that in order to operate in the UK Continental Shelf, the O&G asset holders are expected to follow certain requirements.

19.6.13.4.7 Hornsea Four intends to apply standards and codes of practices from Procedures, Legislation, and Guidance relevant to the UK Continental Shelf e.g., DNVGL-RP-0360 (DNV GL, 2016). Risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel will

be employed during the installation, operations and maintenance of the Hornsea Four infrastructure. Incremental additional risk to the pipelines from this potential initiator is considered negligible.

19.6.13.4.8 Considering that Hornsea Four will be implemented and operated in accordance with good industry practice, the risk of impact from human factors is considered broadly acceptable.

19.6.13.5 Violation

19.6.13.5.1 Human factors involved in the earlier conceptual design stages of the installation lifecycle can influence the likelihood of the occurrence of hazardous event. When installations have not been designed and constructed, and / or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards, a violation is said to have occurred.

Potential Consequences

19.6.13.5.2 Loss of containment due to not following procedure and guidelines.

Existing Safeguards / Controls

- Good procedures; and
- Competent personnel.

Analysis of Risk

19.6.13.5.3 As stated above in section 19.6.13.4, human errors can occur in all phases of a project. Human errors, that have the potential to result in MAHs, in the earlier conceptual design stages, can also be initiated from pressures and influences on the individual brought by organisational culture and factors, multi-skilling/tasking, and competences, and the effects these have in impairing human performance.

19.6.13.5.4 The impact of violation is considered similar to 'operator error' and considering that risk mitigating measures such as good work practices and procedures, training, and the use of competent personnel is being employed in the design of the Hornsea Four infrastructure, the introduction of additional risk to the pipelines from this potential initiator is considered negligible. The risk is considered to be broadly acceptable.

19.6.13.6 Deficient Procedures – Operational / Maintenance

19.6.13.6.1 If deficient procedures are applied during the installation, operations, and maintenance of Hornsea Four export cables, there is potential that pipelines with crossings will be affected due to additional hazards over and above the pipeline design tolerance.

19.6.13.6.2 As there are no intra-field pipeline-ECC crossings, this impact is not considered applicable.

19.6.13.7 Vessel Impact

19.6.13.7.1 Vessel impact concerns the potential additional hazards associated with vessel movements in and around the pipeline corridor, due to the presence of Hornsea Four construction and operation. This may include the following types of vessels: standby vessels, supply vessels, DSVs, survey vessels, barges, and cable installation vessels.

19.6.13.7.2 The interaction between vessels and pipelines will potentially result from dropped objects and/ or anchor snagging.

19.6.13.7.3 Dropped object risks are addressed in section 19.6.13.8 of the report.

19.6.13.7.4 Anchor snagging risks are addressed in section 19.6.13.10 of the report.

19.6.13.8 Dropped Objects

19.6.13.8.1 This involves additional hazards to Neo's pipeline as a result of abnormal external load / dropped objects from vessels associated with Hornsea Four.

19.6.13.8.2 According to the Offshore Technology Report 2001/013 (HSE, 2002), the principal categories of load are: dead loads, imposed (operational) loads, environmental loads, deformation loads - loads associated with imposed deformations and imposed strains; and accidental loads, results from accidental events, such as collision, dropped objects, fire and explosion and other abnormal events.

19.6.13.8.3 For the interaction between Hornsea Four and the pipeline, accidental loads are the only relevant potential hazards that could arise from this interaction.

Potential Consequences

19.6.13.8.4 Loss of containment from rupture of flowlines due to dropped objects from Hornsea Four vessels during installation and maintenance of Hornsea Four.

Existing Safeguards / Controls

19.6.13.8.5 As per Offshore Technology Report 2001/013 (HSE, 2002), the pipeline installation should be so designed and, if necessary, protected that the consequences of damage are acceptable and that an adequate margin of safety is maintained.

19.6.13.8.6 As with the hazards associated with collision, the usual measures employed in controlling the hazards from dropped objects include:

- Inherent Safety in design and operation;
- Prevention through procedures, personnel, high visibility, communications, incident reporting and analysis, and detection;
- Control through: Quality Assurance, Operating envelope, Procedures, and barriers;
- Mitigation through: Physical Protection and Robust Structure; and
- The subsea infrastructure will be marked in sea charts and other layout drawings.

Analysis of Risk

19.6.13.8.7 According to section 3.G16 of GASCET (HSE, 2006), the pipeline should have been designed and constructed, and/or re-assessed, maintained and repaired in accordance with the latest edition of a recognised standard, recommended practice or code of practice for accidental hazards. General requirements for accidental hazards are found in:

- Loads, Offshore Technology Report – OTO 2001/013 (HSE, 2002);
- Petroleum and Natural Gas Industries – Fixed Steel Offshore Structures – ISO 19902 (ISO, 2011);
- Technical Safety – S-001 (NORSOK, 2008);
- Documentation for Operation – Z-001 (NORSOK, 1998);
- Risk and Emergency Preparedness Analysis – Z-013 (NORSOK, 2001); and
- Explosion Resistant Design for Offshore Structures – Technical Note No 4 (SCI, 1996).

19.6.13.8.8 Other requirements are found in DNV RPF-107 – RP Risk Assessment of Pipeline Protection (DNV, 2010).

19.6.13.8.9 Also, the relevant Legislation, ACOP and Guidance that apply includes:

- Offshore Installations Safety Case Regulations – HSE-UK SCR (HSE, 2015);
- Offshore Installations and Wells (Design and Construction, etc) Regulations (HSE, 2008); and
- Assessment Principles for Offshore Safety Cases [APOSC] (HSE, 2016).

19.6.13.8.10 As the relevant UK Continental Shelf Procedures, Legislation, and Guidelines will be adhered to and maintained in designing and installation of the pipeline, it is assumed that all design, prevention and control measures for pipelines installed in the UK Continental Shelf will be adhered to. Therefore, it is not perceived that potential additional risks initiated as a result of Hornsea Four will surpass those for which the pipelines should be designed to withstand. As a result, the introduction of additional risks from this potential initiator is negligible and considered to be broadly acceptable.

19.6.13.8.11 As part of Hornsea Four's commitment Co107 (see Volume A4, Annex 5.2: Commitment Register), crossing and proximity agreements with known existing pipeline and cables operators will be sought.

19.6.13.9 Seismic Event

19.6.13.9.1 Hornsea Four will not induce any seismic events. It will however in and around the array area induce a degree of ground shaking during the installation of foundations due to drilling or piling.

19.6.13.9.2 Details of the duration of piling operations in the array area and the array area are documented in section 19.4.2.2.

19.6.13.9.3 The timing and execution of these foundation operations will be planned in consultation between NEO and Hornsea Four, and these operations will be performed in accordance with good practice. The risk is negligible and therefore considered to be broadly acceptable.

19.6.13.10 Anchor – Snagging / Dropping

19.6.13.10.1 Ships may anchor under various circumstances including the following:

- Normal anchoring:
  - when waiting on berths or for permission to use a controlled channel;
  - when necessary to aid manoeuvring in restricted areas; and
  - when performing survey or construction operations.
- Emergency anchoring:
  - following mechanical breakdown of the propulsion or steering system;
  - following an accident such as major fire or a collision; and
  - to slow down the ship in order to avert a possible collision or ramming or grounding.

19.6.13.10.2 Hazards to pipelines can arise either at the time of anchoring or subsequently if the ship should drag its anchor due to the effects of wind, wave and/or current, and also when the ship tries to retrieve the anchor.

19.6.13.10.3 In normal anchoring, there should be minimal risk to the pipelines, which are shown on charts and protected by anchoring safety zones. The anchor safety zones typically extend at least 0.5 nautical miles to either side of the pipelines.

19.6.13.10.4 At the time of anchoring, the risk to the pipeline is either that the anchor is dropped onto the pipeline or that the anchor is dragged across the pipeline. If the anchor hooks the pipeline but does not cause immediate damage, there will be a further risk of damage when the ship comes to try to haul the anchor back in.

19.6.13.10.5 Good seamanship will avert impact from emergency anchoring. Good seamanship involves anchoring well away from pipelines, in water of an appropriate depth (neither too shallow nor too deep) and in an area where the seabed is known to have good anchor holding properties. In addition, under weather conditions when dragging might occur, it is normal good practice to keep engines on standby and to make regular checks on position. Sometimes ships will leave their anchorages if dragging is anticipated.

19.6.13.10.6 The cause of anchors dropping accidentally is mainly due to failure of the brake systems when anchors are made ready for use, i.e., when mechanical securing systems are removed. The risk to the pipeline due to dropping anchors at sea is considered negligible, because the anchors should not be made ready for use and should be secured.

19.6.13.10.7 The Hornsea Four export cable installation operations may include, but not be limited to, survey vessels, clearance vessels, cable installation vessels, cable burial vessels, remedial works vessels and post installation survey vessels, none of which are expected to make use of anchors or anchor spreads but may be required in shallow waters (less than 15 m) or where difficult conditions dictate. The Hornsea Four operations and maintenance operations associated with the export cables will involve mainly external inspection survey vessels, possibly accompanied by Remotely Operated Vehicle (ROV). Remedial protection replenishment may also be required. Such vessels are unlikely to make use of anchors or anchor spreads but may do so should conditions dictate. Should cable inspections, or cable testing identify a need for repair operations, a repair vessel, and associated support vessels will be required, which could involve anchorage. Initially, DNV guidelines shall be adhered to with respect the minimum distance between any existing subsea asset and the placement of any anchors. These distances shall be discussed and agreed with the subsea asset owner.

19.6.13.10.8 Considering the types of vessels that Hornsea Four intends to make use of during installation and maintenance of the cable, the likelihood of anchor incidents leading to snagging, hooking or dropping is considered negligible. The risk is therefore considered to be broadly acceptable.

19.7 TIER 3

19.7.1.1.1 As per the tier grouping, Tier 3 assets are defined as those assets not within 10 nm but raised during consultation by a relevant stakeholder; or assets not within 10 nm but where the route to the asset will require deviation as a result of Hornsea Four array area.

19.7.1.1.2 It is considered that as all NEO Tier 3 assets are south of Hornsea Four HVAC booster station search area, and southwest of Hornsea Four array area, Hornsea Four will not have any additional impact on the operations and maintenance of these assets.

19.7.1.1.3 As a result of this, no Tier 3 assessments have been conducted for NEO.

19.8 NEO Summary

19.8.1.1.1 The table below presents the risk summary for the assessment performed for the NEO assets. The structure of the table is in line with the Tier grouping and order in which the hazards were assessed.

Table 19-2: Hazards and Risk Summary – Neo Petroleum

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
TIER 1							
	N/A	N/A	N/A	N/A			N/A
TIER 2							
	TIER 2 – PLATFORMS						
		Structural Integrity	Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Vessel Impact	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Helicopter Impact	All Assets	Very Unlikely	Local Damage	Broadly Acceptable
		Loss of Maritime Integrity - Loss of Stability		All Assets			Not Considered Further
		Loss of Maritime Integrity - Loss of Position		All Assets			Not Considered Further
		Vessel Access (Deviation) - Construction and Operations		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
		Vessel Access (Proximity) - Construction and Operations		All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
	TIER 2 – PLATFORMS SYSTEMS						
		Loss of Containment - Process		All Assets			Not Considered Further
		Loss of Containment - Pipelines		All Assets			Not Considered Further
		Loss of Containment - Fire & Explosion		All Assets			Not Considered Further
		Emergency Response		All Assets	Very Unlikely	Slight Impact	Broadly Acceptable
	TIER 2 – ASSOCIATED SYSTEMS						
		Wells		All Assets	Unlikely	Minor Damage	Broadly Acceptable
		Diving		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Human Factor		All Assets	Very Unlikely	Moderate Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Platforms (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (CAT)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Helicopter - Impaired Access to O&G Vessels (SAR)		All Assets	Very Unlikely	Serious Impact	Broadly Acceptable
		Non-Process Fires & Explosions		All Assets	Very Unlikely	Local Damage	Broadly Acceptable

Tier		Hazards	Sub-Groups	Assets	Likelihood	Severity	Risk
		Loss of Containment - Outboard Pipelines / Intra-field Pipelines	Fatigue / Vibration	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Incorrect Installation	All Assets			Not Considered Further
			Operator Error – Inadequate Training / Competency	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Violation	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Deficient Procedures – Operational / Maintenance	All Assets			Not Considered Further
			Vessel Impact	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Dropped Objects	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
			Seismic Event	All Assets	Very Unlikely	Slight Damage	Broadly Acceptable
			Anchor – Snagging / Dropping	All Assets	Very Unlikely	Minor Damage	Broadly Acceptable
TIER 3							
	N/A	N/A	N/A	N/A			N/A

20 Commercial Considerations

20.1 Introduction

20.1.1.1.1 Chapters 7 – 19 above identified hazards (see section 6.2 for hazard topics / guidewords) using the Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases (GASCET) (HSE, 2006) framework, established the likelihood of hazardous events, evaluated the consequences and indicated an associated risk level. A conclusion as to the acceptability of the risk was provided for each hazard, and risk reduction measures were identified if necessary. These risk assessments related to safety only and the associated conclusions reflect whether the presence of Hornsea Four has any implications for the safety of each stakeholder's assets and associated operations.

20.1.1.1.2 In addition to these hazards and safety assessments, there are also a number of commercial impacts that need consideration. These are separate from the safety assessments in Chapters 7 – 19. For example, where a safety assessment has concluded "broadly acceptable", this means that the risk to safety is considered to be low but there may still be commercial impacts e.g., related to access or lost production time.

20.1.1.1.3 This chapter sets out the main commercial impacts in generic terms that may arise as a result of Hornsea Four. Ongoing consideration of these issues is therefore commercial and will be undertaken by the Applicant in the spirit of coexistence as required by national planning policy. The section below presents the topic areas considered to have commercial implications.

20.2 Commercial Impacts

20.2.1 Future Developments

20.2.1.1.1 The Offshore Installations Interfaces (OII) Annex assesses all existing assets and any firm future developments, which are either in the public domain with a Field Development Plan (FDP) submitted or where detailed information has been provided through consultation including certainty of the plans going ahead. This approach is aligned with the methodology for Cumulative Effect Assessment (CEA) and certainty in development proposals.

20.2.1.1.2 In assessing the potential for cumulative effects from Hornsea Four, it is important to bear in mind that projects, predominantly those 'proposed', may or may not be taken forward for development. Therefore, there is a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals.

20.2.1.1.3 Hornsea Four is continually engaging with operators to ensure we are informed of future developments at the earliest opportunity. Once a sufficient level of detail becomes available, or an FDP is made, then an assessment will take place and the annex will be updated accordingly.

20.2.1.1.4 The consideration of future developments will be dependent on the sufficient provision, by the operator, of details as to the location of any prospects, and certainty as to the likelihood of a development going ahead.

20.2.2 Helicopter Transport

20.2.2.1.1 The construction of Hornsea Four means that some Oil and Gas (O&G) operators may have to adapt their current helicopter operations to / from helideck-equipped oil and gas platforms and helideck-equipped vessels contracted by O&G operators. The presence of Hornsea Four may reduce access compared to the current level of access that operators have to their assets, noting that at present weather conditions alone can impair routine O&G helicopter access and egress. Therefore, in conditions with poor visibility, this could lead to the following commercial impacts:

- Crew unable to access a platform/work vessel to undertake work or having to access platform/work vessel via alternate means. This event could lead to delays in conducting planned or corrective maintenance, excess technician time, and/or extra helicopter fees, or result in deferred production due to unavailability of specialist personnel to perform essential maintenance/repair;
- Delays resulting in crew unable to leave platform / work vessel to reach shore after shift. This could lead to additional man-hour payments;

20.2.2.1.2 However, there are access enhancement measures/ technologies currently in use in the UK North Sea that can be applied to alleviate these commercial impacts.

20.2.3 Radar Early Warning Systems (REWS)

20.2.3.1.1 For certain O&G operators the signal efficiency of a given Radar Early Warning System (REWS) may reduce due to shadowing effects caused by the presence of offshore wind turbines. Potential options for mitigating REWS impacts include:

- Data fusion from the three REWS installations to reduce the effect of shadowing and further reduction in detection gaps due to the elevated thresholds;
- The use of adaptive thresholding algorithms such as Constant False Alarm Rate (CFAR) may reduce the affected area;
- The use of advanced filtering techniques and radar signal non-acquire zones can reduce the effect of turbines on threshold levels and hence improve the detection regions; and
- Hardware upgrades.

20.2.3.1.2 The implementation of such systems would have a commercial impact.

20.2.3.1.3 For some operators and due to re-arrangement of shipping routes, an increase in Closest Point of Approach (CPA) alarms may be experienced on platforms due to busier and closer shipping routes. This could potentially result in an increase of platform personnel man-hours to deal with these alarms. Alternatively, considering the potential increase in alarms, the existing procedure could be reviewed with the objective to tailor for more alarms. Also, given the expected increase of demand requirement for the alarms (REWS), which is considered a Safety and Environmental Critical Element (SECE), the Performance Standard (PS) and associated written scheme of verifications could be reviewed.

20.2.4 Vessels Mileage

20.2.4.1.1 Despite the conclusion of the safety assessment of “broadly acceptable”, the construction and operation of Hornsea Four may increase the number of miles travelled by vessels contracted by O&G operators for operations related to construction, operation and maintenance. This is because the presence of Hornsea Four may require current vessel routes to be modified or deviated. If there is a demonstrable (supported by evidence) increase in costs due to the modification of vessel routes then this may trigger discussion between the parties.

20.3 Approach

20.3.1.1.1 Consultation with oil and gas stakeholders began in Q4 2018, early in Hornsea Four’s development, and is documented in Table 11.3 of Volume A2, Chapter 11: Infrastructure and Other Users. This engagement provided an understanding of the interfaces between the parties, both in terms of physical assets and timeframes for construction, operations, maintenance, decommissioning and also in terms of the associated commercial impacts.

20.3.1.1.2 Regular consultation has been ongoing with the relevant stakeholders with the aim to address any residual commercial impacts and work towards a pragmatic approach to coexistence, in accordance with policies

set out in Section 11.3 of the Volume A2, Chapter 11: Infrastructure and Other Users. In particular, policy EN-3 states that "Where a proposed offshore wind farm potentially affects other offshore infrastructure or activity, a pragmatic approach should be employed by the IPC. Much of this infrastructure is important to other offshore industries as is its contribution to the UK economy." Our pragmatic approach therefore aims to ensure both renewables and Oil and Gas can coexist and provide valuable contributions to the UK economy and energy supply.

20.3.1.1.3 Commercial negotiations may be required, focussing on applicable specific issues. These negotiations may be purely cost related, involve technical experts to assess cost implications or include opportunities to collaborate and undertake further research. Acknowledging that discussion between the parties may be commercially sensitive, where it is appropriate to do so the parties will also engage the relevant regulatory authorities.

20.3.1.1.4 The Applicant aims to resolve commercial issues individually with each relevant operator and implement tailored solutions to ensure the continued economic viability of Hornsea Four and the offshore oil and gas projects considered in this report.

21 References

1. Ørsted, Orbis Energy Limited (2019) Hornsea Four Oil & Gas Consultations Standalone Report, Doc. Ref: Orbis P1221-04, Rev. No.: F01, 14 June 2019.
2. HSE UK, Offshore Installations (Safety Case) Regulations 2015 and associated Guidance Document L154.
3. HSE UK, Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995 and associated Guidance Document L65, Third Edition, 2016.
4. HSE UK, Guidance for the Topic Assessment of The Major Accident Hazard Aspects of Safety Cases (GASCET), April 2006.
5. Department of Energy (1990), The Hon Lord Cullen's Report, The Public Inquiry into the Piper Alpha Disaster, November 1990.
6. HSE-UK, Guidance on Risk Assessment for Offshore Installations: Offshore Information Sheet No. 3/2006.
7. Netherlands Regulatory Framework (NeRF) – Maritime (2015), Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU), MODU Code 2009, 2015.
8. DNV GL (2016) Recommended Practice: Subsea Power Cables in Shallow Water, Doc. Ref: DNVGL-RP-0360, Edition March 2016.
9. DNV GL (2016) Recommended Practice: Risk Assessment of Pipeline Protection, Doc. Ref: DNVGL-RP-F107, Edition March 2010.
10. Ørsted, Manchester Advanced Radar Services (2020) Hornsea Project Four, Environmental Statement (ES), Appendix B of ES Annex 11.1: Radar Early Warning Technical Report, Version B, September 2021.
11. Ørsted, Anatec (2021) Hornsea Project Four, Environmental Statement (ES), Appendix A of ES Annex 11.1: Helicopter Access Report: Assessment of the Operational Impact of Hornsea Project Four on Helicopter Operations to Adjacent Gas Installations, Doc. Ref. A4481-ORS-TN-01, Rev. 09, September 2021.
12. Ørsted, Anatec (2021) Hornsea Project Four, Environmental Statement (ES), Appendix A of ES Annex 11.1: Helicopter Access Report: Appendix A1 – Platform Specific Data for Helicopter ARA to Gas Installations Adjacent to Hornsea Project Four, Doc. Ref. A4481-ORS-TN-02, Rev. 02, September 2021.
13. Ørsted, Anatec (2021) Hornsea Project Four, Environmental Statement (ES), Appendix C of ES Annex 11.1: Allision Technical Report: Assessment of the Impact of Hornsea Four on Offshore Oil and Gas Installations (Collision & Vessel/Rig Access), Doc. Ref. A4481-ORS-OGA-3, Rev. 3b, September 2021.
14. Terma (2021) Wind turbine RCS assessment from radar data recorded at Hornsea One, Document No. 1739964-RA, 2021.
15. Vinnem, J.E. (1999) Offshore Risk Assessment: Principles, Modelling and Applications of QRA Studies, Springer Science+Business Media Dordrecht, 1999.
16. Ørsted, Anatec (2020) Navigational Risk Assessment, Doc. Ref: A4300-ORS-NRA-01.
17. Ørsted (2019) Hornsea Project Four: Environmental Statement (ES), PINS Document Reference: A1.4, APFP Regulation: 5(2)(a), Volume A4: Chapter 4: Project Description, Doc. Ref: A1.4, Version A, March 2020.
18. HSE-UK, Competence Assessment for the Hazardous Industries, Research Report 086, 2003.
19. HSE-UK, Human Factors Assessment of Safety Critical Tasks, Offshore Technology Report – OTO 1999/092, July 2000.
20. HSE-UK, Evaluation Report on OTO 1999/092 Factors Assessment of Safety Critical Tasks, Research Report 033, 2002.

21. HSE-UK, Preventing the Propagation of Error and Misplaced Reliance on Faulty Systems: A Guide to Human Error Dependency, Offshore Technology Report – OTO 2001/053, 2001.
22. HSE-UK, Loads, Offshore Technology Report – OTO 2001/013, 2002.
23. ISO, Petroleum and Natural Gas Industries - Fixed Steel Offshore Structures – ISO 19902:2007, 2011.
24. NORSOK, Technical Safety - S-001, Edition 4, February 2008.
25. NORSOK, Documentation for Operation – Z-001, Rev. 04, March 1998.
26. NORSOK, Risk and Emergency Preparedness Analysis – Z-013, Rev. 02, 2001.
27. SCI, Explosion Resistant Design of Offshore Structures: (FABIG Technical Note 4), 1996.
28. HSE-UK, Offshore Installations and Wells (Design and Construction, etc) Regulations, Edition 2, 2008.
29. Assessment Principles for Offshore Safety Cases [APOSC], August 2016.
30. D F Bacon, A Proposed Method for Establishing An Exclusion Zone Around A Terrestrial Fixed Radio Link Outside Of Which A Wind Turbine Will Cause Negligible Degradation Of The Radio Link Performance, Version 1.1, 28th October 2002.