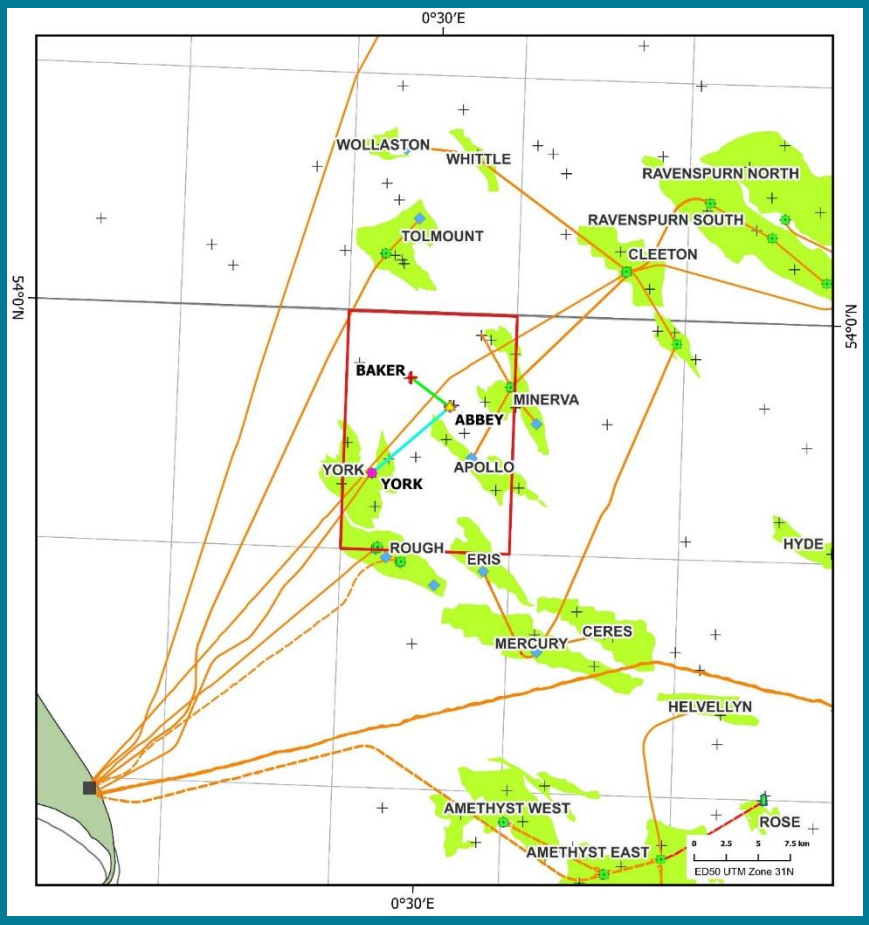
Petrogas North Sea Limited

Abbey & Baker Field Development Environmental Statement



النفط والغاز
PETROGAS
E&P

OPRED Reference Number: ES/2026/023

30th July 2026

ENVIRONMENTAL STATEMENT DETAILS

Section A: Administrative Information

A1 – Project Reference Number

Number: ES/2026/023

A2 – Developer Contact Details

Company Name: Petrogas North Sea Limited

Contact Name: Andrew Buchan

Contact Title: Project Contact

A3 – ES Contact Details (if different from above)

As above.

A4 – ES Preparation

Please confirm the key expert staff involved in the preparation of the ES:

Name	Company	Title	Relevant Qualifications / Experience
John Girling	Orbis Energy Limited	Director	Over 20 years environmental consultancy experience in the oil and gas industry. He has a M.Sc (by research) in Environmental Science (Environmental Toxicology) and a B.Sc (Hons) in Marine & Freshwater Biology.
Fay Dobson	Orbis Energy Limited	Director	Over 20 years environmental consultancy experience in the oil and gas industry. She has a first class B.Sc (Hons) degree in Environmental Science.
Dominic Harrison	Orbis Energy Limited	Senior Consultant	Over 12 years environmental consultancy experience in the oil and gas industry. He has a first class master's degree in Environmental Science (MEnvSci).
Chloe Elkington	Orbis Energy Limited	Consultant	Over 3 years environmental consultancy experience in the oil and gas industry. She has a B.Sc (Hons) degree in Marine Biology.
Caitlin Killick	Orbis Energy Limited	Consultant	Over 2 years environmental consultancy experience in the oil and gas industry. She has a B.Sc (Hons) degree in Environmental Management.
Aaron Adal	Orbis Energy Limited	Consultant	Over 2 years environmental consultancy experience in the oil and gas industry. He has a first class B.Sc (Hons) degree in Geography.

A5 – Licence Details

a) Please confirm licence(s) covering proposed activity or activities

Licence number(s): P2582 & P2433

b) Please confirm licences and current equity

Licence Number: P2582	
Licensee	**Percentage Equity**
Petrogas North Sea Limited	100%
Licence Number: P2433	
Licensee	**Percentage Equity**
Petrogas North Sea Limited	100%

Section B: Project Information

B1 – Nature of Project

a) Please specify the name of the project.

Name: Abbey & Baker Field Development

b) Please specify the name of the ES (if different from the project name).

As above.

c) Please provide a brief description of the project:

Petrogas North Sea Limited, hereafter referred to as 'Petrogas', is planning to develop the Abbey & Baker gas fields in the Southern North Sea (SNS). Abbey sits within United Kingdom Continental Shelf (UKCS) Block 47/3i (Licence P.2582) in a water depth of 42.4 metres (m), approximately 40 kilometres (km) northeast of the Yorkshire coastline and 152 km southwest of the of the UK/Netherlands transboundary line at their closest points. Baker sits within UKCS Block 47/3f (Licence P.2433) in a water depth of 47.75 m and is located approximately 3.8 km to the northwest of Abbey (see Figure 1). Petrogas are 100% owner and operator of the licences.

Petrogas is proposing to develop the Abbey & Baker fields via four subsea gas wells; three at Abbey and one at Baker. The Baker well will be tied into a production manifold at the Abbey location, via a ca. 3.8 km 8-inch pipeline and an electro-hydraulic umbilical. The Abbey & Baker fluids will be commingled at the production manifold, with the combined Abbey & Baker production exported via a new 8 km 8-inch production pipeline and electro-hydraulic umbilical to the York Not Permanently Attended Installation (NPAI) platform. At York, Abbey & Baker will be tied into the existing 16-inch pipeline for export onshore to Perenco UK Limited's Dimlington Terminal via Centrica Energy Storage Limited's Easington Terminal for processing. First gas is currently targeted for 2029.

Petrogas is currently planning to undertake development drilling between Q4 of 2027 to Q3 of 2028, with installation of the subsea infrastructure between Q4 of 2028 and Q1 of 2029. First gas is targeted for Q2 2029.

Abbey & Baker hydrocarbon production rates are anticipated to peak in 2030 at 2,959,169.5 cubic metres (104.5 million standard cubic feet) of gas per day and 13.6 tonnes (22.1 cubic metres) of condensate per day (High case), after which there is a steady decline over the life of the field.

The Abbey & Baker subsea infrastructure will have a design life of 20 years, and the economic field life is expected to be between 11 to 16 years, depending on production performance . On cessation of production, the Abbey & Baker facilities will be decommissioned in accordance with the requirements of the prevailing UK and International law.

B2 – Project Location

a) Please indicate the offshore location(s) of the main project elements.

Aspect	Abbey Drill Centre	Baker Production Well	York Platform
Location (Lat/Long) [1]	53° 56’ 7.607” N 0° 31’ 25.909” E	53° 57' 16.584 N 0° 28' 34.511 E	53° 53’ 12.469” N 0° 26’ 3.117” E
UKCS Block	47/3i	47/3f	47/3a
ICES Rectangle	36F0		
Distance from nearest coastline (Withernsea, Yorkshire)	40 km NE	38 km NE	31 km NE
Distance from nearest median line (UK / Netherlands)	152 km WSW	156 km WSW	159 km WSW
Nearest Marine Protected Area	Within Southern North Sea Special Area of Conservation (SAC) (Winter Area)	Within Southern North Sea SAC (Winter Area)	Within Southern North Sea SAC (Winter Area) and Holderness Offshore Marine Conservation Zone (MCZ)

[1] ED50 UTM Zone 31N.

B3 – Previous Applications

If the project, or an element of the project, was the subject of a previous consent application supported by an ES, please provide details of the original project.

N/A

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Abbreviations

˚ C	Degrees Celsius
µg.kg^{-1}	Micrograms per kilogram
µm	Micrometres
‰	Parts per thousand
ACA	Action Co-ordinating Authority
AHV	Anchor Handling Vessel
AIS	Automatic Identification System
ALARP	As Low as Reasonably Practicable
APS	Announced Pledges Scenario
AR5	Fifth Assessment Report
AR6	Sixth Assessment Report
BAOAC	Bonn Agreement Oil Appearance Code
BAP	Biodiversity Action Plan
bbl	Barrel
bcm	Billion Cubic Metres
BEMS	Business Excellence Management System
BoCC	Birds of Conservation Concern
BOE	Barrel of Oil Equivalent
BOP	Blowout Preventor
BSL	Benthic Solutions Limited
Ca.	Circa
CAPEX	Capital Expenditure
CB	Carbon Budget
CBGDP	Carbon Budget and Growth Delivery Plan
CCC	Climate Change Committee
CH_4	Methane
CHARM	Chemical Hazard Assessment and Risk Management
cm	Centimetres
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
COLREG	International Regulations for Preventing Collisions at Sea
CoP	Cease of Production
COP	Conference of Parties

CPI	Carbon Preference Index
CSV	Construction Support Vessel
CtL	Consent to Locate
dB	Decibel
dB re 1µPa @ 1 m	Decibels relative to one micro-Pascal
DESNZ	Department for Energy Security and Net Zero
DGT	Dimlington Gas Terminal
DHCI	Downhole Chemical Injection
DHG	Downhole Gasification
DHPT	Downhole Pressure and Temperature
DHSV	Downhole Safety Valve
DP	Dynamically Positioned
DSV	Diver Support Vessel
DVV	Dual Van Veen
EBS	Environmental Baseline Survey
EDGAR	Emissions Database for Global Atmospheric Research
EEMS	Environmental and Emissions Monitoring System
EF	Emission Factors
EIA	Environmental Impact Assessment
EJ	Exajoules (10^{18} J)
EMODnet	European Marine Observation and Data Network
ENVID	ENVironmental and Socio-economic impact IDentification
EPOs	Environmental Protection Objectives
EPS	European Protected Species
EPU	Electric Power Unit
ERAP	Emissions Reduction Action Plan
ERL	Effects Range Low
ERM	Effects Range Median
ERRV	Emergency Response and Rescue Vessel
ES	Environmental Statement
ESAS	European Seabirds at Sea
ESDV	Emergency Shutdown Valve
EU	European Union
EUNIS	European Nature Information System

FCS	Favourable Conservation Status
FDP	Field Development Plan
FLNG	Floating Liquefied Natural Gas
FLO	Fisheries Liaison Officer
FOCI	Feature of Conservation Importance
Frac	Hydraulic fracturing / fraccing
FRP	Favourable Reference Population
GCB	Global Carbon Budget
GHG	Greenhouse Gas
GML	Global Monitoring Laboratory
GOGET	Global Oil and Gas Extraction Tracker
GOR	Gas to Oil Ratio
GST	Global Stocktake
Gt	Gigatons
GWP	Global Warming Potential
HC	Hydrocarbon
HD	High Definition
HF	High Frequency
HLV	Heavy Lift Vessel
HM	Heavy Metal
HMCS	Harmonised Mandatory Control System
HP	High Pressure
HPAI	Highly Pathogenic Avian Influenza
HPU	Hydraulic Power Unit
HSE	Health, Safety and Environmental
HSEQ	Health, Safety, Environment and Quality
HSEx	Health and Safety Executive
HSG	Herring Spawning Ground
HYCOM	Hybrid Coordinate Ocean Model
Hz	Hertz
IEA	International Energy Agency
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organization
ISEP	Institute of Sustainability and Environmental Professionals
IPCC	Intergovernmental Panel on Climate Change

ITOPF	International Tanker Owner Pollution Federation
IUCN	International Union for the Conservation of Nature
JNCC	Joint Nature Conservation Committee
Kg	Kilograms
kg/m^3	Kilograms per cubic metre
kHz	Kilohertz
km	Kilometres
km^2	Square kilometres
kt	Kilotonnes (10^6 kg)
L	Length
LAT	Lowest Astronomical Tide
LCV	Light Construction Vessel
LF	Low Frequency
LNG	Liquefied Natural Gas
LOC	Loss of Containment
LP	Low Pressure
LSE	Likely Significant Effects
LTOBM	Low Toxicity Oil Based Mud
LWD	Logging while drilling
m	Metres
m^2	Square metres
m^3	Cubic Metres
m/s	Metres per second
MAPP	Major Accident Prevention Policy
MarLIN	Marine Life Information Network
MARPOL	International Convention for the Prevention of Pollution from Ships
MAT	Master Application Template
Mbbl	Million barrels (10^6 bbl)
MBES	Multibeam Echosounder
MCAA	Marine and Coastal Access Act
MCA	Maritime and Coastguard Agency
MCS	New Master Control Station
MCZ	Marine Conservation Zone
MEG	Monoethylene Glycol
MEI	Major Environmental Incident

MeOH	Methanol
MER	Maximising Economic Recovery
$mg.kg^{-1}$	Milligrams per kilogram
$mg/cm^2/day$	Milligrams per centimetre squared per day
mg/l	Milligrams per litre
Mm^3	Million cubic metres (10^6 m^3)
mm	Millimetres
MMMU	Marine Mammal Management Unit
MMO	Marine Management Organisation
MMscf/d	Million Standard Cubic Feet per Day
MoD	Ministry of Defence
MODU	Mobile Offshore Drilling Unit
MPA	Marine Protected Area
MPS	Marine Policy Statement
Mt	Megatonnes (10^9 kg)
Mtoe	Million Tons of Oil Equivalent
MRU	Mechanical Refrigeration Unit
MU	Management Unit
N_2O	Nitrous Oxide
NAEI	National Atmospheric Emissions Inventory
NB	Nominal Bore
NDC	Nationally Determined Contribution
NESO	National Energy System Operator
NFFO	National Federation of Fishermen's Organisations
nm	Nautical Miles
NMPi	National Marine Plan Interactive
NNS	Northern North Sea
NNW	North Northwest
NOAA	National Oceanic and Atmospheric Administration
NORBRIT Agreement	The Norway-UK Joint Contingency Plan
NORM	Naturally Occurring Radioactive Material
NPAI	Not Permanently Attended Installation
NSTA	North Sea Transition Authority
NSTD	North Sea Transition Deal

NTS	National Transmission System
NUI	Normally Unmanned Installation
NW	Northwest
NZE	Net Zero Emissions by 2050 Scenario
ODP	Oil Discharge Permit
OESEA	Offshore Energy Strategic Environmental Assessment
OEUK	Offshore Energies UK
OGA	Oil and Gas Authority
OMAR	Offshore Major Accident Regulator
OPEP	Oil Pollution Emergency Plan
OPEX	Operating Expenditure
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSPAR	Oslo and Paris Convention/Commission
PAH	Polycyclic Aromatic Hydrocarbons
PCS	Production Control System
PCW	Phocid Carnivores in Water
PETS	Portal Environmental Tracking System
PEXA	Practice and Exercise Area
Pg	Petagrams
PGR	Production Gap Report
PLONOR	Pose Little or No Risk
PNEC	Predicted No-effect Concentration
PNS	Petrogas North Sea Limited (referred to as Petrogas in the ES)
PON1	Petroleum Operations Notice 1
ppb	Parts per billion
ppm	Parts per million
PSA	Particle Size Analysis
PSD	Particle Size Distribution
psi	Pounds per square inch
PST	Production Screen Test
PTS	Permanent Threshold Shift
RCP	Representative Concentration Pathways
ROV	Remote Operated Vehicle
RQ	Risk Quotient
RWL	Relief Well Location

RYA	Royal Yachting Association
SAC	Special Area of Conservation
SAT	Subsidiary Application Template
SCANS	Small Cetacean Abundance of the North Sea
SDG	Sustainable Development Goal
SDU	Subsea Distribution Unit
SE	Southeast
SELcum	Cumulative Sound Exposure Level
SGMD	Scottish Government Marine Directorate
SIMPROF	Similarity Profile Analysis
SNCBs	Statutory Nature Conservation Bodies
SNS	Southern North Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
SOSI	Seabird Oiling Sensitivity Index
SPA	Special Protection Area
SSE	South Southeast
SSIV	Subsea Isolation Valve
SSP	Shared Socio-economic Pathways
SSS	Sidescan Sonar
SURF	Subsea Umbilicals, Risers and Flowlines
THC	Total Hydrocarbon Concentration
The Project	Abbey & Baker Field Development
TD	Total Depth
TEC	Tubing Encased Conductor
Tm^3	Trillion cubic metres (10^{12} m^3)
TOC	Total Organic Carbon
TOM	Total Organic Matter
TRSCSSV	Tubing Retrievable, Surface Controlled Subsurface Safety Valve
TSS	Total Suspended Solids
TUTU	Topsides Umbilical Termination Unit
TVDss	True Vertical Depth Subsea
UHB	Upheaval Buckling
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
UKHO	United Kingdom Hydrographic Office

UKOOA	UK Offshore Operators Association
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VHF	Very High Frequency
VMS	Vessel Monitoring System
VTS	Vessel Traffic Survey
W	Width
W/m^2	Watts per Square Metre
WBM	Water Based Mud
WHPS	Well Head Protection Structure
WMO	World Meteorological Organisation
WMP	Waste Management Plan
WOAD	Worldwide Offshore Accident Database
yr	Year
ZRF	Zero Routine Flaring

Non-Technical Summary

Introduction

Petrogas North Sea Limited, hereafter referred to as Petrogas, is planning to develop the Abbey & Baker gas fields in the Southern North Sea (SNS). Abbey sits within United Kingdom Continental Shelf (UKCS) Block 47/3i (Licence P.2582) in a water depth of 42.4 metres (m), approximately 40 kilometres (km) north east of the Yorkshire coastline and 152 km south west of the of the UK/Netherlands transboundary line (Figure 1). Baker sits within UKCS Block 47/3f (Licence P.2433) in a water depth of 47.7 m and is located approximately 3.8 km to the north west of Abbey. Petrogas is 100% owner and operator of the licences.

The Abbey field was first discovered in 1974 and subsequently appraised by Amoco in 2001. In 2002, British Gas drilled and completed a development well (47/3b-12), but the field did not produce at economically viable rates and the well was subsequently plugged and abandoned. In 2024, Petrogas discovered the Baker field with exploration well 47/3f-16. Following this, Petrogas drilled, completed and hydraulically fractured appraisal well 47/3i-17z in the Abbey field, which proved the presence of moveable commercial volumes of hydrocarbons. Petrogas is now proposing to develop the Abbey & Baker fields with first gas targeted for Q2 2029.

An Environmental Statement (ES) has been prepared to present the findings of the Environmental Impact Assessment (EIA) carried out for the proposed Abbey & Baker Field Development (hereafter referred to as 'the Abbey & Baker Development' or 'the Project'), as required under The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020. The ES has been prepared by Petrogas in conjunction with Orbis Energy Limited (the EIA Consultant). This section forms the non-technical summary of the ES. The EIA has been undertaken with reference to the new supplementary guidance for assessing the effects of downstream Scope 3 emissions on climate from offshore oil and gas projects (DESNZ, 2025a).

Project Description

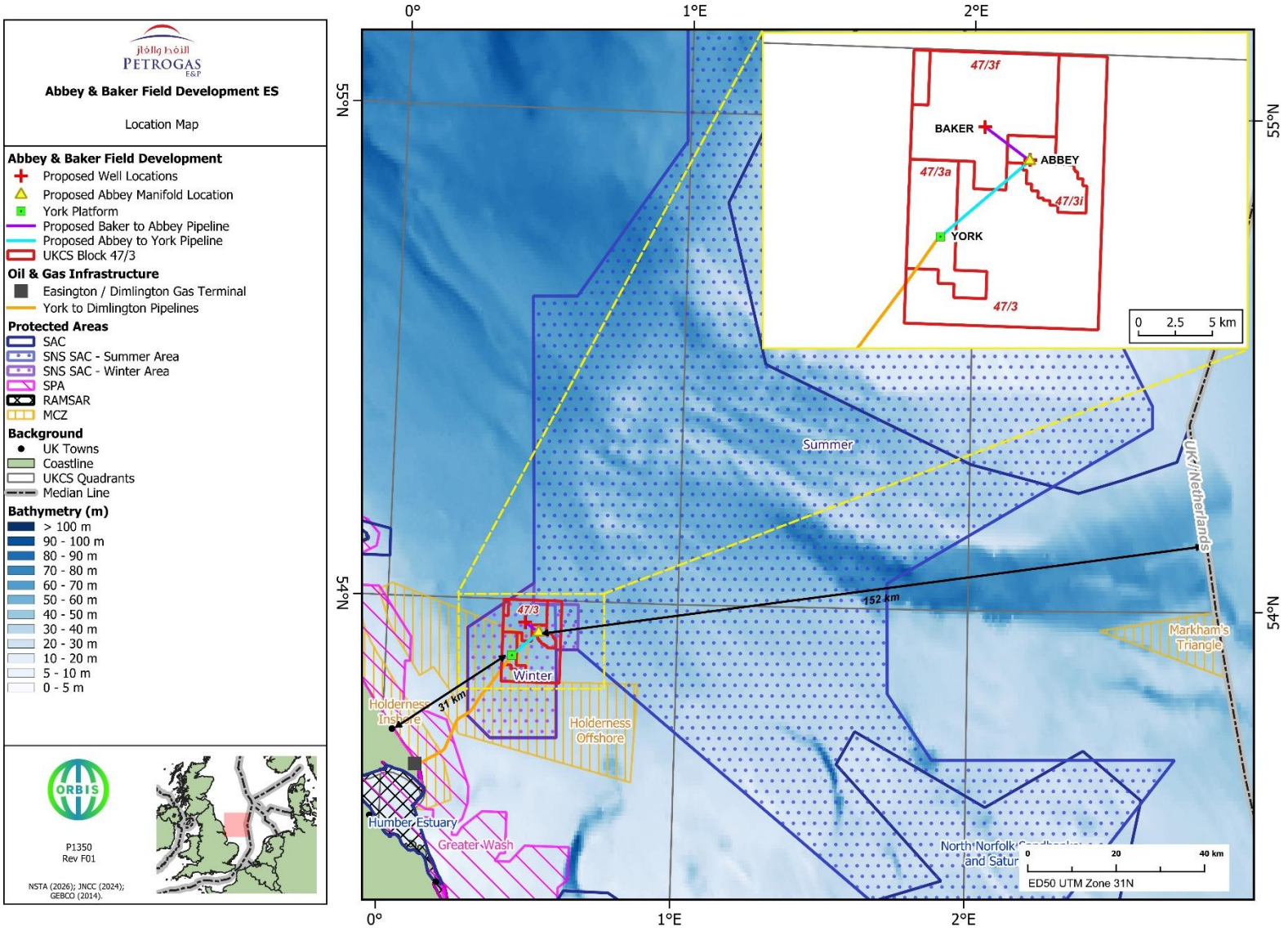
The Abbey field will be developed via three subsea horizontal production wells (A1, A2 and A3) that will be hydraulically stimulated. The wells will be drilled from a single drill centre with separate top-hole locations and will be tied back to a new production manifold located adjacent to the wells, ca. 70 to 80 m away. One of the Abbey wells (A2) was drilled as an appraisal well (47/3i-17z) in Q4 2024/Q1 2025. It has already been successfully completed and stimulated and is currently suspended, pending additional clean up and running of a subsea Xmas tree. The Baker field will be developed via a single deviated subsea well, which will be conventionally completed.

Drilling Operations

A drilling rig has yet to be contracted for the Abbey & Baker Development, however, it is expected that the two Abbey wells and the Baker well will be drilled from a heavy-duty jack-up drilling rig, similar to the Abbey A2 Appraisal Well and Baker Exploration well. In the worst case, the rig will have to be moved onto location three times; onto the Abbey location twice using anchors and chains for positioning (once to complete the Abbey A2 well and once to drill and complete the Abbey A1 and A3 wells) and the Baker location once without the use of anchors or chains. In the worst case the rig will be on location for up to 364 days.

The Abbey wells generally follow the same design and will be drilled to a depth of around 10,500 – 11,000 feet (3,200 – 3,300 m) true vertical depth subsea (TVDss), with horizontal sections of more than 1,200 metres (m) (4,000 feet). The Baker well will be drilled to a depth of around 11,000 feet (3,353 m) TVDss, with the reservoir sections being approximately 554 feet (169 m). For the proposed Abbey and Baker wells, it is currently assumed that seawater and sweeps and water based mud (WBM) will be used to drill the two top hole sections, with low toxicity oil based mud (LTOBM) used to drill the remainder of the well sections. Cuttings from the top hole section will be discharged directly from the wellbore at the seabed, cuttings from the next section will be circulated back to the MODU and discharged at sea; cuttings from all remaining sections will be shipped to shore.

Figure 1: Location of the Proposed Abbey & Baker Development



Subsea Infrastructure

Following drilling and completion at the proposed Abbey and Baker wells, it is proposed that a subsea wellhead and xmas tree will be installed by the MODU. Each of the Abbey and Baker wellheads and xmas trees will be enclosed within their own dedicated Wellhead Protection Structure (WHPS), which is fishing friendly, to ensure the tree and its connections are not damaged by dropped objects or impacts and snagging loads associated with fishing gear. Following the installation of the Xmas Tree and Tree Cap, a Debris Cap is run down and locked to the top of the WHPS. The Debris Cap provides dropped object protection for the Xmas Tree.

In addition, a manifold will be installed ca. 70 – 80 m from the Abbey wellheads. The proposed Abbey production manifold will enable the sequential or simultaneous tie-in of up to four wells, with all production from Abbey & Baker commingled before routing to York.

Petrogas is currently undecided as to whether a subsea isolation valve (SSIV) will be required for the Abbey & Baker Development. However, for the purposes of this ES, Petrogas has included an SSIV on the Abbey to York pipeline, just north east of the York platform, to provide a worst case assessment of the seabed disturbance and installed subsea infrastructure.

All tie in spools for the Abbey & Baker Development will sit within statutory subsea 500 m exclusion zones for the Abbey & Baker infrastructure; these will be protected by concrete mattresses. There are no plans to use rock dumping at these locations. Approximately 336 mattresses (assumed 6 m x 3 m each) and 150 grout bags (assumed 1 m x 1 m each), including contingency, might be required.

Pipeline and Umbilical Installation

A 3.8 km 8-inch diameter rigid pipeline and an umbilical, with a crossing over the Cleeton export pipeline (PL447), will tie the Baker well back to the Abbey production manifold. The Abbey production manifold will be tied back to the York platform (now in Cease of Production operating in light house mode), located in UKCS Block 47/3a, via an 8 km 8-inch diameter rigid export pipeline with no crossings required. A new 8 km umbilical, providing electrohydraulic controls and chemical services from the York platform to the Abbey & Baker facilities, is also required with no crossings over other infrastructure. The pipeline and umbilical will be trenched and buried with natural seabed material and supplementary rock, where required, for protection and upheaval buckling mitigation.

It is estimated that, in the worst case scenario for both of the pipelines, 6,300 tonnes of rock split equally between the pipelines may need to be deposited in order to mitigate upheaval buckling; 3,150 tonnes for the Abbey to York pipeline and 3,150 tonnes for the Baker to Abbey pipeline. Additional rock will also need to be deposited where the pipelines and umbilicals exit the trenches at Baker, Abbey and York. It is estimated that up to 2,000 tonnes of rock with a berm width of 6 m may need to be deposited over the lines for protection at these locations. In addition, in the worst case, 4,000 tonnes of rock may be required for the crossings over the Cleeton export pipeline (PL447).

In the first instance pipeline and umbilical route selection will endeavour to minimise the need for boulder removal & seabed disturbance by avoiding the boulders as far as possible. However, any medium to large boulders (0.5 m – 1 m) within the two 25 m corridors surrounding the 12 m seabed disturbance corridors will first be identified and removed from the separate pipeline and umbilical corridors with the use of a sled or, if the boulders are embedded into the seabed, by individually dragging them using a cable and sling.

Production

Following first gas which is currently targeted for Q2 2029, Abbey & Baker production rates are anticipated to peak in 2030 at 2,959,169.5 cubic metres (104.5 million standard cubic feet) of gas per day and 13.6 tonnes (22.1 cubic metres) of condensate per day (High case), after which there is a steady decline over the life of the field.

As Abbey & Baker will be a subsea development, production from the field will be processed onshore at the Dimlington Gas Terminal. Atmospheric emissions during the Abbey & Baker production phase will therefore mainly arise from power generation requirements at the Dimlington Gas Terminal. Any condensate water generated during processing of the Abbey & Baker production fluids will be disposed at the Dimlington Gas Terminal via the existing produced water system, the impact from which is outside of the scope of this ES.

Decommissioning

The Abbey & Baker subsea infrastructure is expected to produce hydrocarbons between 11 and 16 years depending on the reserves, the production rate and the life of the infrastructure. On cessation of production, the Abbey & Baker facilities (including the York platform) will be decommissioned in accordance with the requirements of the prevailing UK and International law.

Concept Selection

Initial technical studies confirmed that the optimum development option for Abbey in terms of economics, risk and environmental impact is via a subsea tie-back to a suitable host facility. A standalone development concept, which in this instance would have been a subsea development with a pipeline directly back to shore, is not economically viable and was discounted.

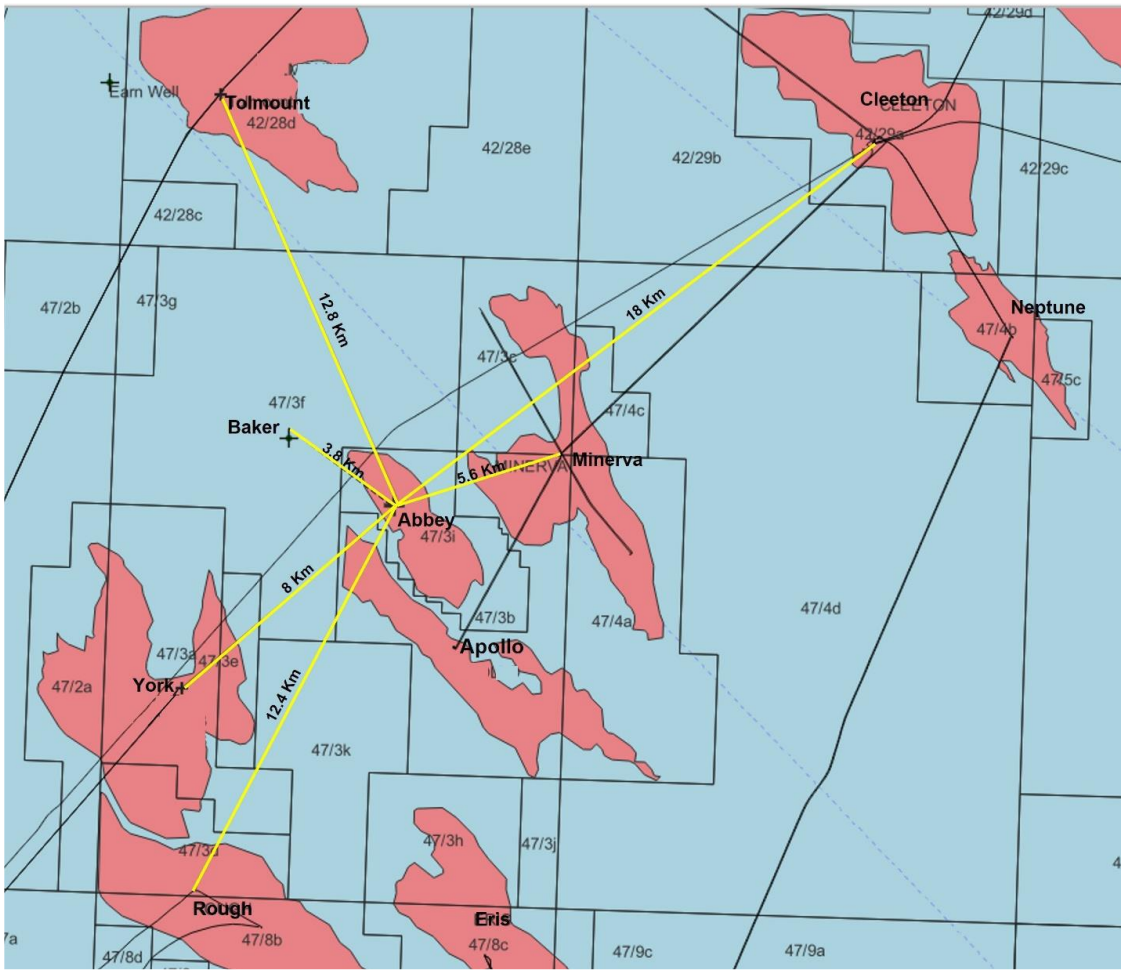
For Baker, the viability and environmental impact of the following development options was considered:

- **Well Option 1**: Standalone subsea tie-back to a suitable host facility (separate to the Abbey Development)
- **Well Option 2**: Subsea tie-in to the Abbey manifold

Analysis of these options concluded that tie-in to the Abbey manifold, via a ca. 4 km, 8 inch diameter pipeline, was the preferred option, due to lower cost, ease of engineering and lower environmental impact (i.e. shorter pipeline length to Baker).

Several potential host facility and tie-back route options were explored during the project feasibility / concept select phase, as illustrated in Figure 2.

Figure 2: Potential Host Facilities / Tie-back Options for the Abbey & Baker Development



From the initial five potential hosts, the viability and environmental impact of the following host options which met the criteria for detailed screening assessment included:

- **Host Option 1**: Subsea tie-in to spare riser via a ca. 8 km 8-inch pipeline between Abbey and York.
- **Host Option 2**: Subsea tie-in via a ca. 18 km pipeline between Abbey and Cleeton.
- **Host Option 3**: Subsea tie-in to spare riser via a ca. 12.8 km 8-inch pipeline between Abbey and Tolmount.

Cleeton was subsequently rejected due to a number of factors, such as aging infrastructure, higher costs and potential earlier COP date, in favour of Tolmount and York, with these two options taken forward for further detailed evaluation.

In summary, York assessed better when compared to Tolmount and will be the chosen host for the Abbey & Baker Development. Key differentiators between Tolmount and York as potential hosts for the Abbey & Baker Development include:

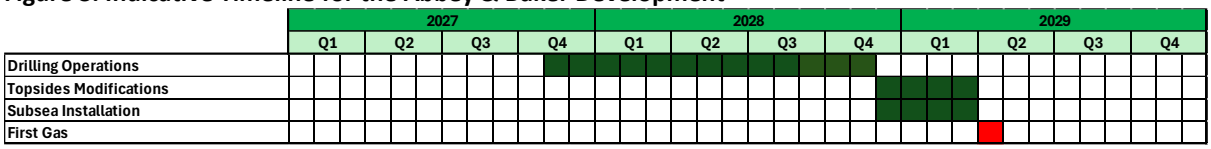
- The main environmental difference is the reduced length of the York pipeline route comparted with the Tolmount pipeline, which will lead to less seabed disturbance.
- The atmospheric emissions at Tolmount are greater for pipeline installation activities as Tolmount is 60% longer in length and therefore will require more vessel days to install, leading for more GHG emissions from fuel.
- Lower carbon intensity at York.
- York has significantly reduced OPEX compared to Tolmount due to higher offshore and terminal tariffs.

The selected concept for the Abbey & Baker Development is a subsea development, consisting of three development wells at Abbey connected to a production manifold, and one development well at Baker, with an 8km pipeline and umbilical between Abbey and York and a 3.8km pipeline and umbilical between Abbey and Baker. Extensive study work has demonstrated this to be technically viable, employing proven technologies and installation methodologies. Cost and schedule estimates demonstrate the potential for an economically viable development.

Project Schedule

The indicative timeline for the proposed Abbey & Baker Development is provided in **Figure 3**.

Figure 3. Indicative Timeline for the Abbey & Baker Development



The Existing Environment

The EIA process requires a comprehensive review of the existing environment in order to provide a basis for assessing the potential interactions between a project and the receiving environment. A high-level summary of the environmental sensitivities within the vicinity of the proposed Abbey & Baker Field Development area is provided below.

The description of the baseline environment is largely based on data provided in the OPRED Offshore Energy Strategic Environmental Assessment (SEA) Reports (2003-2016), as well as other published data sources, supported by site-specific survey data.

Site-specific data which was collected by GEOxyz in association with Benthic Solutions Limited (BSL) on behalf of Petrogas for the Abbey drill centre location between December 2022 and January 2023, Abbey to York pipeline and Baker site between January and March 2024, and Baker to Abbey pipeline in August 2025 has been incorporated, where relevant (refer to Figure 4).

Physical Environment

The proposed Abbey & Baker development is located within UKCS Block 47/3, approximately 40 kilometres (km) east of the Yorkshire coastline (refer to Figure 1 above). The water depth at the proposed Abbey drill centre was ranged from between 40.4 m Lowest Astronomical Tide (LAT) to 47.4 m LAT, with the seabed gently undulating around 43.2 m LAT. Along the Abbey to York pipeline route corridor centreline, water depths varied between 40.65 m LAT, towards the northeastern corner of the route, to 51.26 m LAT located in a depression slightly south of the central route (GEOxyz, 2023a; GEOxyz, 2024a). The Baker site survey area features water depths ranging from 47.04 m LAT in the north to 49.78 m LAT in a crescent-shaped channel in the west. The water depth at the proposed Baker well location is 47.75 m LAT. The seabed is relatively flat with no bedforms (GEOxyz, 2024b). Water depths along the Abbey to Baker pipeline corridor range from 48.6 m LAT in the northwest to 36.9 m LAT in the southeast (GEOxyz, 2025a).

The majority of Abbey site survey area was dominated by megaripples, indicating a south-southeasterly current direction. These megaripples showed heights of 5-10 cm within the site survey area. Sand waves were visible in the northeast and southeast corners of the site survey area, with a maximum height of approximately 1 m. Numerous cobbles and boulders were present within the overall survey area. Higher densities of boulders were evident within the site survey area, where megaripples became more apparent (GEOxyz, 2023a). Within the Abbey to York pipeline route corridor a band of silty sand and larger area of sand were interpreted to span across the route towards the northeastern end of the survey area, with sediment waveforms observed towards the southwestern end of the route and megaripples located in the central third as well as along a strip crossing the seabed close to the York platform. Despite this, the seabed sediment morphology was mostly described as flat (GEOxyz, 2024a). Anthropogenic features, including two soft ropes, three features identified as debris/suspected debris, an L-shaped rockdump and ten concentrated jack-up footprints were documented in the southwestern half of the survey area. These anthropogenic features are associated with the York gas field.

Throughout the Baker site survey area, seabed sedimentation is comprised exclusively of sand, and wide stretches of megarippled sediment are present in the majority of the eastern and northwest part of the Baker survey area. At the Baker site; 818 boulders were recorded, 35 features classed as debris were recorded, and 217 features classed as fish traps were recorded (GEOxyz, 2024c).

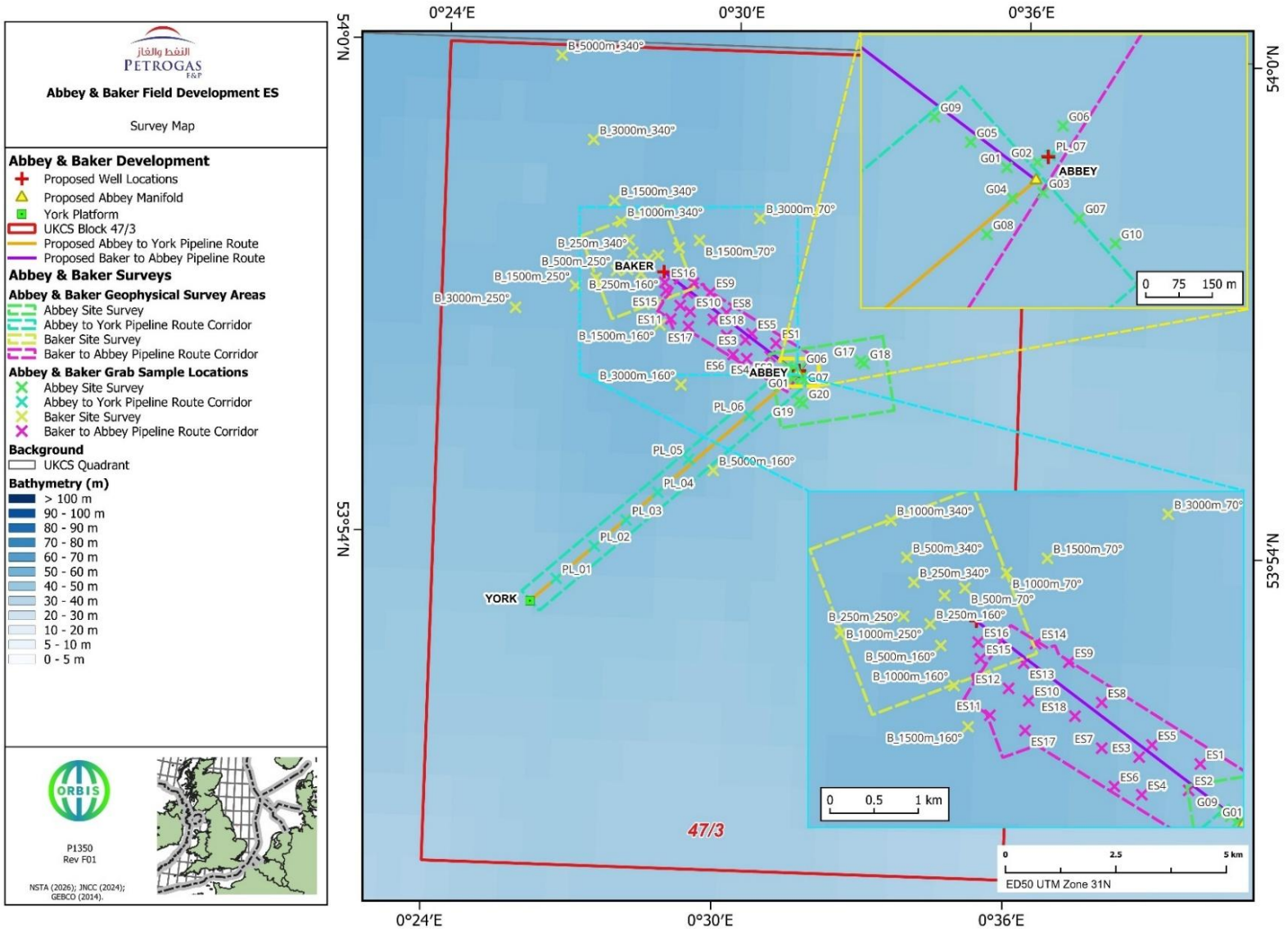
Within the Baker to Abbey pipeline route corridor survey area, seabed sedimentation is composed exclusively of gravelly sand. The seabed sediment consisted of flat gravelly sand in the southwest, with stretches of megaripples in most of the northwest part of the survey area. Within the Baker to Abbey pipeline route corridor, 1,674 features classed as boulders were recorded, 2 features were classed as debris, 32 were classed as suspected debris, 1 was classed as a post drill well and 9 were classed a as seabed mounds (GEOxyz, 2025b).

Seabed sediments were interpreted to vary between gravelly Sand with shell fragments and Sand for the Abbey drill centre. Within the Abbey pipeline route corridor to York, seabed sediments were predominantly identified as gravelly sand interspersed with three separate narrow bands of high reflective coarser sediments (sandy gravel and gravel) (GEOxyz, 2023a; GEOxyz, 2024a). Sediments found throughout the Baker site survey area were comprised mostly of sand (GEOxyz, 2024b). Within the Abbey to Baker pipeline route corridor the seabed sediment consisted exclusively of flat gravelly sand with stretches of megaripples in the northwest (GEOxyz, 2025a).

Across the proposed Abbey & Baker Development area, no significant correlations ($p>0.05$) were observed between total organic matter (TOM) and the proportions of gravel, fines, or sand. The organic content of the sediments is therefore unlikely to be acting as a reducing factor for benthic abundance, biomass and species diversity (Hyland *et al*., 2005).

The waves in the North Sea occur as a result of long period swells from the northern North Sea (NNS) and North Atlantic, and also from locally generated storms. The wave cycle in the SNS is seasonal with maximum wave heights occurring during the winter (January). Water circulation in the SNS tends to be in a south easterly direction along the coast towards the English Channel. In the vicinity of the Abbey & Baker development the major residual current flow is to the east. Modelled data indicates maximum tidal rates are 0.073 metres per second (m/s) and 0.593 m/s for neap and spring peak flows respectively (DESNZ, 2022; ABPMer, 2008).

Figure 4: Location of Abbey & Baker Site Specific Areas and Survey Stations



Although offshore winds may blow from any direction, the wind regime in the SNS is dominated by winds from between south and north-west. Easterly winds are uncommon. Winds speeds in summer are generally between 1 to 11 m/s, becoming stronger in winter when a greater proportion of strong to gale force winds, 14 to 32 m/s, is encountered (DESNZ, 2022). Both annual mean surface salinity and annual mean near seabed salinity in the vicinity of the proposed Abbey & Baker development range from 34.2 parts per thousand (‰) to 34.6‰. Annual mean surface temperatures in the vicinity of the proposed Abbey & Baker development range from 5°C to 15°C, while annual mean near seabed temperatures range from 5°C to 14°C (NMPi, 2026).

Climate Change and GHG Emissions

Over recent decades, scientific consensus has confirmed that the Earth's climate is undergoing significant change, largely driven by anthropogenic GHG emissions. Global mean concentrations for well-mixed GHGs (carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)) in 2019 correspond to increases of about 47%, 156%, and 23%, respectively, above the levels in 1750 (representative of the pre-industrial era) (high confidence) (IPCC, 2023) and in nearly all considered scenarios and modelled pathways, global warming is predicted to continue to increase in the near term (2021–2040) (IPCC, 2023b).

The WMO (2026) confirms that 2015–2025 were the hottest eleven years on record, with 2025 reaching approximately 1.43°C above the 1850–1900 baseline. Rising global temperatures have increased the frequency and severity of extreme weather events, including heatwaves, floods, droughts, wildfires, and storms (UNEP, 2025; WMO, 2026).

The United Nations Framework Convention on Climate Change (UNFCCC) commits countries to stabilise GHG levels, with the Conference of the Parties (COP) as its decision-making body. COP21 in 2015 created the Paris Agreement, requiring nations to limit warming to well below 2°C and pursue 1.5°C through nationally determined contributions (NDCs). Progress against the Paris Agreement is reviewed every five years via the Global Stocktake (GST) process, which at COP28 in 2023 showed warming projections of 2.4–2.6°C, above the 1.5°C goal, demanding rapid cuts of 43% by 2030 and Net Zero CO_2 by 2050. It is still considered technically possible that we can limit long-term global temperature rise to 1.5°C (WMO, 2025), however, at the recent COP30 in Brazil it was acknowledged that the world is likely to breach this threshold in the next decade, at least temporarily.

The GST process was informed by the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) cycle. AR6 defines five plausible future storylines (SSP1-5) describing global societal development (population, economy, technology and energy) to understand challenges for climate mitigation/adaptation. These are combined with Representative Concentration Pathways (RCPs), which define different levels of GHG forcing, to create scenarios like SSP1-2.6 (sustainable world with strong climate action) or SSP5-8.5 (fossil-fuelled world with high emissions), used in IPCC reports to model future climate impacts and vulnerability.

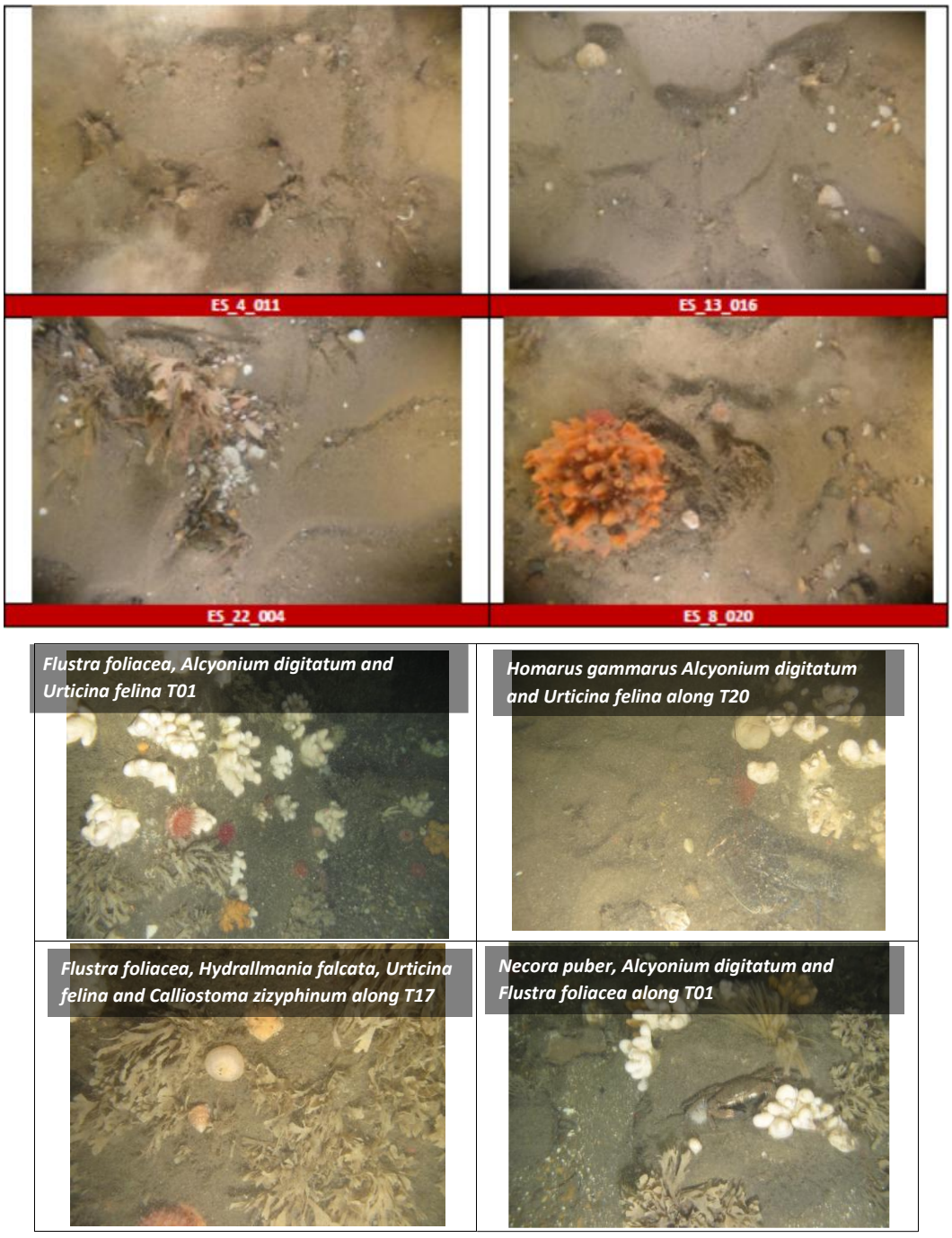
Biodiversity

The collective term plankton describes the plants (phytoplankton) and animals (zooplankton) that live freely in the water column and drift passively with the water currents. Plankton form the base of the food chain, therefore changes in the abundance and composition of the planktonic community can have impacts on higher consumers. Zooplankton is a primary food source for fish, seabirds and whales. The zooplankton community in the Abbey & Baker areas includes the larval stages of fish (ichthyoplankton), larval decapods (crustaceans) and echinoderms, as well as copepods and krill (also crustaceans).

Benthos describes the organisms that live within and on the seabed. Benthic organisms can be classified further into infauna, organisms that live within the sediment, and epifauna, organisms that live on top of the seabed (attached or mobile). In general, the seabed faunal community in the vicinity of the Abbey & Baker Development is expected to be relatively abundant and diverse; characteristic of sandy and mixed sediments. Species including starfish, brittle stars, crabs, lobsters, flatfish, hydroids, anthozoans and urchins have been observed in the area (see Figure 5 and Figure 6).

Figure 5: Example Species and Seabed Images within the Abbey & Baker Development Area

Figure 6: Example Species and Seabed Images within the Abbey & Baker Development Area



A number of fish species are likely to be present within the Abbey & Baker Development area. Species that may spawn within the vicinity include cod (*Gadus morhua*), herring (*Clupea harengus*), lemon sole (*Microstomus kitt*), plaice (*Pleuronectes platessa*) (high intensity), sandeels (*Ammodytidae* sp.) sole (*Solea solea*) and sprat (*Sprattus sprattus*). The area surrounding the Abbey & Baker development may also act as a nursery grounds for cod (high intensity), herring (high intensity), lemon sole, mackerel (*Scomber scombrus*), plaice, sandeels, sole, sprat and whiting (*Merlangius merlangus*) (high intensity). Species of sharks, skates and rays may also be present in the vicinity of the Abbey & Baker Development, these include cuckoo skate, small-spotted catshark, spiny dogfish, spotted ray, thorny skate, starry smoothound, blonde ray and thornback ray.

A number of seabirds are present in the vicinity of the Abbey & Baker Development area throughout the year; the area is considered important for kittiwake (*Rissa tridactyla*), guillemot (*Uria aalge*) and puffin (*Fratercula arctica*) in the breeding season. Species which are likely to be present in the area during the breeding bird season, in addition to kittiwake, guillemot and puffin, include sandwich tern (*Thalasseus sandvicensis*), razorbill

(*Alca torda*), northern gannet (*Morus bassanus*). Seabird sensitivity to oil pollution within the Abbey & Baker Development area is considered to be generally high to very high between February to November, apart from April which is low, and medium in December and January.

Species of marine mammals likely to be present in the waters of the Southern North Sea (SNS) and the vicinity of the proposed Abbey & Baker development include harbour porpoise, minke whale, bottlenose dolphin, common dolphin and white-beaked dolphin. Additionally, white-sided dolphin has been observed in the waters surrounding the proposed development. Two species of seals; grey seal (*Halichoerus grypus*) and the harbour (or common) seal (*Phoca vitulina*) are found along the English coast. Important numbers of grey and harbour seals are present off the east coast of England, particularly around The Wash where harbour seals forage over a wide area. Studies of grey seals have indicated that their density within the proposed Abbey & Baker Development area is high; however, studies of harbour seals have indicated that their density within the proposed Abbey & Baker Development area is low.

The proposed Abbey & Baker development area is located within the Southern North Sea Special Area of Conservation (SAC); the Southern North Sea SAC is designated for the protection of the harbour porpoise; an Annex II species. Approximately 4.7 km of the proposed Abbey to York pipeline is located within the Holderness Offshore Marine Conservation Zone (MCZ); the Holderness Offshore MCZ is designated for the protection of the North Sea glacial tunnel valleys (inner Silver Pit), subtidal coarse sediment, subtidal sand, subtidal mixed sediments and the presence of Ocean Quahog (*Arctica islandica*). The section of the proposed Abbey to York pipeline route located in the MCZ contains both the subtidal sand (MD52) and subtidal coarse sediment (MD32) habitats protected by the MCZ. One adult (shell size >5 cm) specimen of *A. islandica* was also recovered during grab sampling operations, which is located within the MCZ. Although, no evidence of their distinct siphons was seen on any of the video footage or still photographs within the pipeline route survey area in the MCZ. The North Sea glacial tunnel valleys are located approximately 40 km from the proposed Abbey & Baker Development. The Holderness Inshore MCZ is located approximately 25 km west of the proposed Abbey & Baker development; the Greater Wash SPA is located approximately 20 km to the west; the Flamborough Head SAC is located approximately 35 km to the northwest, the Flamborough and Filey Coast SPA is located approximately 39km to the northwest and the Humber Estuary SPA/RAMSAR is located approximately 36 km northwest.

Human Environment

Fishing effort in the vicinity of the Abbey & Baker Development tends to be highest in May between July and August and in October. The area is utilised by both the UK and international fishing fleets. Fishing activity in the Abbey & Baker Development area is dominated by traps. In the vicinity of the proposed Abbey & Baker development the shellfish (potting) fishing effort was found to be high. The pelagic and demersal fishing effort was found to be low in the vicinity of the proposed Abbey & Baker development.

Commercial shipping activity within the vicinity of the Abbey & Baker Development is considered to be relatively high, with the majority of vessels consisting of container ships, ferries and fishing vessels.

The proposed Abbey & Baker Development will tie into the existing York platform located approximately 8 km southwest of the proposed Abbey drill centre. The York field is currently owned and operated by Spirit Energy. Subject to commercial negotiation, Petrogas plan to take over ownership and responsibility for the operations of this platform as part of the Abbey & Baker Development. The closest surface oil and gas infrastructure to the proposed Abbey & Baker Development is the Minerva platform, operated by Perenco UK Limited, which is located approximately 5 km east northeast of the proposed Abbey drill centre. One pipeline is within the vicinity of the proposed Abbey & Baker Development, this is the active Cleeton CP to Dimlington gas pipeline (PL447) operated by Perenco, which crosses the Abbey to Baker pipeline approximately 1.5 km along the route from the Abbey manifold side

The proposed Hornsea Project Four cable corridor (operated by Ørsted Power (UK) Limited) which is currently in planning, is located approximately 8.9 km northeast from the proposed Baker well. It is unlikely installation operations will occur before the proposed Abbey & Baker Development has been completed, with offshore cable installation currently planned to take place during 2028. However, there are no military Practice and Exercise Areas or wrecks designated as historic Marine Protected Areas, scheduled monuments or war graves within the vicinity of the proposed Abbey & Baker Development area.

Identification and Assessment of Potentially Significant Impacts

The EIA process undertaken for the Abbey & Baker Development has aimed to identify and assess all potentially significant environmental effects arising from the proposed project (both from planned activities and unplanned (accidental) events). Cumulative and transboundary impacts have also been considered.

For planned activities, the significance of environmental effects has been evaluated by considering the sensitivity of the receptor affected in combination with the magnitude of impact that is likely to arise. For unplanned events, such as accidental hydrocarbon releases, significance has been determined using a risk assessment approach, where the likelihood (probability) of the unplanned event occurring is considered against the consequence (significance of effect) if the event was to occur.

An initial scoping exercise identified a number of aspects (activities or events) which could potentially result in significant environmental effects. A comprehensive assessment was therefore undertaken for these aspects and, where necessary, measures identified to prevent or reduce what might otherwise be significant adverse environmental effects through design evolution or operational mitigation measures. These aspects were then reassessed assuming the successful implementation of the identified mitigation measures to determine residual effects.

A summary of the main findings of the EIA process is provided below.

Physical Presence

The physical presence of the Abbey & Baker development, below the sea surface, has the potential to interfere with the activities of other users of the sea (specifically shipping and fishing). The temporary presence of the mobile offshore drilling unit (MODU) and other working vessels, at the surface can pose a navigation hazard to shipping and fishing vessels and may lead to an accidental event such as a collision. The risk of a collision will be minimised by implementing measures, including marking of the 500 m exclusion zones on appropriate navigation charts, using guard vessels to ensure other sea users are aware of the operations and following standard maritime communication and notification measures. Below the sea surface the long-term presence of the seabed development infrastructure will pose a potential snagging hazard to fishing gears in the area. Additionally, during the installation of the pipelines and umbilicals, fishing vessels will be temporarily displaced from the working corridors, with the area remaining unavailable to commercial fisheries until rock has been placed over the lines for protection and upheaval buckling mitigation. Fishing activity will also be excluded from the 500 m exclusion zones in place around the wellheads during the life of the Abbey and Baker fields. The total area that will be lost (2.4 km^2), however, represents a very small proportion of the entire fishing area available in the SNS. All seabed infrastructure and the rock berms over the length of the pipeline and umbilical will be designed to be either fishing friendly or overtrawlable. In conclusion, no significant adverse residual effects to other sea users (shipping and fishing) are predicted as a result of the physical presence of the Abbey & Baker development.

Seabed Disturbance

The estimated worst case total temporary area of seabed disturbed from the development of the Abbey & Baker fields is 697,041.6 m^2 (0.697 km^2). The worst-case total area of seabed disturbed in the long term by the subsea structures and protection material for the life of the Abbey & Baker development is estimated to be 39,883.25 m^2 (0.0399 km^2). The seabed will be disturbed through the siting of the MODU, the discharge of drill cuttings, muds and cement and the installation of the Abbey & Baker subsea infrastructure (pipelines, umbilicals, production manifold, wellheads, WHPS, Xmas trees, tie-in spools, jumpers and SSIV) and associated protection material. Impacts to the seabed have the potential to interfere and cause adverse effects to seabed sediments, seabed communities (i.e. benthic flora and fauna) and fish.

The siting of the MODU will cause localised direct damage (from spudcan and anchor depressions) and will also result in sediment re-suspension, and subsequent smothering of habitats and species (from anchor chain movements) to the seabed totalling an area of ca. 0.0234 km^2 across all three potential jack-up locations. Sessile epifauna, and a proportion of the infauna (animals that burrow into the sediment or form tubes within it) in the direct footprint area of the MODU from the spudcans will be lost from compression. In addition, the indirect effects of the use of anchors at both Abbey locations include the re-suspension of sediments, and subsequent smothering of seabed habitats and species, which are likely to occur over a wider area as sediments are re-suspended and transported away from the immediate vicinity of the MODU anchoring area. However, recovery

and re-colonisation of the impacted area is expected to occur as soon as the MODU departs with no long term changes to the benthic community predicted. Seabed disturbance caused by siting the jack up drilling rig at the proposed Abbey and Baker wells may also affect foraging behaviour of and temporarily displace fish from their spawning and nursery areas. Due the localised area of impact and the mobile nature of the species, any displaced fish are likely to find foraging opportunities, as well as suitable spawning and nursey areas in adjacent locations. The spawning grounds within which the Abbey & Baker development area is located is part of wider spawning grounds within the SNS and, as such, is not considered to be a key habitat for these fish species. Given the sediment type (sand and gravelly sand) and moderate energy environment, any seabed depressions are not expected to persist beyond the short to medium term.

An accommodation unit will be located at the York platform location for four months. The York Platform requires modifications in order to receive the production from and provide controls to the Abbey & Baker Development. The siting of this accommodation unit is estimated to disturb an area of the seabed measuring ca. 0.011 km^2 in the worst case. Sessile epifauna, and a proportion of the infauna (animals that burrow into the sediment or form tubes within it) in the direct footprint area of the accommodation unit from the legs will be lost from compression. In addition, the indirect effects of the use of anchors at York include the re-suspension of sediments, and subsequent smothering of seabed habitats and species, which are likely to occur over a wider area as sediments are re-suspended and transported away from the immediate vicinity of the accommodation unit anchoring area. However, recovery and re-colonisation of the impacted area is expected to occur as soon as the accommodation unit departs with no long term changes to the benthic community predicted. Seabed disturbance caused by siting the accommodation unit at the York platform may also affect foraging behaviour of and temporarily displace fish from their spawning and nursery areas. Due the localised area of impact and the mobile nature of the species, any displaced fish are likely to find foraging opportunities, as well as suitable spawning and nursey areas in adjacent locations. The spawning grounds within which the Abbey & Baker development area is located is part of wider spawning grounds within the SNS and, as such, is not considered to be a key habitat for these fish species. Given the sediment type (sand and gravelly sand) and moderate energy environment, any seabed depressions are not expected to persist beyond the short to medium term.

As a worst case, it has been assumed that the WBM cuttings discharged from the Abbey wells (1,759 tonnes combined) and Baker well (809 tonnes) will be deposited within an area of ca. 0.21 km^2 at the Abbey A1 and A3 wells and 0.16 km^2 at the Baker well (up to 0.37 km^2 in total), with high exposure level of WBM cuttings likely to be deposited within an area of 0.03 km^2 surrounding the Abbey A1 and A3 wells and 0.04 km^2 surrounding the Baker well Any drill cuttings which may be contaminated with residues of reservoir hydrocarbons and cement would also be deposited within this area. The effects on seabed fauna from the deposition of WBM cuttings and fine solids are usually subtle or undetectable, although the presence of drilling material at the seabed close to the drilling location (less than 500 m) is often detectable chemically. A number of fish species are known to use the waters in the vicinity of the Abbey & Baker development location, and some use the area as a spawning and / or nursery ground. Exposure to increased turbidity caused by the proposed operations may reduce the visual acuity of fish utilising the area potentially affecting foraging behaviour. Fish may also be temporarily displaced from their spawning and nursery areas due to the settlement of drill cuttings and muds on the seabed. However, given the localised area of impact and the mobile nature of the species, any displaced fish are likely to find foraging opportunities, as well as suitable spawning and nursey areas in adjacent locations. In addition, near seabed current velocities and sediment mobility in the SNS area appear generally sufficient to prevent detectable local accumulation of cuttings from persisting in the short to medium term.

The installation of the proposed Abbey & Baker pipelines, umbilicals and subsea structures, together with the associated rock protection and concrete mattresses, has the potential to result in a worst case temporary direct impact on the seabed over an estimated area of 0.293 km^2 in the worst case; and a long term direct impact on the seabed over an estimated area of 0.0399 km^2. This is small in comparison to the area of similar habitat available across the wider area. The area beneath the subsea infrastructure and protection material will become unavailable for re-colonisation by soft sandy sediment inhabiting infauna and over time a new rocky substrate habitat will become established. Ultimately, this new seabed feature is expected to be colonised by the same types of mobile and encrusting epifaunal animals already present on cobbles and boulders in the wider area. Some studies demonstrate mortality of fish eggs when smothered by even a thin veneer of sediment, which could occur during the pipeline and umbilical installation, however many studies show no significant effects on fish egg and larval development and mortality. The introduction of novel hard substrata by the Abbey & Baker development is very small and, whilst it will represent a change to the benthic environment locally it is not expected to cause any widespread changes to the marine life present in the area.

Habitat assessment results for Abbey & Baker also highlighted the presence of *Sabellaria* in isolated patches across the survey areas, associated with areas of coarser substrate, such as within the 300 m zone around the proposed Abbey drill centre. However, the available information from camera ground-truthing data indicates that these *Sabellaria* aggregations do not constitute Annex I reef habitat, as they are present as low-lying aggregations or crusts and do not meet the required level of elevation from the surrounding seabed to be classified as reef.

There was no evidence to indicate the presence of Annex I 'Stony Reef' habitats within the vicinity of the Baker well location, Abbey to York pipeline route or Baker to Abbey pipeline route. However, the Abbey drill centre location was identified as having the potential for Annex I 'stony reef' habitats, with occurrences of 'Low Reef' identified within 300 m of the proposed Abbey drill centre to the south west. Research has shown that stony reefs have a limited tolerance to direct physical, with recovery not expected for an extended period. As such, a decision was made to move the drill centre ca. 70 m to the north east to avoid placement of the drilling rig and deposition of cuttings on the identified 'Low Reef' sites. In addition, Petrogas has committed to micro siting of the pipeline, in order to avoid significant impact to the potential stony reef habitat.

Ocean quahog (*A. Islandica*), an Oslo and Paris Commission (OSPAR) Threatened and/or Declining species, has also been reported to inhabit the wider region surrounding the proposed Abbey & Baker Development. No adult (>5cm shell size) living specimens of A. islandica and no evidence of their distinct siphons was seen on any of the video footage or still photographs within the Abbey drill centre. In the Baker site survey area, two specimens (one adult, one juvenile) were recovered during grab sampling operations. In addition, one individual was observed atop the seabed, with a single siphon also observed. Single juvenile specimens (<5 cm) of live A. islandica were recorded within the Abbey site survey area at four stations and within the Baker site survey area at two stations. One adult (shell size >5 cm) specimen of A. islandica was recovered along the Abbey to York pipeline route, approximately 7.2 km southwest from the proposed Abbey drill centre (within 1 km of the York platform). No evidence of A. islandica's distinct siphons was seen on any of the video footage or still photographs along the Abbey to York pipeline route. The ocean quahog is highly sensitive to physical pressures such as sediment deposition; therefore, the installation of the Abbey & Baker development subsea infrastructure has the potential to cause direct mortality to ocean quahog. The introduction of a new stable hard substrata to the area will also cause a direct reduction in suitable seabed habitat that could support ocean quahog.

The entirety of the proposed Abbey & Baker Development is located within the SNS SAC which is designated for the protection of harbour porpoise. Any temporary or long term disturbance to the seabed habitat that could affect the prey of the harbour porpoise or their prey within the SAC will be highly localised. Given the flexibility of the harbour porpoise diet, there should be no adverse long-term changes regarding availability of prey. In addition, approximately 4.8 km of the proposed Abbey to York pipeline route corridor is located within the Holderness Offshore MCZ. The MCZ is designated for North Sea glacial tunnel valleys (inner Silver Pit), subtidal coarse sediment, subtidal sand, subtidal mixed sediments and the presence of Ocean Quahog (*Arctica islandica*). Any long term or temporary disturbance caused by the proposed Abbey & Baker development will result in a very small impact of the protected habitat type. In view of the conservation objectives of the SNS SAC and Holderness Offshore MCZ, no likely significant effects are predicted as a result of the proposed activities either alone or in-combination with other plans or projects.

In conclusion, no significant adverse residual effects to seabed sediments, seabed communities, fish or protected areas are predicted from seabed disturbance associated with the Abbey & Baker development operations.

Underwater Noise Emissions

Underwater noise generated during the proposed Abbey & Baker development has the potential to disturb, or cause injury to, a number of species in the marine environment, particularly marine mammals. Significant levels of underwater noise may be generated and transmitted considerable distances in the marine environment when there is a requirement for vessels to use Dynamic Positioning thrusters and the use of vessel machinery. Marine mammals are unlikely to be injured by the noise generated from the DP vessels, and vessel equipment but may experience responses of behavioural disturbance.

For marine mammals, it is acknowledged that the maximum anticipated underwater SELcum criteria from the DP vessels is below the thresholds for potential injury of marine mammals in terms of permanent threshold shift (PTS) to the majority of marine mammals. However, the underwater noise generated by the DP vessels may exceed the PTS for Very High Frequency cetaceans (e.g. harbour porpoise). Based on a simple spherical spreading sound propagation model, this threshold is potentially exceeded approximately 3 m from the noise source

(vessel). Though, it is extremely unlikely that marine mammals would venture this close to the vessel and therefore they are not expected to be injured by the proposed Abbey & Baker Development operations.

In addition, all of these noise generating activities will be temporary in nature and very localised. Petrogas will implement measures to mitigate any potential impacts including optimising duration of drilling and installation activities to minimise vessel usage. In conclusion, no significant adverse residual effects to marine mammals or the conservation objectives of the SNS SAC are predicted from noise associated with the Abbey & Baker development operations. It is also unlikely that any cumulative impacts will occur. There are no operational, under construction or consented offshore windfarms in the immediate vicinity of the proposed Abbey & Baker Development area; and given the mitigation measures which will be in place for the Abbey & Baker Development, any potential simultaneous noisy activity from other oil and gas developments should not act in combination with any other development to produce significant cumulative effects

Greenhouse Gas Emissions

GHG emissions will be produced from the Abbey & Baker Development contributing to global GHG emissions in the atmosphere. The worst-case total gross GHG emissions generated over the life of the Abbey & Baker Development are estimated to be ca. 16,509.35 kt of CO_2e, based on the High (P10) production case. These GHG emissions can be categorised as follows:

- Scope 1 emissions are direct emissions from sources that are owned or controlled by the reporting company;
- Scope 2 emissions are emissions generated from purchased or acquired (not applicable to this ES); and
- Scope 3 emissions are all indirect emissions (not included in scope 2) that are a consequence of the activities of the reporting company, but occur at sources owned or controlled by another company.

During the development of the Abbey & Baker fields, upstream indirect scope 3 GHG emissions will be generated from combustion of hydrocarbons for power generation on the MODU, vessels, and helicopters.

Pre-production, upstream direct scope 1 GHG emissions will be generated from well testing (flaring) and clean-up of the Abbey & Baker wells. Additionally, during the production phase, upstream direct scope 1 GHG emissions will be generated from operation of the York Platform, namely diesel combustion for power generation.

During the production phase, indirect downstream scope 3 emissions will be generated from processing, transportation and distribution of the Abbey & Baker hydrocarbons, as well as from the end use of the sold product. To ensure a worst-case scenario has been assessed, it is assumed that all Abbey & Baker hydrocarbons are eventually combusted, although in reality the actual end use and fate of the Abbey & Baker hydrocarbons may vary. Scope 3 end-use emissions represent by far the largest component of the total GHG emissions which will be generated by the Abbey & Baker Development over the life of the field (ca. 85%).

Hydrocarbons from the Abbey & Baker fields will be processed onshore at the DGT; the liquids (condensates) will be removed and transported to the Saltend Refinery for further processing, while the gas will be treated and compressed for export into the National Transmission System. All gas produced from the Abbey & Baker fields will therefore be used domestically and not exported. The Abbey & Baker Development when processed via the DGT will not result in an increase in fuel gas combustion or venting at the terminal above the current operational baseline threshold. As such, the GHG intensity of DGT (reported as 13.95 kg CO_2e/boe in 2025) will decrease once the Abbey & Baker Development comes online.

To place the GHG emissions generated from the Abbey & Baker Development in a global context, a comparison has been made with the median global GHG emissions projected under the IPCC's Shared Socio-economic Pathways. These pathways illustrate how emissions may evolve under varying levels of climate ambition; from very low (SSP1-1.9) pathways consistent with limiting warming to 1.5°C, to very high (SSP5-8.5) pathways associated with continued fossil fuel use and limited mitigation. The GHG emissions generated from the Abbey & Baker Development represent a negligible share of projected global totals, between ca. 0.00304% and 0.0066% of median global emissions in 2030, and 0.0007% to 0.0029% in 2040, depending on the pathway.

This point is further illustrated by the fact that the worst case total GHG emissions generated from the Abbey & Baker Development over the life of the field (ca. 2029 – 2044) represent less than 0.0097% of the remaining

global carbon budget under a 1.5°C scenario (170 $GtCO_2e$; GCP, 2025), 0.0031% under a 1.7°C scenario (525 $GtCO_2e$; GCP, 2025), and less than 0.0016% under a 2.0°C scenario (1,055 $GtCO_2e$; GCP, 2025).

From a cumulative perspective, it is acknowledged that Trout et al. (2022) have concluded that combustion of fossil fuel reserves within already operating or under-development infrastructure will generate approximately 936 Gt CO_2, which exceeds the remaining global carbon budget under a 1.5°C-compatible scenario (170 Gt CO_2e; GCP, 2025), but remains within the remaining global carbon budget for a 2.0°C scenario (1,055 $GtCO_2e$; GCP, 2025). The combustion of hydrocarbons from the Abbey & Baker Development (i.e. the total Scope 3 end use emissions), would account for just 0.01089% of the remaining global carbon budget under a 2˚ C scenario.

The Global Oil and Gas Extraction Tracker (GOGET) (GEM, 2026) also provides comprehensive data on oil and gas projects worldwide, including production volumes and reserves from active extraction areas, areas under development and oil and gas discoveries. Abbey & Baker's P10 field reserves (8,206 Mm^3 of gas and 2.14 MMbbl of condensate) add only a very small fraction towards the global reserves recorded within GOGET; increasing global gas reserves by 0.0058% and global condensate reserves by 0.0096%.

Given the above, it is clear that the Abbey & Baker Development on its own would not significantly affect a GHG emissions reduction trajectory towards achieving net zero by 2050, particularly as the Abbey & Baker Development is scheduled to cease production prior to 2050. However, regardless of whether the Project goes ahead, given the range of possible emissions reduction pathways available, which are dependent on the scale of effort different countries make to reduce their national emissions, it is uncertain whether net zero on a global basis will be achieved by ca. 2050. However, the effect of the proposed Abbey & Baker Development on this uncertain baseline is not significant given the negligible proportional impact of the Project.

At a national level, the Abbey & Baker Development is aligned with UK oil and gas sector specific net zero policies and plans. Petrogas is committed to minimising the amount of GHG emission produced from the proposed development. During drilling and installation operations, vessel days and fuel consumption will be reduced, as far as practicable. The well test and well clean-up activities will be designed not only to achieve their goals but to provide an optimal duration and reduce flaring to minimise the GHG emissions produced.

The GHG emissions generated from the Abbey & Baker Development represent a small proportion of GHG emissions typically arising from oil and gas developments in the UKCS and will contribute a small fraction of CO_2e emissions towards future UK carbon budget targets (ca. 0.45410% of carbon budget 5, 0.55689% of carbon budget 6 and 0.49301% of the proposed carbon budget 7) and the UK's NDC targets (ca. 0.82688% of the 2030 NDC allowance and ca. 0.66278% of the 2035 NDC allowance). As such, the GHG emissions generated by the Abbey & Baker Development would have no material influence on the UK's ability to meet its statutory carbon budget targets or NDC emissions reduction targets, resulting in a minor adverse magnitude of impact which is determined to be not significant.

All gas produced from the Abbey & Baker fields will flow into the NTS via the DGT and will be used domestically and not exported, thereby helping contribute to energy security during the UK's transition to net zero. Responsible stewardship of remaining offshore reserves ensures that the UK meets its energy demand while retaining control over GHG emissions.

Marine Discharges

The main operational discharges into the marine environment from the proposed Abbey & Baker development will occur as a result of the discharge of drill cuttings, muds and cement, chemicals during drilling, installation and hook-up and commissioning activities and completion brine during well clean-up activities. Upon release, these discharges will be subject to rapid dilution and dispersion and are not expected to persist within the marine environment. Additionally, a number of studies have shown that any impacts will be limited to the local area in the immediate vicinity of the discharge location and therefore no significant adverse residual effects are predicted.

Petrogas will implement a range of measures to mitigate any potential impacts including undertaking a chemical risk assessment to identify the risk profile of chemicals being used and / or discharged in accordance with the requirements of the Offshore Chemicals Regulations 2002 (as amended). Where practicable, chemicals with a higher risk profile will be substituted out in favour of those with an improved environmental profile and chemical use and discharge will be minimised to as low as practically possible. During the proposed drilling operations, cuttings / mud cleaning equipment will ensure optimal cuttings cleaning prior to discharge and recovered WBM will be reused/ re-circulated where practical. In addition, WBM will be mixed offshore to ensure that only what

is required is used. In addition, even though the lower hole sections of the Abbey and Baker Development wells will be drilled using LTOBM, these cuttings will be returned to the MODU, separated from the mud system, and contained for skip and ship to shore for treatment and disposal; and any recovered LTOBM will be recycled within a closed-loop drilling system. Therefore, no routine discharge of LTOBM-contaminated cuttings or reservoir hydrocarbon residues on cuttings is anticipated to the marine environment. Any discharges of residual reservoir hydrocarbons will be treated to meet oil-in-water limits of less than or equal to 30 mg/l. The discharge stream will also be monitored and sampled in accordance with an approved Oil Discharge Permit.

Accidental Events

All offshore activities associated with the Abbey & Baker Development will carry a potential risk of hydrocarbon pollution to sea; however, hydrocarbon spills from normal oil and gas operations are uncommon and can be effectively mitigated against.

In planning its activities, Petrogas' primary focus is to ensure that all practicable measures are taken to prevent the occurrence of such accidental events and, should they occur, mitigate their effects. The consequences of an accidental release will vary depending on the quantity and type of hydrocarbon spilt, the wind speed and direction and sea state and the sensitivity of receptors depending on the time of year.

The worst-case spill scenario from the Abbey & Baker Development would be an uncontrolled flow of condensate from the proposed Baker development well (i.e. a well blowout). Oil spill modelling has been conducted to determine the fate of Baker hydrocarbons released from this worst case scenario. The modelling predicts a very low probability of surface oil crossing the Netherlands (3 – 17%), German (2 – 5%), Danish (1 – 2%), Belgian (2%), and French (1%) median lines. In addition, there is a low probability of shoreline oiling occurring in the Netherlands (1%), Germany (2%), Denmark (1%), and France (1%). There is a moderate possibility shoreline oiling will occur on the UK shoreline, located approximately 40 km southwest of the Abbey & Baker Development. The maximum probability of shoreline oiling on the UK coastline occurs during the spring with a 58 % chance and the minimum time to shore occurs during the autumn, with oil reaching the coastline within 101 hours. However, the Baker condensate is a light hydrocarbon and, as such, it would be rapidly broken up by wind and wave action and evaporate. The risk of an accidental release occurring from the Abbey & Baker Development will be minimised through the implementation of physical barriers such as downhole safety valves, maintenance to minimise leaks, and the development and implementation of handling and operational procedures and training.

Measures to respond to a spill from the MODU or the Abbey & Baker subsea facilities once operational will be covered in approved oil pollution emergency plans, which will be prepared in advance of drilling operations commencing offshore. As such, the overall risk to the marine environmental from an accidental release of hydrocarbons from the Abbey & Baker development is considered to be Low and not significant.

Waste Management

Several different waste streams will be generated throughout the lifespan of the Abbey & Baker Development. Waste management will be undertaken in compliance with current environmental legislation and Petrogas's own waste procedures. The management of offshore waste generated on the UKCS is strictly regulated and the UK has well-established infrastructure in place to manage this waste effectively.

Environmental Management

Petrogas conducts all of its activities and operations in accordance with a Business Excellence Management System (BEMS), which has been designed to meet the requirements of ISO 14001. This system provides the structured management framework within which environmental impacts are identified, assessed, controlled, and monitored.

The Petrogas BEMS is the mechanism that ensures the company standards are maintained, that the commitments specified in the ES are met and that unforeseen aspects of the proposed Abbey & Baker development are detected. This structured management approach will be used to ensure that the on-going process of identification, assessment and control of environmental risks will continue throughout planning and operations of the field development.

Conclusion

In summary, it is concluded that the proposed Abbey & Baker Development will not result in any significant environmental effects provided that all identified mitigation measures are implemented. Petrogas's management approach will be used to ensure that the on-going process of identification, assessment and control of environmental risks will continue throughout planning and operations of the Abbey & Baker Development In addition, no significant in-combination, cumulative or transboundary effects are considered likely to arise from the proposed Abbey & Baker Development.

1 Introduction

1.1 Background

Petrogas North Sea Limited, hereafter referred to as Petrogas, is planning to develop the Abbey & Baker gas fields in the Southern North Sea (SNS). Abbey sits within United Kingdom Continental Shelf (UKCS) Block 47/3i (Licence P.2582) in a water depth of 42.4 metres (m), approximately 40 kilometres (km) north east of the Yorkshire coastline and 152 km south west of the UK/Netherlands transboundary line, at their closest points. Baker sits within UKCS Block 47/3f (Licence P.2433) in a water depth of 47.7 m and is located approximately 3.8 km to the north west of Abbey (see Figure 1.1). Petrogas is 100% owner and operator of the licences.

Abbey was discovered and appraised by wells 47/3-2 and 47/3b-6A drilled by Amoco in 1974 and 2001 respectively. A development well, 47/3b-12, drilled by British Gas as part of the Juno project, was completed in 2002 but did not produce at economically viable rates and was subsequently plugged and abandoned. Petrogas drilled, completed and hydraulically fractured the Abbey appraisal well 47/3i-17z in 2025 - this proved the presence of moveable commercial volumes of hydrocarbons when the reservoir was hydraulically stimulated. The well flowed at a proppant free rate of 24 million standard cubic feet per day (MMscf/d). The well was then suspended pending development. Baker was discovered by Petrogas in 2024 with exploration well 47/3f-16.

Petrogas is proposing to develop Abbey & Baker via four subsea gas wells (three at Abbey and one at Baker). The Baker well is approximately 3.8 km from the Abbey location. Baker will be produced via an 8-inch diameter pipeline and electro-hydraulic umbilical tied into a production manifold at the Abbey location and then be commingled with the Abbey wells. The combined Abbey & Baker production will be tied back via a new 8 km 8-inch production pipeline and electro-hydraulic umbilical to the York Not Permanently Attended Installation (NPAI) platform, (hereafter referred to as the 'York platform'). From York, Abbey & Baker production will be exported onshore via the existing 16-inch diameter export pipeline to Perenco UK Limited's Dimlington Terminal via the Easington Terminal (operated by Centrica Energy Storage +) for processing.

In order to obtain a Development and Production Consent for the proposed Abbey & Baker Field Development, Petrogas is required to submit a Field Development Plan (FDP) to the North Sea Transition Authority (NSTA). As the proposed Abbey & Baker Field Development will extract more than 500,000 cubic metres of gas per day, the FDP must be supported by an Environmental Statement (ES), which needs to be submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) for approval under The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020.

This document is the ES for the proposed Abbey & Baker Field Development (hereafter referred to as 'the Abbey & Baker Development' or 'the Project') and presents the findings of the Environmental Impact Assessment (EIA) undertaken to determine if there are any significant effects of the Project on the environment.

1.2 Project Overview

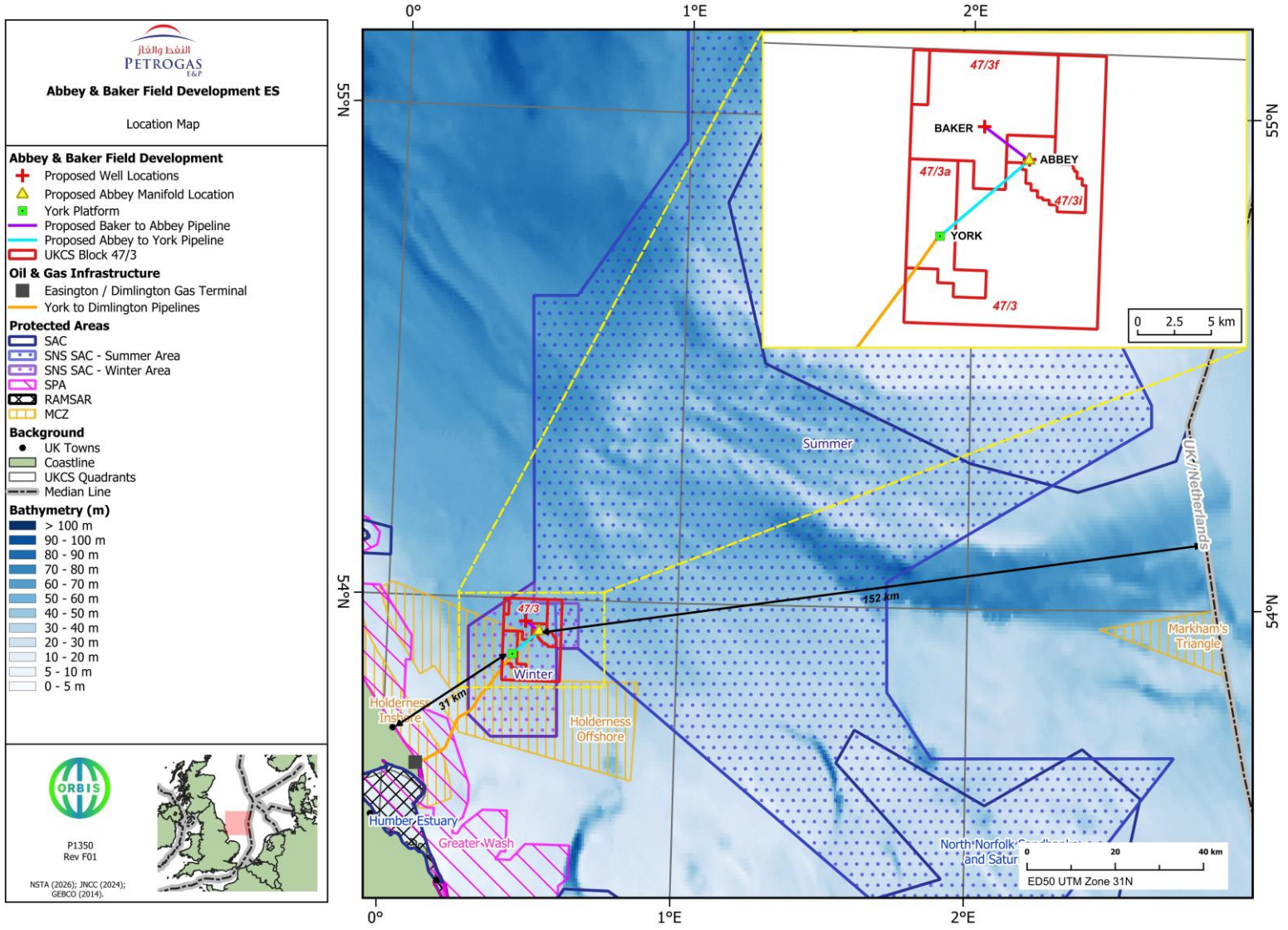
The Abbey field will be developed via three subsea horizontal production wells (A1, A2 and A3) that will be hydraulically stimulated. The Abbey wells will be drilled with separate top-hole locations and will be tied back to a new production manifold located adjacent to the wells, circa (ca.) 70 to 80 m away. The Abbey A2 well was drilled as an appraisal well (47/3i-17z) in Q4 2024/Q1 2025[1]. It has already been successfully completed and stimulated and is currently suspended, pending running of a subsea Xmas tree.

The Baker field will be developed via a single deviated subsea well, which will be conventionally completed. A 3.8 km 8-inch rigid pipeline and an umbilical will tie the Baker well back to the Abbey production manifold.

[1] The 47/3i-17(z) was permitted under Screening Direction (MAT Ref: DRA/1065).

The Abbey & Baker production manifold will be tied back to the York platform, which is currently in a state of Cease of Production (CoP) and in light house mode, located in UKCS Block 47/3a, via an 8 km 8-inch diameter rigid export pipeline. A new 8 km umbilical, providing electro-hydraulic controls and chemical services from the York platform to the Abbey & Baker facilities, is also required. The pipeline and umbilical will be trenched and buried with natural seabed material and supplementary rock, where required, for protection and upheaval buckling mitigation.

Figure 1.1: Location of the Proposed Abbey & Baker Development



The York platform is currently hydrocarbon free with only temporary navigational aids operational. At the time when the ES is issued, Spirit Energy and Petrogas will have signed a conditional sale and purchase agreement for purchase by Petrogas of Spirit Energy's interest in the York Licence and York facilities. Upon satisfaction of those conditions, which include regulatory approval, Petrogas will assume ownership and operatorship of the York Licence and facilities. The York platform topsides will be upgraded to receive the Abbey & Baker production stream. From York, the production stream will be exported onshore via the existing York export pipeline to the Easington Terminal and onwards to the Dimlington Gas Terminal for processing prior to sale. Located at the onshore terminals, a new methanol corrosion inhibitor supply package will use the existing piggy backed pipeline from the Easington Terminal to York to supply methanol and corrosion inhibitor to Abbey & Baker wells via the electro-hydraulic umbilicals.

The location of the proposed Abbey & Baker infrastructure is summarised in Table 1.1.

Table 1.1. Location of Proposed Abbey & Baker Development Infrastructure

Aspect	Abbey Drill Centre	Baker Production Well	York Platform
Location (Lat/Long) [1]	53° 56’ 7.436” N 0° 31’ 26.240” E [2]	53° 57' 16.584 N 0° 28' 34.511 E	53° 53’ 12.469” N 0° 26’ 3.117” E
UKCS Block	47/3i	47/3f	47/3a
ICES Rectangle	36F0		
Distance from nearest coastline	40 km NE (Withernsea, Yorkshire)	38 km NE (Withernsea, Yorkshire)	31 km NE (Withernsea, Yorkshire)
Distance from nearest median line	152 km WSW (UK / Netherlands)	156 km WSW (UK / Netherlands)	159 km WSW (UK / Netherlands)
Nearest Marine Protected Area	Within Southern North SAC (Winter Area)	Within Southern North Sea SAC (Winter Area)	Within Southern North Sea SAC (Winter Area) and Holderness Offshore MCZ

[1] ED50 UTM Zone 31N.

[2] This is the location of the ‘as-drilled’ A2 well. The A1 well will be located ca. 9 m to the northeast of the A2 well. The A3 well will be located ca. 9 m to the southeast of the A2 well. The Abbey production manifold will be located ca. 70 -80 m southwest from the A2 well.

Petrogas intends to complete the A2 well as a producer and drill and complete the A1, A3 and Baker development wells. The subsea infrastructure, including pipelines umbilicals and manifold, will be installed and tied back to York.

Abbey & Baker production rates are predicted to peak at 2.96 million cubic metres (104.5 million standard cubic feet) per day of gas in Year 2 (high case) and 99.3 tonnes (781 bbl) of condensate per day also in Year 2 (high case), assuming all four wells come online Q2 2029. Following this production rates are expected to decrease as the field life continues.

The Abbey & Baker subsea infrastructure will have a design life of 20 years and the economic field life is expected to be 15 years depending on the reserves, the production rate and gas price. The York platform was constructed with a design life of 25 years in 2013, however, platforms often stay in situ for much longer periods than originally designed for. On cessation of production, the Abbey & Baker facilities will be decommissioned in accordance with the requirements of the prevailing UK and International law.

1.3 Scope and Purpose of the ES

The scope of the EIA and resultant ES includes the following activities:

- The drilling and completion of two production wells (A1 and A3) in the Abbey field and one production well in the Baker (B1) field, as well as the completion of the currently suspended A2 well in the Abbey field;
- Installation of subsea infrastructure, including production pipeline, umbilical and manifold to support tie-back of the wells to the existing York platform;
- York platform topside modifications, including the use of an accommodation unit for up to four months;
- Presence and operation of the York platform beyond the currently planned decommissioning date;
- Operation, maintenance and inspection of the Abbey & Baker subsea facilities and the York platform, including incremental greenhouse gas (GHG) emissions from power requirements at the York platform, and maintenance and inspection programmes for the York platform and Abbey & Baker subsea facilities;
- Decommissioning of the Abbey & Baker infrastructure on cessation of production.

The purpose of this ES is to provide an assessment of the likely significant environmental effects that may arise from the proposed Abbey & Baker Development and to identify the measures, which will be put in place to minimise these effects.

1.4 Structure of the ES

The structure of this ES is summarised in Table 1.2.

Table 1.2. ES Structure

Section Content	Content
Non-Technical Summary	A high-level summary of the EIA to allow the non-specialist reader to understand the proposed Abbey & Baker Development and its main environmental impacts and proposed mitigation measures.
Main Document	
Section 1: Introduction	Introduces the Project, outlines the scope and purpose of the ES, lists applicable environmental legislation, identifies areas of uncertainty and summaries the key issues raised during the stakeholder engagement process.
Section 2: Project Alternatives	Outlines the main concept options (alternatives) considered for the Project.
Section 3: Project Description	Describes the subsea infrastructure to be installed for the Project and provides an overview of each lifecycle phase of the proposed Abbey & Baker Development, including drilling, installation, production, inspection and maintenance, and decommissioning activities.
Section 4: Existing Environmental Baseline	Describes the baseline environment in the Project area, with particular emphasis on those aspects which are likely to be affected by the proposed development activities.
Section 5: Assessment Methodology	Presents the impact assessment methodology used for the EIA and identifies those aspects of the environment that are likely to be significantly affected by the Project.
Sections 6 – 11: Assessment Sections	These sections assess if the Project is likely to have any significant effects on the environment, define the proposed mitigation measures which will be implemented and determine the residual impacts (i.e. they document the assessment results). Where relevant, transboundary, in-combination and cumulative impacts are also assessed.
Section 12: Waste Management	Provides a high-level description of Petrogas waste management strategy for the Project.

Section Content	Content
Section 13: Environmental Management	Describes Petrogas Business Excellence Management System (BEMS) and the management processes that will be applied throughout the Project to ensure adverse impacts on the environment are minimised. Includes a register of Project commitments.
Section 14: Conclusions	Reports the conclusions of the EIA process.
Section 15: References	Provides a bibliography of data sources referenced in the ES.
Section 16: Glossary	A list of a list of technical terms with definitions.
Appendices	
Appendix A: Legislation and Marine Policy	Provides an overview of the key environmental legislation and marine policy pertinent to the Project.
Appendix B: ENVID Registers	Presents the results from the ENVID workshop undertaken for the Project.
Appendix C: Drill Cuttings Modelling	Presents the results of the drill cuttings and muds dispersion modelling study undertaken for the Project.
Appendix D: Quantification of GHG Emissions	Sets out the methodology (calculations, emissions factors and assumptions) used to quantify the GHG emissions generated from the Project.
Appendix E: Oil Spill Modelling	Presents the results of the oil spill modelling study undertaken for the Project.

1.5 Legislation and Policy Framework

1.5.1 Environmental Legislation

The Petroleum Act 1998 establishes the regulatory regime which is applicable to oil and gas exploration and production in the UK. It vests all rights to the nation's petroleum resources in the Crown, but permits the NSTA to grant licences that confer exclusive rights to 'search and bore for and get' petroleum.

The NSTA license, regulate and influence the UK oil and gas industry, supporting UK energy security, driving emissions reduction from UK supplies and helping to accelerate the transition to Net Zero to realise the potential of the North Sea as an integrated energy basin.

The Petroleum Act is supplemented by various environmental Acts and Regulations, which Petrogas will need to ensure compliance with. OPRED is responsible for regulating environmental and decommissioning activity for offshore oil and gas operations on the UKCS and is part of the Department for Energy Security and Net Zero (DESNZ).

As noted in Section 1.1, the EIA undertaken for the proposed Abbey & Baker Development as reported in this ES has been carried out in accordance with the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (the 'EIA Regulations'). These regulations require that where a project falls within Schedule 1 of the Regulations, there is a mandatory requirement for an EIA and the application for a development and production consent must be supported by an ES. The Abbey & Baker Development qualifies as a Schedule 1 project as it will involve the extraction of gas for commercial purposes, where the amount of extracted hydrocarbons exceeds 500,000 cubic metres (m^3) per day. The EIA has been undertaken with reference to the Offshore EIA Regulations Guidance (BEIS, 2021b), as well as the new supplementary guidance for assessing the effects of downstream scope 3 emissions on climate from offshore oil and gas projects (DESNZ, 2025a).

Other environmental Acts and Regulations pertinent to the Project and therefore considered during the EIA process include, but are not limited to:

- The Climate Change Act 2008 (as amended);
- The Energy Act 2008 (as amended);
- Marine and Coastal Access Act 2009 (as amended);
- The Merchant Shipping (Oil Pollution Preparedness, Response and Cooperation) Regulations 1998 (as amended);
- The Offshore Chemicals Regulations 2002 (as amended);
- The Offshore Installations (Emergency Pollution Control) Regulations 2002;
- The Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015;
- The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended);
- The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended).

Further detail on these items of legislation, as well as other international treaties and agreements such as the Oslo and Paris (OSPAR) Convention, applicable to the Project is provided in Appendix A.

1.5.2 Marine Planning Policy

Through the Marine and Coastal Access Act (MCAA) 2009, the UK Government introduced a number of measures to deliver its vision of 'clean, healthy, safe, productive, and biologically diverse oceans and seas'. This included the introduction of a new marine planning system with the Marine Management Organisation (MMO) being delegated a number of marine planning functions, although the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) manage a number of licencing functions pertaining to offshore energy activities rather than the MMO.

In line with the MCAA, a number of marine plans have been developed for inshore and offshore waters around the UK. Marine plans, together with the overarching Marine Policy Statement (MPS), underpin the planning system for inshore and offshore activities and contribute to the achievement of sustainable development in the UK marine area.

In relation to offshore oil and gas exploration and production activity, the MPS states, "*Obtaining the UK's hydrocarbon supplies from indigenous sources minimises dependence upon foreign imports and thus enhances our security of energy supply. Maximising the economic recovery of UK oil and gas resource sustainably is therefore a priority in the UK's energy supply and energy security strategies*" (para. 3.3.8) (HM Government, 2011).

The Project lies within the area of the East Offshore Marine Plan (HM Government, 2014), which aims to help ensure sustainable development of the marine area through informing and guiding regulation, management, use and protection of the area.

The proposed Abbey & Baker Development, as described in this ES, has been assessed against all relevant East Offshore Marine Plan objectives and policies, to confirm that the Project will not adversely impact them (see Appendix A for further details).

1.5.3 UK Government's Energy Policy and Net Zero Target

The UK's Climate Change Act 2008 (as amended) sets a legal requirement to achieve a 100% reduction in net GHG emissions by 2050 relative to 1990 levels ('net zero'). This delivers on the commitment that the UK made by signing the Paris Agreement[2].

For the UK oil and gas industry, the revised Oil and Gas Authority (OGA) Strategy (OGA, 2020), which amends the Maximising Economic Recovery (MER) UK Strategy, came into force in February 2021 and places an obligation on the oil and gas industry to assist the Secretary of State in meeting the net zero target by 2050. Specifically, the industry must take the steps necessary to:

[2] The Paris Agreement aims to restrict global temperature change to well under 2°C, and pursue efforts to keep it below 1.5°C.

a. Secure that the maximum value of economically recoverable petroleum is recovered from the strata beneath relevant UK waters; and, in doing so,

b. Take appropriate steps to assist the Secretary of State in meeting the net zero target, including by reducing as far as reasonable in the circumstances GHG emissions from sources such as flaring and venting and power generation, and supporting carbon capture and storage projects.

The North Sea Transition Deal (BEIS, 2021a) sets out an ambitious plan for how the UK's offshore oil and gas sector and the UK Government will work together to meet stretching GHG emissions reduction targets, including development and implementation of the NSTA's Net-Zero Asset Stewardship Expectation 11 (NSTA, 2021). The deal includes early reductions in offshore production emissions of 25% by 2027; and 50% by 2030, against a 2018 baseline, to meet the sector's aim of creating a Net Zero basin by 2050.

Further requirements for the oil and gas industry to meet the UK's net zero obligation are outlined in the OGA Plan (NSTA, 2024a) to reduce UKCS GHG emissions from oil and gas extraction, which builds on and consolidates guidance on flaring and venting and the NSTA's Net-Zero Asset Stewardship Expectation 11.

In October 2025, the UK Government published the Carbon Budget and Growth Delivery Plan (CBGDP) (HM Government, 2025) which sets out how the government plans to meet its statutory carbon budgets (five-year caps on emissions levels set under the Climate Change Act 2008). It includes commitments to electrify upstream oil and gas production and abate emission from routine flaring and venting during oil and gas production.

Following this, in November 2025, the UK Government published the North Sea Future Plan (DESNZ, 2025b), which outlines a comprehensive strategy aimed at managing the North Sea's oil and gas resources while transitioning to clean energy.

The North Sea Future Plan sets out the UK Government's vision for the North Sea, namely:

"To foster an internationally-leading offshore clean energy industry, which ensures good, long-term jobs, growth and investment in communities across the North Sea, in tandem with a sustainable transition in oil and gas – boosting the country's economy and energy security, in line with our climate obligations."

It acknowledges that North Sea oil and gas production will continue to play an important role in the UK's energy mix in the decades to come, as well as its non-energy uses, such as in the petrochemicals industry. Ongoing investment and continued opportunities in oil and gas – particularly in the next few years – are fundamental to UK Government's ambition to ensure that oil and gas workers experience a fair, orderly and prosperous transition in the North Sea.

The North Sea Future Plan also outlines changes to the NSTA's objectives to allow the NSTA to move beyond Maximising Economic Recovery (MER) to cover economic, Net Zero and transition factors. The NSTA's revised objectives, which will be legislated for in the future, will now broadly cover:

- Objective 1 (Economic) – To maximise societal economic value of a relevant activity.
- Objective 2 (Net Zero) – To assist the Secretary of State in meeting the duty under section 1 and section 4(1)(b) of the Climate Change Act 2008 including supporting decarbonisation of relevant upstream activities.
- Objective 3 (Transition) – To enhance the long-term benefits of the transition to clean energy technologies in the UKCS by considering workers, communities and supply chains.

Further information on UK legislation and policies, including oil and gas specific strategies, which aim to mitigate climate change is provided in Section 9.3.

1.6 Areas of Uncertainty

This ES is prepared prior to detailed engineering studies being concluded. As a result, some assumptions have been made during the EIA process, including:

- The base case is that the pipelines and umbilical will be plough and trenched, however, if vessel availability for the trenching machine does not align with timeline, then jetting and mechanical cutter could be considered;
- It is currently assumed that there will be no requirement for a Subsea Isolation Valve (SSIV). However, the environmental impact of an SSIV has been included in the ES. The Health and Safety Executive may deem the inclusion of an SSIV in the Abbey & Baker necessary.
- To assess the effects of downstream scope 3 emissions on climate from the Abbey & Baker Development, Petrogas has made the assumption that all end use Abbey & Baker hydrocarbons are eventually combusted (refer to Section 9). This assumption is consistent with the guidance for assessing the global environmental impacts of proposed oil and gas projects issued by DESNZ in June 2025.

Where assumptions have been made, the environmental worst-case option has been assessed in the ES.

1.7 Stakeholder Engagement

There have been scoping meetings held with OPRED, the Joint Nature Conservation Committee (JNCC) and Maritime & Coastguard Agency (MCA) to introduce the project, present the results of the Abbey & Baker habitat assessment and environmental baseline surveys, as well as other known key environmental sensitivities in the area, and provide an update on the EIA. The outcome of this meeting was used to inform the scope of the EIA and content of this ES.

The key issues raised during the stakeholder engagement process and, where applicable, how these issues have been addressed within the ES, are detailed in Table 1.3.

Table 1.3. Summary of Key Issues Raised during the Stakeholder Engagement Process

Organisation	Issues Raised	Addressed in ES
OPRED	In relation to Net Zero, OPRED confirmed that the ES should set out how the proposed development will help deliver on the pathway to achieving net zero. In addition, OPRED confirmed that emissions arising at the construction and fabrication of the subsea infrastructure and pipeline onshore do not need to be included in the ES. The following aspects should be considered in the assessment: • Carbon intensity of production and how bringing the wells online will impact the carbon intensity of production from York. • How production will fit with targets set within the following: UK Energy White Paper, The World Bank Zero Routine Flaring, North Sea Transition Deal, NSTA Stewardship Expectations 11, Offshore Energies UK (OEUK) Roadmap to 2035. • Clearly detail the additional emissions arising from the project and include a comparison of emissions from the host facility if the development did not go ahead. • Provide summary of a methane action plan. • Environmental Management Systems. • Any environmental initiatives. • Mitigation measures. • The aggregated emissions of GHGs over the field life.	Sections 3 and 9
	Requested that information relating the pipeline protection is included in the ES and that a justification is provided for rock dumping the entire line.	Sections 2 and 3
	Herring spawning survey results are presented in the ES.	Section 4
	Acknowledged that Petrogas will be conducting oil spill modelling for a worst case blowout scenario and noted that the ES would also need to assess the potential for a major environmental incident (MEI) to occur.	Section 10
JNCC	Recommended that the field development location map show the proposed infrastructure in relation to nearby marine protected areas.	Figure 1.1 in Section 1.1
	Concerned about rock dumping the entire length of the pipeline and requested that a technical justification for this requirement is presented in the ES.	Sections 2 and 3

Organisation	Issues Raised	Addressed in ES
	Noted that the ES should include quantities and location of rock dump and concrete mattresses required for the subsea infrastructure. It should also review the feasibility of removing this material during decommissioning.	Section 3
	Happy to see that Petrogas was moving the well location away from a potential area of reefiness.	Sections 4 and 7
	JNCC acknowledged that Petrogas were undertaking a herring spawning assessment.	Section 4
MCA	Raised a question regarding the consent to locate and when the shipping risk assessment work would be completed. Petrogas stated that as this is a subsea development, the shipping risk assessment wouldn't be completed for the ES, but will be completed as part of the consent to locate permit.	Section 2.2

2 Project Alternatives

2.1 Introduction

Petrogas has explored various concepts to develop the Abbey & Baker fields. This section of the ES describes the main alternatives considered, the associated environmental implications of each option and the reasons why the selected development concept has been chosen.

It references the Abbey & Baker Field Development Concept Select Report (ABB-0000-TEC-RPT-PTG-0000-00083-00) undertaken to determine the optimum development plan for the fields in terms of economics, technical risk and operability and environmental impacts.

The proposed Abbey & Baker Development concept has been selected and defined with consideration to the central obligation of the OGA Strategy (OGA, 2021), being to:

- Secure the maximum value of economically recoverable hydrocarbon reserves; and, in doing so;
- Take appropriate steps to assist the Secretary of State in meeting the Net Zero target, including by reducing as far as reasonable in the circumstances GHG emissions.

Petrogas is also cognisance of the requirements of NSTA's Net Zero Stewardship Expectation 11 (NSTA, 2021).

Note, the NSTA have provided its non-objection to the selected concept.

2.2 Development Concept

The selected concept for the Abbey & Baker Development is a subsea development, consisting of three development wells at Abbey and one development well at Baker, tied back to York platform.

A standalone development concept, which would have been a subsea development with a pipeline directly back to shore, is not economically viable for Abbey & Baker and was discounted.

2.2.1 Baker Well Option Selection

Two possible options were evaluated to develop Baker, namely:

1. Standalone subsea tie-back to a suitable host facility (separate to the Abbey Development)
2. Subsea tie-in to the Abbey manifold

Analysis of these options (as summarised in Table 2.1) concluded that tie-in to the Abbey manifold, via a ca. 4 km, 8 inch diameter pipeline, was the preferred option, due to lower cost, ease of engineering and lower environmental impact (i.e. shorter pipeline length to Baker).

Concept select work therefore focused on screening hosts which could support the development of Abbey as a subsea tie-back, with Baker developed via tie-in to the Abbey manifold.

Table 2.1: Baker Tie-back Screening Analysis

	Standalone subsea tie-back to a suitable host facility	Subsea tie-in to the Abbey manifold
Strengths	• Enhanced metering accessibility • Improved pipeline availability • Optimized liquids handling • Future field development accommodation • Streamlined well commissioning • Simplified Farm-Out potential	• Minimized Capital Expenditure (CAPEX) compared to a tie-back • Reduced topsides facility modifications • Simplified subsea infrastructure • Reduced environmental impact
Weaknesses	• Increased Capital Expenditure (CAPEX) • Increased environmental impact • Subsea manifold requirement • Impact on safety case • Increased topsides facility footprint • Augmented maintenance requirements	• Operational constraints due to baker well properties • Increased Abbey subsea manifold size • Complexities in start-up and commissioning • Production backout potential
Opportunities	• Enhanced Farm-Out attractiveness	• Pipeline diameter optimization • Riser retention for future fields
Threats	• Increased pipeline management and decommissioning costs	• Single point of failure • Reduced farm-out flexibility

Concept Decision: Baker well will be a Subsea tie-in to the Abbey manifold

2.2.2 Initial Host Facility Screening

A preliminary, qualitative, option screening process was completed for six credible Abbey & Baker Development host facility / tie-back options, within a ca. 20 km radius of the Abbey & Baker fields (as illustrated in Figure 2.1), as well as a new direct export route direct to shore.

The credibility of each potential concept was confirmed by comparison against the following Abbey & Baker Development functional requirements

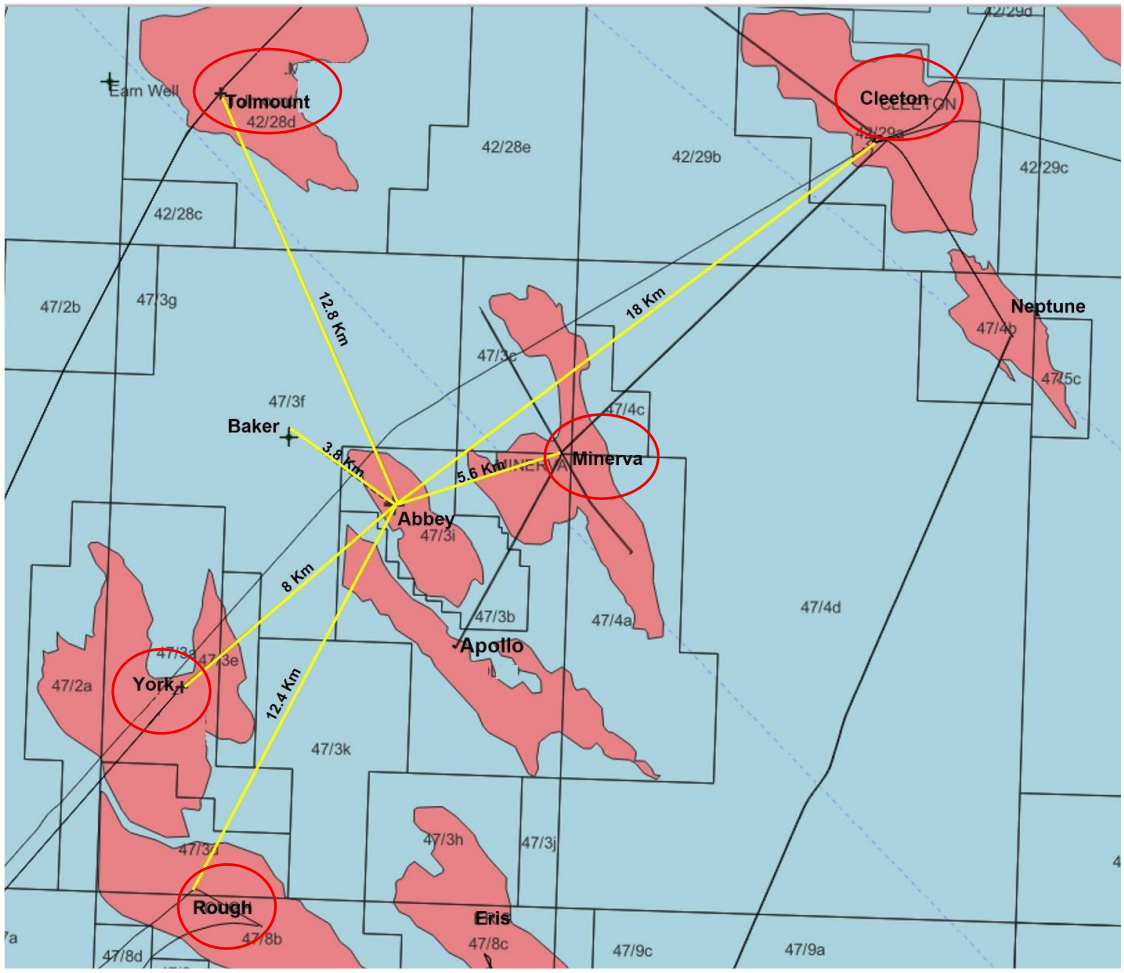
- Capacity to integrate up to four development wells (3 x Abbey + 1 x Baker)
- Provides a base for the tie-in of third-party business or other assets
- Use of proven technology with record of UK success
- Maximise recovery in terms of revenue (high performing wells)
- Has process facilities and ullage sufficient for P90 production
- Is suitable for the relatively shallow water depth
- Delivers first gas in 2029
- Achieves a dry gas production of 110 MMscf/d for a minimum 10-year field life
- Could incorporate proppant and sand control to minimise and monitor for proppant breakthrough
- Consideration of power generation and communications, controls and instrumentation, chemical injection and bulk chemical storage requirements
- Minimises GHG emissions in the production and transportation of the Abbey & Baker gas

As a result, four options (Rough, Minerva, subsea hot tap into the Cleeton pipeline and the direct export route to shore) were deemed not viable, as detailed in Table 2.2.

The remaining three options (York, Cleeton and Tolmount) were considered to be potentially viable options and were subject to comparison, the results of which are outlined in Table 2.3.

Cleeton was subsequently rejected due to a number of factors, such as aging infrastructure, higher costs and potential earlier CoP date (Table 2.3), in favour of Tolmount and York, with these two options taken forward for further detailed evaluation (refer to Section 2.2.2).

Figure 2.1: Potential Host Facilities / Tie-back Options for the Abbey & Baker Development



[1] Red circles indicate potential host options. For Cleeton, tie-back to the Cleeton platform, as well as a subsea hot tap into the Cleeton export pipeline (PL447) was screened.

Table 2.2: Screened Out Host Facility / Export Route Options

Host / Export Route Option	Approx Distance to Abbey (km)	Comment on Suitability
1. Rough	12.4	• Operator unwillingness to consider third party tie-ins due to conversion of facility to an energy hub. • Timescales will not work for Abbey & Baker.
2. Minerva NUI	5.6	• Minerva platform (installed 2003) produces through Cleeton (installed 1988). Both are old facilities with obsolescence issues. • Abbey & Baker wells require continuous methanol (MeOH) or monoethylene Glycol (MEG) hydrate inhibition whilst Minerva and Cleeton wells only require intermittent inhibition. There is no MeOH pipeline from shore to Cleeton / Minerva for continuous injection. Cleeton supplies Minerva with MeOH via a subsea pipeline, which requires MeOH to be shipped to Cleeton and stored in a tank. Production through Minerva would therefore require additional 70m^3 MeOH shipments to Cleeton, estimated at 2 per week initially, 200 over field life. • De-rated 250 barg Cleeton MeOH distribution pumps would require booster pumps to be installed on Minerva. • Minerva has only 6-inch spare riser, Abbey & Baker requires 8-inch, imposing production constraints or significant cost to retro-fit a new riser on an old platform. • Abbey & Baker production would back our Minerva and Cleeton production. • New allocation metering facilities would need to be installed on Minerva for Abbey & Baker.
3. Direct pipeline to shore	40	• Schedule risk due to delays in receiving regulatory approvals and stakeholder concern regarding significant works (e.g., trench and burial of 40 km gas and chemical injection piggy-back pipelines). • Drilling of shaft through cliffs required within environmentally sensitive and protected areas. • Highest CAPEX option.
4. Subsea Hot tap into Cleeton export pipeline (PL447)	1.5	• Lack of Operator willingness to engage in discussion. • No simple route for umbilical for controls chemicals and methanol. • Requires subsea fiscal metering for Abbey & Baker.

Table 2.3: Host Comparison Summary

Assessment Criteria	York	Cleeton	Tolmount
Technical	• Platform less than 15 yrs old (1st gas 2013) and in good condition. 16-inch pipeline and 3-inch methanol line; condition is generally good. • York has spare risers and J-tubes suitable for Abbey & Baker and other third parties. • York topsides have space capacity for future facilities. • No access to offshore produced water treatment facilities.	• Ageing facility, gas production ceased in 1999. Extensive topsides modifications required as there is no spare riser or J-tube. • Requires bulk chemicals to be tankered to platform. • MeOH requirements for Abbey & Baker could not be met by Cleeton without additional extensive modifications • Access to offshore produced water treatment facilities.	• Relatively new platform (1st gas 2022), 20 inch pipeline and 3 inch methanol line to Easington Terminal. • No access to offshore produced water treatment facilities.
Longevity	• York CoP Q3 2024; however, ability for Petrogas to take over ownership of platform	• Cleeton CoP date is 2030 (based on information provided by Operator).	• Due to decline in Tolmount profiles, Abbey & Baker would have significant operating cost to maintain longevity of host.
Seabed Disturbance	• Lowest seabed impact and footprint, based on ca. 8 km export route between Abbey and York.	• Highest seabed impact and footprint, based on ca. 18 km export route between Abbey and Cleeton.	• Seabed impact and footprint higher than York, but lower than Cleeton, based on ca. 12.8 km export route between Abbey and Host
GHG Emissions	• Installation operations result in lowest GHG emissions related to short duration of pipelaying and simple tie-in activities (Subsea Umbilicals, Risers and Flowlines (SURF) Programme: 73 days). • Abbey & Baker picks up 100% of York GHG emissions from platform power generation.	• Installation operations result in highest GHG emissions due to longest duration of pipelaying and complex tie in requirements (SURF Programme: 171 days) • GHG emissions from power generation at Cleeton are uncertain.	• Installation operations result in slightly higher GHG emissions compared to York, but lower than Cleeton, due to the shorter pipeline route and simple tie-in requirements (SURF Programme: 83 days) • Abbey & Baker would account for ca. 23% of total platform GHG emissions (power generation and venting). GHG emissions minimised via use of high efficiency gas microturbines.

Assessment Criteria	York	Cleeton	Tolmount
Commercial	• At the time when the ES is issued, Spirit Energy and Petrogas will have signed a conditional sale and purchase agreement for purchase by Petrogas of Spirit Energy's interest in the York Licence and York facilities. Upon satisfaction of those conditions, which include regulatory approval, Petrogas will assume ownership and operatorship of the York Licence and facilities. This removes constraint of CoP and provides Petrogas with the most flexibility for future opportunities.	• Challenges in reaching agreement with current operator (high cost).	• Discussions with Operator identified there would be backout of Tolmount should Abbey & Baker fluids be produced via Tolmount, as well as formation water constraints.
Key			
	Potentially viable option		Option not viable

2.2.3 Concept Select – Detailed Host Selection – York or Tolmount

York

The York is a Not Permanently Attended Installation (NPAI), located ca. 8 km south west of the Abbey field. The platform is currently in light house mode with all existing York wells plugged and abandoned and only temporary NAV aids are operational (Figure 2.2). If Petrogas select the York option, they would take operatorship of the York to Dimlington pipeline.

Development of Abbey & Baker via York would require:

- Installation of an 8 km 8 inch diameter rigid pipeline and umbilical between the Abbey manifold and the York platform.
- Reuse of the existing 16 inch diameter export pipeline from York to Dimlington Terminal via Easington Terminal.
- Reuse of the existing piggy backed 3 inch diameter methanol pipeline from Easington Terminal to the York platform A new methanol and corrosion inhibitor package will be installed at the onshore terminal.
- Topsides modifications/construction on York:
    - Subsea tie in to existing spare riser
    - Pipe work and instrumentation from riser to existing export pipework
    - Tie in of new umbilical pulled in via existing spare J tube
    - New Topsides Umbilical Termination Unit (TUTU) for tie in of the new umbilical
    - New Hydraulic Power Unit (HPU)
    - New Master Control Station (MCS)
    - Control system upgrade
    - Pressure Control Valve
    - Additional chemical injection facilities
    - Reinstatement of all existing systems

Tolmount

Tolmount is a Not Permanently Attended Installation (NPAI) located ca. 12.8 km north northwest of the Abbey field, is currently operating with production from the Tolmount and East Tolmount fields. The only processing of production fluids carried out on Tolmount is to remove free water, which is treated and disposed of offshore; the platform can handle up to 2,000 barrels water per day (bwpd) produced water. Gas, condensate and residual water is exported via the subsea pipeline to the Easington Terminal for processing. Methanol and corrosion inhibitor are supplied via an existing pipeline from Easington Terminal (Figure 2.2).

Development of Abbey & Baker via Tolmount would require:

- Installation of a 13 km 8 inch diameter rigid pipeline and umbilical between the Abbey manifold and Tolmount;
- Topsides modifications/construction on Tolmount
    - Subsea tie in to existing spare riser
    - Pipe work valves and instrumentation from riser to tie in pipework
    - Tie in of new umbilical pulled in via existing spare J tube
    - New TUTU for tie in of the new umbilical
    - New HPU
    - New MCS
    - Control system modifications
    - Pressure control valve
    - Solids filter
    - Additional chemical injection facilities

York and Tolmount were assessed to compare their relative merits on 3 factors:

- Environmental Assessment
- Economic Assessment
- Future Opportunity Assessment

Figure 2.2: Tolmount and York Platforms

Host Assessment

The environmental impacts and GHG emissions (including carbon intensity of each option) generated by the Abbey & Baker Development options have been assessed.

Assumptions on the potential allocation of Abbey & Baker production at each host facility (aligned to CoP date), were used to calculate production carbon intensity between the two options (Table 2.4). This allowed the options to be compared on an individual basis. The GHG emissions from drilling operations and the well testing will be the same, so that was not part of the assessment. The main difference will be in the pipeline installation activities, as Tolmount is 60% longer in length and therefore will require more vessel days to install, leading for more GHG emissions from fuel.

As the York and Tolmount pipelines are very similar in location, there was no discernible differences in the sediment or benthic baseline from the survey data and therefore this was removed from the assessment. The main environmental difference is the reduced length of the York pipeline route comparted with the Tolmount pipeline, which will lead to less seabed disturbance. The Tolmount pipeline and umbilical route is 60% longer than York (12.8 km rather than 8 km). The results of the comparison between the two hosts is shown in Table 2.4.

Table 2.4: Environmental and GHG Emissions Assessment of the two Host Options

	Tolmount	York
Length of Pipeline (km)	12.8km	8km (lower disturbance)
Length of Pipeline within MPAs (km)	Southern North Sea SAC – 9.6km	Southern North Sea SAC – 8km Holderness Offshore MCZ - 4.7km
Carbon Intensity (kg CO_2e / boe) Note 1	0.10	0.06
Pipeline installation tCO_2e emissions Note 2	7,114	6,231

Key: Green = Better or equal option. Orange = Less favourable option

Note 1: Annual Carbon Intensity of the host option platform Scope 1 emissions only, assuming 100% hydrocarbon recovery.

Note 2: Includes pipelay, trench and burial and pipeline protection

The main differences in the Carbon Dioxide equivalent (CO_2e) emissions are in the subsea scope (pipeline length) and carbon intensity. For the Tolmount Host option, Abbey & Baker will share production operations with the Tolmount wells. The addition of Abbey & Baker production will make negligible impact to the atmospheric emissions of either platform. The gas and diesel generator emissions will not increase with the small additional electrical load, and during operation the additional logistics (flights, vessels etc.) will also be negligible. The current CoP of Tolmount is in 2034, and this would end current platform emissions. Therefore, it is reasonable to allocate all Tolmount emissions to Abbey & Baker after 2034. It has been assumed at 6 full years of emissions for Tolmount, which impacts the carbon intensity at Tolmount and increases it over York.

York has been put into lighthouse mode (via battery and solar Panels) by Spirit (September 2024) including plug and abandoning all York wells and making York Hydrocarbon free. If Abbey & Baker go through York, then all emissions initially during lighthouse mode and then later during production, will be allocated to Abbey & Baker. The facilities on York are very basic with limited electrical load and small diesel generators. The current plan is for no operational trips to the platform via helicopter and a single annual Walk to Work Campaign. In the P10 scenario, Abbey & Baker CoP is assumed 2044 for both hosts.

At the end of field life, the Abbey & Baker Development will be decommissioned. The decommissioning process will generate atmospheric emissions both directly from cessation operations such as well plug and abandonment activities, recovery of the topsides and subsea equipment, associated vessel traffic, and indirectly through the reuse and recycling of materials (e.g. steel). Petrogas has not included the platform decommissioning emission in the assessment, as these emissions would have originally been included in Spirit Energy's emissions plan for the removal the platform.

The overall assessment of the Environmental Impact of the two host options confirms that the York option has lower total emissions and generally lower impact (shorter subsea pipeline).

CAPEX and Operating Expenditure (OPEX) Comparison

York has significantly reduced OPEX compared to Tolmount due to higher offshore and terminal tariffs.

The economic evaluation shows the York Host concept to be superior to the Tolmount Host and the recommended host for Abbey & Baker.

2.2.4 Preferred Host Option

Key differentiators between Tolmount and York as potential hosts for the Abbey & Baker Development include:

- The main environmental difference is the reduced length of the York pipeline route comparted with the Tolmount pipeline, which will lead to less seabed disturbance.

- The atmospheric emissions at Tolmount are greater for pipeline installation activities as Tolmount is 60% longer in length and therefore will require more vessel days to install, leading for more GHG emissions from fuel.
- Lower carbon intensity at York.
- York has significantly reduced OPEX compared to Tolmount due to higher offshore and terminal tariffs.

In summary, the York assessed better when compared to Tolmount and will be the chosen host for the Abbey & Baker Development.

Host Decision: Tie-back to York

2.2.5 Concept Emissions Assessment

Aligned with the North Sea Future Plan (DESNZ, 2025b) and in accordance with the OGA Strategy and OGA Plan to reduce UKCS GHG emissions from oil and gas extraction, the selection of the development concept for Abbey & Baker has been informed by carbon intensity and infrastructure reuse considerations. Key benefits of the chosen concept include:

- Maximising use of existing oil and gas infrastructure, avoid the need for new-build processing or export infrastructure
- Aiding, where feasible, future field developments, including those outside the licence area

The overall life-cycle GHG emissions of the Abbey & Baker Development via York, are approx. 15,607,857 tonnes CO_2e .

The selection of a subsea tie back to an existing platform for the Abbey & Baker development means that the GHG emissions will be significantly lower than that generated by a new platform and new export pipeline, and this supports the requirements of the NSTAs Net Zero Strategy.

It is common practice for SNS platforms to:

- Use diesel driven generators for power generation
- Vent and / or flare gas to atmosphere with calculation methods (rather than metering) used to quantify these emissions

However, selection of the York platform as the host facility has the following advantages:

- There is no flare package
- There is a vent line on the existing pig launcher package but there is no planned pigging required during the operation of the pipeline for the Abbey Baker production.
- There is minimum infrastructure on the York platform and power requirements are low

York is a relatively new platform with an export pipeline and access to a Terminal with certainty for life of field refining and access to the National Transmission System (NTS).

It is widely acknowledged that on the pathway to Net Zero emissions, oil and gas will continue to play an important part of the energy mix for the foreseeable future. Moreover, according to the Climate Change Committee (CCC), the UK will require 13–15 billion barrels of oil and gas equivalent in the period 2025 to 2050 but is currently only forecast to produce 4 billion (CCC, 2025a; NSTA, 2025b). In a time of historically low domestic energy production with more than 40% of the UK's energy now imported (DESNZ, 2025b), responsible development of UKCS oil and gas fields ensures that the UK meets its energy demand while retaining control over emissions. In addition, gas produced domestically during the foreseeable future is likely to help reduce demand for an equivalent volume of gas that is imported, which will have a higher carbon intensity because of the methods of international transportation.

By lowering dependence on fossil fuel imports, the UK can cut GHG intensities. In 2025, the Dimlington Gas Terminal (DGT) had a reported GHG intensity of 13.95 $kgCO_2e$/barrel of oil equivalent (boe). This is

well below the UKCS average of 28 kgCO2e/boe, and significantly lower than the average GHG intensity of imported Liquefied Natural Gas (LNG) (85 kgCO2/boe) (NSTA, 2025b).

In summary, Abbey & Baker will reduce the overall energy intensity of gas produced through DGT providing lower carbon, indigenous gas during the transition to renewable energy, helping contribute to energy security and assist in the delivery of Net Zero UK carbon emissions by 2050.

Section 9 of this ES assesses the impact of the upstream and downstream GHG emissions generated from the proposed Abbey & Baker Development on the climate and the significance of any likely effects.

2.3 Abbey Well Count & Design

The Abbey field will be developed with three horizontal multi-fracked wells. The well placement is based on both the structural and fault interpretation. The suspended 47/3b-17z (Abbey 02) well will be re-instated and tied back to the export facilities. Abbey 01 and Abbey 03 will be drilled to optimise the depletion of the field. Both new wells will be drilled and completed using the same methodology as the 47/3b-17z (Abbey 02) well.

During the option screening process, the use of standard vertical, horizontal, and multi-bore wells of conventional well design, casing and completion (without well stimulation) were reviewed and discounted as previous wells drilled into this structure suffered from sub-commercial well flow rates due to low permeability sandstone within the reservoir.

To facilitate commercial resource recovery, the Abbey development wells will require:

- The drilling of horizontal wells to maximise the length of available reservoir sand face; and
- Well stimulation

Of the well stimulation options considered, acid matrix stimulation was screened out as this method is best suited for use on carbonate reservoirs where the stimulation potential is higher than that observed with sandstone reservoirs and formation damage and emulsion generation is much higher due to the complex reaction chemistry occurring within sandstone reservoirs.

The two remaining credible well stimulation options, hydraulic fracturing and the use of Fishbone technology (i.e. multiple small diameter laterals drilled into reservoir), were evaluated and scored for their applicability for the Abbey wells (Table 2.5).

Table 2.5: Evaluation of Credible Development Well Options Abbey

Criteria	Option 1: Fractured horizontal wells (hydraulic fracking)	Option 2: Multiple small diameter laterals (e.g. Fishbone technology)
Technical	Well understood and widely implemented technology	Novel technology with no record of UK success
Production and reserves deliverability	Historical well data indicates expected success with well deliverability and reserves production and represents MER	Uncertainty over success of using this approach
Health and safety	No significant issues anticipated for achieving compliance with UK Health, Safety and Environment (HSE) legislation or from the demonstration of ALARP with well stimulation vessel	No significant issues anticipated for achieving compliance with UK HSE legislation or from the demonstration of ALARP
Environmental	Higher quantity of well clean-up discharges Higher GHG emissions from use of well stimulation vessel Opportunity to do well clean up via platform which will reduce emissions	Lower GHG emissions and quantity of well clean-up discharges
Schedule	Likely to achieve first gas date	Novel technology increases schedule risk
Societal - Fisheries / Navigation / Other Sea Users	Increased potential for interaction with other sea users from additional well stimulation vessel trips	Moderate interaction with other sea users
Societal - Employment / Resource use	Higher resource use (fuel, proppant manufacture)	Moderate resource use
Commercial	None foreseen	None foreseen
Cost and Economics	Acceptable CAPEX costs considering potential recovery of commercial reserves - MER compliant	Risk of higher CAPEX costs resulting from delays with successful implementation of novel technology

Key: Green = Better or equal option. Orange = Less favourable option

In conclusion, propped hydraulic fracturing was favoured as it is a proven technology for the delivery of commercial well flow rates from 'tight gas' sandstone reservoirs. The use of fishbone technology was ultimately screened out as it presented a higher level of uncertainty regarding the technical risk posed from the use of novel technology (with no proven UK success), which could also negatively impact CAPEX and the project schedule. Further enhancements to the current completion philosophy (in terms of enhanced productivity and reduced costs) will be evaluated during the detailed design phase of the project.

2.4 Abbey Subsea Well Configuration Options

The Baker field will be developed via a single well protected by a subsea wellhead protection structure (WHPS). However, as Abbey will be developed via three subsea wells the following configuration options were assessed, as summarised in Table 2.6:

- Option 1: Drilling Template and Separate Production Manifold Configuration
- Option 2: Integrated Drilling Template and Manifold Configuration

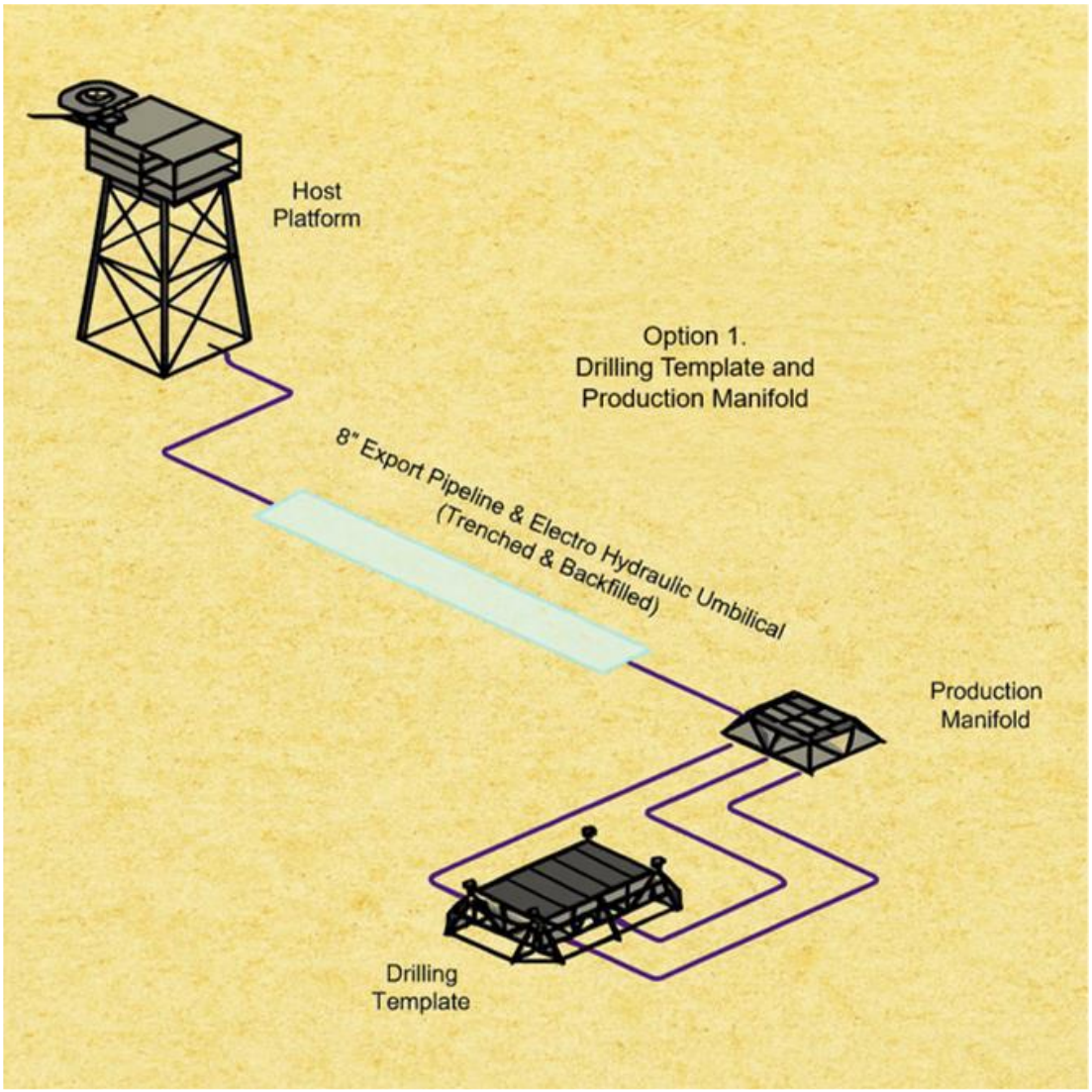
- Option 3: Locally Dispersed Well Configuration (wells connected to a production manifold within one 500 m zone)

Option 1 : Drilling Template and Manifold

For this option, the subsea architecture consists of a 4-slot drilling template which houses and provides protection for the production Xmas trees. Each tree is connected by its own 6-inch diameter flow line to the adjacent subsea production manifold which will also have a spare tie in point for a potential fourth well (Figure 2.3).

Electro-hydraulic controls and chemical injection capability is provided via control jumpers between each tree and the subsea manifold. The subsea manifold is connected to the host facility by an 8-inch diameter rigid flow line and umbilical. There is a common flowline and umbilical to the host platform which is the same for all subsea infield options.

Figure 2.3: Option 1 Separate Template and Manifold

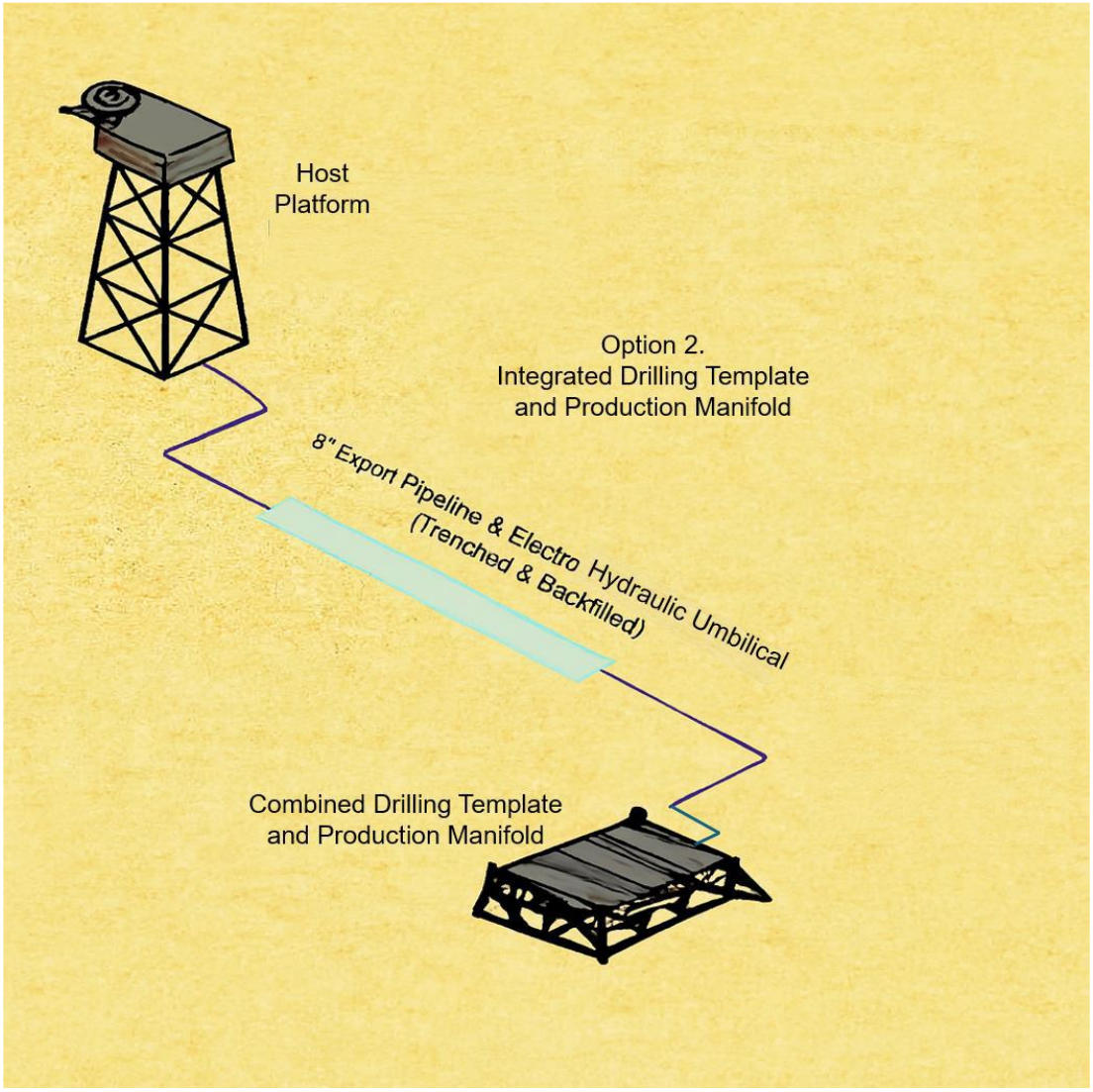


Option 2: Integrated Drilling Template and Manifold Configuration

With this option, the well drilling slots are integrated within the production manifold (Figure 2.4).

Electro-hydraulic controls and chemical injection capability is provided via control jumpers between each tree and a Subsea Distribution Unit (SDU) housed within the integrated Drilling Template / Production Manifold structure. The subsea manifold is connected to the host facility by an 8-inch diameter rigid flow line and umbilical. There is a common flowline and umbilical to the host platform.

Figure 2.4: Option 2 Integrated Drilling Template and Production Manifold



Option 3: Dispersed Wells Within 500m Zone

With this option, each well is drilled from a separate top-hole location and tied back to a subsea production manifold (i.e. there is no drilling template).

Each well will be tied back to the production manifold using individual flow lines and electrohydraulic controls and chemical injection control jumpers. The exact location of each well would be subject to further evaluation during detailed design. Each individual well will have a fishing friendly protective structure. There is a common flowline and umbilical to the host platform.

Figure 2.5: Option 3 Dispersed Wells

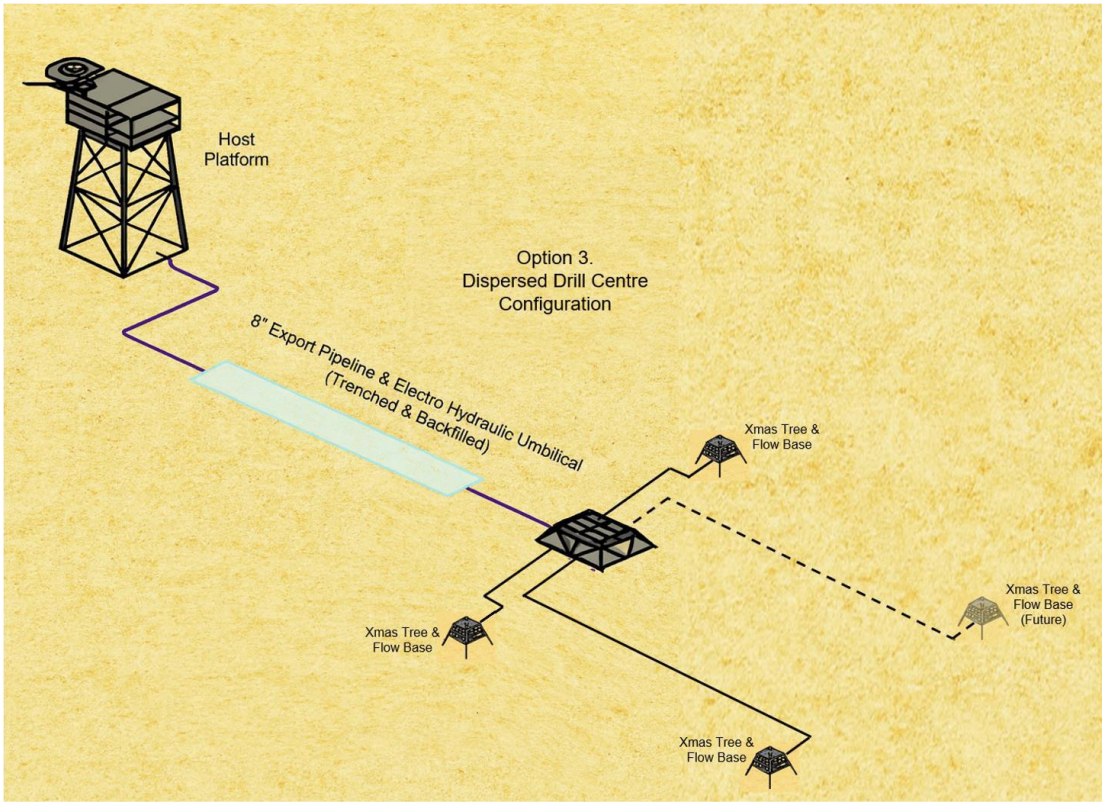


Table 2.6: Evaluation of Credible Abbey Infield Subsea Development Options

Criteria	Option 1: Drilling Template and Manifold Configuration	Option 2: Integrated Drilling Template and Manifold Configuration	Option 3: Locally Dispersed Wells and Manifold Configuration
Technical	No rig move required once on site. - Requires CSV to install drill template. - Latest studies have identified a significant increase in the weight and footprint of drilling template and associated protection structure. - Also resulting in a more complicated installation e.g. increased stabilisation.	No rig move required once on site. - Similar to option 1. Latest studies have identified significantly increase in weight and footprint due to protection and stability needs. - Also resulting in a more complicated installation e.g. increased stabilisation.	Base case no rig move required once on site and rig shall be able to reach all well surface locations. - Requires more metrology and site visits. - Simpler and more conventional design, and single well protection structures can be installed from rig. - The Abbey A2 well was completed in 25 as an appraisal / development well and proved the concept / design.
Production & reserves deliverability	No impact	No impact	No impact
Health and safety	No significant issues anticipated for achieving compliance with UK HSE	No significant issues anticipated for achieving compliance with UK HSE	No significant issues anticipated for achieving compliance with UK HSE

Criteria	Option 1: Drilling Template and Manifold Configuration	Option 2: Integrated Drilling Template and Manifold Configuration	Option 3: Locally Dispersed Wells and Manifold Configuration
	or for the demonstration of legislation ALARP.	legislation or for the demonstration of ALARP.	legislation or for the demonstration of ALARP.
Environmental	Smaller Localised seabed footprint. - GHG emissions less than Option 2 and similar to Option 3 - Less rig moves than option 3 but this offset with the need for CSV to install Xmas tree protection structures.	Intermediate seabed footprint and disturbance. - Slightly higher GHG emissions compared with Option 1. Greatest GHG emissions compared with other options due to complexity of installation and number of different vessels required	Smallest seabed facilities footprint with only 3-off well structures, smaller than drilling template configuration which is designed for 4-off wells with larger associated protection structure. - Similar GHG emissions to Option1, more rig moves than Option1 which is offset against not needing to use CSV to install Xmas tree protection structures
Schedule	Likely to achieve first gas date.	Likely to achieve first gas date.	Likely to achieve first gas date.
Commercial	No significant difference.	No significant difference.	No significant difference.
Cost and Economics	Mid range CAPEX option compared with Option 1&3. - Avoids schedule risk to Heavy Lift Vessel (HLV) and rig moves (waiting on weather). - Further study work on this option revealed cost escalations in the following areas: - Design -Fabrication - Installation Resulting in Option 1 being mid range in CAPEX terms compared with Options 1 & 3.	Increased CAPEX compared to option 1. Schedule risk to HLV (waiting on weather).	Lowest overall CAPEX option correlated to several factors: simplest design, smallest design and lightest structures, this includes taking account of additional rig moves. - With phased drilling program Option 3 is the lowest amount of pre-investment in subsea facilities prior to FID compared with other options. This reduces financial risk exposure.

Key: Green = Better or equal option. Orange = Less favourable option

To summarize the assessment (Table 2.6), the separate Locally Dispersed Wells and Manifold Configuration (Option 3) is preferred due to:

- Lowest CAPEX
- Lowest risk as Xmas tree protection structures can be installed from any rig
- Conventional design
- It is the simplest option to decommission due to the size and weight of facilities compared with other options.

Abbey Subsea Well Configuration Decision: Locally Dispersed Wells and Manifold Configuration

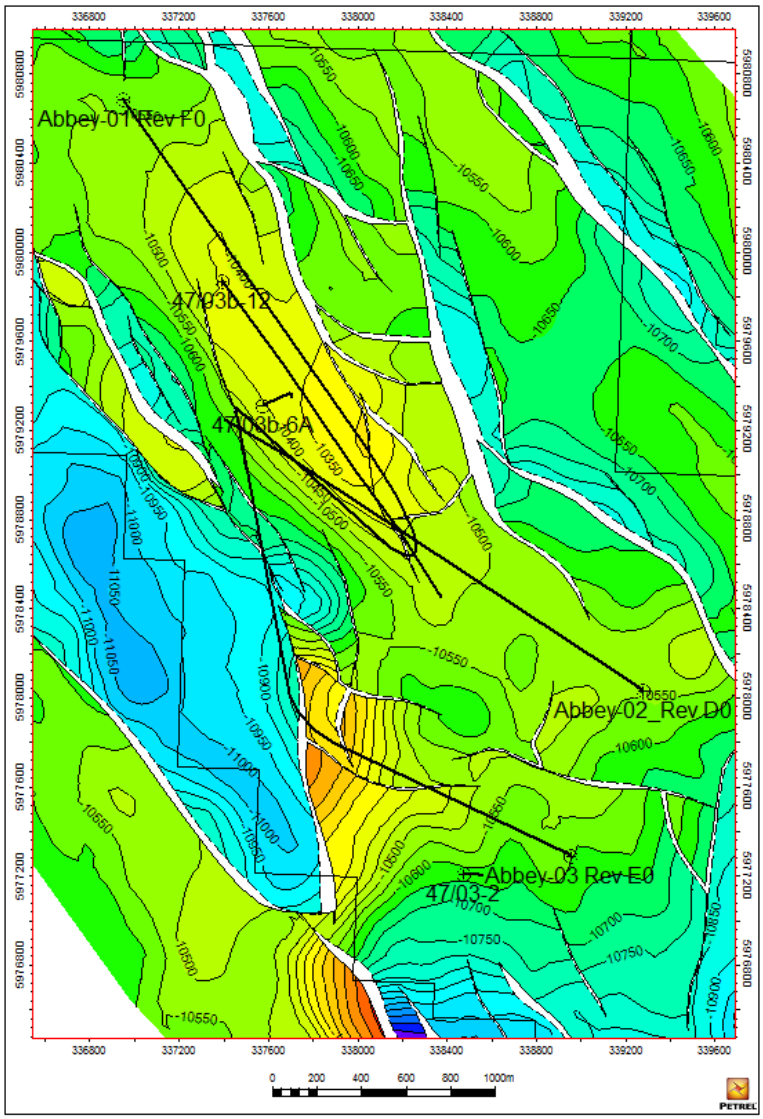
3 Abbey & Baker Project Description

3.1 Abbey & Baker Field and Development Concept

The proposed Abbey & Baker development is targeting two light gas reservoir at a depth of circa 10,500 – 11,000 feet vertically subsea. The Abbey reservoir is classified as a "tight" reservoir due to the nature of the Leman sandstone reservoir. Previous conventional wells drilled into the reservoir encountered low permeability and sub-optimal flow rates. The Baker reservoir quality is significantly better than Abbey and will be completed with a conventional gravel pack lower completion.

The orientation and the width of the Abbey structure leads itself to the wells being orientated Northwest to Southeast (NW-SE) along the crest of the structure (Figure 3.1). The spatial extent of the reservoir predicates that a third well is required to be drilled in the southern area of the field perpendicular to the two crestal well as it is not possible to effectively develop this area of the field with two very long crestal wells.

Figure 3.1: Abbey Reservoir Top Rotliegend Depth Structure Map



The Baker reservoir is a well-defined tilted fault block/horst striking North Northwest – South Southeast (NNW-SSE). Following assessment of the core data and sedimentology it has been concluded that drilling a horizontal well through the reservoir and across any faults is unsuitable as it would carry severe risk of collapse whilst drilling and is not required for deliverability reasons. As such, it has been

decided the optimal approach is a vertical or inclined well located up dip from the Baker exploration well (47/03f-16).

The development plan for Abbey & Baker is therefore based around a four well concept; three located at Abbey and one at Baker. One of the three wells at Abbey (Abbey A2) was drilled as an appraisal well in Q4 2024/Q1 2025 and is currently suspended. Drilling and completion of the second and third wells (A1 and A3) at Abbey; drilling and completion of the fourth well at Baker; and completion of the existing appraisal well (Abbey A2) as a producer fall into the scope of the Abbey & Baker Development and production consent application and therefore this ES.

Previous conventional wells drilled into the Abbey reservoir encountered low permeability and sub-optimal flow rates. However, the available well test data has proved that a significant increase in well deliverability can be attained through stimulation of the wells in low reservoir permeability. Modelling has concluded that between five and nine hydraulic stimulations per well should form the basis of the field development. The full hydrocarbon column will be stimulated hence reducing the uncertainty regarding vertical connectivity. The stimulations are equally spaced along these wells and will propagate longitudinally with respect to the planned wells. This is not required for the Baker Development well.

It has been identified that the Baker well shall require sand control within the lower completion to limit solids production during the life of the well. As a result, it has been determined that gravel pack will be the optimal lower completion design for the life of the Baker well.

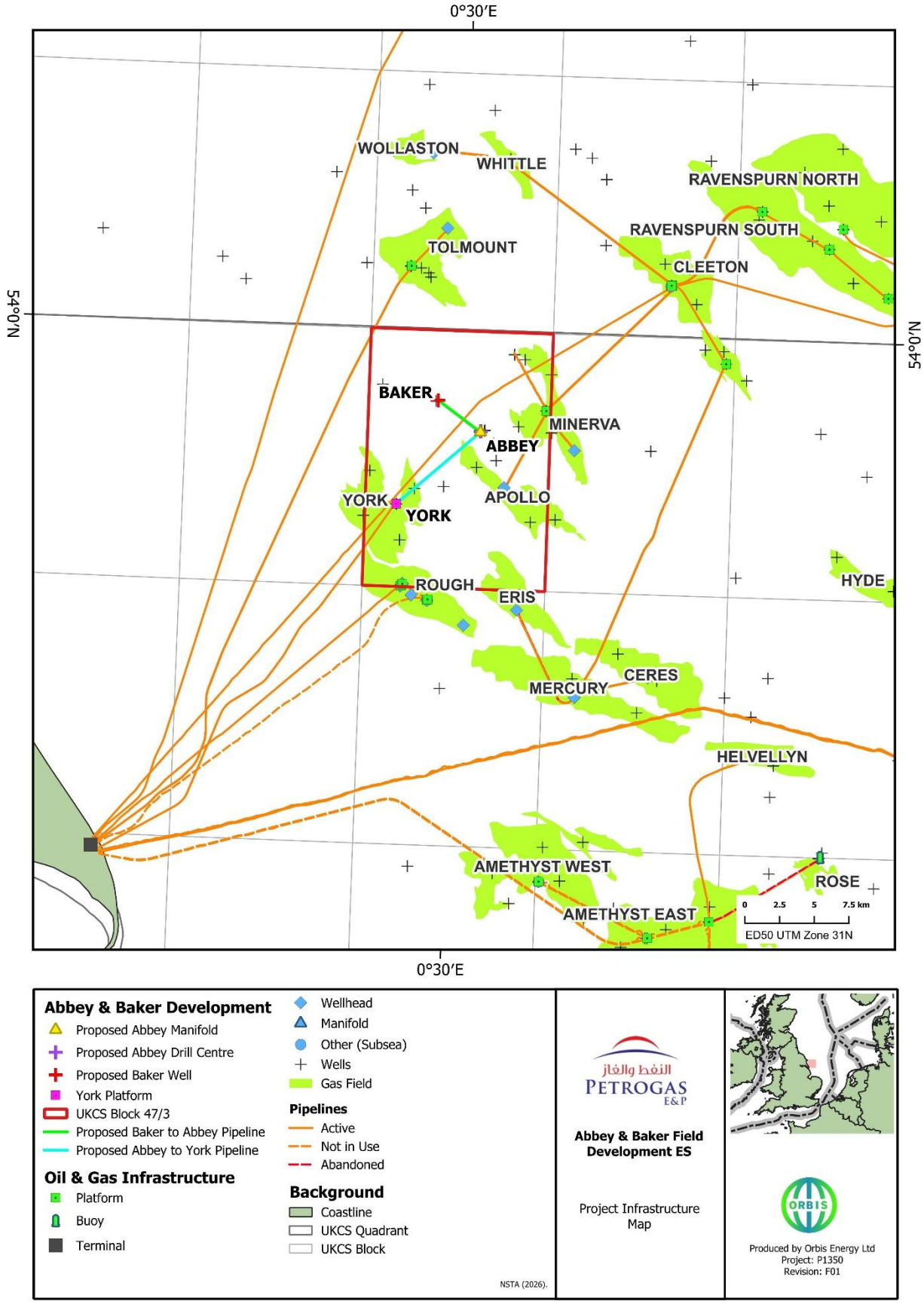
The Abbey wells will be drilled from a single drill centre and will be constructed with individual wellhead protection structures. Once completed, all three of the production wells will be tied back to a new production manifold located adjacent to the wellhead structures, which in turn will be tied back to the York platform via a 8 km 8-inch diameter rigid export pipeline (Figure 3.2). A new 8 km umbilical, providing control and chemical services from the York platform to the Abbey facilities, is also required. The pipeline and umbilical will be trenched and buried along the whole route, with spot rock protection, where required, for protection and upheaval buckling mitigation.

The Baker well will be drilled at a location approximately 3.8 km from the Abbey wells and will be constructed with an individual WHPS. Once completed, the Baker well will be tied back to the Abbey production manifold via a 3.8 km 8-inch diameter pipeline (Figure 3.2). A new 3.8 km umbilical, providing control and chemical services to Baker via the Abbey facilities, is also required. The Baker pipeline and umbilical will also be trenched and buried along the whole route, with spot rock protection, where required, for protection and upheaval buckling mitigation.

The York platform topsides will be upgraded to receive the Abbey & Baker production stream, which will pass through a pressure control valve, before passing through York and being exported via existing infrastructure to the Dimlington Gas Terminal, on the east coast of England, for processing to National Grid specifications before export into the National Transmission System.

The design life of the Abbey & Baker infrastructure (pipeline, umbilical and wellheads) will be 20 years, although the economic field life is expected to be approximately 11 to 16 years, depending on production performance.

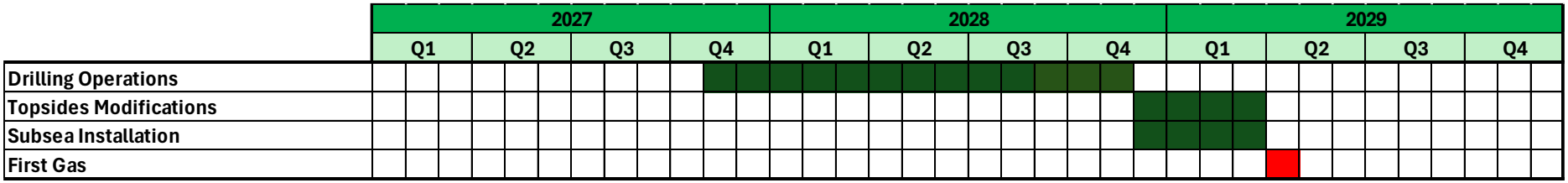
Figure 3.2: Proposed Abbey & Baker Field Development



3.2 Project Schedule

The Abbey & Baker project schedule targets drilling of the Baker well in Q4 2027, completion of the existing Abbey appraisal well as a producer in Q1 2028, drilling of the second and third Abbey development wells in Q2 2028 and Q3 2028 respectively, and installing the subsea infrastructure between Q4 2028 and Q1 2029. First gas is targeted for Q2 2029 (Figure 3.3).

Figure 3.3: Abbey & Baker Field Development Project Schedule



3.3 Drilling Operations

3.3.1 Well, Completion and Drilling Strategy

The Abbey and Baker wells will follow a typical SNS development well configuration with a 30 inch conductor, 13-3/8 inch surface casing, 9-5/8 inch casing, 7 inch drilling liner and completed with a 4-1/2 inch liner cemented across the main reservoir section.

The two top-hole sections of the wells (down to 13-3/8 inch surface casing setting depth) will be drilled and the high-pressure wellhead housings installed.

Abbey Well Design

The Abbey wells generally follow the same design and will be drilled to a depth of around 10,500 – 11,000 feet (3,200 – 3,300 m) true vertical depth subsea (TVDss), with horizontal sections of more than 1,200 m (4,000 feet) (Table 3.1). The precise reservoir penetrations of the wells will be refined during detailed design.

Table 3.1: Abbey Well Design

Well Name	MDBRT (m)	TVDBRT (m)	Horizontal Section (m)	Max. DLS (deg/30m)
A1	5,312	3,260.5	1,476	2.81
A3	5232.9	-3268.7	1,277	2.9

In order to maximise the production from the wells they will be hydraulically stimulated by placing resin coated proppant to hold fractures open. The proppant will be deployed from a dedicated stimulation vessel before the wells are flowed back to the drilling rig to establish a proppant free flow rate.

Baker Well Design

The Baker well will be drilled to a depth of around 11,000 feet (3,353 m) TVDss, with the reservoir sections being approximately 169 m (554 feet) (Table 3.2). The precise reservoir penetrations of the wells will be refined during detailed design.

Table 3.2: Baker Well Design

Well Name	MDBRT (m)	TVDBRT (m)	Max. DLS (deg/30m)
Baker	3,356	3,268	2.51

It has been identified that the Baker well shall require sand control within the lower completion to limit solids production during the life of the well. As a result, it has been determined that gravel pack will be the optimal lower completion design for the life of the Baker well.

3.3.2 Drilling Rig, Logistics and Support

A drilling rig has yet to be contracted for the Abbey & Baker Development , however, it is expected that the two Abbey wells and the Baker well will be drilled from a heavy duty jack-up drilling rig, similar to the Abbey A2 development well.

The base case assumes two rig moves: initially to the Baker location, followed by relocation to the Abbey location, from which all wells can be drilled from a single jack-up position.

Firstly, to drill the Baker development well, undertake clean-up operations, and then hook-up and commission the well for production (phase 1); secondly to remove the plug from the previously drilled Abbey A2 development well and install the xmas tree in preparation for hook-up and commissioning

operations (phase 2); and finally to drill the second and third Abbey development wells, undertake clean-up operations, and then hook-up and commission the wells for production (phase 3). For the purpose of a worst case assessment of emissions; it has been assumed that the rig will be on location for 364 days including contingency for delays.

For the purposes of the impact assessment, it is assumed that the rig will be three legged and jacked up on three spud cans. As a worst case scenario, it has been assumed that four anchors with chains will be required to move the rig on location at Abbey. This is due to the presence of the infrastructure at the Abbey A2 well. These anchors will be removed from the seabed once the rig is in position. Each anchor will weigh up to 7.5 tonnes, with outer dimensions measuring approximately 3.65 m (W) x 4.2 m (L), equating to a seabed footprint of ca. 15.33 square metres (m^2). The estimated length of each mooring chain will be approximately 525 m in length with approximately half of this length laid on the seabed. The precise anchor mooring spread for the Mobile Offshore Drilling Unit (MODU) will be undertaken prior to bringing the rig onto location and will take into account the water depth, currents, tides, prevailing wind conditions and any seabed features at the drilling locations. Two anchor handling vessels (AHV) will be required to place the anchors and with all anchors run the lines shall be tensioned to stalling power and the rig winched on to final location. Once in position, the rig will then be jacked up and the anchors will be recovered by the AHVs.

It is unlikely that rig stabilisation will be required due to the presence of chalk within 1 m of the seabed surface. Rig stabilisation was not required during the drilling of the Abbey A2 appraisal well, due to the weight of the heavy duty rig and there was no expected scour risk. No anchors will be required at the Baker well.

When on location at both Abbey and Baker, a 500 m radius safety zone will be in place around the drilling rig for the duration of the proposed operations and an Emergency Rescue and Recovery vessel (ERRV) / Standby Vessel will be stationed in the vicinity of the rig to assist in the event of an emergency. In addition, the rig will be supported by a single supply vessel operating out of a supply base in Aberdeen, which is likely to visit the rig twice a week during the proposed operations. A stimulation vessel will also be required for the hydraulic fracture (frac) operations on Abbey A1 and A3 detailed in Section 3.3.3.

Rig crews will be transferred to and from the drilling rig by helicopter. It is predicted that up to four scheduled flights will be made to the rig per week from Norwich for the duration of the proposed operations.

A summary of the vessel and helicopter requirements for the proposed operations, along with typical fuel consumption rates are provided in Table 3.3.

Table 3.3: Worst Case Vessel and Helicopter Overview for Abbey & Baker Drilling Campaign

Vessel	Function	Duration in Field (days) [1]	Typical Fuel Consumption	Total Fuel Consumption (tonnes)	Emissions (tonnes CO_2e)
MODU	Drill well	364	14 tonnes per day	5,096.00	16,538.07
AHVs	1 AHV is required to place and remove anchors at Abbey	6	14 tonnes per day	84.00	272.61
Tugs	2 Tugs are required to move the rig into position	6	8 tonnes per day per vessel	96.00	311.55
ERRV / Standby Vessel [2]	Assist in the event of an emergency	364	2 tonnes per day	728.00	2,362.58
Supply vessel [2]	Logistic support and transportation of goods, tools, equipment	104	6 tonnes per day	624.00	2,025.07
Stimulation Vessel [2]	Fracking	18	28 tonnes per day	504.00	1,635.63
Helicopter	Transfer crew to and from drilling rig	4 return flights per week [3]	0.813 tonnes per return flight	169.10	546.77
Total Estimated Fuel / Emissions for Drilling Operations				**7,301.10**	**23,692.28**

[1] Includes an allowance for vessel mobilisation, transit and demobilisation, where relevant.
[2] Any vessels used will be Dynamically Positioned (DP)
[3] Assumes 52 weeks in 364 days, 4 return flights per week = 208 return flights.

3.3.3 Well Design

The proposed well profile for the Baker production well is detailed in Table 3.4 and illustrated in the well schematic provided in Figure 3.4. The proposed well profile for the Abbey production wells are detailed in Table 3.5 and Table 3.6 and illustrated in the well schematics provided in Figure 3.5 and Figure 3.6.

A similar process will be followed for all well sections in the two Abbey and the Baker production wells down to the 12.25-inch section. Following the drilling of these upper sections, the two Abbey wells will follow a similar procedure, while the Baker well will follow a different well design. A 36 inch diameter top-hole section will be drilled using seawater and sweeps, then the top 10 to 15m shall proceed to be opened up to 42 inches to accommodate a 36-inch extension joint on the Low Pressure Wellhead Housing and the well re-displaced to spud mud. A 6 joint conductor with a 30 x 20 inch shoe shall be run on 30-inch environmental riser and cemented to seabed using a stab in shoe. A 17½ inch section will then be drilled through the conductor and a 13⅜ inch diameter steel casing installed and cemented into place. The 13⅜-inch surface casing and High Pressure Wellhead Housing shall be run on the 18-inch high pressure riser and cemented in place with a dual surface release cement plug. A 12¼ inch section will then be drilled and a 9⅝ inch- diameter steel casing installed and cemented into place. As a worst case scenario, it is assumed there may be a requirement for a well re-spud, for example, if hole collapse or boulder interference results in a stuck pipe in the top hole 36-inch section or 17½ inch section.

Baker Lower Sections

The 9½ x 8½ inch wellbore section will be drilled and a 7 x 7 ⅝ inch liner will be installed. Finally, the 6 inch wellbore section will be drilled through the reservoir. Well placement is not considered to be a concern for the Baker well and it is not identified as a candidate to require any advanced logging while drilling (LWD) tools. Once at total depth (TD), an appropriate sand control lower completion shall be run. Based on the results of a sanding study the base case lower completion shall be gravel pack.

Abbey Lower Sections

The 9½ x 8½ inch wellbore section will be drilled and a 7 x 7 ⅝ inch liner will be installed. Finally, the 6 inch wellbore section will be drilled through the reservoir and hydraulic fracture operations followed by completion will be undertaken in the open hole.

Table 3.4: Baker Well Profile (Worst Case)

Hole Diameter (inches)	Casing Diameter (inches)	Casing Type	MD Depth (m)
36	30	Conductor	160
36 (Re-spud)	30	Conductor	160
17½	13⅜	Surface Casing	840
17½ (Re-spud)	13⅜	Surface Casing	840
12¼	9⅝	Production Casing	2,441
9½ x 8½	7	Production Liner	3,187
6	4½	Gravel Pack Lower Completion	3,356

Table 3.5: Abbey A1 Well Profile (Worst Case)

Hole Diameter (inches)	Casing Diameter (inches)	Casing Type	MD Depth (m)
36	30	Conductor	160
36 (Re-spud)	30	Conductor	160
17½	13⅜	Surface Casing	931
17½ (Re-spud)	13⅜	Surface Casing	931
12¼	9⅝	Production Casing	2,854
9½ x 8½	7	Production Liner	3,812
6	4½	Packer Sleeve Completion	5,312

Table 3.6: Abbey A3 Well Profile (Worst Case)

Hole Diameter (inches)	Casing Diameter (inches)	Casing Type	MD Depth (m)
36	30	Conductor	160
36 (Re-spud)	30	Conductor	160
17½	13⅜	Surface Casing	923
17½ (Re-spud)	13⅜	Surface Casing	923
12¼	9⅝	Production Casing	3,017
9½ x 8½	7	Production Liner	3,658
6	4½	Packer Sleeve Completion	5232.9

Figure 3.4: Baker Well Schematic

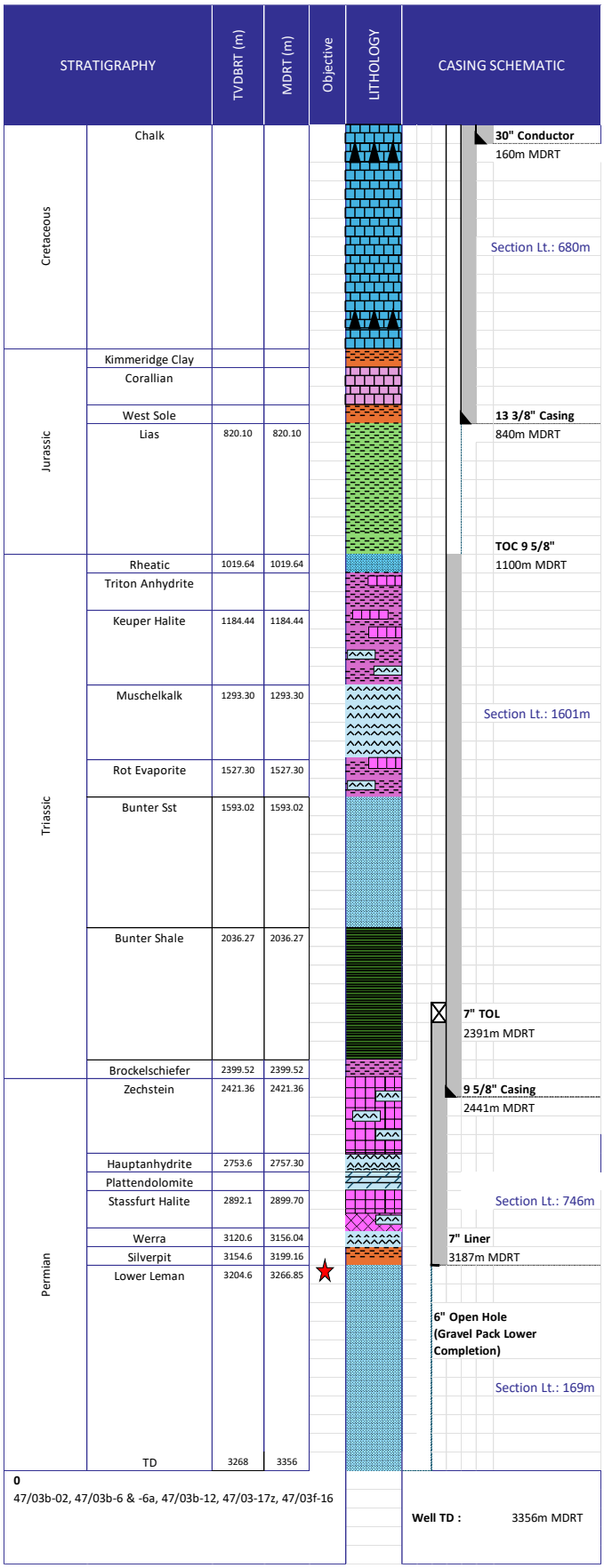


Figure 3.5: Abbey A1 Well Schematic

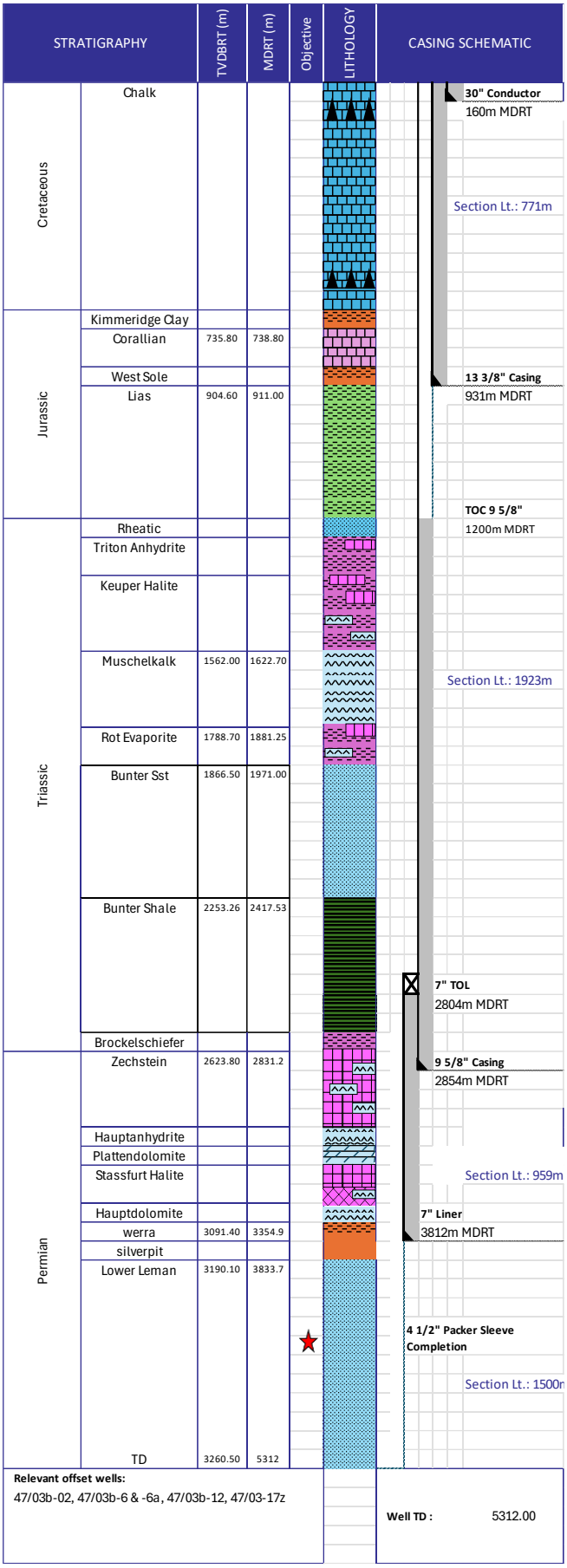
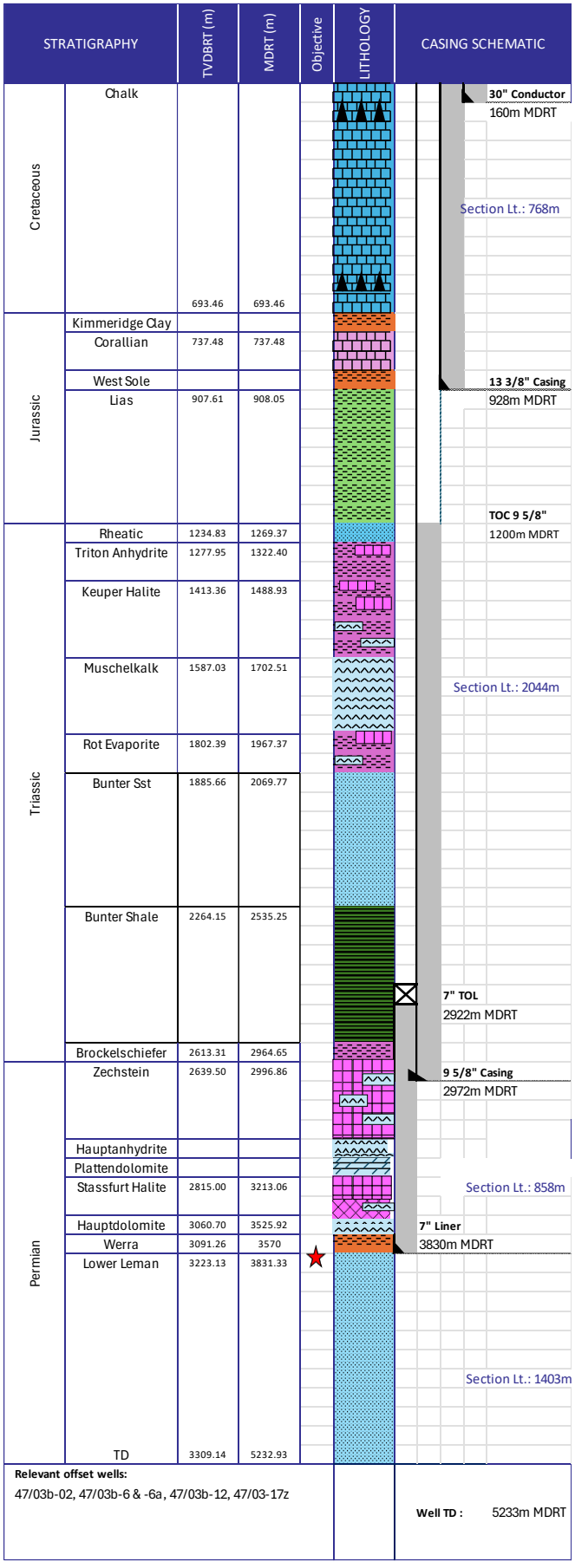


Figure 3.6: Abbey A3 Well Schematic



Lower Completion Design

Baker Development Well

It has been identified that the Baker well shall require sand control within the lower completion to limit solids production during the life of the well.

A sanding study has been completed utilising the acquired sidewall core plugs from the 47/3f-16 exploration well. The results of the sanding study have determined gravel pack as the optimal lower completion design for the life of the Baker well.

The completion tubing is expected to be 4 ½ x 5 ½ inch with a chemical injection facility, and a downhole safety valve. The completion material will be selected based on review of well chemistry from the as drilled Baker 47/3f-16 well results. A downhole pressure gauge and temperature sensor will be installed.

Abbey A1 and A3 Wells

It is proposed that the Abbey reservoir will undergo hydraulic stimulation across five to nine zones to achieve the desired production levels. Hydraulic stimulation, also referred to as hydraulic fracturing or "fracking," involves the injection of fluid and proppant at high pressure into low-permeability rock formations to create fractures and enhance permeability. In the case of Abbey, this process is expected to improve gas recovery.

A concept selection process was conducted to evaluate suitable completion and stimulation technologies. The first appraisal well, A02, was successfully drilled, completed, and stimulated, thereby validating the proposed design.

For subsequent wells, the recommended completion strategy is the same multistage fracturing sleeve completion installed in a 6-inch open hole. This approach provides greater confidence in fracture placement and proppant distribution.

A key advantage of this design is that hydraulic fracturing can be performed using a work string, thereby eliminating high-pressure exposure to the upper completion and subsea tree. Additionally, in the event of a proppant screen-out, flow can be rapidly reversed at higher rates, enabling effective well clean-up without the need for a time-consuming coiled tubing operation, while also reducing well test clean-up times.

Upper Completion Design

The upper completion will incorporate a tapered tubing design, consisting of 5½-inch tubing from the tubing hanger to the downhole safety valve, reducing to 4½-inch tubing below to meet the expected production rate requirements over the life of the well. The final tubing weight and grade will be confirmed following detailed tubing stress analysis.

The completion string will be landed in a 13⅝-inch × 5½-inch tubing hanger, designed to provide annulus access and accommodate multiple control line penetrations. These will support the Tubing Retrievable Surface-Controlled Subsurface Safety Valve (TRSCSSV), Downhole Chemical Injection (DHCI), and Downhole Pressure and Temperature (DHPT) monitoring systems.

The TRSCSSV will be installed no less than 100 m below the wellhead, within the 9⅝-inch casing, where it will function as a fail-safe barrier to prevent the uncontrolled release of reservoir fluids.

A DHCI mandrel will be included to enable the injection of chemical inhibitors or water via a ⅜-inch injection line, providing contingency capability for scale inhibition and salt precipitation management. Although no scale or salt precipitation issues are currently anticipated for the Abbey or Baker wells, this functionality is included as a precaution.

Real-time reservoir monitoring will be achieved through the installation of a permanent downhole pressure and temperature gauge located above the production packer. The DHPT system will transmit data to surface via a ¼-inch tubing-encased conductor (TEC).

The completion will isolate the tubing–casing annulus within the 7-inch casing using a production packer, which will form part of the primary well integrity envelope.

3.3.4 Mud System, Cuttings Disposal and Chemical Use

During the proposed drilling operations, a variety of chemicals will be used to facilitate the drilling processes and the safe completion of the wells including drilling fluid (or mud) chemicals, cementing chemicals, well clean-up and completion and hydraulic fracture chemicals. In addition, a number of chemicals will be used on the drilling rig for maintenance, such as detergents to wash the rig and lubricants for certain equipment and machinery. The Blowout Preventor (BOP) will also require chemicals for control and operation in the form of hydraulic fluids.

The use and discharge of the chemicals in offshore waters is regulated through The Offshore Chemicals Regulations (2002) (as amended). Prior to drilling the Abbey and Baker wells, Petrogas will therefore seek consent from the OPRED for the use and discharge of chemicals during the proposed drilling operations. A Drilling Operations Master Application Template (MAT) and associated Chemical Permit Subsidiary Application Template (SAT) will be submitted via the Portal Environmental Tracking System (PETS) on the UK Energy Portal. All chemicals proposed to be used will be selected based on their technical specifications and environmental performance. Chemicals with substitution warnings will be avoided where technically possible.

Drilling Mud and Cuttings

Drilling mud serves a number of functions including maintaining hydrostatic pressure within the wellbore, circulating rock fragments (termed 'cuttings') back to the drilling rig, preservation of the wellbore to facilitate casing / completion installation and cooling and lubrication of the drill bit.

For the proposed Abbey and Baker wells, it is currently assumed that seawater and sweeps and water based mud (WBM) will be used to drill the two top hole sections (36 and 17½ inch), with low toxicity oil based mud (LTOBM) used to drill the remainder of the well sections (12¼, 8½ x 91/2 and 6 inch sections) (refer to Table 3.7, Table 3.8, and Table 3.9).

The plan for the top hole section (36 inch) is to drill the section with seawater and sweeps, displacing to spud mud at the total depth of the section, without a marine riser connecting the wellbore to the MODU. All drill cuttings, fluids and chemicals from the 36 inch section will therefore be discharged from the wellbore at the seabed. The top 10 to 15m shall then proceed to be opened up to 42 inches to accommodate a 36-inch extension joint on the Low Pressure Wellhead Housing and the well re-displaced to spud mud. A 6 joint conductor with a 30 x 20 inch shoe shall be run on 30-inch environmental riser and cemented to seabed using a stab in shoe. All drill cuttings from the subsequent well section (17.5-inch and the contingent re-spud section) will be circulated back to the MODU, processed on-board and discharged at sea at approximately 2 m below the sea surface.

The 17.5-inch surface hole shall be drilled vertically using a motor assembly and TCI bit to the top of the Lias formation. Initially the section shall be drilled with seawater and sweeps. Then displaced to a KCl inhibited system 50m prior to entering the Kimmeridge Claystone formation, to provide adequate inhibition over the reactive clay formation. The 13⅜-inch surface casing and High Pressure Wellhead Housing shall be run on the 18-inch high pressure riser and cemented in place with a dual surface release cement plug.

Once the 36 and 17.5 inch sections have been drilled the mud pits will be flushed clean with fresh seawater, with residual WBM chemical traces discharged from the MODU. The lower sections of the well (including the 12.25, 8.5 x 9.5 and 6 inch well sections) will be drilled with LTOBM. Due to concerns about contamination, discharge of untreated drill cuttings contaminated with LTOBM to sea is prohibited.

A typical LTOBM contains base oil, calcium chloride brine, an emulsifying surfactant, lime and organophilic clay. Cuttings contaminated with LTOBM will be returned to the drilling rig, separated

from the LTOBM and then contained in enclosed skips until they can be skipped and shipped to shore for onshore processing and disposal at a licenced treatment and landfill site. The recovered LTOBM will be recycled downhole by the mud pump in a closed loop system, ensuring that the mud is continuously recycled during the drilling programme Table 3.8 and Table 3.9 detail the proposed drilling mud requirements for the Abbey and Baker wells, the estimated quantity of cuttings which will be generated and the proposed disposal route.

Table 3.7: Estimated Quantity of Cuttings Generated from Drilling the Baker Development Well (Worst Case)

Diameter of well section (inches)	Mud Type	Length of section (metres)	Volume of section (cubic metres)	Estimated weight of cuttings (kg) Note 1
36 Note 2	WBM	72	50.13	130,331.65
17.5	WBM	680	105.52	274,356.76
12.25	LTOBM	1,601	121.74	316,514.91
8.5	LTOBM	750	34.30	89,174.18
6	LTOBM	300	5.47	14,228.35
Worst-Case Cuttings from a re-spud				
36	WBM	72	50.13	130,331.65
17.5	LTOBM	680	105.52	274,356.76
Maximum Anticipated Total Cuttings:				***1,229,294.26***
Return to shore (LTOBM cuttings):				***419,917.44***
Total discharged to sea at surface (WBM cuttings):				***548,713.52***
Total discharged at seabed (WBM cuttings):				***260,663.30***

Note 1 Assuming a rock density of 2.6 tonnes per m^3

Note 2 Incudes the top 12 m section that will be opened up to 42 inches

Table 3.8: Estimated Quantity of Cuttings Generated from Drilling the Abbey A1 Well (Worst Case)

Diameter of well section (inches)	Mud Type	Length of section (metres)	Volume of section (cubic metres)	Estimated weight of cuttings (kg)[Note 1]
36 [Note 2]	WBM	72	50.13	130,331.65
17.5	WBM	771	119.64	311,072.16
12.25	LTOBM	1,923	146.22	380,173.75
8.5	LTOBM	959	43.86	114,024.05
6	LTOBM	1,500	27.36	71,141.73
Worst-Case Cuttings from a re-spud				
36	WBM	82	50.13	130,331.65
17.5	WBM	771	119.64	311,072.16
Maximum Anticipated Total Cuttings:				***1,448,147.15***
Return to shore (LTOBM cuttings):				***565,339.53***
Total discharged to sea at surface (WBM cuttings):				***622,144.32***
Total discharged at seabed (WBM cuttings):				***260,663.30***

[Note 1] Assuming a rock density of 2.6 tonnes per m^3

[Note 2] Incudes the top 12 m section that will be opened up to 42 inches

Table 3.9: Estimated Quantity of Cuttings Generated from Drilling the Abbey A3 Well (Worst Case)

Diameter of well section (inches)	Mud Type	Length of section (metres)	Volume of section (cubic metres)	Estimated weight of cuttings (kg) [Note 1]
36 [Note 2]	WBM	72	50.13	130,331.65
17.5	WBM	763	118.40	307,844.43
12.25	LTOBM	1,750	133.07	345,971.95
8.5	LTOBM	970	44.36	115,331.94
6	LTOBM	1,500	27.36	71,141.73
Worst-Case Cuttings from a re-spud				
36	WBM	72	50.13	130,331.65
17.5	LTOBM	763	118.40	307,844.43
Maximum Anticipated Total Cuttings:				***1,408,797.78***
Return to shore (LTOBM cuttings):				***532,445.62***
Total discharged to sea at surface (WBM cuttings):				***615,688.86***
Total discharged at seabed (WBM cuttings):				***260,663.30***

[Note 1] Assuming a rock density of 2.6 tonnes per m^3

[Note 2] Incudes the top 12 m section that will be opened up to 42 inches

When drilling through the pay zone, in the event that condensate is encountered, it is anticipated that the drill cuttings and muds may contain residues of reservoir hydrocarbons; this would be bound in the

rock removed from the well by the drilling fluid (LTOBM). However, as the LTOBM is being returned to shore, no reservoir hydrocarbons on cuttings are planned to be discharged to the marine environment.

Cement

Following completion of each well section, the steel casings will be cemented in place to form a seal between the casing and formation. The cement also acts as a pressure barrier between the casing and formation.

Most cement will remain in the annulus between the casing and the rock formation, but some will be discharged at the seabed when cementing the 30 inch conductor as excess cement is pumped which provides visual confirmation that the cement job is complete. A remote operated vehicle (ROV) will be used to monitor cement returns during this phase to help ensure the volume of cement discharged to the seabed is kept at a minimum. Cement may also reach the seabed when cementing the 13 3/8-inch casing, but there are relatively small cement volumes in this section and accurately calculated estimates for excess cement will be made.

In addition, some cement and chemicals may be discharged as the cementing unit is cleaned between sections. The quantity discharged will be minimised by constant monitoring of the cementing operation and mixing of the cement as required. Typically, only 10% of the total cement slurry will be discharged to the sea surface due to the clean-out of mixing pits following cementing operations, with up to 20% discharge for the cement spacer chemicals. Petrogas are still working on finalising the chemical list and discharge amounts for development operations.

In addition, an aborted discharge of cement may be required in the event of an operational problem, such as a problem with the mix or if an issue occurs which prevents pumping the cement into the well. If the cement cannot be pumped downhole it must be disposed of rapidly to avoid it flash setting and, consequently, causing damage to the cement unit. The consequence of not aborting a cement job could result in major re-construction work being required on existing MODU systems and facilities.

The likelihood of an aborted discharge event being required is very low. The only other alternative to discharging the cement batch would be to skip and ship the slurry to shore, as re-using the slurry, injecting it down hole or retarding to prevent setting are not considered to be feasible options for these operations. However, skip and ship is not the preferred option as the slurry is likely to set and require the use of a jack hammer to get the cement out. In addition, transport and handling operations associated with this option would result in additional environmental impacts due to increased vessel movements resulting in air pollutant emissions from vessel engines and the potential for onshore impacts related to disposal options. Shipping the cement batch to shore would also involve increased safety risks.

Hydraulic Fracture Chemicals

There will be returns of water from the well from frac operations on the Abbey A1 and A3 wells (the Baker well does not need hydraulic fracturing).

The total estimated maximum volume of returns will be 2,500 m^3 per well. Using this worst-case value and the maximum oil in water concentration of the discharge being 30 milligrams per litre (mg/l), a total of 75 kilograms (kg) of hydrocarbons could be discharged per well. This discharge volume will also be metered prior to discharge.

Significant amounts of hydrocarbons are not expected to be found in the treated produced water. An Oil Analyser will be used to analyse oil in any fluids prior to discharge. Any oil concentration higher than 30 mg/l will be re-circulated and filtered until any oil in water is below this limit.

Fracturing treatments and diagnostic injections will be pumped from a stimulation vessel into the Abbey A1 and A3 wells. The stimulation vessel is a self-contained fracturing equipment fleet containing all water, additives, proppant, equipment and people to perform the fracturing operations. The vessel typically returns to port to reload water, additives and proppant every one to three fracturing stages. The stimulation vessel will hook up to the MODU within the MODU 500m exclusion zone.

The target reservoir sections of each well will be in the region of 5,000 feet and assumes up to 6 Longitudinal Frac treatments per well through frac sleeves with the 3 Crestal & 3 Flank/Toe stages. The

spacing between the fracture initiation points (perforated intervals) still requires to be defined but is expected to be close to 1,000 feet. Further modelling is being conducted at this stage.

3.3.5 Well Testing and Clean-Up

Baker Well

After well construction, the well will be prepared to production screen test (PST) spec mud for deployment of the lower open hole gravel pack completion. The well will be circulated to a brine system, and a gravel pack operation will be performed across the reservoir. On completion, a wellbore cleanout scraper assembly will be run to remove deposited debris. A low concentration surfactant cleanup pill will be pumped, followed by displacement with pre filtered brine to provide a clean environment for upper completion installation and well cleanup, reduce interface fluids, and maintain overbalance. The Blowout Preventor (BOP) cavities will then be jetted to remove debris.

Following completion of the jetting operation, the well will be artificially lifted using nitrogen to reduce the hydrostatic of the completion brine and initiate well flow. A well clean-up operation will then be undertaken to recover and remove residual drilling and completion fluids from the wellbore. These fluids will be returned to the surface and processed through filtration and treatment systems to reduce the oil content to 30 mg/l or less prior to batch discharge. Representative samples will be collected and analysed before discharge to confirm compliance with applicable discharge criteria.

Up to 200 m^3 of treated brine may be discharged during the clean-up operation, corresponding to an estimated hydrocarbon (condensate) content of approximately 6 kg.

During this phase, hydrocarbons and associated gases produced from the well will be routed through a temporary well test package, resulting in a controlled and temporary period of gas flaring.

Abbey A2 Well

The Subsea Tree shall be run, the well re-entered and a final / extensive well clean up completed via a rig based test package, with estimated volumes of fluids being approximately 2,500 m^3, which once treated / reduced to at least at 30 mg/l, would produce up to 75 kg of hydrocarbons to be discharged to sea. The well shall then be suspended ready to go on to production.

Abbey A1 and A3 Wells

Prior to production, the Abbey A1 and A3 wells will be cleaned up to remove any drilling fluids waste and debris remaining in the well to prevent damage to the pipeline. The wellbore will be cleaned-up with the in-situ drilling mud, then changed out to sodium chloride brine, then a further clean-up above the lower completion completed using the in-situ brine, before finally running the upper completion.

Once hydraulically stimulating operations are complete and the proppant is in place, a well clean-up process will be undertaken to ensure that any loose proppant is removed from the well and returned to the surface to be shipped back to shore. This clean up phase will result in a quantity of gas flaring in excess of a conventional well test. There are overriding technical issues that make it critical for all loose proppant to be removed before the wells begin production.

Petrogas will likely need to undertake an extended well tests at Abbey for the successful clean-up of all frac intervals and the maximum recovery of frac fluids which could be significant volume. Each frac interval must be thoroughly cleaned to remove residual proppant, debris, and completion fluids. A longer well test period will provide sufficient time to ensure each interval is effectively cleaned until BSW (Basic Sediment and Water) is within acceptable specifications. This is crucial to prevent blockages that could reduce the well's overall efficiency.

During the well test, all LTOBM cuttings will be skipped and shipped to shore for treatment. Interface fluids may contain residual LTOBM, with a maximum of 91 m^3 per well expected. After filtration to 30 mg/l, this corresponds to approximately 2.73 kg of residual hydrocarbons discharged per well at Abbey.

After successful deployment of the lower completion, a wellbore cleanout scraper assembly will be run to remove deposited debris. A low concentration surfactant cleanup pill will then be pumped, followed by displacement with pre filtered Sodium Chloride brine to ensure a clean environment for testing,

minimise interface fluids, and maintain overbalance. A jetting assembly will subsequently be run to the BOP to remove debris from its cavities.

Cleanup and completion brine contaminated with hydrocarbons will be processed through the slops treatment system to achieve an oil concentration of 30 mg/l or less before batch discharge. Samples will be taken prior to each discharge to confirm compliance. As mentioned in Section 3.3.4, up to 2,500 m^3 of treated brine may be discharged per well following frac operations, equating to approximately 75 kg of condensate per well.

Capturing the gas and processing it via a Floating Liquified Natural Gas (FLNG) facility was considered, but this would be prohibitively expensive and complex and may require commissioning of a new vessel, which would have its own significant emission costs. Newer technologies designed to lower or eliminate emissions during well clean up were considered, but are not feasible for the purpose of well clean up, as they use equipment and instrumentation to take measurements downhole, rather than relying on flowing the well fluids to surface which is essential to the achievement of clean up objectives.

As these alternatives are not feasible, steps have been taken regarding the use of proppant and the subsequent clean up flaring process to minimise GHG emissions as far as possible. The hydraulically stimulating operation will be designed to optimise the amount of proppant used, reducing the quantity manufactured and transported along with associated emissions. This will also help keep the duration of each clean up phase as short as possible. The flaring will be thoroughly planned and monitored throughout so it can be stopped in real time rather than carry on to a fixed duration unnecessarily. Flaring equipment will be selected, and other measures developed to achieve optimal combustion efficiency, as this will not only reduce local air pollution, but it will also minimise the proportion of unburnt methane. The available technologies will be closely considered at the detailed design stage and Petrogas will look to select systems which reduce the quantity of CO_2e released per unit volume of gas burnt, as well as reduce the proportion of unburned gas. Give the significance of this issue and with an understanding that new technologies are emerging continuously, Petrogas will continue to monitor potential options for the potential reduction or elimination of flaring during the well clean up stage and this will be given due consideration during the detailed planning phase.

The completion design has been modified from that assumed at concept selection with an aim to reduce the time to complete the well and reduce the time needed for well clean up.

The likely sequence of events for clean-up will be as follows:

- Open each well and flow; initially the well will produce only calcium chloride brine, which will be discharged to sea via the drilling rig;
- The water/hydrocarbon interface fluids will be captured and tested:
  - If oil in water concentration is equal to or below 30 mg/l, then the fluids will be discharged overboard in accordance with the Oil Discharge Permit; or
  - If oil in water concentration is above 30 mg/l they will be filtered until they are below 30 mg/l for overboard discharge;
- Clean-up will be monitored to capture data on the amount of water and suspended solids in the produced fluids (called the basic sediment and water specification);
- The clean-up / well test of the Baker well is expected to take 2 days, the clean-up of the Abbey A2 well is expected to take 5 days, and the clean-up of the Abbey A1 and A3 wells is expected to take 7 days per well (14 days total), giving a total planned flaring of 21 days. During this time up to 9,950 tonnes of equivalent hydrocarbon may be flared, of which 9,680 tonnes are gas and 270 tonnes are condensate. This will produce emissions totalling 40,610.58 tonnes of CO_2e (see Appendix D for details of the calculations).

Following clean-up / well test, the wells will be closed in, ready for production through the platform.

3.4 Abbey and Baker Subsea Infrastructure

This section describes the installation of the Abbey & Baker Development subsea infrastructure, including:

- Wellheads and Xmas Trees;
- Production Manifold;
- Export Pipelines;
- Electric/Hydraulic Control Umbilicals;
- Production Control System;
- Tie-in arrangements.

There are no subsea process facilities at either Abbey or Baker, with production from the Abbey and Baker wells comingled into a common process header at the Abbey manifold for on pass to the York topsides via a subsea export pipeline. An existing riser has been allocated at the York platform for Abbey & Baker. No processing is undertaken on the York platform. Processing will be undertaken onshore at the Dimlington Gas Terminal facilities.

A flow assurance study has been performed to determine the overall operating philosophy for the fields and quantify the chemical injection requirements. Hydrate control and corrosion management will be facilitated by continuous injection of a methanol / corrosion inhibitor cocktail at the Xmas trees.

3.4.1 Wellheads and Xmas Trees

It is planned to complete each of the Abbey and Baker wells with a DrilQuip subsea wellhead and xmas tree with 6,500 pounds per square inch (psi) rating which will be installed by the MODU. The xmas tree is fitted with hydraulic actuated valves and it is possible to bleed the A-Annulus into production flowline. The tubing hanger is dressed with metal-to-metal annular seal and mounted with three annulus shuttle valves. It has penetrations for downhole safety valve (DHSV) line, 3/8 inch chemical injection line and downhole gasification (DHG) electrical line. The xmas tree is also fitted with pressure and temperature sensors.

The Abbey and Baker wellheads and Xmas trees will be enclosed within their own dedicated WHPS, which is fishing friendly, to ensure the tree and its connections are not damaged by dropped objects or impacts and snagging loads associated with fishing gear (Figure 3.7).

The worst case size of the WHPS will be approximately 7.88 m x 7.88 m (62.09 m^2), with a height of 7.423 m. It has a maximum angle of approximately 58° from the true horizontal plane for truncated pyramid shaped structure, to assist trawl equipment and trawl wire deflection. The sides slope so at the highest point it measures 4.192 x 4.192 m. As a worst case, the installation of three wellheads and xmas trees with a WHPS will result in a seabed disturbance of 186.27 m^2 (0.00019 km^2), assuming each WHPS measures 7.88 m x 7.88 m.

The WHPS is mounted on to the 36-inch Landing Joint, which is part of the 30-inch Conductor String. Accidental or snag loading imparted on the WHPS is transferred directly though the Conductor String into the formation. The WHPS will be gravity based; however, at the four corners of the WHPS are Drop-Down (extendable) legs for the purpose of snag prevention. An ROV is employed to remove two retaining pins per leg, once removed the legs weight allows penetration of the seabed.

Following the installation of the Xmas Tree and Tree Cap, a Debris Cap is run down and locked to the top of the WHPS. The Debris Cap provides dropped object protection for the Xmas Tree.

Figure 3.7: Abbey & Baker Wellhead Protection Structure

The Abbey wellheads will be tied back to the production manifold at Abbey with 6 inch flowlines and control jumpers.

The Baker wellhead will be tied back to the production manifold at Abbey via an 8 inch pipeline and subsequently will tie-in to the manifold via a tie-in spool.

3.4.2 Production Manifold

A subsea production manifold with be installed approximatly 70 – 80 m from the Abbey Xmas trees location.

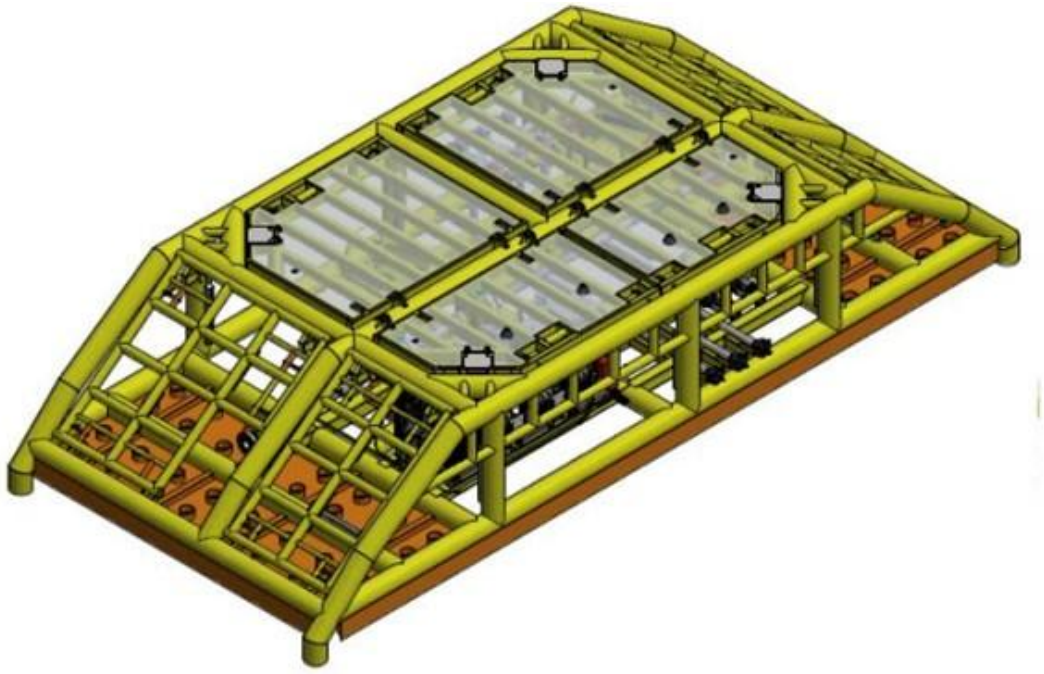
The Abbey subsea production manifold will enable the sequential or simultaneous tie-in of up to four wells.

The main features of the subsea production manifold are as follows:

- An outer fishing friendly, anti-snagging, gravity based protection structure (subject to detailed design);
- Dropped object protection incorporated into the manifold roof;
- Two off production headers (i.e. one off for Abbey and one off for Baker) each sized as equivalent to the respective pipeline diameters;
- All piping to be super duplex including the tie-in spools to the three off Abbey Xmas trees to accommodate the low temperature and corrosion requirements;
- Housing for the subsea distribution unit (SDU) and umbilical termination units (UTA) including space for one additional future UTA;
- Access and support for the individual umbilical jumpers used to connect the SDU mounted on the manifold to each of the 3 off Abbey Xmas trees;
- Double block and bleed ROV operated valves on the header branch connection to the Abbey header;
- Space to accommodate piping, valves, umbilical, UTA for potential future tie-ins;
- An 8 inch diameter cross over connection between to the two headers to allow Baker gas to flow to the Abbey York pipeline.

The production manifold foundation will be gravity based and a typical manifold struture is shown in Figure 3.8. The overall dimensions of the manifold are estimated to be approximately 21 m x 12 m (252 m^2).

Figure 3.8: Typical Production Manifold Structure

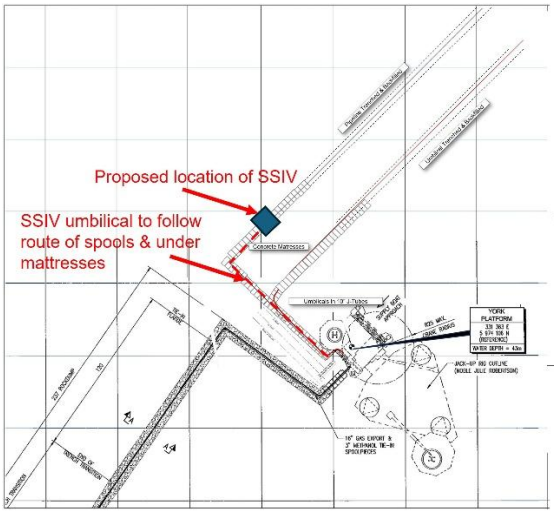


3.4.3 Subsea Isolation Valve (SSIV)

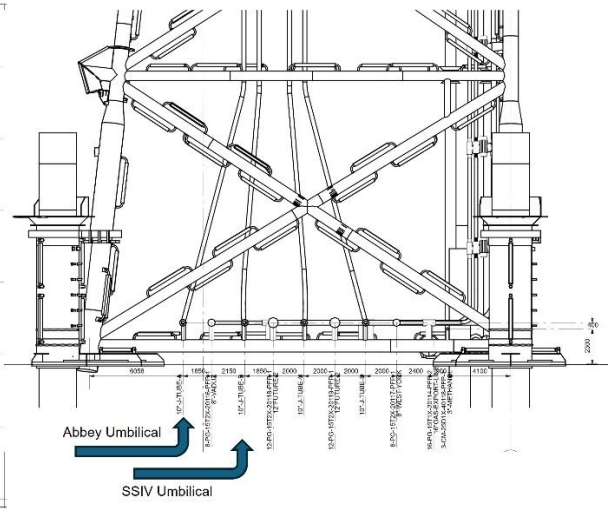
At the time of writing this ES, Petrogas is undecided as to whether a subsea isolation valve (SSIV) will be required for the Abbey & Baker Development. However, for the purposes of this ES, Petrogas has included the SSIV to provide a worst case assessment of the seabed disturbance and installed subsea infrastructure.

If installed, the SSIV will be located on the Abbey to York pipeline, just north east of the York platform (Figure 3.9). Of note, the SSIV umbilical specification is still be determined and confirmed.

Figure 3.9: The Abbey SSIV Location



York Platform Approach – Plan View



York Platform Looking North East– J-tubes

The overall dimensions of the SSIV are estimated to be approximately 18.8 m x 7.8 m (146.98 m^2).

3.4.4 Production Pipelines and Umbilicals

Pipeline Design

Abbey to York Pipeline

An 8 inch diameter gas export pipeline, 8 km in length, will connect the Abbey production manifold to the existing riser and process plant on the York Platform. The carbon steel pipeline will be routed directly to the York Platform in a SW direction, with no pipeline crossings required.

Preliminary flow assurance studies have been carried out resulting in the following conclusions that are key to the design of the production facilities:

- An 8-inch diameter production line is sufficient for the production rates expected;
- Hydrates will be managed by the continuous injection of methanol;
- There is no requirement to pig or sphere the line during production due to the low liquid hold up predicted throughout the life of the field;
- A temporary pig/launcher receiver will be required for commissioning;
- Corrosion inhibitor is required and will be dosed on a continuous basis (its included with the methanol mix);
- Although produced water is not predicted, spare hoses will be provided in the umbilical if additional chemical treatment is needed in the future.

Baker to Abbey Pipeline

An 8 inch Nominal Bore (NB) diameter gas export pipeline, approximately 4 km (3.818 km) in length, will connect the Baker Development well to the Abbey production manifold and onto the existing riser and process plant on the York Platform. The carbon steel pipeline will be routed directly to the Abbey manifold in a SE direction, with one pipeline crossing over the Cleeton export pipeline (PL447) required.

Preliminary flow assurance studies have been carried out resulting in the following conclusions that are key to the design of the production facilities:

An 8 inch diameter production line is sufficient for the production rates expected;

- Hydrates will be managed by the continuous injection of methanol;
- There is no requirement to pig or sphere the line during production due to the low liquid hold up predicted throughout the life of the field;
- A temporary pig/launcher receiver will be required for commissioning;
- Corrosion inhibitor is required and will be dosed on a continuous basis (its included with the methanol mix).

Umbilical Design

Two thermoplastic tube umbilicals will provide all power, control, communication, hydraulic power and chemical injection functions for the safe and efficient control of the Abbey & Baker subsea equipment.

The Abbey to York umbilical will be routed directly via an existing J-Tube on York Platform to the Abbey production centre. The main umbilical will continue on to the Abbey production centre with no pipeline crossings.

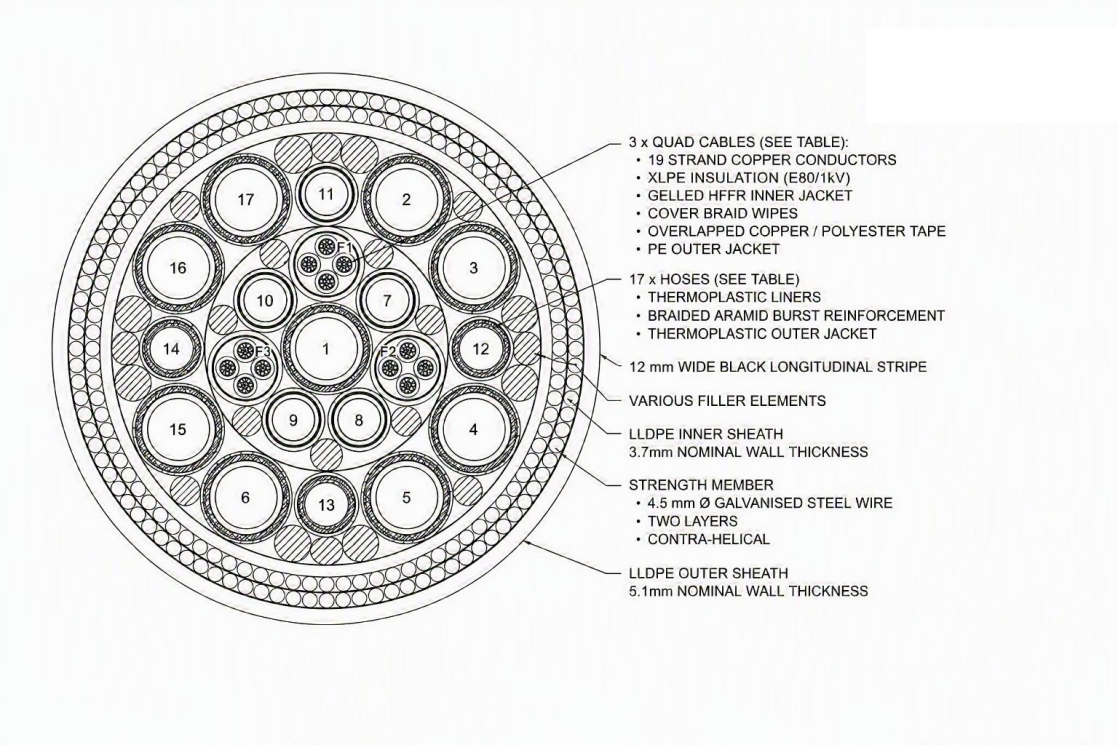
The Baker to Abbey umbilical will be routed from the Abbey production centre to the Baker development well, crossing one pipeline (PL447) along the route. The functions of the umbilicals are summarised in Table 3.10.

Table 3.10: The Abbey & Baker Control Umbilical Functions

Purpose	Number of Hoses / Tubes	Fluid	Note
MeOH / Corrosion Inhibitor	6	MeOH / Corrosion Inhibitor	¾-inch tubes, one for each well plus a spare
Chemical Injection to Trees	5	Scale Inhibitor or other future chemical.	½ inch Direct Chemical Injection to Trees in the event of scale or anhydride is presence
HP Hydraulic Supply	3	Water Based Control Fluid	½ inch HP Control Circuit, includes a spare
LP Hydraulic Supply	3	Water Based Control Fluid	¾ inch LP Control Circuit includes a spare
Power / Communications	3	N/A	16 mm^2 quad cores, includes a spare

The umbilicals will be manufactured from thermoplastic hoses with cables for power and communication, the cross section is illustrated in Figure 3.10. The umbilicals will be pressure tested on completion of manufacture and will be installed pre-filled, with the control lines filled with the appropriate hydraulic fluid and the chemical injection lines will be filled with a suitable spacer chemical. Spare hoses will be provided in the umbilical if additional chemical treatment is needed in the future.

Figure 3.10: The Abbey & Baker Umbilical Cross Section



Pipeline and Umbilical Installation Operations

It is intended that the pipelines and umbilicals will be installed using the reel-lay or conventional 'S' lay methods onto the seabed before trenching by plough and mechanical backfilling is completed. Seabed sediments along the proposed pipeline/umbilical route are mainly sandy and are considered suitable for all various trenching techniques.

The final trenching method will be selected by the subsea installation contractor considering the following:

- Not all subsea installation contractors have access to conventional plough equipment;
- The high bollard pull (>300Te) vessels required to pull a conventional plough are now in short supply in the North Sea and may attract a significant premium depending on market conditions;
- Note that a surface laid pipeline with blanket rock placement only (i.e. no trenching) would require significantly more rock than any of the trenched solutions.

However, for the purposes of this ES, trenching and backfilling via a plough has been assessed, as this represents the worst-case scenario for seabed disturbance and fuel consumption by vessels. If a jetted or mechanically cut trenching solution is selected, the items listed above will also apply; therefore, additional rock contingency has been included in the assessment to allow for this.

Abbey to York Pipeline and Umbilical

The initiation of the Abbey to York pipeline will require the installation of a temporary initiation anchor (either a conventional anchor or dead man anchor) and the use of an initiation wire, which will connect between the anchor and the end of the pipeline. The initiation wire for the pipeline is expected to be no longer than 500 m in length. Following the installation of the pipeline the anchor and wire will be recovered. The Abbey to York umbilical will be pulled up through the J-tube at the York platform and then subsequently laid moving away from the York platform; thus an initiation anchor and wire will not be required for umbilical installation.

The pipeline and umbilical will be installed separately. For both the pipeline and umbilical, it has been assumed that the entire length (8 km) of the pipeline and umbilical will be placed into two separate ploughed trenches in the seabed with approximately 50 m of separation and mechanically backfilled, with a seabed disturbance corridor of approximately 12 m for each trench. The pipeline and umbilical will be buried approximately between 1 m and 1.5 m below the seabed. Separate trenches are required, as placing both the pipeline and umbilical into the same trench leaves the umbilical vulnerable to damage due to the increased temperature from the pipeline adversely affecting the thermoplastic umbilical hoses and by the backfill plough during burial. As a worst case, it is therefore anticipated that, as a maximum, 187,200 m^2 (0.1872 km^2) of seabed would be directly impacted, assuming a pipeline and umbilical length of ca. 8 km each and two 12 m wide corridors.

In the first instance pipeline and umbilical route selection will endeavour to minimise the need for boulder removal & seabed disturbance by avoiding the boulders as far as possible. However, any medium to large boulders (0.5 m – 1 m) within the two 25 m corridors surrounding the 12 m seabed disturbance corridors will first be identified and removed from the separate pipeline and umbilical corridors with the use of a sled or, if the boulders are embedded into the seabed, by individually dragging them using a cable and sling. In the case that up to 50 boulders may need to be removed within the combined pipeline and umbilical corridors, the estimated total disturbance arising from this operation has been conservatively estimated to total to approximately 50 metres squared (m^2) (0.00005 km^2).

Baker to Abbey Pipeline and Umbilical

The initiation of the Baker to Abbey pipeline will use the same method as the Abbey to York pipeline. The Baker to Abbey umbilical will also be installed with the use of a temporary initiation anchor (either a conventional anchor or dead man anchor) and the use of an initiation wire, which will connect between the anchor and the end of the umbilical. The initiation wire for the pipeline is expected to be no longer than 500 m in length. Following the installation of the umbilical the anchor and wire will be recovered.

The Baker to Abbey pipeline and umbilical will also be installed separately. For both the pipeline and umbilical, it has been assumed that the entire length of the pipeline (3.818 km) and umbilical (4 km) will be placed into two separate ploughed trenches in the seabed with approximately 50 m of separation and mechanically backfilled, with a seabed disturbance corridor of approximately 12 m. There is a slight difference in length between the pipeline and umbilical due to their difference in materials; the pipeline will consist of a straight steel pipeline with tie-in spools at each end, and the

umbilical consists of a flexible cable cut to a pre-determined length. The umbilical will tie directly into the Abbey & Baker Development infrastructure. The pipeline and umbilical will be buried approximately between 1 m and 1.5 m below the seabed. Separate trenches are required, as placing both the pipeline and umbilical into the same trench leaves the umbilical vulnerable to damage by the backfill plough during burial. As a worst case, it is therefore anticipated that, as a maximum, 93,816 m^2 (0.0938 km^2) of seabed would be directly impacted, assuming a pipeline length of ca. 3.818 km and umbilical length of ca. 4 km and two 12 m wide corridors.

In the first instance pipeline and umbilical route selection will endeavour to minimise the need for boulder removal & seabed disturbance by avoiding the boulders as far as possible. However, any medium to large boulders (0.5 m – 1 m) within the two 25 m corridors surrounding the 12 m seabed disturbance corridors will first be identified and removed from the separate pipeline and umbilical corridors with the use of a sled or, if the boulders are embedded into the seabed, by individually dragging them using a cable and sling. In the case that up to 25 boulders may need to be removed within the combined pipeline and umbilical corridors, the estimated total disturbance arising from this operation has been estimated to total to approximately 25 m^2 (0.000025 km^2).

Pipeline Protection

Burial of the pipelines will assist in protection against upheaval buckling, where temperature changes cause the pipeline to move to relieve the expansion forces. The potential for upheaval buckling is directly related to the as-trenched shape of the pipeline where deviations in height away from a perfectly straight pipe are susceptible to upheaval buckling. The target pipeline burial depth should be sufficient to prevent upheaval buckling for the majority of deviations in height. However, for larger imperfections, the backfill cover height provided by the backfilled sediment may not, on its own, be sufficient to resist upheaval buckling and at these locations placement of rock may be required (spot rock dumping).

Rock is considered the most appropriate mitigation measure for upheaval buckling. A rock placement vessel would deposit rock on the seabed along the pipeline route corridors via a fall pipe, which will terminate few metres above the seabed (Figure 3.13). The position of the fall pipe in relation to the seabed would be controlled by ROV. Any rock required for upheaval buckling (UHB) mitigation will be sited within a ca. 6 m wide corridor centred above the pipeline. When rock is dumped over a pipeline the majority of the rock is retained in the central section of the berm and this is where the main volume of the rock is placed, hence a 3 m berm width has been used to calculate the coverage length . However, a small volume of the rock will spread out along the edges and therefore from a seabed disturbance viewpoint the berm width is wider; hence a 6 m width has been used for the purpose of calculating the seabed disturbance.

The requirement for rock to be deposited along the pipelines will be determined by reviewing as-trenched and as-backfilled survey data against the critical trench imperfection criteria defined during detailed design. As such, the exact locations and amounts cannot be given in this ES. However, it is estimated that, in the worst case scenario for both of the pipelines, 6,300 tonnes of rock split equally between the pipelines may need to be deposited in order to mitigate upheaval buckling; 3,150 tonnes for the Abbey to York pipeline and 3,150 tonnes for the Baker to Abbey pipeline. As a worst case, it is estimated that this rock will be laid along 4.2 km of the pipelines; 2.1 km along the Baker to Abbey pipeline, and 2.1 km along the Abbey to York pipeline. The estimated total disturbance arising from these rock deposits is 25,200 m^2 (0.0252 km^2); 12,600 m^2 (0.0126 km^2) along the Baker to Abbey pipeline, and 12,600 m^2 (0.0126 km^2) along the Abbey to York pipeline (see Table 3.11).

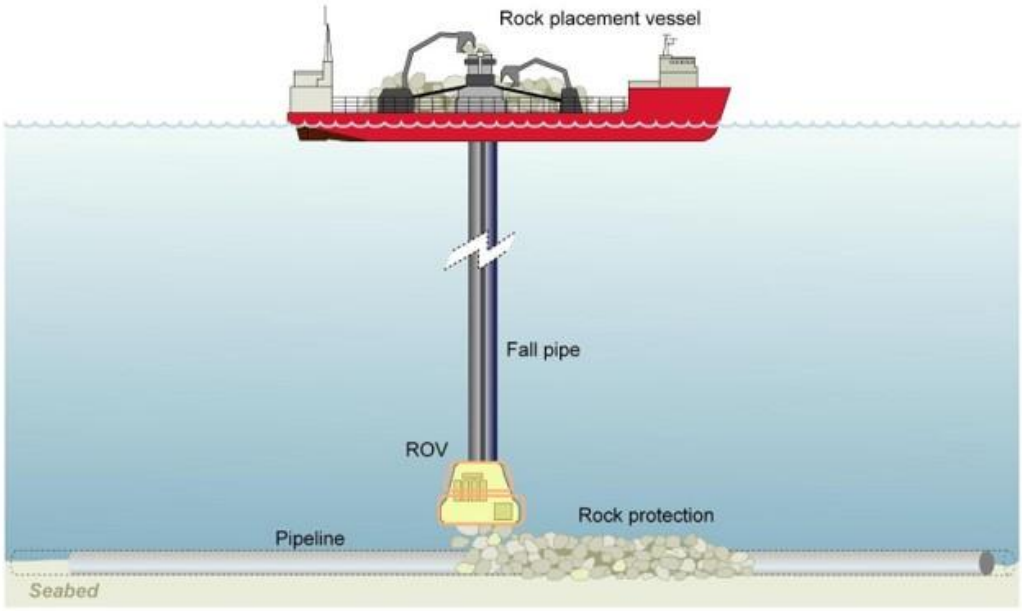
Additional rock will also need to be deposited where the pipelines and umbilicals exit the trenches at Baker, Abbey and York (50 m sections for the pipelines and 25 m sections for the umbilical). It is estimated that up to 2,000 tonnes of rock with a berm width of 6 m may need to be deposited over the lines for protection at these locations (See Table 3.11).

Pipeline Crossings

In addition, as shown in Figure 3.2, the proposed route of the Baker to Abbey pipeline and umbilical cross the existing 36-inch Cleeton export pipeline, which is surface laid. Crossing designs are not yet matured for this ES, but are likely to entail rock placement. The impact assessment presented in this ES is based on the worst case assumption of 4,000 tonnes of rock required for the crossings, and

potentially trench transitions. The rock berms placed for the crossings will be placed up to 250 m either side of the pipeline and umbilical with a berm width of 6 m; two separate crossings will be constructed, one for the pipeline and one for the umbilical. The disturbance area for these pipeline crossings will therefore total 6,000 m^2 (0.006 km^2).

Figure 3.11: Rock Placement Vessel



Rock Quantity Estimate

An estimate of the quantity of rock that may need to be deposited and the potential seabed disturbance for pipeline installation is provided in Table 3.11. It is expected that all rock deposited will remain in-situ in the environment.

Table 3.11: Abbey Rock Quantity Estimate for Pipeline and Umbilical Installation

Purpose of Rock Placement	Rock Quantity (tonnes)	Length of Disturbance	Width of Disturbance	Seabed Footprint
UHB Mitigation on Abbey to York Pipeline	3,150	2.1 km	6 m	12,600 m^2
UHB Mitigation on Baker to Abbey Pipeline	3,150	2.1 km	6 m	12,600 m^2
Trench Transitions (if required)	2,000	300 m	6 m	1,800 m^2
Baker to Abbey Pipeline and Umbilical / Cleeton Pipeline Crossings	4,000	1,000 m	6 m	6,000 m^2

3.4.5 Tie-in Arrangements

Table 3.12 summarises the tie-in arrangements for the Abbey development.

As the tie in spools will sit within statutory subsea 500 m exclusion zones, these will be protected by concrete mattresses. There are no plans to use rock dumping at these locations. The tie-in spools between the Abbey wells and the manifold at Abbey will be fabricated from Super Duplex steel. The tie-in spools between the Abbey to York pipeline to the Abbey manifold and all spools at the York end

will be fabricated from Carbon Steel. The tie-in spools from the Baker to Abbey pipeline to the Abbey manifold will be fabricated from Super Duplex Steel.

Approximately 336 mattresses (assumed 6 m x 3 m) and 150 grout bags (assumed 1 m x 1 m), including contingency, might be required.

It is estimated that the tie-in arrangements for the proposed Abbey & Baker development will impact an area of seabed totalling 6,198 m^2 (0.0062 km^2) (see Table 3.12).

The pipeline tie-ins will be made by a Diver Support Vessel (DSV) lifting spools into place with the make-up to the structures and pipelines being made by diver. The umbilical tie-ins will be made by a DSV with the make-up to the structures being made by ROV.

Table 3.12: Seabed Footprint of the Abbey & Baker Tie In Lines

Tie-in	Diameter (NB)	Materials	Length (m)	Protection Material [1, 2]	Seabed Footprint (m^2)
1 x tie-in spool at York (Abbey to York pipeline to riser)	8 inch	Carbon steel	256	48 x Mattresses	864
1 x untrenched section of the Abbey to York umbilical (approach to York J-tube)	8 inch	Carbon Steel	256	25 x Mattresses, 30 x Grout Bags	480
1 x tie-in spool at Abbey (Abbey to York pipeline to manifold)	8 inch	Carbon steel	69.7	37 x Mattresses	666
1 x untrenched section of Abbey to York umbilical (approach to Abbey manifold)	8 inch	Carbon Steel	69.7	35 x Mattresses, 20 x Grout Bags	650
3 x tie-in spools at Abbey (manifold to Abbey trees)	6 inch	Super Duplex	74.13, 68.94 and 74.63	39 x Mattresses, 75 x Grout Bags	777
1 x tie-in spool at Abbey (Baker to Abbey pipeline to manifold)	8 inch	Carbon Steel	69.7	37 x Mattresses	666
1 x untrenched section of Baker to Abbey umbilical (approach to	8 inch	Carbon Steel	69.7	35 x Mattresses, 20 x Grout Bags	650

Tie-in	Diameter (NB)	Materials	Length (m)	Protection Material [1, 2]	Seabed Footprint (m^2)
Abbey manifold)					
1 x tie-in spool at Baker (Baker tree to Baker to Abbey pipeline)	8 inch	Super Duplex	70	35 x Mattresses	630
1 x untrenched section of Baker to Abbey umbilical (approach to Baker Treel)	8 inch	Super Duplex	70	45 x Mattresses, 5 x Grout Bags	815
				Total Seabed Footprint (m^2)	6,198

[1] Worst case mattress dimensions are yet to be determined but are likely to be 6 x 3 x 0.3 m
[2] Worst case grout bag dimensions are yet to be determined but are likely to be 1 m x 1m

3.4.6 Hook-Up and Commissioning Operations

Where feasible, as much equipment as possible will be pre-commissioned onshore. It is anticipated that:

- The umbilicals will be pressure tested on completion of manufacture and will be installed, pre-filled with the control lines filled with the appropriate hydraulic fluid and the chemical injection lines will be filled with a suitable spacer chemical;
- Offshore, the production pipeline will be flooded with treated water and hydrostatically strength pressure tested (typically 120% of line volume). The treated water may contain biocide, oxygen scavenger and a dye for leak testing. The flowline will then be depressurised (excess treated water will be discharged at the pipeline ends) and left on the seabed flooded with treated water;
- The spool pieces will be hydrotested onshore and will be installed, pre-filled with chemicals to protect the infrastructure integrity typically MEG gel and potentially also dye, to facilitate leak testing;
- Following tie-in of all the components, an overall leak test will be conducted.

The use and discharge of chemicals during pipeline commissioning operations will be detailed and assessed in the Pipeline Operations MAT and associated Chemical Permit SAT in accordance with the Offshore Chemicals Regulations 2002 (as amended). Chemicals will be subject to an environmental risk assessment, where applicable and products with an improved environmental profile will be preferentially selected for use.

3.4.7 Vessel Requirements

The installation of the Abbey & Baker subsea infrastructure will be carried out by a number of vessels as detailed in Table 3.13 and Table 3.14.

Table 3.13: Vessel Requirements for Installation of Abbey & Baker Subsea Infrastructure [1]

Operation	Vessel Type	Duration in Field (days)[2]	Typical Fuel Consumption (tonnes per day)	Total Fuel Consumption (tonnes)	Emissions (tonnes CO_2e)[3]
Manifold and Subsea Structures Installation	CSV	13	24	312.00	1,012.53
Pre and Post Operations Surveys	Survey	21	5	105.00	340.76
Pipelay	Pipelay Vessel	17	22	374.00	1,213.74
	Umbilical Installation Vessel	17	22	374.00	1,213.74
	LCV (Crossing and pre-installation)	13	22	286.00	928.16
Tie In Operations	DSV	68	22	1,496.00	4,854.98
Trench and Burial of the Pipeline and Umbilical	Trenching vessel	37	22	814.00	2,641.68
Rock Dumping and Mattresses	Rock Dumping Vessel / DSV	8	9	72.00	233.66
Fishing Scout	Scout Vessel	19	4	76.00	246.64
Guard Vessel	Guard Vessel	47	4	188.00	610.12
			Total:	4,097.00	13,296.01

[1] Any vessels used will be DP vessels

[2] This is considered as worst case and includes mobilisation, travel rime, demobilisation and weather downtime

[3] Emission Factor expressed in terms of kg CO_2e of GHG per unit (DESNZ, 2025c). For 'Marine Gas Oil', kg CO_2e per unit CO_2 = 3205.99000; kg CO_2e per unit N_2O = 38.40721; kg CO_2e per unit CH_4 = 0.90720.

3.5 Host Facility

3.5.1 York Facilities Overview

The York platform is in Cease of Production and currently operating in lighthouse mode. This selected host to Abbey & Baker comprises a NPAI topsides and jacket. The platform includes the abandoned York platform wells and metering, 3rd party tie-back manifold, utilities equipment, a pedestal crane, diesel power generation and Emergency Overnight accommodation and local lifeboat.

At the time when the ES is issued, Spirit Energy and Petrogas will have signed a conditional sale and purchase agreement for purchase by Petrogas of Spirit Energy's interest in the York Licence and York facilities. Upon satisfaction of those conditions, which include regulatory approval, Petrogas will assume ownership and operatorship of the York Licence and facilities.

The existing platform wells plugged and abandoned and the associated process are positively isolated from the existing production manifold and export line. An 8-inch Riser and 10-inch J-tube have been designated for the Abbey & Baker tieback. The Abbey & Baker facilities will have a suitable tie in to the existing export route and will comprise of the following additional new process: Abbey /Baker topsides flowline from the designated 8-inch riser to the York export tie-in, associated control, shutdown and choke valves, and methanol tie-ins.

Hydrocarbon fluids are exported to the CESL Easington Terminal via a 16-inch diameter pipeline and then via local link line to Perenco Dimlington Terminal. A parallel 3-inch piggyback line supplies the York platform with methanol and corrosion inhibitor mix from the onshore terminals. The pipeline has been flooded as part of the Spirit scope and will require de-watering and re-instatement approval. The 3-inch line is currently positively isolated at the Easington Terminal onshore and also offshore on York topsides. This line will be reinstated with a new tie-in to an onshore methanol corrosion inhibitor supply from the Dimlington terminal and a Topside distribution system on the York Platform to feed the required topsides tie in and also to the Abbey and Baker wells via the subsea controls umbilical cores.

It is proposed that the Abbey & Baker wells and production manifold will be monitored and controlled via a Subsea Control System (SCS) the surface elements of which will be installed on the York Platform. The York facility will provide communication links to the onshore reception facility for remote monitoring and control of the Abbey & Baker Development back at Dimlington terminal, this is similar to original York remote control under Spirit operation.

3.5.2 Power Requirements

The electrical distribution system on York comprises of 2 x 60kVA diesel generators on duty/standby operation, which are powering a dedicated switchboard. The current operating philosophy is that the Duty Diesel Generator will be the primary generation unit. There is sufficient electricity generation capacity on the York platform to accommodate the Abbey & Baker Development. The power demand for Abbey & Baker is 0.163 tonnes of fuel per day, which is equivalent to 0.53 tonnes of CO_2e per day. The Abbey & Baker power demand will minimally increase diesel fuel use compared to previous for York usage.

York is currently in lighthouse mode, using solar power for the navigational aids, so the diesel generators are using zero tonnes of fuel per year. Following first gas of the Abbey & Baker Development, there will be a fuel use of 59.6 tonnes per year by the diesel generators at York. This would result in 194.25 tonnes of CO_2e per year (see Appendix D for more details on emissions calculations).

3.5.3 Production Chemicals

Methanol, premixed with corrosion inhibitor, intended for hydrate and corrosion inhibition, will be injected into the Abbey and Baker wells continuously for pipeline protection. This methanol and corrosion inhibitor is pumped from onshore at Dimlington terminal and via a new 3-inch MeOH link line to Easington and then on to the York platform. The methanol corrosion inhibitor mix will be delivered to the Abbey and Baker trees via dedicated umbilical cores. A TUTU on York will be utilised to tie-in chemicals and High Pressure (HP)/Low Pressure (LP) hydraulics to the umbilical (both Abbey to York

and Baker to Abbey). In addition, during production, the water / glycol based hydraulic fluid Oceanic HW 443R (or similar) will be used and discharged during periodic valve use.

3.5.4 Host Facility Modifications

The existing York wells and associated process equipment are isolated and the wells abandoned. The new Abbey to York 8-inch diameter flow line will be routed from the new Emergency Shutdown Valve (ESDV) on the selected riser to the Export route tie-in. The routing will take advantage of the existing real-estate allocation for future 3rd party tie-back facilities. The Abbey & Baker process will include but not limited to the following process valving, control choke, as well as associated vents, drains. The Abbey & Baker wells will be controlled at York by a Subsea controls system comprising TUTU, HP / LP HPU, Electric Power Unit (EPU) for power and signal distribution to the MCS located on the York Platform. The system through the MCS will be interfaced to the Production Control System (PCS) on York for control and shutdowns. Onshore control will be facilitated at the Dimlington terminal control room via local operator station and linked to the York platform and the Abbey and Baker control via an existing Dimlington to York platform LOS link.

The subsea controls umbilical will utilise an existing allocated 10-inch J-tube and tie-in topsides to the associated TUTU.

To complete the York topside modifications, an accommodation jack-up vessel will be at the York platform for up to 4 months, alongside associated supply boats / helicopters. Table 3.14 shows the fuel consumption and atmospheric emissions from the York topside modifications.

Table 3.14: Vessel and Helicopter Requirements for York Topside Modifications

Operation	Vessel Type	Duration in Field (days)	Typical Fuel Consumption	Total Fuel Consumption (tonnes)	Emissions (tonnes CO_2e)[2]
Accommodation Jack up vessel	Jack up	124	10 tonnes per day	1,240	4,024.18
Support Vessel	Vessel	124	6 tonnes per day	744	2,414.51
Helicopter Trips (assumed to be two a week)	Helicopter	2 return flights per week Note 1	0.786 tonnes per return flight	28.30	91.49
			Total:	**2,012.30**	**6,530.17**

Note 1: Assumes 2 return flights per week during 124 day period = 17.71 ~ rounded up to 18 single flights, therefore 36 Return Flights in total.

3.6 Production

Abbey & Baker production fluids will be processed onshore at the Dimlington Gas Terminal, with the gas treated and compressed for export into the National Transmission System. Small volumes of unstabilised condensate will be piped to the Saltend Refinery, for further processing, with stabilised liquid hydrocarbons piped to storage tanks for export via tanker.

3.6.1 Production Profiles

The gas, oil and water production figures for the Abbey & Baker Development are presented in Table 3.15 (High case, P10) and Appendix D. First gas is currently targeted for Q2 2029, therefore 2030 is the first full year of production. The Abbey & Baker fields are expected to produce hydrocarbons for between ten to fifteen years, depending on the reserves and the production rate.

The production predictions are based on an ensemble of reservoir models which reflect the identified range of uncertainty in reservoir parameters and align with the application for development and production consent which will be submitted to the NSTA.

The High case (based on a four well development scenario) results in the maximum volume of hydrocarbon (oil and gas) production at the maximum rate and represents the greatest potential environmental impact. The impact assessment presented in this ES (and all associated calculations for air emissions calculations) has therefore been carried out using the High case. Any condensate water generated during processing of the Abbey & Baker production fluids will be disposed at the Dimlington Gas Terminal via the existing produced water system, the impact from which is outside of the scope of this ES, although there is sufficient capacity in the water handling system at Dimlington Gas Terminal to accommodate Abbey & Baker.

Abbey & Baker hydrocarbon production rates are anticipated to peak in 2030 at 2,959,169.5 cubic metres (104.5 million standard cubic feet) of gas per day and 99.3 tonnes (124.1 cubic metres) of condensate per day (High case), after which there is a steady decline over the life of the field (refer to Figure 3.12 and Figure 3.13).

Table 3.15: Abbey & Baker Gas and Oil Production Volumes, High case [1,2,3]

Year	Oil (tonnes/d)	Oil (m^3/d)	Oil (bbl/d)	Gas (m^3/d)	Gas (MMscf/d)	Water (bbl/d)	Water (m^3/d)
2029	75.2	94.0	591.2	2,224,024.6	78.5	60.8	9.7
2030	99.3	124.1	780.6	2,959,169.5	104.5	83.6	13.3
2031	96.3	120.4	757.3	2,898,595.9	102.4	69.9	11.1
2032	83.0	103.8	652.9	2,519,046.7	89.0	60.5	9.6
2033	66.8	83.6	525.6	2,018,530.7	71.3	54.4	8.6
2034	55.2	69.0	434.0	1,667,703.6	58.9	50.1	8.0
2035	46.6	58.2	366.2	1,408,892.4	49.8	46.7	7.4
2036	39.8	49.7	312.7	1,208,399.6	42.7	45.6	7.2
2037	34.6	43.2	271.8	1,049,828.7	37.1	44.9	7.1
2038	30.1	37.7	236.9	917,234.3	32.4	45.0	7.2
2039	26.1	32.7	205.6	798,579.7	28.2	45.6	7.2
2040	23.0	28.8	180.9	706,908.7	25.0	46.5	7.4
2041	20.4	25.5	160.5	627,088.9	22.1	47.3	7.5
2042	18.1	22.6	142.0	556,308.5	19.6	48.1	7.7
2043	16.0	20.1	126.2	496,093.3	17.5	49.1	7.8
2044	13.1	16.4	102.9	411,142.6	14.5	49.5	7.9

[1] P10 (High case) is defined as the highest estimate of recoverable and/or potentially recoverable volumes from the Abbey and Baker Development based. There is a 10% probability that recovered volumes will meet or exceed the high case estimate.

[2] Production values presented in this table have been rounded up. All calculations in Appendix D were undertaken using the original unrounded data. Reproduction of calculations using the rounded figures in the above table may therefore result in minor discrepancies.
[3] The production volumes presented for 2029 represent 9 months of production averaged over the year (first gas in Q2 2029).

Figure 3.12: Abbey & Baker Gas Production Profiles

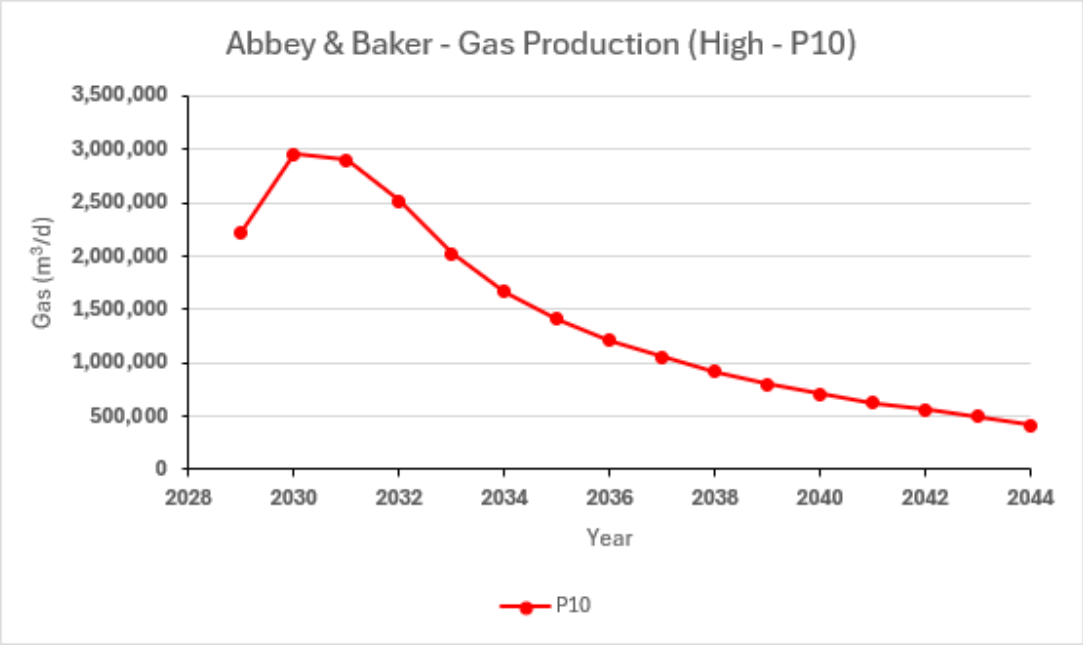
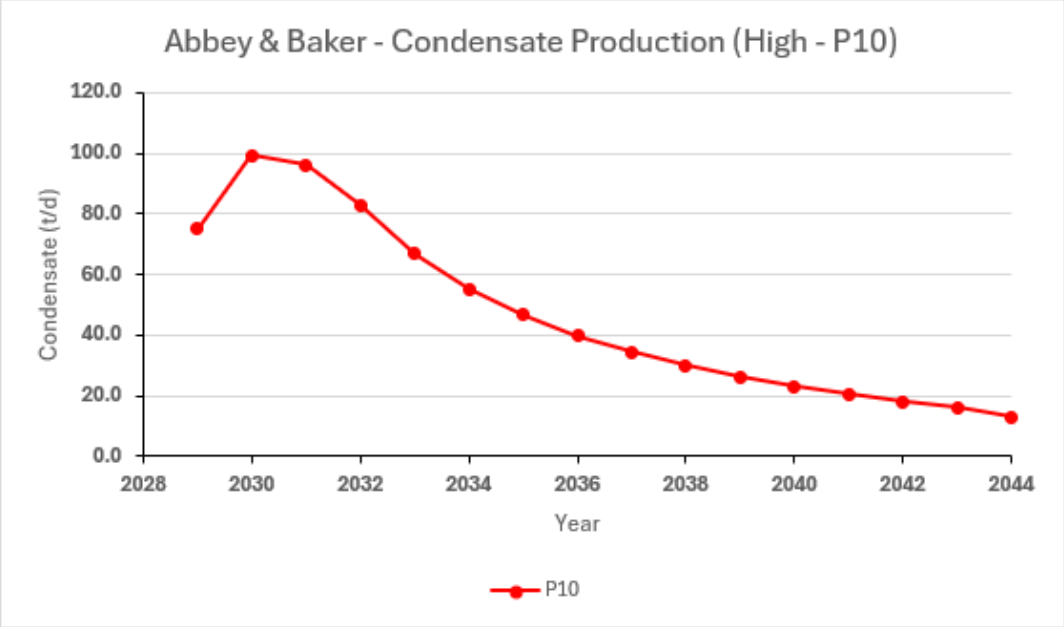


Figure 3.13: Abbey & Baker Condensate Production Profiles



3.6.2 Inspection and Maintenance

An integrity management system will be developed and inspection programmes implemented for the Abbey & Baker subsea system and York platform. However, in general, the equipment is designed for the field life time such that maintenance can be minimised.

External inspection of the pipelines and will take place every 4 years using ROVs. In addition, a visit will be made to the York platform once a year.

The likely vessel requirements for inspection and maintenance of the subsea infrastructure over the life of the Abbey and Baker fields is detailed in Table 3.16.

Table 3.16: Vessel Requirements for Maintenance of Offshore Infrastructure (annually)

Vessel	Function	Total No. of Vessel Days [1]	Fuel Type	Fuel Consumption Rate (tonnes per day) [1]	Total Fuel Consumption (tonnes)	Emissions (tonnes CO_2e) [2, 3]
Standby Vessel	York platform visit (once a year)	14 days per year	Diesel	8.42	117.88	382.56
W2W Vessel	York platform visit (once a year)	14 days per year	Diesel	17.76	248.64	806.91
ROV Vessel	Pipeline Integrity and Inspection survey (every 4 years)	2 days per survey (0.5 days per year)	Diesel	18	9.00	29.21
Helicopter	6 x return flights per W2W visit	6 x return flights	Aviation Fuel	6.4 per return flight	38.4	124.62
				Total:	413.92	1,342.84

[1] Includes an allowance for vessel mobilisation, transit and demobilisation

[2] Emission Factor expressed in terms of kg CO_2e of GHG per unit (DESNZ, 2025c). For vessels 'Marine Gas Oil' has been used: kg CO_2e per unit CO_2 = 3205.99000; kg CO_2e per unit N_2O = 38.40721; kg CO_2e per unit CH_4 = 0.90720.

[3] Emission Factor expressed in terms of kg CO_2e of GHG per unit (DESNZ, 2025c). For helicopters 'Aviation Turbine Fuel' has been used: kg CO_2e per unit CO_2 = 3149.67000; kg CO_2e per unit N_2O = 26.50000; kg CO_2e per unit CH_4 = 2.19520.

3.6.3 Marine Discharges

Water (condensed and potentially produced) and methanol arriving at the Dimlington terminal from all producing fields, plus any methanol injected at Dimlington for hydrate suppression, is commingled in the water / condensate handling system. Methanol and water are separated out from the stabilised condensate in the condensate storage tanks as the lower layer. This is transferred to the Mechanical Refrigeration Unit (MRU) feed tank where it is distilled to recover the methanol with sufficient purity for its reuse for hydrate suppression on the Terminal or offshore. The wastewater, which is separated out during the distillation process flows to the wastewater pit and is disposed of via the existing produced water system, the impact from which is outside of the scope of this ES, although there is

sufficient capacity in the water handling system at the Dimlington Terminal to accommodate the Abbey & Baker Development.

For Abbey and Baker , during production, the water / glycol based hydraulic fluid will be used and discharged during periodic valve use. The use and discharge of this chemical during operations will be detailed and assessed in the appropriate MAT and associated Chemical Permit SAT in accordance with the Offshore Chemicals Regulations 2002 (as amended). Any chemicals used or discharged will be subject to an environmental risk assessment, where applicable and products with an improved environmental profile will be preferentially selected for use.

3.7 Decommissioning

On cessation of production, the Abbey and Baker fields, along with the York platform, will be decommissioned in accordance with the requirements of the prevailing UK and international law.

The main obligations for decommissioning offshore oil and gas operations are set out in OSPAR decision 98/3 (the "Decision 98/3") which specifically prohibits the dumping or leaving in place of installations in the marine environment. However, the OSPAR provisions do not directly apply to pipelines and there are no international guidelines on the decommissioning of disused pipelines. Therefore, pipeline and umbilical decommissioning options will be subject to comparative assessment and assessed in accordance with UK legislation and policy in place at the time of decommissioning.

Petrogas will be liable for the decommissioning, abandonment, and if applicable, removal of the Abbey & Baker infrastructure, alongside the York platform and pipelines to shore, at the end of its operational life. In discussion with OPRED, the work will be carried out in full compliance with the statutory regulations in place at the time of Cessation of Production and following Best Environmental Practice.

It is currently anticipated that the wells will be disconnected from their subsea architecture and will be plugged and abandoned, as per regulatory guidelines at the time, using a MODU or vessel with well intervention capabilities. The conductors and wellheads would then be cut at a depth of 3 m below the mudline and removed.

All subsea infrastructure will be depressurised and flushed to remove residual hydrocarbons and chemicals and left flooded with seawater prior to abandonment. The Abbey & Baker Development subsea structures (xmas trees and manifolds) will be designed to be capable of being removed at the end of their service life, leaving no obstructions above the mud line. The York topside and jacket will be removed.

Petrogas final decommissioning programme (under section 29 of the Petroleum Act 1998) for the Abbey & Baker infrastructure will take account of the following:

- Applicable regulations
- Environmental appraisal
- Specialist vendor services
- Re-use and re-purposing
- Use of industry specific decommissioning experiences and lessons learnt, especially related to SNS facilities
- New technology and innovations available at the time

Decommissioning implications have been considered from a GHG emissions reduction perspective during the field development planning for Abbey & Baker. The simple design and small footprint of the subsea development will reduce the scope of decommissioning operations in terms of items to be removed and limit related operational emissions accordingly.

In addition, when designing the Abbey & Baker Development, consideration was given to the future re-use and/or repurposing of the reservoirs. However, Petrogas have determined that the Abbey & Baker reservoirs are unsuitable for this.

4 The Existing Environment

4.1 Introduction

This section describes the current environment at the proposed Abbey & Baker Development location, which encompasses the Abbey & Baker drill centres and the pipeline and umbilical and routes from Baker to Abbey and from Abbey to the York platform, all of which is situated in UKCS Block 47/3. The description is largely based on data provided in the OPRED Offshore Energy Strategic Environmental Assessment (OESEA) Reports (2003-2022), as well as other published data sources, supported by site-specific survey data as detailed below. The proposed Abbey & Baker Development is located within the OESEA Regional Sea 2 (the 'Southern North Sea' area) (DESNZ, 2022).

4.1.1 Abbey & Baker Site-Specific Data

To inform this ES, Petrogas have commissioned the following environmental surveys:

- Abbey site survey conducted by GEOxyz, in association with Benthic Solutions Limited (BSL) between the 11th December 2022 and 4th January 2023 (GEOxyz, 2023a; GEOxyz, 2023b; GEOxyz, 2023c). Prior to this, in April 2022, Fugro undertook an environmental survey at Abbey, but this was aborted partway through due to poor weather conditions and other logistical issues. The survey conducted by GEOxyz built on the previous Fugro survey by completing the collection of grab samples from the remainder of its preselected locations, as well as revisiting some locations where necessary.
- Abbey to York pipeline route survey conducted by GEOxyz, in association with BSL, between the 20th January 2024 and 6th March 2024 (GEOxyz, 2024a).
- Baker site survey conducted by GEOxyz, in association with BSL between the 20th January and 5th March 2024 (GEOxyz, 2024b; 2024c)
- Baker to Abbey pipeline route survey conducted by GEOxyz, in association with BSL between the 26th and 30th of August 2025 (GEOxyz, 2025a; 2025b).

The scope of these surveys is outlined below and the results have been used, where relevant, to describe the baseline environment within the proposed Abbey & Baker Development area. The Abbey site survey, Abbey to York pipeline survey and Baker site survey all took place before the drilling of the Abbey Appraisal and Baker Exploration wells; the Baker to Abbey pipeline route survey took place following the drilling of these two wells.

Abbey Site Survey

A habitat, herring spawning ground and environmental baseline survey has been carried out over the proposed Abbey drill centre location (hereafter referred to as the 'site survey area').

To aid in the habitat investigation of the site, GEOxyz collected multibeam echosounder (MBES) and side scan sonar (SSS) data across the survey area (4.39 km^2). The MBES and SSS datasets were reviewed onboard the survey vessel to identify areas of potential interest for investigation. Initially nine camera transect locations were identified for investigation (T08 to T16) to ground-truth and map the different habitats observed from the geophysical data. A further seven camera transects (T17 to T23) were proposed to facilitate characterisation of potential Annex I stony reef habitats, where the most significant seabed impacts would be expected to occur. Seabed video footage and still photographs were acquired using a Seabug underwater camera system.

The environmental baseline survey (EBS) sampling strategy of the GEOxyz survey followed on from the scope developed for and carried out by Fugro in April 2022, as discussed above. This consisted of ten pre-selected EBS stations, arranged in a cruciform pattern around the proposed drill centre location radiating out at 50 m, 150m and 250m intervals, in line and perpendicular to the dominant currents. An additional four stations were selected around two Relief Well Locations (RWLs), spaced 50m to the northwest and southeast of each RWL, in line with water movements. A full suite of faunal and physico-chemical samples was retrieved from each station using a Dual Van Veen (DVV) grab sampler.

To inform the herring spawning assessment, sediment samples were also collected from across the site survey area and along the pipeline route, which were sub-sampled for particle size analysis. Results from the particle size analysis of the EBS grab samples have also been used to inform a sandeel spawning assessment.

Figure 4.1 illustrates the location of the sampling stations and camera transects within the Abbey site survey area. Following the Abbey site survey, a decision was made to move the drill centre ca. 70 m to the north east to avoid placement of the drilling rig on areas identified as potential 'Low Reef' sites of stony reef. Any subsequent reference to the proposed 'Abbey Drill Centre' will refer to the relocated drill centre ca. 70 m north east of the initial proposed drill centre location.

Abbey to York Pipeline

A habitat, herring and sandeel spawning ground and environmental baseline survey has been carried out along the proposed pipeline route between Abbey to York. The route surveyed extended 8 km from the York platform to the proposed Abbey manifold location, with acoustic data (MBES and SSS) acquired within a 600 m wide corridor.

Seven environmental stations (PL01 – PL07) were sampled along the proposed pipeline route, all of which were ground-truthed by short camera transects before grabbing. A full suite of faunal and physico-chemical samples was retrieved from each station using a DVV grab sampler. The grab samples were also used in herring and sandeel spawning ground suitability assessments.

The camera transects were collocated with grab sampling stations. An additional camera transect was also surveyed as part of the habitat assessment to investigate a high reflectivity feature with accompanying acoustic shadow estimated to be greater than 25 m^2. The BSL MOD4.3 camera system mounted within the BSL freshwater lens was used during the survey.

Figure 4.3 illustrates the location of the sampling stations and camera transects along the proposed Abbey to York pipeline route.

Baker Site Survey

A habitat assessment, environmental baseline survey, sandeel spawning and nursery ground assessment, and herring spawning and nursery ground assessment have been carried out over the proposed Baker well location. The area surveyed for acoustic data (MBES and SSS) measured approximately 3.97 square kilometres (km^2).

The Baker EBS sampling strategy consisted of twenty-two pre-selected stations, arranged in a cruciform pattern surrounding the proposed Baker well location radiating out at 250 m, 500 m, 1000 m, 1,500 m and 3,000 m spacings, with two additional 5,000 m stations along the predominant current. A full suite of faunal and physico-chemical samples was retrieved from twenty of the twenty-two grab sampling station across the Baker survey area using a DVV grab sampler. During sampling at stations B_250m_160° and B_1000m_70° multiple unsuccessful attempts resulted in reduced samples at these locations (2 and 3 samples respectively out of 4). Results are still available and have been included from these stations.

The camera transects were collocated with grab sampling stations. The BSL MOD4.3 and MOD4.5 camera systems mounted within the BSL freshwater lens was used during the survey.

Figure 4.3 illustrates the location of the sampling stations and camera transects within the Baker site survey area.

Abbey to Baker Pipeline

A habitat assessment, environmental baseline survey, sandeel spawning and nursery ground assessment, and herring spawning and nursery ground assessment have been carried out along the proposed pipeline route between Abbey and Baker.

To aid in the habitat investigation of the route, GEOxyz performed a geophysical and environmental survey to collect MBES, SSS, SBP and MAG data across the survey area (3.56 km^2) which encompassed the Abbey to Baker pipeline corridor (3.5 km x 1 km) that lies in between Baker South and Abbey sites. Data was acquired running twenty-one single-pass main lines in the Abbey to Baker pipeline corridor

spaced at 50 m intervals with additional eight single-pass cross lines spaced at 500 m intervals. Seven additional shorter main lines were added to cover the corners of the Baker South Drill site area but were not part of the main sequence for the corridor.

The Baker EBS sampling strategy during the 2025 survey consisted of eighteen pre-selected EBS stations, with four additional camera-only locations. All sampling locations were ground truthed by short camera transects of approximately 50 m before grabbing. Transects of greater lengths were also carried out. Two DVV grab deployments were required to obtain four grab samples at all eighteen EBS stations.

The camera transects were collocated with grab sampling stations. The BSL MOD4.10 camera system mounted within the BSL freshwater lens was used during the survey.

Figure 4.4 illustrates the location of the sampling stations and camera transects within the Abbey to Baker route area.

Sample Processing and Analysis

All benthic stations sampled in order to establish the environmental baseline underwent the following sampling/sub-sampling:

- 1 x 0.1 m^2 macro-invertebrate replicate samples processed over a 0.5 millimetre (mm) aperture sieve;
- 3 x 0.1m^2 physico-chemical replicate, sub-sampled for particle size distribution (PSD), total organic carbon (TOC), total organic matter (TOM), moisture, heavy and trace metals (HM), and hydrocarbons (HC), at a single surface depth of 0-2 centimetres (cm).

During, the Abbey site survey, additional benthic stations were sampled solely to determine sediment type and suitability for use as a herring spawning ground. These stations underwent the following sampling/sub-sampling:

- A single 0.1m^2 grab sample was collected using a DVV grab, with the surface layer subsampled and suitably stored for particle size analysis onshore.

The results of the analysis have been compared to a variety of reference values relating to regional background levels and threshold effect levels to aid in the interpretation of the data, including UK Offshore Operators Association (UKOOA) (2001), Cefas (MMO, 2015) Cal1 and Cal2 reference values, and National Oceanic and Atmospheric Administration (NOAA) (Buchman, 2008) effect range low (ERL) and effect range median (ERM) levels.

Figure 4.1: Survey Areas and Grab Sampling Locations within the proposed Abbey & Baker Development (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025b)

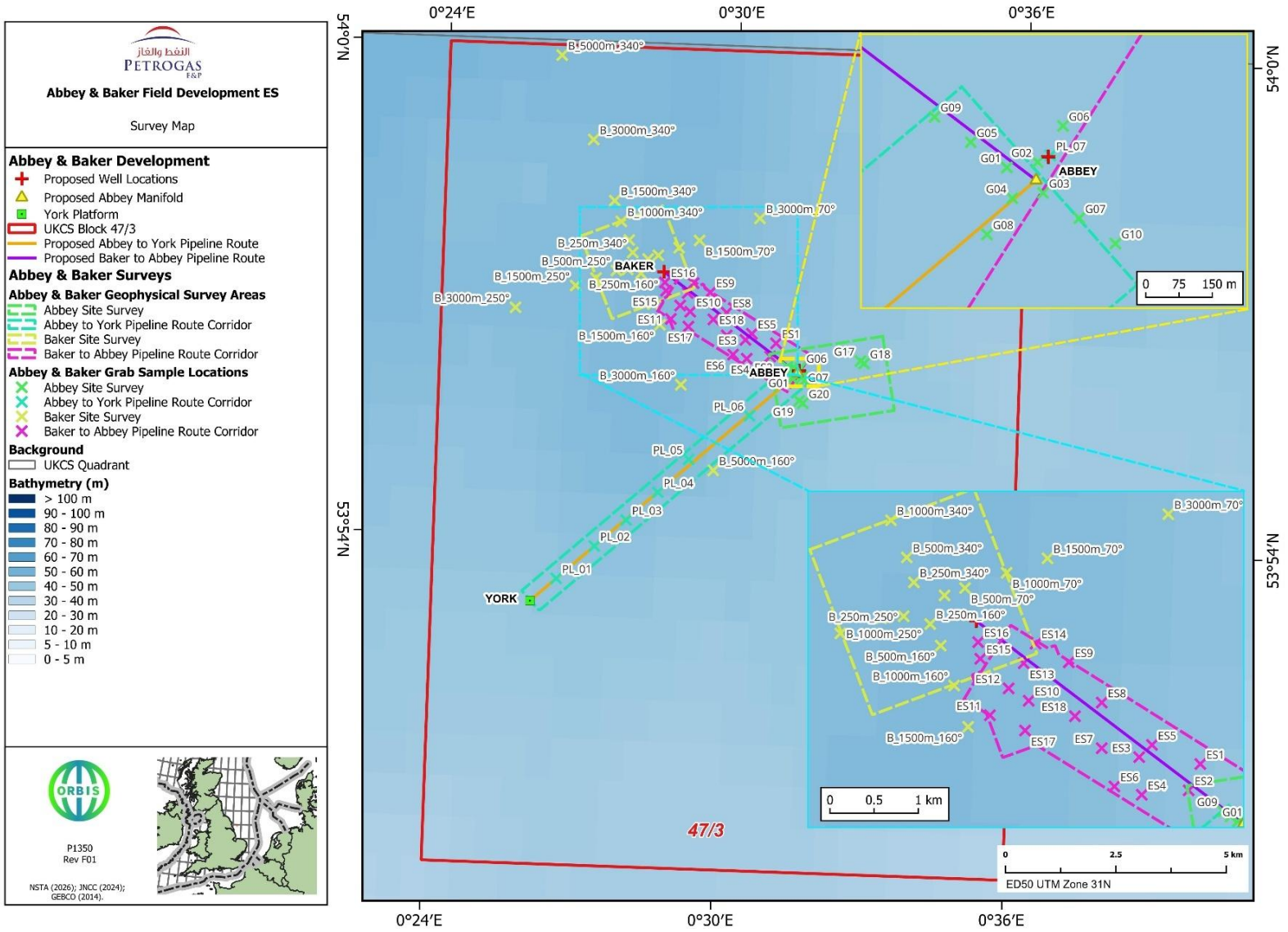
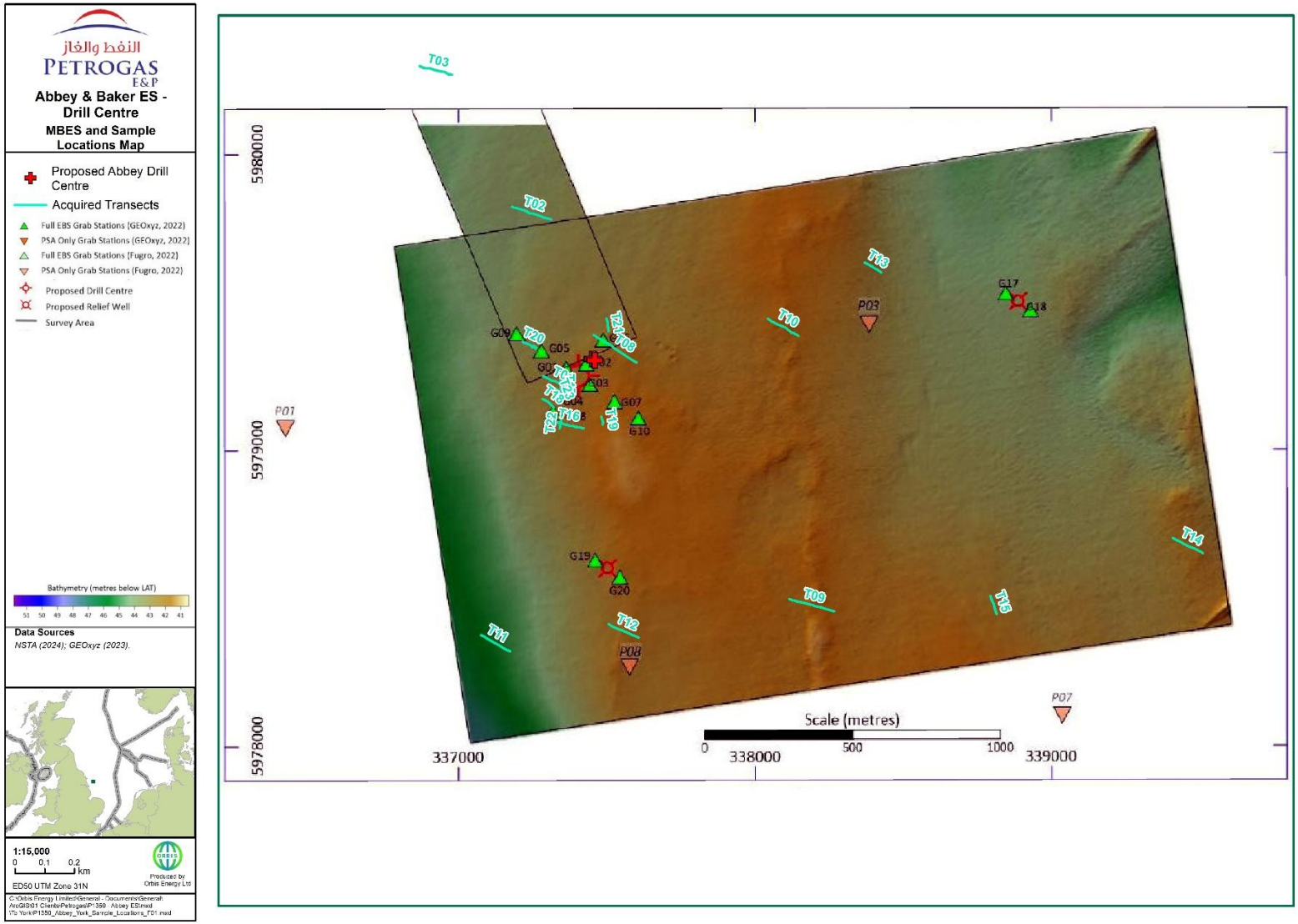


Figure 4.2: MBES Bathymetry Data and Environmental Sampling Strategy for the Abbey Site Survey Area (GEOxyz, 2023a)[1]



[1] The proposed Abbey drill centre is now located ca. 70 m north east of the proposed Abbey drill centre used for the Abbey site survey.

Figure 4.3: MBES Bathymetry Data and Sampling Stations for the Abbey to York Pipeline Route Survey (GEOxyz, 2024a)

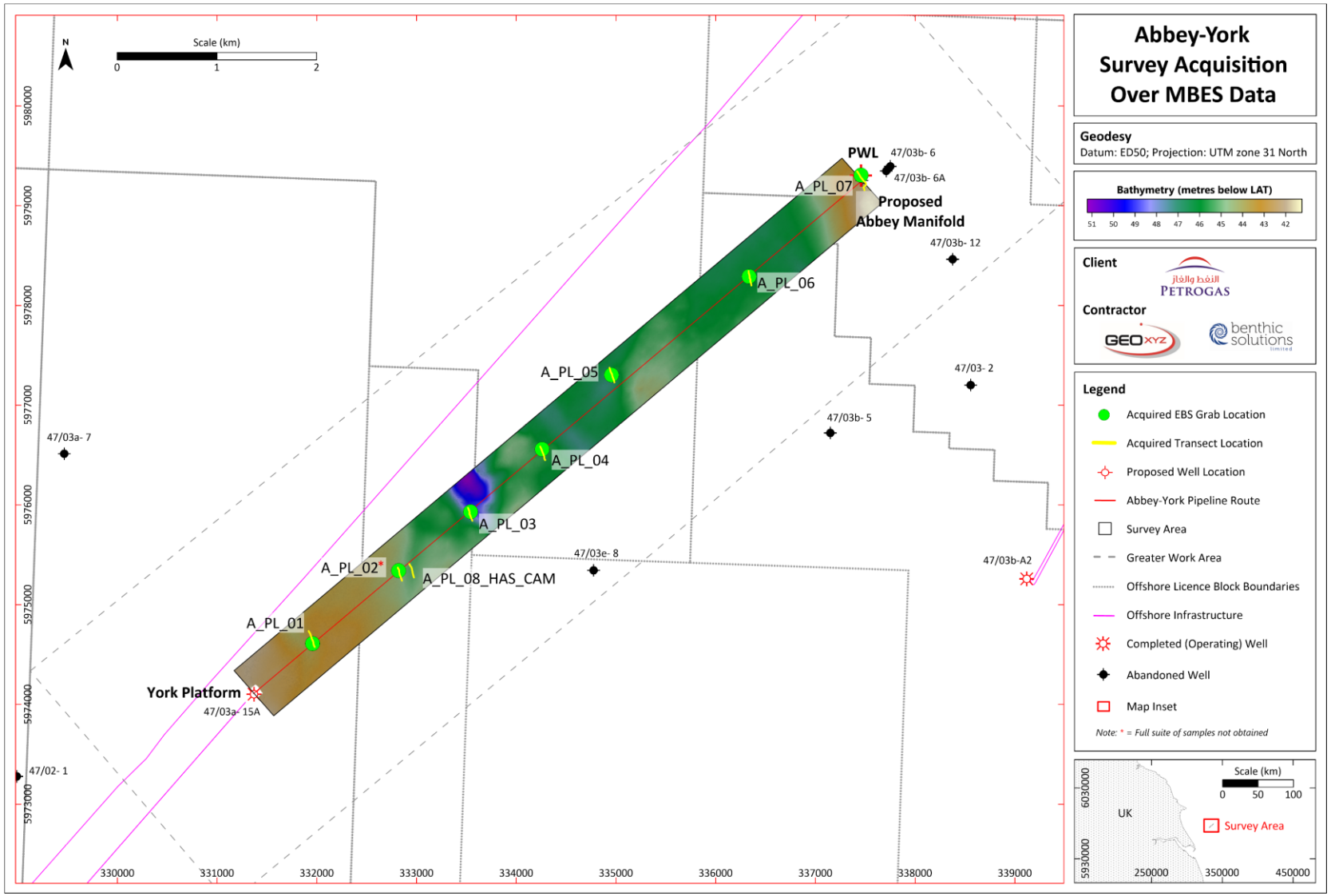
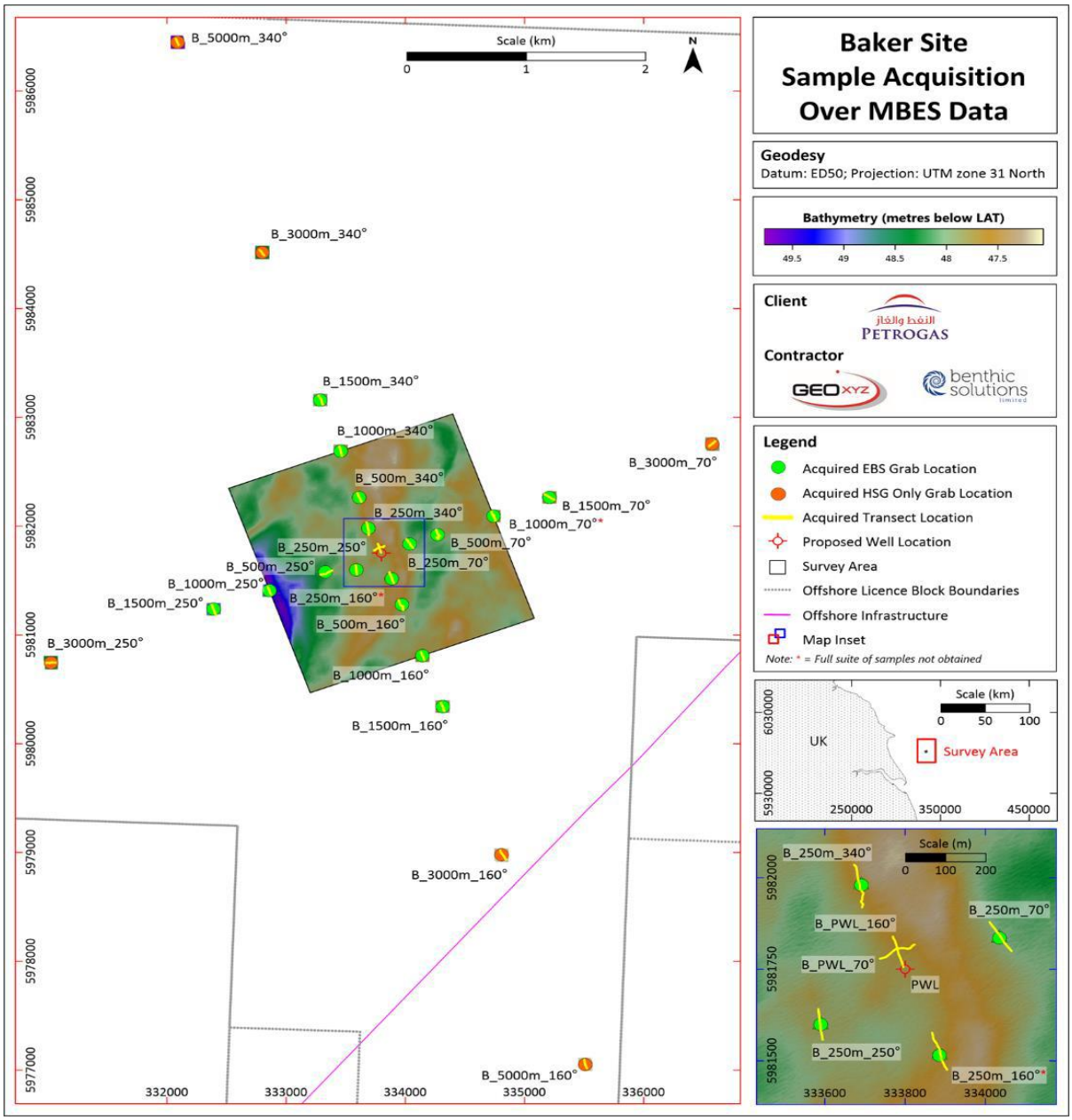
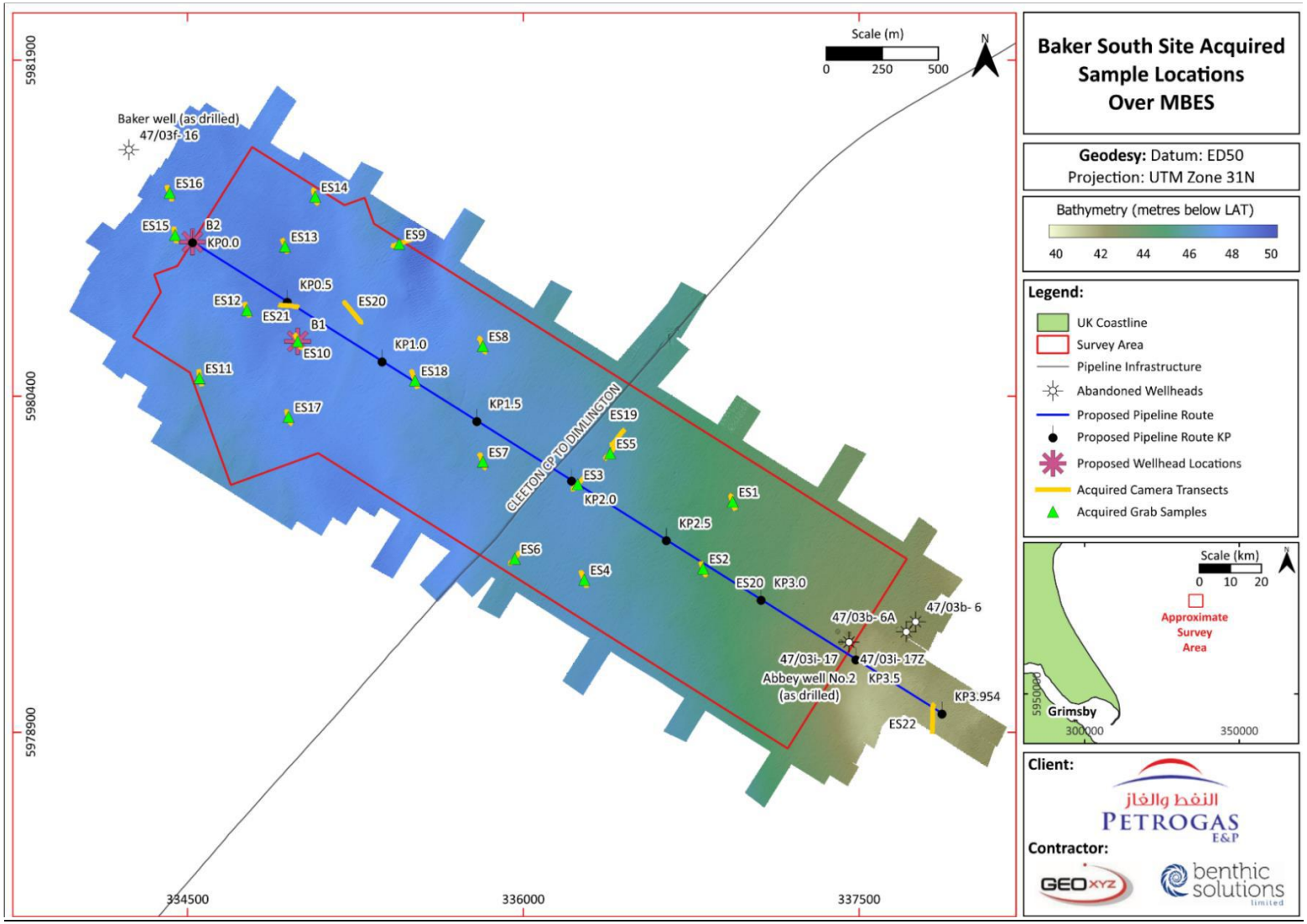


Figure 4.4: MBES Bathymetry Data and Sampling Stations for the Baker Site Survey Area (GEOxyz, 2024b)[1]



[1] 'Proposed Well Location' in this figure is located ca. 629 m West Northwest of the proposed Baker Development Well location for the Abbey & Baker Development

Figure 4.5: MBES Bathymetry Data and Sampling Stations for the 2025 Abbey to Baker Route Survey (GEOxyz, 2025a)



4.2 Physical Environment

4.2.1 Bathymetry and Seabed Features

The proposed Abbey & Baker Development is located within the relatively shallow waters of the SNS. The North Sea is a large shallow water body with a surface area of around 750,000 km^2. The SNS is particularly shallow, with water depths that are predominantly less than 50 m (DESNZ, 2022).

Recorded water depths across the Abbey site survey area ranged from between 40.4 m Lowest Astronomical Tide (LAT) to 47.4 m LAT, with the seabed gently undulating around 43.2 m LAT (see Figure 4.2; GEOxyz, 2023a). Along the Abbey to York pipeline route corridor centreline, water depths varied between 40.65 m LAT, towards the northeastern corner of the route, to 51.26 m LAT located in a depression slightly south of the central route. The seabed gradually deepens towards this depression from both the York platform in the southwest and the Abbey drill centre in the northeast, with a steeper slope gradient recorded in the northeastern survey area (Figure 4.3; GEOxyz, 2024a).

The Baker site survey area features water depths ranging from 47.04 m LAT in the north to 49.78 m LAT in a crescent-shaped channel in the west. The water depth at the proposed Baker well location is 47.75 m LAT. The seabed is relatively flat with no bedforms (Figure 4.4; GEOxyz, 2024b). Water depths along the Abbey to Baker pipeline corridor range from 48.6 m LAT in the northwest to 36.9 m LAT in the southeast (Figure 4.5; GEOxyz, 2025a).

The majority of Abbey site survey area was dominated by megaripples, indicating a south-southeasterly current direction. These megaripples showed heights of 5-10 cm within the site survey area. Megaripples were only absent along western edge of the site survey area and within a central patch of the Abbey site. Sand waves were visible in the northeast and southeast corners of the site survey area, with a maximum height of approximately 1 m. Numerous cobbles and boulders were also present. Higher densities of boulders were evident within the site survey area, where megaripples became more apparent (see Figure 4.6; GEOxyz, 2023a).

Within the Abbey to York pipeline route corridor a band of silty sand and larger area of sand were interpreted to span across the route towards the northeastern end of the survey area, with sediment waveforms observed towards the southwestern end of the route and megaripples located in the central third as well as along a strip crossing the seabed close to the York platform. Despite this, the seabed sediment morphology was mostly described as flat (see Figure 4.7; GEOxyz, 2024a).

Anthropogenic features, including two soft ropes, three features identified as debris/suspected debris, an L-shaped rockdump and ten concentrated jack-up footprints were documented in the southwestern half of the survey area. These anthropogenic features are associated with the York gas field.

Throughout the Baker site survey area, seabed sedimentation is comprised exclusively of sand, and wide stretches of megarippled sediment are present in the majority of the eastern and northwest part of the Baker survey area (see Figure 4.8). At the Baker site; 818 boulders were recorded, 35 features classed as debris were recorded, and 217 features classed as fish traps were recorded (GEOxyz, 2024c).

Within the Baker to Abbey pipeline route corridor survey area, seabed sedimentation is composed exclusively of gravelly sand (see Figure 4.9). The seabed sediment consisted of flat gravelly sand in the southwest, with stretches of megaripples in most of the northwest part of the survey area. Within the Baker to Abbey pipeline route corridor, 1,674 features classed as boulders were recorded, 2 features were classed as debris, 32 were classed as suspected debris, 1 was classed as a post drill well and 9 were classed a as seabed mounds (GEOxyz, 2025b).

4.2.2 Seabed Sediments

The nature of the local seabed sediments is a determining factor in the benthic communities present in the area (Kostylev, 2012).

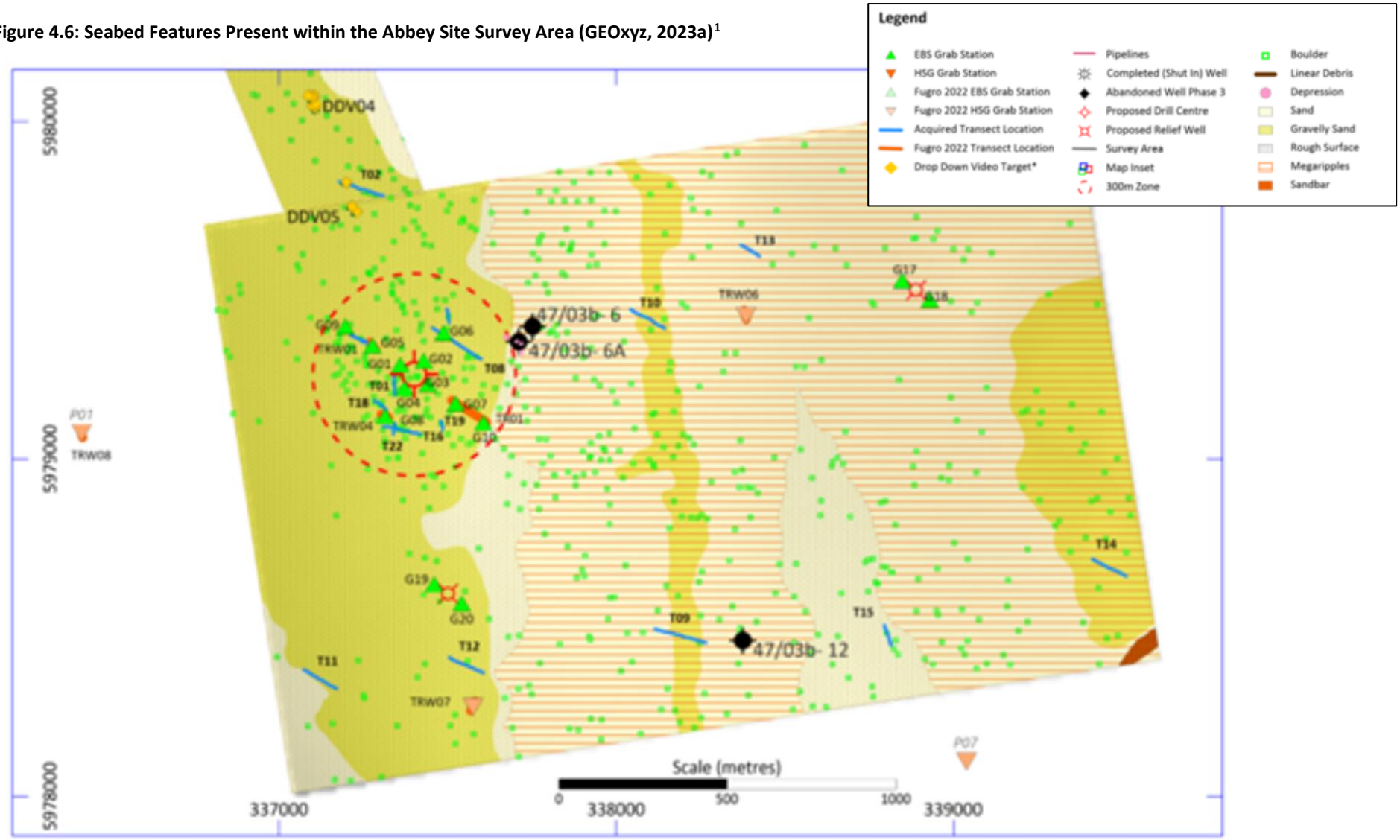
Seabed sediments were interpreted to vary between gravelly Sand with shell fragments and Sand for the Abbey site survey area. The western half of the site survey area, where the proposed drill centre is located, was characterised by generally mottled reflectivity, indicating an area of shell fragments, pebbles, cobbles and boulders identified as primarily Gravelly Sand with shell fragments. Areas of

coarser sediment, comprising scattered cobbles and boulders were imaged during camera transects within the survey area, particularly towards the proposed drill centre (see Figure 4.6; GEOxyz, 2023a).

Within the Abbey to York pipeline route corridor, seabed sediments were predominantly identified as gravelly sand interspersed with three separate narrow bands of high reflective coarser sediments (sandy gravel and gravel), as illustrated in Figure 4.7 (GEOxyz, 2024a).

Sediments found throughout the Baker site survey area were comprised mostly of sand (see Figure 4.8; GEOxyz, 2024b). Within the Abbey to Baker pipeline route corridor the seabed sediment consisted exclusively of flat gravelly sand with stretches of megaripples in the northwest (see Figure 4.9; GEOxyz, 2025a).

Figure 4.6: Seabed Features Present within the Abbey Site Survey Area (GEOxyz, 2023a)[1]



[1] The proposed drill centre in this figure represents the previous (initial) proposed drill centre location which lies ca. 70 m southwest of the current proposed Abbey drill centre

Figure 4.7: Seabed Features Present within the Abbey to York Pipeline Corridor (GEOxyz, 2024a)

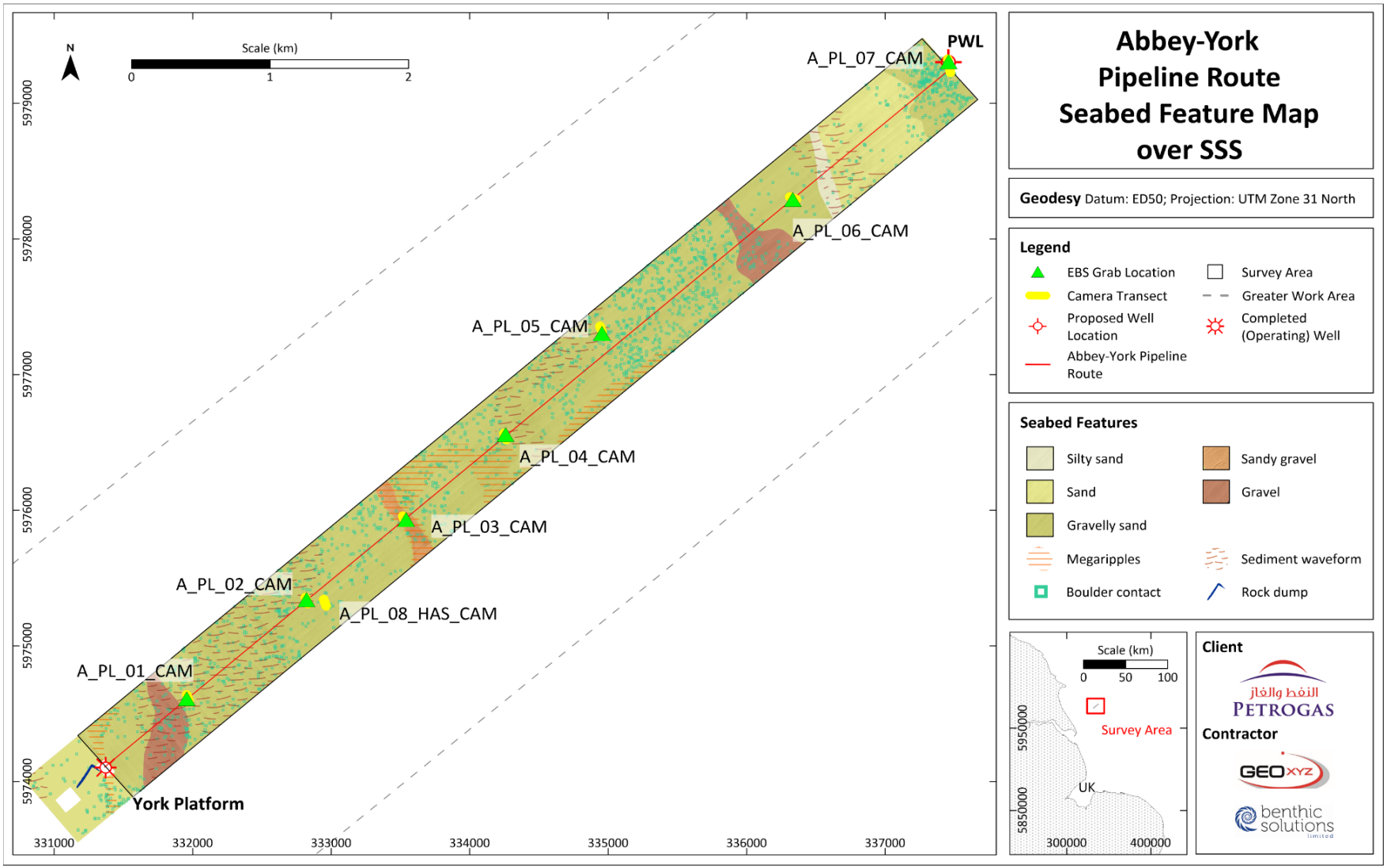
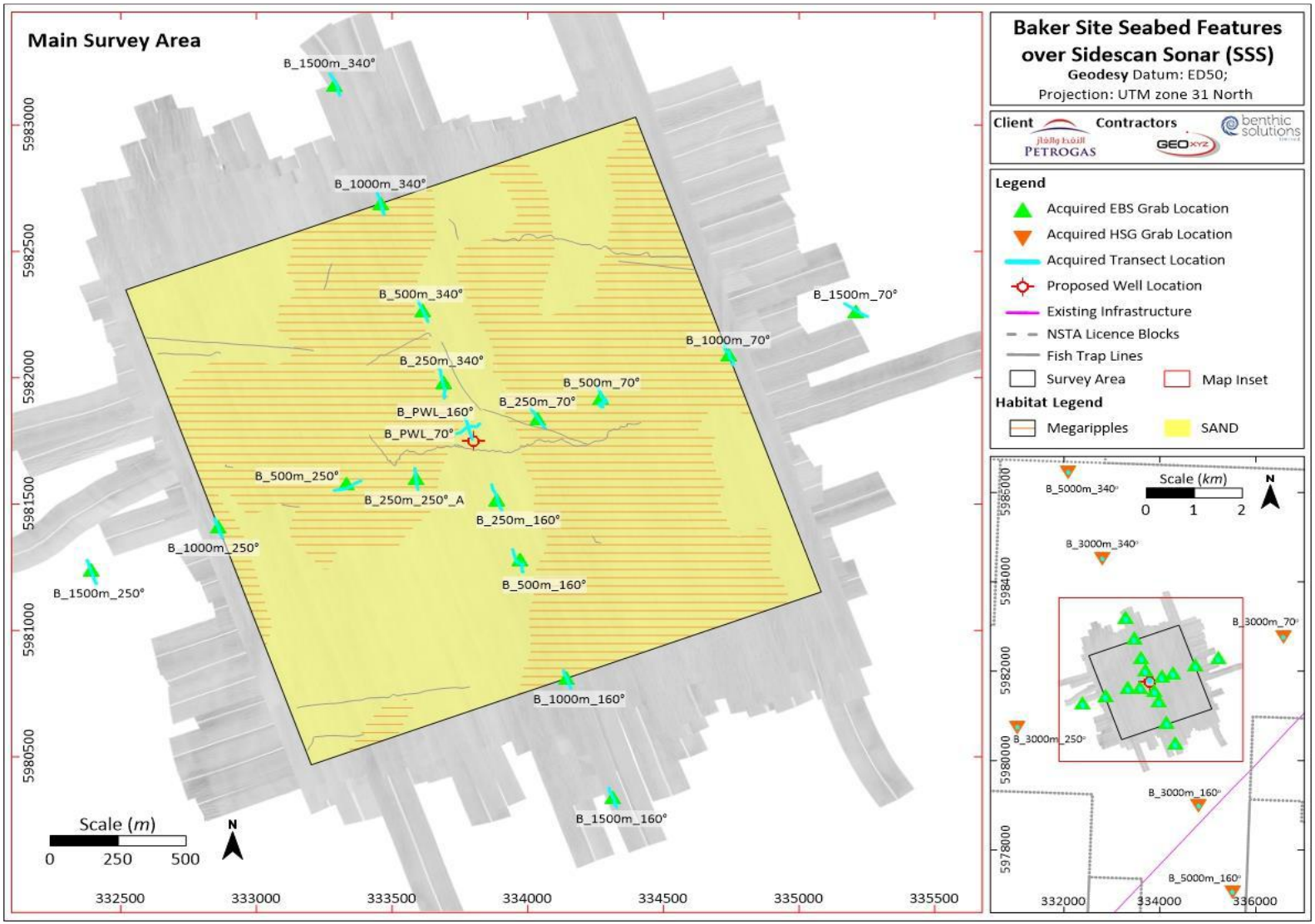
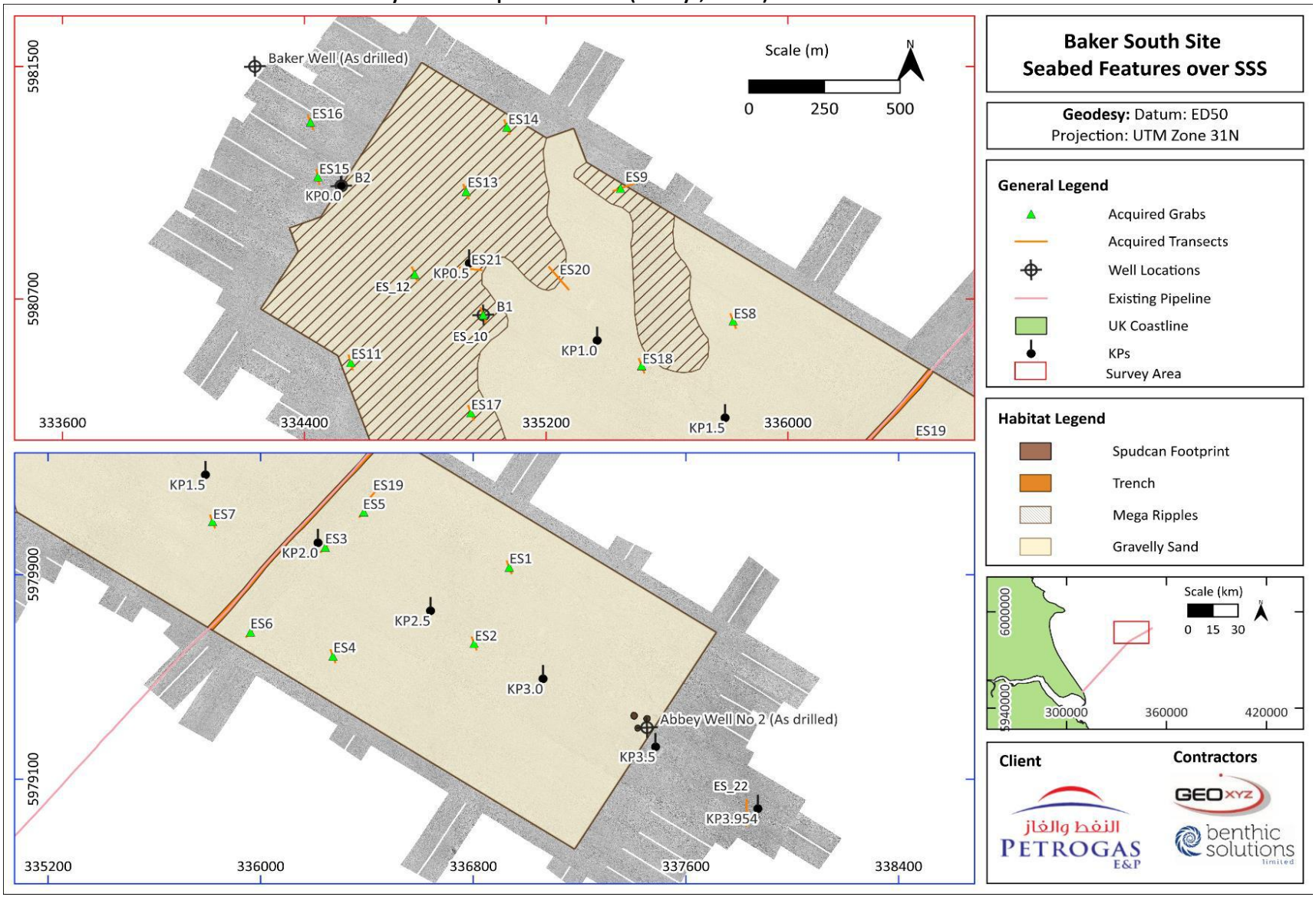


Figure 4.8: Seabed Features Present within the Baker Site Survey Area (GEOxyz, 2024c)[1]



[1] 'Proposed Well Location' in this figure is located ca. 629 m West Northwest of the proposed Baker Development Well location for the Abbey & Baker Development

Figure 4.9: Seabed Features Present within the Abbey to Baker Pipeline Corridor (GEOxyz, 2025b)



Particle Size Analysis

Most benthic organisms exhibit preferences for sediment with particular grain size characteristics. In addition, many contaminants, particularly metals and hydrocarbons, are strongly associated with finer fractions in sediment. Determination of sediment particle size across an area is therefore important to understanding the benthic community.

Sediment samples gathered from the Abbey & Baker surveys were subjected to particle size analysis (PSA). The results of PSA indicated a similar sediment type across the proposed Abbey & Baker development area, with sand dominating the seabed sediment type.

The Abbey site survey area showed sand dominance (mean 84.64%±10.92SD) with a slightly heavier weighting of fines (mean 11.70%±10.30SD) than gravel (mean 3.67%±1.87SD) (GEOxyz, 2023b). The Abbey to York pipeline route survey corridor showed sand dominance (mean 80.4 % ± 7.10 SD), with small proportions of gravel (mean 15.9 % ± 7.35 SD) and almost negligible proportions of fines (3.77 % ± 0.99 SD) (GEOxyz, 2024a). The Baker site survey area showed sand dominance (mean 87.3 % ± 4.9 SD), with small proportions of fines (mean 4.1 % ± 1.6 SD) and gravel (mean 8.6 % ± 16.7 SD) (GEOxyz, 2024b). The Abbey to Baker pipeline route survey corridor showed sand dominance (mean 76.5 % ± 11.7 SD), with relatively small proportions of fines (mean 11.2 % ± 5.0 SD) and gravels (mean 12.4 % ± 8.7 SD) (GEOxyz, 2025a).

The samples collected in the proposed Abbey site survey area were represented by five Folk classifications with most assigned to either 'Gravelly Sand' (53%) or 'Sand' (28%) illustrating the consistent distribution of sands across the survey area. The Wentworth classification scale identified four sediment classifications all of which were sand based (i.e. Medium Sand, Coarse Sand, Fine Sand and Very Coarse Sand). The homogeneous nature of the seabed was further reflected by a low mean sorting coefficient (2.1±0.152 SD), with a majority of stations (60%) defined as 'Poorly Sorted' or 'Very Poorly Sorted' (GEOxyz, 2023b).

All stations within the proposed Abbey to York pipeline route corridor were represented by the Folk classification of 'Gravelly Sand'. The Wentworth classification scale identified two different sediment classifications, 'Medium Sand' (57%) and 'Coarse Sand' (43%). The homogeneous nature of the seabed across the area was well reflected by a low mean sorting coefficient (1.81 ± 0.37) (GEOxyz, 2024a).

The samples collected in the Baker site survey area were represented by four Folk classifications, with the majority assigned to 'Sand' (27%), 'Slightly Gravelly Sand' (36%) or 'Gravelly Sand' (32%). The Wentworth classification scale also identified four sediment classifications of 'Fine Sand', 'Medium Sand', 'Coarse Sand' and 'Pebble'. The homogeneous nature of the seabed was further reflected by a low mean sorting coefficient (1.25 ± 0.51 SD), with most stations were considered to be either 'Poorly Sorted' or 'Moderately Sorted' with two stations (B_500m_250° and B_250m_250°) defined as 'Very Poorly Sorted' (GEOxyz, 2024b).

The samples collected within the Baker to Abbey pipeline route corridor survey area were represented by six Folk classifications, with the majority assigned to 'Gravelly Muddy Sand' (50%) or 'Gravelly Sand' (17%). The Wentworth classification scale identified three sediment classifications which were all sand based (i.e. Medium Sand, Fine Sand, Coarse Sand). The homogeneous nature of the seabed was further reflected by a low mean sorting coefficient (2.27 ± 0.83 SD), with all but one station considered to be either 'Very Poorly Sorted' or 'Poorly Sorted', while station ES15 was 'Moderately Sorted' (GEOxyz, 2025a).

Organic Matter and Organic Carbon

Determining the organic content of sediments is also important to understanding benthic communities. Organic matter is a food source for suspension and deposit feeders and its availability in the sediments can therefore influence benthic communities. An overabundance may lead to reductions in species richness, abundance and biomass (Hyland *et al*., 2005). In addition, many contaminants are strongly associated with organic carbon.

TOC results were low throughout the proposed Abbey site survey area, ranging from 0.13% to 0.38% (mean 0.2%±0.1SD). There were no significant correlations between TOC and proportions of fines, sand and gravel at the Abbey stations, however, there were significant ($p<0.05$) negative correlations with

mean particle size and sediment sorting. This indicates that higher TOC levels were typically seen in sediments characterised by more mixed sediments with smaller mean particle sizes. The lack of correlation between TOC and percent fines, sand and gravel is likely due to the highly homogeneous nature of the seabed sediments across the survey area. It appears unlikely that there has been any influence on TOC from drilling activities across the Abbey site survey area, due to the low levels of TOC recorded. TOC levels recorded during previous regional surveys near the Abbey field were also relatively low, reflecting the low fines and high sand content of the sediment (Fugro, 2022; GEOxyz, 2023b).

The TOC results were also low throughout the proposed Abbey to York pipeline route survey area, ranging from 0.17% to 0.26% (mean 0.21 % ± 0.04 SD)(GEOxyz, 2024a); the Baker site survey area, ranging from 0.14 % to 0.47 % (mean 0.25 % ± 0.09 SD) (GEOxyz, 2024b); and the Abbey to Baker pipeline route survey area, ranging from 0.05 % to 0.40 % (mean 0.15 % ± 0.08 SD) (GEOxyz, 2025a). There were no significant correlations between TOC within the Baker site survey area and the two proposed pipeline route area and proportions of fines, sand and gravel. The lack of correlation between TOC and percent fines, sand and gravel is likely due to the homogeneous nature of the seabed sediments across these three survey areas (GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

TOM content across the Abbey site survey area was low ranging from 0.9 % to 1.8 % (mean 1.3 %), but higher than the UKOOA (2001) 50th percentile for background stations in the SNS (1.12 %) at fourteen of the 17 stations; no stations exceeded the UKOOA 95th percentile level (2.3 %). TOM content was above the UKOOA (2001) 50th percentile for background sediments in the SNS (1.12 %) at all stations along the Abbey to York pipeline route, ranging from 1.5 % to 2.0 % (mean 1.64 %); however, no stations exceeded the UKOOA 95th percentile level (2.3 %).

Across the Baker site survey area, the TOM content ranged from 1.4 % to 2.6 % (mean 1.8 % ± 0.34 SD), with TOM content above the UKOOA (2001) 95th percentile (2.3 %) at two stations (GEOxyz, 2024b). Along the Abbey to Baker pipeline route area, TOM content ranged from 1.8 % to 3.5 % (mean 2.34 % ± 0.52 SD), with all stations above the UKOOA 50th percentile threshold for the SNS (1.12 %) and 10 stations also exceeding the upper 95th percentile value (2.3 %) (GEOxyz, 2025a). High TOM (3.5 %) observed at station ES1, which is located ca. 808 m north west of the proposed Abbey drill centre and ca. 245 m northeast of the proposed Baker to Abbey pipeline route, could be attributed to the higher fines content (26.3 %) in this sample, as finer sediment tend to have greater sorption on increased sediment surfaces (Thompson and Lowe, 2004).

Across the proposed Abbey & Baker Development area, no significant correlations ($p>0.05$) were observed between TOM and the proportions of gravel, fines, or sand. The organic content of the sediments is therefore unlikely to be acting as a reducing factor for benthic abundance, biomass and species diversity (Hyland *et al*., 2005).

Sediment Hydrocarbons

Marine sediments can contain hydrocarbons derived from both natural (geochemical processes and biosynthesise) and anthropogenic sources (e.g. oil spills). The exceedance of background hydrocarbons levels in marine sediments can indicate past and/or present anthropogenic sources. Crude oil is a complex mixture of compounds, including n-alkanes and aromatics (e.g. polycyclic aromatic hydrocarbons; PAHs). These groups can be determined individually, but they may also be analysed as total hydrocarbons (Cefas, 2001). A summary of the sediment hydrocarbon concentrations recorded in the proposed Abbey & Baker Development area are presented in Table 4.1.

Total hydrocarbon concentrations (THCs) of the sediments recorded in the Abbey site survey area were generally moderate (mean 7.6mg.kg^{-1}±1.9 SD), ranging from 5.2 milligrams per kilogram (mg.kg^{-1}) at station G05 (WO5) (178 m northwest of the proposed Abbey drill centre location) to 12.2mg.kg^{-1} at G18 (50m southeast of Relief Well A) (GEOxyz, 2023b). The THC of sediments along the proposed Abbey to York pipeline route was relatively low and consistent, with values ranging from 3.23 mg.kg^{-1} at A_PL_02 to 8.18 mg.kg^{-1} at A_PL_05 (mean 6.03 mg.kg-1 ± 1.89 SD) (GEOxyz, 2024a). The THC of the sediments within the Baker site survey area was also low and fairly consistent across the site, ranging from 3.46 mg.kg^{-1} to 9.75 mg.kg^{-1} (mean 6.75 mg.kg-1 ± 1.68 SD) (GEOxyz, 2024b). The THC of sediments along the proposed Baker to Abbey pipeline route was consistently low, with values ranging from 6.01 mg.kg^{-1} to 19.26 mg.kg^{-1} (mean 11.32 mg.kg^{-1} ± 3.48 SD) (GEOxyz, 2025a).

Throughout the Abbey & Baker survey areas, all stations exceeded the UKOOA (2001) 50th percentile threshold for background stations in the SNS (3.2mg.kg^{-1}), whereas only one station in the Abbey site survey area and eight stations within the Abbey to Baker pipeline route corridor exceeded the upper 95th percentile threshold of 11.4 mg.kg^{-1} (GEOxyz, 2023b; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a). These results show no significant spatial trend and are reflective of background conditions in the SNS region.

The carbon preference index (CPI) is used to assess the relative contribution from petrogenic (petroleum-related) and biogenic (natural) sources in hydrocarbon samples. The CPI for the full saturate range (nC10 to nC37) was consistent across the Abbey site survey area, ranging from 1.07 at station G07 (W03) (155 m southeast of Abbey drill centre location) to 1.41 at station G05 (WO5) (178 m northwest of the Abbey drill centre location), with a mean of 1.20±0.09SD. The aforementioned station - G07(W03)) has the lowest CPI result of the survey reflecting a reduced influence of biogenic n-alkanes. However, in light of the relatively low n-alkane and THC concentrations across the other stations, the CPI recorded likely reflects ambient conditions for this region of the SNS. The CPI for the full saturate range (nC10 to nC37) was also consistent across stations along the Abbey to York pipeline, ranging from 1.25 at A_PL_05 to 1.57 at A_PL_07, with a mean of 1.38 ± 0.12SD. Within the Baker site survey area, the CPI for the full saturate range (nC10 to nC37) was slightly variable, ranging from 1.26 at B_500m_160° to 1.65 at B_500m_250°, with a mean of 1.41. ± 0.09 SD. The results indicate a dominance of biogenic, odd-carbon numbered alkanes across the survey area (GEOxyz, 2024b). Across the Abbey to Baker pipeline route area, the CPI for the full saturate range (nC10 to nC37), ranged from 1.10 at station ES10 to 1.45 at station ES8 (mean of 1.29. ± 0.10 SD) (GEOxyz, 2025a). The results from the Abbey & Baker Development surveys indicate a minor dominance of biogenic, odd-carbon numbered alkanes which are likely to be mostly allochthonous in origin (i.e. originated at a distance from their present location).

Pristane to phytane (types of n-alkane) ratios can also provide information on the relative contribution of biogenic hydrocarbon sources. Pristane is primarily biogenic in origin, whilst phytane is rarely produced biogenically and, in the natural environmental, it is generally absent or only present at low concentrations (McDougall, 2000). A lower pristane to phytane ratio indicates both biogenic and petrogenic sources of n-alkanes, whilst high ratios indicate a dominance of biogenic sources for the n-alkanes. The Abbey & Baker Development surveys found generally high ratios of pristane to phytane, indicating a dominance of the more biogenic pristane, suggesting a general biogenic influence from potential planktonic and terrestrial inputs across the area (GEOxyz, 2023b; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

PAHs are largely formed by the incomplete combustion of organic matter. This includes the combustion of organic material such as forest fires (Youngblood and Blumer, 1975), the burning of fossil fuels and, in the case of offshore oil fields, flare stacks. Total PAH concentrations (2-6 compounds) across the proposed Abbey & Baker Development survey areas were considered to be moderate, with all stations exceeding the UKOOA (2001) 50th percentile reference level for background stations in the SNS (6 µg.kg^{-1}); the majority of stations also exceeded the Cefas cAL1 reference value (100 µg.kg^{-1}). In addition, three stations across the Baker site and three stations within the Baker to Abbey pipeline route corridor survey areas exceeded the 95th percentile reference value for the SNS (366 µg.kg^{-1}); this exceedance alone does not indicate a significant ecological risk (GEOxyz, 2023b; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

Table 4.1: Summary of Seabed Sediment Hydrocarbon (GEOxyz, 2023b; GEOxyz, 2024a)

Station	Depth (m)	Distance from Nearest Existing Well (m)	THC (mg.kg^{-1})	Carbon Preference Index	Pristane / Phytane Ratio	Total PAHs (µg.kg^{-1})	NPD (µg.kg^{-1})
Key:							
	Above UKOOA (2001) 50th percentile			Above UKOOA (2001) 95th percentile		Cefas Cal1 (MMO,2015)	
Abbey Drill Site Survey (GEOxyz, 2023b; Fugro, 2022)							
G01	45.7	357	6.9	1.12	4.77	183	94.7
G02	47.2	286	8.7	1.09	6.78	205	99.8
G03	47.8	296	6.8	1.26	8.48	157	71.0
G04	43.2	365	6.9	1.30	5.61	181	81.9
GO5	45.2	432	7.5	1.41	6.79	173	79.9
G05 (W01)*	45	432	5.2	1.27	4.16	269	151
G06	44.6	224	8.7	1.25	7.28	214	105
G07	45.1	261	7.2	1.31	7.78	251	118
G07 (W03)*	45	261	6.0	1.07	3.11	204	114
G08	45.1	452	9.2	1.18	5.47	254	130
G08 (W04)*	47	452	6.1	1.18	3.16	299	168
G09	45.1	516	10.0	1.26	8.26	262	118
G10	44.2	262	9.0	1.11	5.76	235	108
G17	44.7	1,104	5.5	1.27	8.03	178	81.1
G18	45	1,180	12.2	1.17	9.08	333	159
G19	43.2	761	5.6	1.10	8.03	80.9	35.9
G20	42.3	794	6.9	1.17	7.90	116	51.3
Mean			7.6	1.9	6.5	211.5	103.9
SD			1.9	0.1	1.9	64.1	36.0
CV (%)			24.6	7.8	28.9	30.3	34.6
Abbey to York Pipeline Survey (GEOxyz, 2024a)							
A_PL_01	43.4	776	7.81	1.52	6.24	342	167
A_PL_02	45.0	199	3.23	1.37	4.81	95.2	44.6
A_PL_03	49.2	1,131	6.16	1.29	5.36	271	151
A_PL_04	46.0	1,320	7.44	1.27	5.77	264	134
A_PL_05	46.8	1,968	8.18	1.25	4.03	209	103
A_PL_06	46.3	1,735	4.29	1.40	6.56	167	86.5
A_PL_07	42.8	255	5.12	1.57	9.16	237	105
Mean			6.03	1.38	5.99	227	113
SD			1.89	0.12	1.64	79.5	41.5
CV (%)			31.4	9.0	27.4	35.1	36.8
Baker Site Survey (GEOxyz, 2024b)							
B_5000m_340°	50.2	-	9.62	1.32	3.51	292.65	111.36
B_3000m_340°	49.4	-	7.75	1.31	3.74	230.50	100.07
B_1500m_340°	48.3	-	6.60	1.35	3.14	168.13	75.46
B_1000m_340°	48.0	-	5.03	1.41	3.67	154.99	74.77
B_500m_340°	48.5	-	5.79	1.51	2.45	153.06	71.21
B_250m_340°	47.6	-	6.95	1.34	2.80	316.36	177.06

Station	Depth (m)	Distance from Nearest Existing Well (m)	THC (mg.kg^{-1})	Carbon Preference Index	Pristane / Phytane Ratio	Total PAHs (µg.kg^{-1})	NPD (µg.kg^{-1})
Key:							
	Above UKOOA (2001) 50th percentile			Above UKOOA (2001) 95th percentile		Cefas Cal1 (MMO,2015)	
B_5000m_160°	45.4	-	5.83	1.39	2.26	193.08	100.54
B_3000m_160°	47.7	-	8.88	1.33	3.00	450.57	220.56
B_1500m_160°	47.7	-	6.72	1.45	2.55	222.15	108.74
B_1000m_160°	47.7	-	5.28	1.47	2.93	187.22	89.11
B_500m_160°	47.2	-	7.34	1.26	2.27	194.78	104.48
B_250m_160°	48.1	-	7.25	1.45	3.01	176.26	81.76
B_3000m_250°	49.1	-	6.40	1.54	2.79	186.54	87.55
B_1500m_250°	45.3	-	6.00	1.48	2.75	166.18	80.93
B_1000m_250°	49.7	-	5.00	1.44	3.18	123.85	54.29
B_500m_250°	49.3	-	4.33	1.65	2.27	126.57	59.40
B_250m_250°	47.6	-	3.46	1.42	4.13	130.21	59.55
B_3000m_70°	46.9	-	7.18	1.42	3.15	167.56	83.55
B_1500m_70°	47.3	-	9.75	1.37	5.91	369.04	196.10
B_1000m_70°	47.7	-	9.51	1.33	4.43	306.06	145.22
B_500m_70°	48.3	-	7.66	1.36	5.38	502.86	161.52
B_250m_70°	48.0	-	6.23	1.39	6.03	220.25	105.63
Mean			6.75	1.41	3.42	229.04	106.77
SD			1.68	0.09	1.12	103.33	45.50
CV (%)			24.9	6.3	32.7	45.1	42.6
Abbey to Baker Pipeline Survey (GEOxyz, 2025a)							
ES1	44.6	814.4	14.04	1.19	2.91	424.88	182.16
ES2	45.1	730.2	6.55	1.44	6.70	158.09	81.37
ES3	46.8	1402.0	9.27	1.30	7.01	323.27	155.18
ES4	46.6	1215.4	14.66	1.38	8.93	347.94	170.65
ES5	46.4	1359.7	12.19	1.17	2.68	250.95	114.94
ES6	46.6	1538.8	12.46	1.27	3.71	313.82	157.71
ES7	46.8	1823.6	10.15	1.40	4.03	247.20	117.88
ES8	47.1	1807.9	19.26	1.45	4.81	706.77	339.09
ES9	47.7	1279.3	17.39	1.23	3.91	636.08	349.83
ES10	47.8	1140.4	12.89	1.10	6.09	330.0	154.0
ES11	47.0	1067.0	9.66	1.35	3.14	232.23	108.92
ES12	47.9	888.7	8.56	1.30	2.62	188.29	75.67
ES13	48.1	819.9	11.28	1.21	2.81	186.97	76.67
ES14	47.8	858.2	9.08	1.32	3.33	138.45	53.26
ES15	47.4	432.7	6.01	1.33	7.97	97.35	44.89
ES16	47.8	265.0	11.70	1.28	4.37	252.10	113.80
ES17	47.6	1389.4	8.16	1.34	3.05	165.58	68.25
ES18	47.2	1641.8	10.45	1.21	3.38	160.19	67.64
Mean			11.32	1.29	4.53	290.0	1.35

Station	Depth (m)	Distance from Nearest Existing Well (m)	THC (mg.kg^{-1})	Carbon Preference Index	Pristane / Phytane Ratio	Total PAHs (µg.kg^{-1})	NPD (µg.kg^{-1})
Key:							
	Above UKOOA (2001) 50th percentile		Above UKOOA (2001) 95th percentile			Cefas Cal1 (MMO,2015)	
SD			3.48	0.10	1.96	160.0	0.87
CV (%)			30.73	7.39	43.34	57.21	64.23

* Stations sampled during BOTH Fugro, 2022 and GEOyxz, 2023b (Fugro station name is in brackets) (GEOxyz, 2023b data has been used due to complete sampling during the Fugro, 2022 survey).

Heavy and Trace Metals

Heavy metals such as copper, lead and zinc, are generally persistent and have a tendency to bioaccumulate in the tissues of exposed organisms, particularly species living on or within the seabed sediments, where they can have toxicity impacts on the receptor and subsequently become concentrated through higher levels of the food web. The biological or ecological effects of metals on organisms has been investigated and researchers have defined the term 'effect range low' (ERL) as the lowest concentration of a metal which produces adverse effects in 10% of the data reviewed, additionally the 'effect range median' (ERM) designates the level at which half of the studies reported harmful effects. Therefore, metal concentrations below the ERL value are unlikely to produce harmful effects, while levels above the ERM value are likely to be toxic to some marine organisms (GEOxyz, 2023b; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

Table 4.2 presents a summary of total heavy and trace metal analysis from the Abbey & Baker Development environmental baseline surveys. Barium in the form of barite is a weighting material used to increase the density of drilling muds and can contain measurable concentration of heavy metals as impurities, including cadmium, chromium, copper, lead, mercury, and zinc (NRC, 1983; McLeese *et al*., 1987). The survey areas showed relatively low levels of natural barium; although a number of stations recorded concentrations above the UKOOA (2001) 50th percentile level for background SNS sediments (26.0 mg.kg^{-1}), no stations exceeded the 95th percentile level for background sediments (272.4 mg.kg^{-1}). (GEOxyz, 2023b; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

Barium, arsenic, copper, chromium, lead, nickel, vanadium, zinc and manganese were seen to correlate significantly with each other, indicating similar sediment associations and/or spatial distributions across all of the Abbey and Baker survey areas. Of these metals, only vanadium, lead and zinc recorded concentrations above their respective UKOOA 95th percentile thresholds at selected stations and the levels at those stations were only slightly higher than recorded at other stations. All of the other aforementioned metals exhibited levels consistent with UKOOA (2001) typical background sediments for the SNS, showing no evidence for heavy point source contamination. However, concentrations of Barium within the proposed Baker to Abbey pipeline route corridor, which was sampled following drilling of both the Abbey appraisal well and Baker exploration well, were more elevated than the three previous surveys (See Table 4.2). For iron, the 50th percentile level was also exceeded at some stations, with fairly consistent concentrations across the Abbey site and pipeline route survey area. None of these metals showed any clear spatial patterns of distribution across the Abbey site and pipeline route survey area as a whole (GEOxyz, 2023b; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

Arsenic concentrations were relatively high across the Abbey & Baker Development survey areas as all stations were above the NOAA ERL reference value of 8.2 mg.kg^{-1}. In addition, 8 stations across the Abbey site survey area, 3 stations within the Abbey to York pipeline route corridor, 11 stations across the Baker site survey area and 14 stations along the Abbey to Baker pipeline route also surpassed the Cefas cAL1 reference value of 20 mg.kg^{-1} (GEOxyz, 2024b; GEOxyz, 2025a), suggesting potential risk to the marine environment. However, all results were below the cAL2 threshold (100 mg.kg^{-1}). High concentrations of arsenic in the western part of the SNS are a common feature for offshore environmental surveys and it has been suggested that arsenic and other metals are impacted by a combination of riverine input and the mobilisation of metal-rich shales by historic regional offshore drilling activities (Whalley *et al*., 1999; GEOxyz, 2023b; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

Table 4.2: Total Heavy and Trace Metal Concentrations (mg.kg^{-1} or ppm) (GEOxyz, 2023b; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a)

Station	Depth (m)	Distance from Nearest Well (m)	Al	As	Ba	Cd	Cr	Cu	Fe	Pb	Li	Mn	Hg	Ni	V	Zn
Key																
Above UKOOA SNS 50th %ile (UKOOA, 2001)			Above UKOOA SNS 95th %ile (UKOOA, 2001)			Above NOAA ERL (Buchman, 2008)			Above NOAA ERM (Buchman, 2008)			Above Cefas Cal1 (MMO, 2015)			Above Cefas Cal2 (MMO, 2015)		
Abbey Drill Site Survey (GEOxyz, 2023b; Fugro, 2022)																
G01	45.7	357	1,990	14.6	17.9	0.06	8.5	4.6	9,090	17.9	5.2	339.3	< 0.01	4.8	24.3	23.8
G02	47.2	286	2,750	29.6	28.9	0.05	7.8	5.4	13,600	15.1	7.6	587.6	< 0.01	6.5	33.9	24.1
G03	47.8	296	2,150	24.5	22.7	<0.04	7.4	3.7	11,500	13.2	6.1	431.4	< 0.01	6	28	24.5
G04	43.2	365	2,000	16.1	20.1	0.04	7.8	4.5	8,700	14	5.5	376.9	< 0.01	5	23.7	20.8
G05	45.2	432	2,380	16.2	27.3	0.04	9	3.8	10,200	14.9	6.3	357.2	< 0.01	5.9	26.6	22.4
G05 (W01)*	45	432	3,230	15.1	26.3	0.05	9.8	2.15	10,000	15.7	-	-	0.07	5.1	25.3	21.7
G06A	44.6	224	2,370	22.8	33.8	0.07	8.6	4.2	11,800	17.2	7.5	792.6	< 0.01	6.8	29.4	25.3
G07	45.1	261	2,620	22.1	13.6	<0.01	9.4	1.29	11,900	19.8	-	-	0.05	4.6	31.7	20.9
G07 (W03)*	45	261	3,230	15.1	26.3	0.05	9.8	2.15	10,000	15.7	-	-	0.07	5.1	25.3	21.7
G08	45.1	452	2,010	19.5	38	<0.04	8	3.5	11,100	16.4	5.7	395	< 0.01	5.3	28.7	23.4
G08 (W04)*	47	452	2,730	15.2	13.1	<0.01	10	1.32	8,980	15.1	-	-	0.05	4.4	26.5	19.9
G09	45.1	516	3,970	24.6	77	<0.04	13.1	6.2	15,000	16.8	9.9	581	< 0.01	9.9	35	26.4
G10	44.2	262	2,490	32	41	<0.04	8.9	4.1	14,300	19.5	7.6	755	< 0.01	7.5	37.7	28.5
G17	44.7	1,104	2,130	12.8	16.8	0.05	8.1	4.6	8,790	13.8	5.5	309.7	< 0.01	5.1	21.6	19.4
G18	45	1,180	1,870	11.8	13	<0.04	6.8	3.8	7,800	12.5	5	310.7	< 0.01	4.6	21.1	18.3
G19	43.2	761	1,970	23.6	18.6	0.04	8.6	4.6	11,700	22.4	5.2	591.2	< 0.01	5.7	32.8	25.8
G20	42.3	794	1,980	26.6	15.9	<0.04	8.5	3.7	12,600	23.1	5.5	636.5	< 0.01	5.5	35.8	25.1
Mean			2,462.9	20.1	26.5	0.1	8.8	3.7	11,003.5	16.7	6.4	497.2	0.1	5.8	28.7	23.1
SD			576.8	6.1	15.6	0.0	1.4	1.3	2,079.5	3.0	1.4	168.5	0.0	1.4	5.1	2.8
CV (%)			23.4	30.3	58.8	20.0	15.9	35.9	18.9	18.3	22.3	33.9	19.2	23.6	17.7	11.9
Abbey to York Pipeline Route (GEOxyz, 2024a)																
A_PL_01	43.4	776	3,400	18.9	39.0	<0.04	7.5	2.5	16,600	21.9	10.5	510	0.01	6.2	31.8	30.4
A_PL_02	45.0	199	2,070	26.8	11.5	<0.04	7.9	2.3	12,400	21.6	7.0	856	0.02	6.2	36.9	31.5
A_PL_03	49.2	1,131	2,110	16.9	15.2	<0.04	8.1	2.7	13,100	22.2	6.8	900	0.03	8.1	44.3	31.5

Station	Depth (m)	Distance from Nearest Well (m)	Al	As	Ba	Cd	Cr	Cu	Fe	Pb	Li	Mn	Hg	Ni	V	Zn
Key																
Above UKOOA SNS 50th %ile (UKOOA, 2001)			Above UKOOA SNS 95th %ile (UKOOA, 2001)			Above NOAA ERL (Buchman, 2008)			Above NOAA ERM (Buchman, 2008)			Above Cefas Cal1 (MMO, 2015)		Above Cefas Cal2 (MMO, 2015)		
A_PL_04	46.0	1,320	3,680	27.2	30.2	0.07	14.0	3.6	17,300	19.8	10.6	854	0.03	12.9	42.0	44.7
A_PL_05	46.8	1,968	2,080	18.1	21.2	0.04	9.7	2.3	11,300	19.0	6.0	414	<0.01	8.2	31.1	41.6
A_PL_06	46.3	1,735	2,500	24.6	21.5	<0.04	12.9	2.5	15,000	22.9	7.6	564	<0.01	9.8	39.8	38.6
A_PL_07	42.8	255	1,700	18.0	22.0	<0.04	9.9	1.8	10,000	16.6	5.6	471	<0.01	7.2	29.0	39.5
Mean			2,506	21.5	22.9	0.1	10.0	2.5	13,671	20.6	7.7	653	0.02	8.4	36.4	36.8
SD			748	4.5	9.2	0.0	2.5	0.5	2,725	2.2	2.0	209	0.01	2.4	5.9	5.7
CV (%)			30	21.0	40.1	38.6	25.4	21.7	19.9	10.8	26.3	31.9	42.6	28.2	16.2	15.4
Baker Site Survey (GEOxyz, 2024b)																
B_5000m_340°	50.2		1,760	32.6	13.5	0.1	9.9	2.5	13,500	26.6	6.7	1,172.0	0.03	8.2	44.6	35.6
B_3000m_340°	49.4		2,020	56.5	13.3	0.1	9.3	2.8	19,600	50.7	6.7	1,550.0	0.03	8.9	58.4	59.0
B_1500m_340°	48.3		1,480	19.8	9.2	0.1	8.8	2.5	8,640	23.4	4.0	518.5	0.02	5.9	31.4	28.2
B_1000m_340°	48		1,550	15.5	9.22	0.1	8.1	2.3	9,450	19.0	5.0	459.8	0.02	6.1	26.4	33.8
B_500m_340°	48.5		1,550	19.0	13.6	0.0	8.6	2.8	9,970	23.2	4.5	609.4	0.03	6.2	30.9	53.8
B_250m_340°	47.6		1,790	15.6	29.9	0.1	8.4	2.8	11,300	15.5	5.4	361.0	0.02	5.8	26.9	41.8
B_5000m_160°	45.4		2,810	21.6	30.4	0.1	9.1	3.0	18,600	21.7	9.1	672.0	0.02	7.1	34.4	36.1
B_3000m_160°	47.7		2,810	25.9	41.7	0.1	9.1	2.6	17,800	22.7	9.5	638.2	0.02	7.7	42.3	34.4
B_1500m_160°	47.7		1,970	17.5	18.3	<0.04	15.6	3.0	10,900	20.4	6.2	405.8	0.02	6.4	29.7	30.5
B_1000m_160°°	47.7		1,750	15.6	15.5	0.0	8.3	3.3	9,330	19.5	5.5	469.1	0.02	6.5	27.1	44.6
B_500m_160°	47.2		1,760	24.9	15.6	0.1	9.4	3.6	12,200	30.0	6.4	932.2	0.03	9.9	38.8	67.8
B_250m_160°	48.1		1,740	23.2	14.2	0.1	8.9	2.7	12,700	24.9	5.9	741.2	0.02	7.5	39.6	52.5
B_3000m_250°	49.1		1,900	22.1	9.7	0.1	7.4	2.1	11,000	22.1	5.8	726.0	0.02	6.5	31.7	40.1
B_1500m_250°	45.3		2,190	16.5	21.1	<0.04	9.4	3.2	10,400	19.4	6.2	380.6	0.02	7.2	29.3	73.2
B_1000m_250°	49.7		2,030	25.8	28.1	0.1	9.6	2.9	13,000	28.9	6.1	808.7	0.02	7.4	40.1	36.6
B_500m_250°	49.3		2,980	29.0	20.5	0.1	9.4	3.4	14,600	25.0	9.1	883.4	0.04	9.1	43.4	56.7
B_250m_250°	47.6		2,620	26.5	28.6	0.1	9.0	3.8	14,600	16.3	7.5	523.2	0.02	7.6	36.8	32.7
B_3000m_70°	46.9		2,130	18.9	17.9	0.1	8.3	2.3	10,600	19.3	6.1	661.6	0.03	6.0	28.7	38.6

Station	Depth (m)	Distance from Nearest Well (m)	Al	As	Ba	Cd	Cr	Cu	Fe	Pb	Li	Mn	Hg	Ni	V	Zn
Key																
Above UKOOA SNS 50th %ile (UKOOA, 2001)			Above UKOOA SNS 95th %ile (UKOOA, 2001)			Above NOAA ERL (Buchman, 2008)			Above NOAA ERM (Buchman, 2008)			Above Cefas Cal1 (MMO, 2015)		Above Cefas Cal2 (MMO, 2015)		
B_1500m_70°	47.3		2,340	46.1	19.2	0.1	10.6	3.2	12,000	24.6	6.7	1,438.0	0.02	10.0	50.8	34.2
B_1000m_70°	47.7		2,090	19.0	28.3	<0.04	8.0	2.1	11,900	20.3	6.0	490.8	0.01	5.5	29.0	39.6
B_500m_70°	48.3		2,010	13.6	12.3	<0.04	5.5	1.7	11,400	15.4	5.7	428.8	0.01	4.4	20.7	24.7
B_250m_70°	48		43,200	30.7	79.6	0.0	11.1	3.3	20,800	15.5	14.2	714.7	0.01	10.0	34.4	27.7
Mean			3,931	24.4	22.3	0.1	9.2	2.8	12,922	22.9	6.7	708.4	0.02	7.3	35.2	41.9
SD			8,781	10.3	15.3	0.0	1.8	0.5	3,433	7.4	2.2	323.7	0.01	1.6	8.9	13.1
CV (%)			223	42.2	68.9	34.9	19.9	18.7	26.6	32.4	32.1	45.7	33.6	21.4	25.2	31.3
Abbey to Baker Pipeline Route (GEOxyz, 2025a)																
ES1	44.6	814.4	5,070	32.3	83.3	0.08	13.6	6.4	21,600	21.1	12.7	743.0	0.02	11.0	40.2	37.4
ES2	45.1	730.2	2,950	19.2	49.6	0.05	10.1	3.1	12,400	17.3	7.2	424.3	0.01	6.7	30.7	23.7
ES3	46.8	1402.0	2,420	13.5	24.0	<0.04	8.6	2.3	9,630	14.9	5.8	307.5	0.01	5.2	24.1	20.1
ES4	46.6	1215.4	3,240	20.1	46.8	<0.04	9.5	3.8	14,800	16.7	7.8	479.3	<0.01	7.4	32.8	24.3
ES5	46.4	1359.7	6,280	32.7	82.2	0.05	14.9	6.1	25,000	23.1	18.2	694.8	0.02	13.6	46.4	38.9
ES6	46.6	1538.8	4,280	28.5	71.9	0.05	12.0	3.8	22,000	20.7	10.7	622.4	0.01	9.6	39.0	30.1
ES7	46.8	1823.6	3,790	26.2	44.5	0.05	11.3	3.4	16,400	21.8	9.6	703.9	0.01	8.0	38.0	28.7
ES8	47.1	1807.9	3,820	20.0	51.7	0.04	11.4	3.8	14,600	18.4	10.0	479.6	0.01	7.4	35.6	27.6
ES9	47.7	1279.3	3,910	22.9	34.2	0.04	12.0	5.3	15,300	21.5	8.0	593.9	0.01	8.1	35.7	28.2
ES10	47.8	1140.4	3,580	29.6	66.1	0.05	11.9	3.8	17,100	29.0	9.4	782.9	0.01	8.4	45.7	35.3
ES11	47.0	1067.0	3,620	22.4	35.7	0.04	10.9	4.0	14,800	20.3	8.6	525.8	0.01	8.4	35.4	29.2
ES12	47.9	888.7	4,640	37.1	61.9	0.07	13.6	8.3	21,100	30.2	11.9	1053.0	0.04	10.5	52.5	44.2
ES13	48.1	819.9	3,610	29.4	27.0	0.05	10.9	3.4	16,500	30.7	8.8	843.9	0.02	8.2	42.9	33.5
ES14	47.8	858.2	3,140	24.0	41.1	0.04	10.3	3.0	14,700	24.9	7.6	687.5	0.02	7.4	35.9	30.5
ES15	47.4	432.7	2,380	15.1	38.1	<0.04	9.6	2.7	10,200	14.8	5.3	339.7	0.01	5.8	25.0	22.0
ES16	47.8	265.0	2,440	19.2	21.0	<0.04	9.4	2.8	11,900	21.2	5.8	613.3	0.01	6.2	29.9	25.6
ES17	47.6	1389.4	3,170	26.5	35.4	0.05	11.0	3.0	16,000	26.4	7.7	737.5	0.01	7.6	41.7	32.5
ES18	47.2	1641.8	2,970	21.5	39.2	0.05	9.6	2.9	13,300	20.6	7.4	694.6	<0.01	7.1	33.2	25.9

Station	Depth (m)	Distance from Nearest Well (m)	Al	As	Ba	Cd	Cr	Cu	Fe	Pb	Li	Mn	Hg	Ni	V	Zn
Key																
Above UKOOA SNS 50th %ile (UKOOA, 2001)			Above UKOOA SNS 95th %ile (UKOOA, 2001)			Above NOAA ERL (Buchman, 2008)			Above NOAA ERM (Buchman, 2008)			Above Cefas Cal1 (MMO, 2015)			Above Cefas Cal2 (MMO, 2015)		
Mean			3,628	24.5	47.4	0.05	11.1	4.0	15,963	21.9	9.0	629.3	0.01	8.1	36.9	29.8
SD			989	6.3	18.8	0.01	1.7	1.6	4,161	4.8	3.0	184.4	0.01	2.0	7.3	6.3
CV (%)			27.3	25.9	39.6	22.50	15	39.0	26.1	22.0	33.7	29.3	56.62	24.7	19.9	20.9
Reference Levels																
UKOOA SNS 50th %ile (UKOOA, 2001)			-	-	26.0	0.03	6.5	2.0	5,129	6.0	-	-	0.02	4.0	14.7	12.2
UKOOA SNS 95th %ile (UKOOA, 2001)			-	-	272.4	0.72	44.8	13.9	18,555	21.0	-	-	0.05	21.5	35.8	35.8
OSPAR (2014) / NOAA (Buchman, 2008) ERL			-	8.2	-	1.2	81	34	-	46.7	-	-	0.15	20.9	-	150
NOAA ERM (Buchman, 2008)			-	70	-	9.6	370	270	-	218	-	-	0.71	51.6	-	410
Cefas cAL1 (MMO, 2015)			-	20	-	0.4	40	40	-	50	-	-	0.3	20	-	130
Cefas cAL2 (MMO, 2015)			-	100	-	5	400	400	-	500	-	-	3	200	-	800

* Stations sampled during BOTH Fugro, 2022 and GEOyxz, 2023b (Fugro station name is in brackets) (GEOxyz, 2023b data has been used due to complete sampling during the Fugro, 2022 survey).

4.2.3 Hydrography and Metocean Conditions

Currents and Tides

The waves in the North Sea occur as a result of long period swells from the northern North Sea (NNS) and North Atlantic, and also from locally generated storms. The wave cycle in the SNS is seasonal with maximum wave heights occurring during the winter (January) (DESNZ, 2022).

Water circulation in the SNS tends to be in a south easterly direction along the coast towards the English Channel. In the vicinity of the Abbey & Baker Development the major residual current flow is to the east (DESNZ, 2022). The shallow bathymetry and relatively fast water circulation in this area of the SNS lead to a relatively well-mixed water column throughout the year. This leads to a consistent level of biological productivity throughout the year, with only minor peaks seen in spring and late summer, which are typical of deeper waters (DESNZ, 2022).

The Flamborough head frontal system is located to the north of the Abbey & Baker Development. The Flamborough head frontal system is defined by the distinct temperature gradient between the waters to the north and south of Flamborough Head, where mixing of the warmer waters of the SNS and the cooler waters of the NNS occurs. The subsequent upwelling allows nutrients from deeper, colder waters to be transported to the surface, creating an increased primary biomass production in this area (DEFRA, 2015).

Modelled data indicates maximum tidal rates are 0.073 metres per second (m/s) and 0.593 m/s for neap and spring peak flows respectively (ABPMer, 2008).

Significant Wave Height

Annual mean significant wave height in the vicinity of the proposed Abbey & Baker Development area ranges from 1.21 m to 1.50 m (NMPi, 2026).

Wind Regime

Although offshore winds may blow from any direction, the wind regime in the SNS is dominated by winds from between south and north-west. Easterly winds are uncommon (DESNZ, 2022). Winds speeds in summer are generally between 1 to 11 m/s, becoming stronger in winter when a greater proportion of strong to gale force winds, 14 to 32 m/s, is encountered (DESNZ, 2022).

Temperature and Salinity

The SNS is less saline than the NNS due to receiving significant freshwater input from rivers along its eastern boundary. Saline water of North Atlantic origin enters the SNS via the Dover Straits, and this tends to lead to generally more salty water in the most southerly parts of the North Sea.

Both annual mean surface salinity and annual mean near seabed salinity in the vicinity of the proposed Abbey & Baker Development range from 34.2 parts per thousand (‰) to 34.6‰ (NMPi, 2026). Annual mean surface temperatures in the vicinity of the proposed Abbey & Baker Development range from 5°C to 15°C, while annual mean near seabed temperatures range from 5°C to 14°C (NMPi, 2026).

4.2.4 Climate Change and GHG Emissions

The DESNZ supplementary guidance for assessing the effects of downstream scope 3 emissions on climate from offshore oil and gas projects (DESNZ, 2025a), requires a global baseline scenario of greenhouse gases to be presented in the ES.

Over recent decades, scientific consensus has confirmed that the Earth's climate is undergoing significant change, largely driven by anthropogenic GHG emissions (IPCC, 2019a; IPCC, 2023a; WMO, 2019; WMO, 2025; WMO, 2026; UNEP; 2025).

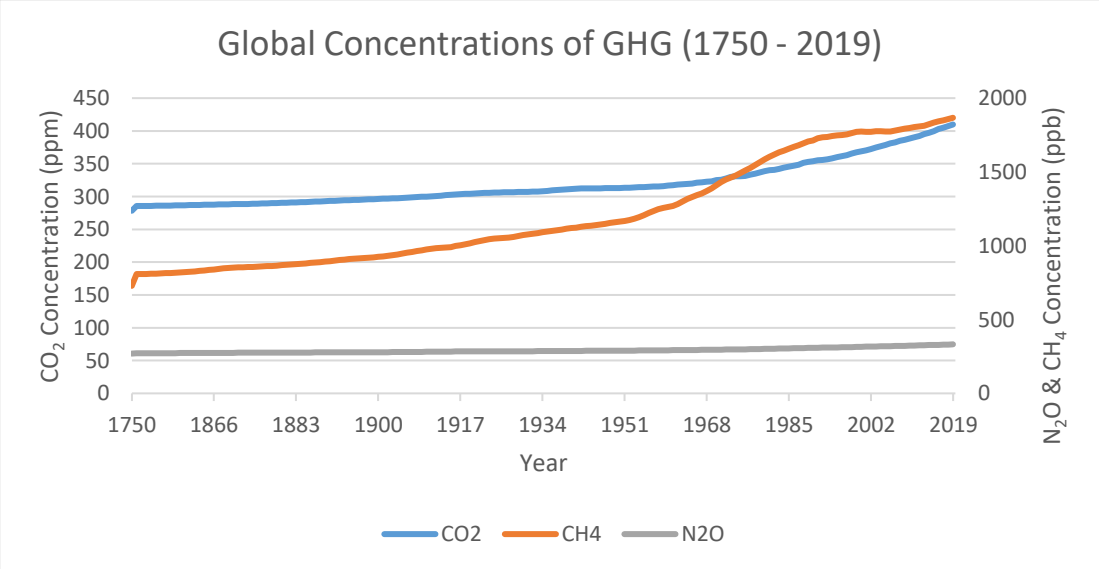
A variety of robust up-to-date data sources have been examined for this section of the ES to characterise the current state of global GHG emissions in the atmosphere (expressed in CO_2e)[1] where available), analyse historical trends, review effects and look at future projections, including:

- Intergovernmental Panel on Climate Change (IPCC) – Sixth Assessment Report 'AR6' (IPCC, 2023a);
- United Nations Environment Programme (UNEP) – Emissions Gap Report 2025 (UNEP, 2025);
- Emissions Database for Global Atmospheric Research (EDGAR) (EDGAR, 2025);
- World Meteorological Organization (WMO) – WMO Greenhouse Gas Bulletin (WMO, 2023);
- World Meteorological Organization (WMO) – State of the Global Climate 2025 (WMO, 2026)
- National Oceanic and Atmospheric Administration (NOAA) – Global Monitoring Laboratory measurements (Lan et al., 2025);
- Indicators of Global Climate Change 2024 (Forster et al., 2025).

Global GHG Emissions – Current Status, Trends and Effects

Since 1850, human activities, including the combustion of fossil fuels, land-use change, and industrial activity have resulted in rapidly increasing concentrations of GHGs in the atmosphere, most notably Carbon Dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Figure 4.10). Global mean concentrations for well-mixed GHGs (CO_2, CH_4 and N_2O) in 2019 correspond to increases of about 47%, 156%, and 23%, respectively, above the levels in 1750 (representative of the pre-industrial era) (high confidence) (IPCC, 2023a). This has unequivocally caused global warming.

Figure 4.10: Global GHG Emissions from 1750 to 2019[1]



[1] Data obtained from IPCC (2023b) Working Group 1 (WG1) Sixth Assessment Report (AR6) Annex III Extended Data

Over the past two decades (2000–2020), CO_2 emissions to the atmosphere from the burning of fossil fuels generally have risen year-on-year, starting at 6.8 petagrams (Pg) of carbon[2] per year in 2000 and reaching a maximum of 10.1 Pg of carbon in 2019 (Jacobson, 2023). The global annual average CO_2,

[1] CO_2e is a metric used to express the impact of different greenhouse gases in terms of the amount of carbon dioxide that would produce the same global warming effect.

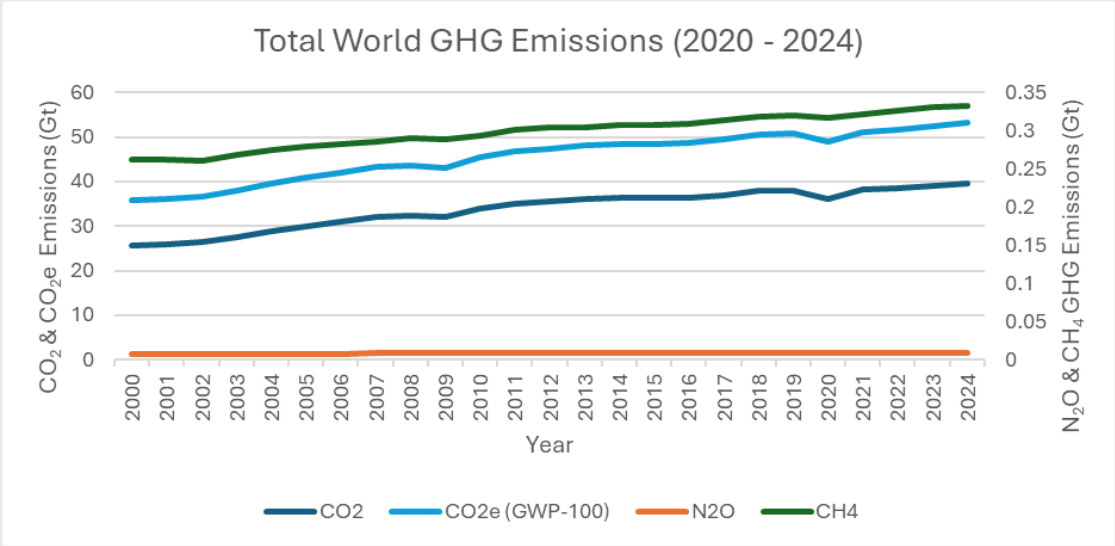
[2] One petagram of carbon is equal to one billion metric ton of carbon or 3.67 billion metric tons of CO_2.

CH_4, and N_2O concentrations all reached a new observed high in 2024, the latest year for which consolidated global figures are available (WMO, 2026).

Over the period 2014–2023, it is estimated that the annual release rate of GHG emissions into the atmosphere averaged 53.6 ± 5.2 Gt CO_2e per year (Forster et al., 2025), with the latest data from EDGAR (2025) indicating that 53.2 Gt CO_2e was released in 2024 (Figure 4.11; EDGAR, 2025). In 2024, global energy-related GHG emissions reached 42.6 Gt CO_2e (IEA, 2025).

In 2024, global GHG emissions set a new record of ca. 57.7±5.5 gigatons (Gt)[3] CO_2e (UNEP, 2025), a 2.7% increase from 2023 levels (56.2±5.2 $GtCO_2e$), with power generation was the largest contributor in 2024 at 15.6 $GtCO_2e$, followed by transport (8.4 $GtCO_2e$) and industry (i.e. fossil fuel combustion to drive on-site industrial processes, such as heating furnaces) (6.5 $GtCO_2e$). Emissions grew across most sectors in 2024, but growth was particularly pronounced in international aviation (+6.3%), continuing the rebound of the sector since the COVID-19 pandemic (UNEP, 2025).

Figure 4.11: Total Global GHG Emissions by CO_2, N_2O, CH_4 and CO_2e (GWP-100 'AR5') [1]



[1] Data obtained from EDGAR (2025) GHG total datasets (1974 – 2024), represented to show Gt of GHG, manipulated from base unit of Gg, to show period 2000 – 2024 (the past two decades).

The Global Monitoring Laboratory (GML) of NOAA measures the atmospheric distribution and trends of CO_2, CH_4 and N_2O. In 2024, global average atmospheric CO_2 was 422.79 parts per million (ppm), a new record high, up from 419.36 ppm in 2023. The 3.72 ppm increase during 2024 was the largest one-year increase on record (Lan et al., 2025; Lindsey, 2025). New record highs were also set in 2024 for global average atmospheric CH_4 and N_2O at 1,929.85 parts per billion (ppb) and 337.72 ppb, respectively (Lan et al., 2025).

The effects of climate change have been observed both quantitatively, i.e. global mean surface temperature rise, sea level rise, ocean heat content, sea ice extent; and qualitatively, i.e. coral bleaching, extreme weather patterns, seasonal shifting, and migratory species changes (IPCC, 2023a; 2019a; 2019b). The WMO confirms that 2015–2025 were the hottest eleven years on record, with 2025 reaching approximately 1.43°C above the 1850–1900 baseline, and that Earth's energy imbalance is now at its highest in the sixty-five-year observational record (WMO, 2026). Over the past two decades, the rate of ocean warming has increased to 0.66 ± 0.10 watts per square metre (W/m^2), with global mean sea level increasing by 0.20 m between 1901 and 2018 (IPCC, 2023a; IOC-UNESCO, 2024). The ocean has also absorbed enough CO_2 to lower its pH by 0.1 units, a 30% increase in acidity (Lindsey, 2025), which has further harmed biodiversity, ecosystems, and food production from shellfish aquaculture and fisheries (WMO, 2026). Rising global temperatures have increased the frequency and severity of extreme weather events, including heatwaves, floods, droughts, wildfires, and storms

[3] One gigaton is equivalent to one billion metric tons (1,000,000,000 tons)

(UNEP, 2025; WMO, 2026), including hurricane Melissa in 2025, the second most intense on record in terms of peak 1-min sustained winds (190 mph) (NOAA, 2025).

Projected Global GHG Emissions and Possible Future Climate Scenarios

Over the life of the Abbey & Baker Development (2029 - 2044), the quantity of global GHGs affecting climate will be subject to both natural and anthropogenic change. In nearly all considered scenarios and modelled pathways, global warming is predicted to continue to increase in the near term (2021–2040) mainly due to increased cumulative CO_2 emissions (IPCC, 2023a).

The United Nations Framework Convention on Climate Change (UNFCCC) is an international agreement that commits countries to efforts to stabilise GHG concentrations to prevent dangerous, human-induced climate change. The 'COP' (Conference of the Parties) is the main decision-making body of the UNFCCC. In 2015, COP21 created the Paris Agreement, a global treaty that commits countries to limit global average temperature to well below 2°C above preindustrial levels and pursuing efforts to limit temperature increase to 1.5°C above preindustrial levels. At the heart of the Paris Agreement are NDCs, which embody efforts by each country to reduce national emissions and adapt to the impacts of climate change.

The Paris Agreement's Global Stocktake (GST) process is designed to evaluate progress on climate action at the global level every five years. The first-ever GST, which concluded at COP28 in December 2023, highlighted that whilst progress has been made since the Paris Agreement — global temperatures are now expected to rise by 2.4-2.6°C by the end of the century, compared to 3.7-4.8°C in 2010 – the world is not on track to limit global warming to 1.5°C (CCC, 2024). It concluded that to keep 1.5°C in reach, deep rapid and sustained reductions in global GHG emissions are required (43% by 2030 and 60% by 2035 from 2019 levels, aiming for net zero CO2 by 2050). Records show that 2024 was the first calendar year that the average global temperature exceeded 1.5°C above its pre-industrial level (EU Copernicus, 2025).

The GST process was informed by the IPCC AR6 cycle, completed in July 2023. AR6 defines a core set of five illustrative Shared Socio-economic Pathways (SSP) scenarios combined with Representative Concentration Pathways (RCP) scenarios – SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5. These scenarios combine baseline socio-economic narratives (the SSPs; SSP1 to SSP5[4]), which incorporate assumptions about future socioeconomic developments (e.g. population growth, economic trends, and technological advancements), with different emissions trajectories informed by the RCP scenarios[5] which impose a level of radiative forcing in 2100, corresponding to a related level of global warming (refer to Table 4.3).

[4] Five pathways have been developed by the international scientific community – sustainable development (SSP1), middle-of-the-road development (SSP2), regional rivalry (SSP3), inequality (SSP4) and fossil-fuelled development (SSP5).

[5] RCP scenarios were defined in the IPCC's fifth assessment reporting cycle (AR5) and show how GHG concentrations can affect global temperatures. For example, RCP 8.5 represents a high-emissions pathway, while RCP 2.6 assumes strong mitigation efforts.

Table 4.3: Shared Socioeconomic Pathways and Changes in Global Surface Temperatures (IPCC, 2023a; 2023b)

GHG Emissions Scenario [1]	Description	Change in Global Surface Temperature (°C)[2] Best Estimate [and very likely range]			Key Assumptions
		Near term (2021 – 2040)	Mid-term (2041 – 2060)	Long-term (2081 – 2100)	
SSP1-1.9 (Very Low)	limit warming to 1.5°C (>50%) with no or limited overshoot	1.5 [1.2 to 1.7]	1.6 [1.2 to 2.0]	1.4 [1.0 to 1.8]	Rapid decarbonisation, societies switch to more sustainable practices, inequality falls. Net zero CO_2 achieved in ca. 2050.
SSP1-2.6 (Low)	limit warming to 2°C (>67%)	1.5 [1.2 to 1.8]	1.7 [1.3 to 2.2]	1.8 [1.3 to 2.4]	Socioeconomic shifts towards sustainability, but reduction in CO_2 emissions is slower than SSP1-1.9. Net zero CO_2 achieved in ca. 2070.
SSP2-4.5 (Intermediate)	limit warming to 3°C (>50%)	1.5 [1.2 to 1.8]	2.0 [1.6 to 2.5]	2-7 [2.1 to 3.5]	Current policies continue. Slow progress toward sustainability and development and income grow unevenly. CO_2 emissions hover around current levels before starting to fall mid-century. Net zero CO_2 is not achieved by 2100.
SSP3-7.0 (High)	limit warming to 4°C (>50%)	1.5 [1.2 to 1.8]	2.1 [1.7 to 2.6]	3.6 [2.8 to 4.6]	Fragmented, high fossil use, inequality. CO_2 emissions roughly double from current levels by 2100
SSP5-8.5 (Very High)	exceed warming of 4°C (>50%)	1.6 [1.3 to 1.9]	2.4 [1.9 to 3.0]	4.4 [3.3 to 5.7]	Rapid economic growth without mitigation, fuelled by exploiting fossil fuels and energy-intensive lifestyles. Current CO_2 emissions roughly double by 2050.

[1] Scenarios relate to SSPs + "forcing", where the number refers to the radiative forcing level in W/m² in the year 2100. For example, 'SSP1-1.9' is a scenario that combines SSP1 with 1.9 W/m² radiative forcing in 2100 (RCP1.9)
[2] Temperature differences relative to the average global surface temperature of the period 1850-1900.

Predicted Effects of Climate Change Over the Life of the Development (pre-2050)

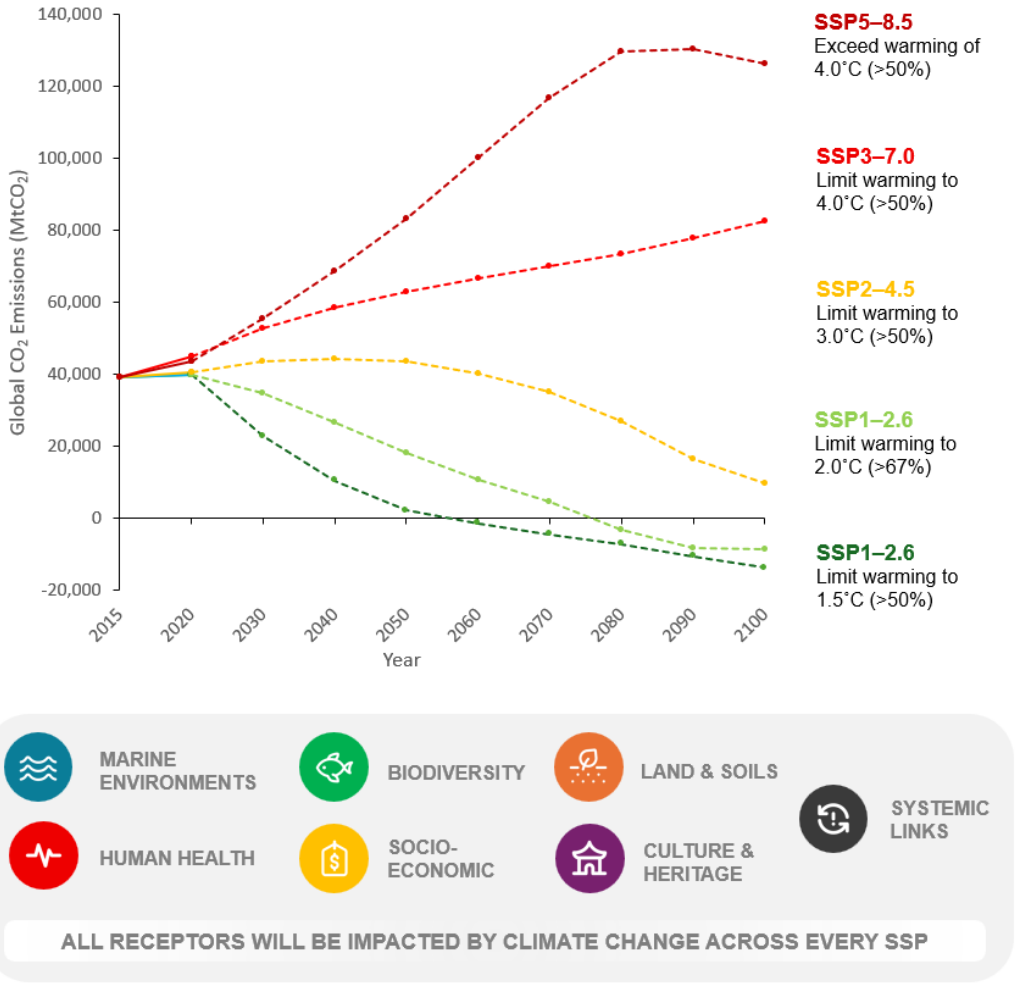
Across all SSP scenarios, near-term warming trajectories converge, meaning the severity of pre-2050 impacts is broadly comparable between SSP scenarios for most receptor groups.

- **Marine environments:** Sea surface temperatures continue to rise under all scenarios, with marine heatwave frequency increasing materially pre-2050 (IPCC, 2021a). Ocean acidification continues to intensify as the ocean absorbs anthropogenic CO_2, with surface pH decline affecting calcifying organisms including corals, molluscs and echinoderms (IPCC, 2019a; Doney et al., 2020). Upper ocean stratification restricts vertical nutrient supply, suppresses primary productivity and weakens the biological pump underpinning oceanic carbon sequestration (IPCC, 2021a). Under the high and very high emission scenarios (SSP3-7.0 and SSP5-8.5), mass coral bleaching and mortality, regional fisheries collapse and kelp forest loss are projected pre-2050 (IPCC, 2022a). Sea level rises of between 0.15–0.29 m relative to 1995–2014 is projected by 2050, depending on the SSP scenario (IPCC, 2023c).
- **Biodiversity:** Climate-driven biodiversity pressures compound non-climate stressors including land-use change, deforestation, pollution and overexploitation across all scenarios pre-2050 (IPCC, 2022a; 2023c). Marine species are already shifting poleward at an average rate of 59 km per decade in response to rising sea temperatures (ibid.), and ocean deoxygenation continues to expand. Under the intermediate, high and very emissions scenarios (SSP2-4.5, SSP3-7.0 and SSP5-8.5), species extinction risk and distribution disruption intensify at every increment of warming (Pörtner et al., 2021).
- **Soils and Land:** Land degradation and climate change interact in a mutually reinforcing cycle pre-2050 across all scenarios: degraded land loses its capacity to absorb carbon, accelerating warming, which in turn exacerbates degradation through drought, desertification, erosion and wildfire (IPCC, 2019a; 2023a). Water-driven soil erosion increases in dryland areas under all scenarios, reducing soil organic carbon and the fertility base for food production (ibid.). Under the high and very high emission scenarios (SSP3-7.0 and SSP5-8.5), elevated evapotranspiration, decreased relative humidity and increased net radiation drive agricultural and ecological droughts in some regions pre-2050 (IPCC, 2021b; 2023a).
- **Human Health:** Climate change acts as a pervasive and indirect health threat pre-2050 under all scenarios, amplifying exposure to heat stress, vector-borne diseases, food and water insecurity, and climate-sensitive infections (IPCC, 2022a; Patz et al., 2005; McMichael et al., 2006).
- **Socio-economic:** More than one billion people in low-lying coastal cities and settlements are projected to face coastal-specific climate hazards by 2050 regardless of the SPP scenario (IPCC, 2022a). Under the intermediate, high and very high emissions scenarios (SSP2-4.5, SSP3-7.0 and SSP5-8.5), compound extreme events — including concurrent heatwaves, droughts, compound flooding and storm surge — drive escalating disruption to supply chains, infrastructure and coastal assets (IPCC, 2021a).
- **Cultural Heritage and Landscape:** Climate change is the fastest-growing threat to UNESCO World Heritage sites, with one in six cultural heritage sites globally already threatened by flooding, coastal erosion, wildfires and increased storminess (UNESCO, 2023). These pressures continue and intensify pre-2050 under all SSP scenarios. In addition, climate-driven displacement and migration begin to threaten intangible cultural heritage including oral traditions and traditional ecological knowledge particularly where communities are forced to relocate (UNESCO, 2023; IPCC, 2022a).
- **Tipping Points and Systemic Links:** Compound extreme events including concurrent heatwaves and droughts, compound flooding and fire weather conditions continue to intensify pre-2050 across all SSP scenarios (IPCC, 2021a). Under high and very high emission scenarios (SSP3-7.0 and SSP5-8.5), permafrost thaw feedback and elevated tipping point risk begin to compound direct warming effects pre-2050 (IPCC, 2019a; Lenton et al., 2019; IPCC, 2023c).

Predicted Effects of Climate Change post-2050 (Post Development Lifecycle)

Post-2050, the gap between low and high emission pathways widens substantially across all receptor groups, driven by the compounding effects of cumulative emissions, system feedbacks and the irreversibility of many climate-driven changes. Under the very low and low emissions scenarios (SSP1-1.9 and SSP1-2.6), warming stabilises and begins to decline; however for the intermediate, high and very high emissions scenarios (SSP2-4.5, SSP3-7.0 and SSP5-8.5), impacts become more catastrophic and more irreversible the higher the SSP (see Figure 4.12).

Figure 4.12: Graph Illustrating the Impacts of Climate Change across different SPP Pathways



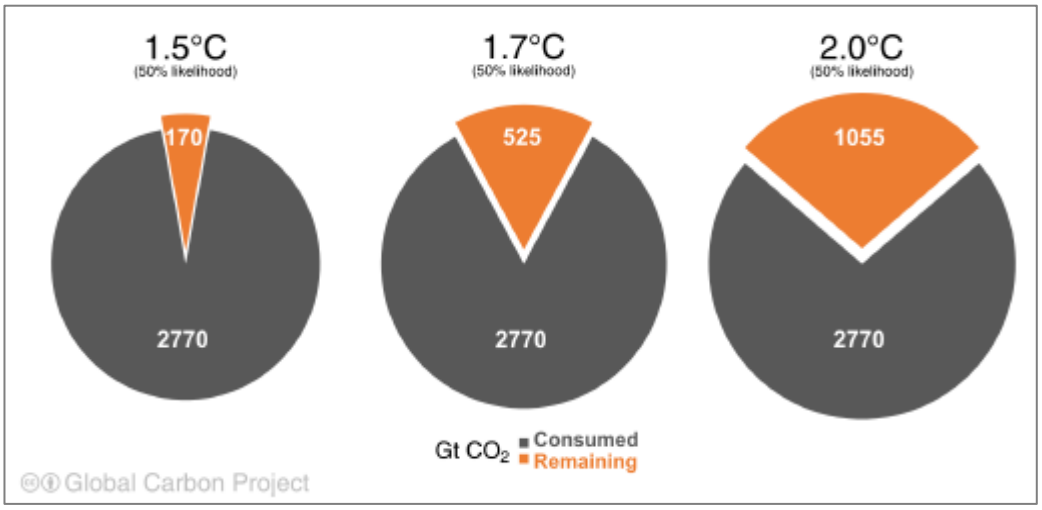
Climate impacts converge pre-2050 across all scenarios. Coastal hazards, heat mortality, and biodiversity loss intensify regardless of emissions and SSP pathway. Post-2050, low pathways stabilise while high pathways trigger tipping points, marine and terrestrial ecosystem damage, and coastal risks. Data source adapted from Riahi et al., 2017 – built on IPCC (2022), IPCC (2023) SSPs.

Remaining Global Carbon Budget

The Global Carbon Project (a Global Research Project of Future Earth and a research partner of the World Climate Research Programme established in 2001) produces an annual Global Carbon Budget (GCB), which tracks the trends in global carbon emissions and sinks and is a key measure of the progress towards the goals of the Paris Agreement. The 2024 GCB projected fossil CO_2 emissions of 37.4 Gt CO_2[6], up 0.8% from 2023 and concludes that there are no clear signs that the world has reached a peak in fossil CO_2 emissions. This was confirmed again in GCP (2025), the 2025 GCB projected fossil CO_2 emissions of 38.1 Gt CO_2, up 1.1% from 2024.

If current trends continue, the remaining global carbon budget for a 50% likelihood to limit global warming to 1.5°C, 1.7°C and 2°C has respectively been estimated at 170 Gt CO_2 (~27% lower than previous year (235 Gt CO_2; GCP, 2024)) (which would be exceeded in 4 years at 2026 emissions levels), 525 Gt CO_2 (12 years) (~10% lower than previous year (585 Gt CO_2; GCP, 2024)) and 1,055 Gt CO_2 (25 years) (~5% lower than previous year (235 Gt CO_2; GCP, 2024)) (Figure 4.13; GCP, 2025).

Figure 4.13: Remaining Carbon Budget (GCP, 2025)



[6] Global fossil CO_2 emissions include the cement carbonation sink. Cement carbonation is a process by which concrete absorbs CO2 from the atmosphere, effectively acting as a carbon sink and helping to mitigate climate change.

4.3 Biodiversity

4.3.1 Plankton

Plankton are defined as small plants (phytoplankton) and animals (zooplankton), which live freely in the water column and move passively with the water currents (Lawrence, 2000). Plankton forms a fundamental link in the food chain and vary seasonally in community structure according to temperature, water column mixing and nutrient availability.

The SNS is characterised by shallow, well-mixed waters, which undergo large seasonal temperature variations (JNCC, 2004). The region is largely enclosed by land and as a result the marine environment is highly dynamic with considerable tidal mixing and nutrient-rich run-off from the land (eutrophication). Under these conditions, nutrient availability is fairly consistent throughout the year therefore organisms with high nutrient uptake that thrive in dynamic waters, such as diatoms, are particularly successful (Margalef 1973, cited in Leterme et al., 2006).

The phytoplankton community is dominated by the dinoflagellate genus *Tripos*, along with higher numbers of the diatom, *Chaetoceros* (subgenera *Hyalochaete* and *Phaeoceros*) than are typically found in the northern North Sea (DESNZ, 2022). Phytoplankton biomass is greater than in the northern North Sea and has been increasing since the 1988 ecological shift (Edwards et al., 2020).

The zooplankton community is dominated by copepods including *Calanus helgolandicus* and *C. finmarchicus* as well as *Paracalanus* spp., *Pseudocalanus* spp., *Acartia* spp., *Temora* spp. and cladocerans such as *Evadne* spp. Commonly seen jellyfish in the region include *A. aurita* and *Chrysaora hysoscella* (Pikesley et al., 2014). However, there has been a marked decrease in copepod abundance in the SNS, which has been linked to changes in global weather phenomena (DESNZ, 2022).

4.3.2 Seabed Communities

The benthos refers to the animals (and plants where light levels are sufficient) that live on or within the seabed. Animal communities are divided at a basic level into infauna and epifauna. Infauna consists of mainly of animals that burrow into the sediment or form tubes in it, generally representing the larger component of benthic communities. Those species which live on, as opposed to in, the seabed including those attached to rocks or other animals are known as epifauna.

Habitat Classification

Data from the European Marine Observation and Data Network (EMODnet) broad-scale seabed habitat map for Europe (EUSeaMap2), indicates that the proposed Abbey & Baker Development area is located within the following European Nature Information System (EUNIS) habitat classifications (see Figure 4.14 and EMODnet, 2021; EEA, 2022):

- Offshore circalittoral sand (MD5) – these habitats are likely to be more stable than their shallower counterparts and characterised by a diverse range of polychaetes, amphipods, bivalves and echinoderms;
- Offshore circalittoral coarse sediment (MD3) – these habitats are quite diverse compared to shallower versions of this habitat and are generally characterised by robust infaunal polychaete and bivalve species.

The habitat assessment surveys undertaken for the proposed Abbey & Baker Development, as described in Section 4.1.1, used a combination of field observations, detailed review of the SSS, bathymetry, video footage, stills images and onsite review of grab samples to identify and map habitat types within the development area. Based on these datasets, the habitats observed during the surveys were broadly consistent with the predicted EUNIS classifications identified above (refer to Table 4.4).

The seabed in bands along both the eastern and western edges of the Abbey site survey area, as well as an irregular strip through the centre of the Abbey site survey area and along small sections of the Abbey to York pipeline route, was characterised by the JNCC/EUNIS habitat classification of 'Offshore Circalittoral Sand' (MD52) (Figure 4.15 and Figure 4.16; GEOxyz, 2023a; GEOxyz, 2024a).

The seabed in two large, irregularly shaped areas running through both the eastern and western halves of the Abbey site survey area and along the majority of the Abbey to York pipeline corridor was characterised by the JNCC/EUNIS habitat classification of 'Offshore Circalittoral Coarse Sediment' (MD32) (Figure 4.15 and Figure 4.16; GEOxyz, 2023a; GEOxyz, 2024a).

Smaller areas of the habitat classification of '*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment' (MC4214) were also present in the central region of the Abbey site survey area at the proposed drill centre (Figure 4.15). Due to the lack of distinct SSS or MBES signatures associated with the ground truthing camera transects across the site, an interpolation of boulder density was undertaken to aid in mapping the MC4214 habitat type (GEOxyz, 2023a).

The seabed sediment across the Baker site survey area and Abbey to Baker pipeline corridor were characterised by the JNCC/EUNIS habitat classification, 'Faunal Communities in Atlantic Offshore Circalittoral Coarse Sediment' (MD321) (Figure 4.15 (Abbey site) and Figure 4.18 (Baker to Abbey)). Based on the macrofauna data, two JNCC/EUNIS habitats were determined: 'Glycera lapidum, Thyasira spp. and *Amythasides macroglossus* in Offshore Gravelly Sand' (MD3211) and *'Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel' (MC3212) (GEOxyz, 2024c; GEOxyz, 2025b).

Further detail on the above listed habitat types are provided below.

Table 4.4: Habitat Types Observed within the Abbey & Baker Development Area (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz,2024c; GEOxyz, 2025b)

JNCC Classification	EUNIS Classification	Transects the Habitat Type Occurs Along [1]
SS.SSa.OSa Offshore Circalittoral Sand	MD52/ A5.27 Atlantic Offshore Circalittoral Sand	**Abbey Site Survey** (T11, T13, T14, TR_W06)
SS.SCS.OCS Offshore Circalittoral Coarse Sediment	MD32/A5.15 Atlantic Offshore Circalittoral Coarse Sediment	**Abbey Site Survey** (T15, T10, T09, TR_W07, TR_W08, T21, T08, TR01, T19, T16, T22_a, TR_W04, T18, T23, T17, T20, TR_W01, TR_W05, DDV04d, DDV04a, DDV05c) **Abbey to York Pipeline Route Survey** (PL_07, PL_06, PL_05, PL_04, PL_03, PL_02, PL_08, PL_01) **Baker Site Survey** (B_PWL_160°, B_PWL_70°, B_PWL_70°_A, B_250m_340°, B_500m_340° , B_1000m_340°, B_1500m_340°, B_3000m_340° , B_5000m_340° , B_250m_70°, B_500m_70° , B_1000m_70°, B_1500m_70°, B_3000m_70°, B_250m_160°, B_500m_160°, B_1000m_160°, B_1500m_160°, B_3000m_160°, B_5000m_160°, B_250m_250°, B_250m_250°_A, B_500m_250°, B_1000m_250°, B_1500m_250°, B_3000m_250°) **Baker to Abbey Pipeline Route Survey** (ES1, ES2, ES3, ES4, ES5, ES6, ES7, ES8, ES9, ES10, ES11, ES12, ES13, ES14, ES15, ES16, ES17, ES18, ES19, ES20, ES21, ES22)
SS.SMx.CMx.FluHyd *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment	MC4214/A5.444 *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment	**Abbey Site Survey** (T15, T09, T10, T12, T21, T08, TR01, T19, T16, T22_a, T18, T23, T17, T20, DDV04a, DDV04b, DDV04c, DDV04d, DDV04e, DDV04f, DDV05a, DDV05b, DDV05c)

[1] Location of transects is shown in Figure 4.2, Figure 4.3, Figure 4.4 and Figure 4.5

Figure 4.14: Predicted Seabed Habitats in the Vicinity of the Abbey & Baker Field Development

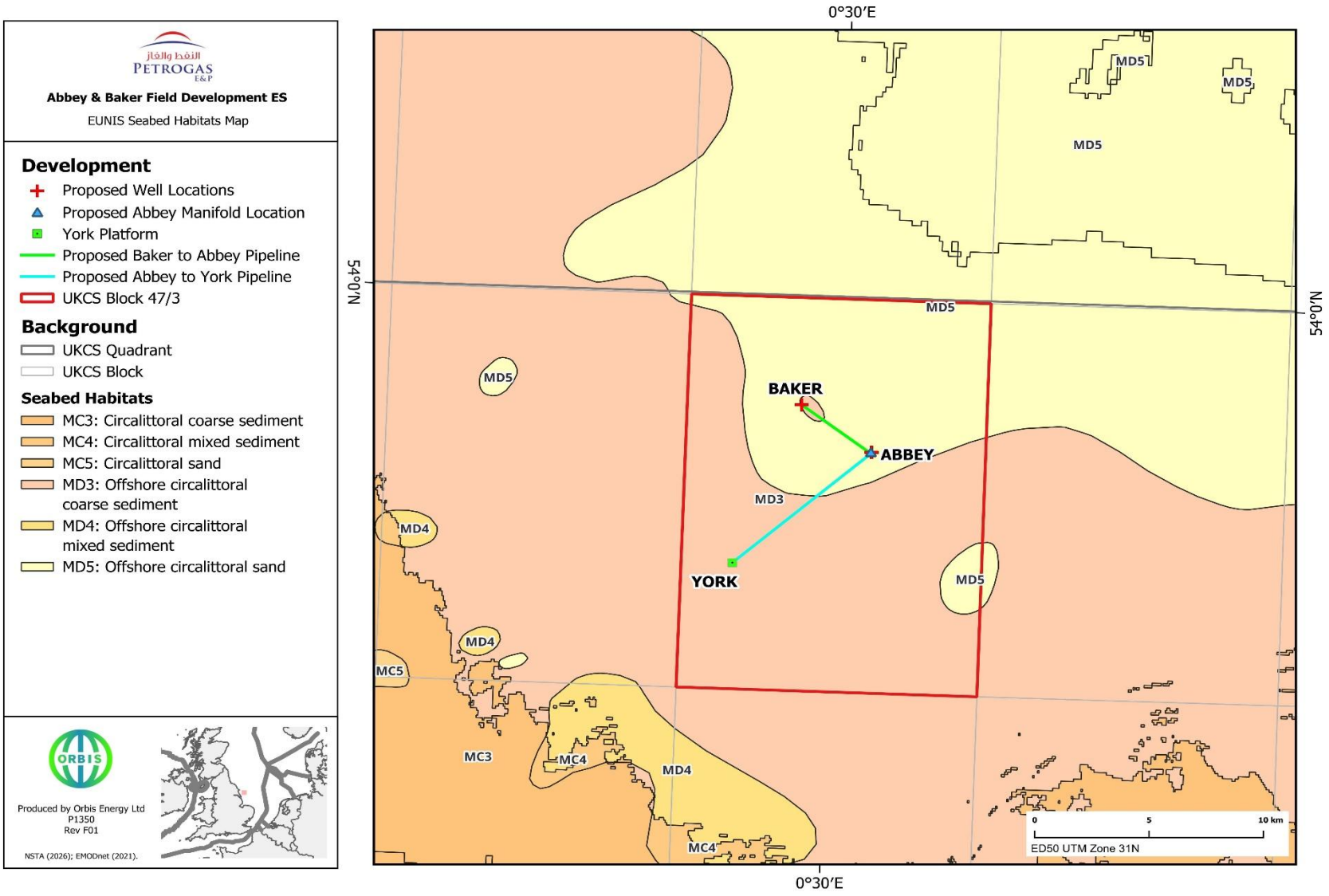
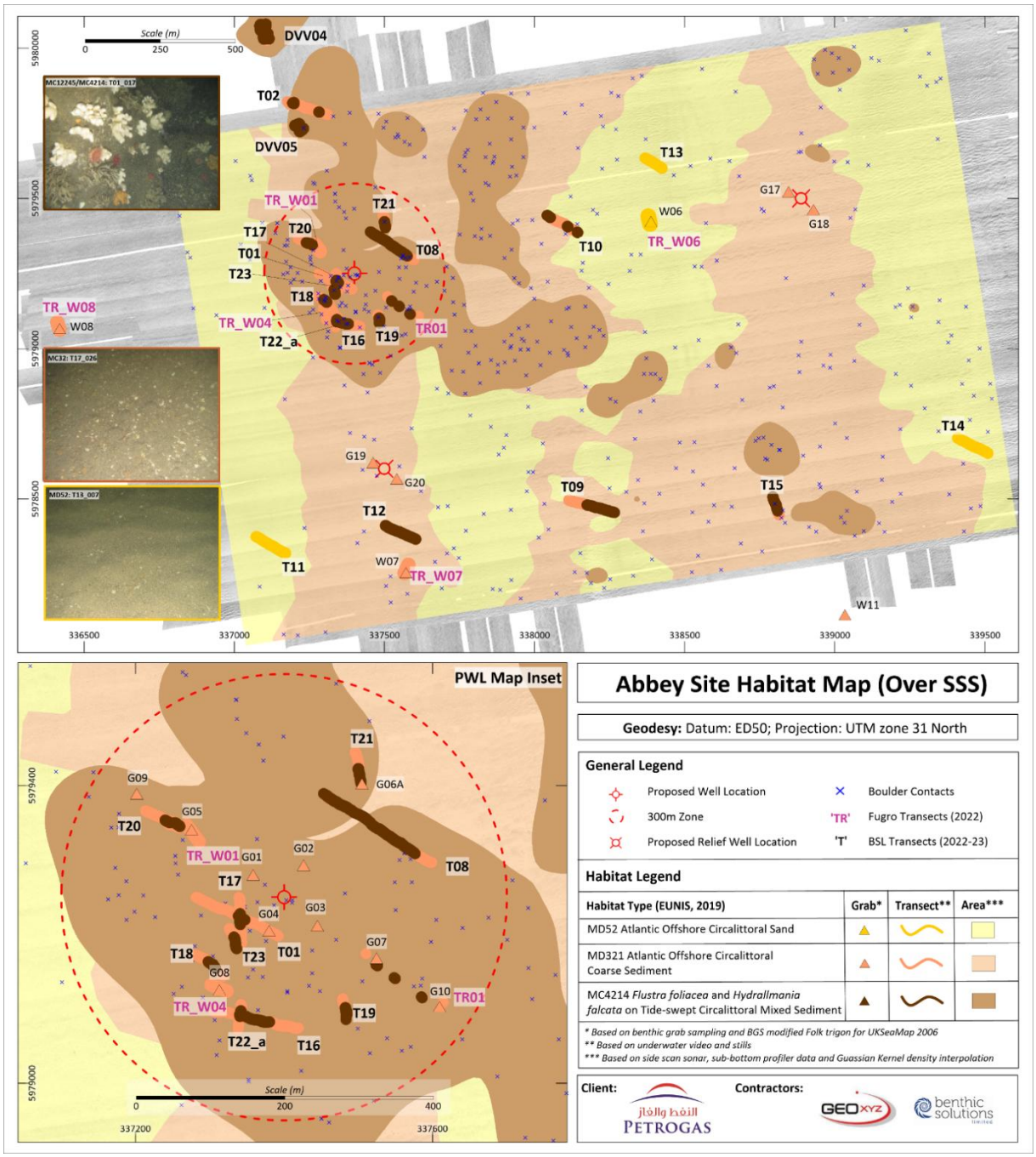


Figure 4.15: Habitat Distribution Over SSS data for the Abbey Site Survey Area (GEOxyz, 2023a)[1]



[1] The proposed drill centre represents previous drill centre which lies approximately 50m southwest of the new Proposed Drill Centre

Figure 4.16: Habitat Distribution Over SSS data for the Abbey to York Pipeline Corridor Survey Area (GEOxyz, 2024a)

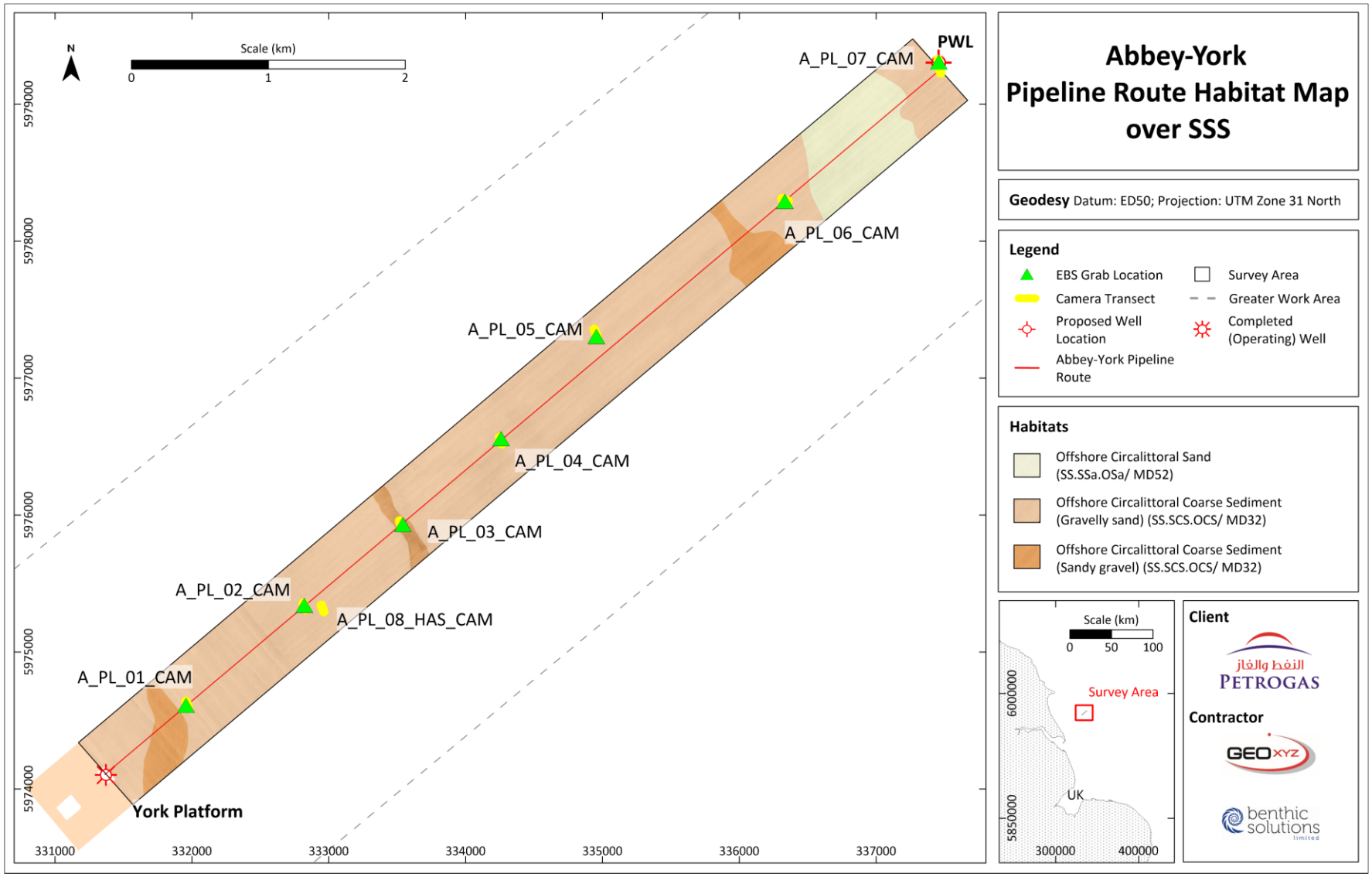
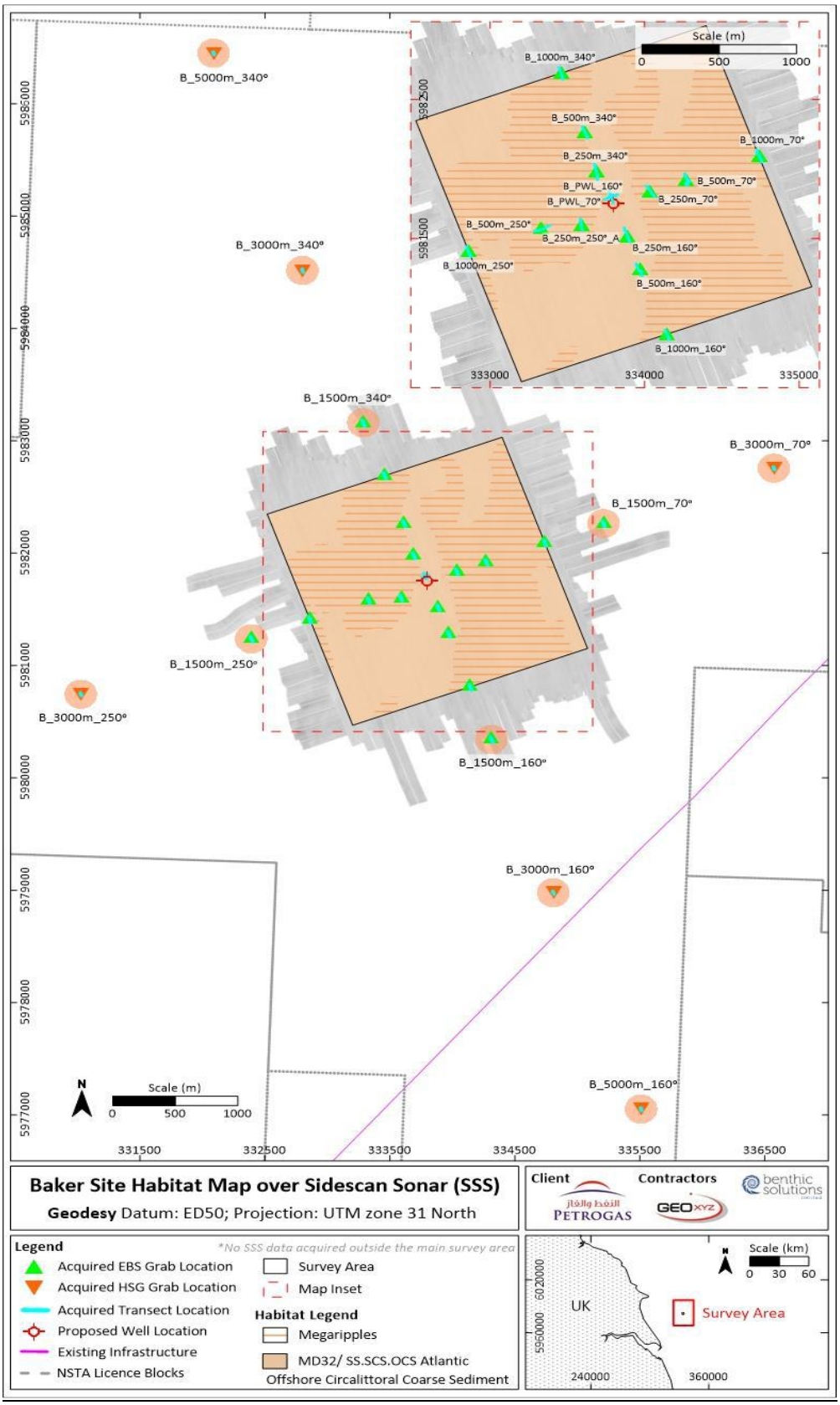


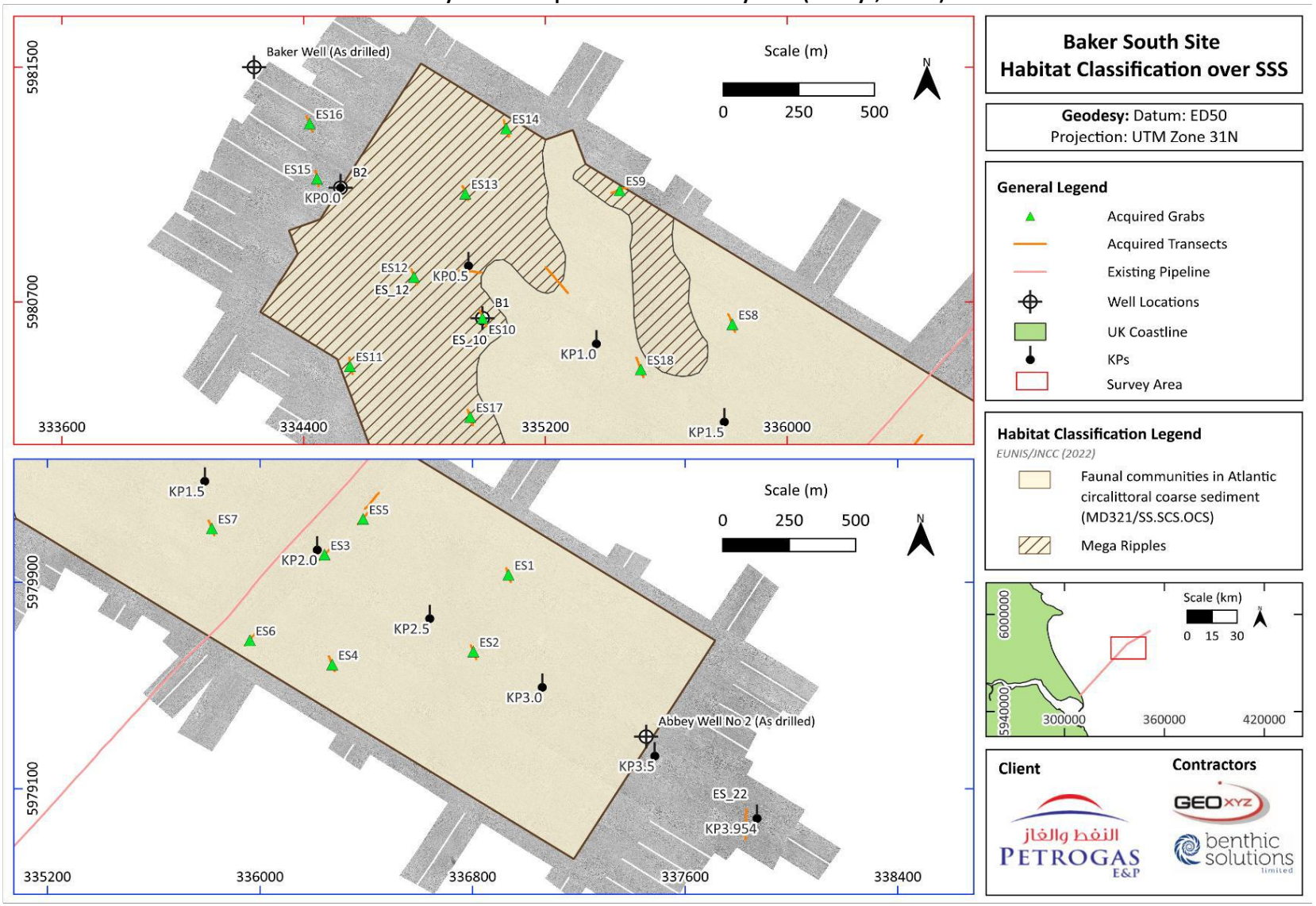
Figure 4.17: Habitat Distribution Over SSS data for the Baker Site Survey Area (GEOxyz, 2024b)[1, 2]



[1] The inset to the top left of the figure shows the Baker site survey in greater detail

[2] 'Proposed Well Location' in this figure is located ca. 629 m West Northwest of the proposed Baker Development well location for the Abbey & Baker Development

Figure 4.18: Habitat Distribution Over SSS data for the Abbey to Baker Pipeline Corridor Survey Area (GEOxyz, 2025a)



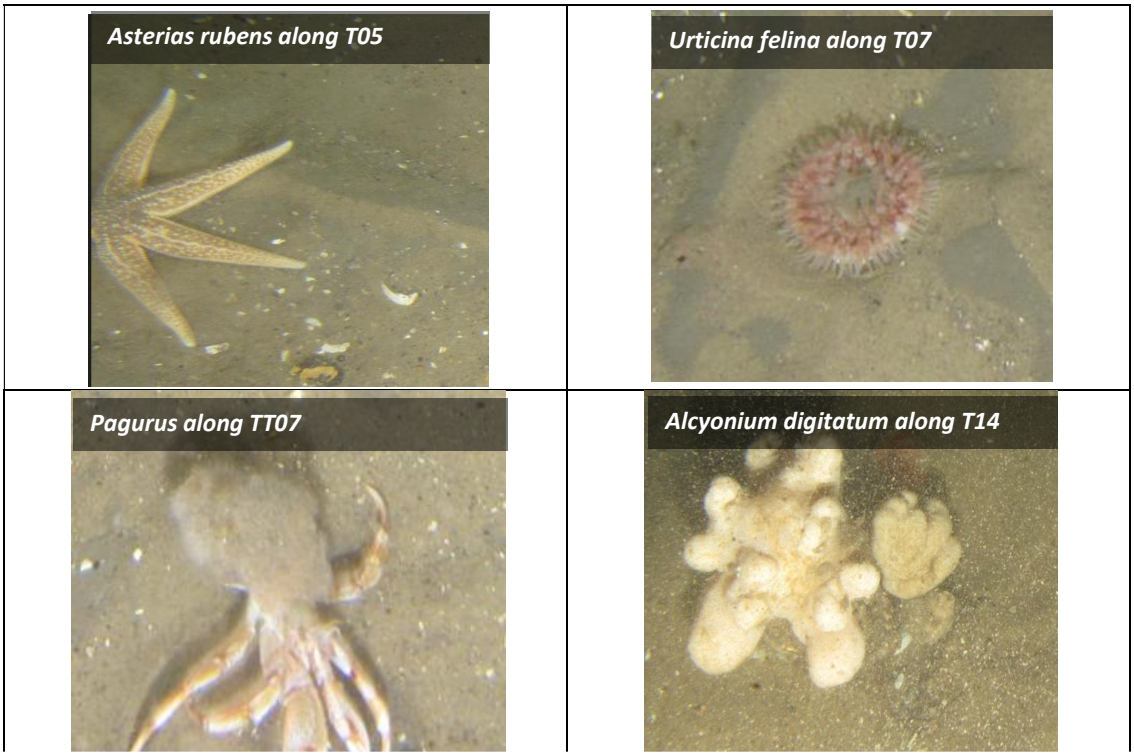
Offshore Circalittoral Sand (MD52)

Example seabed images of 'Offshore Circalittoral Sand' (MD52) from the Abbey site survey area are presented in Figure 4.19. This biotype is likely to be more stable than their shallower counterparts and characterised by a diverse range of polychaetes, amphipods, bivalves, and echinoderms (JNCC, 2022).

Fauna observed on the seabed photographs and video included starfish (*Asterias rubens*) and brittlestars (*Ophiuroidea* sp.), crabs (*Cancer Pagurus, Liocarcinus depurator*), squat and common lobsters (*Munida rugosa, Homarus gammarus*), and flatfish (*Pleuronectiformes* sp.). Sessile organisms which were infrequently attached to sub-surface stones included hydroids (*Nemertesia* sp., *Tubularia* sp.) and anthozoans (*Actiniaria* sp*., Alcyonium digitatum, Urticina felina*) (GEOxyz, 2023a).

One level five biotope exists within the 'Offshore Circalittoral Sand' habitat; '*Owenia fusiformis* and *Amphiura filiformis* in Offshore Circalittoral Sand or Muddy Sand' (GEOxyz, 2023b).

Figure 4.19: Example Conspicuous Fauna Observed in the 'Offshore Circalittoral Sand' Habitat (GEOxyz, 2023a)[N1]



[N1] T05 = 8.6 km from the proposed Abbey drill centre, T07 / TT07 = 5.7 km from the proposed Abbey drill centre, T14 = 2 km from the proposed Abbey drill centre.

Offshore Circalittoral Coarse Sediment (MD32)

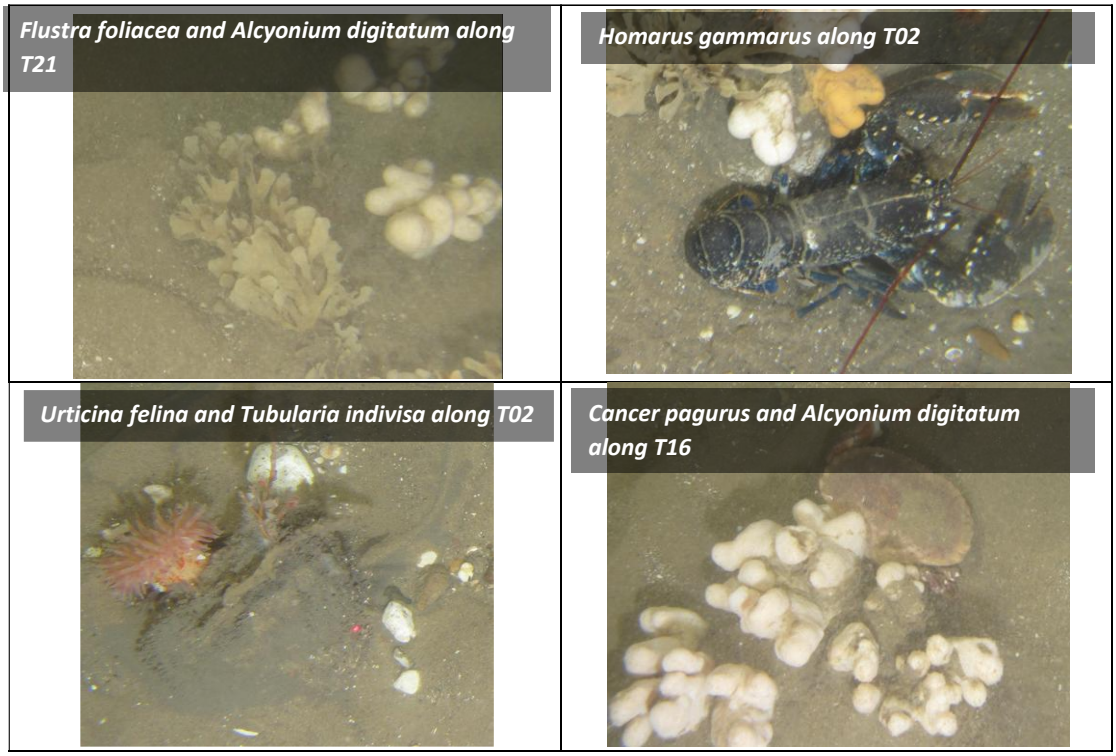
Example seabed images of 'Offshore Circalittoral Coarse Sediment' (MD32) from the Abbey site survey, Abbey to York pipeline survey, Baker site survey and Baker to Abbey pipeline survey are presented in Figure 4.20, Figure 4.21, Figure 4.22 and Figure 4.23. This biotope is quite diverse compared to shallower versions of this habitat and generally characterised by robust infaunal polychaete and bivalve species (JNCC, 2022).

Fauna observed on the seabed photographs and video were similar to the assemblages observed in the 'Offshore Circalittoral Sand' habitat but were of slightly higher diversity and abundance given the greater availability of hard substrate for colonisation. Fauna included common and squat lobsters (*H. Gammarus, Munida* sp.), topshells (*Calliostoma zizyphinum*), hydroids (N*emertesia antennina, Tubularia* sp.), starfish (*A. rubens*), brittlestars (*Ophiuroidea sp*.), and crabs (*Pagurus, Necora puber, L. depurator, C. Pagurus*). Due to the increase in hard substrate, there was a greater abundance of dead man's fingers (*A. digitatum*), Serpulidae tubes, hornwrack (*Flustra foliacea*), and dahlia anemones (*U. felina*).

The sediment characteristics and faunal records indicate a conformance towards the level four EUNIS habitat classification MD32 describing 'Atlantic Offshore Circalittoral Coarse Sediment'. The presence of cobbles and pebbles and observation of small aggregations of ross worm (*Sabellaria spinulosa*) on the cobbles and pebbles warranted further investigation in this habitat type's suitability of presence of Annex I geogenic and biogenic reef habitats (refer to the sub-section below on Potential Sensitive Habitats and Species).

Four level five biotopes were found to exist within the 'Offshore Circalittoral Coarse Sediment' habitat: '*Glycera lapidum, Thyasira* spp. and *Amythasides macroglossus* in Offshore Gravelly Sand'; '*Branchiostoma lanceolatum* in Circalittoral Coarse Sand with Shell Gravel'; '*Sabellaria spinulosa* on stable Circalittoral Mixed Sediment'; '*Mediomastus fragilis*, *Lumbrineris* spp., and Venerid Bivalves in Circalittoral Coarse Sand or Gravel' (GEOxyz, 2023b; GEOxyz, 2024a; GEOxyz, 2024c; GEOxyz, 2025a).

Figure 4.20: Example Conspicuous Fauna Observed in the 'Offshore Circalittoral Coarse Sediment' Habitat (GEOxyz, 2023a) [N1]

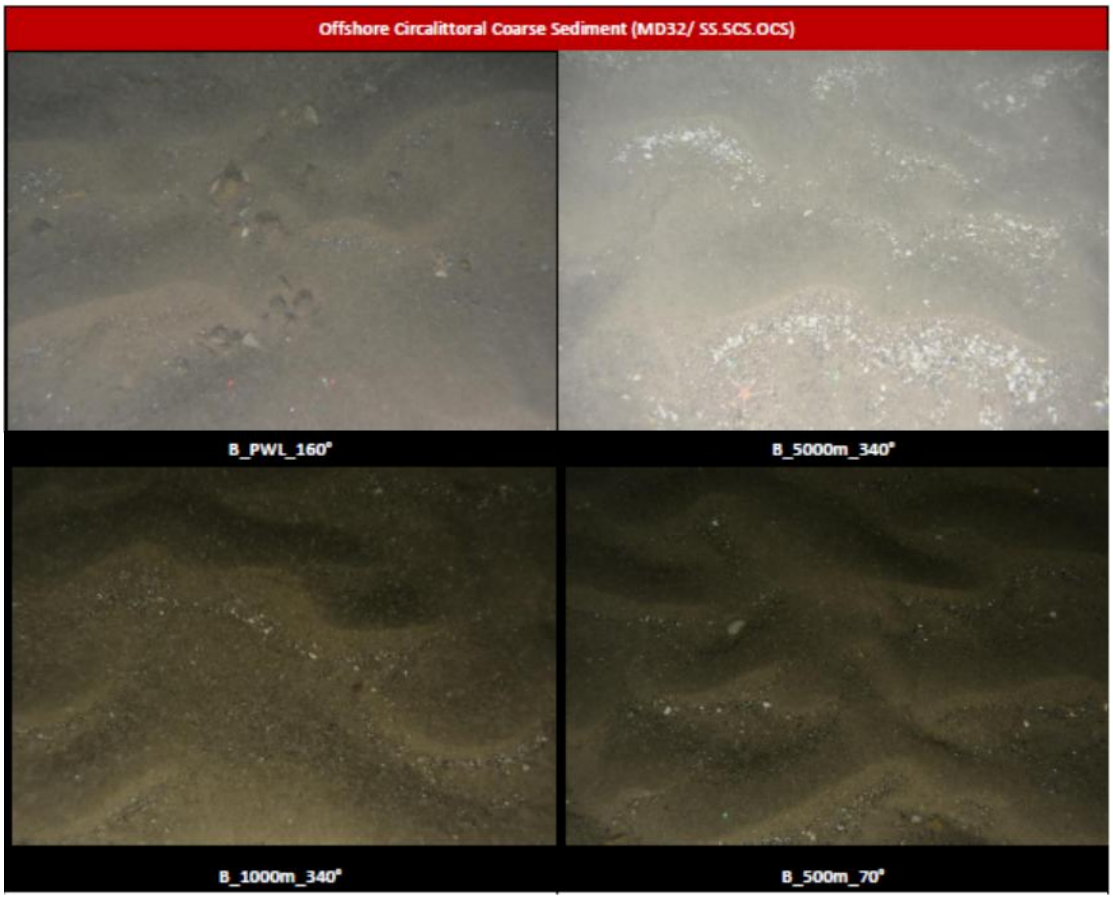


[N1] T21 = 0.1 km from the proposed Abbey drill centre, T02 = 0.5 km from the proposed Abbey drill centre, T16 = 0.2 km from the proposed Abbey drill centre.

Figure 4.21: Examples of the two different 'Offshore Circalittoral Coarse Sediment' Habitats along the proposed Abbey to York Pipeline route (GEOxyz, 2024a) [N1]

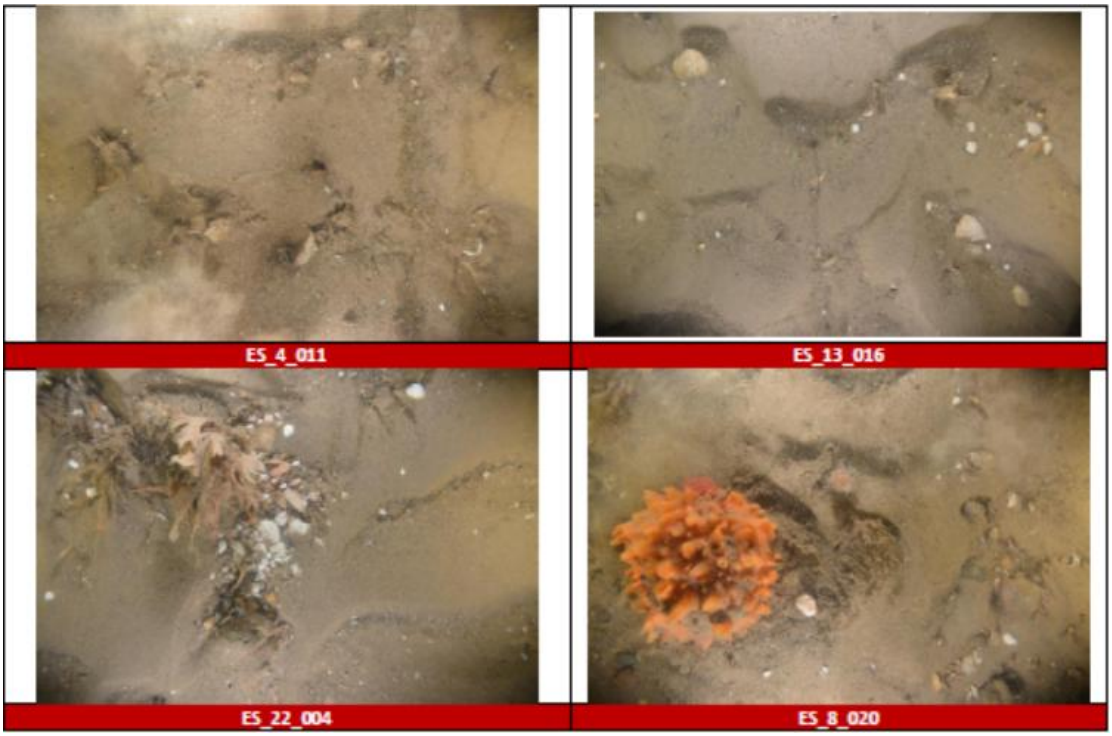
[N1] PL_02 = 6.1 km from the proposed Abbey drill centre and 1.9 km from the York platform, PL_04 = 4 km from the proposed Abbey drill centre and 3.8 km from the York platform, PL_03 = 5.2 km from the proposed Abbey drill centre and 2.8 km from the York platform.

Figure 4.22: Examples of the 'Offshore Circalittoral Coarse Sediment' Habitat within the Baker Site Survey Area (GEOxyz, 2024c) [1]



[N1] B_PWL_160° = 0.64 km from the proposed Baker well location and Abbey & Baker development, B_5000m_340° = 5.42 km from the proposed Baker well location and Abbey & Baker development, B_1000m_340° = 1.44 km from the proposed Baker well location and Abbey & Baker development, and B_500m_70° = 0.36 km from the proposed Baker well location and Abbey & Baker development.

Figure 4.23: Examples of the 'Offshore Circalittoral Coarse Sediment' Habitat along the Baker to Abbey Pipeline route corridor (GEOxyz, 2025a) [N1]



[N1] ES_4_011 = 0.41 km from the proposed Baker to Abbey Pipeline and Abbey & Baker development, ES_13_016 = 42 m from the proposed Baker to Abbey Pipeline and Abbey & Baker development, ES_22_004 crosses the proposed Abbey to York Pipeline route and is 0.38 km from the proposed Abbey manifold location, and ES_8_020 = 0.10 km from the proposed Baker to Abbey Pipeline and Abbey & Baker development.

Flustra foliacea and *Hydrallmania falcata* on Tide-Swept Circalittoral Mixed Sediment (MC4214)

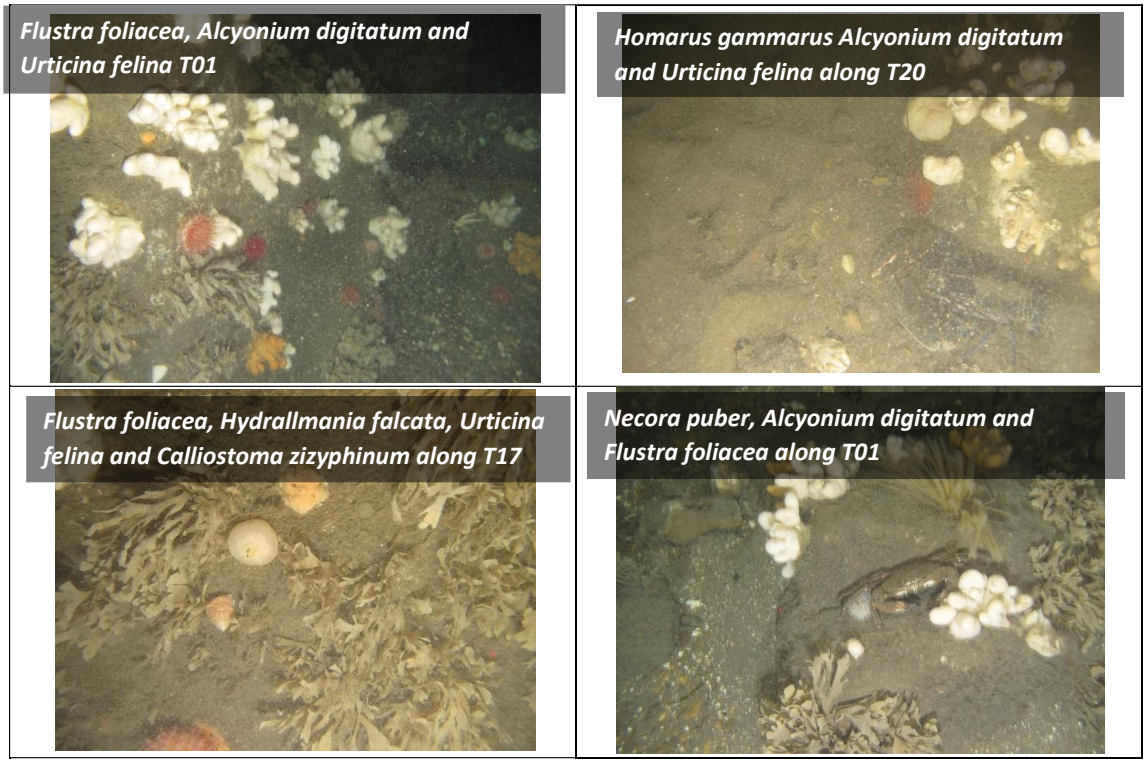
The seabed sediment within this habitat type consisted of clusters of boulders and cobbles in wider areas of mixed sediment in the central region of the Abbey site survey area, in particular covering the proposed drill centre location (see Figure 4.15; GEOxyz, 2023a).

Example seabed images of this habitat type from the Abbey site survey area are presented in Figure 4.24. This habitat represents a transition between sad-scoured circalittoral rock where the epifauna is conspicuous enough to be considered as a biotope. The substrate is composed of boulders, cobbles or pebbles with gravel and sand and occurs in water depths of 5-50m. *Flustra foliacea* and the hydroid *Hydrallmania falcata* characterise this biotope while the anemone *Urticina felina* and the soft coral *Alcyonium digitatum* may also characterise this biotope (JNCC, 2022).

Areas of abundant and diverse sessile assemblages were observed on the boulders present with dead man's fingers (*A. digitatum*), dahlia anemones (*U. felina*) and hornwrack (*F. foliacea*) commonly colonising the rocky substrate. Echinoderms were limited to urchins (Echinoidea), the common starfish (*A. rubens*) and brittlestars (*Ophiuroidea* sp.). The common lobster (*H. Gammarus*) and velvet swimming crabs (*Necora puber*) were observed around the base or atop of the boulders. Fish were absent form this habitat type.

The sediment characteristics and faunal records indicate a conformance towards the level five EUNIS habitat classification MC4214 describing '*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment'. The presence of cobbles and boulders of various sizes warranted further investigation in this habitat type's suitability of presence of Annex I geogenic reef habitats (refer to the sub-section below on Potential Sensitive Habitats and Species).

Figure 4.24: Example Conspicuous Fauna Observed in the '*Flustra foliacea* and *Hydrallmania falcata* on Tide-swept Circalittoral Mixed Sediment' Habitat (GEOxyz, 2023a) [N1]



[N1] T01 = 0.1 km from the proposed Abbey drill centre, T20 = 0.2 km from the proposed Abbey drill centre, T17 = 0.1 km from the proposed Abbey drill centre.

Potential Sensitive Habitats and Species

The following potential sensitive habitats and species are known to occur in the wider region (North Sea), including:

- Stony reefs formed from boulders and cobbles;
- Subtidal Sands and Gravels;
- *Sabellaria spinulosa* biogenic reefs;
- Lesser sandeel (*Ammodytes marinus*) spawning and nursery grounds;
- Herring (*Clupea harengus*) spawning and nursery grounds;
- Ocean quahog (*Arctica islandica*) bivalves.

The habitat assessment and environmental baseline surveys undertaken for the proposed Abbey & Baker Development therefore paid particular attention to establishing whether or not any of the above habitats and/or species occurred within the survey areas, as discussed below. The suitability of the Abbey & Baker Development area for sandeel and herring spawning and nursery grounds has been discussed in Section 4.3.3.

Annex I Stony Reef

The Abbey & Baker fields are situated in an area identified as having the potential for 'stony reef' habitats. 'Stony reef' is listed as a protected habitat in Annex I of the EU Habitats Directive.

Stony reefs are defined by the Habitats Directive as comprising 'areas of boulders (>256mm diameter) or cobbles (64mm – 256mm diameter) which arise from the seafloor and provide suitable substratum for the attachment of algae and/or animal species' (Irving, 2009).

The stony reef assessment for the proposed Abbey and Baker field development (Abbey site survey area, Abbey to York Pipeline route corridor survey and Baker to Abbey Pipeline route corridor survey)

was based on acquired underwater stills taken every 10 seconds along each camera transect. Each still and screen grab was assessed for changes in the composition (i.e. percent coverage) and elevation of cobbles and boulders. In addition, the epifauna coverage on the cobble and boulder fraction of the seabed was assessed, both including and excluding hydrozoan/bryozoan turf, which is regarded as low ecological value by Golding et al. (2020). Each section of the transects where cobbles or boulders were detected was then analysed and categorised according to its composition, elevation, biota cover and extent. The extent, or seabed area, covered by stony substrate was assessed from SSS and/or multibeam bathymetry data when stony substrate was associated with a distinct sonar signature or seabed texture (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2025a).

At the Baker site survey area, sub-surface hard substrate was likely present across the site. However, no hard contact signatures were observed in the geophysical data or at the seabed surface during camera ground-truthing. Consequently, there was no evidence to indicate the presence of Annex I Stony Reef habitats within the Baker site survey area and no further assessment was undertaken (GEOxyz, 2024b).

For this assessment, the Irving (2009) stony reef protocol was split into separate assessments of reef 'structure'. The first reef 'structure' matrix is based on the percentage coverage or composition of cobbles/boulders and assessed against the corresponding cobble/boulder elevation above the surrounding seabed (see Table 4.5).

Table 4.5: Stony Reef Structure Matrix: Elevation vs. Composition (After Irving, 2009)

Reef Structure Matrix			Elevation			
			Flat	<64mm	64mm-5m	>5m
			Not a Reef	Low	Medium	High
Composition	<10%	Not a reef	Not a Reef	Not a Reef	Not a Reef	Not a Reef
	10-40%	Low	Not a Reef	Low	Low	Medium
	40-95%	Medium	Not a Reef	Low	Medium	Medium
	>95%	High	Not a Reef	Medium	Medium	High

Approximately half of the images within the Abbey site survey transects showed evidence of potential stony reef, when analysed for 'reef structure', 693 (37.97 %) were classed as 'Not a Reef', 183 (10.03 %) as 'Low Reef', 35 (1.92 %) as 'Medium Reef' and none as 'High Reef'. This equates to a total of 218 images (11.95 %) showing appreciable reefiness of 'Low Reef' and 'Medium Reef' (GEOxyz, 2023a).

Out of the 77 stills that were taken from transects within the Abbey to York Pipeline route corridor survey area and reviewed for potential stony reef (composition vs elevation), all were categorised as 'No Reef' (42 images, 55 %) or 'Not a Reef' (35 images, 45 %). Therefore, further assessment was not required, as the classifications would remain as 'Not a Reef' or less. This suggests a minimal, if not absent, existence of the Annex I Stony Reef habitat within the survey area (GEOxyz, 2024a).

A total of 16 transects across the Abbey to Baker pipeline route area had a notable presence of cobbles and boulders. In total, 1,117 stills were analysed across these transects. When both composition and elevation were considered, by examining reef 'structure' 964 stills were classed as 'No reef' (86.3 %), while 56 (5.0 %) were classed as 'Not a Reef', 5 (0.4 %) were classed as 'Low Reef' and none classed as 'Medium' or 'High' reef. Therefore, a total of 5 stills (0.4 %), showed appreciable reefiness of 'Low Reef' (GEOxyz, 2025a).

The reef structure (composition vs elevation) results then formed part of the second assessment (structure vs epifaunal coverage) which incorporates consideration of the percentage cover of epifauna colonising the cobble and boulders. Epifauna coverage was quantified both as total epifauna and excluding bryozoan/hydrozoan turf, which is regarded as being of low ecological value on stony reefs by Golding et al. (2020). The mean reefiness (structure vs epifaunal coverage) was calculated per habitat section for each camera transect showing the presence of cobbles and boulders (see Table 4.6).

Overall, consideration of epifaunal coverage on the cobbles and boulders resulted in lower reefiness levels due to the limited coverage of epifauna. The results from the Abbey site survey indicated two ground-truthed occurrences of 'Medium Reef' (structure vs epifauna coverage), both of which occurred

within the 300 m zone around the proposed drill centre, one on transect T20 and the other on TR01 (GEOxyz, 2023a).

Within the Abbey to Baker pipeline corridor, when both reef structure (composition vs elevation) and epifaunal coverage were considered, 56 (5.0 %) stills were classed as 'Not a Reef', while 5 (0.5 %) stills were classed as 'Low Reef', and none were classed as 'Medium' or 'High' reef (GEOxyz, 2025a).

Table 4.6: Stony Reef Structure Matrix: Structure vs. Epifaunal Coverage (Modified Irving, 2009; GEOxyz, 2023a)

Reef Structure Matrix			Reef Structure			
			Not a Reef	Low	Medium	High
Epifaunal Coverage	<10%	Not a Reef	Not a Reef	Not a Reef	Not a Reef	Not a Reef
	10 – 40%	Low	Not a Reef	Low	Low	Medium
	40 – 80%	Medium	Not a Reef	Low	Medium	Medium
	>80%	High	Not a Reef	Medium	Medium	High

Utilising the Irving (2009) guidance, areas of seabed classified as 'Not a Reef', based on reef structure (composition vs elevation vs epifaunal coverage), would still be 'Not a Reef' regardless of whether the extent was <25 m^2 or >25 m^2 (Table 4.7). As such, areas were only calculated for patches of potential stony reef showing mean reefiness (structure vs epifauna coverage) indicating 'Low Reef' or 'Medium Reef' (GEOxyz, 2023a; GEOxyz, 2025a).

Table 4.7: Overall Stony Reefiness Matrix (Structure vs Epifaunal Coverage vs Extent)

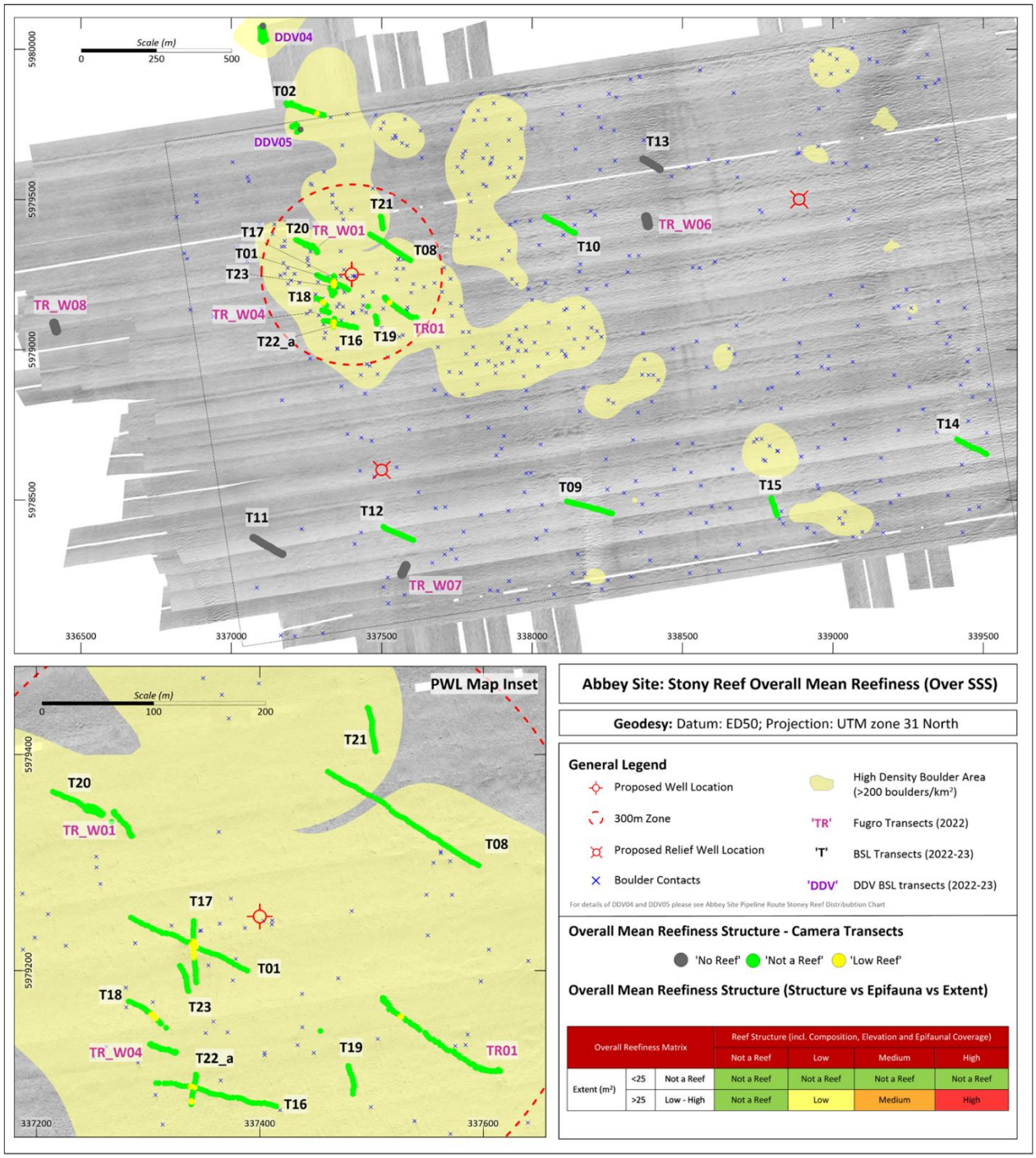
Overall Reefiness Matrix			Reef Structure (incl. Composition, Elevation and Epifaunal Coverage)			
			Not a Reef	Low	Medium	High
Extent (m^2)	<25	Not a Reef	Not a Reef	Not a Reef	Not a Reef	Not a Reef
	>25	Low - High	Not a Reef	Low	Medium	High

The Abbey site survey results indicated nine occurrences of 'Low Reef' in terms of overall reefiness (structure vs epifaunal cover vs epifauna). These comprised single occurrences on each of eight transects within 300 m area of the initial proposed Abbey drill centre (TR01, T08, T16, T17, T18, T22a and T23). There were no occurrences of 'Medium Reef' or 'High Reef', with all other ground-truthing data indicating areas with no cobbles and boulders or were classified as 'Not a Reef' (Figure 4.25; GEOxyz, 2023a). Further review of the identified 'Low Reef' areas using the Golding et al. (2020) criteria indicated that all of these areas could be considered 'possible reef' due to the presence of the level five JNCC/EUNIS biotope MC4214 in wider areas of MD32, and the presence of key reef species (*Nemertesia antennina* and *Alcyonium digitatum*) (GEOxyz, 2023a).

As such, following the Abbey site survey, a decision was made to move the drill centre ca. 70 m to the north east to avoid placement of the drilling rig on areas identified as potential 'Low Reef' sites of stony reef. Any other reference to the proposed 'Abbey Drill Centre' within the ES refers to the relocated drill centre ca. 70 m north east of the initial proposed drill centre location.

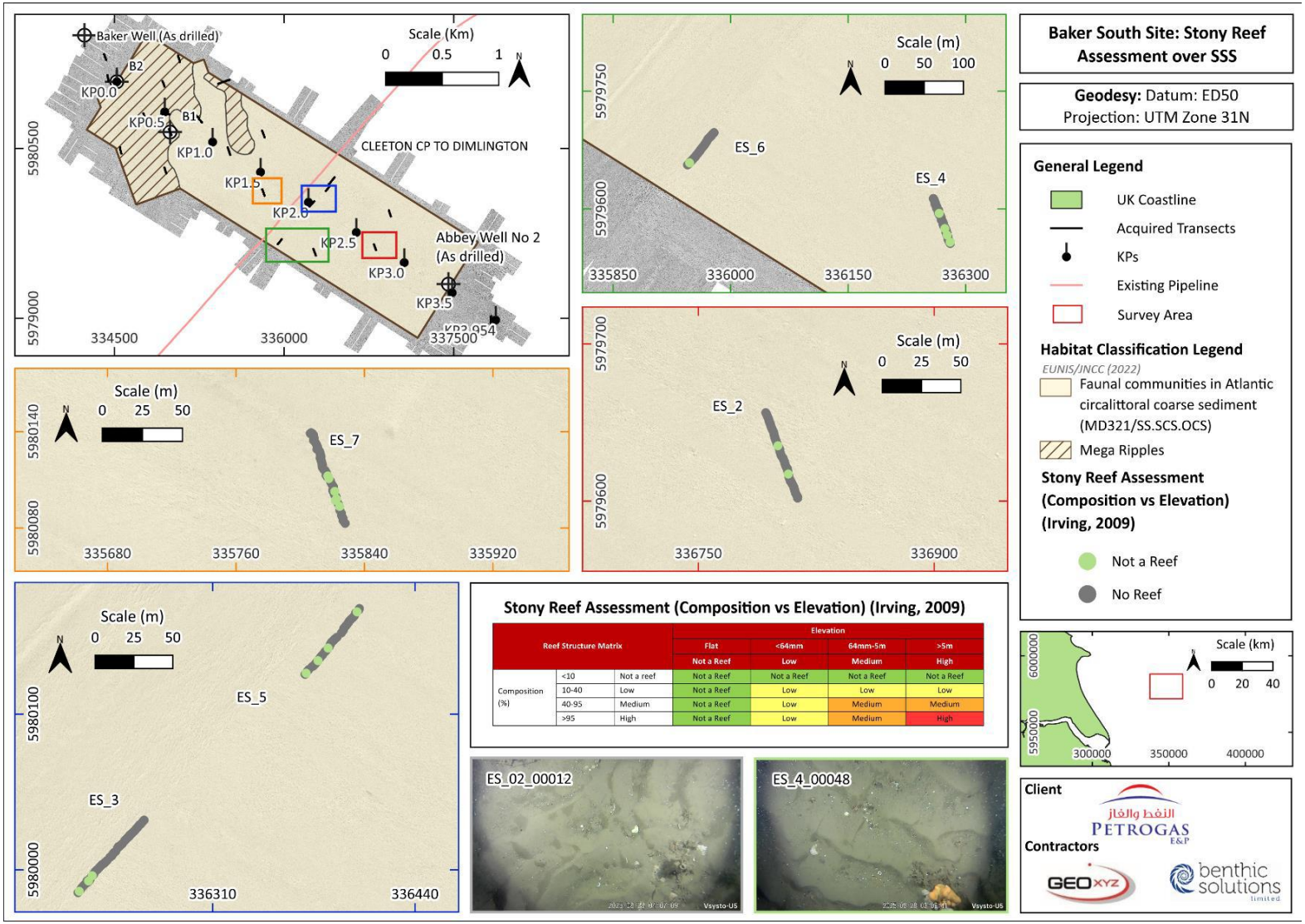
Within the Abbey to Baker pipeline corridor, areas of seabed classified as 'Not a Reef', based on reef structure (composition vs. elevation vs. epifaunal coverage) would still be 'Not a Reef' regardless of whether the extent was <25 m^2 or >25 m^2. As such, areas were only calculated for patches of potential stony reef showing mean reefiness (structure vs. epifauna coverage) indicating 'Low Reef' or 'Medium Reef' structure. The survey results did not identify any continuous areas of 'Low Reef' or higher classification and therefore do not provide sufficient justification for the presence of Annex I geogenic reef habitat along the proposed Abbey to Baker pipeline route (GEOxyz, 2025a).

Figure 4.25: Overall Mean Reefiness (Structure vs Epifauna Coverage vs Extent) Assessment for the Abbey Site Survey Area (GEOxyz, 2023a)[1]



[1] The proposed Abbey drill centre is now located ca. 70 m north east of the proposed Abbey drill centre shown above.

Figure 4.26: Overall Mean Reefiness (Structure vs Epifauna Coverage vs Extent) Assessment for the Abbey to Baker Pipeline Route Survey Area (GEOxyz, 2025a)



Subtidal Sands and Gravels

The subtidal sands and gravel habitat occurs in various marine environments where sediments such as sand, gravel and cobblestone accumulate. The habitat supports a diverse array of species including polychaetes, crustaceans and fish which rely on the habitat for breeding, feeding and shelter. Offshore examples are notably more diverse due to reduced natural disturbances, featuring a range of anemones, polychaetes, bivalves, amphipods as well as mobile and sessile epifauna. These areas support internationally important fish and shellfish fisheries and provides important ecosystem services by improving water quality and acting as a carbon sink.

Upon review of the high-definition video and stills data and particle size data, it was evident that both the proposed Abbey site survey area, Abbey to York pipeline route corridor, Baker site survey area and Baker to Abbey pipeline route corridor contain habitats characterised by the subtidal sands and gravels, with the presence of the JNCC/EUNIS habitat 'Offshore Circalittoral Coarse Sediment (SS.SCS.OCS /MD32) (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

Annex I Biogenic Reef formed by *Sabellaria spinulosa*

Sabellaria spinulosa is a tube-building polychaete worm and can occur as isolated individuals, small aggregations, thin crust-like veneers, or when in large numbers can form hard reef-like structures which can act to stabilise the surrounding seabed (Gibb *et al.,* 2014). As their tubes are built of sand, a high suspended sediment content is essential for growth of reef like structures and the mobile sandy seabed within the survey areas may provide this.

The presence of *S. spinulosa* was noted on 12 camera transects and drop-down video deployments (nine in the Abbey site survey area and three along the Abbey to York pipeline survey corridor) acquired during the 2023 and 2024 surveys. It was also noted during the 2024 Baker site survey, along five camera transects mostly situated towards the southern part of the cruciform survey area. These transects were, therefore, investigated further to assess whether any areas have the potential to be classified as Annex I Biogenic reefs (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b).

No *Sabellaria spinulosa* was observed on any of the ground-truthing video, therefore, there is no evidence of reefs, hummocks, or crusts in the Abbey to Baker pipeline route corridor (GEOxyz, 2025a).

An assessment of 'reefiness' as described by Gubbay (2007) was performed to describe the habitat, focusing on transects where *S. spinulosa* was recorded during review of video footage and stills photographs data (Table 4.8; GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b). Changes in *Sabellaria* 'elevation' (average tube height in cm) and patchiness (percentage cover) were noted during review of camera ground-truthing (GEOxyz, 2023a).

Table 4.8: Sabellaria reefiness criteria as outlined by Gubbay (2007)

Measure of 'Reefiness'	Not a Reef	Low[(c)]	Medium	High
Elevation (average tube height, cm)	<2	2-5	5-10	>10
Area (m^2)	<25	25-10,000	10,000–1,000,000	>1,000,000
Patchiness (% Cover)	<10	10-20	20-30	>30

To apply the Gubbay (2007) protocol to the acquired data, this was further split into separate assessments of reef 'structure' and overall 'reefiness'. The advantage of this method is that it provides a way of combining the three criteria for reefiness: 'elevation' (average tube height in cm), 'area' (m^2) and patchiness (percentage cover). Using this method, patches of *S. spinulosa* aggregations can be classified as 'Not a Reef', 'Low' or 'High' reefiness.

To avoid potential bias towards areas of greater environmental interest by manual selection of still photographs and to quantify the reefiness of heterogenous patches of *S. spinulosa*, screen grabs were acquired every 10 seconds from the high definition (HD) video footage along the camera transects. Each screen grab was assessed for *S. spinulosa* patchiness and tube elevation, which were then combined to assess reef structure.

Of the images reviewed for *S. spinulosa* within the Abbey site area, the vast majority (97.38%) did not show any evidence of *S. spinulosa* aggregations and were labelled as areas of 'No Reef'. Of the images showing *S. spinulosa*, 0.84% were classed as 'Not a Reef', 0.63% as 'Low Reef', 0.63% as 'Medium Reef' and 0.52% as 'High Reef' in terms of patchiness or percentage cover. A different pattern was evident for tube elevation with 2.62% of the images categorised as 'Not a Reef' and all other 97.38% of the images classed as 'No Reef'. When both patchiness and elevation were taken into account, by examining reef 'structure', only 2.62% of the images were classed as 'Not a Reef', driven by the low tube elevation of less than 2cm. The remaining stills were classed as 'No Reef' where *Sabellaria* was absent (see Figure 4.27; GEOxyz, 2023a).

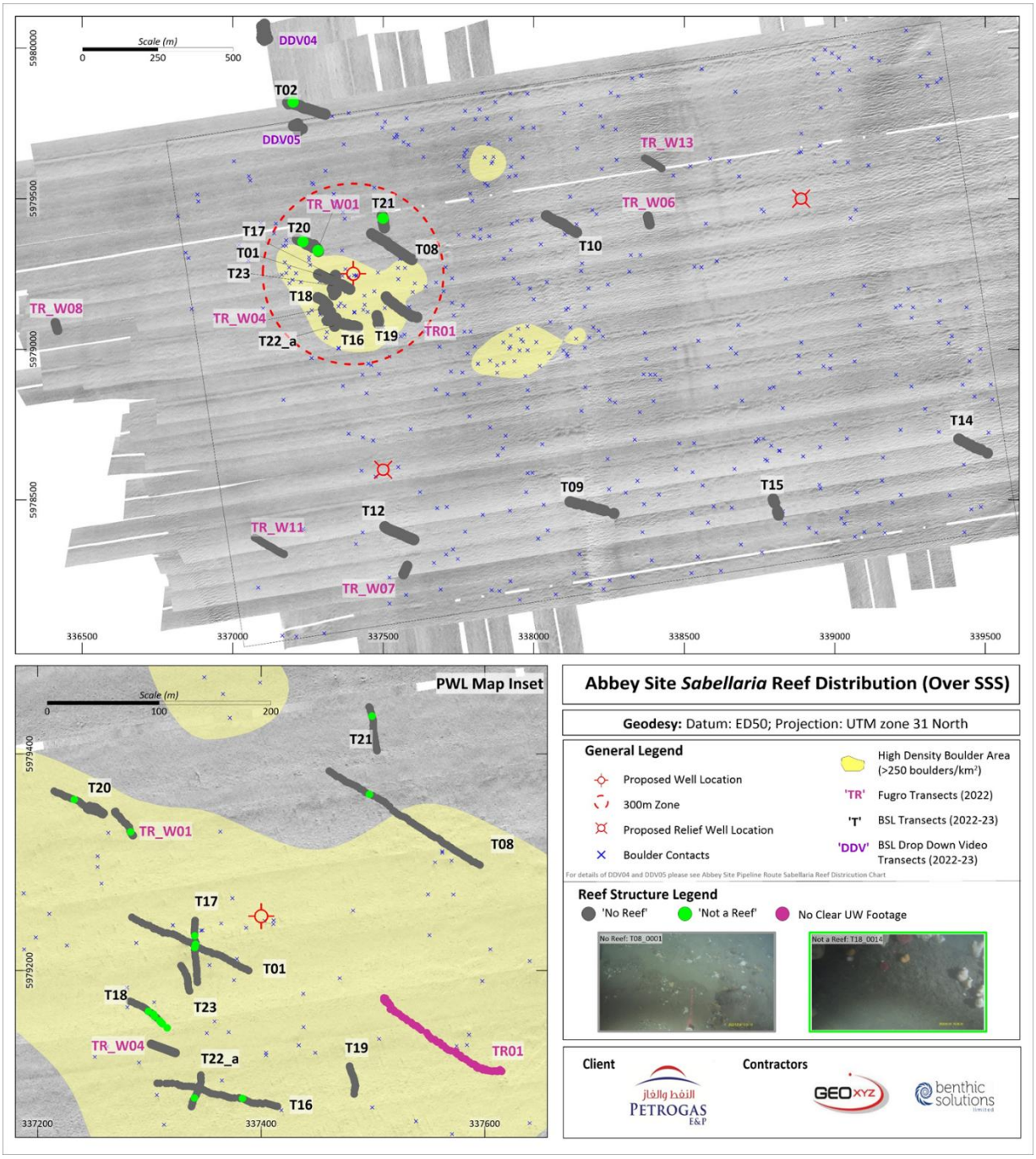
The underwater imagery within the Abbey to York pipeline route corridor indicated a sparse distribution of *S. spinulosa* along all three transects assessed, with just two (7 %) images along transect A_PL_05_CAM and three (12 %) images along A_PL_06_CAM recording a presence of *S. spinulosa*. Of which, a less than 10 % patchiness coverage was observed in all stills, resulting in "Not a Reef" delineation. Images reviewed along transect PL_07 within the Abbey to York pipeline route corridor had observed *S. spinulosa*, with patchiness ranging from 0.4 to 14 % and elevation ranging from 1 to 5 cm. When considering both patchiness and elevation to examine reef structure, a total of two images from 29 were classed as potential 'Low Reef' with the remaining classed as 'Not a Reef' or "No Reef" (GEOxyz, 2024a). The sporadic occurrences of *S. spinulosa* after the second stage of the *S. spinulosa* reefiness investigation resulted in average overall reef structure delineations of 'No reef' and 'Not a Reef' (see Figure.4.28; GEOxyz, 2024a).

The underwater imagery from the Baker site survey indicated a sparse distribution of *S. spinulosa* along all five transects assessed. Three transects identified *S. spinulosa* in just one still image each (3 %): B_1500m_70°, B_1500m_160°, B_5000m_160°. Two transects identified *S spinulosa* in 3 (9 %) and 5 (10 %) still images along transects B_250m_160° and B_500m_160°, respectively. For those stills where *S. spinulosa* was present, less than 10% patchiness coverage was observed in all except one, resulting in "Not a Reef" classifications for those stills. When considering both patchiness and elevation to examine reef structure, a total of 11 images were classed as potential 'Not a Reef' with the remaining classed as "No Reef" (See Figure 4.29; GEOxyz, 2024b).

The mean *Sabellaria* reef structure applicable to each 10-second image has been overlain on the camera track in Figure 4.27, Figure.4.28 and Figure 4.29, to illustrate the variability in *Sabellaria* distribution across the Abbey site survey area, Abbey to York pipeline route corridor and Baker site survey area (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b).

In summary, the habitat assessment results have highlighted the presence of *Sabellaria* in isolated patches across the Abbey & Baker Development survey areas, associated with areas of coarser substrate, such as within the 300 m zone around the proposed Abbey drill centre and southern extent of the cruciform area at Baker. However, the available information from camera ground-truthing data indicates that these *Sabellaria* aggregations do not constitute Annex I reef habitat, as they are present as low-lying aggregations or crusts and do not meet the required level of elevation from the surrounding seabed to be classified as reef. While the presence of biogenic reefs within the area cannot be ruled out, the evidence suggests they are unlikely to be numerous or of a significant size (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b).

Figure 4.27: *Sabellaria spinulosa* reef habitat assessment for the Abbey site survey area (GEOxyz, 2023a)[1]



[1] The proposed Abbey drill centre is now located ca. 70 m north east of the proposed Abbey drill centre shown above.

Figure.4.28: *Sabellaria spinulosa* reef habitat assessment for the Abbey to York pipeline route (GEOxyz, 2023a)[1]

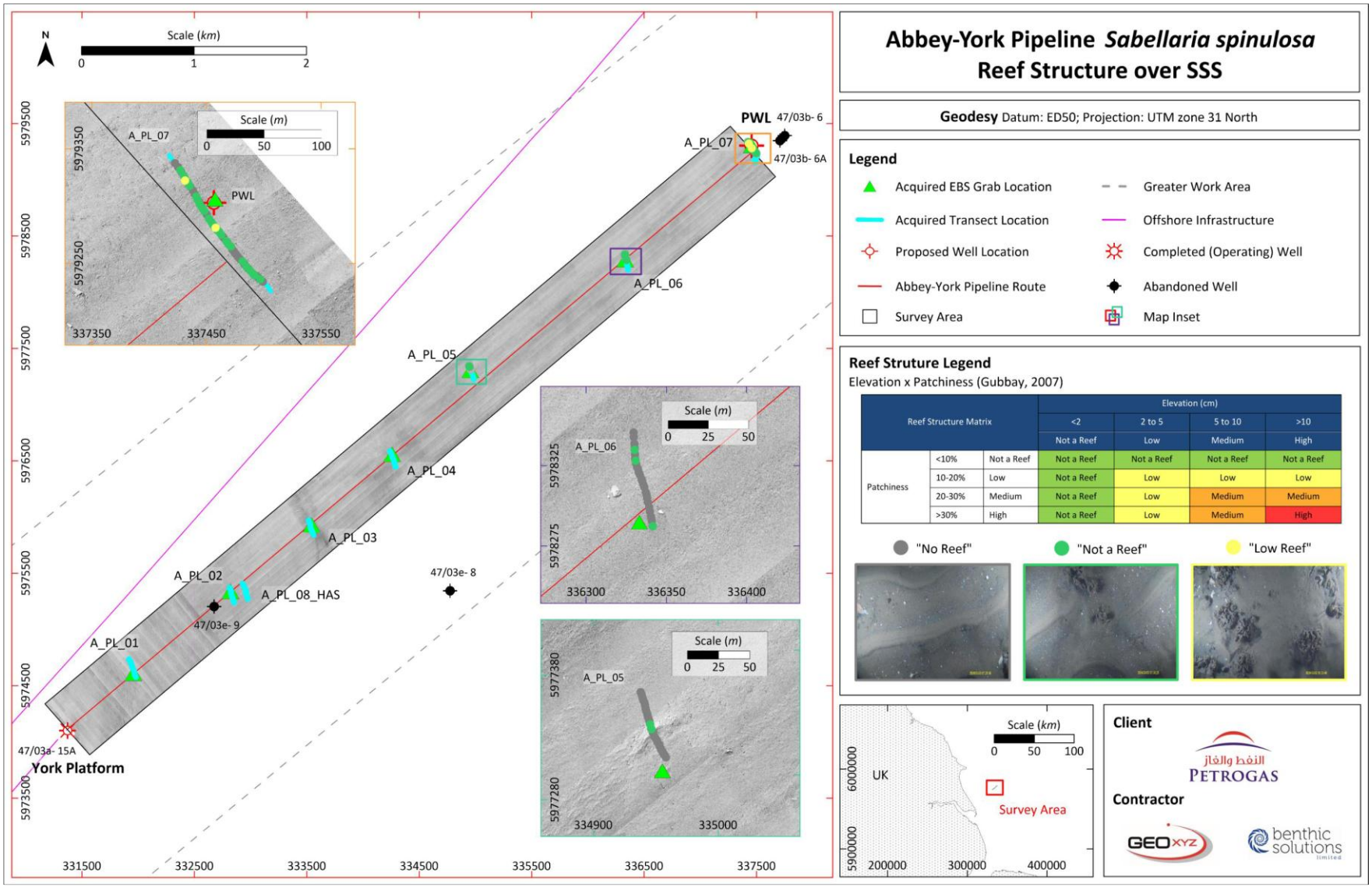
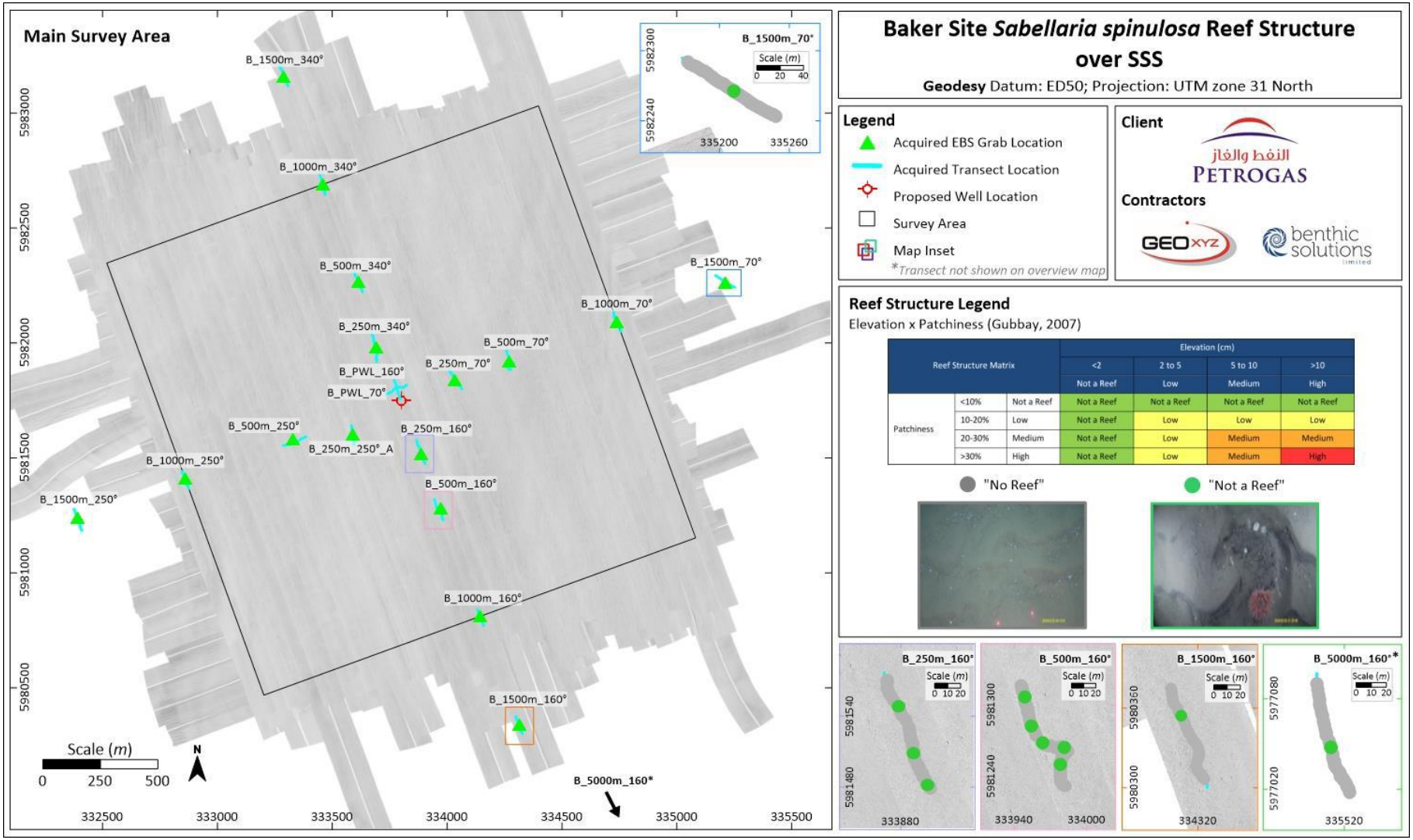


Figure 4.29: *Sabellaria spinulosa* reef habitat assessment for the Baker Site Survey (GEOxyz, 2024b)[1]



[1] 'Proposed Well Location' in this figure is located ca. 629 m West Northwest of the proposed Baker Development well location for the Abbey & Baker Development

Ocean Quahog (*Arctica islandica*)

The ocean quahog (*Arctica islandica*) bivalve species is afforded protected status under the Oslo and Paris (OSPAR) Commission due to its inclusion on the OSPAR list of threatened and/or declining species (OSPAR, 2021). This species is also listed as a Marine Conservation Zone Feature of Conservation Importance (MCZ FOCI) for both inshore and offshore protection (JNCC and Natural England, 2016). Ocean quahogs grow very slowly, and are at particular risk from bottom fishing gear, and, like other slow-growing animals, once their numbers have been reduced their populations can take a long time to recover. The species prefers sand and muddy sands ranging from fine to coarse grains and live buried vertically within the top few centimetres of the sediment, with retractable inhalant and exhalent siphons occasionally visible at the surface.

One adult (shell size >5 cm) specimen was recovered during grab sampling operations at station A_PL_01, which is located approximately 0.8 km northeast of the York platform and approximately 7.2 km southwest from the proposed Abbey drill centre. This specimen was recorded, photographed and returned to the sea. Although, no evidence of their distinct siphons was seen on any of the video footage or still photographs within the drill centre or pipeline survey area. Whilst *A. islandica* are distinctive due to their size, texture and shape, these features generally become more evident when the diameter exceeds 5 cm. Smaller specimen (<5 cm) are difficult to distinguish to the naked eye from other bivalve species during field operations, and so are later reviewed during the taxonomy phase under the microscope. Review of the macrofaunal data revealed a single juvenile specimen (<5 cm) of live *A. islandica* to be present within the proposed drill centre survey area at three stations (G09, G16 and G20), all of which were located within the 'Offshore circalittoral coarse sediment' habitat type (GEOxyz, 2023a).

During the Baker site survey, two specimens (one adult, one juvenile) were recovered during grab sampling operations at station B_5000m_160°. One individual was observed atop the seabed in transect B_3000m_250°, with a single siphon observed along transect B_3000m_340°. Taxonomic analysis revealed two juveniles, one at sample replicate B_1500m_250_F2 and another at B_1000m_250_F2 (GEOxyz, 2024b; 2024c). Whereas, during the Abbey to Baker pipeline route survey, while no live *A. islandica* were observed during camera operations, a relic shell was observed in sample F1 from station ES11. Dring taxonomic review, 17 juvenile individuals were identified at 8 stations (GEOxyz, 2025a; 2025b).

Figure 4.30: Ocean Quahog Specimen atop of Sediment at B_3000m_250° (GEOxyz, 2024b)

Benthic Infaunal Communities

The proposed Abbey & Baker Development area showed a generally high species diversity throughout the surveyed area, with similar species dominating throughout. Macrofaunal analysis was carried out on 34 grab replicate samples obtained within the Abbey site survey area, 13 grab replicate samples along the propose Abbey to York pipeline route (only one replicate could be obtained at Station PL02 due to coarse sediment), 31 grab replicate samples at the Baker site survey area (only one replicate could be obtained at Station B_1000m_70° due to coarse sediment) and 36 grab replicate samples at the Abbey to Baker pipeline route (see Figure 4.1 and Figure 4.2 in Section 4.1.1).

Within the Abbey site survey area, a total of 7,834 individuals (infauna and solitary epifauna) from the 34 replicate samples were analysed. Of the 258 taxa recorded, seven belonged to the solitary epifauna category (specimens which are epifaunal in nature but recorded in low counts), 30 were colonial epifauna and 228 were infauna. Within subsequent analyses, colonial epifauna have been omitted as they are often not possible to enumerate and therefore only assessed on a presence/absence basis. The infaunal taxa consisted of 102 annelid species accounting for 31.1% of the total individuals. Arthropods were represented by 61 species (13.0% of the total individuals), molluscs were represented by 40 species (10.3% of the total individuals), and echinoderms were represented by eight species (16.9% of the total number of individuals). The solitary epifauna comprised of 572 individuals across seven different species; one cnidarian (Actiniaria); three polychaetes; and three barnacles (Arthropoda). All other groups (Foraminifera, Nemertea, Nematoda, Platyhelminthes, Phoronida, Hemichordata, Chordata) were represented by ten species, accounting for 21.3% of the total individuals (GEOxyz, 2023b).

Along the proposed Abbey to York pipeline route, macrofaunal taxonomy of all recovered fauna identified 2,315 individuals (infauna and solitary epifauna) from the thirteen replicate samples analysed. Of the 164 taxa recorded 21 were colonial epifauna, 159 were infaunal and five were solitary epifauna. The infaunal taxa consisted of 86 annelid species accounting for 52.4% of the total individuals. Crustacea represented 30 species (accounting for 18.3% of individuals), while Echinodermata consisted of six species (3.7% of the total individuals). Mollusca were represented by 28 species, accounting for 17.1% of individuals. All other groups (Foraminifera, Nematoda, Nemertea, Platyhelminthes, Phoronida, Hemichordata, Chordata and Cnidaria) were represented by nine species, accounting for 5.5% of the total individuals. A total of 26 taxa were epifaunal in nature: five were considered solitary including two species of barnacle (*Scalpellum scalpellum* and *Verruca stroemia*), two species within Polychaeta (*Hydroides norvegica* and *Sabellaria spinulosa*), and one cnidarian (Actiniaria); and of the 21 taxa identified as colonial epifauna, there were ten species of Bryozoa, ten taxa within Cnidaria and one Porifera (GEOxyz, 2024a).

A total of 4,219 individuals were recorded within the Baker site survey area, of which Annelida had the highest contribution to the total number of individuals. Of the 166 taxa recorded, four were solitary epifauna and 162 were infaunal. The infaunal taxa consisted of 81 Annelida taxa accounting for 50.9 % of the total individuals. Crustacea represented 28 species (accounting for 4.1 % of individuals, while Echinodermata consisted of just 8 species (4.8 % of the total individuals). Mollusca were represented by 36 species, accounting for 13.5 % of individuals. All other groups (Foraminifera, Nematoda, Nemertea, Platyhelminthes, Phoronida, Hemichordata, Chordata and Cnidaria) were represented by nine species, accounting for 23.3 % of the total individuals (GEOxyz, 2024b).

A total of 12,833 individuals (infauna and solitary epifauna) were recorded along the Abbey to Baker pipeline route, of which Annelida had the highest contribution to the total number of individuals. Of the 288 taxa recorded, eight were solitary epifauna and 280 were infaunal. The infaunal taxa consisted of 120 Annelida taxa accounting for 45.2 % of the total individuals. Crustacea represented 85 species (accounting for 16.1 % of individuals), while Echinodermata consisted of just nine species (4.6 % of the total individuals). Mollusca were represented by 56 species, accounting for 11.9 % of individuals. All other groups (Foraminifera, Nematoda, Nemertea, Platyhelminthes, Phoronida, Hemichordata, Chordata and Cnidaria) were represented by 10 species, accounting for 19.8 % of the total individuals (GEOxyz, 2025a).

Primary and Univariate Analyses

Overall, the number of species identified was relatively consistent throughout the Abbey site survey area, though there was some variation in the number of species per station, with numbers ranging from 22 to 104 species. The number of individuals was more variable, with numbers ranging from 54 to 564 across the stations (GEOxyz, 2023b).

In contrast, the number of individuals were relatively variable along the proposed Abbey to York pipeline route, with numbers ranging from 106 to 543 across the sampling stations. The number of species across stations was slightly less variable, ranging from 33 to 79 (GEOxyz, 2024a).

Diversity indices for the Abbey site survey showed a high diversity and consistently distributed community across all stations, with slight variations in spatial patterns relating to natural variation. Additionally, evenness values, a diversity index measuring how close in numbers each species in an area are, are between 0-1 with variation in values demonstrating more variation in communities between species (GEOxyz, 2023b).

Species richness measures indicated a large range in diversities across the Abbey to York pipeline route survey area. With the exception of one station (A_PL_07), species evenness was high at all stations, indicating a relatively even spread of species within the samples. With the exception of one station (A_PL_07), the diversity indices indicated mostly high and good diversity (GEOxyz, 2024a). At station A_PL_07 there was a high abundance of *Sabellaria spinulosa* in the samples analysed (98 individuals in F1 and 488 in F2). As a result, it appears there is a relatively low species diversity at this station, when in fact if *S. spinulosa* were taken out of the diversity calculations then each indices describing the macrofaunal population at A_PL_07, suggest an equally diverse community to the other stations within the pipeline survey area.

Across the Baker site survey area, univariate parameters like the diversity indices showed little variation across the survey area. The number of species identified in the survey area showed some variability, ranging from 23 species per 0.1 m^2 to 59 species per 0.1 m^2 (GEOxyz, 2024b). The same pattern was observed when the number of species were averaged by station, ranging from 31 to 72. The numbers of individuals were relatively variable, ranging from 51 per 0.1 m^2 for sample replicate to 254 per 0.1 m^2 for sample replicate. When averaging the number of individuals across replicates to compare the mean abundance between stations, the abundance ranged from 89 to 216 (GEOxyz, 2024b).

Across the Abbey to Baker pipeline route area, the numbers of individual per 0.1 m^2 ranged from 125 to 829 (mean: 356 ± 182). At station level, total abundance ranged from 411 to 1,508. The number of species per 0.1 m^2 ranged from 41 at to 133. A similar pattern was observed when the number of species were calculated by station, ranging from 73 to 154 (GEOxyz, 2025a).

Overall, these results show highly diverse communities across most stations across the proposed Abbey & Baker Development area, slight variations relating to natural variation is expected considering the sand dominated environment (GEOxyz, 2023b; GEOxyz, 2024a, GEOxyz, 2024b, GEOxyz, 2025a).

Multivariate Analyses

Abbey Site Survey Area

A similarity profile (SIMPROF) analysis of the Abbey site survey identified five statistically distinct macrofaunal clusters, indicating small-scale natural variation in benthic community composition across an otherwise uniform sandy-gravel seabed. Cluster B supported the highest species richness and abundance, followed by Cluster A, while Clusters C and D exhibited the lowest richness. One transitional group (Cluster A/B) displayed characteristics of both Clusters A and B (GEOxyz, 2023b).

The dominant taxa across clusters included *Echinocyamus pusillus*, *Ophelia borealis*, *Scoloplos armiger*, *Mediomastus fragilis*, *Exogone verugera*, Nemertea, Cnidaria and Bryozoa, with variations in relative abundance driving cluster separation (GEOxyz, 2023b).

Correlation testing found no significant relationships between macrofaunal composition and sediment particle size, hydrocarbons or metal concentrations, consistent with the homogeneous sediment conditions across the survey area.

All clusters were dominated by Annelida, both in abundance and species richness, and showed broadly similar phyletic composition. The observed differences in community structure are therefore attributed to natural spatial variability rather than environmental gradients or contaminant influence.

Abbey to York Pipeline Route

A SIMPROF analysis of stations along the proposed Abbey to York pipeline route identified three statistically distinct macrofaunal clusters, primarily influenced by the availability of hard substrata along the route. Although the clusters shared several widespread species, differences in the dominant taxa contributed to their separation. Cluster A was characterised by *Mediomastus fragilis*, *Leiochone*, *Timoclea ovata*, *Echinocyamus pusillus* and *Ophelia borealis*. Cluster B was dominated by *Nemertea*, *Timoclea ovata*, *Echinocyamus pusillus*, *Nematoda* and *Sabellaria spinulosa*, while Cluster C was defined by *Mediomastus fragilis*, *Urothoe marina*, *Leiochone*, *Pisione remota* and *Echinocyamus pusillus* (GEOxyz, 2024a).

Correlation testing showed no significant relationships between macrofaunal composition and sediment particle size, TOC, TOM, hydrocarbons or metal concentrations, reflecting the homogeneous sediment conditions across the site.

Ecological trait analysis indicated that Clusters B and C were dominated by disturbance-sensitive species, whereas Cluster A was dominated by disturbance-tolerant taxa. First-order opportunistic species occurred only in Clusters B and C, while second-order opportunists were present across all Clusters. These findings suggest that natural variation in substratum availability, combined with differences in dominant taxa, is the primary driver of community differentiation along the pipeline route (GEOxyz, 2024a).

Baker Site

A SIMPROF analysis of the Baker site survey identified three distinct macrofaunal clusters, reflecting small-scale natural variability in community composition across an otherwise homogeneous sediment environment. Cluster A contained the highest species richness and faunal abundance, Cluster B showed slightly lower diversity and was located in the eastern survey area, and Cluster C exhibited the narrowest range of diversity values, indicating lower variability in community structure.

All clusters were characterised by a shared suite of dominant taxa, including Nematoda, *Scoloplos armiger*, *Timoclea ovata*, *Ophelia borealis*, Nemertea, *Exogone verugera*, *Leiochone* and *Spiophanes bombyx*. Additional cluster-specific species contributed to differentiation, such as *Travisia forbesii* in Cluster A, *Echinocyamus pusillus* in Clusters A and C, *Eusyllis blomstrandi* and *Aonides paucibranchiata* in Cluster B, and *Amphiura filiformis* in Cluster C (GEOxyz, 2024b).

Correlation testing found no significant relationships between macrofaunal composition and sediment particle size, TOC, TOM or hydrocarbon concentrations, consistent with the uniform sediment conditions across the site (GEOxyz, 2024b).

All clusters were dominated by Annelida, which contributed approximately half of all individuals and species. Nematodes formed the next most abundant group, reflecting their widespread ecological role in North Sea sediments. Solitary epifauna were least abundant in Cluster A and highest in Cluster C due to the presence of *Sabellaria spinulosa*. Overall, phyletic composition was similar across clusters, indicating that natural spatial variation, rather than environmental gradients or contamination, explains the observed community differences.

Abbey to Baker Pipeline Route

A SIMPROF analysis of stations along the proposed Abbey to Baker pipeline route identified two distinct macrofaunal clusters, reflecting small-scale natural variability in seabed sediments and community composition. Cluster A comprised 16 stations and showed high diversity, with variable species richness and abundance. Cluster B consisted of two stations influenced by differing sediment fractions, with ES1 containing the highest proportion of fines and ES3 characterised by elevated gravel content (GEOxyz, 2025a).

Both Clusters shared several dominant taxa, including Nematoda, Spiophanes bombyx, Nemertea and Exogone verugera, although differences in the relative abundance of other key species contributed to Cluster separation. Cluster A was further characterised by *Ophelia borealis*, *Scoloplos armiger*, *Abra prismatica*, *Leiochone*, *Branchiostoma lanceolatum* and *Amphiura filiformis*, while Cluster B was

defined by *Myrianida*, *Sabellaria spinulosa*, *Mediomastus fragilis*, *Gammaropsis maculata*, *Lumbrineris cingulata* and *Bathyporeia tenuipes* (GEOxyz, 2025a).

Correlation testing found no significant relationships between macrofaunal composition and TOC, TOM, hydrocarbons or metal concentrations. A positive correlation with PSD indicated that Cluster A was predominantly sandy, whereas Cluster B was associated with gravelly muddy sand (GEOxyz, 2025a).

Ecological trait analysis showed that both Clusters were dominated by disturbance-tolerant species, followed by disturbance-sensitive taxa. Disturbance-indifferent species and second-order opportunists were present in lower proportions. These findings indicate that natural sediment variability, rather than environmental stressors or contamination, is the primary driver of community differences along the pipeline route.

4.3.3 Fish and Shellfish

Distribution of Adult Populations

Fish are separated into pelagic species, which occur in shoals swimming in mid-levels of the water, typically making extensive seasonal movements or migrations between sea areas and demersal species, which live on or near the seabed.

Although the distribution of adult fish populations is highly fluid, analysis of recent fisheries landings and effort data suggests that adult populations of pelagic species such as herring (*Clupea harengus*) and demersal species such as whiting (*Merlangius merlangus*) make up a large proportion of catches in the vicinity of the proposed Abbey & Baker Development area (MMO, 2025). Species diversity within the fish community is greater in the SNS than in the central or northern North Sea, with high abundances of small demersal species including whiting, grey gurnard (*Eutrigla gurnardus*), horse mackerel (*Trachurus trachurus*) and dab (*Limanda limanda*) (DESNZ, 2022).

There are important herring populations in the SNS at Dogger Bank, located approximately 73 km northeast of the proposed Abbey & Baker Development, where herring spawn from August to September / October. Pelagic larvae then drift towards nursery grounds in the Humber Estuary and the Wash. Sprat are abundant in the shallow waters of the SNS, with spawning taking place along the east coast of England from May to August with a peak during May and June. Nursery grounds are found around the Southern Bight and Dogger Bank (Coull *et al*. 1998). Other clupeids found in the SNS include anchovies (spawn from April to August) and sardines (spawn from June to August). Horse mackerel migrates to the SNS in the summer to spawn (Ellis and Heessen, 2015).

Additionally, a number of shellfish species are also present in the SNS. *Nephrops* are present to the north and west of the Dogger Bank, while pink and brown shrimp are abundant in the Wash and Humber Estuaries, located approximately 45 km and 91 km southwest of the proposed Abbey & Baker Development respectively. The east coast of England is a site of particularly intense spawning by brown crab (Rogers & Stocks, 2001).

Fish observed during the Abbey & Baker surveys included Red Mullet (*Mullus surmuletus*), flatfish (*Pleuronectiformes*), Pogge fish (*Agonus cataphractus*), dragonet (*Callionymus lyra*), long-spined sea scorpion (*Tauruluss* sp.), cod (Gadidae), gurnard (Triglidae) and other unidentified fish (Actinopterygii) (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

Spawning and Nursery Grounds

The North-East Atlantic and North Sea is split into statistical grids called International Council for the Exploration of the Sea (ICES) Rectangles in order to map statistical information about the area. The proposed Abbey drill site and proposed pipeline route are located in ICES Rectangle 36F0.

Spawning Grounds

Data from Coull *et al*. (1998) and Ellis *et al.* (2012) indicates that species that spawn within ICES Rectangle 36F0 includes cod (*Gadus morhua*), herring (*Clupea harengus*), lemon sole (*Microstomus kitt*), plaice (*Pleuronectes platessa*) (high intensity), sandeels (*Ammodytidae* sp.) sole (*Solea solea*) and sprat (*Sprattus sprattus*) (Table 4.11 and Figure 4.39).

Additionally, the Scottish Government Marine Directorate (SGMD) National Marine Plan interactive (NMPi) Map (2026) illustrates likely spawning grounds of Atlantic cod predicted by González-Irusta and Wright (2016), taking account of certain environmental influences. This indicates that the proposed Abbey & Baker Development is located in an area of 'occasional grounds' for spawning cod.

Sandeels are abundant in the SNS and are important prey species for many species of demersal fish. Sandeels have a dependency on specific substrata for spawning, leaving them more vulnerable to disturbance from point sources (DESNZ, 2022). Sandeel eggs are demersal and are laid in sticky clumps on clean, sandy sediments therefore hatching success and recruitment can be affected by activities that disturb seabed sediments. Seabed sediments were interpreted to vary between gravelly Sand with shell fragments, gravelly sand, sand, sandy gravel and gravel throughout the Abbey & Baker Development, meaning an overall suitable area for sandeel spawning activities. Therefore, as discussed in Section 4.3.2, sandeel spawning ground assessments have been undertaken for the proposed Abbey & Baker Development.

Similarly, the aforementioned sediment types mean that the Abbey & Baker Development is a suitable area for herring spawning activities. Therefore, as discussed in Section 4.3.2, herring spawning ground assessments have been undertaken for the proposed Abbey & Baker Development.

The results of both the sandeel and herring spawning ground assessments are discussed below.

Sandeel Spawning and Nursery Grounds

The proposed Abbey & Baker Development area is situated within an area designated by Ellis et al (2012) as low intensity spawning, as well as low intensity nursing grounds for sandeels (refer to Section 4.3.3). The SGMD NMPi map (2026) also illustrates the probability of presence and predicted density of buried sandeels modelled by Langton et al. (2021). The proposed Abbey & Baker Development area contains habitat that is moderately suitable for sandeels, with low to medium densities predicted.

Definitions of sandeel preferred grounds using sediment particle size were provided by Greenstreet et al. (2010). This method utilises the percentage composition of the sediment by weight, which is split into two distinct fractions; silt and fine sand (particles < 0.25mm), and medium to coarse sand (particles 0.25 -2.0mm). The coarse > 2mm fraction, which can often overstate sandeel habitat suitability, is not considered by this method. The sediment fraction data is then used to assess sandeel sediment preference for each station.

Using the method from Greenstreet et al. (2010), In addition, three stations within the vicinity of the Abbey drill centre and three stations within the Abbey to York pipeline route corridor were categorised as 'Suitable', due to the higher proportion (>50%) of medium to coarse sands. The remaining fourteen station within the vicinity of the Abbey drill centre and four stations within the Abbey to York pipeline route corridor were categorised as 'Unsuitable', as a result of the relatively higher proportions of fine sands coupled with lower (<50%) proportions of medium to coarse sediments (see Figure 4.31; GEOxyz, 2023a; GEOxyz, 2024a).

The majority of stations within the Baker site survey area were categorised as 'Unsuitable', with these stations displaying high proportions (>50 %) of silt and fine sands. Nine stations were classed as 'Suitable', and one station, B_5000m_3 0°, was classed as 'Sub-Prime' (see Figure 4.33; GEOxyz, 2024b). Whereas, along the Abbey to Baker pipeline route corridor, stations ES13 and ES17 were classed as 'Suitable' while the remaining stations were categorised as 'Unsuitable' (GEOxyz, 2025a).

Latto et al. (2013) defined the preferred sandeel habitat as a substrate containing high percentages of medium to coarse sand (particle size of 0.25mm to 2mm), with a mud content (particles <63 µm) of less than 10% (Wright et al., 1998; Holland et al., 2005). This method considers sediments with a gravel component to also be suitable for sandeel habitats. To determine areas of potential habitat for sandeel grounds, the particle size analysis results and assigned Folk categories for the grab stations were compared to the parameters specified by Latto et al. (2013) in Table 4.9.

Table 4.9: Sandeel Ground Assessment Categories specified by Latto et al. (2013)

Folk Categories	Habitat Preference
Sand	Preferred
Gravelly Sand	Preferred
Slightly Gravelly Sand	Preferred
Sandy Gravel	Marginal
Other	Unsuitable

Figure 4.32, Figure 4.34, and Figure 4.35; show the results from the analysis of the Folk scale data. All stations within the Abbey Site Survey area, Abbey to York pipeline route corridor, Baker site survey area, and Baker to Abbey pipeline route corridor displayed a consistent sands dominance where the seabed habitat was assigned as 'Offshore Circalittoral Coarse Sediment' (SS.SCS.OCS / MD32), 'Atlantic Offshore Circalittoral Sand' (SS.SSa.Osa / MD52), or '*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment' (SS.SMx.CMx.FluHyd / MC4214) (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

'Preferred' sediments for sandeel grounds were identified at the majority of stations across the Abbey site survey area, Abbey to York pipeline route corridor and Baker site survey area using the Latto et al. (2013) method, with previously 'Unsuitable' stations under the Greenstreet et al. (2010) method of assessment now indicating a sediment composition showing a preference for sandeel habitats (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b). Only one station (G07 (W03)) within the Abbey site survey area was deemed only to be of 'Marginal' suitability (GEOxyz, 2023a). While habitat types were similar within the Abbey to Baker pipeline route corridor, only seven stations were classified as 'Preferred' by Latto et al. (2013), with the remaining 11 deemed 'Unsuitable' (GEOxyz, 2025a). However, video observations confirmed sandeel presence at 11 of the 18 sites within the Baker to Abbey pipeline route corridor, suggesting the area is more likely suitable than unsuitable.

Figure 4.31: Sandeel spawning and nursery grounds along the Abbey to York pipeline route Corridor per Greenstreet et al. (2010)

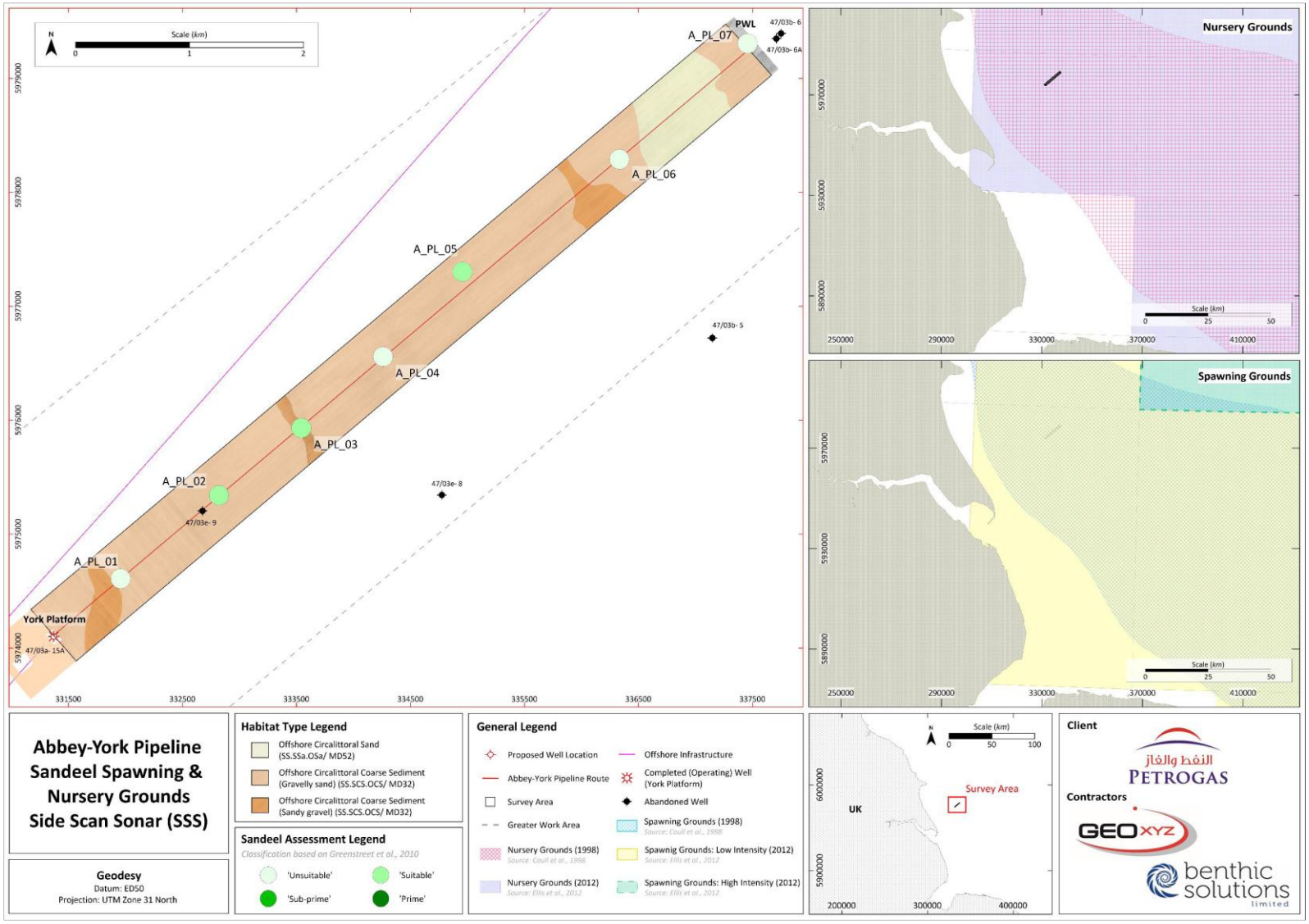
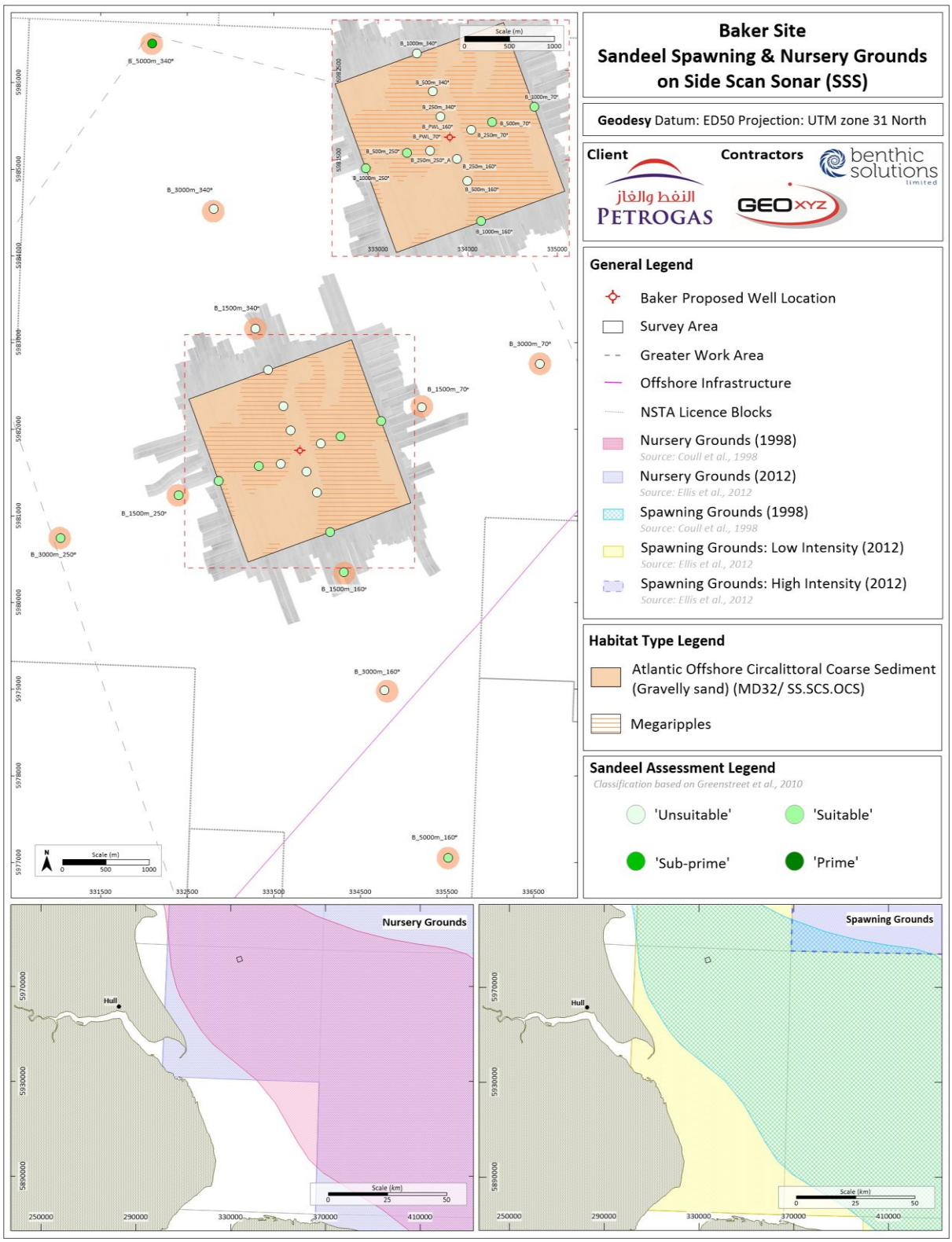


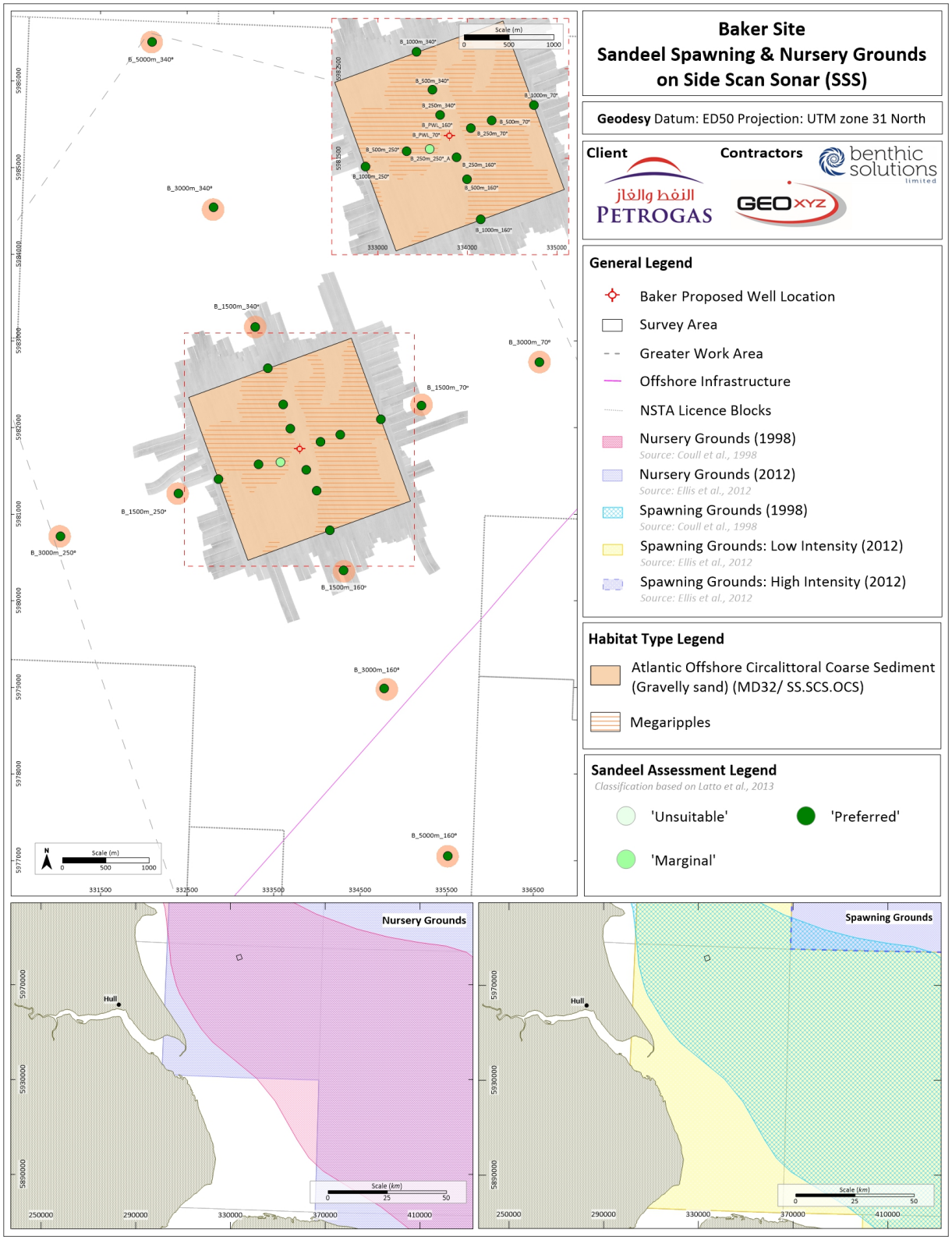
Figure 4.32: Sandeel Spawning and Nursery Grounds per Latto et al. (2013)

Figure 4.33: Sandeel Spawning and Nursery Grounds per Greenstreet et al. (2010) at Baker Site Survey Area[1]



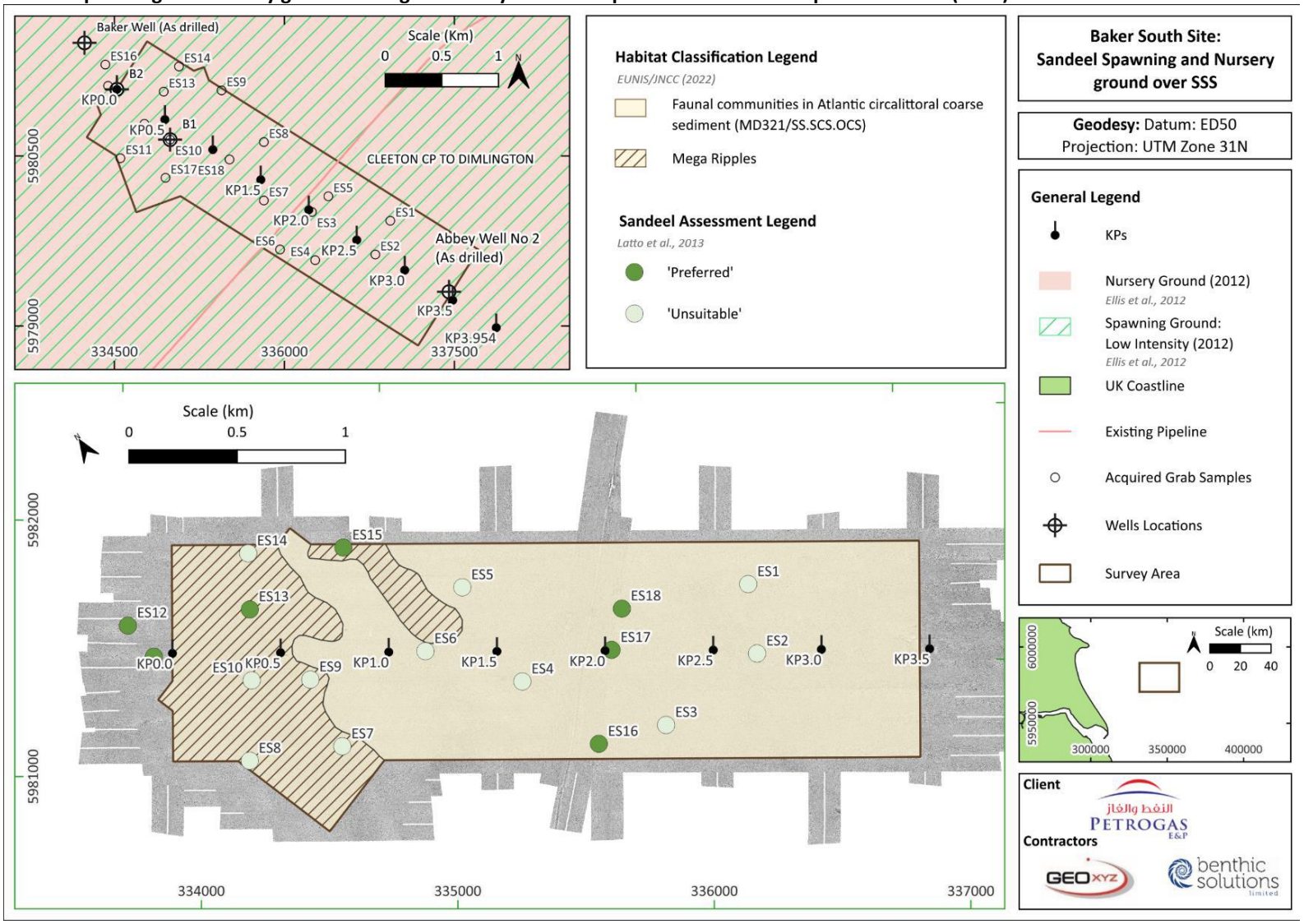
[1] 'Baker Proposed Well Location' in this figure is located ca. 629 m West Northwest of the proposed Baker Development Well location for the Abbey & Baker Development

Figure 4.34: Sandeel Spawning and Nursery Grounds per Latto et al. (2013) at Baker Site Survey Area[1]



[1] 'Baker Proposed Well Location' in this figure is located ca. 629 m West Northwest of the proposed Baker Development Well location for the Abbey & Baker Development

Figure 4.35: Sandeel spawning and nursery grounds along the Abbey to Baker Pipeline Route Corridor per Latto et al. (2013)



Herring Spawning

The Abbey & Baker Development area is situated within the area designated by Ellis et al (2012) as low intensity spawning, as well as high intensity nursing grounds for the species. To determine whether any potential habitat for herring spawning exists, herring spawning ground (HSG) assessments were carried out using the grab samples collected during the Abbey site survey, Abbey to York pipeline route corridor survey, Baker site survey and Baker to Abbey pipeline route corridor survey. Additional sediment samples were collected from 25 stations across the Abbey site survey area and proposed Abbey to York pipeline corridor route, to increase the spread of the grab samples already collected as part of EBS sampling (refer to Section 4.1.1).

The HSG assessments were conducted, with the PSA results from the grab sampling stations assigned to the categories specified by Reach *et al*. (2013), as shown in Table 4.10. Reach et al. (2013) indicated that herring favour sediments comprising <5% mud and >10% gravel (GEOxyz, 2023c).

Table 4.10: Herring Spawning ground assessment categories specified by Reach *et al*. (2013)

Percent Contribution of Mud & Gravel	Folk (1954) Descriptions	Habitat Sediment Preference	Habitat Sediment Classification
<5% mud, >50% gravel	Gravel and part of Sandy Gravel	Prime	Preferred
<5% mud, >25% gravel	Part of Sandy Gravel and part of Gravelly Sand	Sub-prime	Preferred
<5% mud, >10% gravel	Part of Gravelly Sand	Suitable	Marginal
>5% mud, <10% gravel	All other Folk sediment categories	Unsuitable	Unsuitable

The PSA results from the grab sampling stations within the Abbey site survey area utilising the Reach *et al*. (2013) method indicated that none of the grab sampling stations were classified as 'Prime' HSG. Four stations were classified as 'Sub-prime' HSG; and twelve stations were classified as 'Suitable' for HSG. The remaining stations were classed as 'Unsuitable' for HSG; these locations were predominantly associated to areas of 'Offshore Circalittoral Sand' (MD52), within the Abbey site survey area (Figure 4.36; GEOxyz, 2023c).

The PSA results from the grab sampling stations along the Abbey to York pipeline route corridor indicated a range of sediment preferences towards herring spawning ground habitats. Two stations were deemed 'Unsuitable', four stations classified as 'Marginal', and one station considered a 'Sub-Prime to Preferred' classification (see Figure 4.37; GEOxyz, 2024a).

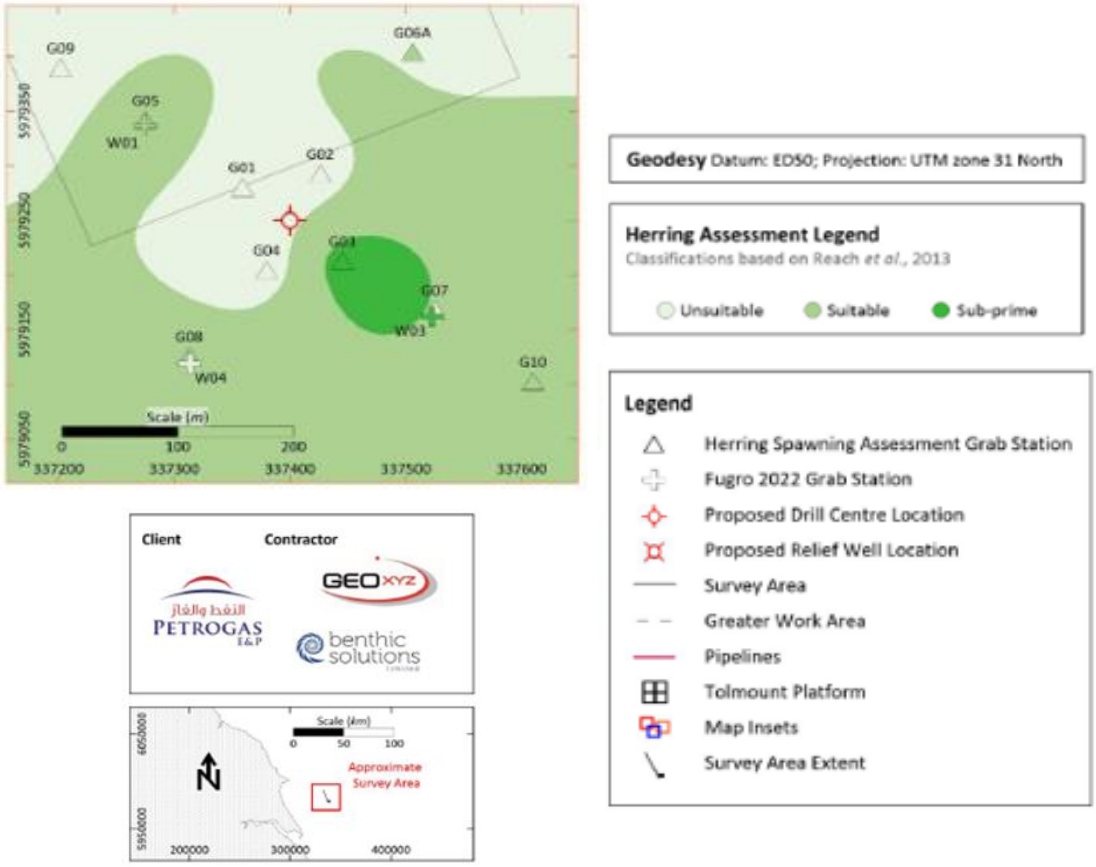
Within the Baker site survey area, PSA results indicated that most stations were deemed 'Unsuitable' for herring spawning. However, one station was classed as 'Prime' (B_250m_250°; located ca. 823 m west of the proposed Baker development well location), and three stations were classified as 'Marginal', suggesting a potential for herring spawning at these locations. This suitability is likely due to the presence of <10 % gravel at most grab sampling stations (see Figure 4.38; GEOxyz, 2024b). Whereas along the proposed Abbey to Baker pipeline corridor, PSA results indicated all stations were deemed 'Unsuitable' for herring spawning likely due to the presence of >5 % fines or <10 % gravel (GEOxyz, 2025a).

Taking into account the results of the HSG assessments, it is not possible to exclude the potential that the Abbey site, Baker site and Abbey to York pipeline route corridor survey area may be used as a herring spawning ground. Considering the survey area as a whole, there is a low to moderate likelihood that the Abbey to York pipeline route corridor and adjacent seabed areas will be used as an HSG, with suitability ranging from 'Sub-prime' at the York end to just 'Suitable' or 'Marginal' at the Abbey drill centre end of the pipeline route corridor. The highest HSG potential is seen within both the Abbey drill centre and to the west of the Baker development well location. However, these areas were typically classified as 'Marginal' or with patchy HSG potential, varying between 'Sub-prime', 'Suitable' and 'Unsuitable'. Only one station, located ca. 823 m west of the proposed Abbey & Baker Development at

its closest point (Baker development well) was classed as 'Prime' (Reach et al., 2013; GEOxyz, 2023c; GEOxyz, 2024a; GEOxyz, 2024b). The full Baker to Abbey pipeline route corridor is not seen as a potential herring spawning grounds, as it has been classed as an 'Unsuitable' habitat (Reach et al., 2013; GEOxyz, 2025a).

Of note, no herring were observed within the Abbey site survey area, Abbey to York pipeline route corridor survey area, Baker site survey area, or Baker to Abbey pipeline route corridor survey area during the analysis of the photographic data (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

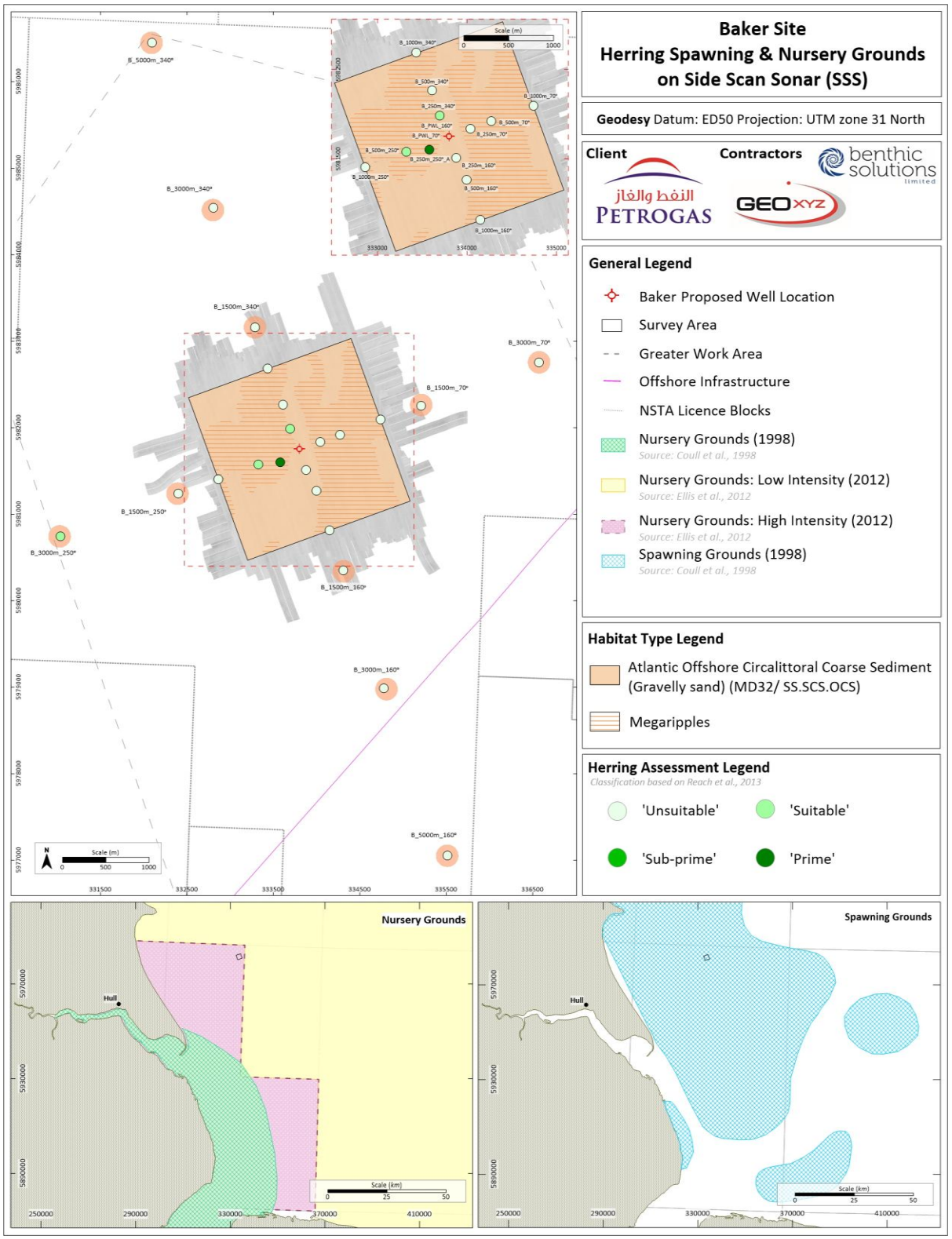
Figure 4.36: Interpolated extent of herring spawning and nursing grounds within the Abbey Site Survey Area with classifications from Reach et al. (2013) (GEOxyz, 2023c)[1]



[1] The 'proposed drill centre' represents previous drill centre which lies approximately 70m southwest of the new Proposed Drill Centre

Figure 4.37: Herring Spawning and Nursery Grounds along the Abbey to York pipeline route Corridor (GEOxyz, 2024a)

Figure 4.38: Herring Spawning and Nursery Grounds within the Baker site survey area (GEOxyz, 2024b) [N1]



[N1] 'Baker Proposed Well Location' in this figure is located ca. 629 m West Northwest of the proposed Baker Development Well location for the Abbey & Baker Development

Nursery Grounds

Species utilising ICES Rectangles 36F0 for nursery grounds include cod (high intensity), herring (high intensity), lemon sole, mackerel (*Scomber scombrus*), plaice, sandeels, sprat and whiting (*Merlangius merlangus*) (high intensity) (Table 4.11 and Figure 4.39; Coull *et al*., 1998; Ellis *et al.,* 2012).

Juvenile Fish

In addition to the mapping of spawning and nursery grounds of key commercial fish species, more recent spatial modelling of the probability of the occurrence of aggregations of 0 group fish species (i.e. fish in the first year of their life) and / or larval stages has been undertaken. This has provisionally identified the spatial distribution of sensitive life stages of commercial fish species (in line with mapping from Coull et al., 1998 and Ellis et al., 2012) that could be affected by offshore oil and gas operations (Aires *et al*., 2014).

Based on spatial modelling of 0 group fish, the proposed Abbey & Baker Development area is not considered to be of high importance to juvenile fish species in their first year of development (Figure 4.40). Of the species mapped, there is a low probability of 0 group aggregations of anglerfish, blue whiting, hake, haddock, mackerel, Norway pout (*Trisopterus esmarkii*), and sole, and moderate probability of cod, herring, horse mackerel, plaice, whiting and sprat in in the vicinity of the proposed Abbey & Baker Development (Aires *et al.,* 2014). It is important to note however that the specific locations of these sites of fish sensitivity are dynamic and may shrink or expand or move over time as maps are updated (Aires *et al.,* 2014).

Table 4.11: Fish Spawning and Nursery Species within the Proposed Abbey & Baker Development Area (ICES Rectangles 36F0) (Coull *et al.,* 1998; Ellis *et al.,* 2012; Aires et al., 2014)

Species	J	F	M	A	M	J	J	A	S	O	N	D
Cod	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Herring[1]	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Lemon sole	N	N	N	N	N	N	N	N	N	N	N	N
Mackerel	N	N	N	N	N	N	N	N	N	N	N	N
Plaice	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Sandeels[2]	N	N	N	N	N	N	N	N	N	N	N	N
Sole	N	N	N	N	N	N	N	N	N	N	N	N
Sprat	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Whiting	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Horse mackerel	J	J	J	J	J	J	J	J	J	J	J	J

Key

N = High intensity nursery as per Ellis *et al.*, 2012

Species = High intensity spawning as per Ellis *et al.,* 2012

J = Moderate probability of juvenile fish species as per Aires *et al*., 2014

	Peak Spawning		Spawning	N	Nursery		No Activity

Notes

[1] Assessment undertaken on sediments from the proposed Abbey & Baker Development area indicates that there is high potential for some areas in the Abbey & Baker Development to be used as herring spawning grounds (GEOxyz, 2023c; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

[2] Assessment undertaken on sediments from the proposed Abbey & Baker Development area indicated potential for the Abbey & Baker Development area to be used as sandeel spawning grounds (GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a).

Although many of the species that may utilise the waters around the proposed Abbey & Baker Development as spawning and / or nursery grounds are fairly widespread throughout the region, a number of these species are listed as Biodiversity Action Plan (BAP) Priority Marine Species in English

waters. These include cod, herring, horse mackerel, sandeels, mackerel, plaice, sole and whiting (JNCC, 2007a). Cod is listed on the OSPAR list of threatened and/or declining species (OSPAR, 2021) and is 'Vulnerable' globally on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. All other fish species are listed as 'Least Concern' on the Red List (IUCN, 2026).

In UK waters there has been significant recent declines of sandeel, cod, haddock and whiting as a result of warming waters over the last 30 years (DESNZ, 2022).

Figure 4.39: Fish Spawning and Nursery Areas across the Proposed Abbey & Baker Development Area

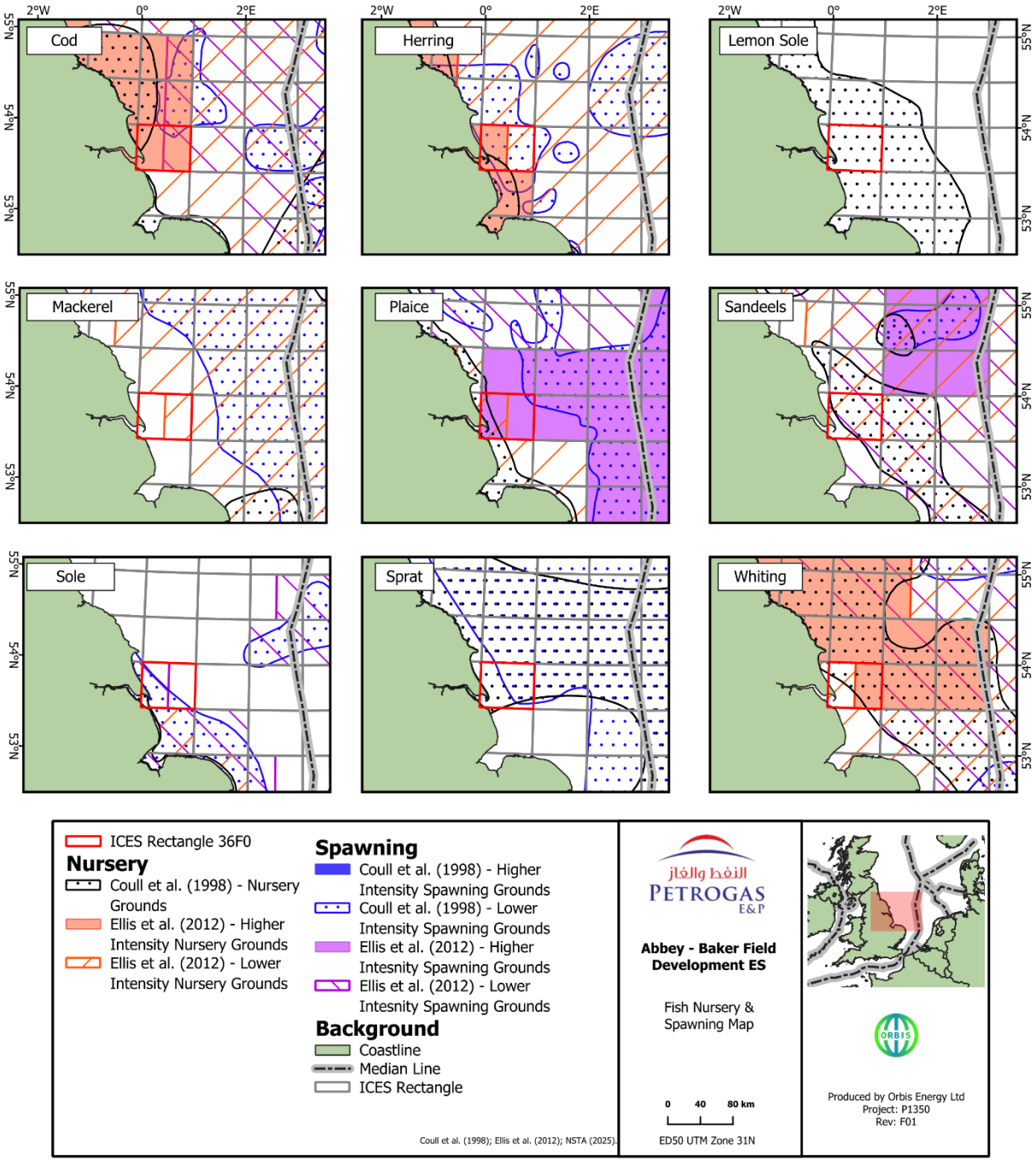
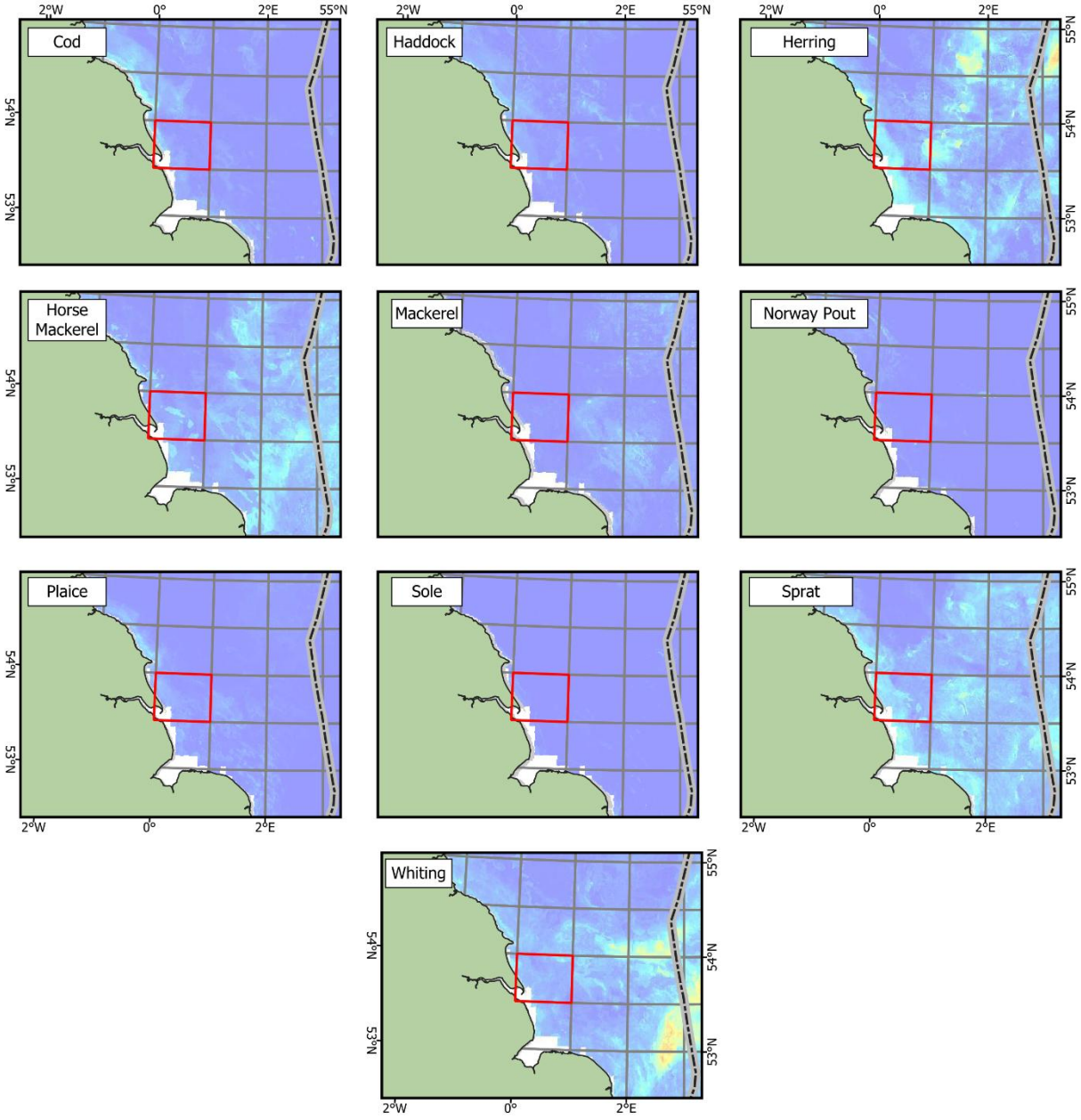


Figure 4.40: Probability of 0 Group Fish Aggregations in the Vicinity of the Abbey & Baker Development Area



Elasmobranchs

Elasmobranch species (sharks, skates, and rays) are also an important component of the North Sea ecosystem. Elasmobranchs have a low fecundity and slow growth rate, leaving them vulnerable to over-fishing pressures and pollution events, and subsequent recovery of populations in response to disturbance events is low.

A survey of the distribution of elasmobranchs in UK waters was undertaken by Ellis *et al*. in 2004. A total of 26 elasmobranch species were recorded throughout the North Sea and surrounding waters. Species which have been recorded in the SNS at various times throughout the year, and may therefore be present in the vicinity of the proposed Abbey & Baker Development, are listed in Table 4.12.

Table 4.12: List of Elasmobranch Species Likely to be found in the Vicinity of the Abbey & Baker Development (Ellis *et al.*, 2004; IUCN, 2026)

Common Name	Latin Name	Depth Range (m)	Global IUCN Status[1]	European IUCN Status [1]
Cuckoo skate	*Leucoraja naevus*	12 – 290	Near Threatened	Near Threatened
Small spotted catshark	*Scyliorhinus canicula*	6 – 308	Least Concern	Least Concern
Spiny dogfish	*Squalus acanthias*	15 – 528	Vulnerable	Endangered
Spotted ray	*Raja montagui*	8 – 283	Least Concern	Least Concern
Thorny skate	*Amblyraja radiata*	32 – 209	Vulnerable	Least Concern
Starry smoothound	*Mustelus asterias*	0 – 100	Near Threatened	Near Threatened
Blonde ray	*Raja brachyura*	14-146	Near Threatened	Near Threatened
Thornback ray	*Raja clavata*	7-192	Near Threatened	Near Threatened

[1] Status as of April 2026

All the species listed in Table 4.12, excluding the small spotted catshark, cuckoo skate, and spotted ray, are of 'Most Concern' due to their unfavourable conservation status (IUCN, 2026). In addition, spiny dogfish, thornback ray and spotted ray are listed on the OSPAR list of threatened and/or declining species (OSPAR, 2021).

4.3.4 Seabirds

Offshore Distribution and Abundance

Seabird presence and abundance is often used as an indicator for assessing the state of the marine environment as their populations and distribution varies with changes in prey abundance, weather, predation and pollution. The offshore waters of the SNS are visited by seabirds mainly for feeding purposes in and around the shallow sandbanks (DESNZ, 2022). Individuals may originate from the onshore colonies, particularly around the Wash and Thames estuaries, or may be migrants through the area.

Of note is that the Greater Wash Special Protection Area (SPA) is located approximately 20 km to the southwest of the proposed Abbey & Baker Development area. This site protects important foraging areas for the largest breeding population of little tern (*Sternula albifrons*) in the UK marine SPA network, as well as sandwich tern (*Thalasseus sandvicensis*) and common tern (*Sterna hirundo*). Several other SPAs are located along the north east English coastline, including the Flamborough and Filey Coast SPA located ca. 38 km northwest of proposed Baker well which protected features include Black-legged kittiwake (Breeding) (*Rissa tridactyla*) (see Section 4.3.6).

Seabird species originating from these SPAs such as the sandwich tern, razorbill (*Alca torda*), northern gannet (*Morus bassanus*), black-legged kittiwake, common guillemot (*Uria aalge*) and Atlantic puffin (*Fratercula arctica*), may therefore forage within the offshore waters of the proposed Abbey & Baker Development area during the breeding bird season (see Table 4.13).

Table 4.13: Seabirds Potentially Foraging in the Proposed Abbey & Baker Field Development Area during the Breeding Bird Season (JNCC, 2023a; Woodward *et al*., 2019)

Species	Mean Maximum +1SD Foraging Range (km)	Originating SPA / Ramsar	Type of Feeder
Sandwich Tern	34.3±23.2	Greater Wash	Surface
Razorbill	88.7±75.9	Flamborough and Filey Coast	Diver
Northern Gannet	315.2±194.2	Flamborough and Filey Coast	Diver
Black-legged Kittiwake	156.1±144.5	Flamborough and Filey Coast	Surface
Common Guillemot	73.2±80.5	Flamborough and Filey Coast	Diver
Atlantic Puffin	137.1±128.3	Flamborough and Filey Coast	Diver

The European Seabirds at Sea (ESAS) database is the most complete and longstanding dataset detailing the distribution of seabirds at sea, compiling a range of boat and transect data over a period of 29 years. During the breeding season (March - September) the database predicts that at-sea seabird densities in the proposed Abbey & Baker Development area are moderate at less than 50 seabirds per km^2, with the area considered to be important for kittiwake, guillemot and puffin (JNCC, 2019; Kober *et al*., 2010).

Once the breeding season is complete seabirds disperse into areas further offshore, although the extent to which they disperse varies between species. During the winter months (November – March) the at-sea seabird density in the proposed Abbey & Baker Development is predicted to be lower compared to seabird density in the breeding season, at less than 23 seabirds per km^2. The most abundant species found in the area at this time include gannet, great black-backed gull (*Larus marinus*) and herring gull (*Larus argentatus*) (JNCC, 2019; Kober *et al*., 2010).

The JNCC prepares the latest analysed trends in abundance, productivity, demographic parameters, and diet of breeding seabirds, from the Seabird Monitoring Programme (JNCC, 2023a). This data provides at-a-glance UK population trends as a percentage of change in breeding numbers from complete censuses. From the year 2015 to 2021, 25 species were monitored, and there is confidence in the trends of 21 of these species, with 11 of these 21 having declined in population since the 1998-2002 census. Species with declining population trends include black- legged kittiwake (-42%) and great black-backed gull (-40%). Breeding seabird numbers of some species have shown a long-term decline, probably as a result of a shortage of key prey species such as sandeel associated with changes in oceanographic conditions (DESNZ, 2022). This is further exacerbated by fish stock depletion by commercial fisheries, meaning there's not enough food to go around during the important breeding season. In contrast, seabird species with increasing population trends include razorbill (+18%) and northern gannet (+38%). Species that remained stable (change within +/- 10%) include common guillemot, common tern, and sandwich tern (JNCC, 2023a).

Five new species have been added to the UK Birds of Conservation Concern (BoCC) 'Red' list, indicating they are now at significant risk of local extinction. These species include Leach's storm-petrels, common gulls, great black-backed gulls, Arctic terns, and great skuas. They join the previously listed kittiwakes, herring gulls, roseate terns, Arctic skuas, and puffins, all of which are also highly threatened. Research comparing the Seabird 2000 consensus with the Seabirds Count (Burnell et al., 2023) has revealed substantial declines in bird populations across the UK. Noteworthy decreases include a 52% drop in common gulls, a 79% decline in Leach's storm-petrels, and a 43% reduction in great black-backed gulls. Britain and Ireland account for 64% to 67% of the global population of great skuas. However, the outbreak of Highly Pathogenic Avian Influenza (HPAI) has led to a 76% decline in the 2023 colony count—representing 83% of the UK Seabirds Count population—resulting in the reclassification of

great skuas from the BoCC 'Amber' to 'Red' list. The effects of HPAI have also contributed to a 7% and 25% decline in the breeding populations of herring gulls and lesser black-backed gulls, respectively, at selected natural nesting sites, based on pre- and post-HPAI counts (Tremlett et al., 2024). The impact of HPAI on their winter populations, however, remains uncertain.

Seabird Sensitivity to Oiling

Seabird populations are particularly vulnerable to surface pollution. The sensitivity of bird species to oil pollution varies considerably throughout the year and is dependent on a variety of factors, including time spent on the water, total biogeographical population, reliance on the marine environment and potential rate of population recovery. Species considered most sensitive to sea surface pollution are those which spend a great deal of time on the sea surface, for example puffin, guillemot, and razorbill. Species considered to be at lower risk, due to spending less time on the sea surface, include gannet and kittiwake.

The Seabird Oil Sensitivity Index (SOSI) (Webb *et al*., 2016) combines seabird data collected between 1995 and 2015 and individual seabird species index values to create a single measure of seabird sensitivity to oil pollution. The SOSI score for each UKCS Block is ranked into sensitivity categories, from 1 (extremely high sensitivity) to 5 (low sensitivity). An assessment of the median SOSI scores for Block 47/3, within which the proposed Abbey & Baker Development area is located, indicate that sensitivity is generally high to very high between February to November, apart from April which is low, and medium in December and January (Table 4.14; Webb *et al*., 2016).

Table 4.14: Seabird Sensitivity to Oiling within the Proposed Abbey & Baker Development Area (Webb et al., 2016)

UKCS Block	J	F	M	A	M	J	J	A	S	O	N	D
42/27	3	2	2	2	2	2	4	2	3	3	3	4
42/28	5	2	2	2	3	2	3	3	3	3	3	4
42/29	5	2	1	1	4	1	3	3	3	3	5	4
47/2	3	2	2	5	3	2	5	2	3	3	3	4
47/3	**4**	**2**	**2**	**5**	**4**	**2**	**3**	**3**	**3**	**3**	**3**	**4**
47/4	5	1	2	2	5	2	4	3	3	3	4	4
47/7	3	3	2	5	4	2	5	3	3	1	3	4
47/8	4	3	2	5	5	3	5	3	3	1	3	4
47/9	4	2	2	5	5	4	5	3	4	1	2	3

Key: 1 = Extremely High; 2 = Very High; 3 = High; 4 = Medium; 5 = Low; 'N' = No Data.
SOSI sensitivity category in red and underlined indicates an indirect assessment of SOSI scores, in light of coverage gaps.
Row in bold indicates the UKCS block within which the proposed Abbey & Baker Development area is located.

4.3.5 Marine Mammals

Cetaceans

Cetacean abundance in the SNS is relatively low compared to the northern and central North Sea, with the exception of the harbour porpoise (*Phocoena phocoena*). Ten species of cetacean have been sighted in the SNS, however only the harbour porpoise and the white-beaked dolphin (*Lagenorhynchus albirostris*) are considered to be regularly occurring. Minke whale (*Balaenoptera acutorostrata*) is a frequent seasonal visitor, whilst bottlenose dolphin (*Tursiops truncatus*) and white-sided dolphin (*Lagenorhynchus acutus*) are considered uncommon visitors (DESNZ, 2022).

Harbour porpoises are found in persistently high densities year-round at the inner Silver Pit, in summer at the north-western edge of Dogger Bank, and in winter in offshore areas east of Norfolk and east of the outer Thames estuary. The Southern North Sea Special Area of Conservation (SAC) has been

designated to protect these areas and the proposed Abbey & Baker Development lies within this SAC (refer to Section 4.3.6 for further details).

The UK Statutory Nature Conservation Bodies (SNCBs) have defined Marine Mammal Management Units (MMMUs) for seven cetacean species (harbour porpoise, common dolphin, bottlenose dolphin, white-beaked dolphin, white-sided dolphin, Risso's dolphin and minke whale) in UK waters in order to provide an understanding of the geographical range and abundance of marine mammal populations, and subpopulations, to aid conservation and management purposes. The Management Units (MUs) within which the Abbey & Baker Development are located, along with the corresponding abundance of animals within these units, are listed in Table 4.15 (IAMMWG, 2022).

Table 4.15: Estimates of Cetacean Abundance in the Relevant MMMUs (IAMMWG, 2022)

Species	Management Unit	Abundance of Animals	95 % Confidence interval	Density [1]
Bottlenose dolphin	Greater North Sea (639,886 km^2)	2,022	548 – 7,543	0.003
Harbour porpoise	North Sea (678,206 km^2)	346,601	289,498 – 419,967	0.511
Risso's dolphin	Celtic and Greater North Seas (1,560,875 km^2)	12,262	5,227	0.007
Common dolphin		102,656	58,932 – 178,822	0.065
Minke whale		20,118	14,061 – 28,786	0.012
White-beaked dolphin		43,951	28,439 – 67,924	0.028
White-sided dolphin		18,128	6,049 – 54,323	0.011

[1] Density (individuals per km) was calculated using the total area of the MU and the abundance of animals within that MU

It is evident that harbour porpoise are the most abundant species in the North Sea compared to other species identified in Table 4.15, despite its MMMU being smaller in area than all species, apart from bottlenose dolphin.

The relative abundance and density of cetaceans in the vicinity of the Abbey & Baker Development can also be derived from data obtained during the Small Cetacean Abundance of the North Sea (SCANS-IV) aerial and ship-based surveys. This project identified the abundance and density of cetacean species within predefined sectors of the North Sea and North-East Atlantic. The proposed Abbey & Baker Development is situated within SCANS-IV Block NS-C (Table 4.16) in which harbour porpoise, bottlenose dolphin, common dolphin, minke whale and white-beaked dolphin have been recorded (Gilles et al., 2023). It should be noted that although density estimates are shown in Table 4.16, they are only an example of what densities could be encountered in the area due to the wide-scale nature of the SCANS-IV survey and the fact the data was only collected in the summer of 2022.

Table 4.16: Estimated Abundance and Density of Cetaceans in UK Waters from the SCANS IV Aerial Survey Area Block NS-C (Gilles et al., 2023)

Species	SCANS-IV Block 'NS-C'		Total (Aerial Survey Blocks)	
	Abundance	Density [1]	Abundance	Density [1]
Harbour porpoise	36,286	0.603	409,244	0.279
Bottlenose dolphin	2,520	0.042	80,809	0.055
Common dolphin	192	0.003	317,527	0.216
White-beaked Dolphin	894	0.015	67,138	0.046
Minke whale	412	0.007	12,417	0.009

As the SCANS-IV survey area encompasses a relatively large geographical area and is therefore unlikely to accurately reflect the abundance and densities of cetaceans which may be present within the vicinity of the proposed Abbey & Baker Development, data from the JNCC Atlas of Cetacean Distribution in north-west European Waters has been used to give a more localised indication of the seasonal distribution of cetaceans. The seasonal sightings data for ICES Rectangles 36F0 is summarised in Table 4.17. This indicates that bottlenose dolphin, common dolphin, harbour porpoise, white-beaked dolphin and white-sided dolphin have previously been observed in the area (Reid *et al.*, 2003). However, it is important to note that the lack of recorded sightings does not necessarily preclude the presence of a species at a certain time of year. In addition, the highly mobile nature of cetaceans means that species that are found within the area in general may be present at other times of the year.

Table 4.17: Cetacean Sightings in ICES Rectangles 36F0 (Reid *et al.*, 2003)

Species	J	F	M	A	M	J	J	A	S	O	N	D
Bottlenose Dolphin												
Common Dolphin												
Harbour Porpoise												
White-beaked Dolphin												
White-sided Dolphin												

Key (Number of individuals per hour of sightings effort)

High (>100)	Medium (10 – 100)	Low (1 – 10)	Very Low (0 – 1)	No sightings

All cetaceans (whales, dolphins, and porpoises) are listed as European Protected Species (EPS) under Annex IV of the Habitats Directive. Harbour porpoise is also listed on the OSPAR List of Threatened and/or Declining Species (OSPAR, 2021) and harbour porpoise and bottlenose dolphin are listed under Annex II of the Habitats Directive. All of the species mentioned are listed as UK BAP priority species (JNCC, 2007a), but are regarded as being of 'Least Concern' in terms of their population threats (IUCN, 2026).

Of note is that there has been a change in the overall conservation status of cetaceans in UK waters from favourable to unknown since 2013. This is due to the implementation of a more robust assessment methodology, supported by updated European Union (EU) Commission guidance, which requires consideration of population trends in setting the Favourable Reference Population (FRP) value. However, this requires a higher number of UK population estimates over time than are currently available, resulting in the unknown conclusion (DESNZ, 2022).

Multiple studies have been undertaken that aim to predict the future distributions, behaviours and health of cetacean populations. In general, they note that, in the UK and wider north-west European waters, the main effects of climate change on cetaceans will be:

- Geographical range shifts appear to be occurring, with northward extensions of the range of warmer water species, such as striped dolphin, short-beaked common dolphin, and possible range contractions of cold-water species such as white-beaked dolphin.
- Continued rises in sea temperature could result in a shift in the species composition for cetaceans around the British Isles, with increased biodiversity particularly of subtropical and warm temperate pelagic species.
- Species that traditionally make long-distance seasonal migrations (e.g. most baleen whales) will likely arrive earlier or remain in high latitudes for longer, with increased breeding attempts.
- Ecosystem regime shifts in UK waters may result in lower food availability for a number of marine mammal species, and lead to re-distribution of some regional populations.

- In low latitude, warm water regions, some species have experienced occasional mass die-offs linked to the presence of algal toxins. These may now also be affecting marine mammal species in mid-latitudes, including harbour seals.
- Responses of marine mammals to climate change, both at individual and population levels, remain poorly understood. Predicting future impacts is challenging, and it is currently unrealistic to assess these for specific time horizons beyond the likely continuations of range shifts which are already being observed.

Pinnipeds

Two species of seals; grey seal (*Halichoerus grypus*) and the harbour (or common) seal (*Phoca vitulina*) are found along the English coast. Important numbers of grey and harbour seals are present off the east coast of England, particularly around The Wash where harbour seals forage over a wide area.

Grey and harbour seals are both listed under Annex II of the EU Habitats Directive, requiring the designation of SACs in order to protect these species. In addition, harbour and grey seals are listed as UK BAP priority marine species (JNCC, 2007a).

Grey Seals

The UK hosts around 34% of the world population of grey seals and 95% of the EU population. Several colonies exist on the east coast of England, including Donna Nook, Blakeney Point, Horsey, Flamborough Head and The Wash. There were 10,735 grey seals counted in Southeast England between the August 2022 and 2023 surveys at haul out sites (SCOS, 2025).

Grey seals forage in the open sea and return regularly to haul out on land where they rest, moult and breed. Grey seal foraging movements are on two geographical scales: long and distant trips from one haul-out site to another; and local repeated trips to discrete foraging areas (McConnell et al. 1999). Foraging areas can be up to 100 km offshore and connected to haul-out sites by prominent high-usage corridors (Jones et al., 2015). The at-sea distribution (relative density) of grey seals in the vicinity of the proposed Abbey & Baker Development area is high (between 0.01 – 0.05% of the population per 25 km^2) (See Figure 4.41; Carter et al., 2022). Densities at sea are lower during pupping and breeding season, which in south-east Britain occurs between early November to mid-December, and during the moulting season (which in the UK is between December and April) (SCOS, 2022).

Harbour Seals

Around 32% of EU harbour seals are found in the UK. Their distribution on the east coast of the UK is restricted, concentrating in major estuaries including the Thames, The Wash, and the Moray Firth. The south-east coast of England hosts several harbour seal colonies and haul-out sites, and total count for the region was 3,752 in 2020. The largest colony in the UK is The Wash, with an estimated 3,372 individuals counted in 2022 (SCOS, 2022).

In general, the harbour seal tends to forage within 40 – 50 km of its haul out sites (SCOS, 2022), however tagging studies have demonstrated that individuals from haul-out sites in The Wash forage for much greater distances than individuals from elsewhere in the UK (Sharples et al., 2012). The at-sea distribution (relative density) of harbour seals in the vicinity of the proposed Abbey & Baker Development area is low (< 0.005% of the population per 25 km^2) (See Figure 4.41; Carter et al., 2022). Additionally, harbour seals spend more time ashore at haul-out sites from June to July during breeding and in August during moulting season, and thus densities at sea are lower during this time (SCOS, 2022).

Management Units

The UK SNCBs have defined MUs for grey and harbour seals in inshore UK waters in order to provide an understanding of their geographical range, and abundance of their populations, and subpopulations, to aid conservation and management purposes. The proposed Abbey & Baker Development is not located within a MU for seals as these are specific to inshore waters (IAMMWG, 2013; SCOS, 2024). However, it is noted that the seaward extent of these MUs is illustrative and not definitive, as seals will cross MU boundaries on a regular basis. Table 4.18 therefore lists the MU for seals which is adjacent to the proposed Abbey & Baker Development, along with the corresponding abundance of animals within this unit.

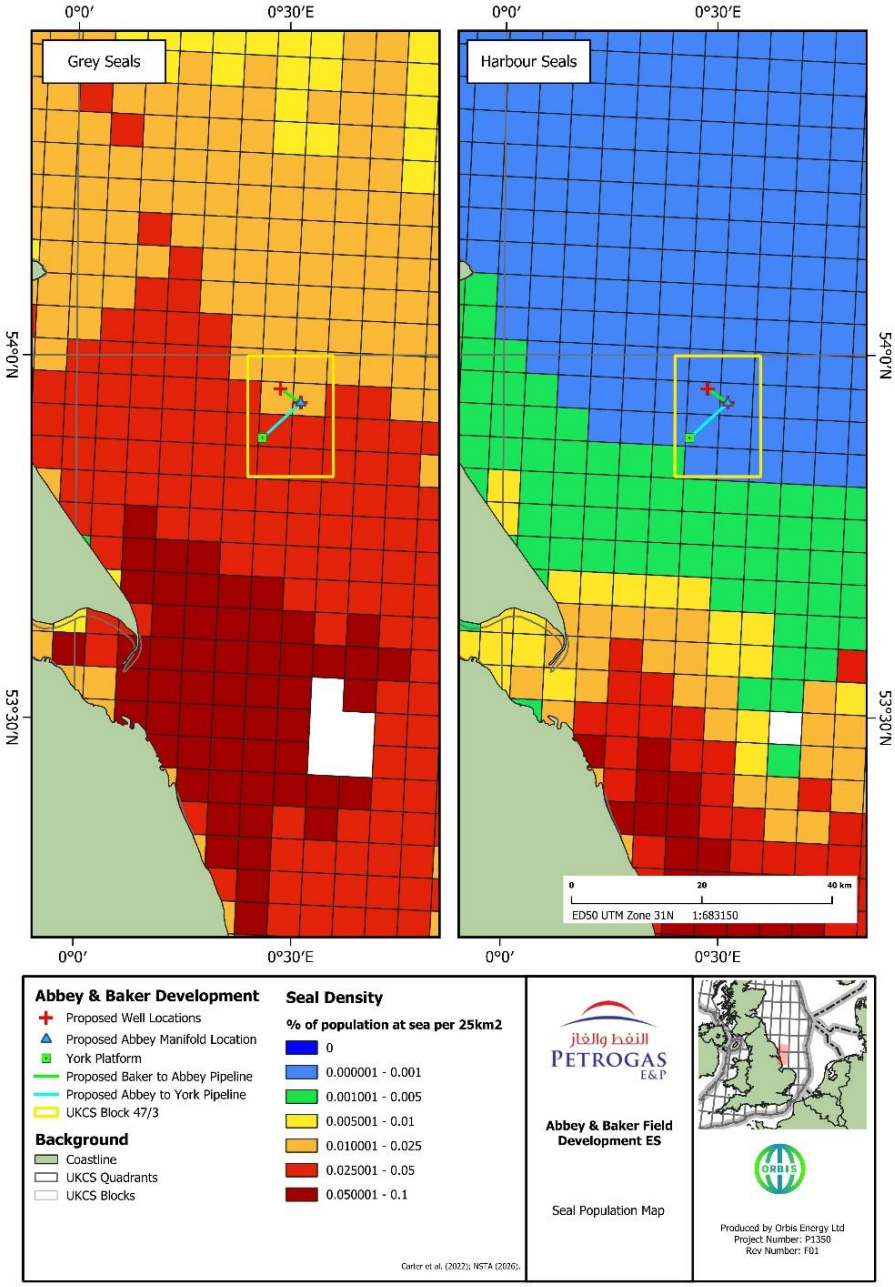
Table 4.18: Population Sizes of Seals in MUs (SCOS, 2024)

Species	Management Unit	Seal Count [N1]	Estimated Population Size [N2]	Survey Years
Harbour Seal	North East England	106	147	2019 - 2021
Grey Seal		5,446	[N2]	2010 - 2021

[N1]: Most recent count data for Grey and Harbour seals in North East England MU was surveyed during 2020, 2022 and 2023 (SCOS, 2024). The Tees data collected and provided by the Industry Nature Conservation Association.
[N2]: Mean latest population estimate for Harbour seals in 2023 (SCOS, 2024), Grey seal population model estimates for not available.

In the UK, recent demographic changes (increases in most grey seal populations and declines in some harbour seal populations) could potentially be linked in some way to climate-mediated changes in food supply, however, other factors (depletion of food resources from fishing, recovery from epizootics, interspecific competition, density dependent effects) may be more important (DESNZ, 2022).

Figure 4.41: Seal Density in the vicinity of the Abbey & Baker Development (Carter *et al.*, 2022)



4.3.6 Marine Protected Areas

The proposed Abbey & Baker Development area is located within the Southern North Sea SAC, designated for the protection of harbour porpoises and the Holderness Offshore MCZ. An additional five Marine Protected Areas (MPAs) are located within 40 km of the proposed development area, as listed in Table 4.19 and shown in Figure 4.42 (JNCC, 2025).

Table 4.19: MPAs within 40 km of the Abbey & Baker Development (JNCC, 2025)

Site Name	Distance & Direction [1]
Southern North Sea SAC	0 km
Holderness Offshore MCZ	0 km
Greater Wash SPA	20 km west
Holderness Inshore MCZ	25 km west
Flamborough and Filey Coast SPA	39 km northwest
Flamborough Head SAC	35 km northwest
Humber Estuary SPA / Ramsar	36 km southwest

[1] Distance and direction from the proposed Abbey & Baker Development.

Southern North Sea SAC

The proposed Abbey drill site and the proposed pipeline are located within the Southern North Sea SAC, which has been designated as an area of importance for harbour porpoise, and supports 17.5% of the UK North Sea MU population. The site covers an area of 36,951 km^2. The majority of this site lies offshore, though it does extend into coastal areas of Norfolk and Suffolk. The northern two thirds of the site are recognised as important for porpoises during the summer season, whilst the southern part (in which the proposed Abbey & Baker Development is located) supports persistently higher densities during the winter (October – March) and covers an area of 12,696 km^2 (JNCC, 2023b).

Harbour porpoise are strongly reliant on the availability of prey species due to their high energy demands, and are highly dependent on being able to access prey species year-round. The Southern North Sea SAC is considered an important area for harbour porpoise due to the sandy, coarse sediments covering much of the site, which are thought to be preferred by harbour porpoise as during the winter the site supports persistently higher densities, likely due to availability of prey which includes whiting, herring, sandeels, sprat and cod which are all found to be within the area of interest (JNCC, 2023b).

The conservation objectives of the Southern North Sea SAC are to ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining both the Favourable Conservation Status (FCS) for harbour porpoise in UK waters and FCS of the SNS SAC site (JNCC, 2023b).

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

- Harbour porpoise is a viable component of the site;
- There is no significant disturbance of the species; and
- The condition of supporting habitats and processes, and the availability of prey is maintained.

Holderness Offshore MCZ

Approximately 4.7 km of the proposed Abbey to York pipeline is located within the Holderness Offshore MCZ. The site is located 11 km offshore and covers an area of 1,176 km^2. The MCZ is designated for North Sea glacial tunnel valleys (inner Silver Pit), subtidal coarse sediment, subtidal sand, subtidal mixed sediments and the presence of ocean quahog (*Arctica islandica*) (JNCC, 2025). As mentioned in Section 4.3.2, the section of the proposed Abbey to York pipeline route located in the MCZ contains both the subtidal sand (MD52) and subtidal coarse sediment (MD32) habitats protected by the MCZ. One adult (shell size >5 cm) specimen of *A. islandica* was also recovered during grab sampling operations at station A_PL_01, which is located within the MCZ. This specimen was recorded, photographed and returned to the sea. Although, no evidence of their distinct siphons was seen on any of the video footage or still photographs within the pipeline route survey area in the MCZ.

The diverse seabed within the MCZ allows for a wide variety of species which live both in and on the sediment such as, crustaceans (crabs and shrimp), starfish and sponges. This site is also a spawning and nursing ground for a range of fish species for example lemon sole (*Microstomus kitt*), plaice and European sprat (*Sprattus sprattus*). Therefore, the species living both in and on the sediment may benefit from the protection afforded to the habitat features within this site.

The Conservation Objective for the Holderness Offshore Marine Conservation Zone is that the protected features:

- So far as already in favourable condition, remain in such condition; and
- So far as not already in favourable condition, be brought into such condition, and remain in such condition.

As of March 2021, only the North Sea glacial tunnel valleys (inner Silver Pit), located approximately 40 km from the proposed Abbey & Baker Development, are in favourable condition. All other features for which the site has been designated, are to be brought into favourable condition.

Holderness Inshore MCZ

The Holderness Inshore MCZ is located approximately 33 km west of the proposed Abbey & Baker Development. The MCZ is an inshore site covering an area of approximately 309 km^2 and is located north of the Humber estuary mouth (DEFRA, JNCC & Natural England, 2016).

The MCZ is designated for High energy circalittoral rock, intertidal sand and muddy sand, moderate energy circalittoral rock, spurn Head (subtidal) and "the Binks", subtidal coarse sediment, subtidal mixed sediments, subtidal mud and subtidal sand: all these features are in favourable condition. Spurn Head, which is in the south of the MCZ, is a unique example of an active spit system, extending across the mouth of the Humber Estuary (DEFRA, JNCC & Natural England, 2016).

The Conservation Objective for the Holderness Inshore Marine Conservation Zone is that the protected features are maintained in favourable condition.

Greater Wash SPA

The Greater Wash SPA is located approximately 29 km west of the proposed Abbey & Baker Development. The SPA lies along the east coast of England, predominantly in the coastal waters of the mid–southern North Sea between the counties of Yorkshire to the north and Suffolk to the south. It covers an area of ca. 3,536 km^2 (JNCC, 2020).

The SPA is designated for Annex I species red-throated diver (*Gavia stellata*), little gull (*Hydrocoloeus minutus),* common scoter (*Melanitta nigra*), sandwich tern (*Sterna sandvicencis*), little tern (*Sternula albifrons*) and common tern (*Sterna hirundo*) (JNCC, 2020). However, based on the mean maximum +1SD foraging ranges reported by Woodward et al. (2019), only the sandwich tern is likely to be present in the proposed Abbey & Baker Development area.

The Conservation Objectives for the Greater Wash SPA are to ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;

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

Filey & Flamborough Coast SPA

The Filey and Flamborough Coast SPA is located approximately 42 km northwest of the proposed Abbey & Baker Development. The SPA is in two sections: the southern section extends north from South Landing around Flamborough Head to Speeton; the northern section covers the peninsula of Filey Brigg before extending north west to Cunstone Nab. The seaward boundary extends 2 km throughout the

two sections of the site into the marine environment, running parallel to the landward boundaries to include the adjacent coastal waters. The site covers an area of 78.6 km^2. The SPA is designated for Annex I species black-legged kittiwake (*Rissa tridactyla*), which, according to Woodward et al. (2019), may be present within the vicinity of the proposed Abbey & Baker Development (Natural England, 2019a).

The Conservation Objectives for Filey and Flamborough Coast SPA are to ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;

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

Flamborough Head SAC

The Flamborough Head SAC is located approximately 37 km northwest of the proposed Abbey & Baker Development, and covers an area of 64 km^2. The SAC is designated for reefs, vegetated sea cliffs of the Atlantic and Baltic Coasts and submerged or partially submerged sea caves. Flamborough Head represents the most northerly outcrop of coastal chalk in the UK and the most southerly area of bedrock on the North Sea. The site is characterised by high chalk cliffs (up to 135 m high and covering a distance of about 16 km) which are partly vegetated, over 200 caves and a chalk reef which extends up to 6 km offshore (Natural England, 2018).

The Conservation Objectives for the Flamborough SAC are to ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring;

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

Humber Estuary SPA / Ramsar

The Humber Estuary SPA / Ramsar is located approximately 43 km southwest of the proposed Abbey & Baker Development and covers an area of 370 km^2. The inner estuary supports extensive areas of reedbed, with areas of mature and developing saltmarsh backed by grazing marsh in the middle and outer estuary. On the north Lincolnshire coast, the saltmarsh is backed by low sand dunes with marshy slacks and brackish pools (Natural England, 2019b; JNCC, 2007b).

The SPA is designated for avocet (*Recurvirostra avosetta*), bittern (*Botaurus stellaris*), hen harrier (*Circus cyaneus*), golden plover (*Pluvialis apricaria*), bar-tailed godwit (*Limosa lapponica*), ruff (*Philomachus pugnax*), marsh harrier (*Circus aeruginosus*), little tern (*Sterna albifrons*), shelduck (*Tadorna tadorna*), knot (*Calidris canutus*), dunlin (*Calidris alpina*), black-tailed godwit (*Limosa limosa*) and redshank (*Tringa tetanus*) (Natural England, 2019b; JNCC, 2007b). Based on the mean maximum +1SD foraging ranges reported by Woodward et al. (2019), none of the species which use the SPA are likely to be present within the vicinity of the proposed Abbey & Baker Development area.

The Ramsar site meets the Criteria 1,3,5,6 and 8. The aspects of the site that meet these criteria have been listed below:

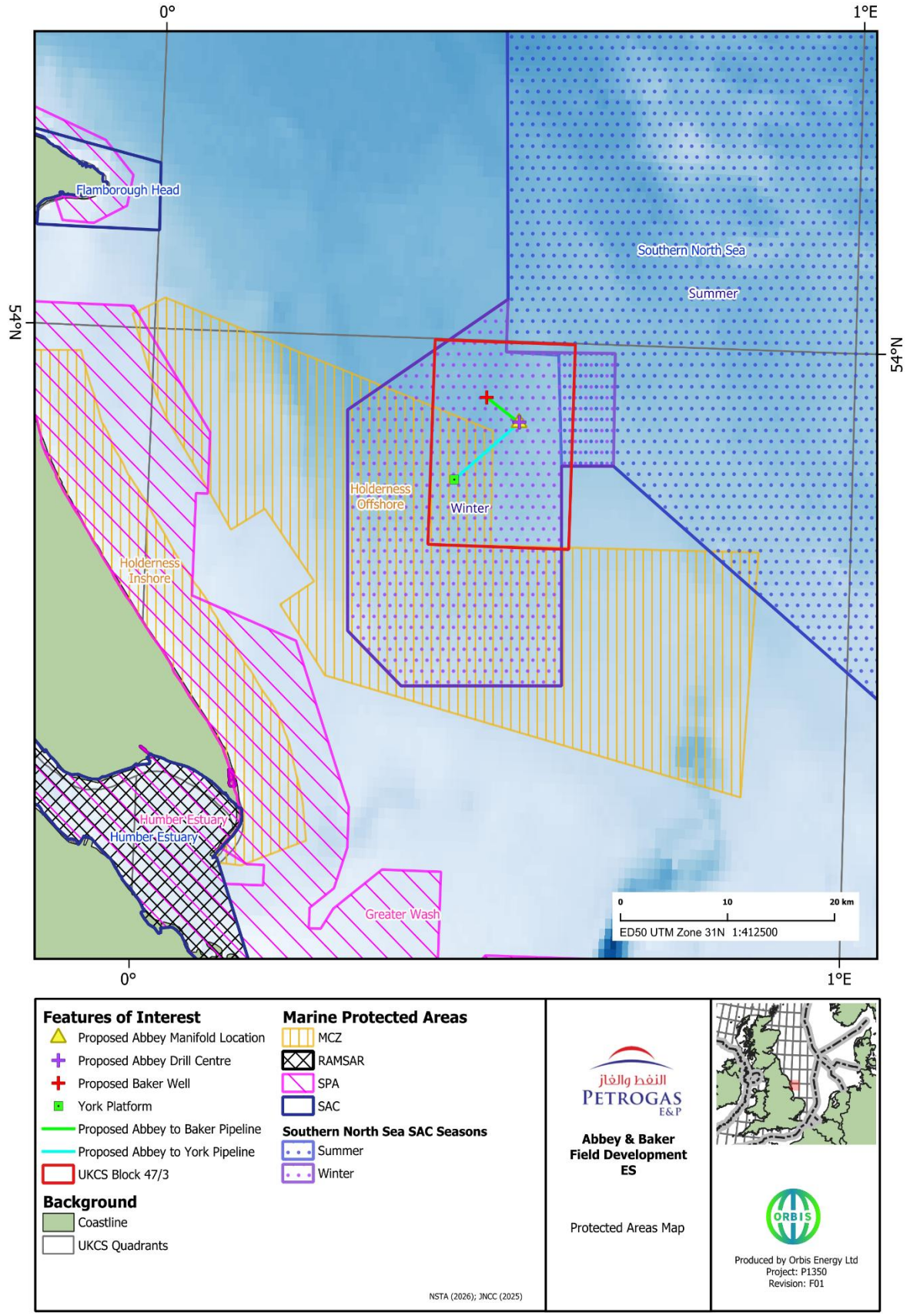
- **Criterion 1 -** The site is a representative example of a near-natural estuary with the following component habitats: dune systems and humid dune slacks, estuarine waters, intertidal mud and sand flats, saltmarshes, and coastal brackish/saline lagoons.
- **Criterion 3 -** The Humber Estuary Ramsar site supports a breeding colony of grey seals Halichoerus grypus at Donna Nook. The dune slacks at Saltfleetby-Theddlethorpe on the southern extremity of the Ramsar site are the most north-easterly breeding site in Great Britain of the natterjack toad (*Bufo calamita*).

- **Criterion 5 -** Assemblages of international importance: 153,934 waterfowl, non-breeding season (5 year peak mean 1996/97-2000/2001)
- **Criterion 6 -** species/populations occurring at levels of international importance
- **Criterion 8 -** The Humber Estuary acts as an important migration route for both river lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*) between coastal waters and their spawning areas.

The conservation objectives of the Humber Estuary SPA / Ramsar are to ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;

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

Figure 4.42: Marine Protected Areas in the Vicinity of the Abbey & Baker Development Area (JNCC, 2025)



4.4 Human Environment

4.4.1 Commercial Fisheries

The North Sea is one of the world's most important fishing grounds, and major UK and international fishing fleets operate in the SNS, targeting a mix of demersal, shellfish and pelagic fish stocks. Fishing effort and landings around the UK is recorded by ICES statistical rectangle; however these data only record effort and landings from UK vessels.

As previously noted, the proposed Abbey & Baker Development area is located within ICES Rectangles 36F0. Data has been collected by the MMO for fishing landings for the period 2015 to 2024. Fishing effort data is also available from the SG-MD for 2015 to 2024.

Fishing Effort

Table 4.20 shows that effort has increased within ICES Rectangle 36F0 by approximately 1.3 times in 2024 since 2015. Monthly fishing effort is relatively high with Traps the preferred fishing method for ICES Rectangle 36F0 in 2024 accounting for 92.30% of the effort, followed by Dredges (7.40%), and Trawls (0.30%) (Marine Scotland, 2015; Marine Scotland, 2020; SG-MD, 2025).

Figure 4.43 presents fishing vessel tracks recorded on Automatic Identification System (AIS) within 10 nautical miles (nm) (18.52 km) of the proposed Abbey drill centre location and previously drilled Baker appraisal well. AIS carriage is mandatory for all fishing vessels 15 m in length and over under UK and EU regulations. Fishing vessels were primarily recorded transiting from the west and actively fishing in close vicinity to the Abbey location. Further vessels tracks indicative of active fishing were noted to the northern and southwestern extent of the 10nm buffer (Anatec, 2024).

Figure 4.43: Fishing Vessel Activities within 10 nm of the Abbey Drill Site Location (Anatec, 2024)

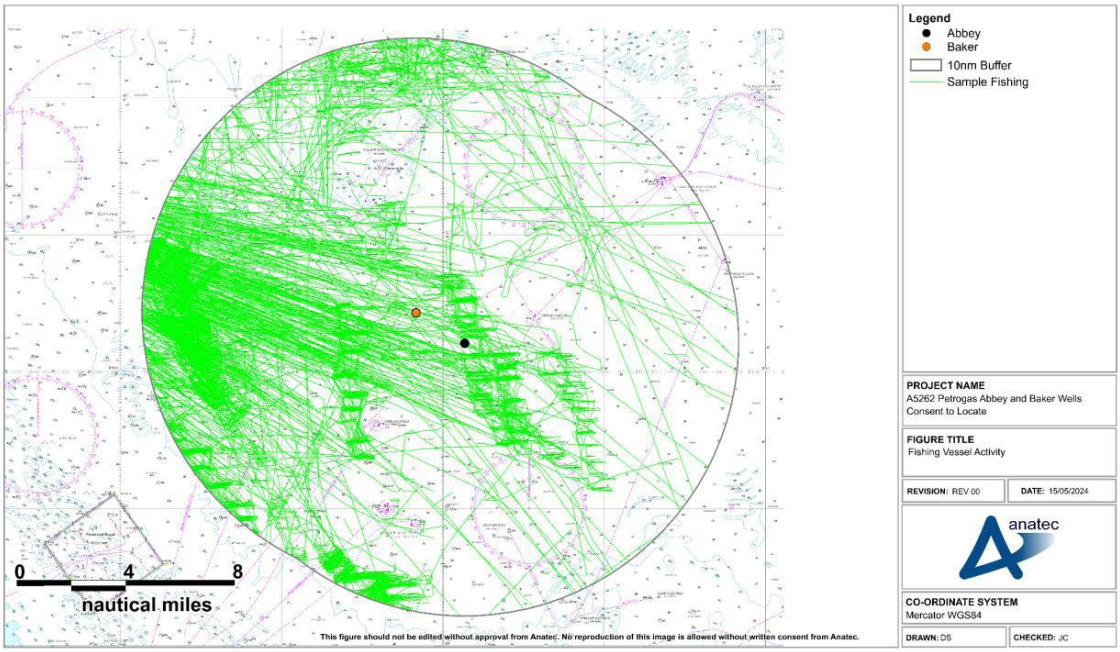


Table 4.20: Number of Days Fished per Month (All Gears) in ICES Rectangles 36F0 from 2015 – 2024 (Marine Scotland, 2015; Marine Scotland, 2020; SG-MD, 2025)

ICES Rectangle 36F0													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total [1]**
2015	118	131	184	263	273	234	279	297	300	267	193	128	2666
2016	106	116	162	158	191	239	297	331	279	226	208	181	2495
2017	167	141	211	230	260	277	306	423	252	258	241	159	2925
2018	136	116	207	248	238	210	285	380	283	246	162	137	2645
2019	142	149	124	173	229	168	277	291	269	243	152	131	2349
2020	135	91	129	76	221	218	306	309	352	287	242	186	2563
2021	292	126	209	235	281	230	345	354	343	319	263	226	3258
2022	209	112	249	253	343	275	353	370	290	316	265	171	3232
2023	175	165	219	199	307	344	436	388	314	384	218	214	3365
2024	138	226	248	273	332	351	446	399	292	320	229	145	3398

Note: Monthly fishing effort by UK vessels landing into Scotland: Blank = no data, D = Disclosive data (indicating very low effort),

[N1] Includes any days that cannot be disclosed in the monthly figures,

green = 0 – 100 days fished, yellow = 101 – 200, orange =201-300, red = ≥301

Fishing Landings

The live weight (tonnes) and value (£) of sea fish landed by UK vessels into the UK and abroad, and landings into the UK by foreign vessels, from the last ten years (between 2015 and 2024) is shown in Table 4.21 for ICES Rectangles 36F0. This indicates that the proposed Abbey & Baker Development area is primarily targeted by shellfish fisheries (SG-MD, 2025; MMO, 2016; 2017; 2018; 2019; 2025).

The most frequently caught species in terms of live weight in 2024 was crabs, accounting for 1,763.32 tonnes, followed by scallops (490.53 tonnes), and lobster (440.51 tonnes). The largest contribution to the fishery in terms of value was lobster, accounting for £6,257,019.96, followed by crabs (£3,277,018.47) and scallops (£957,521.09). The most frequently used gear type was pots and traps, followed by dredges and demersal seines (SG-MD, 2025; MMO, 2016; 2017; 2018; 2019; 2025).

As seen in Table 4.21, overall, in 2024, ICES Rectangle 36F0 had a total value of £10,804,061.44 and live weight of 2,974.98 tonnes across demersal, pelagic and shellfish. In summary, therefore, ICES Rectangle 36F0 (the location of the proposed Abbey & Baker Development area) is subject to high levels of fishing activity.

Table 4.21: Live Weight and Value of Fish and Shellfish from ICES Rectangle 36F0 from 2015 to 2024 (SG-MD, 2025; MMO, 2016; 2017; 2018; 2019; 2025)

Species Type	2024		2023		2022		2021		2020	
	Live Weight (tonnes)	Value (£)	Live Weight (tonnes)	Value (£)	Live Weight (tonnes)	Value (£)	Live Weight (tonnes)	Value (£)	Live Weight (tonnes)	Value (£)
Demersal	5.97	17,673.50	17.42	32,753.02	11.13	20,151.00	30.98	23,820.79	20.49	21,501.94
Pelagic	4.80	7,949.76	1.32	1365.69	5.33	10,614.36	5.20	4,024.75	2.90	3,003.16
Shellfish	2,964.21	10,778,438.18	2,977.81	15,850,502.84	3,402.96	14,520,276.97	3,971.30	15,750,560.76	3,130.48	8,995,013.86
Total	**2,974.98**	**10,804,061.44**	**2996.55**	**15,884,621.55**	**3,419.41**	**14,551,042.33**	**4,007.48**	**15,778,406.30**	**3,153.88**	**9,019,518.96**
Species Type	**2019**		**2018**		**2017**		**2016**		**2015**	
	Live Weight (tonnes)	Value (£)	Live Weight (tonnes)	Value (£)	Live Weight (tonnes)	Value (£)	Live Weight (tonnes)	Value (£)	Live Weight (tonnes)	Value (£)
Demersal	15.33	15,500.35	9.07	10,196.41	5.79	8,999.99	7.80	15,310.32	25.70	44,537.07
Pelagic	-	-	161.57	87,222.38	0.19	165.20	0.04	18.00	3.61	9.00
Shellfish	3,436.43	10,910,287.93	3,678.11	11,022,651.77	3,859.90	11,125,359.40	3,727.75	9,433,068.33	3,467.43	7,760,171.08
Total	**3,451.76**	**10,925,788.28**	**3,848.75**	**11,120,070.56**	**3,865.88**	**11,134,524.59**	**3,735.59**	**9,448,396.65**	**3,496.74**	**7,804,717.15**

4.4.2 Aquaculture and Shellfish Water Protected Areas

There are no aquaculture sites or shellfish protected areas within the immediate vicinity of the proposed Abbey & Baker Development area. The closest aquaculture site is the Pacific Oyster Cultivation: Brancaster-Thornham Oysters on the Brancaster coast located approximately 102 km south of the proposed Abbey pipeline route, and the closest shellfish water protected area is the North East Wash site, located approximately 90 km southeast of the proposed Abbey drill site at its closest point (NMPi, 2026).

4.4.3 Shipping

The density of shipping traffic in the SNS is relatively high due to the presence of fishing vessels, some ferries between the UK and the rest of Europe and cargo and offshore support vessels (DESNZ, 2022).

A plot of the mean route positions relative to the Abbey and Baker drill centre locations is presented in Figure 4.44 (Anatec, 2024). There are 81 shipping routes trafficked by an estimated 8,424 vessels per year passing within 10 nm (18.52 km) of the proposed Abbey & Baker locations. This corresponds to an average of approximately 23 vessels per day, indicating relatively high levels of shipping activity. The main vessel type operating within 10 nm (18.52 km) of the Abbey & Baker locations is cargo, with the predominant size range between 1,500 and 5,000 Dead Weight Tonnes (Anatec, 2024).

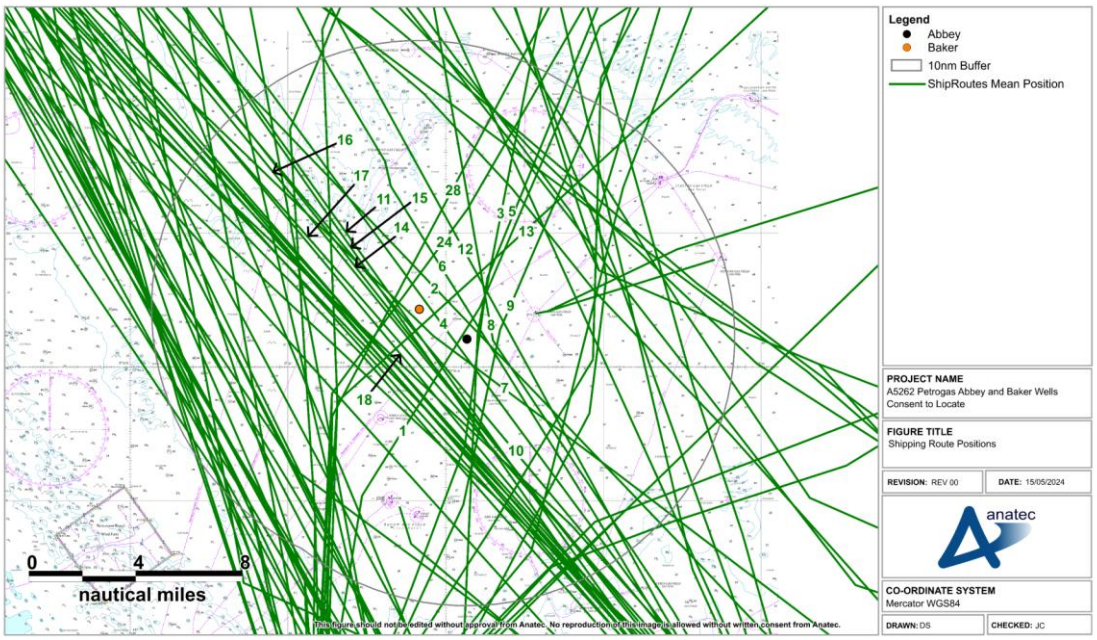
Routes 1 to 18, 24 and 28 pass within 2 nm (3.7 km) of the Abbey & Baker locations. Details of these routes are presented below:

- Routes 2, 4, 6, 8 and 12 pass in a NW/SE direction and are used by an estimated 244 vessels per year, passing at mean distances between 0.3 nm (0.56 km) and 1.5 nm (2.78 km). These routes were typically seen passing to the northeast of the Abbey & Baker locations, the only exception was Route 4, which passes to the northwest of the Abbey & Baker locations.
- Routes 1, 3, 5, 9, 13, 24 and 28 pass in a NE/SW direction and are used by an estimated 326 vessels per year, passing at mean distances between 0.2 nm (0.37 km) and 1.1 nm (2.04 km). Routes 3, 5 and 9 pass southeast of the Abbey & Baker locations and Routes 1, 13, 24 and 28 pass northwest of the location.
- Routes 7, 10, 11 and 14 to 18 pass to the west of the Abbey & Baker locations, passing in a NW/SE direction. These routes are used by an estimated 1,460 vessels per year, passing at mean distances between 0.4 nm (0.74 km) and 1.6 nm (2.96 km).

The remainder of the routes have mean positions of at least 2 nm (3.7 km) from the Abbey & Baker locations.

The York platform has an existing 500 m exclusion zone around the platform, which excludes all shipping and fishing vessels from entering the area. The 500 m exclusion at the York platform will remain in place for the duration of the Abbey & Baker Development.

Figure 4.44: Shipping Route Positions within 10 nm of the Abbey and Baker Drill Site Locations (Anatec, 2024)



4.4.4 Offshore Oil and Gas Activity

The proposed Abbey & Baker Development will tie into the existing York platform located approximately 8 km southwest of the proposed Abbey drill centre. The York field is currently owned and operated by Spirit Energy. Subject to completion of the sale and purchase agreement with Spirit Energy, Petrogas will assume ownership and responsibility for the operations of this platform as part of the Abbey & Baker Development.

The closest surface oil and gas infrastructure to the proposed Abbey & Baker Development is the Minerva platform, operated by Perenco UK Limited, which is located approximately 5 km east northeast of the proposed Abbey drill centre (see Figure 4.45) (NSTA, 2026a).

One pipeline is within the vicinity of the proposed Abbey & Baker Development, this is the active Cleeton CP to Dimlington gas pipeline (PL447) operated by Perenco, which crosses the Abbey to Baker pipeline approximately 1.5 km along the route from the Abbey manifold side (see Figure 4.45).

A total of 77 wells have previously been drilled within UKCS Blocks 47/3 (56 development, 14 appraisal, and 7 exploration). Of these, 20 are currently listed as in production, 1 has been shut in, 10 have been plugged and the remaining 46 have been fully abandoned (NSTA, 2026a).

In addition, the Rough Gas Storage facility (operated by Centrica Storage Limited) lies approximately 10 km from the proposed Abbey & Baker Development (see Figure 4.46).

4.4.5 Renewable Energy, Carbon Capture & Storage and Subsea Cables

The nearest submarine cable to the proposed Abbey & Baker Development is the active VSNL North Europe telecom cable, operated by VSNL Telecoms, located approximately 47 km to the north west of the proposed Abbey & Baker Development area at its nearest point (see Figure 4.46; KIS-ORCA, 2025).

The proposed Hornsea Project Four cable corridor (operated by Ørsted Power (UK) Limited) which is currently in planning, is located approximately 8.9 km northeast from the proposed Baker well. There is potential for installation operations overlap with drilling operations for the proposed Abbey & Baker Development; offshore cable installation is currently planned to take place during 2028. Installation operations are however, unlikely to occur during the same period as the Abbey & Baker subsea infrastructure installation. The active Westermost Rough wind farm (operated by Ørsted Power (UK) Limited) lies approximately 18 km southwest of the proposed Abbey to York pipeline, and the active

Humber Gateway wind farm (operated by E.ON Climate and Renewables) lies approximately 24 km to the southwest of the proposed Abbey to York pipeline (see Figure 4.46; Crown Estate, 2026).

The Endurance carbon capture and storage site (BP Exploration Company Limited), currently under construction, is located approximately 34 km northeast of the proposed Abbey & Baker Development. Offshore construction and drilling are scheduled to begin in Q1 2026, with start-up planned for 2028. Although the main construction and drilling phases for Endurance occur earlier, some later-stage activities could overlap with elements of the proposed Abbey & Baker Development. Drilling for the Abbey & Baker wells is expected to begin in Q4 2027, followed by subsea infrastructure installation between Q4 2028 and Q1 2029, which may coincide with parts of Endurance's commissioning or early operational period (see Figure 4.46; Crown Estate, 2026).

4.4.6 Aggregate Dredging and Disposal Activity

The Humber 1 aggregate production agreement area (operated by CEMEX UK Marine Ltd) lies approximately 29 km southwest of the proposed Abbey to York pipeline route; the Humber 2 aggregate production agreement area (operated by CEMEX UK Marine Ltd) lies approximately 27 km southwest of the proposed Abbey to York pipeline route; the Humber 3 aggregate production agreement area (operated by CEMEX UK Marine Ltd) lies approximately 28 km south southwest of the proposed Abbey to York pipeline route, and the Humber 4 aggregate production agreement area (operated by CEMEX UK Marine Ltd) lies approximately 28 km south of the proposed Abbey to York pipeline route (see Figure 4.46; Crown Estate, 2026).

There are no sites licenced for disposal of dredged material within the vicinity of the proposed Abbey & Baker Development area (Crown Estate, 2026).

Figure 4.45: Oil and Gas Infrastructure in the Vicinity of the Proposed Abbey & Baker Field Development (NSTA, 2026a)

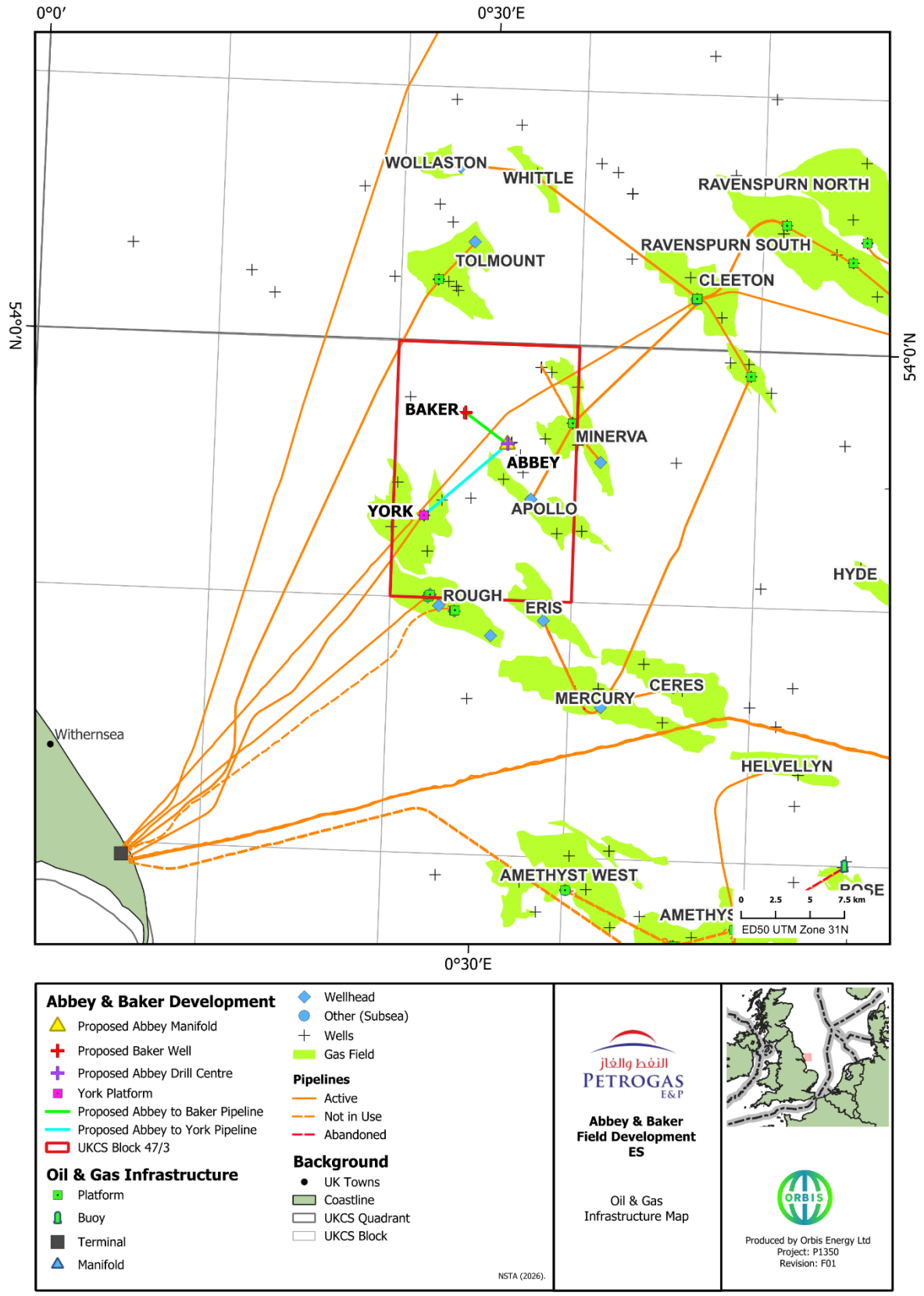
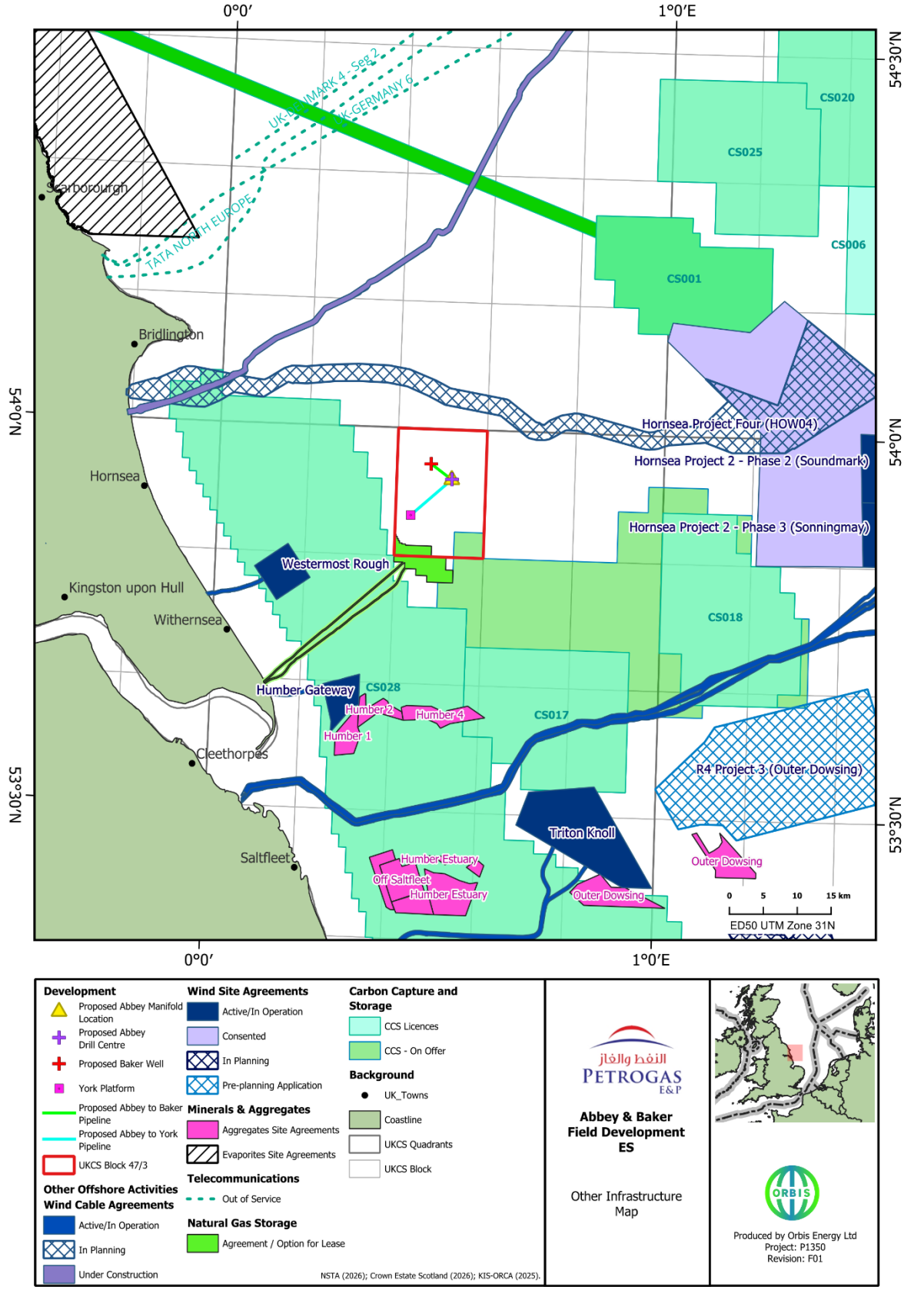


Figure 4.46: Other Infrastructure in the Vicinity of the Proposed Abbey & Baker Field Development (Crown Estate, 2026)



4.4.7 Military Activity

There are no military Practice and Exercise Areas (PEXAs) designated in the vicinity of the proposed Abbey & Baker Development area (DESNZ, 2022). However, a licence condition identified by the Ministry of Defence (MoD) exists for UKCS Block 47/3 as it lies within a MoD training range (OGA, 2019). The licence condition stipulates that the MoD must be consulted 12 months in advance of placement of any installation (fixed or floating) that is intended for drilling for or getting hydrocarbons, or for fluid injection (OGA, 2019).

4.4.8 Wrecks

No protected wrecks are located in the vicinity of the proposed Abbey & Baker Development area, but according to the UK Hydrographic Office dataset, there are three non-dangerous wrecks located approximately 1 km from the proposed Abbey & Baker Development area. One wreck (Wreck ID= 9079) at a depth of 41 m always under water, is located 1.2 km northeast of the proposed Abbey drill centre. The second wreck (Wreck ID= 9054) at a depth of 42 m always under water, is located 0.92 km northwest of the proposed pipeline route at the York platform end. The final wreck (Wreck ID= 9106), at a depth of 41 m always under water, is located 0.6 km southwest of the proposed pipeline at the York platform end tie-in (UKHO, 2025). These wrecks were not observed during either the Abbey site survey or Abbey to York pipeline corridor route survey (GEOxyz, 2023a; GEOxyz, 2024a).

4.4.9 Tourism and Leisure

The risk of interaction with tourism and leisure-based activities is minimal given the offshore location of the proposed Abbey & Baker Development (the York platform is located ca. 31 km from Withernsea on the Yorkshire coast, with the Abbey drill centre located ca. 40 km away and the Baker well ca. 38 km from the coast), however, these activities could be threatened in the event of a major accidental condensate spill approaching the coast.

Leisure-based and tourist activities are fairly widespread along the east coast of England. The wild and unspoilt natural scenery of much of the northeast and east of England attracts many tourists in pursuit of open-air leisure activities including walking, bird watching, wildfowling and golf. Many of the area's coastal towns have had a long association with the tourism industry and several locations along the coast from Scarborough to Spurn Head are designated bathing waters (DEFRA, 2022).

Recreational boating and sailing are also popular in the coastal waters adjacent to the proposed Abbey & Baker Development area, with activity hotspots around Whitby, Scarborough, Bridlington, Hornsea and Withernsea where marinas, slipways, and Royal Yachting Association (RYA) clubs and training centres are present. Motorboat activity potential is particularly high around Bridlington (approximately 45 km northwest of the proposed Abbey & Baker Development), up to ca. 14 km offshore, whilst sailing activity potential is more restricted to the near shore. Two large RYA general boating areas stretch from Cloughton to just north of Flamborough Head, and from the southern tip of Flamborough Head to Hornsea; the proposed Abbey & Baker Development is located approximately 31.5 km west from the areas described at its closest point (DEFRA, 2022).

4.4.10 Natural Disasters

Due to the very low likelihood of occurrence of natural disasters in the North Sea, such as earthquakes of major magnitude, tsunamis or tornados, this event has been scoped out for this assessment.

5 Assessment Methodology

5.1 Introduction

The method Petrogas has used to determine if the proposed Abbey & Baker Development (the Project) is likely to have any significant effects on the environment is described in this section and follows EIA good practice guidance (e.g. EC, 2017; CIEEM, 2018; SNH and HES, 2018; IEMA, 2016).

The process commences with the identification of Project activities (or aspects) that could impact environmental and socio-economic receptors, with consideration given to both planned (routine) activities and unplanned (accidental) events.

The terms "impact" and "effect" have different definitions in EIA and one drives the other. Impacts are defined as changes to the environment as a direct result of Project activities. Effects are defined as the consequences of those impacts upon receptors.

The type of impacts which could occur from the Project are categorised as follows:

- **Direct:** resulting from a direct interaction between a planned or unplanned project activity and a receptor;
- **Indirect:** occurring as a consequence of a direct impact and may arise as a result of a complex pathway and be experienced at a later time or spatially removed from the direct impact;
- **In-combination:** arising from different activities within the Project resulting in several impacts on the same receptor or where different receptors are adversely affected to the detriment of the entire ecosystem;
- **Cumulative:** resulting from incremental changes caused by other past, present or reasonably foreseeable projects/proposals together with the Project itself.
- **Transboundary:** extending beyond the boundaries of the UKCS (i.e. impacting on other countries).

The nature, duration, scale and frequency of these impacts can be described as adverse or positive, short-, medium- or long-term, temporary or permanent, localised or widespread, one-off, intermittent or continuous.

Impacts that could potentially result in significant effects have been subject to detailed assessment based on best available scientific evidence and professional judgement so that, where necessary, measures can be taken to prevent, reduce or offset what might otherwise be significant adverse effects on the environment through design evolution or operational mitigation measures.

Residual effects are those that are predicted to remain assuming the successful implementation of the identified mitigation measures and are reviewed by Petrogas to confirm that the Project complies with legal requirements and does not adversely impact Marine Planning policy goals and objectives (refer to Appendix A).

5.2 Identification of Environmental Impacts

In order to identify the environmental impacts which could arise from the Abbey & Baker Development, an ENVironmental and socio-economic impact IDentification (ENVID) workshop was undertaken by Petrogas and the EIA team on 30th September 2025. The purpose of the ENVID was to identify potentially significant aspects requiring detailed assessment in the ES, along with any project specific mitigation measures for consideration. The results of the ENVID workshop are documented in the ENVID Registers provided in Appendix B.

5.2.1 Aspects Subject to Further Assessment

Petrogas has determined that the aspects summarised in Table 5.1 could potentially result in significant environmental effects. A comprehensive assessment has therefore been undertaken for these aspects, using the significance criteria defined in Section 5.3, the results of which are documented in Sections 6 to 11 of the ES.

Table 5.1: Aspects Subject to Further Assessment

Assessment Topic	Aspect	Receptors	ES Section
Physical Presence	Presence of MODU and vessels during drilling, installation and commissioning activities Physical presence of the wellheads and xmas trees following MODU departure Presence of subsea infrastructure and associated protection material (rock, mattresses etc)	Commercial Shipping, Commercial Fisheries	Section 6
Seabed Disturbance	Siting of the MODU on the seabed Siting of the York accommodation unit on the seabed Deposit of drill cuttings and cement on the seabed Installation of pipelines and umbilicals (boulder removal, followed by laying then trench and burial) Installation of Abbey & Baker subsea infrastructure Installation of tie-in spools & jumpers at Abbey, Baker and York Laying of rock, concrete mattresses for protection / stability / trench transitions Construction of pipeline crossings (PL447 - Cleeton CP to Dimlington)	Water Quality, Seabed Sediments, Benthic Communities, Fish & Shellfish, Marine Protected Areas	Section 7
Underwater Noise Emissions	Noise from propellers / DP thrusters on vessels during drilling Operation of equipment on MODU (e.g. rotating machinery)	Marine Mammals, Marine Protected Areas	Section 8
Greenhouse Gas Emissions	Power generation on MODU, vessels and helicopters during drilling, installation, commissioning, inspection and maintenance activities Flaring of hydrocarbons during the well flow test and cleanup Operation of the York Platform, namely diesel combustion for power generation Downstream processing, transportation and distribution of Abbey & Baker hydrocarbons End use emissions from burning the extracted hydrocarbons	Climate	Section 9

Assessment Topic	Aspect	Receptors	ES Section
Marine Discharges	Discharge of Drill cuttings and muds Use and discharge of drilling, cementing, completion (including fracking / stimulation) chemicals Use and discharge of chemicals during hook-up and commissioning of subsea infrastructure, including commissioning and preservation fluids Production chemical discharge of hydraulic fluid from subsea infrastructure Discharge of chemicals or hydrocarbons during subsea intervention activities, including well intervention operations	Water Quality, Plankton, Fish & Shellfish, Marine Mammals, Marine Protected Areas	Section 10
Accidental Events	Well blowout (releasing large quantities of condensate and gas) in the event of a loss of well control MODU, York temporary accommodation unit or vessel collision (loss of diesel inventory) Production pipeline rupture (including in the event of a vessel collision with the York platform), releasing large quantities of hydrocarbons / gas to sea Emergency Gas Venting at the York Platform	Water Quality, Seabed Sediments, Plankton, Benthic Communities, Fish & Shellfish, Seabirds, Marine Mammals, Marine Protected Areas, Commercial Shipping, Commercial Fisheries, Tourism & Leisure, Population & Human Health, Climate	Section 11

5.2.2 Aspects Scoped out of Further Assessment

A number of aspects were not considered to result in significant environmental effects and were therefore scoped out from further assessment. A justification for this is provided in Table 5.2.

Table 5.2: Aspects Scoped out of Further Assessment

Topic	Aspect (Project Activities / Unplanned Events)	Justification / Control Measures
Physical Presence	Artificial light emitted from the MODU and vessels during drilling, installation and commissioning activities	Abbey & Baker are located approximately 37 km from sensitive seabed breeding areas on the coast. The possibility of reducing the time lights are switched on will be investigated.
	Presence of the York platform after previous planned decommissioning date	There is already a York 500 m surface safety zone; this will remain in place until York is eventually decommissioned.
	Presence of the York accommodation unit during topsides modifications	The entirety of the accommodation unit will be located within the York 500 m safety zone.
Seabed Disturbance	Inspection, maintenance and repair of subsea infrastructure	The subsea equipment is designed for the field life time such that limited maintenance is required. Any disturbance to the seabed resulting from the repair of

Topic	Aspect (Project Activities / Unplanned Events)	Justification / Control Measures
		subsea infrastructure, if required, would be small scale and localised.
Underwater Noise Emissions	Use of propellers / DP thrusters on installation and commissioning vessels, including general noise and vibration of equipment whilst operating (trench and burial)	Noise and vibration may cause localised, temporary changes in the distribution of sensitive marine fauna in the immediate vicinity of the MODU / vessel. However, the limited temporal scale of vessel use during the Abbey & Baker Development means any changes would be small-scale and would not result in population level effects (refer to Section 8 for further justification).
Airborne Noise Emissions	Use of helicopters	Helicopter movements will be optimised by careful planning. Any impacts to seabirds from airborne noise emissions will therefore be short term, limited to temporary disturbance and/or displacement from foraging areas. Alternative foraging habitat is available to seabirds in the wider area.
Air Quality	Power generation on MODU, vessels and helicopters during drilling, installation, commissioning, inspection and maintenance activities Flaring of hydrocarbons during the well flow test and cleanup Operation of the York Platform, namely diesel combustion for power generation	The release of contaminants such as particulates, NOx and VOCs can contribute to the formation of local tropospheric ozone and photochemical smog, resulting in a reduction in local air quality, which in turn can result in effects on human health. However, given the open and dynamic metocean environment in the SNS region, it is anticipated that any pollutants released into the air from the temporary offshore operations associated with the Abbey & Baker Development will disperse rapidly under most conditions to levels approaching background within a few tens of metres of their source. As such, although there could be a short-term deterioration in local air quality, the magnitude of impact will be Negligible.
Marine Discharges	Runoff from MODU, York temporary accommodation unit and vessel decks	Given the offshore location of the proposed Abbey & Baker Development, any discharges to sea will rapidly disperse.
	Discharge of greywater, blackwater, bilge tanks and food waste from MODU; York temporary accommodation unit; York platform; and drilling, commissioning and construction vessels	Food waste will be macerated to increase the rate of dispersion and biodegradation at sea and waste water will be treated before being discharged to sea, in accordance with the requirements of the MARPOL convention. Only vessels adhering to the International Maritime Organisation (IMO) 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Species will be used.
Solid Waste	Onshore disposal of solid waste generated during drilling, installation, commissioning and maintenance activities	Waste will be dealt with in accordance with regulatory requirements. The principles of the Waste Management Hierarchy will be followed, licensed waste contractors will be used and Waste Management Duty of Care audits will be carried out. Vessels will conform to their own Waste Management Plans.
Use of Resources	Resource use during drilling, installation, commissioning and maintenance operations	The use of natural resources will be minimised, as far as practicable. Subsea structures will be designed with consideration to decommissioning.

Topic	Aspect (Project Activities / Unplanned Events)	Justification / Control Measures
Accidental Events	Minor release of hydrocarbons / chemicals to sea (e.g. from drains, bunkering operations etc.) during drilling, installation and commissioning, topsides modification or maintenance and well intervention activities	Any impacts on water quality and marine fauna will be localised and temporary. Standard operating procedures will be adhered to, e.g. bunkering in good light, regular hose inspection, correct storage and segregation of chemicals etc.
	Small release of hydraulic fluid, e.g. from ROV operations / hydraulic equipment / subsea control system failure	Any impacts on water quality and marine fauna will be localised and temporary. Appropriate maintenance, and pre-use checks will be carried out on hydraulic equipment and ROVs. Only Cefas registered hydraulic chemicals will be in use. Closed loop control system will be in place for subsea facilities.
	Dropped objects resulting in unplanned disturbance to seabed	Dropped object procedures are industry-standard and will be employed throughout the proposed operations.

5.3 Significance Evaluation

This section describes the criteria used in this ES for determining the likely significance of effects on the environment to ensure the assessment process is as transparent and consistent as possible. Where uncertainty exists, this has been acknowledged in the assessment text in Sections 6 to 11. The exception to this is Section 9 (Greenhouse Gas Emissions), which has used different criteria to assesses the impact of GHG emissions generated from the proposed Abbey & Baker Development on the climate. Given the global nature of climate change, the principles set out in the Institute of Sustainability and Environmental Professionals (ISEP) (2026) have been used to help determine the significance of the likely effects (refer to Section 9.6.2 for further details).

5.3.1 Planned Events

For planned activities, the significance of environmental effects has been evaluated by considering the **sensitivity** of the receptor affected in combination with the **magnitude** of impact that is likely to arise, having regard to:

- The magnitude and spatial extent of the impact (geographical area and size of the population likely to be affected)
- The nature of the impact
- The transboundary nature of the impact
- The intensity and complexity of the impact
- The probability of the impact
- The expected onset, duration, frequency and reversibility of the impact
- The cumulation of the impact with the impact of other existing and / or approved projects and / or projects not yet approved, but that Petrogas is aware of
- The possibility of effectively reducing the impact

Sensitivity Criteria

Sensitivity is a function of the value of the receptor (a measure of its importance, rarity and worth), its capacity to accommodate change when a pressure is applied (resistance or tolerance), and its subsequent recoverability (resilience). The criteria presented in Table 5.3 has been used as a guide to determine the sensitivity of receptors.

Table 5.3: Determining Sensitivity

		Resistance and Resilience			
		Very High	***High***	***Medium***	***Low***
Value	***Low***	Low	Low	Medium	Medium
	Medium	Low	Medium	Medium	High
	High	Low	Medium	High	Very High
	Very High	Medium	High	Very High	Very High

Definitions:	
Resistance and Resilience	
Very High:	Highly adaptive and resilient to pressure. High recoverability in the short-term.
High:	Some tolerance / capacity to accommodate pressure. High recoverability in the medium-term.
Medium:	Limited tolerance / capacity to accommodate pressure. Recoverability is slow and/or costly.
Low:	Very limited or no tolerance / capacity to accommodate pressure. Recovery is unlikely or not possible.
Value	
Very High:	Very high value and/or of international importance.
High:	High value and/or of national importance.
Medium:	Moderate value and/or of regional importance.
Low:	Low value and/or of local importance.

Magnitude of Impact Criteria

The magnitude of impact considers the characteristics of the change that is likely to arise (a function of the spatial extent, duration, reversibility and likelihood of occurrence of the impact) and can be adverse or positive. Where it is not possible to quantify impacts, a qualitative assessment has been carried out, based on best available scientific evidence and professional judgement. The criteria presented in Table 5.4 has been used as a guide to define the magnitude of impact.

Table 5.4: Determining Magnitude of Impact

Magnitude	Definition
Substantial	Widespread long-term change in baseline environmental conditions, with poor potential for recovery. Impact may be one-off, intermittent or continuous and/or experienced over a very wide area (i.e. international in nature). Impact will result in environmental quality standards or threshold criteria being routinely exceeded.
Major	Widespread medium to long-term, but reversible change in baseline environmental conditions. Impact may be one-off, intermittent or continuous and/or experienced over a wide area (i.e. national in scale). Impact is likely to result in exceedance of environmental quality standards or threshold criteria.

Magnitude	Definition
Moderate	Medium-term, temporary change in baseline environmental conditions or longer-term changes in areas surrounding the immediate footprint of the Project. Impact may be one-off, intermittent or continuous and/or regional in scale (i.e. beyond the area surrounding the Project site to the wider region). Impact could result in one-off exceedance of environmental quality standards or threshold criteria.
Minor	Short-term, temporary change in baseline environmental conditions or localised longer-term changes within the footprint of the Project. Impact may be one-off, intermittent and/or localised in scale. Impact would not result in exceedance of environmental quality standards or threshold criteria.
Negligible	Immeasurable or undetectable changes (i.e. within the range of normal natural variation).

Significance of Effects

The overall significance of an effect has been determined by cross referencing the sensitivity of the receptor with the magnitude of impact, using the matrix shown in Table 5.5.

Table 5.5: Significance Evaluation Matrix (Planned Activities)

		Magnitude of Impact				
		Negligible	Minor	Moderate	Major	Substantial
Receptor Sensitivity	Low	Negligible	Minor	Minor	Minor	Minor / Moderate[1]
	Medium	Negligible	Minor	Minor	Moderate	Moderate / Major[1]
	High	Negligible	Minor	Moderate	Major	Major
	Very High	Negligible	Minor / Moderate[1]	Moderate / Major[1]	Major	Major

[1] The choice of significance level is based upon professional judgement.

Effects classed as **Major** or **Moderate** are considered to be 'significant' in EIA terms and therefore mitigation measures are required to be identified in order to prevent, reduce or offset adverse significant effects or enhance positive effects. The overall significance of the effect is then re-evaluated, taking the mitigation measures into consideration, to determine the residual effect utilising the methodology outlined above.

Effects classed as **Minor** are not considered to be significant and are usually controlled through good industry practice.

Effects classed as **Negligible** are also not considered to be significant.

5.3.2 Unplanned Events

For unplanned events, such as accidental hydrocarbon releases, significance has been determined using a risk assessment approach, where the likelihood (probability) of the unplanned event occurring is considered against the consequence (significance of effect) if the event was to occur.

The consequence (significance of effect) has been determined using the methodology for planned events as described in Section 5.3.1 above. The likelihood of an unplanned event occurring has been determined using the criteria presented in Table 5.6 as a guide.

Table 5.6: Determining Likelihood of Occurrence

Likelihood	Definition
Extremely Rare	Event is extremely unlikely to occur during the Project, given good industry practice. Frequency of event: 1×10^{-4}.
Rare	Event is very unlikely to occur during the Project, given good industry practice. Frequency of event: 1×10^{-3}.
Unlikely	Event is unlikely to occur during the Project, given good industry practice. Frequency of event: 1×10^{-2}.
Possible	Event could occur during the Project, based on industry data. Frequency of event: 1×10^{-1}.
Likely	Event is likely to occur at least once during the Project. Frequency of event: > 1

A risk category (low, medium or high) has then been assigned to the unplanned event using the matrix shown in Table 5.7.

Table 5.7: Significance Evaluation Matrix (Unplanned Events)

		Consequence (Significance of Effect) [1]			
		Negligible	Minor	Moderate	Major
Likelihood of Event	Extremely Rare	LOW	LOW	MEDIUM	MEDIUM
	Rare	LOW	LOW	MEDIUM	MEDIUM
	Unlikely	LOW	LOW	MEDIUM	HIGH
	Possible	LOW	MEDIUM	MEDIUM	HIGH
	Likely	LOW	MEDIUM	HIGH	HIGH

[1] The consequence (significance of effect) has been determined using the methodology for planned events as described in Section 5.3.1 above.

High risk events are considered to be "significant" in EIA terms and are unacceptable.

Medium risk events are also considered to be "significant" in EIA terms, unless it can be demonstrated that the risk has been reduced to as low as reasonably practicable (ALARP) through mitigation measures and good industry practice.

Low risk events are not considered to be "significant" in EIA terms, but should still be controlled through good industry practice.

6 Physical Presence

6.1 Introduction

The temporary presence of the MODU and vessels and the long-term presence of the Abbey & Baker subsea infrastructure once installed have the potential to obstruct or exclude other sea users. This section therefore assesses the potentially significant impacts on other sea users, namely shipping and commercial fisheries, which could arise from:

- Presence of MODU and support vessels during drilling operations (up to three rig moves);
- Presence of vessels during installation, inspection, maintenance and decommissioning activities;

Ongoing presence of subsea infrastructure, associated protection material and 500 m exclusion zones surrounding the Abbey well locations and Baker well location.

6.2 Assessment of Impacts

6.2.1 Commercial Shipping

The proposed drilling phase will involve the use of a jack-up drilling rig, which will be on location at Abbey and Baker for a period of up to 364 days. A number of support vessels will also be on location or transiting to / from the Abbey and Baker locations during this period, including ERRV, supply and support vessels (see Section 3.3.2). Drilling operations are currently scheduled to be undertaken in Q4 2027 to Q3 2028. While the MODU is on location at the proposed Abbey wells and proposed Baker well, a 500 m safety exclusion zone will be in place, which will be patrolled by the ERRV; the stimulation vessel will be located within the MODU 500 m safety exclusion zone during operations. As such, an area of 0.8 km^2 at the sea surface will be unavailable to commercial shipping at each location. Although the 500 m safety zone around the MODU will be temporary, Petrogas will apply for a 500 m subsea exclusion zone through the Health and Safety Executive to be in place around the Abbey A1, Abbey A3, and Baker well from the point when the MODU moves off location (a 500 m subsea exclusion zone is already in place at the Abbey A2 well). Commercial shipping will therefore have to avoid this area for the life of the Abbey & Baker field development.

Shipping densities in proximity to the Abbey and Baker field areas are busy similar to other regions of the Southern North Sea, with an average of approximately twenty-three vessels per day passing within 10 nm of Abbey and Baker (see Section 4.4.3). Whilst the MODU is moored on location at Abbey and Baker, shipping vessels may increase their passing distance, which could lead to extended passage times and have knock-on effects on the users of other nearby shipping routes in the area. From the review of the effect on navigation, it is concluded that 23 routes pass within two nautical miles of the Abbey and Baker locations and may be affected by the operation. However, sea room is available should any vessels wish to increase their clearance while maintaining a safe distance from other nearby offshore installations (Anatec, 2024).

Given the above, shipping vessels may have to re-route around the Abbey and Baker locations. This could lead to extended passage times and have knock-on effects on the users of other nearby shipping routes in the area. Shipping activity is considered to be moderate to high in the area, with vessels mostly comprised of fishing vessels, some ferries between the UK and the rest of Europe and cargo and offshore support vessels (see Section 4.4.3). Notwithstanding this, a full collision risk assessment has been undertaken by Petrogas to inform the Consent to Locate (CTL) permit applications, which are required to site the MODU and subsea infrastructure at the Abbey and Baker locations.

This has calculated that the annual vessel collision frequency is estimated to be 3.2×10^{-3}, corresponding to a collision return period of 309 years at Abbey. While for Baker, the annual vessel collision frequency is estimated to be 5.0×10^{-3}, corresponding to a collision return period of 199 years. This is above the historical average vessel collision frequency for offshore installations on the UKCS, which reflects the high level of commercial shipping traffic passing in proximity to Abbey and Baker (Anatec, 2024).

In addition, during the subsea infrastructure installation and hook-up commissioning phase, a number of DP vessels will be on location for a period of months from 2028 to 2029. The vessels required include, Construction Support Vessel (CSV), survey vessel, pipelay reel-lay vessel, umbilical installation vessel, Light Construction Vessel (LCV), DSV, trenching vessel, rock dumping vessel, scout vessel and guard vessel (see Section 3.4.7). The main navigational hazard will be associated with the installation of the pipeline and umbilical as activity at Abbey, Baker and York will be within 500 m safety zones. Petrogas therefore proposes to utilise up to three guard vessels to guard partly constructed facilities when the installation vessels are not on location (e.g. between pipe lay vessel demob and trenching vessel arrival, or after spools installation but before protective mattresses are installed). at The vessels involved in subsea infrastructure installation operations will also update their marks, lights and navigational status broadcast on AIS to indicate to other vessels when they are restricted in manoeuvrability. Shipping lanes are unlikely to be impacted in the event that the lay corridors are pre-cleared. This requires residual boulders greater than 0.5 m to be moved to a disposal corridor located approximately 11 m away from the edge of the cleared corridor.

The sensitivity of shipping to displacement as result of the Abbey and Baker development is therefore considered to be **Low**. The receptor is of regional importance, classed as Medium value, but resistance and resilience is Very High as there is adequate sea room for shipping to re-route or avoid the Abbey and Baker locations, as necessary. The magnitude of impact is predicted to be **Minor** as any impact will be localised to the proposed Abbey and Baker development. Effects on shipping from the physical presence of the MODU and vessels during drilling, subsea infrastructure installation and hook-up commissioning activities, as well as the long term presence of the Abbey and Baker 500 m safety exclusion zones, are therefore assessed as **Minor** and not significant.

In addition, the likelihood of a collision event occurring is considered to be **Rare**. The significance of effect on the marine environment in the event of a collision (i.e. the release of diesel) is assessed as **Minor**, which results in a **Low** risk overall. Mitigation measures are proposed in Section 6.4 to ensure that the risk is ALARP.

6.2.2 Commercial Fishing

The physical presence of the Abbey and Baker seabed infrastructure will pose a potential snagging hazard to fishing gears towed along the seabed. The area in the vicinity of the proposed Abbey and Baker development has limited trawl fishing due to the number of static fishing gear (crab and lobster pots) and the associated buoys.

Vessel Monitoring System (VMS) data indicates that Abbey and Baker are located within an area of high shellfish fishing effort, targeting species including crabs, scallops and lobster (see Section 4.4.1). Throughout the year, catches are relatively high within ICES Rectangle 36F0, with a peak in the summer to autumn months. In addition, fishing vessels have been recorded to be actively fishing in the vicinity of the Abbey and Baker development. Multiple vessels are therefore likely to be working at the Abbey and Baker locations simultaneously.

Once the MODU moves off location, fishing will be displaced from a smaller area throughout the life of the field development, which corresponds to the 500 m statutory subsea exclusion zones that Petrogas intends to apply for around the Abbey A1 and A3 wells, plus the existing A2 well (equivalent to an area of 2.4 km^2) and Baker (equivalent to an area of 0.8 km^2). In addition, to further reduce the risk of snagging, the wellheads and Xmas trees will be protected by an industry standard fishing friendly WHPS. Note, the formation of anchor mounds is unlikely for this development, given the sandy nature of the sediments at the Abbey and Baker locations (see Section 4.2.2).

In addition to the above, during installation of the pipelines and umbilicals, fishing vessels will be temporarily displaced from the working corridors, with the area remaining unavailable to commercial fisheries until rock has been placed over the lines for protection and upheaval buckling mitigation. In the case that the trench and burial method is used for the pipeline and umbilical installations, the buried pipelines will be overtrawlable. In addition, the profile of any rock berms once deposited will be overtrawlable. Based on a maximum working corridor width of 25 m for the pipelines (8 km in length at Abbey to York and 3.8 km in length at Abbey to Baker) and 25 m for the umbilical (8 km in length at Abbey to York and 4 km in length at Abbey to Baker), it is estimated that in the worst case vessels will be displaced from an area of approximately 0.59 km^2. An additional area may be impacted in the event

that the lay corridors are pre-cleared. In this instance, residual boulders greater than 0.5 m will be moved to a disposal corridor located approximately 11 m away from the edge of the cleared corridor and their as-left position recorded. As noted above, to minimise the risk to fishing vessels, Petrogas proposes to use up to three guard vessels to guard partly constructed facilities when the installation vessels are not on location. This approach has been discussed with the National Federation of Fishermen's Organisations (NFFO) and Petrogas will continue to consult with the NFFO during the detailed design phase and planning process for the subsea infrastructure installation activities.

To ensure the integrity of the Abbey and Baker infrastructure at the seabed and prevent damage in the event of contact with fishing gears, the Abbey and Baker WHPS's will all be designed to be fishing friendly. Concrete mattresses will be placed over the tie-in spools and control jumpers located within the 500 m safety zones at Abbey, Baker and York (see Section 3.4.4).

In summary, fishing vessels will need to avoid the Abbey and Baker development area whilst the proposed subsea infrastructure installation operations are ongoing, assumed to be from Q4 2028 to Q1 2029. There will therefore be a temporary loss of fishing grounds which could result in an economic impact on the local fisheries that normally operate in the area.

Given the above, the sensitivity of commercial fishing to displacement is considered to be **Medium.** The area of the Abbey and Baker fields is heavily fished; the receptor therefore has a Very High value, but there is adequate sea room in the wider SNS area for fishing vessels to switch to alternative fishing grounds, hence resistance and resilience is Very High. The magnitude of impact is predicted to be **Minor** as any impact will be localised to the Abbey & Baker Field Development location. The rock berms over the length of the pipelines and umbilicals and the tie-in and protection structures will all be overtrawable. In the long term, fishing vessels will only be prevented from fishing in an area of 2.4 km^2 at the Abbey well locations and 0.8 km^2 at the Baker well location. Effects on commercial fishing from physical presence are therefore **Minor** and not significant. Mitigation measures are proposed in Section 6.4 to ensure that good industry practice is followed.

6.3 Impacts to the East Offshore Marine Plan

The physical presence of the jack-up drilling rig and operational vessels has the potential to impact the following East Offshore Marine Plan objectives:

- **EC2 -** Proposals that provide additional employment benefits should be supported, particularly where these benefits have the potential to meet employment needs in localities close to the marine plan areas.
- **GOV2 -** Opportunities for co-existence should be maximised wherever possible.
- **GOV3 -** Proposals should demonstrate in order of preference:
  a) that they will avoid displacement of other existing or authorised (but yet to be implemented) activities;
  b) how, if there are adverse impacts resulting in displacement by the proposal, they will minimise them;
  c) how, if the adverse impacts resulting in displacement by the proposal, cannot be minimised, they will be mitigated against or;
  d) the case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts of displacement.

The physical presence of the jack-up drilling rig and operational vessels will aim to utilise local contractors in the area and a support base close to the proposed operations in order to meet objective EC2. The presence of the jack-up drilling rig and operational vessels have the potential to interfere with the achievement of objectives GOV2 and GOV3, however this is unlikely to occur following the implementation of the mitigation measures listed in Section 6.4, and for the reasons listed in Sections 6.2.1 and 6.2.2.

6.4 Mitigation Measures

Impacts from the physical presence of the MODU and vessels during drilling, subsea infrastructure installation and hook-up and commissioning activities, as well as the long term presence of the Abbey

and Baker subsea infrastructure, associated protection material and 500 m safety exclusion zones, will be minimised by the implementation of the following mitigation measures:

- Up to three separate 500 m safety zones (are and) will be designated around the MODU and a dedicated ERRV, equipped with AIS and/or ARPA will be present during the drilling operations to monitor movements of other vessels in the area and prevent them entering the safety zone.
- A Vessel Traffic Survey (VTS) was conducted in 2024 prior to the drilling of the Abbey Appraisal and Baker Exploration well. However, this survey only has a validity of one year and thus a new study will be required along with a Collision Risk Assessment. These will be prepared to support the CtL permit applications required to site the MODU and subsea infrastructure at the Abbey & Baker Development locations and all vessels will comply with the International Regulations for Preventing Collisions at Sea (COLREG).
- Information on the location of the MODU, MODU anchor positions, 500m safety zones, subsea infrastructure (i.e. wellhead/tree, WHPS and pipelines) and vessel operations will be communicated to other sea users via the United Kingdom Hydrographic Office (UKHO), MCA, FishSAFE, Kingfisher Information Services, Notices to Mariners and Radio Navigation Warnings.
- Petrogas will continue to consult with NFFO during the detailed design phase and planning process for the subsea infrastructure installation activities. A Fisheries Liaison Officer (FLO) will be appointed to maintain good communication with local fisheries and co-ordinate activities, particularly during installation of the pipelines and umbilicals.
- Through careful planning, the number of vessels and length of time they are required on site for installation operations, will be reduced as far as practicably possible.
- Where boulders (>0.5 m) are required to be removed from the pipeline lay corridors, the as-left position of any relocated boulders will be recorded and reported via Kingfisher.
- Vessels involved in subsea infrastructure installation operations will update their marks, lights and navigational status broadcast on AIS to indicate when they are restricted in manoeuvrability. This will assist any passing vessels that encounter the installation vessels.
- Up to three guard vessels will be present to guard partly constructed facilities when the installation vessels are not on location, prior to the deposit of protection (rock) on top of the lines, to ensure that other sea users are aware of the ongoing operations.
- Pipeline working corridors will be minimised, as far as possible.
- Prior to installation, Petrogas will apply for 500 m subsea exclusion zones to be in place around the subsea infrastructure at the Abbey A1 and A3 and Baker well locations.
- Maintenance inspection surveys will be undertaken throughout the life of the Abbey & Baker fields to ensure the seabed infrastructure and associated protection material remain in a favourable condition.

6.5 Residual Effects

No significant residual effects on other sea users are predicted as a result of the physical presence of the jack up MODU and / or vessels during drilling, installation, inspection and maintenance and decommissioning activities or the long-term presence of the Abbey & Baker subsea infrastructure and associated protection / stabilisation material. There is adequate sea room for shipping to re-route or avoid the Abbey & Baker locations, as necessary, particularly given that Abbey & Baker is subject to moderate volumes of routine vessel traffic compared to other North Sea areas. Fishing vessels will be temporarily displaced from the Abbey & Baker Development area for several months from 2027 to 2029 during the drilling and installation phases, with an area of 3.2 km^2 at the Abbey & Baker well locations lost for the life of the field development.

6.6 Transboundary Impacts

The Abbey & Baker Development is located approximately 152 km to the east of the UK/Netherlands median line. Although fishing activity in the Abbey & Baker Development area is generally high, information on the location of the MODU (including anchor positions), 500m safety zone, subsea infrastructure and vessel operations will be communicated to international fishing organisations, with known vessels working in the area. The area which will be lost to fisheries for the life of the Abbey & Baker Development (3.2 km^2 at the well locations) represents a small fraction of the total sea available. Furthermore, non-UK fishing vessels will be made aware of the Abbey & Baker Development through adequate charting of infrastructure. On this basis it is considered that there will be no significant transboundary impacts on other sea users.

6.7 Cumulative Impacts

The closest surface oil and gas infrastructure to the proposed Abbey & Baker Development is the Minerva platform, operated by Perenco UK Limited, which is located approximately 5 km east northeast of the proposed Abbey drill centre. Pipelines within the vicinity of the proposed Abbey & Baker Development, include the active Cleeton CP to Dimlington gas pipeline (PL447) operated by Perenco, located approximately 0.3 km northwest of the proposed Abbey & Baker Development; the York Production and Methanol pipelines (PL2917 and PL2918), located less than 0.1 km to the southwest of the proposed Abbey to York pipeline; and the Apollo to Minerva gas pipeline (PL1937) operated by Perenco, which is located approximately 3.7 km southeast of the proposed Abbey & Baker Development (refer to Section 4.4.4).

There are no operational, under construction or consented offshore windfarms in the vicinity of the proposed Abbey & Baker Development area. The closest offshore windfarm is the proposed Hornsea Project Four cable corridor (operated by Ørsted Power (UK) Limited), which is currently in planning, is anticipated to be located approximately 10.5 km north from the Abbey Drill Centre and the proposed Abbey pipeline route. It is likely that installation operations will overlap with the proposed Abbey & Baker Development, with offshore cable installation currently planned to take place during 2028. The impact from the installation of the Hornsea Project Four cable is temporary and is unlikely to result in any permanent impacts.

The active Westermost Rough wind farm (operated by Ørsted Power (UK) Limited) lies approximately 25 km southwest of the proposed Abbey drill centre and 18 km from the proposed pipeline, and the active Humber Gateway wind farm (operated by E.ON Climate and Renewables) lies approximately 31 km and 24 km to the southwest of the proposed Abbey drill centre and pipeline. The Endurance carbon capture storage site (BP Exploration Company Limited), currently in the agreement/ option for lease stage, lies approximately 34 km northeast of the proposed Abbey & Baker Development.

The other oil and gas developments in the area will also utilise vessels which have the potential to act cumulatively in increasing vessel collision risk. However, given the mitigation measures which will be in place for the Abbey & Baker Development and other oil and gas operations, increased vessel presence should not act in combination with any other development to increase collision risk.

Given the low levels of fishing effort recorded in the vicinity of the proposed Abbey & Baker Development and the temporary nature of the drilling, installation, inspection and maintenance and decommissioning activities, it is considered that there will be no significant cumulative impact on commercial fishing.

Long term loss of access is restricted to an area totalling 2.4 km^2 at the Abbey well locations and 0.8 km^2 surrounding the Baker well location for the life of the field development. This is very small in comparison to the fishing grounds available in the wider SNS area. In addition, as the Abbey and Baker tie-ins and WHPSs will all be designed to be fisher friendly and the rock berm covering the pipelines and umbilicals, tie-ins and jumpers will be fisher friendly, a significant cumulative increase in snagging risk with other oil and gas development in the area is not anticipated.

7 Seabed Disturbance

7.1 Introduction

This section discusses the potentially significant environmental impacts on seabed sediments, seabed communities and fish arising from:

- Siting of the jack-up drilling rig;
- Deposit of drill cuttings and cement on the seabed;
- Installation of the pipeline and umbilical (rock protection option);
- Installation of the wellheads and WHPS;
- Installation of the Production Manifold, SSIV, tie-in spools, jumpers and protective mattresses.

7.2 Quantification of Impact Area

7.2.1 Siting of the Jack-Up Drilling Rig

As described in Section 3.3.2, the two Abbey wells and one Baker well will be drilled from a jack-up drilling rig, which will be on location at Abbey and then Baker. The base case assumes two rig moves: initially to the Baker location, followed by relocation to the Abbey location, from which all wells can be drilled from a single jack-up position. In a worst-case scenario, up to three rig moves may be required if Abbey A1 and A3 are determined to be outside the reach envelope of the contracted jack-up skid envelope when it is cited at the Abbey A2 location. This ES has assessed the worst case.

It is assumed that the rig will be three legged and jacked up on three spud cans. It is unlikely that rig stabilisation will be required due to the presence of chalk within 1 m of the seabed surface. Previously, rig stabilisation was not required during the drilling of the Abbey A02 appraisal well or the drilling of the Baker exploration well, due to the weight of the heavy duty rig and there was no expected scour risk. Per move, the deployment of the three spudcans is estimated to disturb an area of seabed equal to 763.5 m^2 (0.0008 km^2), this equates to a total seabed disturbance of 2,290 m^2 (0.0023 km^2) for the three moves.

In addition, as a worst case scenario, it has also been assumed that four anchors with chains will be required to move the rig on location at the Abbey wells (A1, A2 and A3). This is due to the presence of the infrastructure at the Abbey A2 well and are not required for the Baker well location. These anchors will be removed from the seabed once the rig is in position. Each anchor will weigh up to 7.5 tonnes, with outer dimensions measuring approximately 3.65 m (W) x 4.2 m (L), equating to a seabed footprint of ca. 15.33 m^2 per anchor; totalling to a seabed disturbance area of 122.64 m^2 (0.000123 km^2) for the anchors used at both Abbey moves. The estimated length of each anchor chain will be approximately 525 m in length with approximately half of this length laid on the seabed. It has been assumed that a 10 m wide corridor of seabed will be disturbed per mooring chain during the move from standoff position to working position. Therefore, the deployment of four anchor chains for two moves at the Abbey drill centre will disturb an area of seabed equal to 21,000 m^2 (0.021 km^2).

The total seabed disturbance area from the three movements of the MODU onto location is therefore equal to ca. 23,412.64 m^2 (0.0234 km^2).

7.2.2 Siting of the Accommodation Unit at the York Platform

As described in Section 3.5.4, the York Platform requires modifications in order to receive the production from and provide controls to the Abbey & Baker Development. In order to carry out these operations, an accommodation unit will be located at the York platform location for up to four months. Currently, no commercial agreements are in place regarding the specific accommodation unit to be used for this; therefore, in order to assess the worst case seabed disturbance, it is assumed that the accommodation unit will be jacked up on six legs without spud cans. It is unlikely that stabilisation will be required due to the presence of chalk within 1 m of the seabed surface. Stabilisation was not

required for the MODU during the drilling of the Abbey A02 appraisal well or the drilling of the Baker exploration well, due to the weight of the heavy duty rig and there was no expected scour risk. The deployment of the six legs is estimated to disturb an area of seabed equal to 117.81 m^2 (0.00012 square kilometres (km^2)) (each leg is assumed to have a diameter of 5 m).

In addition, as a worst case scenario, it has also been assumed that, due to the presence of the York platform, four anchors with chains will be required to move the rig on and off location to prevent risk. These anchors will be removed from the seabed once the rig is in position. Each anchor will weigh up to 7.5 tonnes, with outer dimensions measuring approximately 3.65 m (W) x 4.2 m (L), equating to a seabed footprint of ca. 15.33 m^2 per anchor; totalling to a seabed disturbance area of 61.32 m^2 (0.000061 km^2) for the anchors used at the York platform location. The estimated length of each anchor chain will be approximately 525 m in length with approximately half of this length laid on the seabed. It has been assumed that a 10 m wide corridor of seabed will be disturbed per mooring chain during the move from standoff position to working position. Therefore, the deployment of the four anchor chains for the move onto the working position for the York platform will disturb an area of seabed equal to 10,500 m^2 (0.011 km^2).

The worst case total seabed disturbance area from the siting of the accommodation unit onto location at the York platform is therefore equal to ca. 10,679.13 m^2 (0.011 km^2).

7.2.3 Deposit of Drill Cuttings, Muds and Cement on the Seabed

As described in Section 3.3.4, the top hole section (36-inch) for the Baker well and two Abbey wells will be drilled riserless, with seawater and frequent bentonite “sweeps” passed down the well to clean out the hole. In the worst case, there may be a requirement for a well re-spud, for example, if hole collapse or boulder interference results in a stuck pipe in the top hole 36-inch section. Cuttings from the top-hole section (including the contingency re-spud) will be discharged directly from the wellbore at the seabed and will form small piles in the immediate vicinity of the Baker well and Abbey drill centre location.

An environmental riser will be installed following the drilling of the 36 inch section; this will be used to circulate cuttings and WBM from the 17.5 inch section back to the MODU. All drill cuttings and WBM from the 17.5 inch sections (including a contingency side-track scenario to account for potential wellbore instability or drilling issues) will be circulated back to the MODU, processed on board and discharged into the sea from the MODU.

LTOBM will be used to drill the remainder of the well sections (12¼, 8½ and 6 inch sections). Petrogas is also including a contingency 6-inch sidetrack in the case of any other drilling issues. Cuttings contaminated with LTOBM will be returned to the drilling rig, separated from the LTOBM and then contained in enclosed skips until they can be skipped and shipped to shore for onshore processing and disposal at a licenced treatment and landfill site. The recovered LTOBM will be recycled downhole by the mud pump in a closed loop system, ensuring that the mud is continuously recycled during the drilling programme.

For the purposes of the cuttings dispersion assessment, a worst-case discharge scenario has been adopted which includes re-spud options and contingency side-track drilling of the 17½ inch section for each well. The modelled discharge volumes are summarised in Table 7.1.

Table 7.1: Worst-case modelled discharge volumes used in the drill cuttings and muds dispersion assessment (RPS, 2026)

Well	Cuttings (m^3)	Mud Solids (m^3)
Abbey A1	410	76
Abbey A3	406	75.2
Baker	374	68.8
Abbey Wells Total (A1 + A3)	**816**	**151.2**
Overall Total (all wells)	**1,190**	**220**

Simulations of these drilling releases in relation to the Abbey site have been completed using the three-dimensional dispersion model (MUDMAP) by RPS on behalf of Petrogas. Ten years (2010 to 2019 (inclusive)) of Hybrid Coordinate Ocean Model (HYCOM) current data was generated, which included the combined influence of ocean and tidal currents. The current data is suitably long enough to be indicative of interannual variability in ocean currents. To account for variability in potential spud dates and current conditions, 50 simulations were undertaken per well, with results for Abbey A1 and Abbey A3 combined to provide a stochastic annual worst-case assessment for the Abbey location (RPS, 2026).

A conservative low exposure threshold of 10 milligrams per centimetre squared per day (mg/cm²/day) has been applied for this study. Accordingly, moderate and high exposure thresholds are set at ≥30 mg/cm²/day and ≥100 mg/cm²/day, respectively. Equivalent sediment thicknesses were calculated based on the anticipated total discharge period of 24 days for the two Abbey wells and 9 days for the Baker well and an assumed in-situ bulk density of 2,600 kilograms per cubic metre (kg/m³) (RPS, 2026).

Based on the combined Abbey well discharge duration the low exposure threshold of 10 mg/cm²/day corresponds to 1.11 mm of sediment accumulation over this period. Additionally, moderate and high exposure thickness thresholds would equate to 3.33 mm to 11.11 mm, respectively. Regarding the Baker well discharges, the low exposure threshold of 10 mg/cm²/day corresponds to 0.44 mm of sediment accumulation over this period. Additionally, moderate and high exposure thickness thresholds would equate to 1.33 mm and 4.44 mm, respectively (RPS, 2026).

These align with literature findings such as Gilmour (2002), who observed that older corals suffer injury from 2 mm sediment layers applied every two days, with larger polyps showing damage at 5 mm and 10 mm sediment layers. Mesocosm experiments by Trannum et al. (2010) showed that cuttings layers as thin as 3 mm cause gradual community declines over six months in soft-sediment communities (RPS, 2026).

Figure 7.1 presents the maximum thicknesses in each grid cell from all 100 simulations pertaining to both Abbey wells to define the potential exposure from the discharge of cuttings and muds during the modelled operational period. Figure 7.2 presents the maximum thicknesses in each grid cell from all 50 simulations pertaining to the Baker well to define the potential exposure from the discharge of cuttings and muds during the modelled operational period. For both the Abbey A1 and A3 and the Baker wells, the drill cuttings and muds predominantly settled along the north-west to south-east, coinciding with the dominant current directions at the release locations (RPS, 2026).

The maximum predicted thickness of deposited cuttings and muds for all wells was associated with the drilling of the riserless discharge (i.e., 26 x 36 x 42 inch bore diameter well interval), which were returned directly to seafloor from a discharge height of 2 m above the seafloor. A maximum thickness of 1.05 m was predicted within 20 m of the discharge location for both the Abbey A1 and A3 wells; a maximum thickness of 0.59 m was predicted within 20 m of the discharge location for the Baker well (RPS, 2026).

Table 7.2 summarises the total area of coverage and the maximum distances for each thickness threshold from the release locations.

Based on the assessment of 100 simulations for the Abbey A1 and A3 wells combined, the maximum distances from the release locations to the edge of the low, moderate and high exposure thresholds is

predicted to be 0.41 km, 0.28 km and 0.12 km, respectively. Additionally, the total area of coverage for the low, moderate and high exposure thresholds are predicted to be 0.16 km^2, 0.07 km^2 and 0.03 km^2, respectively (RPS, 2026).

Based on the assessment of 50 simulations for the Baker well, the maximum distances from the release location to the edge of the low, moderate and high exposure thresholds is predicted to be 0.42 km, 0.28 km and 0.18 km, respectively. Additionally, the total area of coverage for the low, moderate and high exposure thresholds are predicted to be 0.21 km^2, 0.09 km^2 and 0.04 km^2, respectively (RPS, 2026).

Of note, any cement that is pumped to the seabed (refer to Section 3.3.4) will remain within the area impacted by the cuttings pile.

Table 7.2: Predicted areas of coverage and maximum distances from the Abbey A1 and A3 wells release locations to each reporting threshold based on the results of all 100 simulations (50 per well) (RPS, 2026)

Reporting Criteria	Total area of coverage (km^2)	Maximum distance (km) from the release location
1.11 mm (Low Exposure)	0.16	0.41
3.33 mm (Moderate Exposure)	0.07	0.28
11.11 mm (High Exposure)	0.03	0.12

Table 7.3: Predicted areas of coverage and maximum distances from the Baker well release locations to each reporting threshold based on the results of all 50 simulations (RPS, 2026)

Reporting Criteria	Total area of coverage (km^2)	Maximum distance (km) from the release location
0.44 mm (Low Exposure)	0.21	0.42
1.33 mm (Moderate Exposure)	0.09	0.28
4.44 mm (High Exposure)	0.04	0.18

Figure 7.1: Predicted Maximum Bottom Thickness from the Discharge of Drill Cuttings and Muds from the Abbey A1 and A3 wells. Results are based on 100 Simulations (RPS, 2026)

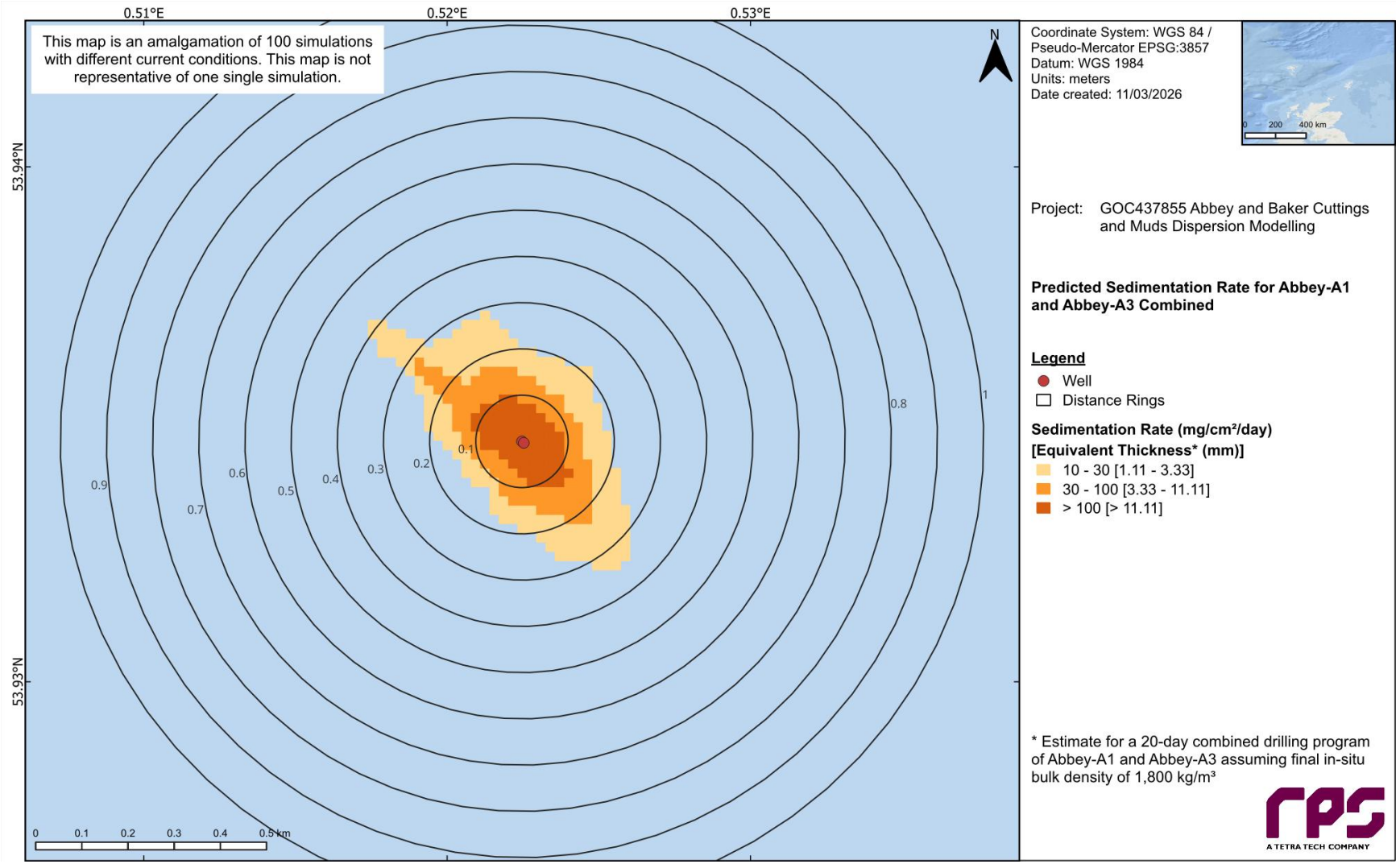
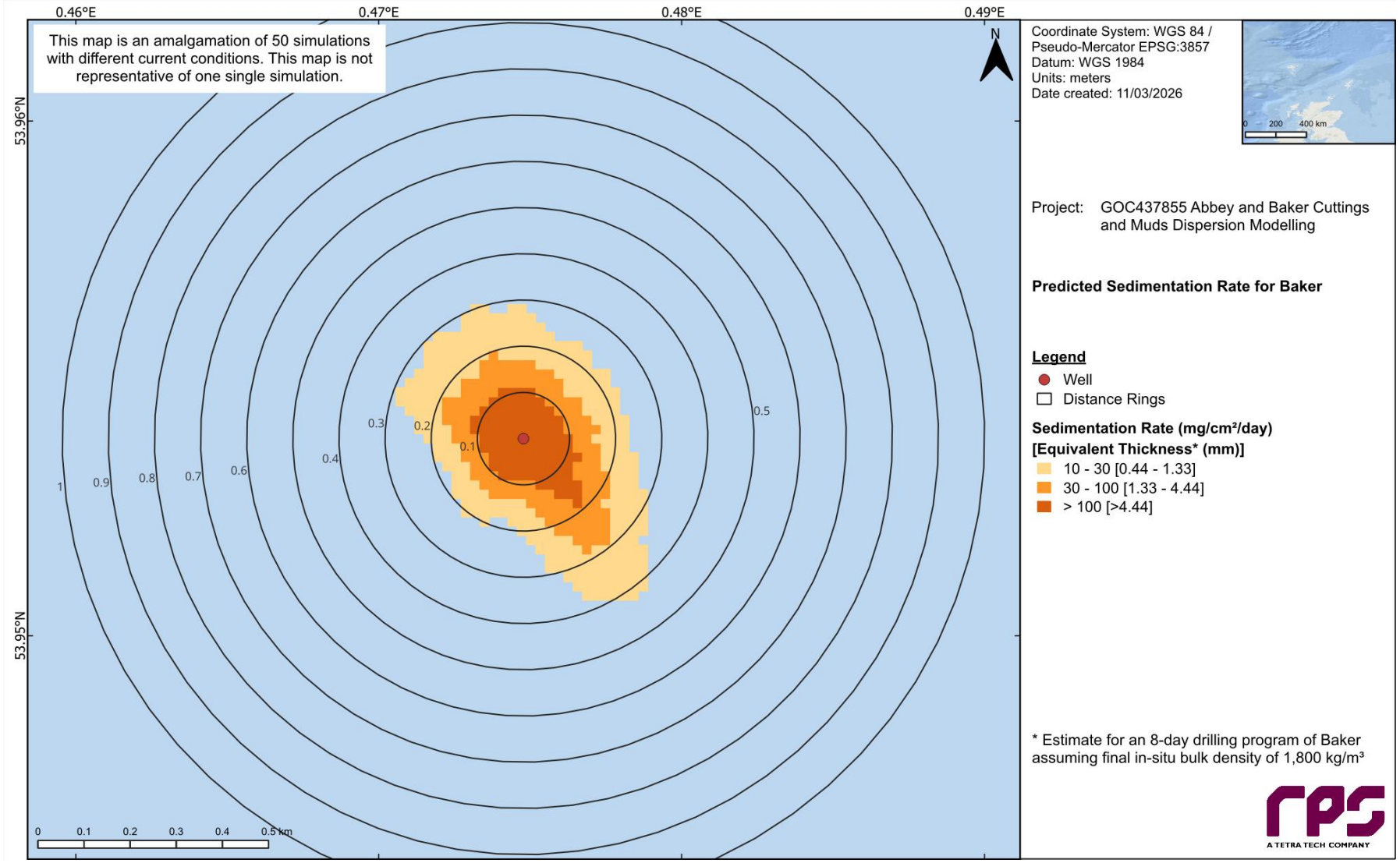


Figure 7.2: Predicted Maximum Bottom Thickness from the Discharge of Drill Cuttings and Muds from the Baker well. Results are based on 50 Simulations (RPS, 2026)



7.2.4 Installation of the Pipeline and Umbilical

Table 7.4 summarises the total area of seabed that may be disturbed during the installation of the pipelines and umbilicals (based on the Project Description in Section 3.4.3).

Table 7.4: Estimated Extent of Disturbed Seabed from the Installation Operations for the Pipelines and Umbilicals

Assumptions	Estimated Area of Seabed Disturbance				Total	
	Temporary Impact		Long Term Impact			
	m^2	km^2	m^2	km^2	m^2	km^2
Boulder Removal [1]	-	-	75	0.00008	**100**	**0.0001**
Trench and burial in two separate trenches along the entire length of the Baker to Abbey pipeline and umbilical [2]	93,816	0.094	-	-	**93,816**	**0.094**
Trench and burial in two separate trenches along the entire length of the Abbey to York pipeline and umbilical [3]	187,200	0.187	-	-	**194,250**	**0.1942**
UHB Mitigation [4]	-	-	25,200	0.0252	**25,200**	**0.0252**
Pipeline Crossing [4]	-	-	6,000	0.006	**6,000**	**0.006**
Trench Transition [4]	-	-	1,800	0.0018	**1,800**	**0.0018**
Temporary Initiation Anchors and Wires [5]	3,108	0.003	-	-	**3,108**	**0.00312**
Total	**284,124**	**0.284**	**33,075**	**0.033**	**317,224**	**0.317**

[1] Assumes up to 50 boulders may need to be removed from each lay corridor (Baker to Abbey and Abbey to York).
[2] Assumes two separate trenches with a width of 12 m each and a length of 3.818 km for the pipeline and 4 km for the umbilical.
[3] Assumes two separate trenches with a width of 12 m each and a length of 8 km each.
[4] See assumptions in Table 3.11 in Section 3.4.3.
[5] Assumes anchor dimensions of ca. 6 m by 6 m, impacting an area of 108 m^2 for the Baker to Abbey pipeline and umbilical and Abbey to York pipeline, and an initiation wire length for the pipelines and umbilical of 500 m with a 2 m wide disturbance corridor, impacting an area of 3,000 m^2.

Although the majority of the impact from pipeline installation operations is temporary, there is potential for long term seabed disturbance. Any large boulders will first be identified and removed from the separate pipeline and umbilical corridors with the use of a 'V' shaped sled or, if the boulders are embedded into the seabed, by individually dragging them to one side using a cable and sling direct from

a vessel. The estimated total disturbance arising from these operations has been estimated to total to approximately 75 m^2 (0.00008 km^2) spread across both lay corridors (refer to Section 3.4.3).

It is also estimated that, in the worst case scenario for both of the pipelines, 6,300 tonnes of rock split equally between the pipelines may need to be deposited in order to mitigate upheaval buckling; 3,150 tonnes for the Abbey to York pipeline and 3,150 tonnes for the Baker to Abbey pipeline. As a worst case, it is estimated that this rock will be laid along 4.2 km of the pipelines; 2.1 km along the Baker to Abbey pipeline, and 2.1 km along the Abbey to York pipeline. Any rock required for upheaval buckling (UHB) mitigation will be sited within a ca. 6 m wide corridor centred above the pipeline. The estimated total disturbance arising from these rock deposits is 25,200 m^2 (0.0252 km^2); 12,600 m^2 (0.0126 km^2) along the Baker to Abbey pipeline, and 12,600 m^2 (0.0126 km^2) along the Abbey to York pipeline.

Additional rock will also need to be deposited where the pipelines and umbilicals exit the trenches at Baker, Abbey and York (50 m sections for the pipelines and 25 m sections for the umbilical). It is estimated that up to 2,000 tonnes of rock with a berm width of 6 m may need to be deposited over the lines for protection at these locations. The total length of the pipelines transition will be 200 m and the total length on umbilical transition will be 100 m. Each trench transition rock placement will have a width of 6 m. The estimated total disturbance arising from these trench transitions is 1,800 m^2 (0.0018 km^2).

In addition, the proposed route of the Baker to Abbey pipeline and umbilical cross the existing 36-inch Cleeton export pipeline, which is surface laid and exposed. Using the highest impact assumption of 4,000 tonnes of rock being required for the crossings, including trench transition. The estimated total disturbance arising from the pipeline crossings is 6,000 m^2 (0.006 km^2)(refer to Section 3.4.3 for more detail).

In addition, the initiation of the Baker to Abbey pipeline and umbilical, and Abbey to York pipeline will require the installation of a temporary initiation anchor (either a conventional anchor or dead man anchor, approximately 6 m by 6 m) and the use of an initiation wire, which will connect between the anchor and the end of the pipeline / umbilical. The anchor is estimated to impact 36 m^2 of seabed per line. The initiation wire for both the pipelines and umbilical is expected to be no longer than 500 m in length. To allow for the lateral movement of the wire on the seabed during installation and retrieval, a 2 m wide disturbance corridor has been assumed, with ca. 1,000 m^2 of seabed impacted per line. In total, therefore, deployment and retrieval of the initiation anchor and wire will temporarily disturb an area of approximately 3,108 m^2 (0.00311 km^2). Following the installation of the pipeline/umbilical the anchor and wire will be recovered.

The total seabed disturbance area from boulder clearance; laying and trenching and burial of the pipelines and umbilicals; installation of protection for UHB mitigation and trench transition; the construction of pipeline crossings; and the use of temporary initiation anchors and wires is equal to ca. 317,224 m^2 (0.317 km^2); with 33,100 m^2 (0.033 km^2) of this disturbance causing a long term impact and the remaining 284,124 m^2 (0.284 km^2) a temporary impact (see Table 7.4).

7.2.5 Installation of the Abbey & Baker Development Subsea Infrastructure

The total seabed footprint caused by the installation of the seabed infrastructure associated with the Abbey & Baker Development is summarised in Table 7.5 (based on the project description in Sections 3.4.1, 3.4.2 and 3.4.4). In total, the seabed disturbance associated with the installation of infrastructure associated with the Abbey & Baker Development is estimated to be 15,609.08 m^2 (0.016 km^2), with the long term loss of available seabed estimated to be 6,783.25 m^2 (0.0068 km^2) and the temporary area of seabed impacted estimated to be 8,825.83 m^2 (0.0088 km^2).

Table 7.5: Estimated Area of Seabed Occupied by the Abbey & Baker Development Subsea Infrastructure

Subsea Item	Assumptions	Temporary Disturbance Area (m^2) [4]	Long Term Disturbance Area (m^2)	Total Seabed Footprint (m^2)
Wellheads / Xmas Trees / Wellhead Protection Structures (WHPS) [1]	Outermost dimensions of the WHPS are 7.88 m by 7.88 m – 3 WHPS will be installed (2 at Abbey, 1 at Baker)	106.57	186.27	292.84
Production Manifold	Overall dimensions of the manifold are 21 m by 12 m (1 manifold will be installed at the Abbey drill centre)	70	252	322
Subsea Isolation Valve (SSIV) [2]	Overall dimensions of the SSIV are 18.82 m by 7.81 m (SSIV will be installed within the York 500 m zone)	57.26	146.98	204.24
Tie-in spools and control jumpers [3]	Spools and jumpers will be surface laid at Abbey, Baker and York and protected with concrete mattresses and supported by grout bags	8,592	6,198	14,790
	Total	**8,825.83**	**6,783.25**	**15,609.08**

[1] WHPS will be located on top of the xmas trees and wellheads. The xmas trees will be located on top of the wellheads.
[2] The SSIV has been included as a contingency in order to assess the worst-case seabed disturbance. Current plans do not involve the use of an SSIV, but there is a potential for the HSEx (Health and Safety Executive) to stipulate that use of an SSIV is necessary.
[3] See assumptions in Table 3.12 of Section 3.4.4.
[4] A 1 m corridor of temporary disturbance surrounding each item is assumed when the infrastructure is initially placed on the seabed.

7.2.6 Estimated Total Seabed Disturbance Area

Table 7.6 summarises the highest impact total area of seabed that could be disturbed as a result of the Abbey & Baker Development. The estimated highest impact total temporary area of seabed disturbed from the Abbey & Baker Development is 697,041.6 m^2 (0.697 km^2). The highest impact total area of seabed disturbed in the long term by the subsea infrastructure, rock protection, concrete mattresses and grout bags for the life of the Abbey & Baker Development is estimated to be 39,883.25 m^2 (0.0399 km^2).

Areas of seabed subject to temporary disturbance will begin to recover on completion of the operations as discussed in Section 7.3. In contrast long term impacts to the seabed are associated with infrastructure that will be in place for the duration of the Abbey & Baker Development (ca. 11 years). Long term impacts may extend beyond the field life of the Abbey & Baker Development, depending on the methods and options available at the time of decommissioning.

Table 7.6: Estimated Extent of Seabed Disturbed from the Abbey & Baker Development (Assessing the Worst Case Options)

Aspect	Assumptions	Estimated Area of Seabed Disturbance (Worst Case)			
		Temporary Impacts		Long Term Impacts	
		m^2	km^2	m^2	km^2
Siting of the Jack-up Rig (Section 7.2.1)	• The MODU will be moved onto location three times: 763.5 m^2 will be disturbed by 3 spudcans per move • Four anchors with chains will be required to move the rig on and off location at the Abbey A2 well and the Abbey A1 and A3 wells. • Each anchor: 3.65 m x 4.2 m = 15.33 m^2 • Maximum length of mooring line on the seabed per move at Abbey = 1,050 m. 10 m wide corridor of mooring chain lateral movement.	23,412.64	0.0234	-	-
Siting of the Accommodation Unit at the York Platform (7.2.2)	• The accommodation unit will be moved onto location once: 117.81 m^2 will be disturbed by 6 legs per move • Four anchors with chains will be required to move the rig on and off location at the York platform. • Each anchor: 3.65 m x 4.2 m = 15.33 m^2 • Maximum length of mooring line on the seabed = 1,050 m. 10 m wide corridor of mooring chain lateral movement.	10,679.13	0.0011	-	-
Deposit of drill cuttings and cement on the seabed (Section 7.2.3)	• The majority of drill cuttings from the Abbey A1 and A3 wells, as well as the cement, will be deposited out to a maximum distance of ca. 0.41 km from each release location, aligned with the direction of the current • The majority of drill cuttings from the baker well, as well as the cement, will be deposited out to a maximum	370,000	0.37	-	-

Aspect	Assumptions	Estimated Area of Seabed Disturbance (Worst Case)			
		Temporary Impacts		Long Term Impacts	
		m^2	km^2	m^2	km^2
	distance of ca. 0.42 km from each release location, aligned with the direction of the current				
Installation of Pipelines and Umbilicals (Section 7.2.4)	• Boulder Clearance Operations: 100 m^2 • Laydown and Trench and Burial of the Baker to Abbey and Abbey to York Pipelines and Umbilicals: 281,016 m^2 • Rock Protection for both pipelines: 25,200 m^2 • Pipeline Crossings: 6,000 m^2 • Trench Transition: 1,800 m^2 • Temporary Initiation Anchors and Wires: 3,108 m^2	284,124	0.284	33,075	0.033
Installation of the Subsea Infrastructure (Section 7.2.5)	• Installation of Abbey & Baker Development subsea infrastructure (wellheads, xmas trees, WHPS, production manifold, SSIV, tie-in spools, jumpers, concrete mattresses and grout bags): 15,609.08 m^2 in total, with 6,783.25 m^2 being long term	8,825.83	0.0088	6,783.25	0.00068
	Total:	**697,041.6**	**0.697**	**39,858.25**	**0.0399**

7.3 Assessment of Impacts

7.3.1 Siting of Jack-up Drilling Rig

Siting of the jack-up rig (three times, with anchors and anchor chains used at the Abbey wells) at the Abbey and Baker locations will impact an area of seabed equal to ca. 23,412.64 m^2 (0.00234 km^2). As described in Section 7.2.1, areas of the seabed where each of the spud cans and anchors are placed will be compressed as they sink into the seabed. In addition, the spud cans may create a pit on the seabed once the rig departs.

In the case of siting the rig at the Abbey wells (A1, A2 and A3), the movement of the mooring lines attached to the anchors as they sweep across the seabed will also cause localised direct abrasion damage to the habitats and species beneath for the duration of their deployment. In addition, when the anchors and chains are removed, scars, and sometimes anchor mounds, may be left on the seabed. In particular, anchor mounds may be formed during the retrieval of anchors in sedimentary areas, particularly where clay is present immediately beneath the surficial sediments. The indirect effects of the anchoring include the re-suspension of sediments, and subsequent smothering of seabed habitats and species, which are likely to occur over a wider area as sediments are re-suspended and transported away from the immediate vicinity of the MODU anchoring area.

Seabed Sediments

As noted above, the spudcans will physically disturb the seabed sediment. The longevity of the spudcan depressions on the seabed is dependent on the type and energy of the local benthic environment. Habitats with a naturally high rate of disturbance, such as wave or current exposed unconsolidated fine grained sediments in shallow water, tend to recover from disturbance within months (Foden *et al*. 2009). This is likely to be the case for the proposed Abbey & Baker development given its location in the SNS.

Anchoring of the jack-up drilling rig will physically disturb the seabed sediment. There is little quantitative information available on the likely recovery time from the physical disturbance of anchor placement. However, indications are available from studies carried out for seabed disturbance from towed fishing gear (Løkkeborg, 2005). These suggest that it is likely that some level of recovery will occur in the sediments following anchoring operations. The longevity of the physical abrasion scars on the seabed is dependent on the type and energy of the local benthic environment. Seabed scars in higher energy, sandy or shallow environments may disappear within days or months of initial disturbance, whilst those in lower energy silty and deeper areas may still be faintly visible after 18 months.

As discussed in Section 4.2.2, seabed sediments within the Abbey & Baker development have been identified as being sandy, showing moderate amounts of gravel and fines and a negligible silt and clay content (GEOxyz, 2023a; GEOxyz, 2024a; GEOxyz, 2024b; GEOxyz, 2025a). The Abbey & Baker development is also located within a highly dynamic area with strong near-seabed currents and highly mobile sediments (DESNZ, 2022). Consequently, any spudcan depressions resulting from the siting of the jack-up rig at the Abbey drill centre and Baker well location have the potential to persist only in the short to medium term. In addition, any seabed scarring resulting from the anchoring of the MODU at the proposed Abbey drill centre have the potential to persist only in the short to medium term and the likelihood of anchor mounds forming is very low.

The sensitivity of seabed sediments to the siting of the drilling rig at the Abbey & Baker development is therefore considered to be **Low**. The receptor is of local importance for sediment type, classed as Low value, and the overall resistance and resilience is High as recoverability is expected in the short to medium term given the sediment type and fast water circulation. The magnitude of impact is predicted to be **Minor**; it will be limited to a very small area (ca. 0.00234 km^2), with any change to baseline conditions predicted to be temporary in nature. Effects on seabed sediments from the footprint of the drilling rig are therefore assessed as **Minor** and not significant.

Seabed Communities

The vulnerability of benthic species to the effects of physical disturbance and smothering (through the resuspension of sediments) is variable and dependant on the individual's mobility, physiology and ecology. Annelid species dominated the infaunal community at the proposed Abbey drill centre and Baker well location accounting for 31.1 % and 46.6 % of the total individuals respectively. These species were followed by Arthropods, molluscs, and echinoderms (GEOxyz, 2023b; GEOxyz, 2024b; GEOxyz, 2025a).

Sessile epifauna, and a proportion of the infauna (animals that burrow into the sediment or form tubes within it) such as polychaete worms in the direct footprint area of the drilling rig (ca. 0.00234 km^2) may experience injury and mortality from compression and abrasion. However, recovery is expected to occur once the drilling rig has moved off location. The re-colonisation of the impacted area can take place in a number of ways, including mobile species moving in from the edges of the area (immigration), juvenile recruitment from the plankton, or from burrowing species digging back to the surface (Neal and Avant, 2008). Where sedimentation does impact negatively on benthic species, consequences are likely to be short-lived for the majority of species as most of the smaller sedentary species (such as polychaete worms) have short lifecycles and recruitment of new individuals from outside of the disturbed area will be rapid (Tillin and Tyler-Walters, 2014).

The habitat assessment results for the Abbey site survey (the Abbey drill centre area) highlighted the presence of the habitat type '*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment' (MC4214) in the north and central region of the Abbey site survey area (Refer to Section 4.3.2).

This biotope is characterized by mobile pebbles and cobbles; pressures that lead to penetration and disturbance could damage associated species through abrasion and by overturning surfaces could result in the smothering of fauna or reductions in respiration, feeding efficiency or fertilization of gametes in the water column. The biotope is, however, likely to be exposed to at least seasonal movement of substrata and this movement and scour maintains this biotope by preventing species that require more stable habitats from colonizing and developing stable populations. The Marine Life Information Network (MarLIN) Sensitivity Assessment indicates a Medium resilience (recovery within 2 – 10 years) and Medium sensitivity to penetration or disturbance of the substratum subsurface (i.e. spudcan placement), and to the abrasion / disturbance to the surface of the substratum (Readman and Watson, 2024).

The habitat assessment results within the vicinity of the Abbey drill centre and Baker well location also highlighted the presence of *Sabellaria* in isolated patches across the survey area, associated with areas of coarser substrate, such as within the 300 m zone around the proposed drill centre. However, the available information from camera ground-truthing data indicates that these *Sabellaria* aggregations do not constitute Annex I reef habitat, as they are present as low-lying aggregations or crusts and do not meet the required level of elevation from the surrounding seabed to be classified as reef (refer to Section 4.3.2).

There was no evidence to indicate the presence of Annex I 'Stony Reef' habitats within the vicinity of the Baker well location (refer to Section 4.3.2). The Abbey drill centre location was, however, identified as having the potential for Annex I 'stony reef' habitats, with occurrences of 'Low Reef' identified within 300 m of the proposed Abbey drill centre location to the south west. Research has shown that stony reefs have a limited tolerance to direct physical, with recovery not expected for an extended period. As such, a decision was made to move the drill centre ca. 70 m to the north east to avoid placement of the drilling rig on the identified 'Low Reef' sites (refer to Section 4.3.2 and Figure 7.3).

Ocean quahog (*Arctica Islandica*), an OSPAR Threatened and/or Declining species, has also been reported to inhabit the wider region surrounding the proposed Abbey & Baker Development. More specifically the Holderness Offshore MCZ, within which, 4.8 km the proposed Abbey to York pipeline route is located is designated for the conservation of *A. islandica*. No adult (>5cm shell size) living specimens of *A. islandica* and no evidence of their distinct siphons was seen on any of the video footage or still photographs within the Abbey drill centre. In the Baker site survey area, two specimens (one adult, one juvenile) were recovered during grab sampling operations. In addition, one individual was observed atop the seabed, with a single siphon also observed. Single juvenile specimens (<5 cm) of live

A. islandica were recorded within the Abbey site survey area at four stations and within the Baker site survey area at two stations (refer to Section 4.3.2).

The ocean quahog is of conservation importance due to its slow growth, late age of reaching reproductive maturity and vulnerability to disturbance. The MarLIN indicates that individuals of *A. islandica* have Very Low resilience (negligible or prolonged recovery) and high sensitivity to sub-surface abrasions / penetration (i.e. spudcan and anchor placement) and surface abrasions (i.e. anchor chain movement on the seabed) (Tyler-Walters & Sabatini, 2017). To note, anchors and anchor chains will only be used to move the rig into place at the Abbey wells; little evidence of the presence of adult *A. islandica* individuals has been found within the vicinity of the Abbey drill centre (refer to Section 4.3.2).

In summary, the sensitivity of seabed communities to the footprint of the drilling rig, and anchors and chains at the Abbey and Baker wells is considered to be **Low**. Some of the receptors are of national importance and are of High value, but for the majority of species the overall resistance and resilience is High as recoverability of benthic communities is expected in the short term. Ocean quahog are the exception to this, being of **Very High** sensitivity, as they have a Low resistance and resilience to sub-surface abrasion. The magnitude of impact is predicted to be **Minor** as any impact will be limited to a very small area (ca. 0.00234 km^2) and will be temporary in nature, occurring in the short to medium term. Effects on seabed communities from the siting of the jack-up drilling rig are therefore assessed as **Minor** and not significant.

Fish

The Abbey & Baker development area is located within the spawning grounds for a number of fish species (refer to Section 4.3.3), including herring and sandeels which have a dependency on specific substrata for spawning and are therefore considered to be the most vulnerable to seabed disturbance.

Seabed disturbance caused by siting the jack up drilling rig at the proposed Abbey drill centre and Baker well location may affect foraging behaviour (Bakke *et al*., 2013) and temporarily displace fish from their spawning and nursery areas. However, given the localised area of impact (ca. 0.00234 km^2) and the mobile nature of the species, any displaced fish are likely to find foraging opportunities, as well as suitable spawning and nursey areas in adjacent locations. The spawning grounds within which the Abbey & Baker development area is located is part of wider spawning grounds within the SNS and, as such, is not considered to be a key habitat for these fish species.

Herring and sandeels are a commercially and ecologically important fish species which lay their eggs only in clean, sandy, and gravelly sediments. Sandeels are a key prey resource, particularly for seabirds, and an important link between zooplankton and top predators (Frederisken *et al*., 2006). Sandeels and herring are also UK BAP

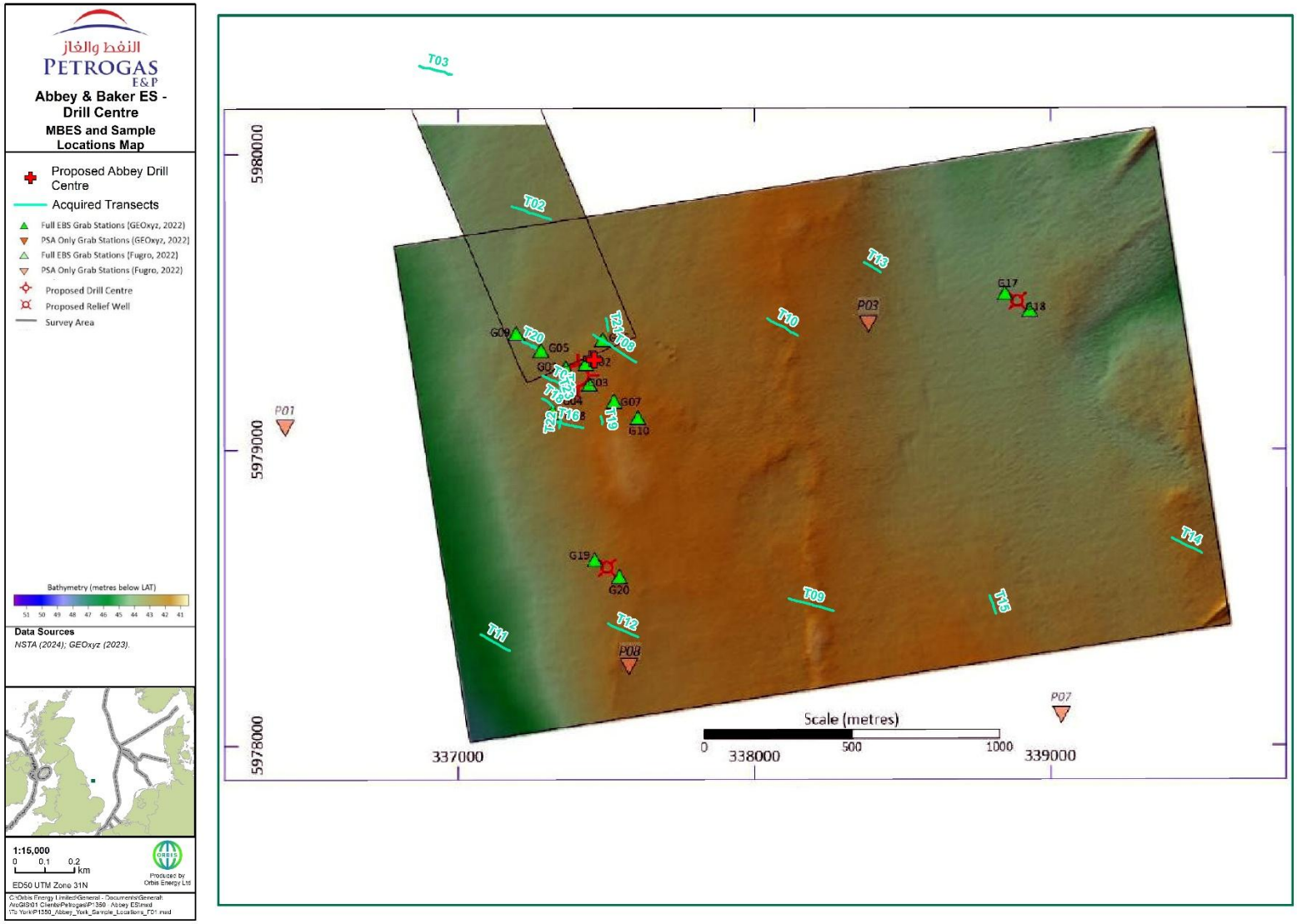
species (JNCC, 2007a). Fish egg development and hatching success is vulnerable to the effects of sediment smothering and abrasion (DESNZ, 2022).

As discussed in Section 4.3.3, the proposed Abbey & Baker Development area contains habitat that is moderately suitable for sandeels, with Langton *et al.* (2021) predicting a low to medium density of sandeels in this region. The sandeels spawning ground assessments undertaken for the proposed Abbey & Baker Development indicated areas of low to moderate potential ('Unsuitable', 'Suitable', 'Preferred' or 'Sub-prime') for the area to be used as a sandeel spawning ground (refer to Section 4.3.3).

However, the herring spawning ground assessment undertaken for the proposed Abbey & Baker Development did not indicate high potential (i.e. 'Prime' or 'Preferred' classification) for the area to be used as a herring spawning ground. This excludes one station located ca. 823 m to the west of the Abbey & Baker development, which is classed as 'Prime'.

In summary, the sensitivity of spawning fish to the footprint of the drilling rig is considered to be **Low** as the species present are typical of the wider area. The receptors are of national importance and are of High value, and the overall resistance and resilience is Very High as recoverability is expected in the short term. The magnitude of impact is predicted to be **Negligible** with immeasurable changes in the baseline environment. Effects on spawning fish from the from the siting of the drilling rig on seabed are therefore assessed as **Negligible** and not significant.

Figure 7.3: Current and Previous Proposed Abbey Drill Centre Locations in Relation to Stony Reef Areas



7.3.2 Siting of the Accommodation Unit at the York Platform

In the worst case, siting of the accommodation unit at the York platform will impact an area of seabed equal to circa. 10,679.13 m^2 (0.0011 km^2). As described in Section 7.2.2, areas of the seabed where each of the legs and anchors are placed will be compressed as they sink into the seabed and the legs may create a pit on the seabed once the rig departs.

In addition, the movement of the mooring lines attached to the anchors as they sweep across the seabed will also cause localised direct abrasion damage to the habitats and species beneath for the duration of their deployment. In addition, when the anchors and chains are removed, scars, and sometimes anchor mounds, may be left on the seabed. In particular, anchor mounds may be formed during the retrieval of anchors in sedimentary areas, particularly where clay is present immediately beneath the surficial sediments. The indirect effects of the anchoring include the re-suspension of sediments, and subsequent smothering of seabed habitats and species, which are likely to occur over a wider area as sediments are re-suspended and transported away from the immediate vicinity of the accommodation unit anchoring area.

Seabed Sediments

As noted above, the legs will physically disturb the seabed sediment. The longevity of the leg depressions on the seabed is dependent on the type and energy of the local benthic environment. Habitats with a naturally high rate of disturbance, such as wave or current exposed unconsolidated fine grained sediments in shallow water, tend to recover from disturbance within months (Foden *et al*. 2009). This is likely to be the case for the proposed Abbey & Baker development given its location in the SNS.

Anchoring of the accommodation unit will physically disturb the seabed sediment. There is little quantitative information available on the likely recovery time from the physical disturbance of anchor placement. However, indications are available from studies carried out for seabed disturbance from towed fishing gear (Løkkeborg, 2005). These suggest that it is likely that some level of recovery will occur in the sediments following anchoring operations. The longevity of the physical abrasion scars on the seabed is dependent on the type and energy of the local benthic environment. Seabed scars in higher energy, sandy or shallow environments may disappear within days or months of initial disturbance, whilst those in lower energy silty and deeper areas may still be faintly visible after 18 months.

As discussed in Section 4.2.2, seabed sediments within the vicinity of the York platform have been identified as being sandy, showing moderate amounts of gravel and fines and a negligible silt and clay content (GEOxyz, 2024a). The York platform is also located within a highly dynamic area with strong near-seabed currents and highly mobile sediments (DESNZ, 2022). Consequently, any depressions resulting from the siting of the accommodation unit at the York platform have the potential to persist only in the short to medium term. In addition, any seabed scarring resulting from the anchoring of the accommodation unit at the York platform have the potential to persist only in the short to medium term and the likelihood of anchor mounds forming is very low.

The sensitivity of seabed sediments to the siting of the accommodation unit at the York platform is therefore considered to be **Low**. The receptor is of local importance for sediment type, classed as Low value, and the overall resistance and resilience is High as recoverability is expected in the short to medium term given the sediment type and fast water circulation. The magnitude of impact is predicted to be **Minor**; it will be limited to a very small area (ca. 0.0011 km^2), with any change to baseline conditions predicted to be temporary in nature. Effects on seabed sediments from the footprint of the drilling rig are therefore assessed as **Minor** and not significant.

Seabed Communities

The vulnerability of benthic species to the effects of physical disturbance and smothering (through the resuspension of sediments) is variable and dependant on the individual's mobility, physiology and ecology. Annelid species dominated the infaunal community at the York platform (within the Abbey to York pipeline route corridor) accounting for 52.4 % of the total individuals respectively. These species were followed by Arthropods, molluscs, and echinoderms (GEOxyz, 2024a).

Sessile epifauna, and a proportion of the infauna (animals that burrow into the sediment or form tubes within it) such as polychaete worms in the direct footprint area of the accommodation unit (ca. 0.0011 km^2) may experience injury and mortality from compression and abrasion. However, recovery is expected to occur once the accommodation unit has moved off location. The re-colonisation of the impacted area can take place in a number of ways, including mobile species moving in from the edges of the area (immigration), juvenile recruitment from the plankton, or from burrowing species digging back to the surface (Neal and Avant, 2008). Where sedimentation does impact negatively on benthic species, consequences are likely to be short-lived for the majority of species as most of the smaller sedentary species (such as polychaete worms) have short lifecycles and recruitment of new individuals from outside of the disturbed area will be rapid (Tillin and Tyler-Walters, 2014).

The habitat assessment results within the vicinity of the York platform also highlighted the presence of *Sabellaria* in isolated patches across the survey area, associated with areas of coarser substrate. However, the available information from camera ground-truthing data indicates that these *Sabellaria* aggregations do not constitute Annex I reef habitat, as they are present as low-lying aggregations or crusts and do not meet the required level of elevation from the surrounding seabed to be classified as reef (refer to Section 4.3.2; GEOxyz, 2024a). In addition, there was no evidence to indicate the presence of Annex I 'Stony Reef' habitats within the vicinity of the York platform (refer to Section 4.3.2; GEOxyz, 2024a).

Ocean quahog (*Arctica Islandica*), an OSPAR Threatened and/or Declining species, has also been reported to inhabit the wider region surrounding the proposed Abbey & Baker Development. More specifically the Holderness Offshore MCZ, within which, the York platform is located is designated for the conservation of A. islandica. One adult (shell size >5 cm) specimen of *A. islandica*, an OSPAR Threatened and/or Declining species, was recovered along the Abbey to York pipeline route, approximately 7.2 km southwest from the proposed Abbey drill centre (within 1 km of the York platform). No evidence of *A. islandica*'s distinct siphons was seen on any of the video footage or still photographs along the Abbey to York pipeline route (refer to Section 4.3.2).

The ocean quahog is of conservation importance due to its slow growth, late age of reaching reproductive maturity and vulnerability to disturbance. The MarLIN Sensitivity Assessment indicates that individuals of *A. islandica* have very low resilience (negligible or prolonged recovery possible) and high sensitivity to sub-surface abrasions / penetration (i.e. leg and anchor placement) and surface abrasions (i.e. anchor chain movement on the seabed) (Tyler-Walters & Sabatini, 2017). To note, anchors and anchor chains will only be used to move the accommodation unit into place at the York platforms; the anchors and chains will be removed once the accommodation unit is jacked up in place (refer to Section 7.2.2).

In summary, the sensitivity of seabed communities to the footprint of the accommodation unit, and anchors and chains at the York platform is considered to be **Low**. Some of the receptors are of national importance and are of High value, but for the majority of species the overall resistance and resilience is High as recoverability of benthic communities is expected in the short term. Ocean quahog are the exception to this, being of **Very High** sensitivity, as they have a Low resistance and resilience to sub-surface abrasion. The magnitude of impact is predicted to be **Minor** as any impact will be limited to a very small area (ca. 0.0011 km^2) and will be temporary in nature, occurring in the short to medium term. Effects on seabed communities from the siting of the jack-up drilling rig are therefore assessed as **Minor** and not significant.

Fish

The Abbey & Baker development area (including the York platform) is located within the spawning grounds for a number of fish species (refer to Section 4.3.3), including herring and sandeels which have a dependency on specific substrata for spawning and are therefore considered to be the most vulnerable to seabed disturbance.

Seabed disturbance caused by siting the accommodation unit at the York platform may affect foraging behaviour (Bakke *et al*., 2013) and temporarily displace fish from their spawning and nursery areas. However, given the localised area of impact (ca. 0.0011 km^2) and the mobile nature of the species, any displaced fish are likely to find foraging opportunities, as well as suitable spawning and nursey areas in adjacent locations. The spawning grounds within which the Abbey & Baker development area (including

the York platform) is located is part of wider spawning grounds within the SNS and, as such, is not considered to be a key habitat for these fish species.

Herring and sandeels are a commercially and ecologically important fish species which lay their eggs only in clean, sandy, and gravelly sediments. Sandeels are a key prey resource, particularly for seabirds, and an important link between zooplankton and top predators (Frederisken *et al*., 2006). Sandeels and herring are also UK BAP species (JNCC, 2007a). Fish egg development and hatching success is vulnerable to the effects of sediment smothering and abrasion (DESNZ, 2022).

As discussed in Section 4.3.3, the area within the vicinity of the York platform contains habitat that is moderately suitable for sandeels, with Langton *et al.* (2021) predicting a low to medium density of sandeels in this region. The sandeels spawning ground assessments undertaken within the vicinity of the York platform indicated areas of low to moderate potential ('Unsuitable', 'Suitable', 'Preferred' or 'Sub-prime') for the area to be used as a sandeel spawning ground (refer to Section 4.3.3).

However, the herring spawning ground assessment undertaken for the area within the vicinity of the York platform did not indicate high potential (i.e. 'Prime' or 'Preferred' classification) for the area to be used as a herring spawning ground (refer to Section 4.3.3).

In summary, the sensitivity of spawning fish to the footprint of the accommodation unit is considered to be **Low** as the species present are typical of the wider area. The receptors are of national importance and are of High value, and the overall resistance and resilience is Very High as recoverability is expected in the short term. The magnitude of impact is predicted to be **Negligible** with immeasurable changes in the baseline environment. Effects on spawning fish from the from the siting of the accommodation at the York platform on seabed are therefore assessed as **Negligible** and not significant.

7.3.3 Discharge of Drill Cuttings, Muds and Cement

As discussed in Section 7.2.3, as a worst case, it has been assumed that the WBM cuttings discharged from the Abbey and Baker wells (809 tonnes from the Baker well and 1,759 tonnes from the combined Abbey A1 and A3 wells) have the potential to be deposited within an area of up to 0.21 km^2 surrounding the Abbey A1 and A3 wells combined and 0.16 km^2 surrounding the Baker well (0.37 km^2 in total) (based on a low exposure threshold for bottom deposition of 1.11 mm for the Abbey A1 and A3 wells, and 0.44 m for the Baker well) (RPS, 2026). A high exposure level of WBM cuttings are likely to be deposited within an area of 0.03 km^2 surrounding the Abbey A1 and A3 wells and 0.04 km^2 surrounding the Baker well (RPS, 2026). Any cement discharged at the seabed during cementing operations will also be deposited here.

Research has shown that the effects on seabed fauna from the deposition of WBM cuttings and fine solids are usually subtle or undetectable, although the presence of drilling material at the seabed close to the drilling location (less than 500 m) is often detectable chemically (e.g. Cranmer, 1988, Neff *et al*. 1989, Hyland *et al*. 1994, Daan & Mulder, 1996). The main components of WBM are naturally occurring products (e.g. barite and bentonite clay), to which may be added various products to ensure the mud has suitable properties. The mud components are generally low risk and many chemical components are labelled as PLONOR (Pose Little or No Risk to the marine environment). Barium in the form of barite is a weighting material used to increase the density of drilling muds and can contain measurable concentration of heavy metals as impurities, including cadmium, chromium, copper, lead, mercury, and zinc (NRC, 1983; McLeese *et al*., 1987). As a result of this, Ba in the seabed sediment can be used as an indication of previous drilling activities.

The proposed Abbey & Baker development area has previously been subject to drilling activities. The Abbey field, previously known as Artemis, was discovered, and appraised by wells 47/3-2 and 47/3b-6A, drilled by Amoco in 1974 and 2001 respectively. These wells are located approximately 2.4 km southwest and less than 1 km to the east of the proposed Abbey drill site. A development well, 47/3b-12, located approximately 1.5 km southeast of the proposed Abbey drill site, drilled by British Gas as part of the Juno project, was completed in 2002 but was not produced and is now abandoned. Therefore, there could be some historical contamination of the sediments in the area from these previous drilling operations. However, within the Abbey and Baker survey areas, barium levels were found to be below or consistent with the UKOOA 50th percentile reference value for background sediments in the SNS (26mg.kg^{-1}) at the majority of stations, and below the 95th percentile reference

value for background sediments in the SNS (272.4mg.kg^{-1}) at the remaining stations, indicating no evidence of drilling related contamination (refer to Section 4.2.2.).

Seabed Sediments

The seabed sediments within the Abbey & Baker development were interpreted to vary between gravelly sand with shell fragments, gravelly sand, and sand, with very small patches of sandy gravel and gravel. The discharge of drill cuttings, muds and cement from the Abbey & Baker development wells will initially alter the seabed topography and sediment structure of a very small area close to the wells. The material deposited will be a mixture mostly of cuttings (rock fragments and sediment removed from the well) of various sizes and drilling mud including particles of barite (barium sulphate) and bentonite, a mineral clay. It is feasible that changes in sediment particle size characteristics could affect the suitability of the seabed for re-colonisation by species normally characteristic of the area, although in a dynamic area such as this it is anticipated that the sediments will rapidly return to their original composition under the influence of seabed currents and natural sedimentation.

In the SNS, near-bed current velocities and sediment mobility are generally sufficient to prevent detectable local accumulation of cuttings. It has been predicted that any surface-hole cuttings piles in the southern and central North Sea area will be dispersed typically over a timescale of one to five years, mainly through re-suspension and bedload transport due to tidal and wave-induced currents (DTI, 2001). However, in areas of shallow water (<50 m) that are subject to strong currents, the drill cuttings are rapidly dispersed and cuttings piles are unlikely to form (Breuer *et al*. 2004).

The sensitivity of seabed sediments to the discharge of drill cuttings, muds and cement as a result of the Abbey & Baker development wells is therefore considered to be **Low**. The receptor is of local importance for sediment type, classed as Low value, and the overall resistance and resilience is High as seabed currents are likely to prevent local accumulations of cuttings or piles from persisting. The magnitude of impact is predicted to be **Minor** as the disturbance to seabed sediments will be localised to the Abbey drill centre and Baker well locations. Effects on seabed sediments from the discharge of drill cuttings, muds and cement are therefore assessed as **Minor** and not significant.

Seabed Communities

The accumulation of WBM drill cuttings, mud and cement at the Abbey & Baker development is likely to change the benthic community in the immediate area by burying some animals and impairing the feeding and respiration of others. It is expected that the communities in the immediate vicinity of the well will be lost, and that increased concentrations of suspended particles near the seabed may also impair respiratory and feeding processes, inducing metabolic stress and reducing growth and survival rates. Filter feeding organisms (for example, hydroids and bryozoans) that rely on suspended particles as a source of food are likely to be more vulnerable to the impacts of the drilling operations than the scavengers that rely on the deposition of suspended material. The net result therefore is likely to be a reduction in species diversity and production and a change in the species composition of the community, predicted to be within ca. 280 m of the Abbey A1 and A3 wellheads, and the Baker wellhead respectively (the areas experiencing moderate to high exposure to cuttings)(RPS, 2026).

The WBM cuttings may elevate the local seabed Ba levels as well as trace metals associated with the Ba. Barite consists of barium sulphate, an insoluble, chemically inert mineral powder that normally contains measurable concentrations of several trace metals. As such, Ba is “biologically unavailable” and will have no measurable chemical effect on the benthic fauna (Jenkins et al., 1989, Hartley, 1996, Neff, 2005). The environmental impact of other trace metals will depend on their concentration in the WBM-contaminated cuttings, which depends to some extent on the geological source of the barite. However, Neff et al. (1989) found that metals associated with drilling mud barite are virtually unavailable to marine organisms that may come into contact with the discharged drilling fluids.

Given the above, as the main impact is purely physical, it is anticipated that the sediment communities will begin to recover once the drilling operations have ceased. Re-colonisation of the impacted area can take place in a number of ways, including mobile species moving in from the edges of the area (immigration), usually more effective for the larger epifaunal species, juvenile recruitment from the plankton or from burrowing species digging back to the surface.

Considerable data has been gathered from the North Sea and other production areas, indicating that localised physical effects are the dominant mechanism of ecological disturbance, where WBM cuttings, muds and cements are discharged (DECC, 2011).

For example, a comprehensive desk study of the composition, environmental fates and biological effects of WBM cuttings and muds was prepared on behalf of the Petroleum Environmental Research Forum and the American Petroleum Institute by Neff (2005). The review, covering more than 200 publications and reports, concludes that effects of WBM cuttings piles on bottom living biological communities are caused mainly by burial and low sediment oxygen concentrations resulting from organic enrichment. Toxic effects, when they occur, are probably caused by sulphide and ammonia by-products of organic enrichment (DECC, 2011).

Further evidence of recovery of seabed communities following drilling can be seen from the research work undertaken by AUMS (1987). A benthic environmental survey was undertaken in 1987 at three single well sites in the central North Sea (at depths of 102, 120 and 130 m respectively). The wells had been drilled five years prior to the survey using a WBM and a total of approximately 800 tonnes of cuttings had been deposited on the seabed at each location. The results of the survey indicated that, with the exception of a slightly elevated barium concentration, levels of sediment metals and hydrocarbons were similar to background concentrations. The analysis of the benthic fauna indicated that, even at sites closest to the wellheads, full recovery of the impacted sediments had taken place. These well sites were revisited by Oil and Gas UK (formerly UKOOA) in 2005 with analysis of the sediment samples showing that the area had recovered to be consistent with background conditions (Hartley Anderson Ltd, 2005).

In addition, field studies in the United States of America have shown that recovery of benthic communities impacted with water based drilling discharges is likely to be very rapid (i.e. within a few months) (Neff et al., 1989).

The habitats and species present across the proposed Abbey & Baker development are typical of the SNS region. Annelid species dominated the infaunal community accounting for 42.6 % of the total individuals. These species were followed by arthropods, molluscs, and echinoderms (refer to Section 4.3.2).

The habitat assessment results within the vicinity of the Abbey drill centre highlighted the presence of the habitat type '*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment' (MC4214) in the north and central region of the Abbey site survey area (Refer to Section 4.3.2).

Smothering by 30 cm of sediment is likely to prevent feeding, and hence growth and reproduction, as well as respiration in the bryozoans. In addition, associated sediment abrasion may remove the bryozoan colonies. A layer of sediment will probably also interfere with larval settlement (Tyler-Walters, 2005). However, *Flustra foliacea* dominated communities were subject to sediment transport (mainly sand) and periodic, temporary, burial (ca <5 cm) in a tide-swept region of the central English Channel (Holme & Wilson, 1985). Therefore, the MarLIN Sensitivity Assessment indicates a High resilience (full recovery within 2 years) and Low sensitivity to heavy smothering and siltation rate changes (i.e. cement, cuttings deposit pile formation)(Readman and Watson, 2024).

As noted in Section 7.3.1, although isolated patches of *Sabellaria spinulosa* were recorded across the Abbey & Baker Development area, the available information from camera ground-truthing data indicates that these *Sabellaria* aggregations do not constitute Annex I reef habitat.

There was no evidence to indicate the presence of Annex I 'Stony Reef' habitats within the vicinity of the Baker well location, Abbey to York pipeline route or Baker to Abbey pipeline route. The Abbey drill centre is, however, situated in an area identified as having the potential for Annex I 'stony reef' habitats. Research has shown that stony reefs have a limited tolerance to direct physical pressures, with recovery not expected for an extended period. However, the drill site underwent a move 70 m northeast to aim to reduce the likeliness that cuttings are deposited on potential reef sites. The drill site is now located approximately 130 m northeast from the closest area of 'low reef' (see Figure 7.3). As discussed in Section 7.2.3, it is likely that the high exposure thickness of WBM cuttings discharged from the drilling rig at the Abbey A1 and A3 wells (>11.11 mm) will be distributed within an area out to a maximum distance of ca. 120 m from the release locations. The remainder of the WBM cuttings particles at a low exposure thickness (>1.11 mm) will travel up to around 410 m from the release

location, but are likely to be so widely spread that they are unlikely to be detectable against background sediments.

One adult (shell size >5 cm) specimen of *A. islandica*, an OSPAR Threatened and/or Declining species, was recovered along the Abbey to York pipeline route, approximately 7.2 km southwest from the proposed Abbey drill centre; two specimens (one adult and one juvenile) specimens were recovered from within the vicinity of the Baker development well; and no adult (>5cm shell size) living specimens of *A. islandica* were recovered from within the vicinity of the Abbey drill centre or along the Baker to Abbey pipeline route. No evidence of *A. islandica*'s distinct siphons was seen on any of the video footage or still photographs within the Abbey drill centre, along the Abbey to York pipeline route or along the Baker to Abbey pipeline route. However, within the Baker site survey area one individual was observed atop the seabed, with a single siphon also observed. Juvenile specimens (<5 cm) of live *A. islandica* were recorded within the Abbey site survey area at four stations, within the Baker site survey area at two stations and along the Baker to Abbey pipeline at eight stations (refer to Section 4.3.2).

Ocean quahog burrow into the sediment, they use a short inhalant siphon which sits above the sediment surface for feeding and respiration (Taylor, 1976). Powilliet et al. (2006) found that in laboratory conditions, although *A. islandica* took many days to reach the surface of the sediment in a heavy siltation scenario, no mortality occurred. In addition, in field conditions, it was able to reach the surface of sediment and no effect on its growth or population structure was evident (Powilliet et al., 2009). The MarLIN indicates high resilience (full recovery within 2 years) to both low and high rates of siltation and therefore low sensitivity to the pressure (Tyler-Walters & Sabatini, 2017).

In summary, the sensitivity of seabed communities, including ocean quahog, to the discharge of drill cuttings, muds and cement from the Abbey & Baker development wells is generally considered to be **Low**. Some of the receptors are of national importance and are of High value, but for the majority of species the overall resistance and resilience is Very High as recoverability of benthic communities is expected in the short term. The magnitude of impact is predicted to be **Minor;** there will only be a temporary change to the baseline conditions, predicted to occur in the short to medium term, with any impacts (high threshold exposure) occurring limited to a small area, ca. 0.03 km^2 surrounding the proposed Abbey A1 and A3 wells, and ca. 0.04 km^2 the proposed Baker development well . Effects on seabed communities from the discharge of drill cuttings, muds and cement are therefore assessed as **Minor** and not significant.

Fish

As discussed in Section 4.3.3, a number of fish species are known to use the waters in the vicinity of the Abbey & Baker development location, and some use the area as a spawning and / or nursery ground. Exposure to increased turbidity caused by the proposed operations may reduce the visual acuity of fish utilising the area potentially affecting foraging behaviour. Fish may also be temporarily displaced from their spawning and nursery areas due to the settlement of drill cuttings and muds on the seabed. However, given the localised area of impact and the mobile nature of the species, any displaced fish are likely to find foraging opportunities, as well as suitable spawning and nursey areas in adjacent locations.

It should be noted that benthic spawners, such as sandeels and herring are particularly vulnerable to seabed disturbance, with egg development and hatching success vulnerable to the effects of smothering (DTI, 2001). A number of studies have been conducted on the effects of sedimentation on fish egg development of commercially valuable fish species, particularly in relation to dredging operations. Results are variable with some demonstrating mortality of fish eggs when smothered by even a thin veneer of sediment (DOER, 2000) and other studies showing no significant effects on fish egg and larval development and mortality (Auld and Schubel, 1978; Kiørboe *et al*., 1981). However, those potential spawning grounds identified within the vicinity of the Abbey & Baker development are part of wider spawning grounds around the Southern North Sea and this area is not considered to be a critical habitat for these species.

As discussed in Section 4.3.3, sandeels and spawning grounds may be present as the proposed Abbey & Baker Development contains habitat that is moderately suitable for sandeels, with Langton *et al*. (2021) predicting a low to medium density of sandeels in this region. The sandeels spawning ground assessments undertaken for the proposed Abbey & Baker Development indicated areas of low to

moderate potential ('Unsuitable', 'Suitable', 'Preferred' or 'Sub-prime') for the area to be used as a sandeel spawning ground (refer to Section 4.3.3).

However, the herring spawning ground assessment undertaken for the proposed Abbey & Baker Development did not indicate high potential (i.e. 'Prime' or 'Preferred' classification) for the area to be used as a herring spawning ground. This excludes one station located ca. 823 m to the west of the proposed Baker development well in the Abbey & Baker development, which is classed as 'Prime'.

In summary, the sensitivity of spawning fish to the discharge of drill cuttings, muds and cement as a result of the Abbey & Baker development is considered to be **Low** as the species present are typical of the wider area. The receptors are of national importance and are of High value, and the overall resistance and resilience is Very High as recoverability is expected in the short term. The magnitude of impact is predicted to be **Negligible** with immeasurable changes in the baseline environment. Effects on spawning fish from the discharge of drill cuttings, muds and cement are therefore assessed as **Negligible** and not significant.

7.3.4 Installation of Subsea Infrastructure and Protection Material

The installation of the proposed Abbey to York and Baker to Abbey pipelines and umbilicals and Abbey & Baker subsea infrastructure, together with the associated rock protection and concrete mattresses, has the potential to result in a worst case temporary direct impact on the seabed over an estimated area of 0.293 km^2; and a worst case long term direct impact on the seabed over an estimated area of 0.0399 km^2 (see Section 7.2.6).

Water Quality

There is a potential that the installation of the subsea infrastructure required for the proposed Abbey & Baker Development could result in a reduction of water quality. This could arise from the resuspension of sediment during the installation of the subsea infrastructure at the Abbey, Baker and York locations, and the installation of the production pipelines and umbilicals leading to increased turbidity and a higher concentration of contaminated sediments in the water column. The greatest amount of sediment resuspension will take place during the pipeline and umbilical trench and burial operations.

Suspended sediment is not expected to persist within the water column beyond a day following the completion of subsea infrastructure installation activities (Dale et al., 2011; Black and Parry, 1999). It is worth noting that during installation of the pipelines and umbilicals, increased suspended sediment in the water column is unlikely to occur across the full length of the pipeline and umbilical trenches (ca. 8 km for Abbey to York and ca. 4 km for Baker to Abbey) during a 24 hour period. These operations will take place over several days focussing on smaller segments of the route each day (refer to Section 3.4.6).

In addition, at stations within the vicinity of and along the proposed pipeline and umbilical routes (A_PL_01 to A_PL_07 and ES1 to ES18), ERM values were not exceeded for any heavy metals. Therefore, heavy metal concentrations will not be elevated to point of affecting the water quality when the sediment becomes suspended (See Section 4.2.2). The heavy metal concentrations along the pipeline and umbilical routes and within the vicinity of the pipeline route were also similar to background levels (See Section 4.2.2). In summary, the resuspension of sediments arising from the installation of subsea infrastructure is unlikely to result in high turbidity for a prolonged period or a significant concentration of contaminants entering the water column.

The sensitivity of water quality to the increase turbidity as a result of the Abbey & Baker Development is considered to be **Low**. The receptor has a Low value; as only the water column in relatively close proximity to the installation operations will be impacted, hence it is considered to be of local importance; but the overall resistance and resilience is Very High as recoverability is expected in the short term. The magnitude of impact is predicted to be **Negligible** with immeasurable changes in the baseline environment pertaining to water quality. Effects on water quality from the installation of subsea infrastructure are therefore assessed as **Negligible** and not significant.

Seabed Sediments

Temporary Impact

There will be temporary disturbance arising from the trenching and backfill operations during the installation of the pipelines and umbilicals, use of temporary initiations anchors and wires, and the installation of subsea infrastructure at Abbey, Baker and York estimated to amount to approximately 0.293 km^2 (see Section 7.2.6).

It is likely that a proportion of the sediments displaced for the purpose of pipeline laying and burial will become suspended in the bottom few metres of the water column. Within the vicinity of the proposed seabed infrastructure, the sediments are relatively coarse (gravelly and sandy) in nature which means that plumes or re-suspended sediment will tend to re-settle quickly and will not be prolonged or affect large areas. The trench and burial operations may also result in the temporary formation of mounds either side of the pipelines and umbilicals during the trenching phase which will be replaced during the burial phase.

Furthermore, the operations to install the subsea infrastructure at Abbey, Baker and York and the use of the temporary initiation anchors and wires will physically disturb the sediment. However, as discussed in Section 7.3.1, it is likely that any seabed scarring will persist only in the short to medium term and given the sandy and gravelly sediment type and at Abbey & Baker, alongside the development being located within a highly dynamic area with strong near-seabed currents, the likelihood of mounds forming is very low.

In summary, sensitivity of seabed sediments to the temporary seabed disturbance as a result of the Abbey & Baker subsea infrastructure installation is therefore considered to be **Low**. The receptor is of local importance for sediment type, classed as Low value, and the overall resistance and resilience is High as seabed currents and coarse nature of the sediment means that plumes or re-suspended sediment will tend to re-settle quickly and will not be prolonged or affect large areas. The magnitude of impact is predicted to be **Minor** given the small worst case area for temporary seabed disturbance (0.293 km^2) which will be impacted compared to the available sandy sediment habitat type in the wider SNS, and the temporary nature of any impacts. Effects on seabed sediments from the temporary seabed disturbance as a result of the Abbey & Baker subsea infrastructure installation are therefore assessed as **Minor** and not significant.

Long Term Impact

Installation of the subsea infrastructure will result in the loss of sandy and gravelly sediment habitat from the area, and the introduction of novel hard substrata. This will mostly comprise of rock protection berms over the pipelines and umbilicals, concrete mattresses, grout bags, and the subsea infrastructure items. In the worst case (including the SSIV), the total area of long-term sandy sediment habitat loss is estimated to amount to approximately 0.0399 km^2 for the life of the Abbey & Baker development (ca. 11 years) and beyond depending on how the infrastructure is decommissioned. This area is small in comparison to the area of similar habitat available across the wider area.

In summary, the sensitivity of seabed sediments to the long term disturbance from the installation of subsea infrastructure, rock protection, concrete mattresses and grout bags as a result of the Abbey & Baker development is considered to be **Medium** in the vicinity of the proposed Abbey & Baker development. The receptor is of local importance for sediment type, classed as Low value, but the overall resistance and resilience is Medium, as there will be a permanent change to the habitat type, which will last for as long as the subsea infrastructure, rock protection, concrete mattresses and grout bags remain in place. The magnitude of impact, however, is considered to be **Negligible** given the small worst case area (0.0399 km^2) which will be impacted compared to the available sandy and gravelly sediment habitat type in the wider SNS. Effects on seabed sediments from the subsea infrastructure installation activities are therefore assessed as **Negligible** and not significant, particularly as the impacted sediment is characteristic of the wider area.

Seabed Communities

Temporary Impact

The installation of the pipelines and umbilicals, installation of subsea infrastructure, and the use of temporary initiation anchors and wires will also result in sediment suspension and re-settlement outside of their direct footprint. Exposure to higher than normal loads of suspended sediments have the potential for negative impacts on habitats and species in the surrounding area. The re-settlement of sediments may result in the smothering of epifaunal species (Gubbay, 2003) with the degree of impact related to their ability to clear particles from their feeding and respiratory surfaces (Rogers, 1990). However, Defra (2010) states that impacts arising from sediment re-suspension are short-term (generally over a period of a few days to a few weeks). In addition, infaunal communities are naturally habituated to sediment transport processes and are therefore less susceptible to the direct impact of temporarily increased sedimentation rates. Depending on the sedimentation rates, infaunal species and communities can also work their way back to the seabed surface through blanket smothering (Neal and Avant, 2008).

Within the vicinity of the proposed Abbey & Baker Development, the sediments are relatively coarse (sandy and gravelly) in nature which means that plumes or re-suspended sediment will tend to re-settle quickly and will not be prolonged or affect large areas. Where sediment re-suspension does occur, the majority of species present, particularly the infaunal communities, are expected to recover in the short term (Defra, 2010). Furthermore, large scale field experiments by Dernie *et al*. (2003) investigated the response to physical disturbance of marine benthic communities within a variety of sediment types (clean sand, silty sand, muddy sand and mud). Of the four sediment types investigated, the communities from clean sands (such as those prevalent in the Abbey & Baker development area) had the most rapid recovery rate following disturbance and mud the slowest.

The habitats and species present across the proposed Abbey & Baker development are typical of the SNS region (refer to Section 7.3.3). In addition, the habitat assessment results for the Abbey & Baker Development highlighted the presence of the EUNIS biotope complex 'Offshore Circalittoral Sand' (MD52 / SS.SSa.OSa) within the Abbey site survey area, and the presence of 'Offshore Circalittoral Coarse Sediment' (MD32 / SS.SCS.OCS) through the Abbey & Baker Development (Refer to Section 4.3.2). Both of these habitat types are encompassed within the UK BAP 'Offshore subtidal sands and gravels' (BRIG, 2011).

The particle structure of these habitats ranges from mainly sand, through various combinations of sand and gravel, to mainly gravel. While very large areas of seabed are covered by sand and gravel in various mixes, much of this area is covered by only very thin deposits over bedrock, glacial drift or mud. The strength of tidal currents and exposure to wave action are important determinants of the topography and stability of sand and gravel habitats. The diversity of flora and fauna living within these biotopes varies according to the level of environmental stress to which they are exposed (BRIG, 2011). Due to the dynamic environment within which the Abbey & Baker Development is located, recovery of this habitat is expected in the short to medium term.

The habitat assessment results for the Abbey & Baker Development highlighted the presence of the habitat type '*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment' (MC4214) in the at the proposed Abbey drill centre (Refer to Section 4.3.2).

Smothering by 30 cm of sediment is likely to prevent feeding, and hence growth and reproduction, as well as respiration in the bryozoans. In addition, associated sediment abrasion may remove the bryozoan colonies. A layer of sediment will probably also interfere with larval settlement (Tyler-Walters, 2005). However, *Flustra foliacea* dominated communities were subject to sediment transport (mainly sand) and periodic, temporary, burial (ca <5 cm) in a tide-swept region of the central English Channel (Holme & Wilson, 1985). Therefore, the MarLIN Sensitivity Assessment indicates a High resilience (full recovery within 2 years) and Low sensitivity to heavy smothering and siltation rate changes (i.e. sedimentation arising from installation of the Abbey & Baker Development infrastructure); and a Medium resilience (full recovery within 2 – 10 years) and Medium sensitivity to the disturbance of both the surface and subsurface of the substratum (i.e. trench and burial, deposition of infrastructure) (Readman and Watson, 2024).

The Abbey & Baker Development is situated in an area identified as having the potential for Annex I 'stony reef' habitats. Stony reefs have a limited tolerance to direct physical impact, with recovery not expected for an extended period. There was no evidence to indicate the presence of Annex I 'Stony Reef' habitats within the vicinity of the Baker well location, Abbey to York pipeline route or Baker to

Abbey pipeline route. The Abbey drill centre is, however, situated in an area identified as having the potential for Annex I 'stony reef' habitats. Research has shown that stony reefs have a limited tolerance to direct physical pressures, with recovery not expected for an extended period. However, the drill site underwent a move 70 m northeast to aim to reduce the likeliness that the installation of subsea infrastructure at Abbey, the installation of the pipelines and umbilicals, or the installation of any protection materials (rock, concrete mattresses, grout bags) will significantly impact the stony reef habitat (see Figure 7.3).

As mentioned in Section 7.3.3, ocean quahog (*A. islandica*) has been recorded to be present within the Abbey & Baker Development area. The ocean quahog is highly sensitive to physical pressures such as surface abrasion and subsurface disturbance, but not sediment deposition as discussed in Sections 7.3.1, 7.3.2 and 7.3.3. Therefore, while the installation of the Abbey & Baker development subsea infrastructure has the potential to cause direct mortality; any sedimentation arising from the installation of the infrastructure is unlikely to affect *A. islandica*.

In summary, the sensitivity of seabed communities to the temporary seabed disturbance as a result of the installation of the Abbey & Baker Development infrastructure is generally considered to be **Low**. Some of the receptors are of national importance and are of High value, but for the majority of species the overall resistance and resilience is Very High as recoverability of benthic communities is expected in the short term. Ocean quahog and the habitat MC4214 are the exception to this, being of **Very High** sensitivity, as they have a Low resistance and resilience to sub-surface abrasion. The magnitude of impact is predicted to be **Minor;** there will only be a temporary change to the baseline conditions, predicted to occur in the short to medium term, with any changes occurring being limited to a small area (ca. 0.284 km^2) in the worst case. Effects on seabed communities from the temporary seabed disturbance as a result of the installation of the Abbey & Baker Development infrastructure are therefore assessed as **Minor** and not significant.

Long Term Impact

The seabed beneath the subsea infrastructure and protection material will be compacted. The sessile epifauna, and a proportion of the infauna (animals that burrow into the sediment or form tubes within it) such as polychaete worms in the direct footprint area of the Abbey development field infrastructure will be lost from compression and abrasion. However, the consequences for most species in context to the wider region are expected to be short-lived as most of the smaller sedentary species (such as polychaete worms) have short lifecycles and high reproductive rates (Tillin and Tyler-Walters, 2014). Annelid species dominated the infaunal community within the Abbey & Baker Development accounting for 42.6 % of the total individuals. These species were followed by arthropods, molluscs, and echinoderms (refer to Section 4.3.2).

The physical presence of the subsea structures, the rock protection over the pipeline and umbilical, as well as the mattresses at the tie-in locations, will introduce a new stable hard substrata to the area and over time a new rocky substrate habitat will become established. Seabed animals within the direct footprint of the protective rock material will be damaged, displaced or smothered resulting in the mortality and loss of individuals of species but the material itself could, over time, function as reef habitat providing additional attachment sites for the indigenous sessile communities, such as bryozoans or sponges, as well as refugia for mobile epibenthos such as Paguroidea or fish. Pidduck et al. (2017) highlight that rock dump material has the potential to act as an artificial reef supporting reef communities. The rate of colonisation of the rock protection material, if used, will be dependent on recruitment rates from local reproducing populations. Ultimately this new seabed feature is expected to be colonised by the same types of mobile and encrusting epifaunal animals already present on cobbles and boulders in the wider SNS area.

On the whole, epifaunal coverage was low across the Abbey & Baker Development area and was generally limited to encrusting species such as Cnidaria, Porifera, Entoprocta, Bryozoa and Chordata, in total 11.3 % of all the taxa identified were considered to be colonial epifaunal species (refer to Section 4.3.2). Therefore, it is possible that the introduction of a stable hard substrata in the area could encourage colonisation by similar species. Colonisation of steel structures on the seabed will be slowed by any protective wraps or antifouling applied, whereas colonisation of introduced rock deposits will be relatively uninhibited.

The habitat assessment results for the Abbey & Baker Development highlighted the presence of the EUNIS biotope complex 'Offshore Circalittoral Sand' (MD52 / SS.SSa.OSa) within the Abbey site survey area, and the presence of 'Offshore Circalittoral Coarse Sediment' (MD32 / SS.SCS.OCS) through the Abbey & Baker Development (Refer to Section 4.3.2). Both of these habitat types are encompassed within the UK BAP 'Offshore subtidal sands and gravels' (BRIG, 2011).

The particle structure of these habitats ranges from mainly sand, through various combinations of sand and gravel, to mainly gravel. While very large areas of seabed are covered by sand and gravel in various mixes, much of this area is covered by only very thin deposits over bedrock, glacial drift or mud. The strength of tidal currents and exposure to wave action are important determinants of the topography and stability of sand and gravel habitats. A physical loss of this habitat type (i.e. installation of subsea infrastructure) would significantly alter the character of the biotope. The MarLIN Sensitivity Assessment indicates a High sensitivity to a physical loss of the habitat type as all habitat types are considered to have No resistance to this pressure and recovery is Very low for the duration that the subsea infrastructure is in place.

The habitat assessment results for Abbey highlighted the presence of the habitat type '*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment' (MC4214) in the vicinity of the Abbey drill centre (Refer to Section 4.3.2).

This habitat type is characterized by the hard substratum provided by the pebbles and cobbles to which the key characterizing species can firmly attach to (Connor et al., 2004). A physical loss of this habitat type (i.e. installation of subsea infrastructure) would significantly alter the character of the biotope. The MarLIN Sensitivity Assessment indicated a High sensitivity to a physical loss of the habitat type as the biotope is considered to have No resistance to this pressure and recovery is Very low for the duration that the subsea infrastructure is in place.

As noted in Section 7.3.1, 7.3.2 and 7.3.3, although isolated patches of *Sabellaria spinulosa* were recorded across the Abbey & Baker Development area, the available information from camera ground-truthing data indicates that these *Sabellaria* aggregations do not constitute Annex I reef habitat.

There was no evidence to indicate the presence of Annex I 'Stony Reef' habitats within the vicinity of the Baker well location, Abbey to York pipeline route or Baker to Abbey pipeline route. The Abbey drill centre is, however, situated in an area identified as having the potential for Annex I 'stony reef' habitats. Stony reefs have a limited tolerance to direct physical impact, with recovery not expected for an extended period. To minimise disturbance to the 'Low Reef' areas within the vicinity of the drill centre; the drill centre, where the Abbey subsea infrastructure will be located, underwent a move 70 m northeast (See Figure 7.3).

As aforementioned, ocean quahog (*A. islandica*) has been recorded to be present within the Abbey & Baker Development area. The introduction of a new stable hard substrata to the area will cause a direct reduction in suitable seabed habitat that could support ocean quahog, with Tillin *et al*. (2010) reporting the species as having a high sensitivity to physical change to another seabed habitat type.

Overall, the introduction of novel hard substrata by the Abbey & Baker development is very small and localised (confined to an area of ca. 0.0399 km^2 in the worst case) and, whilst it will represent a change to the benthic environment locally it is not expected to cause any widespread changes to the marine life present in the area.

In summary, the sensitivity of seabed communities to long term impacts from the installation of seabed infrastructure and protection material as a result of the Abbey & Baker development is considered to be **Very High**. The habitats and species present are typical of this area (note, the impact to the Holderness Offshore MCZ is discussed separately below), classed as being of national importance and of High value, and the overall resistance and resilience is Low as there will be a permanent change to the habitat type. However, the magnitude of impact is predicted to be **Minor** as although the impact will last for the duration of the Abbey & Baker development, only a small area (0.0399 km^2) will be impacted in the worst case. Effects on seabed communities from installation of seabed infrastructure and protection material are therefore assessed as **Minor** and not significant, given that any change to the benthic environment will be local and is not expected to cause any widespread changes to the marine life present in the area.

Fish

Temporary Impact

Increased turbidity caused by seabed disturbance from the installation of subsea infrastructure at the Abbey, Baker and York locations, the installation of the pipelines and umbilicals, and the use of temporary initiation anchors and wires in the proposed Abbey & Baker Development area may affect foraging behaviour of fish due to reduced visual acuity (Bakke et al., 2013) and could temporarily displace fish from their spawning and nursery areas. However, given the localised area of impact (ca. 0.284 km^2) and the mobile nature of the species, any displaced fish are likely to find foraging opportunities, as well as suitable spawning and nursery areas in adjacent locations.

The spawning grounds within which the Abbey & Baker Development area is located is part of wider spawning grounds within the SNS and, as such, is not considered to be a key habitat for these fish species. As noted above, survey across the Abbey & Baker Development area have found the habitat has low to moderate suitability for sandeel and herring spawning. A number of studies have been conducted on the effects of sedimentation on fish egg development of commercially valuable fish species, particularly in relation to dredging operations. Results are variable with some studies demonstrating mortality of fish eggs when smothered by even a thin veneer of sediment (DOER, 2000), however many studies show no significant effects on fish egg and larval development and mortality (Auld and Schubel, 1978; Kiørboe et al., 1981; DOER, 2000).

In summary, the sensitivity of spawning fish to the temporary seabed disturbance as a result of the installation of the Abbey & Baker Development infrastructure is considered to be **Low** as the species present are typical of the wider area. The receptors are of national importance, with some on the IUCN Red List of Threatened Species and are therefore of High value, but their overall resistance and resilience is Very High as recoverability is expected in the short term. The magnitude of impact is predicted to be **Negligible** with immeasurable changes in the baseline environment. Effects on spawning fish from the temporary seabed disturbance as a result of the installation of the Abbey & Baker Development infrastructure are therefore assessed as **Negligible** and not significant.

Long Term Impact

The physical presence of the Abbey & Baker development subsea infrastructure, rock protection and mattresses on the seabed will provide a new stable hard substrata, resulting in the long term loss of seabed habitat within an area of ca. 0.0399 km^2. However, the spawning grounds within which the Abbey & Baker development area is located are part of wider spawning grounds within the SNS and, as such, is not considered to be a key habitat for these fish species.

As discussed in Section 4.3.3, sandeels and spawning grounds may be present as the proposed Abbey Development contains habitat that is moderately suitable for sandeels, with Langton *et al*. (2021) predicting a low to medium density of sandeels in this region. In addition, the sandeels spawning ground assessments undertaken for the proposed Abbey & Baker Development indicated areas of low to moderate potential ('Unsuitable', 'Suitable', 'Preferred' or 'Sub-prime') for the area to be used as a sandeel spawning ground (refer to Section 4.3.3).

However, the herring spawning ground assessment undertaken for the proposed Abbey & Baker Development did not indicate high potential (i.e. 'Prime' or 'Preferred' classification) for the area to be used as a herring spawning ground. This excludes one station located ca. 823 m to the west of the proposed Baker development well in the Abbey & Baker development, which is classed as 'Prime' (refer to Section 4.3.3).

In summary, the sensitivity of spawning fish to the long term disturbance as a result of the installation of seabed infrastructure and protection material as a result of the Abbey & Baker development is considered to be **Low** as the species present are typical of the wider area. The receptors are of national importance, with some on the IUCN Red List of Threatened Species, and are therefore of High value, but the overall resistance and resilience is Very High as recoverability is expected in the short term. The magnitude of impact is predicted to be **Negligible** with immeasurable changes in the baseline environment due to the very small area affected (ca 0.0399 km^2). Effects on spawning fish from the installation of seabed infrastructure and protection material are therefore assessed as **Negligible** and not significant.

7.3.5 Impacts to the Southern North Sea Special Area of Conservation (SNS SAC)

The proposed Abbey & Baker development is wholly located within the winter area of the SNS SAC, which is designated for the protection of the Annex II species harbour porpoise. The site covers an area of 36,951 km^2 and supports an estimated 17.5 % of the UK North Sea MU population of harbour porpoises. The northern two thirds of the site, covering an area of 27,000 km^2, is recognised as important for harbour porpoises during the summer season (April – September), whilst the southern part, covering an area of 12,687 km^2 as there is some overlap with the northern part, supports persistently higher densities during the winter (October – March) (JNCC, 2023b).

The conservation objectives of the SNS SAC are to ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining FCS for harbour porpoise in UK waters. In the context of natural change, this will be achieved by ensuring that:

- Harbour porpoise is a viable component of the site;
- There is no significant disturbance of the species; and
- The condition of supporting habitats and processes, and the availability of prey is maintained.

Potential Temporary Impacts on the Designated Features of the Southern North Sea SAC

The temporary seabed disturbance from the proposed Abbey & Baker will not significantly impact on the harbour porpoise or other marine mammals and therefore not impact on the conservation objective of the SNS SAC. However, the proposed siting of the Jack-up drilling rig; siting of the accommodation unit at York; deposit of drill cuttings, muds and cement and; installation of subsea infrastructure and protection materials have the potential to impact the designated feature of the SNS SAC by way of impacting prey availability. In the worst case, the total area of temporary seabed disturbance in within the SNS SAC is estimated to amount to ca. 0.697 km^2 (0.0055 % of the winter area; 0.00189 % of the total SAC area). This area is small in comparison to the area of similar habitat within the SNS SAC.

Harbour porpoise are strongly reliant on the availability of prey species (sandeels, herring, mackerel, cod and whiting) due to their high energy demands, and are highly dependent on being able to access prey species year-round. The Abbey & Baker development area is located within the nursery and spawning grounds for a number of prey species (refer to Section 4.3.3), including herring and sandeels which have a dependency on specific substrata for spawning and are therefore considered to be the most vulnerable to seabed disturbance.

As discussed in Section 4.3.3, the proposed Abbey & Baker Development area contains habitat that is moderately suitable for sandeels, with Langton et al. (2021) predicting a low to medium density of sandeels in this region. The sandeels spawning ground assessments undertaken for the proposed Abbey & Baker Development indicated areas of low to moderate potential ('Unsuitable', 'Suitable', 'Preferred' or 'Sub-prime') for the area to be used as a sandeel spawning ground (refer to Section 4.3.3). However, the herring spawning ground assessment undertaken for the proposed Abbey & Baker Development did not indicate high potential (i.e. 'Prime' or 'Preferred' classification) for the area to be used as a herring spawning ground. This excludes one station located ca. 823 m to the west of the Abbey & Baker development, which is classed as 'Prime'.

Although there is an area of temporary disturbance within the Southern North Sea SAC, it is noted in Sections 7.3.1, 7.3.2 and 7.3.3 that any impacts to fish species, including those used by harbour porpoise as prey, will be negligible. This is both due to the relatively small magnitude of impact, and fish species' Very High resistance and resilience to seabed disturbance.

Potential Long Term Impacts on the Designated Features of the Southern North Sea SAC

The long-term seabed disturbance from the proposed Abbey & Baker will not significantly impact on the harbour porpoise or other marine mammals and therefore not impact on the conservation objective of the SNS SAC. However, the proposed installation of subsea infrastructure and protection materials have the potential to impact the designated feature of the SAC by way of impacting prey availability. In the worst case, the total area of long term seabed disturbance in within the Southern North Sea SAC is estimated to amount to ca. 0.0399 km^2 (0.00031 % of the winter area; 0.00011 % of

the total SAC area). This area is small in comparison to the area of similar habitat within the Southern North Sea SAC.

Harbour porpoise are strongly reliant on the availability of prey species (sandeels, herring, mackerel, cod and whiting) due to their high energy demands, and are highly dependent on being able to access prey species year-round. The Abbey & Baker development area is located within the nursery and spawning grounds for a number of prey species (refer to Section 4.3.3), including herring and sandeels which have a dependency on specific substrata for spawning and are therefore considered to be the most vulnerable to seabed disturbance.

As previously mentioned, the proposed Abbey & Baker Development area contains habitat that is moderately suitable for sandeels, with Langton et al. (2021) predicting a low to medium density of sandeels in this region. The sandeels spawning ground assessments undertaken for the proposed Abbey & Baker Development indicated areas of low to moderate potential ('Unsuitable', 'Suitable', 'Preferred' or 'Sub-prime') for the area to be used as a sandeel spawning ground (refer to Section 4.3.3). However, the herring spawning ground assessment undertaken for the proposed Abbey & Baker Development did not indicate high potential (i.e. 'Prime' or 'Preferred' classification) for the area to be used as a herring spawning ground. This excludes one station located ca. 823 m to the west of the Abbey & Baker development, which is classed as 'Prime'.

The physical presence of the Abbey & Baker development subsea infrastructure, rock protection and mattresses on the seabed will provide a new stable hard substrata, resulting in the long term loss of seabed habitat. This has the potential to impact the condition of supporting habitats and processes, and the availability of prey. However, the spawning grounds within which the Abbey & Baker development area is located are part of wider spawning grounds within the SNS and, as such, is not considered to be a key habitat for these fish species.

As noted in Section 7.3.2 and 7.3.4, any impacts to fish species, including those used by harbour porpoise as prey, will be negligible. This is both due to the relatively small magnitude of impact, and fish species' Very High resistance and resilience to seabed disturbance.

In-Combination Effects

The overall area of seabed estimated to be permanently impacted by other projects within the SNS SAC, based on publicly available information (noting that data was not available for all projects), in-combination with the proposed Abbey & Baker Development activities, is summarised in Table 7.7.

Table 7.7: Total Estimated In-combination Permanent Seabed Impacts (Loss of Prey Habitat) within SNS SAC

Project	Area of Seabed Permanently Impacted within the Winter Area of the SAC (km^2)	Area of Seabed Permanently Impacted within the total SAC (km^2)	Distance / Direction from Development
Abbey & Baker Development [1]	0.0399	0.0399	-
Northern Endurance Development [2]	-	0.1683	34 km Northeast
Southwark Pipeline [3]	-	0.007	118 km Southeast
Tyne Pipelines Decommissioning [4]	-	0.00046	85 km Northeast
Seven Seas Wellhead Protection Structure Decommissioning [5]	-	0.000012	58 km Southeast
Kilmar Decommissioning [6]	-	0.019	66 km Northeast
Garrow Decommissioning [7]	-	0.017	48 km Northeast
Leman F & G NUIs Decommissioning [8]	-	0.0016	137 km Southeast
Johnston Decommissioning [9]	-	0.00012	39 km Northeast
Hewett Subsea Installations Decommissioning [10]	0.0012	0.0012	124 km Southeast
LOGGS Area Decommissioning [11]	-	0.0134	81 km East Southeast
Victoria Decommissioning [12]	-	0.0008	128 km East Southeast
Wenlock Decommissioning [13]	-	0.0005	123 km East Southeast
Ensign Decommissioning [14]	-	0.0242	91 km East Southeast
Hunter and Rita Decommissioning [15]	-	0.00044	116 km East Northeast
Hewett Platforms Decommissioning [16]	-	0.0201	124 km Southeast
Dogger Bank South (East and West) Offshore Wind Farm [17]	-	2.05	86 km Northeast
Hornsea Four Offshore Wind Farm [18]	-	3.7	37 km East
East Anglia ONE North Offshore Wind Farm [19]	1.88	1.88	205 km Southeast
East Anglia TWO Offshore Wind Farm [20]	2.02	2.02	208 km Southeast
North Falls Offshore Wind Farm [21]	5.45	5.45	251 km Southeast
Total:	**9.3911**	**15.414**	-
% of SNS SAC Impacted:	**0.074**	**0.042**	-

[1] Installation of rock cover over the pipelines and umbilicals, seabed infrastructure and associated protection materials (refer to Section 7.2.6).

[2] https://assets.publishing.service.gov.uk/media/651eba807309a1000db0a8d7/NS051-EV-REP-000-00021_NEP_Environmental_Statement__1_.pdf
[3] https://assets.publishing.service.gov.uk/media/6082dad7d3bf7f01386b4463/Southwark_Pipeline_ES__1__.pdf
[4] https://assets.publishing.service.gov.uk/media/695cf66e4b69d216c438a0f8/Tyne_Pipelines_EA.pdf
[5] https://assets.publishing.service.gov.uk/media/683dd876a9b2749a8095e08c/Seven_Seas_WHPS_DP.pdf
[6] https://assets.publishing.service.gov.uk/media/681a4885386c17c856f17347/Kilmar_EA.pdf
[7] https://assets.publishing.service.gov.uk/media/67fcffec694d57c6b1cf8ccc/Garrow_EA.pdf
[8] https://assets.publishing.service.gov.uk/media/659fefb73308d2000d1fbe69/Leman_F___G_EA.pdf
[9] https://assets.publishing.service.gov.uk/media/639304ece90e0769c39ee0ce/AB-JO-XGL-LL-SU-RP-0003_B03_-_Johnston_EA.pdf
[10]https://assets.publishing.service.gov.uk/media/6368db0dd3bf7f75567c10d9/EniUK_Hewett_Subsea_Installations_Removal_Environmental_Appraisal_-_Approved.pdf
[11] https://assets.publishing.service.gov.uk/media/6262b6c68fa8f523b6414dac/LDP4_EA.pdf
[12] https://assets.publishing.service.gov.uk/media/626015068fa8f54a8bb65bb8/Victoria_EA.pdf
[13] https://assets.publishing.service.gov.uk/media/6216321fd3bf7f4f0399d088/Wenlock_EA.pdf
[14] https://assets.publishing.service.gov.uk/media/6128a08bd3bf7f63b19ceabf/Ensign_EA_final.pdf
[15] https://assets.publishing.service.gov.uk/media/607ff80fd3bf7f013c8f44c4/AB-HR-XGL-LL-SU-RP-0004_B04_-_Hunter_+_Rita_EA.pdf
[16]https://assets.publishing.service.gov.uk/media/60648a4fd3bf7f0c921dcc46/Environmental_Appraisal_Hewett_Platforms.pdf
[17] https://nsip-documents.planninginspectorate.gov.uk/published-documents/EN010125-000464-7.9%20ES%20Chapter%209%20-%20Benthic%20and%20Intertidal%20Ecology.pdf
[18] https://nsip-documents.planninginspectorate.gov.uk/published-documents/EN010125-000464-7.9%20ES%20Chapter%209%20-%20Benthic%20and%20Intertidal%20Ecology.pdf
[19] https://nsip-documents.planninginspectorate.gov.uk/published-documents/EN010077-001090-6.1.9%20EA1N%20Environmental%20Statement%20Chapter%2009%20Benthic%20Ecology.pdf
[20] https://nsip-documents.planninginspectorate.gov.uk/published-documents/EN010078-001110-6.1.9%20EA2%20Environmental%20Statement%20Chapter%2009%20Benthic%20Ecology.pdf
[21] https://nsip-documents.planninginspectorate.gov.uk/published-documents/EN010119-000450-3.1.12_ES%20Chapter%2010%20Benthic%20and%20Intertidal%20Ecology.pdf

The long-term prey habitat loss resulting from the above listed projects represents a relatively small percentage of the SAC at ca. 0.074 % in the Winter area and 0.042% throughout the total SAC and any impacts relating to the rock substrate (either rock which is introduced to the site or rock decommissioned in situ) are predicted to be highly localised. Of note, for Abbey & Baker, although a small amount of new hard substrate may be introduced into the SNS SAC with the placement of subsea infrastructure and if protection / stabilisation material is required; based on the small area of seabed that will be impacted (0.0399 km^2), in comparison to the overall SAC area (36,951 km^2) and overall winter area within the SAC (12,687 km^2), no likely significant effects are predicted as a result of the proposed activities either alone or in-combination with other plans or projects.

In contrast, any temporary disturbance to the seabed within the SAC from the above listed projects is expected to recover within the short to medium term as the SNS area is characterised by a shallow bathymetry with relatively fast water circulation. In addition, given the limited scale and duration of the disturbance, it is not anticipated to significantly impact the site's conservation objectives surrounding harbour porpoises or their prey species.

Given the above, it is therefore considered that in-combination impacts will not have a likely significant effect on the qualifying features of the SNS SAC.

7.3.6 Impacts to the Holderness Offshore Marine Conservation Zone

The proposed Abbey & Baker Development, more specifically, approximately 4.8 km of the Abbey to York pipeline corridor route, and the York platform are located within the Holderness Offshore MCZ. The site is located 11 km offshore and covers an area of 1,176 km^2. The MCZ is designated for the following five features (JNCC, 2024):

- Subtidal coarse sediment;
- Subtidal sand;
- Subtidal mixed sediments;
- Ocean quahog (*Arctica islandica*);

- North Sea glacial tunnel valleys (inner Silver Pit)

The Conservation Objective for the Holderness Offshore MCZ is that the protected features:

- So far as already in favourable condition, remain in such condition; and
- So far as not already in favourable condition, be brought into such condition, and remain in such condition.

Table 7.8 lists the conservation objectives with respect to each designated protected feature of the Holderness Offshore MCZ. As of March 2021, only the North Sea glacial tunnel valleys (inner Silver Pit) are in favourable condition. All other features for which the site has been designated, are to be brought into favourable condition (JNCC, 2021b).

Table 7.8: Conservation Objectives of the Designated Features of the Holderness Offshore MCZ (JNCC, 2021a)

Designated Feature	Conservation Objective
Subtidal coarse sediment	• Extent is stable or increasing; and • Structures and functions, its quality, and the composition of its biological communities (which includes a reference to the diversity and abundance of species forming part of or inhabiting that habitat) are such as to ensure that it remains in a condition which is healthy and not deteriorating Any temporary deterioration in condition is to be disregarded if the habitat is sufficiently healthy and resilient to enable its recovery. Any alteration to that feature brought about entirely by natural processes is to be disregarded.
Subtidal sand	
Subtidal mixed sediments	
Ocean quahog (*Arctica islandica*)	The quality and quantity of its habitat and the composition of its population in terms of number, age and sex ratio are such as to ensure that the population is maintained in numbers which enable it to thrive. Any temporary reduction of numbers is to be disregarded if the population is sufficiently thriving and resilient to enable its recovery. Any alteration to that feature brought about entirely by natural processes is to be disregarded.
North Sea glacial tunnels valleys	• Extent, component elements and integrity are maintained; • Structure and functioning are unimpaired; and • Surface remains sufficiently unobscured for the purposes of determining whether the conditions in the points above are satisfied. Any obscurement of that feature brought about entirely by natural processes is to be disregarded. Any alteration to that feature brought about entirely by natural processes is to be disregarded.

Potential Temporary Impacts on the Designated Features of the Holderness Offshore MCZ

The proposed installation of the Abbey to York pipeline and umbilical (trench and burial); installation of the protection / stabilisation materials at York; and the siting of the accommodation unit at York have the potential to impact the designated features of the MCZ. In the worst case, the total area of temporary seabed disturbance within the Holderness Offshore MCZ is estimated to amount to

approximately 0.1192 km^2 (0.01 % of the total area of the MCZ). This area is small in comparison to the area of similar habitat available within the Holderness Offshore MCZ.

Subtidal coarse sediment, Subtidal sand and Subtidal mixed sediments

The habitat assessment results for the Abbey & Baker Development highlighted the presence of the EUNIS biotope complexes 'Offshore Circalittoral Sand' (MD52 / SS.SSa.OSa) and 'Offshore Circalittoral Coarse Sediment' (MD32 / SS.SCS.OCS) within the Abbey to York pipeline route corridor which is located within the Holderness Offshore MCZ (Refer to Section 4.3.2). All of these habitat types are encompassed within the UK BAP 'Offshore subtidal sands and gravels' and make up two of the three protected habitat types within the Holderness Offshore MCZ (subtidal sand and subtidal coarse sediment) (BRIG, 2011; JNCC, 2024).

The particle structure of these habitats ranges from mainly sand, through various combinations of sand and gravel, to mainly gravel. While very large areas of seabed are covered by sand and gravel in various mixes, much of this area is covered by only very thin deposits over bedrock, glacial drift or mud. The strength of tidal currents and exposure to wave action are important determinants of the topography and stability of sand and gravel habitats. The diversity of flora and fauna living within these biotopes varies according to the level of environmental stress to which they are exposed (BRIG, 2011). Due to the dynamic environment within which the Abbey & Baker Development is located, recovery of this habitat is expected in the short to medium term. In addition, the temporary disturbance within the MCZ is limited in scale, amounting to approximately 0.1192 km^2 (0.01% of the MCZ) and therefore will not significantly impact the conservation objectives set for this feature (refer to Table 7.8).

Ocean Quahog (*A. islandica*)

As mentioned in Section 7.3.2 and 7.3.4, ocean quahog (*A. islandica*) has been recorded to be present within the Abbey & Baker Development area. The ocean quahog is highly sensitive to physical pressures such as surface abrasion and subsurface disturbance, but not sediment deposition as discussed in Sections 7.3.1, 7.3.2, 7.3.3 and 7.3.4. Therefore, the installation of the Abbey & Baker development subsea infrastructure has the potential to cause direct mortality to ocean quahog; any sedimentation arising from the installation of the infrastructure is unlikely to affect *A. islandica*. However, the temporary disturbance within the MCZ is limited scale, amounting to approximately 0.1192 km^2 (0.01 % of the MCZ) and therefore is unlikely to significantly impact the conservation objectives set for this feature (refer to Table 7.8).

North Sea Glacial Tunnel Valleys

The Abbey & Baker Development is not located in proximity to the North Sea glacial tunnel valley (Inner Silver Pit) protected by the MCZ (the feature lies approximately 30 km southeast of the proposed development), so is unlikely to have an effect on the feature or significantly impact the conservation objectives associated with this feature (refer to Table 7.8).

Potential Long Term Impacts on the Designated Features of the Holderness Offshore MCZ

Installation of the Abbey to York pipeline and umbilical rock protection / stabilisation material and protection materials at York will result in the loss of sandy and mixed sediment habitat from the area, and the introduction of novel hard substrata. In the worst case, the total area of long-term sandy and mixed sediment habitat loss within the Holderness Offshore MCZ is estimated to amount to approximately 0.0089 km^2 (0.00076 % of the total MCZ area) for the life of the Abbey & Baker Development (ca. 11 years) and beyond depending on how the infrastructure is decommissioned. This area is small in comparison to the area of similar habitat available within the Holderness Offshore MCZ.

Subtidal coarse sediment, Subtidal sand and Subtidal mixed sediments

The habitat assessment results for the Abbey & Baker Development highlighted the presence of the EUNIS biotope complexes 'Offshore Circalittoral Sand' (MD52 / SS.SSa.OSa) and 'Offshore Circalittoral Coarse Sediment' (MD32 / SS.SCS.OCS) within the Abbey to York pipeline route corridor which is located within the Holderness Offshore MCZ (Refer to Section 4.3.2). All of these habitat types are encompassed within the UK BAP 'Offshore subtidal sands and gravels' and make up two of the three protected habitat types within the Holderness Offshore MCZ (subtidal sand and subtidal coarse sediment) (BRIG, 2011; JNCC, 2024).

The particle structure of these habitats ranges from mainly sand, through various combinations of sand and gravel, to mainly gravel. While very large areas of seabed are covered by sand and gravel in various mixes, much of this area is covered by only very thin deposits over bedrock, glacial drift or mud. The strength of tidal currents and exposure to wave action are important determinants of the topography and stability of sand and gravel habitats. A physical loss of this habitat type (i.e. installation of subsea infrastructure) would significantly alter the character of the biotope. The MarLIN Sensitivity Assessment indicates a High sensitivity to a physical loss of the habitat type as all habitat types are considered to have No resistance to this pressure and recovery is Very low for the duration that the subsea infrastructure is in place. However, the long term disturbance within the MCZ is very limited in scale, amounting to approximately 0.0089 km^2 (0.00076 % of the MCZ) and therefore is not significantly impact the conservation objectives set for this feature (refer to Table 7.8).

Ocean Quahog (*A. islandica*)

As aforementioned, ocean quahog (*A. islandica*) has been recorded to be present within the Abbey & Baker Development area. The introduction of a new stable hard substrata to the area will cause a direct reduction in suitable seabed habitat that could support ocean quahog, with Tillin et al. (2010) reporting the species as having a high sensitivity to physical change to another seabed habitat type. However, the long term disturbance within the MCZ is very limited in scale, amounting to approximately 0.0089 km^2 (0.00076 % of the MCZ) and therefore is not significantly impact the conservation objectives set for this feature (refer to Table 7.8).

North Sea Glacial Tunnel Valleys

The Abbey & Baker Development is not located in proximity to the North Sea glacial tunnel valley (Inner Silver Pit) protected by the MCZ (the feature lies approximately 30 km southeast of the proposed development), so is unlikely to have an effect on the feature or significantly impact the conservation objectives associated with this feature (refer to Table 7.8).

Any long term disturbance caused by the proposed Abbey & Baker Development will result in a very small, permanent reduction in protected habitat type (0.00076 % of the Holderness Offshore MCZ). As mentioned above, this will not result in a significant impact to achieving the site's conservation objectives (refer to Table 7.8). Any other impacts are deemed temporary and of a small scale (0.01 % of the Holderness Offshore MCZ).

In-Combination Effects

The overall area of seabed estimated to be permanently impacted by other projects within the Holderness Offshore MCZ, based on publicly available information (noting that data was not available for all projects), in-combination with the proposed Abbey & Baker Development activities, is summarised in Table 7.9.

Table 7.9: Total Estimated In-combination Permanent Seabed Impacts within Holderness Offshore MCZ

Project	Area of Seabed Permanently Impacted within the MCZ (km^2)	Distance to Development
Abbey & Baker Development	0.0089	-
Northern Endurance Development [2]	0.009912	34 km Northeast
Total:	**0.019**	-
% of SNS SAC Impacted:	**0.0016**	-

[1] Installation of rock cover over the pipelines and umbilicals, installation of SSIV (included as a contingency) and protection materials at the York platform (refer to Section 7.2.6 and 3.4.4).
[2] https://assets.publishing.service.gov.uk/media/651eba807309a1000db0a8d7/NS051-EV-REP-000-00021_NEP_Environmental_Statement__1_.pdf

The long-term habitat loss resulting from the above listed projects represents a relatively small percentage of the MCZ at ca. 0.0016 % and any impacts relating to the rock substrate (either rock which is introduced to the site or rock decommissioned in situ) are predicted to be highly localised. Of note, for Abbey & Baker, although a small amount of new hard substrate may be introduced into the Holderness Offshore MCZ if the SSIV and protection / stabilisation material are required; based on the small area of seabed that will be impacted (0.0089 km^2), in comparison to the overall MCZ area (1,176 km^2), no likely significant effects are predicted as a result of the proposed activities either alone or in-combination with other plans or projects.

In contrast, any temporary disturbance to the seabed within the MCZ from the above listed projects is expected to recover it is assumed recovery will occur within the short to medium term as the SNS area is characterised by a shallow bathymetry with relatively fast water circulation. In addition, given the limited scale and duration of the disturbance, it is not anticipated to undermine the site's conservation objectives or result in an adverse effect on site integrity.

Given the above, it is therefore considered that in-combination impacts will not have a likely significant effect on the protected features of the MCZ.

7.4 Mitigation Measures

Seabed disturbance impacts as a result of the proposed Abbey & Baker development will be minimised by the implementation of the following mitigation measures:

- Use the minimum appropriate number of drilling rig anchors and length of anchor chains to maintain stability and integrity.
- MODU anchors will be set at the optimum angle for the local seabed sediments, reducing the potential drag across the seabed and helping them to become suitably embedded.
- The MODU anchoring system (anchors and chains) will be placed in accordance with site survey results so as to prevent damage to sensitive seabed habitats.
- A full Chemical Hazard Assessment and Risk Management (CHARM) assessment of the proposed chemicals to be used and discharged, as required under the Offshore Chemicals Regulations 2002 (as amended), will be undertaken during the permitting process prior to drilling operations commencing and, as part of chemical selection and assessment process, less hazardous alternatives will be sought in preference for any chemicals identified to be high risk (e.g. those with substitution warnings).
- A ROV will be used to monitor cement returns when cementing the 30 inch conductor and 13 3/8 inch casing to help ensure the volume of cement discharged to the seabed is kept at a minimum.
- Route selection and optimisation will be based on acquired Environmental, Geophysical, and Geotechnical survey data.
- Working corridors will be minimised as far as possible.
- Any boulders removed from the pipeline and umbilical lay corridors will be placed appropriately on the seabed to avoid a snag hazard and their as-left position recorded.
- Use of DP installation vessels as opposed to anchored vessels.
- Rock will be deployed from a DP rock dumping vessel using a fall pipe and the rate and locations of deployment will be controlled on board the vessel and monitored using high resolution survey / sonar equipment.
- Size of subsea infrastructure will be optimised for the Abbey & Baker Development.
- Subsea infrastructure layout and pipeline crossing designs optimised to minimise material deposited.
- Concrete mattresses will be deployed from a vessel with a ROV and acoustic positioning to monitor placement of material and ensure that it is directed to the required area.

- Minimise amount of deposited material whilst still achieving the required level of stabilisation / protection.
- Monitoring of integrity of subsea infrastructure, including the pipeline / umbilical and stabilisation material throughout production operations and taking remedial action, if required.

7.5 Residual Effects

In summary, no significant residual effects on water quality, seabed sediments, seabed communities or fish are predicted as a result of disturbance to the seabed during the life of the Abbey & Baker field development. The worst case total area of seabed that will be directly impacted temporarily by the Abbey & Baker development is estimated at around 0. 0.697 km^2, and the worst case total area of seabed that will be directly impacted in the long term by the Abbey & Baker development is estimated at around 0.0399 km^2. It is unlikely that both of these full areas will be affected due to the conservative disturbance areas presented for installation of the subsea infrastructure, pipelines and umbilicals. This is a relatively small area in comparison to the seabed available in the SNS region (62,000 km^2), with similar water depths, sediment types and benthic communities (Cameron et al., 1992). It is, however, recognised that some aspects associated with the Abbey & Development (i.e. installation of the subsea structures, pipeline and umbilical and associated protection material) will have longer term impacts on sediment communities, due to permanent habitat change, although direct physical injury of benthic species will only occur when the infrastructure or material is first placed on the seabed.

7.6 Transboundary Impacts

No significant transboundary impacts are predicted as a result of the proposed Abbey & Baker Development, given the localised nature of any impacts and the distance to the nearest transboundary line (the UK / Netherlands median line) located approximately 152 km to the east of the proposed Abbey & Baker development at its closest point.

7.7 Cumulative Impacts

Effects of seabed disturbance resulting from oil and gas activities will be cumulative to those of other activities. The Abbey & Baker field development is located within an area of high fishing intensity for shellfish species using demersal gear (both mobile and passive), and as such, it is considered that the contribution of other forms of seabed disturbance, such as offshore installation activities, are minor in comparison to the direct physical effects of fishing (refer to Section 4.4.1; DESNZ, 2022).

The proposed Abbey & Baker development lies within an area of moderate oil and gas activity (refer to Section 4.4.4) and will tie back into the existing York platform and pipeline located approximately 8 km south west of the proposed Abbey drill centre. The closest surface oil and gas infrastructure to the proposed Abbey & Baker development is the Minerva platform, operated by Perenco, which is located approximately 5 km east northeast of the proposed Abbey drill centre. As this field is currently producing, the only activities that could result in cumulative seabed disturbance impacts are in the event of any maintenance construction work (e.g. spot rock-deposits) or incremental drilling activity. As such it is unlikely that there will be any significant cumulative impacts with respect to seabed disturbance and ongoing production activities.

Petrogas is aware of the plans to develop the Endurance carbon storage site located approximately 34 km northeast of the proposed Abbey & Baker development. Under the plan outlined in the Northern Endurance Environmental Statement, it is unlikely that development activities for both the Endurance carbon storage site and proposed Abbey & Baker development will be ongoing at the same time; offshore construction and drilling are anticipated to take place at the Northern Endurance carbon storage site from Q3 2025 – Q3 2026. The two developments are both located in similar EUNIS habitats, with both being predominantly comprised of the habitats MD3 and MD5 (See Section 4.3.2). While the Endurance carbon storage site development is anticipated to directly impact a seabed area totalling 54.28 km^2; the Abbey & Baker development is estimated to have a relatively small temporary impact area (0. 0.697 km^2), and a relatively small long term impact area (0.0399 km^2). This coupled with the

distance and time between the two projects and the mitigation measures that will be implemented, significant cumulative impacts with respect to seabed disturbance are therefore not predicted.

In addition, Petrogas is also aware of the plans to develop the Hornsea Four Offshore Wind Farm; the cable corridor for this site is located approximately less than 10 km from the proposed Abbey & Baker Development. If this development proceeds under the plan outlined in Ørsted Power's Hornsea Four application documents, it is likely that installation operations will overlap with the proposed Abbey & Baker development operations; offshore cable installation is anticipated to take place during 2028. The two developments are both located in similar EUNIS habitats, with both being predominantly comprised of the habitats MD3 and MD5 (See Section 4.3.2). While the Hornsea Four cable installation is anticipated to directly impact a seabed area totalling 100.6 km^2, the Abbey & Baker development is estimated to have a relatively small temporary impact area (0. 0.697 km^2), and a relatively small long term impact area (0.0399 km^2). This coupled with the distance between the two projects and the mitigation measures that will be implemented, significant cumulative impacts with respect to seabed disturbance are therefore not predicted.

8 Underwater Noise Emissions

8.1 Introduction

Marine fauna, including fish and marine mammals, have developed a range of complex mechanisms for both emitting and detecting underwater noise signals that allow them to communicate, avoid predators and other perceived dangers, locate food and mates, and navigate (Richardson et al., 1995; DOSITS, 2017). Sounds are particularly important for intra-species communication as they can convey significant amounts of information quickly and over great distances (DOSITS, 2017). As such, many marine species are vulnerable to anthropogenic noises that may disrupt their ability to perceive their surrounding environment.

Development activities identified during the ENVID workshop that may generate underwater noise have been scoped in on the basis that the main noise sources will be the DP vessels used for drilling and subsea installation, together with noise from equipment operating on both the DP vessels and the MODU. All other potential noise sources have been scoped out as their underwater acoustic output is minimal and not considered relevant for further assessment.

Any potential impacts on seabirds, fish and commercial fishing are scoped out of detailed assessment as the drilling and subsea installation activities generates only relatively low-intensity, continuous noise from DP thrusters and vessel machinery, which is not expected to cause any significant disturbance to these receptors.

8.2 Assessment of Impacts

8.2.1 Abbey & Baker Noise Sources

It is acknowledged that the DP vessels and vessel equipment associated with both the drilling and subsea installation activities for the Abbey & Baker Development will generate underwater noise of a continuous (non-impulsive) nature.

There will be some sound and vibration associated with the proposed drilling operations. This sound will propagate from any rotating machinery such as generators, pumps and the drilling unit and risers (McCauley, 1994). Noise levels associated with a typical jack-up rig are in the vicinity of 127 dB re 1µPa at 1 m (Evans, 1996). The noise produced will be of a relatively low level, although it will be continuous and generated for long periods throughout the proposed drilling options

The highest sound levels are expected from short-term energy-demanding activities, for example when using DP thrusters to position vessels on location (Genesis, 2011). A vessel using DP thrusters can produce sound at levels between 108 and 182 dB re 1µPa at 1m at dominant frequencies between 50 Hz and 7 kHz (McCauley, 1994; Simmonds et al., 2004). The DP thrusters continually produce cavitation bubbles that, when they implode, leads to the generation of underwater noise (Fischer, 2000; Wyatt, 2008).

The potential effects of underwater noise emissions on marine fauna depends on the characteristics of the sound (e.g. type, intensity, spectra, duration), the physical characteristics of the environment in which sound propagates, the acoustic sensitivity of the receiver, and their interaction in space and time. Potential effects range from masking biological communication and causing small behavioural reactions, to chronic disturbance, injury and mortality (OSPAR, 2009).

8.2.2 Potential Impacts on Marine Mammals

Marine mammals, in particular, cetaceans, rely almost exclusively on sound for navigating, foraging, breeding and communicating (Clark, 1990; Edds-Walton 1997; Tyack and Clark, 2000). The extent to which intense underwater sound might adversely impact a species is dependent upon the incident sound level, sound frequency, and duration of exposure and/or repetition rate of the sound wave.

The Southall et al. (2019) guidance groups marine mammals into categories of similar species and applies filters to the unweighted noise to approximate the hearing sensitivities of the receptor. The hearing groups given in Southall et al. (2019) are summarised in Table 8.1, along with the corresponding

marine mammal species that have been recorded in the SNS. The marine mammals most likely to be in the Abbey & Baker area are bottlenose dolphin, common dolphin, harbour porpoise, white-beaked dolphin, white-sided dolphin and grey seal (Section 4.3.5).

Table 8.1: Marine Mammal Hearing Groups and their Generalised Hearing Range (Southall et al., 2019)

Functional Group	Estimated Auditory Bandwidth	Marine Mammal Species Found in the SNS [1]
Low-frequency (LF) cetaceans	7 Hz – 35 kHz	Minke whale, fin whale
High-frequency (HF) cetaceans	150 Hz – 160 kHz	White-sided dolphin, white-beaked dolphin, common dolphin, Risso's dolphin, killer whale, bottlenose dolphin
Very High-frequency (VHF) cetaceans	275 Hz – 160 kHz	Harbour porpoise
Phocid carnivores in water (PCW)	50 Hz to 86 kHz	Harbour seal, grey seal

[1] See Section 4.3.5

Marine mammals may not be injured by the noise generated from the DP vessels, and vessel equipment but reported responses of behavioural disturbance include avoidance, changes in swimming speed, direction and surfacing patterns, alteration of the intensity and frequency of calls (Erbe et al., 2019). Harbour porpoise and minke whale have been shown to respond to vessels by moving away from them, while some other species, such as common dolphin, have shown attraction (Palka & Hammond, 2001). In addition, observations at installations in the North Sea have shown harbour porpoises regularly frequenting and actively foraging around platforms (Todd et al., 2009).

For marine mammals, it is acknowledged that the maximum anticipated underwater SELcum criteria from the DP vessels is below the thresholds for potential injury of marine mammals in terms of permanent threshold shift (PTS) to LF cetaceans, HF cetaceans and PCWs (Southall et al., 2019). However, the underwater noise generated by the DP vessels may exceed the PTS for VHF cetaceans (e.g. harbour porpoise), which for non-impulsive noise sources is 173 dB re 1µPa2s (Southall et al, 2019). Based on a simple spherical spreading sound propagation model[1], this threshold is potentially exceeded approximately 3 m from the noise source assuming a maximum sound level of 182 dB re 1µPa at 1m. Though, it is extremely unlikely that marine mammals would venture this close to the vessel and therefore they are not expected to be injured by the proposed Abbey & Baker Development operations.

The sensitivity of marine mammals from the use of DP thrusters and operation of equipment during the drilling activities has been evaluated as **High**; the receptor is of international importance (Very High value) and has some tolerance / ability to adapt to the effect (High resistance and resilience). As there is the potential for underwater noise generated by the DP vessels and MODU equipment may exceed the PTS for VHF cetaceans, the magnitude of the impact has been assessed as **Minor**, although it is likely that marine mammals will move out of the area of once the proposed drilling operations have commenced. Effects on marine mammals as a result of the underwater noise emissions generated from the use of DP thrusters and operation of equipment are therefore predicted to be **Minor**.

In comparison, the sensitivity of marine mammals from the use of DP thrusters and operation of equipment during the subsea installation activities has been evaluated as **High**; the receptor is of international importance (Very High value) and has some tolerance / ability to adapt to the effect (High resistance and resilience). As while the DP vessels and vessel equipment during the subsea installation

[1] Based on the sound attenuation equation from Richardson et al. (1995) - Transmission Loss = 20Log(R/R0) dB – where, R0 = the reference range, usually 1 metre, and R = the distance from the reference range.

activities may cause some disturbance, the magnitude of the impact has been assessed as **Negligible**, as it is likely that marine mammals will move out of the area once the proposed subsea installation operations have commenced. Effects on marine mammals as a result of the underwater noise emissions generated from the use of DP thrusters and operation of equipment are therefore predicted to be **Negligible**.

Given the above, effects on marine mammals from the underwater noise emissions produced during the proposed Abbey & Baker Development are therefore predicted to be **Minor** to **Negligible**. To mitigate against any potential impacts, Petrogas will ensure that machinery and equipment will be in good working order and well-maintained.

8.2.3 Potential Impacts on Southern North Sea SAC

The proposed Abbey & Baker Development is located within the Southern North Sea SAC (refer to Section 4.3.6). The conservation objectives of the Southern North Sea SAC are to ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining Favourable Conservation Status (FCS) for harbour porpoise in UK waters.

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

- Harbour porpoise is a viable component of the site;
- There is no significant disturbance of the species; and
- The condition of supporting habitats and processes, and the availability of prey is maintained.

The Southern North Sea SAC covers an area of 36,951 km^2 and supports an estimated 17.5% of the UK North Sea MU population of harbour porpoises. The northern two thirds of the site is recognised as important for harbour porpoises during the summer season (April – September), whilst the southern part supports persistently higher densities during the winter (October – March). The winter area of the SAC covers 12,696 km^2, and the summer area of the SAC covers an area of 27,028 km^2.

Although harbour porpoises are generally expected to show some habituation to routine vessel noise, increases in vessel activity associated with the Abbey & Baker Development could still lead to localised and temporary disturbance. This may result in individuals avoiding areas where Abbey & Baker Development vessels are operating or reducing their foraging effort during periods of heightened activity. Harbour porpoises have been observed to show negligible responses to large, slow-moving ships (Oakley et al., 2017). As a worst case, individuals may be displaced from, or reduce foraging effort in, areas close to vessels (Verboom and Kastelein, 2005), with some displacement reported out to 400 m from a vessel (Akkaya Bas et al. 2017, Pollacheck 1990).

These behavioural effects are expected to be temporary, with porpoises resuming activities relatively quickly once a vessel has passed (Hermannsen et al. 2014, Wisniewska et al. 2018a). As a high frequency echolocator, harbour porpoises use signals well beyond the low frequencies predominantly produced by vessels and may therefore be less sensitive to vessel noise than lower-frequency toothed whale species (Wisniewska et al., 2018b).

The total area of the SAC for harbour porpoise is 36,951 km^2 and the proportion of the SAC that could be impacted by sound associated with the Abbey & Baker Development vessels is very small, up to an area of 0.8 km^2 at the sea surface will be unavailable for each vessel.

Therefore, in view of the conservation objectives of the SAC, no likely significant effects (LSE) on the Southern North Sea SAC are predicted as a result of the proposed drilling and subsea installation operations.

8.2.4 European Protected Species (EPS) Risk Assessment

JNCC has produced good practice guidelines (JNCC, 2010) and protocols for marine industries on how to assess the likelihood of committing an offence under The Conservation of Offshore Marine Habitats and Species Regulations 2017, how to avoid it and whether a licence to carry out activity might be required or not. It is considered that adherence to these guidelines constitutes best practice and will minimise the risk of committing an injury offence.

With regards to a disturbance offence, this is more likely where an activity causes persistent (sustained and chronic) noise in an area for long periods of time. For most cetacean populations in the UK, disturbance in terms of the EPS is unlikely to result from single, short-term operations such as the proposed Abbey & Baker drilling and subsea installation operations. Although the activity may result in temporary sporadic disturbance to cetaceans, it is unlikely to impair the ability of an animal to survive or reproduce nor result in significant effects on the local abundance or distribution. However, in order to minimise the risk of disturbance to an EPS, mitigation measures have been proposed in Section 8.3.

Given the above, the proposed Abbey & Baker Development will therefore not constitute an offence under The Conservation of Offshore Marine Habitats and Species Regulations 2017.

8.3 Mitigation Measures

Petrogas will ensure that the following measures will be adopted to ensure that sound levels, and their effects upon potential receptors, are minimised to reduce the risk of disturbance to fish, marine mammals and seabirds. Specifically, this will involve applying the following measures:

- Operational and maintenance procedures on vessels will aim to optimise the efficiency of equipment; and
- Vessel use will be optimised where possible by minimising the number of vessels required and vessel movements.

8.4 Residual Effects

In summary, it is possible that short term behavioural effects may be observed among marine mammals, as a result of the underwater noise emissions generated from the proposed Abbey & Baker Development, but any impacts will be mitigated by adherence to the mitigation measures detailed in Section 8.3 such that any residual effects are predicted to be **Negligible** and not significant.

8.5 Transboundary Impacts

The Abbey & Baker Development lies approximately 152 km to the south west of the UK / Netherlands median at its closest point. Given the distance, underwater noise emissions generated from the proposed Development operations are unlikely to be detected into international waters and therefore no significant transboundary impacts are anticipated.

8.6 Cumulative Impacts

There is the potential for underwater noise emissions to have a cumulative impact on marine fauna, particularly on marine mammals, if non-impulsive noise was generated from other anthropogenic sources (e.g. vessel use from other SNS oil and gas activity or renewable energy activity) within a similar timeframe.

There are no operational, under construction or consented offshore windfarms in the vicinity of the proposed Abbey & Baker Development area. The closest active offshore windfarm is the Westermost Rough wind farm, located approximately 18 km southwest of the Abbey & Baker Development (refer to Section 4.4.5). The closest proposed Hornsea Project Four cable corridor, which is currently in planning, is located approximately 8.9 km northeast of the Abbey & Baker Development.

The other oil and gas developments in the area may also be undertaking noisy activities which have the potential to act cumulatively with the Abbey & Baker Development in increasing injury risk to fish, marine mammals and seabirds. However, given the mitigation measures which will be in place for the Abbey & Baker Development, simultaneous noisy activity should not act in combination with any other development to produce significant cumulative effects.

9 Greenhouse Gas Emissions

9.1 Introduction

This section assesses the significance of the likely effects of GHG emissions generated by the proposed Abbey & Baker Development, namely CO_2, CH_4 and N_2O, on the climate. It has been written with reference to the new DESNZ supplementary guidance for assessing the effects of downstream Scope 3 emissions on climate from offshore oil and gas projects (DESNZ, 2025a), published following the Finch judgment, 2024[1] and the Jackdaw / Rosebank judgment, 2025[2]. As discussed in Section 4.2.6, anthropogenic sources of GHG emissions are implicated in amplifying the natural greenhouse effect resulting in climate change. The potential effects of GHG emissions are therefore global in scale.

This section is structured as follows:

- **Section 9.2 (GHG Emissions Sources):** defines the direct and indirect GHG emissions sources arising from the Abbey & Baker Development.
- **Section 9.3 (Environmental Protection Objectives):** sets out the key international climate change agreements and UK climate legislation and policies designed to reduce GHG emissions and reach net zero by 2050.
- **Section 9.4 (UK Oil & Gas Industry - Net Zero Targets and Progress to Date):** describes the North Sea Transition Deal (NSTD), a strategic partnership between the UK government and the offshore oil and gas industry to support the sector's shift toward net zero and identifies the key milestones achieved to date.
- **Section 9.5 (Petrogas's Approach to Decarbonisation):** presents Petrogas's commitments to conducting business in an environmentally responsible and sustainable manner from a net zero perspective.
- **Section 9.6 (Assessment of Impacts):** assesses the impact of the GHG emissions generated from the proposed Abbey & Baker Development on the climate and the significance of any likely effects, using the principles set out in ISEP (2026). GHG emissions have been evaluated in the context of a global baseline scenario of GHGs, as described in Section 4.2.6, with consideration in this chapter given to the impact the emissions will have on emissions reduction pathways, as well as UK net zero pathways and oil and gas decarbonisation policies and plans. Note, the alternative concept options considered for the Abbey & Baker Development are explored in Section 2, but do not significantly affect the estimate of total GHG emissions to be generated.
- **Section 9.7 (Mitigation measures):** identifies the measures available to Petrogas to reduce the GHG emissions generated by the Abbey & Baker Development.
- **Section 9.8 (Other Relevant Considerations):** provides information on how the proposed Abbey & Baker Development would contribute to the UK's energy security and economic growth, align with the UK Government's stated objectives for the future of the North Sea and enable a managed transition to net zero.
- **Section 9.9 (Residual Effects):** presents the residual effects which will remain after the implementation of the proposed mitigation measures.

[1] Finch Judgment, 2024: UK's Supreme Court ruling in 2024 that a decision to grant planning permission for an onshore oil development project at a site in Surrey was unlawful, because downstream GHG emissions from the combustion of the oil produced were not assessed in the EIA as part of the planning decision.

[2] Jackdaw / Rosebank Judgment, 2025: Scotland's Court of Session ruling in 2025 in relation to assessment of downstream Scope 3 emissions under The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020.

9.2 GHG Emissions Sources

To help delineate direct and indirect emission sources, the GHG Protocol, a widely used international accounting tool for government and business leaders to understand, quantify, and manage GHG emissions, categorises GHG emissions into the following three 'Scopes':

- Scope 1 covers direct GHG emissions from sources that are owned or controlled by the company;
- Scope 2 covers indirect GHG emissions generated from purchased or acquired electricity, steam, heat and cooling;
- Scope 3 emissions include all other indirect GHG emissions that occur in a company's value chain, which are not directly controlled or owned by the company.

Table 9.1 categorises the GHG emissions which will be generated from the proposed Abbey & Baker Development into the relevant GHG Protocol Scope, noting that Petrogas has control over its direct emissions and has limited or no influence over its indirect emissions, particularly those associated with the end use of sold hydrocarbons.

Table 9.1: GHG Emission Types, Scopes and Abbey & Baker Development Sources

Emissions Type	GHG Protocol Scope	Definition [1]	Abbey & Baker Development GHG Emissions Sources
Direct emissions	Scope 1	Emissions from sources that are owned or controlled by the reporting company	• Well testing (flaring) and clean up activities. • Operation of the York Platform, namely diesel combustion for power generation.
Indirect emissions [2]	Scope 2	Emissions generated from purchased or acquired electricity, steam, heat and cooling	• Not applicable as electricity will not be purchased or acquired by Petrogas for the Abbey & Baker Development.
	Scope 3	All indirect emissions (not included in scope 2) that are a consequence of the activities of the reporting company, but occur at sources owned or controlled by another company	• Fuel burnt for power generation on the MODU, vessels and helicopters during drilling, installation, inspection, maintenance and decommissioning activities; • Downstream processing, transportation and distribution of Abbey & Baker hydrocarbons, prior to end use of sold products; • Burning of the extracted Abbey & Baker hydrocarbons (i.e. end use of sold products, based on the presumption that all end use Abbey & Baker hydrocarbons are eventually combusted).

[1] Definitions taken from Greenhouse Gas Protocol Corporate Value Chain (Scope 3) Standard
[2] Indirect emissions are a consequence of the activities of the reporting company, but occur at sources owned or controlled by another company.

The GHG Protocol further divides Scope 3 emissions into distinct categories split between two main groups: upstream and downstream emissions.

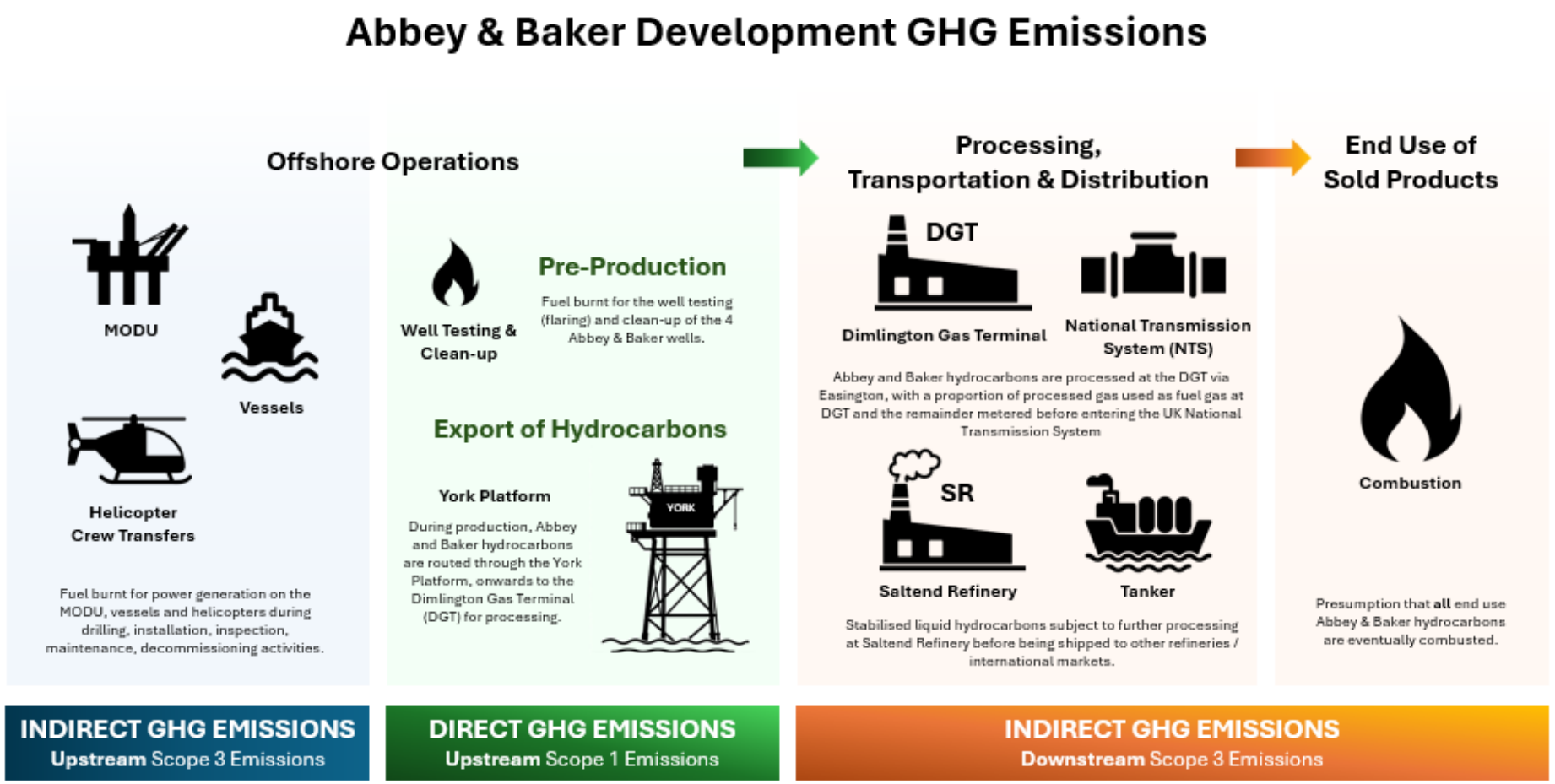
For Abbey & Baker, Scope 3 upstream emissions are the indirect emissions which will be generated by Petrogas's contractors offshore when extracting, producing and exporting Abbey & Baker

hydrocarbons to the DGT, as well as during offshore decommissioning operations upon cessation of production.

Scope 3 downstream emissions are the indirect emissions which will be generated from the downstream processing, transportation and distribution of the Abbey & Baker hydrocarbons and from the end use of the sold product (namely, the presumption that all end use Abbey & Baker hydrocarbons are eventually combusted).

Figure 9.1 provides an overview of the GHG emissions sources and GHG Protocol Scopes relevant to the proposed Abbey & Baker Development value chain.

Figure 9.1: Overview of Abbey & Baker Development GHG Emission Sources and GHG Protocol Scopes over the Project Value Chain



9.3 Environmental Protection Objectives

Environmental Protection Objectives (EPOs) related to climate change are the international agreements and national legislation and policies, which aim to mitigate climate change, with a target of reaching net zero[3] global GHG emissions. A summary of key climate change EPOs relevant to oil and gas projects has been provided below, along with applicable UK Government net zero strategies and sector specific policies and plans. These have been considered when assessing the impact of the proposed Abbey & Baker Development's GHG emissions on the global climate.

9.3.1 International Agreements

The UNFCCC signed in 1992, is the principal global treaty for coordinating international responses to climate change. It entered into force in March 1994 and has been ratified by 197 countries. COP, which meets annually, is the supreme decision-making body of the UNFCCC and relies on the scientific assessments of the IPCC to inform its decisions and guide negotiations. The IPCC produces co-ordinated assessments of climate science, the social and economic impacts of climate change, and potential response strategies, achieving this through a series of assessment cycles. The 6th IPCC assessment report cycle concluded in March 2023, the conclusions from which have been used to inform this assessment.

The Kyoto Protocol was the first global initiative to minimise GHG emissions, adopted at COP3 in 1997 and ratified by the UK in May 2022. It set legally binding quantified targets for developed, industrialised countries to reduce their GHG emissions on average by 5% by 2012 (in relation to 1990), followed by a second commitment period to reduce emissions on average by 18% by 2020 (in relation to 1990).

Building upon this, the Paris Agreement was adopted at COP21 in 2015 and requires all major GHG emitting countries to reduce their emissions. The aim of the Paris Agreement is to restrict global temperature change to well under 2°C above pre-industrial levels and pursue efforts to keep it below 1.5°C. The Agreement also established Nationally Determined Contributions (NDCs), which describe individual countries' climate action plans. The UK ratified the Paris Agreement on 18 November 2016.

The United Nations Sustainable Development Goals (SDGs) were established to promote peace, prosperity, and environmental protection by 2030. These goals were adopted by all UN Member States in 2015 as part of the 2030 Agenda for Sustainable Development. The Paris Agreement is explicitly referenced in SDG 13 (Climate Action), which is focused on limiting and adapting to climate change (United Nations, 2025).

9.3.2 UK Climate Change Legislation

The Climate Change Act 2008 (as amended) sets a legal requirement to achieve a 100% reduction in net GHG emissions by 2050 relative to 1990 levels ('net zero') and delivers on the commitment that the UK made by ratifying the Paris Agreement. The Act also established the Climate Change Committee (CCC), an independent statutory body set up to advise the UK government on setting and meeting GHG reduction goals.

The Climate Change Act requires the UK government to set five-yearly legally binding carbon budgets, 12 years in advance, from 2008 to 2050, which restrict the amount of GHGs the UK can emit (Table 9.2). The UK is currently in the Fourth Carbon Budget period (2023 - 2027).

Under the Paris Agreement, the UK has also set two NDC emissions reduction targets, as detailed in Table 9.2.

[3] A state where the amount of GHGs emitted is balanced by the amount removed from the atmosphere.

Table 9.2: UK Carbon Budgets & NDCs

Carbon Budget / NDC	Carbon Budget Level	Reduction Below 1990 Levels	Met?
1st Carbon Budget (2008 to 2012)	3,018 $MtCO_2e$	26%	Yes
2nd Carbon Budget (2013 to 2017)	2,782 $MtCO_2e$	32%	Yes
3rd Carbon Budget (2018 to 2022)	2,544 $MtCO_2e$	38%	Yes
4th Carbon Budget (2023 to 2027)	1,950 $MtCO_2e$	52%	-
NDC (2030)	-	68%	-
5th Carbon Budget (2028 to 2032)	1,725 $MtCO_2e$	58%	-
6th Carbon Budget (2033 to 2037)	965 $MtCO_2e$	77%	-
NDC (2035)	-	81%	-
7th Carbon Budget (2038 to 2042) [1]	535 MtCO2e	87%	-

[1] Published by the CCC in February 2025. The UK Government will respond to the CCC's advice and set the seventh carbon budget in law by 30 June 2026.

9.3.3 UK Net Zero Strategies and Sector Specific Policies and Plans

In 2021, the UK submitted its Net Zero Strategy: Build Back Greener (HM Government, 2021) to the UNFCCC, which set out how it proposes to deliver the Fourth, Fifth and Sixth Carbon Budgets and the 2030 NDC, as well as net zero GHG emissions by 2050. However, following the energy security crisis and rising gas and fossil fuel prices in 2022, an Independent Review of Net Zero (DESNZ, 2023a; 2023b) was commissioned to make recommendations on how the UK could achieve its legally binding net zero target in a way that drives economic growth, energy security, and affordability.

Powering Up Britain, The Net Zero Growth Plan (DESNZ, 2023b) builds on the Net Zero Strategy, and responds to the recommendations made in the Independent Review of Net Zero. It acknowledges that fossil fuels will retain a crucial role in the energy system until there are credible clean energy alternatives that can replicate their role, with natural gas playing a role for years to come, particularly in the hardest to decarbonise sectors. Following this, the UK Government published the Clean Power 2030 Action Plan (DESNZ, 2024a), which outlines the UK government's strategy to achieve a fully decarbonised electricity system by 2030 and the Carbon Budget and Growth Delivery Plan (HM Government, 2025), which sets out how the UK will continue to reduce emissions in line with the Climate Change Act.

The 'Balanced Pathway' Scenario (CCC, 2025a) is a framework proposed by the CCC for the UK's approach to achieving net zero emissions by 2050. In the Net Zero aligned Balanced Pathway scenario, there is a declining but continued demand for oil and gas through 2050 which requires that the UK imports oil and gas given the projected levels of UK production.

The UK's net zero targets and strategies are supported by sector-specific policies and plans. Both the North Sea Transition Deal (refer to Section 9.4) and the British Energy Security Strategy (HM Government, 2022) are predicated on continuing UK North Sea oil and gas production alongside mandating GHG emissions reductions and decarbonisation. The OGA Strategy (OGA, 2020) maintained MER of hydrocarbons as the NSTA's Central Obligation and clarified that this included the objective of net zero by 2050. In November 2025, the UK Government published the North Sea Future Plan (DESNZ, 2025b), which also recognises the important role that oil and gas will play in the UK's energy mix for decades.

To promote industry good practice, MER and efforts to achieve net zero by 2050, the NSTA has produced a set of stewardship expectations. Stewardship Expectation 11 'Net Zero' sets out the NSTSA's view as to how UK North Sea companies can reduce their GHG emissions and support delivery of the UK's net zero target. Building on Stewardship Expectation 11, in March 2024 the NSTA published

the OGA Plan (NSTA, 2024a), which sets out the requirements for industry to meet the requirement, as set out in the OGA Strategy, for GHG emissions reductions from the production of oil and gas.

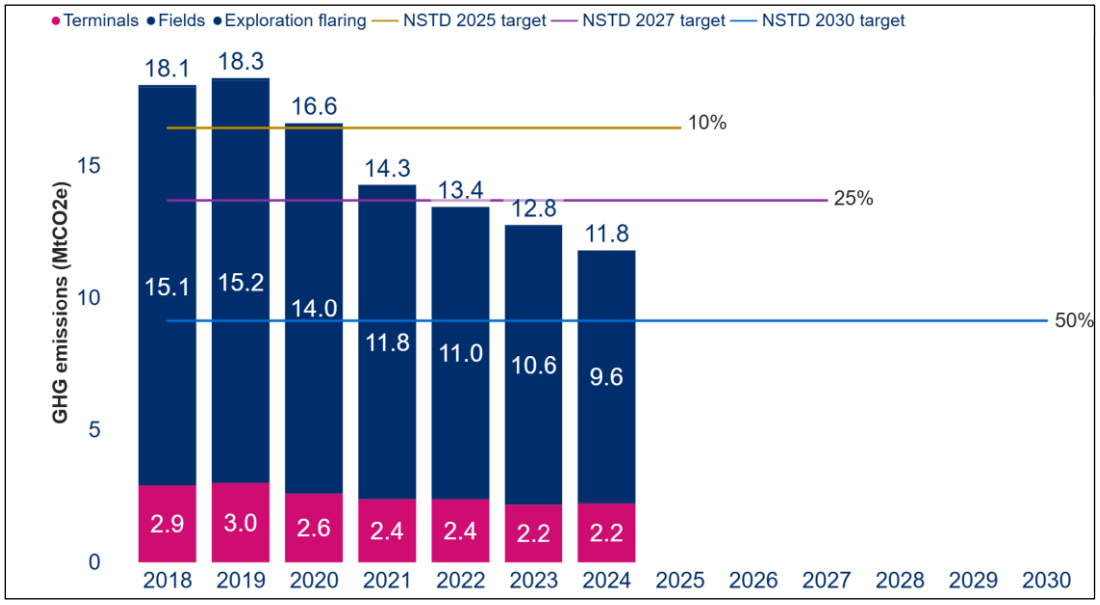
The Zero Routine Flaring (ZRF) Initiative, introduced by the World Bank in 2015, commits the UK government and industry to end routine flaring at production sites no later than 2030 and to ensure that new developments are designed without the need for routine flaring of any associated gas which may be produced from the field. The UK is also a member of the Global Methane Pledge, to collectively reduce global methane emissions by at least 30% by 2030 compared to 2020 levels. As a subsea development, once Abbey & Baker comes online, there will be no routine flaring or venting of gas offshore.

The majority of upstream GHG emissions generated offshore during the development of the Abbey & Baker field will be as a result of vessel usage. In 2023, the IMO adopted the IMO 2023 Strategy (IMO, 2023). This envisages an average reduction in carbon intensity of international shipping of least 40% by 2030 (as compared to 2008). It also sets out an ambition that zero or near-zero GHG emission technologies, fuels and/or energy sources represent at least 5% of the energy used by international shipping by 2030.

9.4 UK Oil & Gas Industry - Net Zero Targets and Progress to Date

The NSTD prescribes reductions against a 2018 baseline in offshore production GHG emissions of 10% by 2025, 25% by 2027 and 50% by 2030, pursuant to creating a net zero basin by 2050. To date the UK's oil and gas industry has successfully reduced upstream emissions by 34%, surpassing the 2027 target (Figure 9.2). Based on the current trajectory, the target of halving emissions between 2018 and 2030 is well within reach (OEUK, 2025a; NSTA, 2025a).

Figure 9.2: Progress of UK upstream oil & gas GHG emissions against NSTD targets (NSTA, 2025a)



In 2024, GHG emissions from the production of UK oil and gas, which includes emissions from offshore oil and gas fields, onshore processing terminals and oil and gas exploration activity, totalled an estimated 11.8 Megatonnes (Mt) CO_2e. To put this in content, GHG emissions from upstream oil and gas activity accounted for 3.3% of net UK territorial GHG emissions in 2023, according to data from the National Atmospheric Emissions Inventory (NAEI) (NSTA, 2025a).

The majority of GHG emissions from the production of UK oil and gas are generated from the offshore installations, with the largest contributors being gas and diesel combustion for power generation, followed by flaring and venting (NSTA, 2025a). Emissions from offshore installations fell in 2024, down 5% compared to 2023 and 34% against the 2018 baseline year, driven by improvements in power efficiency and management, reductions in venting and flaring and asset decommissioning (OEUK, 2025a).

Methane emissions from offshore installations have reduced substantially since the NSTD was agreed, down by 57% against a 2018 baseline, delivering a reduction of 0.85 million tonnes of CO_2e and exceeding the original target of 50% by 2030 (OEUK, 2025a).

Beyond 2030, absolute emissions associated with oil and gas production are predicted to fall steeply along with output, but also due to the reduction in flaring and venting, and lower-emission installations taking over from older and more energy-intensive installations (OEUK, 2024).

9.5 Petrogas' Approach to Decarbonisation

This section outlines Petrogas's approach to decarbonisation. Petrogas North Sea Limited is a subsidiary of Petrogas E&P and operates under the Group's policies. In line with the Petrogas E&P Vision and Environmental, Social and Governance (ESG) Policy, Petrogas is committed to conducting our business in an environmentally responsible and sustainable manner, reducing our carbon footprint and maximising energy efficiency to contribute to the global effort to mitigate climate change.

To support delivery of the UK government's net zero GHG emissions reduction target by 2050, we are aligned with the objectives and targets of the NSTD and manage our operations in accordance with the NSTA's Net Zero Stewardship Expectation 11 and the OGA Plan to reduce UKCS GHG emissions.

In order to achieve continuous improvement in our GHG emissions reduction performance, we will ensure our operations, and the projects we invest in, comply with the following net zero commitments:

- Embedding GHG emissions reduction into our business processes and investment decisions.
- Maximising the energy efficiency of our operations.
- Assessing GHG emissions reduction performance of our value chain in the procurement of goods and services.
- Engaging the value chain and affected Stakeholders in seeking opportunities for GHG emissions reduction initiatives.
- Exploring synergies between offshore operations undertaken in our licenses and those of other licensees to reduce GHG emissions (e.g. vessel sharing opportunities).
- Implementing best available technology at our assets to minimise GHG emissions according to the ALARP principles.
- Ensuring all new developments are planned, designed and developed on the basis of zero routine flaring and venting.
- Advocating low carbon power for our operations, exploring opportunities for electrification, where technically and economically viable.
- Striving to minimise the use of virgin material and the production of waste, seeking opportunities to maximise reuse of material and infrastructure during the whole life cycle of our installations.
- Measuring, monitoring and publicly reporting GHG emissions from our operations, and the projects we invest in.
- Participating in industry collaborations aimed at decarbonising the UKCS, through emissions reduction and energy efficiency improvement initiatives associated with our operations.

9.6 Assessment of Impacts

The significance of the GHG emissions generated from the Abbey & Baker Development has been assessed using a matrix-based approach, in which receptor sensitivity and impact magnitude are combined to determine the overall level of significance, as discussed in Section 9.6.2. Appendix D provides a breakdown of the emissions generated from the sources identified in Section 9.2 and outlines the method, assumptions and GHG conversion factors used to quantify the emissions.

9.6.1 Quantification of GHG Emissions

Total GHG Emissions

Table 9.3 quantifies the GHG emissions (expressed in terms of kilotonnes (kt) of CO_2e) arising from the proposed Abbey & Baker Development, over the life of the field in the High (P10) production case scenario. The High production case has been used to inform the assessment as it represents the worst-case scenario in terms of total production volume and resulting GHG emissions.

Table 9.3: Abbey & Baker Development Total GHG Emissions (Worst Case)

Emissions Category	Total GHG Emissions (kt CO_2e) [1]
	High Case
Total Direct GHG Emissions (Scope 1) [2]	43.68
Total Indirect Upstream GHG Emissions (Scope 3) [3]	65.00
Total Indirect Downstream GHG Emissions (Scope 3) [4]	16,400.67
Grand Total	**16,509.35**

[1] Refer to Appendix D for the methodology used to estimate GHG emissions.
[2] Accounts for upstream GHG emissions generated at the York Platform and from pre-production well testing (flaring) and clean-up activities.
[3] Accounts for GHG emissions arising from offshore operations, namely from fuel burnt for power generation on the MODU, vessels and helicopters during drilling, installation, inspection, maintenance and decommissioning activities.
[4] Accounts for GHG emissions related to downstream processing, transportation and distribution of Abbey & Baker hydrocarbons, before they reach the end user, as well as end use GHG emissions arising from the combustion of Abbey & Baker gas in homes, businesses and power stations and from the combustion of Abbey & Baker condensate, assuming this is refined into petrol, which is then combusted in vehicles.

In summary, the worst-case total gross GHG emissions generated over the life of the Abbey & Baker Development are estimated to be ca. 16,509.35 kt of CO_2e, based on the High (P10) production case.

Scope 3 emissions are estimated on the worst case assumption of end use combustion of all the extracted Abbey & Baker hydrocarbons. This represents by far the largest component of the total GHG emissions generated over the life of the field (ca. 85% of the total CO_2e emissions) and hence the assessment outlined below is focused on the overall lifecycle net effect and not individual project lifecycle stages.

No Project ('Do Nothing') Scenario

The non-development of the Abbey & Baker fields (the 'do-nothing' scenario) would avoid project-related GHG emissions but would also result in the non-recovery of a viable domestic hydrocarbon resource, with no associated contribution to UK energy supply or economic activity.

The global demand for oil and gas is expected to persist as the world works towards net zero (refer to Section 9.6.3). Consequently, combustion of hydrocarbons and their associated GHG emissions will be prevalent across future climate pathway scenarios.

All gas produced from the Abbey & Baker field will flow into the NTS via the DGT and will be used domestically and not exported. Abbey & Baker will provide the UK with indigenous gas, helping contribute to energy security during the transition to net zero. Responsible stewardship of remaining

offshore reserves ensures that the UK meets its energy demand while retaining control over GHG emissions (refer to Section 9.8).

9.6.2 Evaluating Significance

The principles set out in ISEP (2026) have been used to help determine the significance of the likely effects of the GHG emissions generated from the proposed Abbey & Baker Development on the global climate, whereby the sensitivity of the receptor (i.e. the global climate) and magnitude of impact have been combined to derive the overall significance level.

As indicated in the DESNZ Supplementary Guidance (DESNZ, 2025a), the sensitivity of the global climate to GHG emissions is High. The current state of the climate and the concentration of CO_2 and other GHGs in the atmosphere is described in Section 4.2.6. The Earth's climate is changing. Global temperatures continue to increase, the WMO (2026) confirms that 2015–2025 were the hottest eleven years on record, with 2024 the warmest year on record, at 1.6°C above pre-industrial average levels. The IPCC AR6 states that it is "unequivocal that human influence has warmed the atmosphere, ocean and land". Estimates of current human-induced long-term global warming are around 1.31°C above pre-industrial levels and are rising at 0.26°C per decade (Forster et al., 2025). It is still considered technically possible, however, that the rise in long-term global temperature can be limited to 1.5°C (WMO, 2025), although at the recent COP30 in Brazil it was acknowledged that the world is likely to breach this threshold in the next decade, at least temporarily.

For this assessment the magnitude of impact on GHG emissions reduction pathways, as well as UK oil and gas decarbonisation policies and plans, has been determined using the significance criteria presented in Table 9.4, noting that the sensitivity of the global climate to GHG emissions is High in all cases.

Table 9.4: Significance Criteria

Magnitude	Definition	Significance[1]
Beneficial	The project results in a reduction in atmospheric GHG concentrations, whether directly or indirectly, compared to the without-project baseline. A project with beneficial effects substantially exceeds net zero requirements with a positive climate impact.	Beneficial
Negligible	The project's GHG impacts would be reduced through measures that go well beyond existing and emerging UK oil and gas sector specific net zero policies and plans. A project with negligible effects has minimal residual emissions and goes substantially beyond a GHG emissions reduction trajectory towards achieving net zero by 2050.	Not Significant
Minor adverse	The project's GHG impacts are mitigated through compliance with applicable up-to-date UK oil and gas sector specific net zero policies and plans and 'good practice' GHG reduction measures. A project with minor adverse effects may have residual GHG emissions but aligns with a GHG emissions reduction trajectory towards achieving net zero by 2050.	
Moderate adverse	The project's GHG impacts are partially mitigated through partial compliance with up-to-date UK oil and gas sector specific net zero policies and plans and 'good practice' GHG reduction measures. A project with moderate adverse effects has residual GHG emissions which fall short of fully aligning with a GHG emissions reduction trajectory towards achieving net zero by 2050.	Significant
Major adverse	The project's GHG impacts are not mitigated and do not comply with UK oil and gas sector specific net zero policies and plans.	

Magnitude	Definition	Significance[1]
	A project with major adverse effects is locking in GHG emissions and does not align with a GHG emissions reduction trajectory towards achieving net zero by 2050.	

[1] This assumes that the sensitivity of the global climate to GHG emissions is High in all cases.

In order to contextualise and evaluate the significance of the Abbey & Baker Development's GHG emissions, the following key data sources have been used:

- IPCC Sixth Assessment Report (AR6) (IPCC, 2023a) which explores the projected climate response to five emissions scenarios based on Shared Socio-economic Pathways (SSPs). The SSPs are baseline narrative scenarios that identify socio-economic and geopolitical assumptions and economic and technological trends. These are then combined with different emissions trajectories, based on the Representative Concentration Pathways (RCP) scenarios from the IPCC's Fifth Assessment Report (AR5), to impose global warming targets.
- International Energy Agency (IEA) World Energy Outlook Scenarios (IEA, 2025), which model future global energy demand and supply under different policy scenarios, including the Net Zero Emissions by 2050 Scenario (NZE) which shows a global pathway to reach net zero emissions from the energy sector by 2050. This emissions trajectory is consistent with keeping the temperature rise in 2100 below 1.5°C (with at least a 50% probability).
- Production Gap Report (2025), which assesses the disparity between government's planned fossil fuel production and production levels consistent with pathways limiting global warming to 1.5 °C and 2 °C. The report provides forward-looking projections of global oil and gas production based on governments' plans and policies, highlighting the extent to which existing and proposed developments exceed levels aligned with internationally agreed climate targets.
- The Global Energy Review 2026 (IEA, 2026) is an annual IEA publication providing an assessment of energy sector trends across all major fuels, technologies, and regions for the preceding calendar year (2025), including energy demand, electricity, and energy-related CO_2 emissions.
- UK carbon budgets, NDCs and the CCC's 'Balanced Pathway' Scenario (CCC, 2025a), which is a framework for the UK's approach to achieving net zero emissions by 2050. The 'Balanced Pathway' scenario includes future projections for UK oil and gas demand and production based on NSTA production projections of existing and future developments (including sanctioned but not yet producing fields).

Where global reduction pathways have been used to help contextualise the magnitude of impact the Abbey & Baker Development's GHG emissions will have on the climate, this approach is considered to be inherently cumulative as these pathways take into account a wide range of existing and planned projects and other activities. These forward-looking pathways provide a proxy for the evolving baseline, as they incorporate anticipated GHG emissions from existing and planned oil and gas developments, such as Abbey & Baker, as well as broader sectoral and policy trends - including those relating to future oil and gas development and consumption.

In addition, to inform the cumulative impact assessment, the Global Oil and Gas Extraction Tracker (GOGET, 2026) has been used to quantify and forecast reserves and production of oil and gas extraction projects, both existing and those under development. Data from Trout et al. (2022) has also been used to determine the committed global CO_2 emissions from fossil fuel-producing infrastructure, defined as existing and under-construction oil and gas fields and coal mines, in comparison to global carbon budgets (GCP, 2025).

Assumptions, Limitations and Uncertainties

The following assumptions, limitations and uncertainties are applicable to the assessment documented below:

- The actual end-use and fate of the Abbey & Baker hydrocarbons may vary. Abbey & Baker gas will enter the UK's NTS via the DGT to be transported through a network of pipelines across the UK. The gas is delivered to places where it is used, such as gas-fired power stations, large

industrial users, or regional gas distribution networks that connect to individual homes and businesses. In contrast, the stabilised liquid hydrocarbons are exported by tanker from the DGT to Saltend Refinery for further processing. From Saltend Refinery, liquid hydrocarbons are primarily sent to refineries worldwide by tanker where they are converted into usable fuels such as gasoline, diesel, and jet fuel. The byproducts from this process often serve as raw materials for chemical productions, leading to the generation of plastics, fertilizers, and pharmaceuticals. As such, it is possible that not all end use Abbey & Baker hydrocarbons will be combusted. However, to ensure a worst case scenario has been presented, for the purposes of this assessment it is assumed that all Abbey & Baker condensate is refined into petrol and is then combusted in vehicles.

- The quantification of GHG emissions is based on well-established emission factors (EFs) derived from recognised guidance (i.e. EEMS, DESNZ, IPCC) and are considered to represent best available data for the purposes of this assessment. EFs for combustion sources are considered to be of low uncertainty; fugitive and venting sources carry comparatively higher uncertainty, as facility-specific operating conditions can diverge from the population-level averages represented in generic guidance, and this limitation is acknowledged in the interpretation of results. Where specific EFs were not available, values have been selected on the basis of professional judgement and documented in Appendix D.
- The assessment uses data from publicly available government and international databases. Some of this data is updated regularly, reflecting analysis of changing trends in product demand or changing composition of fuels, products and GHG inventories. The variations in such numbers are minor, and sensitivity analysis confirms that re-calculating project emissions, or data comparisons, with any updated values would have a low impact on the emissions estimates provided in this ES and would not alter the conclusions of the impact assessment.

The key data sources used to inform the assessment, as listed above, also have assumptions, limitations and uncertainties, as summarised in Table 9.5. These have been factored into the overall conclusions of the assessment, where relevant.

Table 9.5: Assumptions, limitations and uncertainties of modelled datasets

Data Source	Scope of dataset used in assessment	Assumptions, limitations & uncertainties
IPCC (2022b)	Projections of global GHG emissions across emissions reduction pathway scenarios (refer to Section 9.6.4)	All GHG emission metrics used carry inherent limitations and uncertainties, given that they simplify the complexity of the physical climate system and its response to past and future GHG emissions. The emissions pathways and scenarios project the evolution of GHG emissions based on a set of internally consistent assumptions about future socio-economic conditions and related mitigation measures. Key assumptions relate to technology development in agriculture and energy systems and socio-economic development, including demographic and economic projections. The SSP pathways are not empirical projections; CO_2 emissions from land use, land-use change, and forestry (CO_2-LULUCF) are subject to large uncertainties and high annual variability. GHG projections detailed in Table 9.10 represent the median and 5^{th} – 95^{th} percentiles (Lower Range – Upper Range) across modelled pathways only.
PGR (2022)	Projections of global oil and gas production demand across emissions reduction	Conversion factors embedded within the PGR (2022) dataset from EJ/yr to Mbbl (Oil) or Tm^3 (Gas) are derived from 2021 IEA statistics, but since those factors are fixed constants applied across all years, any shift in global fuel quality or composition mix toward 2050 is unaccounted for, adding uncertainty to the physical unit outputs (i.e. Mbbl or Tm^3). The 1.5°C and 2°C

Data Source	Scope of dataset used in assessment	Assumptions, limitations & uncertainties
	pathway scenarios (refer to Section 9.6.3)	pathways are drawn directly from the IPCC AR6 WGIII assessed mitigation scenario database, uncertainty is therefore inherited from the IPCC AR6 model ensemble (refer to limitations in IPCC (2022b) above). The Announced Pledges Scenario (APS) is an IEA modelled scenario reflecting governments' announced climate pledges, even if not yet backed by detailed policies, and are therefore not guaranteed future outcomes.
IEA (2025) WEO-2025 Dataset	Projections of future global energy demand under a Net Zero Emissions by 2050 scenario (refer to Section 9.6.3)	IEA (2025) WEO-2025 dataset covers energy supply, total final consumption, electricity sector, and CO_2 emissions from fossil fuel combustion and industrial processes, although non-combustion GHG sources and LULUCF are excluded. The NZE Scenario returns below 1.5°C by 2100 relying on the input of CO_2 removal technologies that are currently unproven at scale. Furthermore, WEO-2025 does not include the APS, which models a future in which key national energy and climate targets are achieved in full and on time, as at the time of publication an insufficient number of countries had submitted their 2035 NDCs. For this ES, reference year values from IEA (2025) were converted from EJ to Gt CO_2e using IPCC (2006) conversion factor (kg CO_2/GJ, kg CH_4/GJ and kg N_2O/GJ). CH_4 and N_2O default factors apply to technologies without emission controls and are applicable only for steady and optimal combustion conditions; they do not account for start-ups, shutdowns, or partial load operation. The CO_2 emission factor assumes a carbon oxidation factor of 1, i.e., complete combustion.
GCP (2025)	Forecasted remaining global carbon budget (refer to Section 9.6.4)	The remaining carbon budget figures reported by the Global Carbon Budget 2025: 170 $GtCO_2e$, 525 $GtCO_2e$, and 1055 $GtCO_2e$ for 1.5°C, 1.7°C, and 2.0°C respectively are central estimates at a 50% probability threshold from the beginning of 2026. Key uncertainty sources include the transient climate response to cumulative CO_2 emissions, non-CO_2 forcing assumptions, Earth System Feedback corrections for unrepresented processes such as permafrost thaw, and the historical warming baseline (GCP, 2025).
GEM (2026) GOGET Dataset (2026)	Current and forecasted global oil and gas production and field reserves (refer to Section 9.6.3)	Data inclusion is restricted to projects with production of 1 million boe/yr or more and/or reserves of 25 million boe or more, meaning smaller fields are systematically excluded. Coverage is further constrained by a strict public-sources-only policy, meaning any project without publicly accessible data is absent entirely (GEM, 2026).
UK Carbon Budgets (CCC, 2025a; 2025b; 2025c)	UK National Carbon Budget Targets (refer to Section 9.6.5)	CB5 (2028 to 2032) CB6 (2033 to 2037) face delivery uncertainty, with the CCC identifying insufficient plans for 14% of required reductions, principally heat pumps and engineered removals, and a residual gap the Government proposes to close through unquantified measures. The CB6 baseline is further sensitive to macroeconomic conditions, fossil fuel prices and behavioural change (HM Government, 2025; CCC, 2025c).

Data Source	Scope of dataset used in assessment	Assumptions, limitations & uncertainties
		CB7(2038 to 2042) carries greater uncertainty, characterised by the CCC as "ambitious but deliverable" only if significant policy gaps are closed, with cost uncertainty around CCUS, hydrogen and industrial decarbonisation representing the largest risk in 2040 (CCC, 2025a; 2025b)

9.6.3 Abbey & Baker in the Context of Future Oil and Gas Production and Demand

Global Oil and Gas Production and Demand

The IPCC indicates that there is global demand for oil and gas in all future climate scenarios. Success in decarbonisation will reduce the demand for fossil fuels, however not all end-uses are expected to be commercially electrifiable in the short to medium term (i.e. within the life of Abbey & Baker Development) and many will require low GHG liquid and gaseous fuels (IPCC, 2023c).

The UNEP Production Gap Report (PGR) (SEI, 2023; PGR; 2025) evaluates the fossil fuel production outlooks of twenty major producing countries, including the UK, and benchmarks these against climate model projections aligned with the Paris Agreement's temperature objectives. The "production gap" represents the shortfall between governments' planned fossil fuel output and the production levels consistent with pathways limiting global temperature change to 1.5°C or well below 2°C above pre-industrial levels.

Table 9.6 and Table 9.7 compare the proposed Abbey & Baker production rates in five reference years during the period from 2030 to 2050 with predicted future global gas and oil production rates under different international energy demand pathway scenarios, noting that Abbey & Baker will cease production in or before 2044. Table 9.8 compares the proposed Abbey & Baker production rates during this period with predicted future global energy demand for total energy, oil, and gas.

It can be seen from Tables 9.6 to 9.8 that the proposed Abbey & Baker Development contributes a very small percentage towards predicted global oil and gas production rates and forecasted demand, which is insignificant in scale. However, it should be noted that estimating future fossil fuel availability and use across global emissions reduction pathways is subject to considerable uncertainty (IPCC, 2023c; IEA, 2021; IEA, 2025). Integrated assessment models used by the IPCC and IEA show that outcomes vary significantly depending on assumptions about policy strength, energy demand, and technological change. As such, projections of fossil fuel production and consumption should be interpreted as indicative ranges rather than precise forecasts (IPCC, 2023c; IEA, 2021; IEA, 2025).

In addition to the above, the Global Oil and Gas Extraction Tracker (GOGET) (GEM, 2026) provides comprehensive data on oil and gas projects worldwide, including production volumes and reserves from active extraction areas, areas under development and oil and gas discoveries. Abbey & Baker's P10 field reserves (8,206 Mm^3 of gas and 2.14 MMbbl of condensate) add only a very small fraction towards the global reserves recorded within GOGET. At the time of this assessment, the Abbey & Baker Development would increase global gas reserves by 0.0058% (originally 141,496,111 Mm^3/yr) and global condensate reserves by 0.0096% (originally 22,354.26 MMbbl/yr).

Table 9.6: Abbey & Baker Development in the context of Future Global Gas Demand across International Pathways (PGR, 2025)

Parameter	Reference Year				
	2030	2035	2040	2045	2050
IEA Announced Pledges Scenario (APS) [3]					
Global Gas Production Value (Tm^3/yr) [1]	4.03	3.51	3.08	2.76	2.48
Development Projected proportion [2]	0.02680%	0.01465%	0.00840%	N/A	N/A
Pathways Consistent with 2℃ (Median)					
Global Gas Production Value (Tm^3/yr) [1]	3.91	3.67	3.46	3.32	3.34
Development projected proportion [2]	0.02762%	0.01401%	0.00748%	N/A	N/A
Pathways Consistent with 1.5℃ (Median)					
Global Gas Production Value (Tm^3/yr) [1]	2.72	2.37	2.20	1.99	1.78
Development projected proportion [2]	0.03971%	0.02170%	0.01176%	N/A	N/A

[1] Data source (PGR, 2025), values converted from exajoules (EJ) per year (EJ/yr) to Gas using a factor of 0.029 Trillion (Tera, 10^{12}) cubic metres per year (Tm^3/yr).
[2] Based on Abbey & Baker High production case production profile volume for Gas in the reference year (2030 = 1,080.10 Mm^3; 2035 = 514.25 Mm^3, 2040 = 258.73 Mm^3)
[3] An IEA scenario that models future energy demand and supply based on governments' announced climate pledges, even if not yet backed by detailed policies.

Table 9.7: Abbey & Baker Development in the context of Future Global Oil Demand across International Pathways (PGR, 2025)

Parameter	Reference Year				
	2030	2035	2040	2045	2050
IEA Announced Pledges Scenario (APS) [3]					
Global Oil Production Value (Mbbl/d) [1]	90.50	79.98	68.47	59.06	52.16
Development projected proportion [2]	0.00086%	0.00046%	0.00026%	N/A	N/A
Pathways Consistent with 2℃ (Median)					
Global Oil Production Value (Mbbl/d) [1]	99.65	94.00	83.03	69.78	57.83
Development projected proportion [2]	0.00078%	0.00039%	0.00022%	N/A	N/A
Pathways Consistent with 1.5℃ (Median)					
Global Oil Production Value (Mbbl/d) [1]	88.55	78.92	63.32	45.85	32.20
Development projected proportion [2]	0.00088%	0.00046%	0.00029%	N/A	N/A

[1] Data source (PGR, 2025), values converted from exajoules (EJ) per year (EJ/yr) to Oil using a factor of 0.526 million barrels per day (Mbbl/d)
[2] Based on Abbey & Baker High production case profile volume for Oil in the reference year (2030 = 781 bbl/d; 2035 = 366 bbl/d, 2040 = 181 bbl/d) – Refer to Section 3.6.1 for bbl/d rates.
[3] An IEA scenario that models future energy demand and supply based on governments' announced climate pledges, even if not yet backed by detailed policies.

Table 9.8: Abbey & Baker Development in the context of Future Global Energy Supply (IEA, 2025)

Parameter	Reference Year		
	2035	2040	2050
IEA Net Zero Emissions by 2050 Scenario [5]			
Natural Gas World Energy Supply ($GtCO_2e$) [1]	5.12	3.49	1.69
Development projected Gas proportion [2]	0.01876%	0.01385%	N/A
Oil World Energy Supply ($GtCO_2e$) [1]	9.50	6.74	3.33
Development projected Oil proportion [3]	0.00035%	<0.00001%	N/A
Total World Energy Supply ($GtCO_2e$) [1]	42.74	41.26	42.72
Development projected Total proportion [4]	0.00241%	0.00125%	N/A

[1] Source IEA World Energy Outlook 2025 Report (IEA, 2025), reference year values were calculated from EJ to Gt CO_2e using IPCC (2006) conversion factor (kg CO_2/GJ, kg CH_4/GJ and kg N_2O/GJ) alongside relevant AR5 Global Warming Potential (GWP) Values (CO_2 = 1, CH_4 = 28, N_2O = 265).

[2] Gas comparison based on the worst-case total GHG emissions generated from the Abbey & Baker Development in 2035 = 960.45 kt CO_2e / 2040 = 483.32 kt CO_2e, assuming the Abbey & Baker high production case for Gas. The total is based on the total direct GHG emissions (Scope 1) and total indirect downstream GHG emissions (Scope 3) generated in 2035 and 2040, with the Scope 1 emissions adjusted based on Gas:Oil production ratio of 0.95:0.05

[3] Oil comparison based on the worst-case total GHG emissions generated from the Abbey & Baker Development in 2035 = 67.50 kt CO_2e / 2040 = 33.45 kt CO_2e, assuming the Abbey & Baker high production case for Oil. The total is based on the total direct GHG emissions (Scope 1) and total indirect downstream GHG emissions (Scope 3) generated in 2035 and 2040, with the Scope 1 emissions adjusted based on Gas:Oil production ratio of 0.95:0.05

[4] Total World Energy Comparison based on the worst-case total gross GHG emissions generated from the Abbey & Baker Development in 2035 = 1,027.95 kt CO_2e / 2040 = 516.76 kt CO_2e, assuming the Abbey & Baker High production case. The total is based on the total direct GHG emissions (Scope 1) and total indirect downstream GHG emissions (Scope 3) generated in 2035 for Gas[2] + Oil[3].

[5] An IEA Scenario where Net Zero Emissions by 2050 are consistent with keeping the temperature rise in 2100 below 1.5°C (with at least a 50% probability).

UK Oil and Gas Production and Demand

The CCC's Balanced Pathway, an emissions reduction pathway from 2025 to net zero by 2050, is in line with all of the UK's legislated carbon budgets and stated NDCs. The Balanced Pathway involves a steep decline in the consumption of oil and gas, reducing by 84% and 76% from 2026 levels respectively by 2050. However, a demand for oil and gas continues to remain in the net zero aligned Balanced Pathway scenario to 2050 and beyond.

Oil and gas fields in the North Sea are mature and declining in output. Even without any global action to reduce GHG emissions, production is expected to fall significantly by 2050. Declining production from the UK's mature North Sea basin indicates that GHG emissions will fall in the baseline pathway[4] by around 40% by 2040 compared to 2025 levels, including the production emissions from potential new oil and gas fields. After taking account of the reduction in production and refining emissions due to declining baseline activity and cross-economy fuel switching, only around 13 $MtCO_2e$ of emissions remain by 2040. In the Balanced Pathway, around 60% of these remaining emissions are abated. For oil and gas platforms, the majority of abatement results from electrification of offshore oil and gas platforms, and from reducing methane flaring and venting (CCC, 2025a).

The majority of fuels currently used in the UK are traded internationally, and the UK is a net importer of both oil and gas (PGR, 2025; CCC, 2025a). In the short term the UK will continue to be dependent on gas, including for heating buildings and marginal production within the power sector (CCC, 2020) and while demand for petroleum products is likely to fall in some parts of the economy such as road transport (i.e. a shift towards electric vehicles), all major forecasters expect resilient or even growing demand for other uses of hydrocarbons such as petrochemicals (IEA, 2018).

[4] A hypothetical baseline pathway that does not include further climate action.

Table 9.9 and Figure 9.3 compares the Abbey & Baker High case gas production rates with projected UK gas demand and domestic gas production over the Abbey & Baker's likely period of production (2029 – 2044). It can be seen from this that during the period 2029 to 2044, the proposed Abbey & Baker Development would account for ca. 1.87% or less of UK gas demand under the CB7 Balanced Pathway and ca. 1.76% or less under the DESNZ Net Zero Pathway.

Projected UK gas production follows a declining trend, consistent with historical patterns and field maturity in the UKCS, but is less than UK gas demand under both the CB7 Balanced Pathway and DESNZ Net Zero Pathway in all years during the period 2029 - 2044. At its peak, Abbey & Baker makes up ca. 5.41% of projected NSTA (2026b) UK gas production.

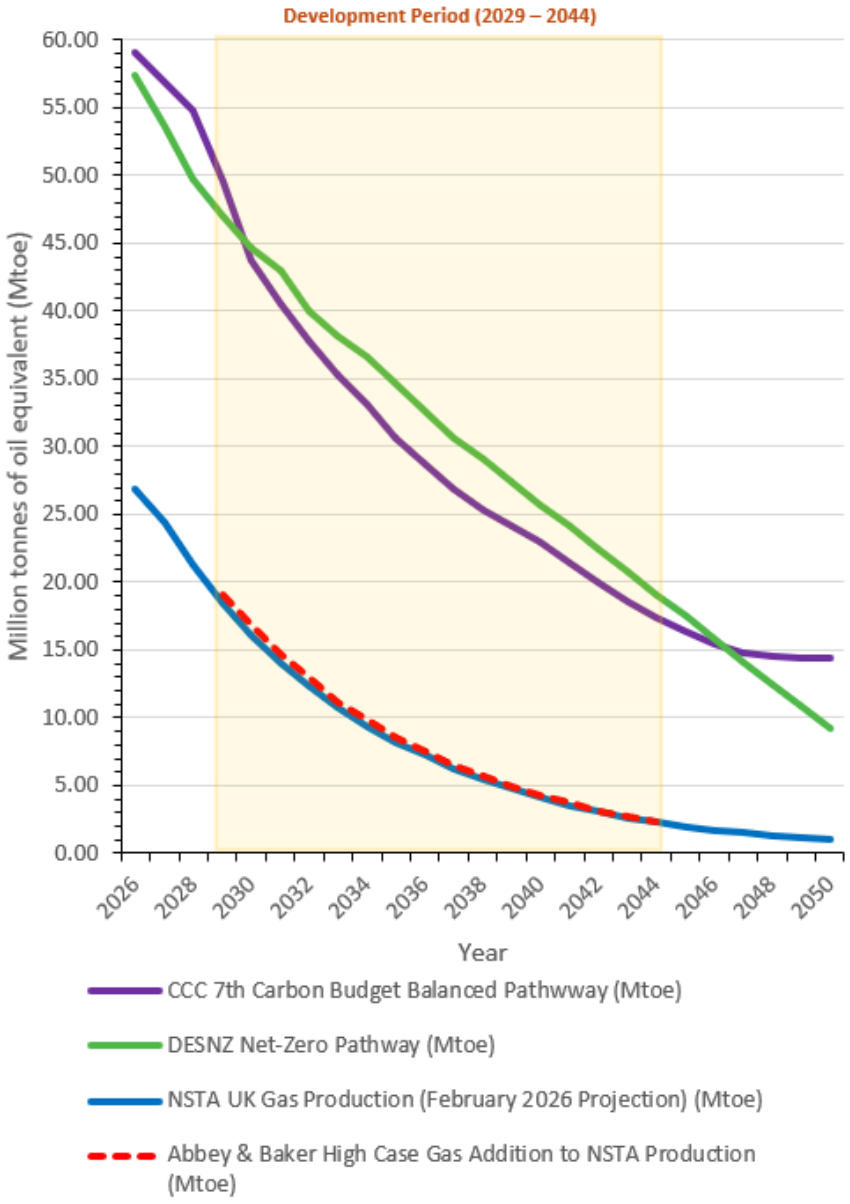
Table 9.9: Abbey & Baker Development in the context of Projected UK Gas Demand and Domestic Production (2029 – 2044) (NSTA, 2026b)

Year	UK Gas Demand				UK Gas Production	
	CCC 7th Carbon Budget Balanced Pathway (Mtoe)[1]	Development projected proportion[2]	DESNZ Net Zero Pathway (Mtoe)[1]	Development projected proportion[2]	NSTA UK (Feb 2026 Projection) (Mtoe)[1]	Development projected proportion[2]
2029	49.62	1.17%	47.00	1.23%	18.47	3.14%
2030	43.69	1.77%	44.72	1.73%	16.07	4.80%
2031	40.53	1.87%	42.97	1.76%	13.98	5.41%
2032	37.77	1.74%	40.02	1.65%	12.29	5.36%
2033	35.34	1.49%	38.16	1.38%	10.72	4.91%
2034	33.07	1.32%	36.56	1.19%	9.41	4.63%
2035	30.66	1.20%	34.65	1.06%	8.24	4.46%
2036	28.64	1.10%	32.61	0.97%	7.24	4.36%
2037	26.88	1.02%	30.71	0.89%	6.29	4.36%
2038	25.27	0.95%	29.05	0.82%	5.50	4.35%
2039	24.10	0.86%	27.40	0.76%	4.78	4.36%
2040	23.00	0.80%	25.74	0.72%	4.10	4.51%
2041	21.48	0.76%	24.09	0.68%	3.56	4.60%
2042	19.96	0.73%	22.43	0.65%	3.05	4.76%
2043	18.55	0.70%	20.78	0.62%	2.66	4.87%
2044	17.37	0.62%	19.13	0.56%	2.29	4.69%

[1] February 2026 Projections (NSTA, 2026b)

[2] Abbey & Baker projected proportion from the high production case (refer to Appendix D and Section 3.6.1) gas converted from tonnes to Million tonnes of oil equivalent (Mtoe); Assumes 1 toe = ~41.868 GJ (IEA, 2023); Assumes 1 tonne of Natural Gas = ~48.5 GJ (based on average 42-55 MJ/kg for Natural Gas (WNA, 2025)), therefore Mtoe = Natural Gas (tonnes) × (48.5/ (41.868 × 10^6)), or 1 t Natural Gas = 0.0000011584 Mtoe.

Figure 9.3: Abbey & Baker Production (High case) in the Context of Future UK Gas Demand and Domestic Production (NSTA, 2026b)



9.6.4 Abbey & Baker in the Context of Global Emissions Reduction Pathways

As noted in Section 4.2.6, the IPCC's SSP scenarios, combined with RCP scenarios - SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5 - provide a framework for assessing future global GHG emissions trajectories under differing socio-economic and policy assumptions. These pathways illustrate how emissions may evolve under varying levels of climate ambition; from very low (SSP1-1.9) pathways consistent with limiting warming to 1.5°C, to very high (SSP5-8.5) pathways associated with continued fossil fuel use and limited mitigation.

It is worth noting that in the most recent Emissions Gap Report (UNEP, 2025), current global climate pledges are off-track, projecting 2.3–2.8°C warming against Paris targets, with a widening emissions reduction gap (UNEP 2025); this is consistent with IEA WEO (2025) assessment of global levels heading towards outcomes in the range of 2.5-3°C. Drawing on this, GHG emissions projections can therefore be reasonably bounded by SSP scenarios consistent with limiting warming below 3°C (SSP1-1.9, SSP1-2.6, SSP2-4.5). Notwithstanding this, the following analysis assesses potential impacts against the full

range of SSP scenarios (SSP1-1.9 through SSP5-8.5) to ensure the assessment remains robust in the event that global mitigation efforts do not materialise as currently pledged.

To place the Abbey & Baker Development in this global context, Table 9.10 compares the total GHG emissions predicted to be generated by the Development in a reference year (2030, 2040) with the median global GHG emissions projected under each SSP scenario to illustrate the proportional contribution of the Project under a range of future climate pathways. Of note, cessation of production for Abbey & Baker is predicted to occur in or before 2044 and therefore the Project will not contribute to global GHG emissions in 2050.

In 2030, Abbey & Baker's projected GHG emissions are estimated to represent between 0.00304% and 0.00655% of median global GHG emissions, and in 2040 projected GHG emissions are estimated to represent between 0.00065% and 0.00287% of median global GHG emissions. These values are dependent on the SSP pathway considered (refer to Table 9.10). The proportion is highest under the SSP1-1.9 (very low) scenario, where global GHG emissions are projected to decline rapidly to around 33 $GtCO_2e$ (median) per year in 2030 / 18 $GtCO_2e$ (median) per year in 2040, and lowest under the SSP5-8.5 (very high) scenario, where emissions reach approximately 71 $GtCO_2e$ (median) per year in 2030 / 80 $GtCO_2e$ (median) per year in 2040. This variation reflects the differing assumptions about future global energy use and mitigation policy embedded within each pathway. Regardless, Abbey & Baker's contribution represents a very small fraction of projected global totals under all SPP scenarios.

The IEA Global Energy Review estimates 2025 global energy-related CO_2 emissions attributable to natural gas and oil at 7,802 $MtCO_2$ and 11,517 $MtCO_2$ respectively, including the industrial process emissions to produce the energy supply (IEA, 2026). The proposed Abbey & Baker Development's total lifetime downstream Scope 3 emissions account for only 0.19639% of a single year's global natural gas share, and 0.00936% of the oil share, reaffirming that the Abbey & Baker Development would not materially influence global CO_2 emissions trajectories.

This point is further illustrated by the fact that the worst case total GHG emissions generated from the Abbey & Baker Development over the life of the field (ca. 2029 – 2044) represent less than 0.0097% of the remaining global carbon budget under a 1.5°C scenario (170 $GtCO_2e$; GCP, 2025), 0.0031% under a 1.7°C scenario (525 $GtCO_2e$; GCP, 2025), and less than 0.0016% under a 2.0°C scenario (1,055 $GtCO_2e$; GCP, 2025).

As context, Trout et al. (2022) have provided a bottom-up assessment of committed CO_2 emissions from existing fossil fuel extraction projects. This study concluded that combustion of reserves within already operating or under-development infrastructure equates to approximately 936 Gt CO_2 (comprised of ca. 446 Gt CO_2 from coal reserves, ca. 323 Gt CO_2 from oil reserves, and ca. 165 Gt CO_2 from gas reserves), which exceeds the remaining global carbon budgets under a 1.5°C-compatible scenario (170 Gt CO_2e; GCP, 2025), but remains within the global carbon budget for a 2.0°C scenario (1,055 $GtCO_2e$; GCP, 2025; Figure 9.4). The combustion of hydrocarbons from the Abbey & Baker Development (i.e. the total Scope 3 end use emissions), would account for just 0.01160% of the remaining Global Carbon Budget under a 2˚ C scenario (121 $GtCO_2$).

Given this negligible proportional impact, the Project on its own would not significantly affect a GHG emissions reduction trajectory towards achieving net zero by 2050, particularly as the Abbey & Baker Development is scheduled to cease production prior to 2050. However, regardless of whether the Project goes ahead, given the range of possible emissions reduction pathways available, which are dependent on the scale of effort different countries make to reduce their national emissions, it is uncertain whether net zero on a global basis will be achieved by ca. 2050.

The potential effects of climate change over the life of the Abbey & Baker Development are illustrated in Figure 9.5 and are discussed in Section 4.2.4. Across all SSP scenarios, near-term warming trajectories converge, meaning the severity of pre-2050 impacts are broadly comparable between SSP scenarios for most receptor groups. Post-2050, the gap between low and high emission pathways widens substantially across all receptor groups, driven by the compounding effects of cumulative emissions, system feedbacks and the irreversibility of many climate-driven changes. The significance of the effects of climate change on global receptors is therefore dependent on the emissions reduction pathway, with SSP1-1.9 being the least severe and SSP5-8.5 being the most severe. However, the effect of the

proposed Abbey & Baker Development on this uncertain baseline is not significant given the negligible proportional impact of the Project.

Table 9.10: Abbey & Baker Development in the context of Future Global Shared Socioeconomic Pathways (IPCC, 2022b)

Parameter	Reference Year			Key Assumptions of SSP
	2030	2040	2050	
GHG Emissions Scenario: SSP 1 – 1.9 (Very Low), limit warming to 1.5°C				
Median Global GHG Emissions ($GtCO_2e/yr$) [1]	33 (22 – 37)	18 (6 – 24)	8 (0 – 15)	Rapid decarbonisation, societies switch to more sustainable practices, inequality falls. Net zero CO_2 achieved in ca. 2050.
Development projected proportion [2]	0.00655%	0.00287%	N/A	
GHG Emissions Scenario: SSP 1 – 2.6 (Low), limit warming to 2°C				
Median Global GHG Emissions ($GtCO_2e/yr$) [1]	40 (30 – 49)	29 (21 – 36)	20 (14 – 27)	Socioeconomic shifts towards sustainability, but reduction in CO_2 emissions is slower than SSP1-1.9. Net zero CO_2 achieved in ca. 2070.
Development projected proportion [2]	0.00540%	0.00178%	N/A	
GHG Emissions Scenario: SSP 2 – 4.5 (Intermediate), limit warming to 3°C				
Median Global GHG Emissions ($GtCO_2e/yr$) [1]	54 (50 – 62)	53 (48 – 61)	52 (45 – 57)	Current policies continue. Slow progress toward sustainability and development and income grow unevenly. CO_2 emissions hover around current levels before starting to fall mid-century. Net zero CO_2 is not achieved by 2100.
Development projected proportion [2]	0.00400%	0.00098%	N/A	
GHG Emissions Scenario: SSP 3 – 7.0 (High), limit warming to 4°C				
Median Global GHG Emissions ($GtCO_2e/yr$) [1]	62 (53 – 69)	67 (56 – 76)	70 (58 – 83)	Fragmented, high fossil use, inequality. CO_2 emissions roughly double from current levels by 2100
Development projected proportion [2]	0.00349%	0.00077%	N/A	
GHG Emissions Scenario: SSP 5 – 8.5 (Very High), exceed warming of 4°C				
Median Global GHG Emissions ($GtCO_2e/yr$) [1]	71 (69 – 81)	80 (78 – 96)	88 (82 – 112)	Rapid economic growth without mitigation, fuelled by exploiting fossil fuels and energy-intensive lifestyles. Current CO_2 emissions roughly double by 2050.
Development projected proportion [2]	0.00304%	0.00065%	N/A	

[1] Data source (IPCC, 2022b; Chapter 3, Table 3.2), median data shown with (Lower Range – Upper Range) of harmonised GHG emissions across the pathways.

[2] Based on the worst-case total gross GHG emissions generated from the Abbey & Baker Development (Downstream Scope 3 + Scope 1) of 2,160.96 kt CO_2e in 2030 and 516.76 kt CO_2e in 2040, assuming the High production case.

Figure 9.4: Existing Fossil Fuel Projects Combustion Reserves as a proportion of the 2.0˚ C Global Carbon Budget (Trout et al., 2022; GCP, 2025)

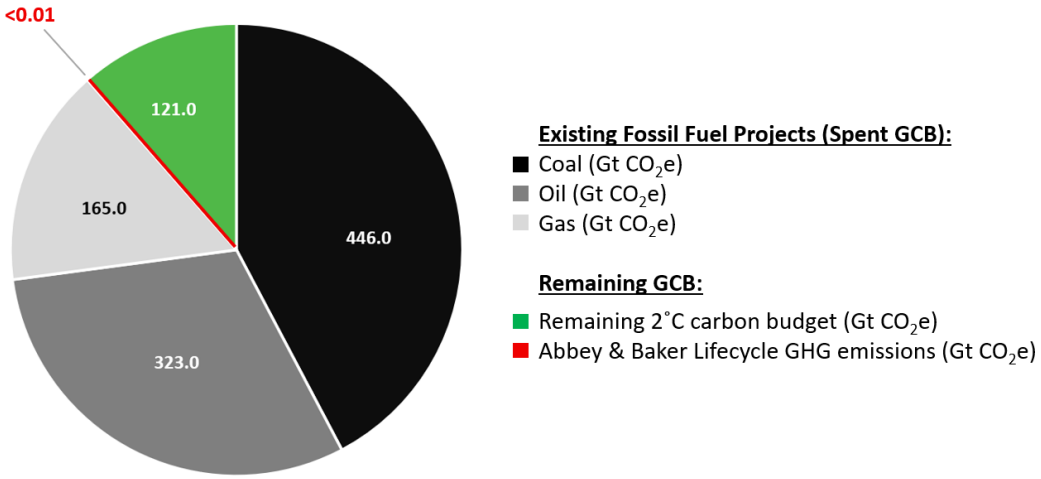
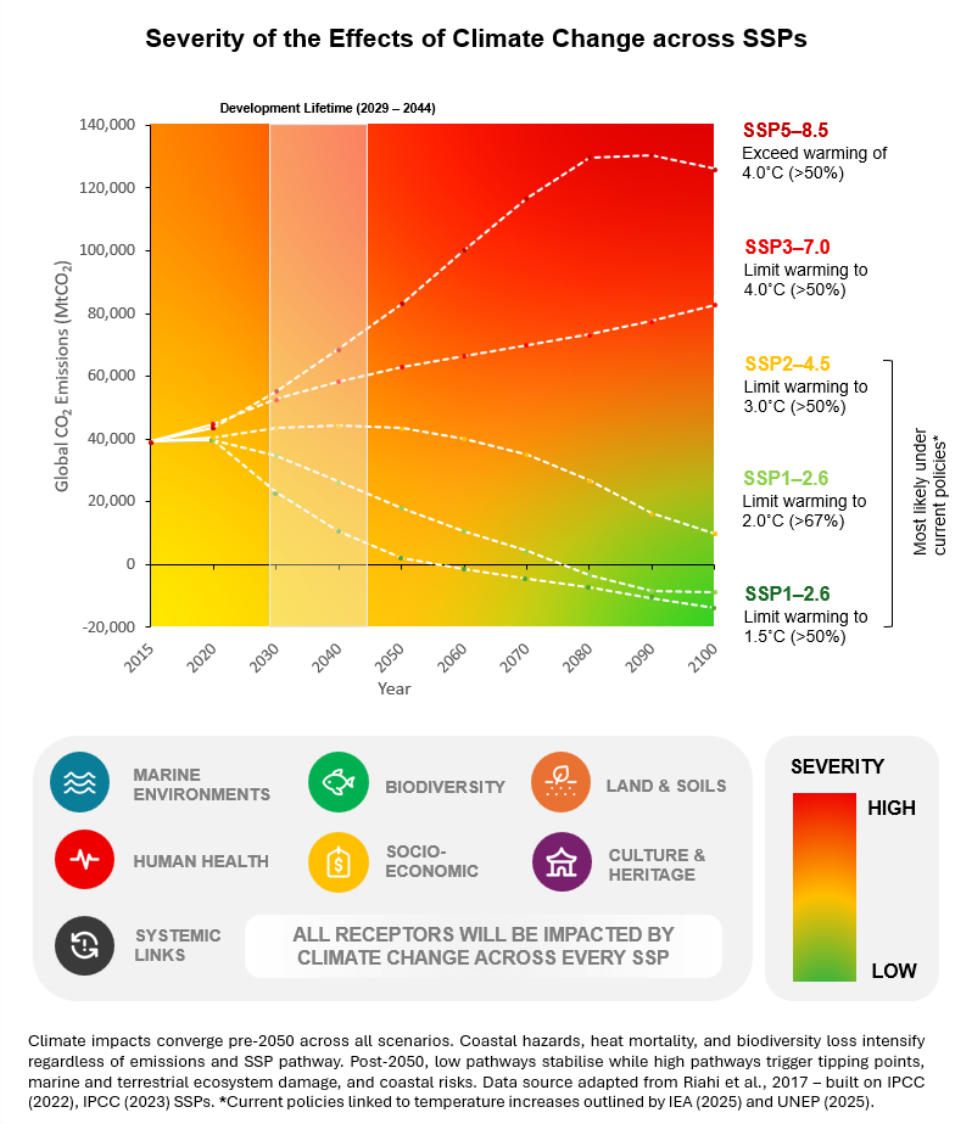


Figure 9.5: Severity of the Effects of Climate Change Across SSPs



Climate impacts converge pre-2050 across all scenarios. Coastal hazards, heat mortality, and biodiversity loss intensify regardless of emissions and SSP pathway. Post-2050, low pathways stabilise while high pathways trigger tipping points, marine and terrestrial ecosystem damage, and coastal risks. Data source adapted from Riahi et al., 2017 – built on IPCC (2022), IPCC (2023) SSPs. *Current policies linked to temperature increases outlined by IEA (2025) and UNEP (2025).

9.6.5 Abbey & Baker in the Context of UK Emissions Reduction Pathways

UK Carbon Budgets

As noted in Section 9.3.2, the Climate Change Act requires the UK government to set five-yearly legally-binding carbon budgets, 12 years in advance, from 2008 to 2050, which restrict the amount of GHGs the UK can emit. UK Carbon Budgets are economy-wide emissions limits, and do not prohibit oil and gas production.

To place the Abbey & Baker Development in the context of the UK carbon budgets, Table 9.11 compares the total gross GHG emissions predicted to be generated by the Abbey & Baker Development with the fifth, sixth and seventh carbon budget allowances (i.e. the budgets which cover the period when the Abbey & Baker field is likely to be in production – note that at the time of writing this environmental statement the seventh carbon budget is yet to be ratified). As it is possible that not all end use Abbey & Baker hydrocarbons will be combusted in the UK, the carbon budget allowances have also been compared with the total direct (Scope 1) GHG emissions predicted to be generated from the Abbey & Baker Development, which will occur in the UK.

Table 9.11: Abbey & Baker Development Emissions in the context of UK Carbon Budgets (CCC, 2025a)

Carbon Budget (CB)	Period	CB Allowance (Mt CO_2e)	Development Total gross GHG projected proportion [1]	Development Scope 1 projected proportion [2]
CB5	2028 to 2032	1,725	0.45410% (7.83 MtCO_2e)	0.00240% (0.04 MtCO_2e)
CB6	2033 to 2037	965	0.55689% (5.37 MtCO_2e)	0.00010% (<0.01 MtCO_2e)
CB7 [3]	2038 to 2042	535	0.49301% (2.64 MtCO_2e)	0.00018% (<0.01 MtCO_2e)

[1] Based on the worst-case total gross GHG emissions (Scope 1 + Scope 3 Upstream (Inspection & Maintenance only for CB6 and CB7) + Scope 3 Downstream) generated from the Abbey & Baker Development for the relevant CB period (7,833.28 kt CO_2e for CB5; 5,374.03 kt CO_2e for CB6; 2,637.58 kt CO_2e for CB7), assuming the Abbey & Baker High production case. Noting that emissions from Abbey & Baker will start in 2029, and end in 2044.
[2] Based on the total direct Scope 1 GHG emissions generated from the Abbey & Baker Development for the relevant CB period (41.34 kt CO_2e for CB5 (includes well testing and clean-up); and 0.97 kt CO_2e for CB6 and CB7), assuming the Abbey & Baker High production case. Noting that emissions from Abbey & Baker will start in 2029, and end in 2044 for the High production case.
[3] At the time of this assessment, CB7 is proposed to be 535 MtCO_2e, and is yet to be ratified.

It can be seen from Table 9.11, that Abbey & Baker's contribution is less than ca. 0.45410% of CB5, 0.55689% of CB6 and 0.49301% of CB7 when comparing the total gross GHG emissions that will be generated during the relevant carbon budget period and less than ca. 0.00240% of CB5, 0.00010% of CB6 and 0.00018% of CB7 when comparing the total direct (Scope 1) GHG emissions that will be generated during the relevant carbon budget period.

Given that this represents an insignificant proportion of the budgets, the GHG emissions generated by the Abbey & Baker Development would have no material influence on the UK's ability to meet its statutory carbon budget targets, resulting in a Minor Adverse magnitude of impact (Not Significant). In addition, UK Carbon Budgets are economy-wide emissions limits, and do not prohibit oil and gas production, including the Abbey & Baker development.

UK Nationally Determined Contribution (NDC)

The UK's 2030 NDC commitment is to reduce all GHG emissions by at least 68% by 2030 compared to 1990 levels, which is aligned with the Paris Agreement pathway for 1.5°C. Since submitting the NDC in December 2020, the UK has published a range of sectoral strategies and plans and has signed up to numerous pledges and actions to deliver on the 2030 target. The target was updated in 2022 but remains at an allowance of 254.08 MtCO_2e (UK Government, 2025). The UK's 2035 NDC target to reduce all GHG emissions by at least 81% by 2035, compared to 1990 levels (excluding international

aviation and shipping emissions) was announced at COP29. The UK NDC was subsequently presented to Parliament in January 2025 (UK Government, 2025). The UK NDC is a 1.5°C aligned, economy-wide absolute emissions reduction target, covering all GHGs, sectors and categories which aims to achieve a target of 254.08 Mt CO_2e by 2030, and 155.3 $MtCO_2e$ by 2035 (UK Government, 2025). The rate of GHG emissions reduction seen in 2023 is roughly in line with the annual pace of change needed to meet the 2030 NDC target (CCC, 2025a).

To place the Abbey & Baker Development in the context of the UK's NDCs, Table 9.12 compares total gross GHG emissions predicted to be generated by the Abbey & Baker Development in 2030 and 2035 respectively with the 2030 and 2035 NDC allowances. As noted above, it is possible that not all end use Abbey & Baker hydrocarbons will be combusted in the UK, therefore the NDC allowances have also been compared with the total direct (Scope 1) GHG emissions predicted to be generated from the Abbey & Baker Development in 2030 and 2035, which will occur in the UK.

Table 9.12: Abbey & Baker Development Emissions in the context of UK NDC targets (UK Government, 2025)

NDC Target	NDC Allowance (Mt CO_2e) [3]	Development Total gross GHG projected proportion [1]	Development Scope 1 projected proportion [2]
NDC 2030	261.5	0.82688% (2.16 $MtCO_2e$)	0.00007% (<0.01 $MtCO_2e$)
NDC 2035	155.3	0.66278% (1.03 $MtCO_2e$)	0.00013% (<0.01 $MtCO_2e$)

[1] Based on the worst-case total gross GHG emissions (Scope 1 + Scope 3 Upstream (Inspection & Maintenance only) + Scope 3 Downstream) generated from the Abbey & Baker Development for the relevant NDC period (2,162.10 kt CO_2e for NDC 2030 and 1,029.10 kt CO_2e for NDC 2035), assuming the Abbey & Baker High production case. Noting that emissions from Abbey & Baker will start in 2029, and end in 2044 for the High production case.

[2] Based on the total direct (Scope 1) GHG emissions generated from the Abbey & Baker Development for the relevant NDC period (0.19 kt CO_2e for NDC 2030 and 0.19 kt CO_2e for NDC 2035), assuming the Abbey & Baker High production case. Noting that emissions from Abbey & Baker will start in 2029, and end in 2044 for the High production case.

[3] 1990 Baseline stated as 817.1 $MtCO_2e$ (UK Government, 2025), refer to Table 9.2 for reduction levels for NDCs.

It can be seen from Table 9.12 that Abbey & Baker's total gross GHG emissions account for ca. 0.82688% of the 2030 NDC allowance and ca. 0.66278% of the 2035 NDC allowance, whilst Abbey & Baker's total direct (Scope 1) GHG emissions account for ca. 0.00007% of the 2030 NDC allowance and ca. 0.00013% of the 2035 NDC allowance.

Given these non-significant proportions, the GHG emissions generated by the Abbey & Baker Development would have no material influence on the UK's ability to meet its NDC emissions reduction targets, resulting in a Minor Adverse magnitude of impact (Not Significant).

9.7 Mitigation Measures

As recognised in the supplementary EIA guidance, Petrogas as the developer does not have direct control over oil and gas end-use scope 3 emissions.

Petrogas's emission reduction initiatives are, therefore, focused on reducing indirect Scope 3 upstream GHG emissions during the development execution and production phases and include:

- The drilling rig selection process will factor in whether an energy control system is installed. The rig operator will be required to be ISO 140001 (Environmental Management) and ISO 50001 (Energy Management) certified.
- Electrical powerpacks, instead of diesel powerpacks, will be used for all services on the rig where these are compatible and available.
- The contracts evaluation process will include emissions information from potential suppliers.
- Compliance with International Maritime Organisation requirements on fuels;

- Optimise drilling, installation, maintenance and repair and decommissioning activities, including vessel movements, by careful planning to optimise fuel use holistically;
- Well test and clean-up durations will be optimised and permitted appropriately.

Responsibility for identification and implementation of emissions reduction initiatives at DGT resides with the DGT operator (Perenco UK Limited) under the regulation of Environment Agency and NSTA in their respective capacities as regulators of onshore Oil and Gas facilities. Petrogas, as the operator of Abbey & Baker, will support the DGT operator as they continue to assess and implement reasonable decarbonisation strategies for DGT, as documented within the DGT Emissions Reduction Action Plan (ERAP).

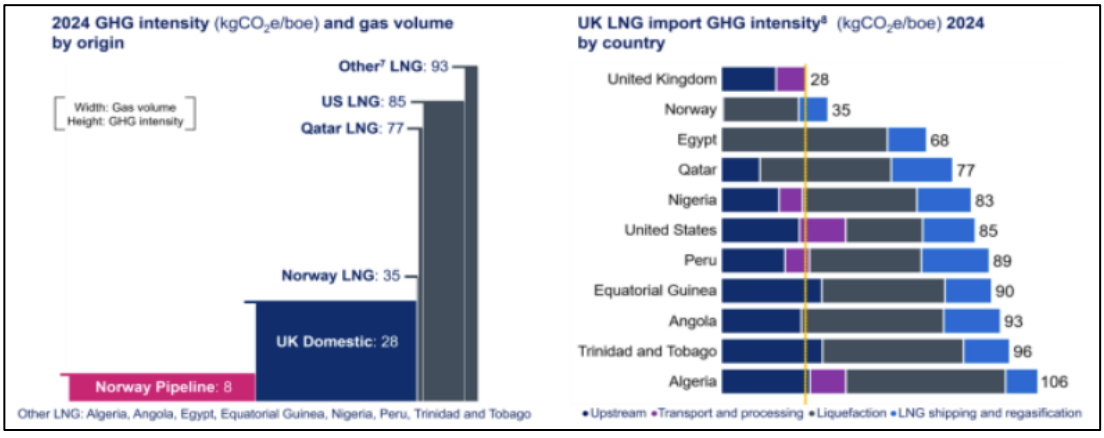
9.8 Other Relevant Considerations

The proposed Abbey & Baker Development concept has been selected and defined with consideration to the central obligation of the OGA Strategy (OGA, 2020) and with cognisance of the requirements of NSTA's Net Zero Stewardship Expectation 11 (NSTA, 2021). The selection of a subsea tie back to an existing platform for the Abbey & Baker Development, with processing undertaken onshore at the DGT, means that the GHG emissions generated will be significantly lower than if a new platform and new export pipeline were to be installed to extract and transport the Abbey & Baker hydrocarbons.

The UK will still require gas for the foreseeable future. National Energy System Operator (NESO) forecasts that the UK will use 53.6 billion cubic metres (bcm) of gas in 2026 falling to 53.3 bcm in 2035, a decline of only 0.6%. Domestic supply is a crucial part of the gas mix and will be for years to come (WGEG, 2026). The UK Net Zero Growth Plan (DESNZ, 2023b) acknowledges that fossil fuels will retain a crucial role in the energy system until there are credible clean energy alternatives that can replicate their role. The Independent Review of Net Zero (Mission Zero, 2023) also recognises that in the short term the UK will still need oil and gas to secure our energy independence and as transition fuels towards 2050 and the Clean Power 2030 Action Plan (DESNZ, 2024a) notes that unabated gas will continue to play a back-up role ensuring security of supply throughout the transition to clean power.

By lowering dependence on fossil fuel imports, the UK can cut GHG intensities. In 2025, the DGT had a reported GHG intensity of 13.95 kg CO_2e/boe. This is well below the UKCS average of 28 kgCO_2e/boe, and significantly lower than the average GHG intensity of imported LNG (85 kgCO_2/boe), as illustrated in Figure 9.6 (NSTA, 2025b).

Figure 9.6: 2024 UK Gas Supply GHG Intensities (NSTA, 2025b)



The Abbey & Baker Development when processed via the DGT will not result in an increase in terminal fuel gas combustion emissions or venting emissions above the baseline operational threshold. The peak gas throughput during Abbey & Baker's operational lifetime from 2029 to 2044 (105 MMscf/d) combined with the DGT's processing throughput base case (110 MMscf/d) does not exceed the DGT's processing sales-gas compressors maximum capacity of 248 MMscf/d each. As such, the GHG intensity of DGT will decrease once the Abbey & Baker Development comes online.

All gas produced from the Abbey & Baker fields will flow into the NTS via the DGT and will be used domestically and not exported. In a time of historically low domestic energy production with more than 40 % of the UK's energy now imported (DESNZ, 2025d), responsible development of low GHG intensity fields ensures that the UK meets its energy demand while retaining control over GHG emissions, energy pricing, and job creation. Moreover, according to the CCC, the UK will require 13–15 billion barrels of oil equivalent in the period 2025 to 2050 but is currently only forecast to produce 4 billion (CCC, 2025c; NSTA, 2025a). In 2024, UK produced gas supplied 39.2% of UK gas demand, whereas piped gas from Norway supplied 45.5% and LNG imports contributed 15.1% (WGEG, 2026).

The Abbey and Baker gas and condensate development is expected to deliver important social and economic benefits through the secure production of domestic energy resources and continued investment in the UK offshore energy sector. The project will support employment across engineering, construction, onshore and offshore operations, marine services, and the wider UK supply chain, helping to sustain highly skilled jobs, specialist capability and the expertise required to support the UK's offshore energy industry. In addition, estimated project expenditure of approximately £300 million will generate economic activity for local and national businesses through the procurement of goods and services during both the development and operational phases. By contributing to indigenous gas production, the project will help reduce reliance on imported hydrocarbons, enhance energy security, and generate wider economic value, including tax revenues associated with project investment, employment, and production. The development will also utilise existing industry expertise and infrastructure where practicable, supporting the long-term sustainability of the UK offshore energy sector and the communities and businesses that depend upon it. The Project therefore aligns with the UK Government’s strategy to maintain domestic production to preserve critical infrastructure, skills, and supply chain capacity for the energy transition.

9.9 Residual Effects

In summary, Scope 3 end-use emissions represent by far the largest component of the total GHG emissions which will be generated by the Abbey & Baker Development over the life of the field (ca. 85%). Petrogas as the developer does not have direct control over oil and gas end-use scope 3 emissions.

At a national level, the Abbey & Baker Development is aligned with UK oil and gas sector specific net zero policies and plans. The GHG emissions generated by the Abbey & Baker Development would have no material influence on the UK’s ability to meet its statutory carbon budget targets or NDC emissions reduction targets, resulting in a Minor Adverse magnitude of impact which is determined to be Not Significant. All gas produced from the Abbey & Baker field will flow into the NTS via the DGT and will be used domestically and not exported, thereby helping contribute to energy security during the UK’s transition to net zero. Responsible stewardship of remaining offshore reserves ensures that the UK meets its energy demand while retaining control over GHG emissions.

In a global context, the Project on its own would not significantly affect a GHG emissions reduction trajectory towards achieving net zero by 2050, particularly as the Abbey & Baker Development is scheduled to cease production in or before 2044. Natural gas will continue to play a crucial role in global energy systems for the foreseeable future, displacing higher-carbon fuels such as coal and heavy fuel oil and supporting the expansion of renewables in the power sector. Regardless of whether the Project goes ahead, given the range of possible emissions reduction pathways available, which are dependent on the scale of effort different countries make to reduce their national GHG emissions, it is uncertain whether net zero on a global basis will be achieved by ca. 2050. However, the effect of the proposed Abbey & Baker Development on this uncertain baseline is not significant given the negligible proportional impact of the Project.

10 Marine Discharges

10.1 Introduction

Petrogas is committed to minimising discharges into the marine environment from its operations, as far as possible. This section assesses the potentially significant impacts on water quality and local flora and fauna that may arise from the following planned operational discharges associated with the proposed Abbey & Baker Development:

- **Discharge of Drill Cuttings and Muds**
  - Dispersion of Suspended Solids.
- **Discharge of Chemicals**
  - Discharge of Drilling, Cementing, Hydraulic Stimulation, Completion and Rig Chemicals during Drilling Operations.
  - Discharge of Subsea Commissioning Chemicals.
  - Discharge of Production Chemicals.
  - Subsea Maintenance and Future Decommissioning Chemical Discharges.
- **Discharge of Fluids Contaminated with Potential Residual Reservoir Hydrocarbons**
  - Hydraulic Stimulation Operation.
  - Well Testing and Clean-up Operations.

10.2 Assessment of Impacts

10.2.1 Discharge of Drill Cuttings and Muds

As described in Section 3.3.4, the Abbey A1, Abbey A3 and Baker Development wells will be drilled conventionally, the Abbey A2 well has already be drilled as a development well. The upper 36 inch hole section, including a worst-case re-spud scenario, will be drilled riserless using seawater and sweeps, with cuttings and associated fluids discharged directly from the wellbore at the seabed. Following installation of the conductor, the 17½ inch section, (including a contingency side-track scenario to account for potential wellbore instability or drilling issues), will be drilled with WBM, initially using seawater and sweeps before displacement to a spud mud / KCl inhibited mud system. For these sections, a 30 inch environmental riser will be installed such that cuttings and unrecoverable muds are returned to the MODU and discharged at or just below the sea surface.

The lower hole sections of the Abbey and Baker Development wells (12¼ inch, 9½ x 8½ inch and 6 inch sections) will be drilled using LTOBM. As discharge of untreated LTOBM-contaminated cuttings to sea is prohibited, these cuttings will be returned to the MODU, separated from the mud system, and contained for skip and ship to shore for treatment and disposal. Recovered LTOBM will be recycled within a closed-loop drilling system. Accordingly, no routine discharge of LTOBM-contaminated cuttings or reservoir hydrocarbon residues on cuttings is anticipated to the marine environment. On this basis, the discharge assessment and supporting cuttings dispersion modelling are focused on the WBM-associated top-hole discharges only.

For the purposes of the dispersion assessment, a worst-case discharge scenario has been adopted which includes re-spud options and contingency side-track drilling of the 17½ inch section for each well. The modelled discharge volumes are summarised in Table 10.1.

Table 10.1: Worst-case modelled discharge volumes used in the drill cuttings and muds dispersion assessment

Well	Cuttings (m^3)	Mud Solids (m^3)
Abbey A1	410	76
Abbey A3	406	75.2
Baker	374	68.8
Abbey Wells Total (A1 + A3)	**816**	**151.2**
Overall Total (all wells)	**1,190**	**220**

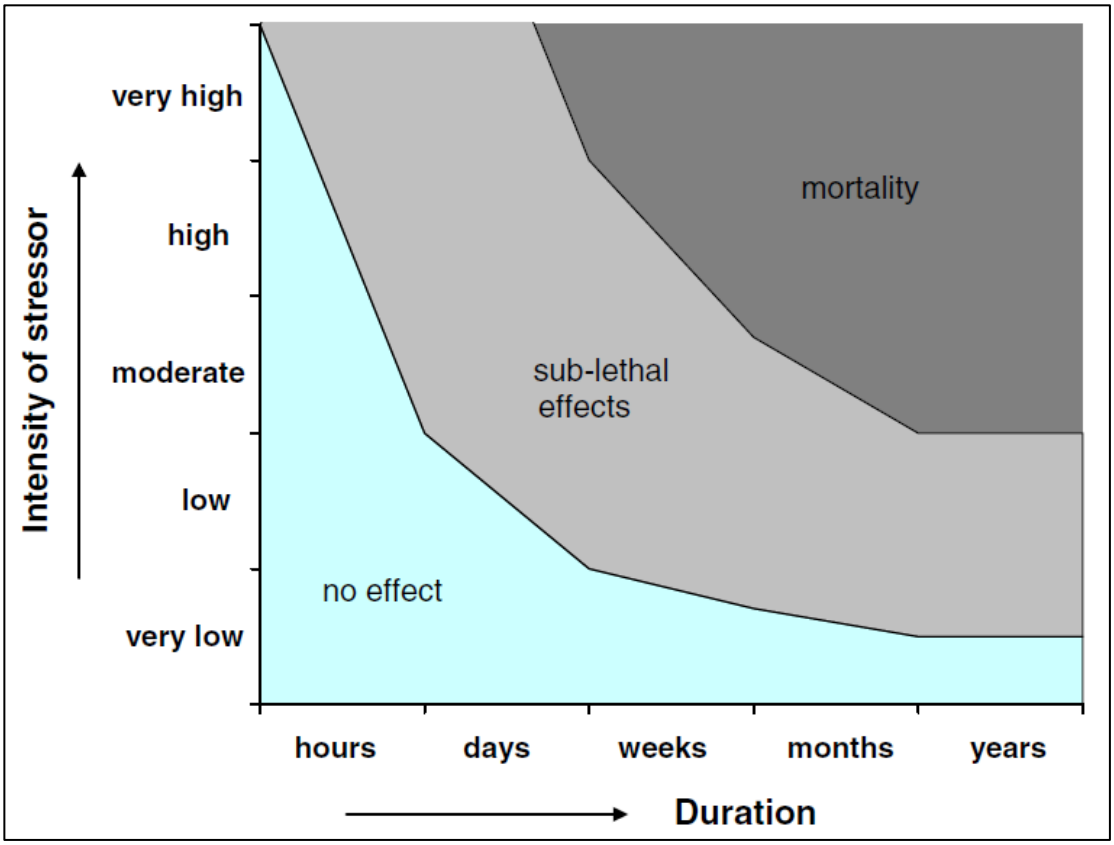
Drill Cuttings and Muds Dispersion Modelling

The discharge of drill cuttings and WBM from the MODU, and seabed release points will result in temporary plumes of suspended solids within the water column. To quantify Total Suspended Solids (TSS) concentrations and support the assessment of potential environmental effects, Petrogas contracted RPS to undertake 3D drill cuttings and muds dispersion modelling using MUDMAP for the Abbey and Baker Development drilling programme. MUDMAP predicts the transport, dispersion and deposition of discharged cuttings and mud solids over time and has been used to assess both water-column TSS concentrations and seabed deposition. A copy of the drill cuttings and muds dispersion modelling report is provided in Appendix C. Settlement of discharged cuttings and muds on the seabed is considered separately in Section 7.

To represent the combined influence of ocean drift currents and tidal currents in the SNS, the modelling used ten years of 3D current data (2010 to 2019) derived from HYCOM and HYDROMAP. The MUDMAP simulations were undertaken using individual 20 km by 20 km model grids for each release location, with a horizontal grid resolution of 20 m and a vertical resolution of 5 m through the water column. Surface discharges were modelled from 1 m below sea level and riserless discharges from 2 m above the seabed. To account for variability in potential spud dates and current conditions, 50 simulations were undertaken per well, with results for Abbey A1 and Abbey A3 combined to provide a stochastic annual worst-case assessment for the Abbey location. Acute exposure was assessed using a 1-hour moving average TSS concentration and chronic exposure using a 24-hour moving average.

A fundamental principle in assessing turbidity effects is the relationship between the intensity of exposure (i.e. TSS concentration or sedimentation rate) and the duration over which that exposure occurs (Figure 10.1). High intensity exposures over short durations may result in acute stress responses, while lower intensity exposures over longer durations can result in comparable cumulative impacts.

Figure 10.1: Conceptual relationship between the intensity and duration of a stress event and the risk of sublethal and lethal effects on corals. The figure illustrates the general relationship between the magnitude of an increase in turbidity or sedimentation above background levels (vertical axis), how long it lasts (horizontal axis) and the onset of effects on corals (Erftemeijer et al., 2012) [Note 1]



Note 1: Although cold-water corals have not been recorded in vicinity of the Abbey & Baker Development location within the SNS, by applying thresholds based on coral responses, this assessment adopts a worst-case conservative benchmark that ensures the protection of the most sensitive ecosystem components.

In pristine offshore environments, background TSS concentrations are generally low, typically <10 mg/L, although naturally turbid nearshore systems can experience levels >100 mg/L (Erftemeijer et al., 2012). Experimental studies indicate that short-term TSS spikes of 50–100 mg/L can induce acute, sub-lethal stress responses, including increased mucus production and reduced photosynthetic efficiency (Browne et al., 2015; Stump et al., 2019). Longer-term exposures at lower concentrations (15–50 mg/L) have been associated with chronic physiological impairment, reduced reproductive success and increased mortality (Browne et al., 2015; Erftemeijer et al., 2012). The final TSS thresholds derived for this assessment are presented in Table 10.2 (RPS, 2026).

Table 10.2: Reporting Thresholds for TTS Concentrations for the drill cuttings and unrecoverable muds discharge modelling (RPS, 2026)

Impact Level	Acute Exposure (1-hour averaged concentration) (mg/L)	Chronic Exposure (24-hour averaged concentration) (mg/L)	Notes/Comments
No Impact	<10	<5	Background or natural variability; corals tolerate well.
Low Exposure	10	5	Minor physiological stress; corals acclimate to short pulses.
Moderate Exposure	50	15	Sub-lethal effects; mucus production, reduced photosynthesis.
High Exposure	> 100	> 50	Tissue damage, mortality risk; chronic exposure particularly harmful.

The modelling indicates that TSS elevations associated with the discharge of drill cuttings and muds will be temporary, localised and rapidly attenuated with distance from the discharge location (refer to Figure 10.2 to Figure 10.5).

For the combined Abbey A1 and Abbey A3 wells, the stochastic assessment shows that, under acute exposure conditions, the low exposure threshold of 10 mg/L extends to a maximum of 0.34 km from the release location, while the moderate exposure threshold of 50 mg/L extends to 0.04 km and the high exposure threshold of 100 mg/L does not extend beyond 0.02 km. The total area exceeding the acute low exposure threshold is 0.26 km². Under chronic exposure conditions, the 5 mg/L threshold extends to 0.35 km, the 15 mg/L threshold extends to 0.10 km, and the 50 mg/L threshold does not extend beyond 0.03 km, with a total area of 0.23 km² exceeding the chronic low exposure threshold (Table 10.3).

For the Baker well, the stochastic assessment shows that under acute exposure conditions, the low exposure threshold of 10 mg/L extends to a maximum of 0.43 km from the release location, while the moderate exposure threshold of 50 mg/L extends to 0.04 km and the high exposure threshold of 100 mg/L does not extend beyond 0.02 km. The total area exceeding the acute low exposure threshold is 0.35 km². Under chronic exposure conditions, the 5 mg/L threshold extends to 0.36 km, the 15 mg/L threshold extends to 0.12 km, and the 50 mg/L threshold does not extend beyond 0.03 km, with a total area of 0.26 km² exceeding the chronic low exposure threshold (Table 10.3).

Deterministic modelling outputs indicate that the highest TSS concentrations remain vertically constrained close to the discharge horizon (RPS, 2026). For riserless seabed discharges, the highest concentrations are largely confined to the lower water column, reflecting the near-bed release and rapid settling of coarser material. For discharges at the sea surface, the highest concentrations are largely confined to the upper water column and attenuate rapidly with depth as the plume disperses and mixes. In both cases, elevated TSS concentrations are short-lived and restricted to the near field, with rapid dilution occurring beyond the immediate discharge area under the prevailing hydrodynamic conditions of the SNS.

These results demonstrate that increases in suspended solids concentrations arising from the discharge of drill cuttings and WBM will be short-term, spatially limited and rapidly diluted. Elevated concentrations are transient in nature, typically persisting for short periods (on the order of hours) at any given location due to the continuous dispersion and advection of the plume. Higher exposure thresholds occur only in very close proximity to the discharge point, and wider water-column effects are therefore considered to be low.

Table 10.3: Predicted total areas of coverage and maximum distances to acute and chronic exposure from the release locations to each reporting threshold based on the results of all 150 simulations (50 simulations per well) (RPS, 2026)

Reporting Threshold	Annual			
	Abbey Wells (A1 & A3 Combined) (Figure 10.2 & Figure 10.3)		Baker Well (Figure 10.4 & Figure 10.5)	
	Total Area of Coverage (km²)	Maximum Distance (km) from the Release Location	Total Area of Coverage (km²)	Maximum Distance (km) from the Release Location
Acute Exposure (1-hour averaged concentration)				
10	0.26	0.34	0.35	0.43
50	<0.01	0.04	0.01	0.04
100	<0.01	0.02	<0.01	0.02
Chronic Exposure (24-hour averaged concentration)				
5	0.23	0.35	0.26	0.36
15	0.03	0.10	0.03	0.12
50	<0.01	0.03	<0.01	0.03

Figure 10.2: Predicted maximum 1-hr moving average of TSS concentrations, representing acute exposure, from the discharge of drill cuttings and muds. Results are based on 100 simulations and represent annual conditions for the Abbey–A1 and Abbey–A3 wells

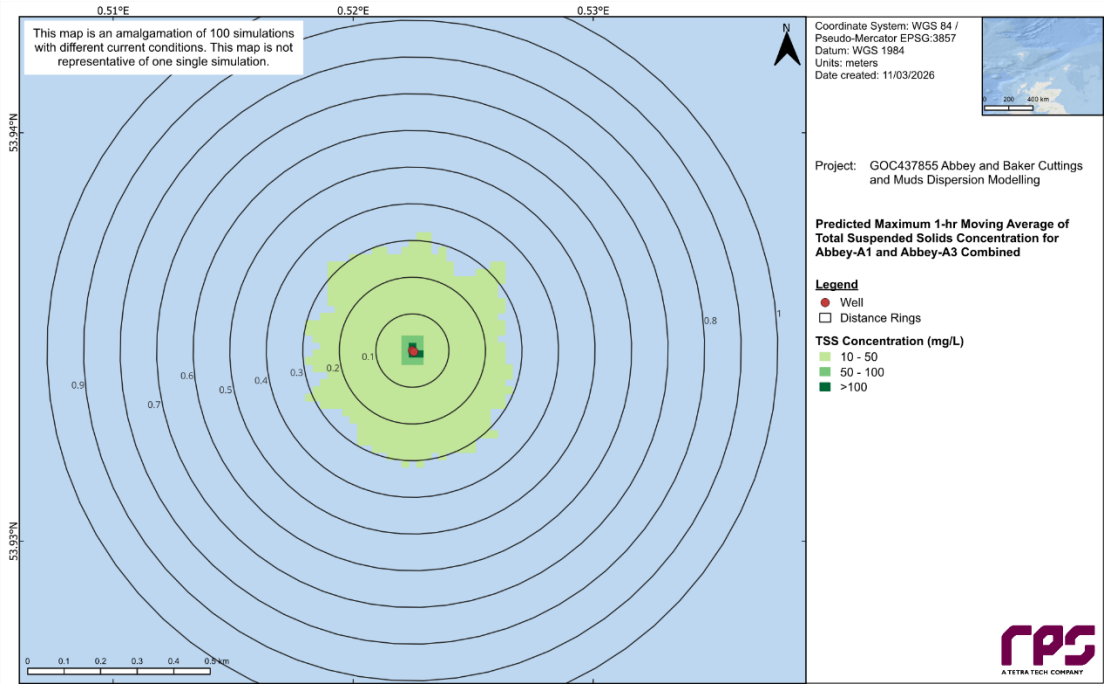


Figure 10.3: Predicted maximum 24-hr moving average of TSS concentrations, representing chronic exposure, from the discharge of drill cuttings and muds. Results are based on 100 simulations and represent annual conditions for the Abbey-A1 and Abbey–A3 wells

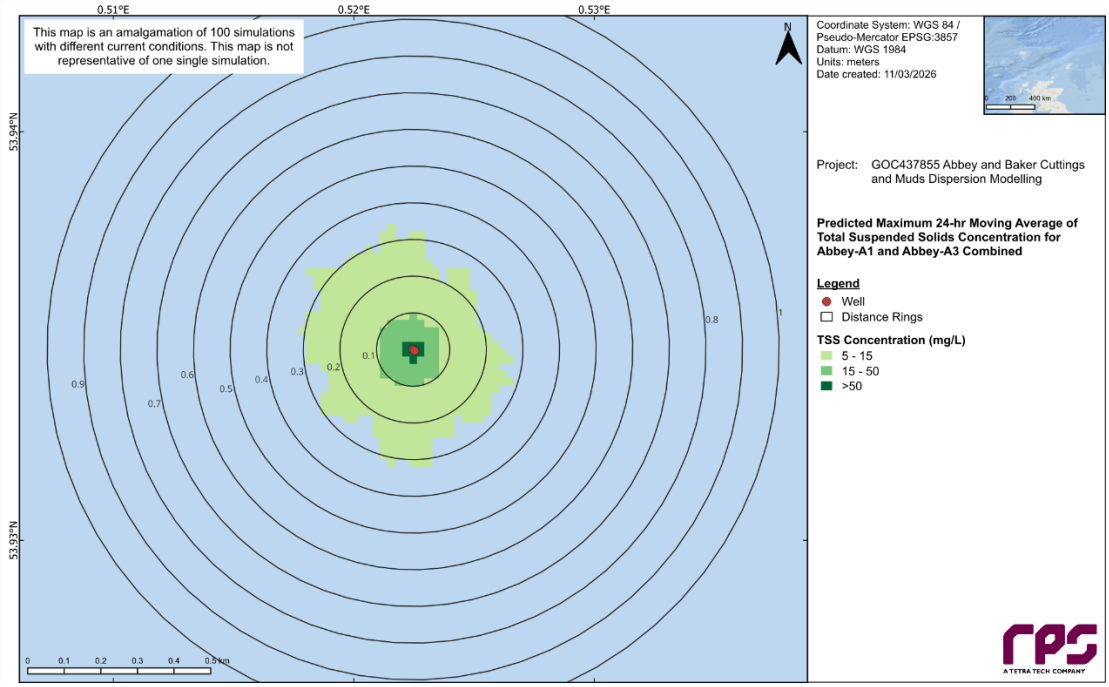


Figure 10.4: Predicted maximum 1-hr moving average of TSS concentrations, representing acute exposure, from the discharge of drill cuttings and muds. Results are based on 50 simulations and represent annual conditions for the Baker well

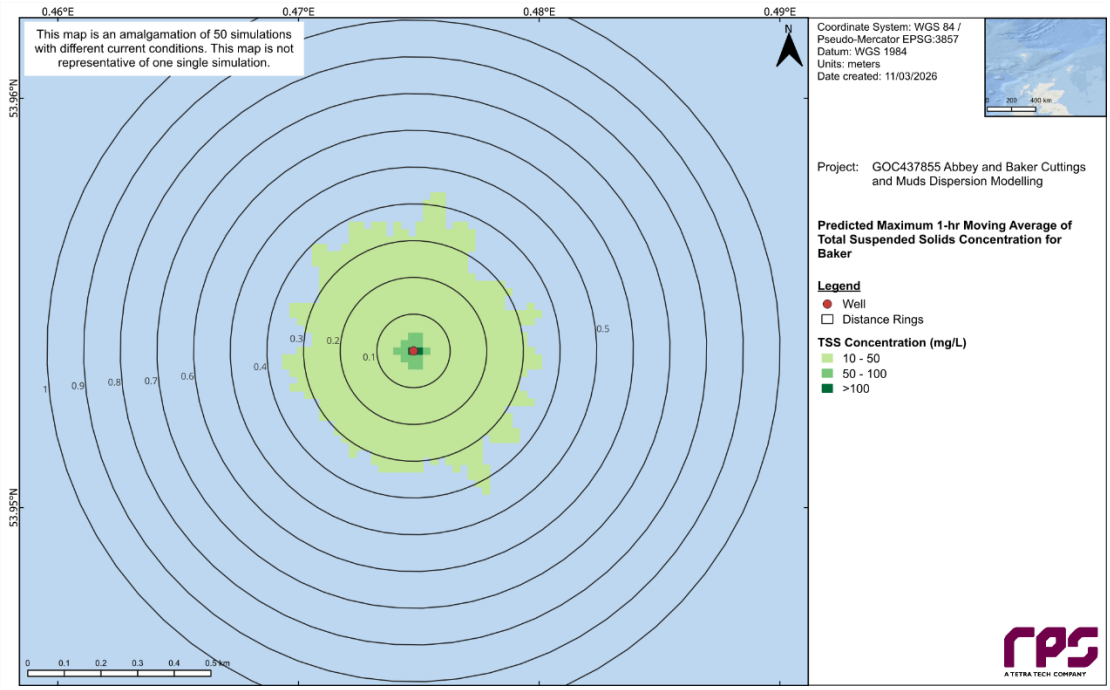
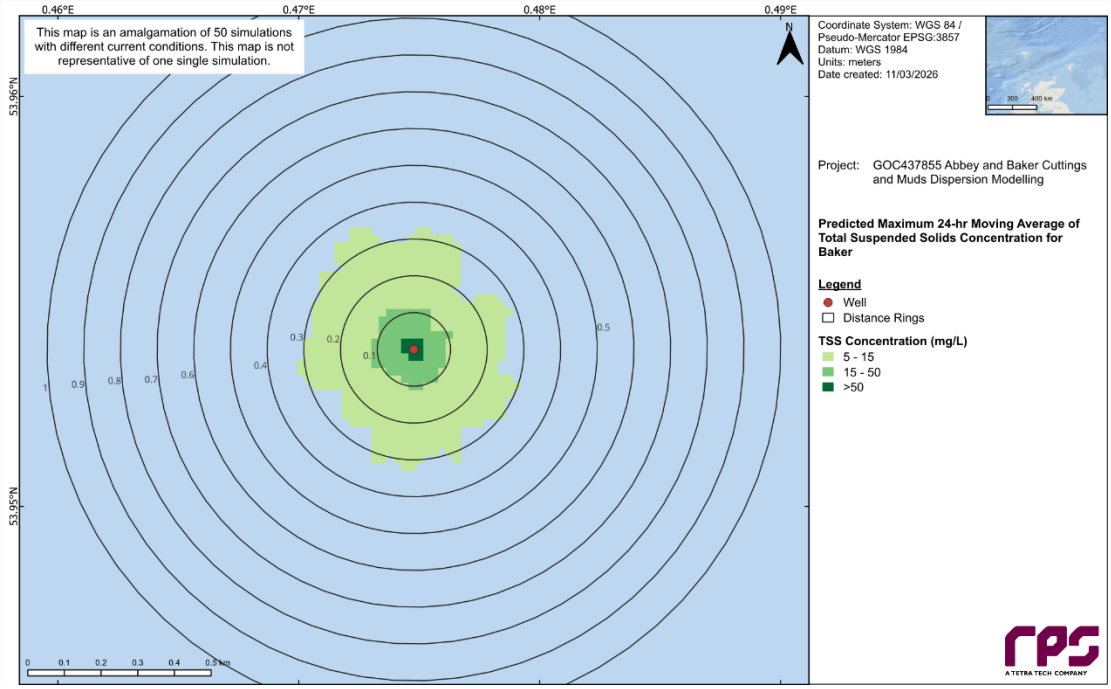


Figure 10.5: Predicted maximum 24-hr moving average of TSS concentrations, representing chronic exposure, from the discharge of drill cuttings and muds. Results are based on 50 simulations and represent annual conditions for the Baker well



Water Quality

The sensitivity of the water column to contamination from the discharge of WBM drill cuttings and muds is considered to be **Low**. The receptor has a Low value, as only the water column in relatively close proximity to the discharge point will be affected and is therefore considered to be of local importance. The SNS is characterised by relatively shallow water depths, strong tidal currents and a well-mixed water column, resulting in high rates of dilution and dispersion. Consequently, water quality in the area is subject to rapid flushing and mixing processes. The receptor resistance and resilience are therefore considered to be Very High to WBM drill cuttings and mud discharges. Modelling indicates that acute (1-hour) TSS elevations are highly localised, with low exposure extending to a maximum of 0.43 km and moderate to high exposures confined within 0.04 km, while chronic (24-hour) exposure is more limited, extending to a maximum of 0.36 km with effects transient and typically lasting for short periods (on the order of hours) at any given location. The magnitude of impact is considered to be **Minor**, reflecting a short-term and localised deviation from baseline environmental conditions associated with elevated TSS concentrations. Effects on water quality due to the discharge of WBM drill cuttings and muds are therefore assessed as **Minor**.

Plankton

The sensitivity of plankton to the planned discharge of WBM drill cuttings and muds is considered to be **Low**. The receptor is of Medium value, as plankton communities are of regional importance within the SNS, forming a key component of the marine food web. Plankton communities are known to vary seasonally in response to water temperature, water column mixing, currents and nutrient availability (Lawrence, 2000; JNCC, 2004). However, the temporary effluent plume generated by the discharge of WBM drill cuttings and muds is predicted to be highly localised and short-lived, with rapid dilution and dispersion within the water column. Plankton communities are characterised by short generation times, rapid population turnover and high reproductive potential, which support recovery following short-term, localised disturbances (Lalli and Parsons, 1997). The receptor resistance and resilience are therefore considered to be Very High. The magnitude of impact is assessed as **Negligible**, as any increases in TSS concentrations are expected to be transient and confined to the near-field of the discharge. Any effects on plankton are anticipated to be immeasurable or undetectable. Effects on plankton due to the discharge of WBM drill cuttings and muds are therefore assessed as **Negligible**.

Benthic Communities

The impact to benthic communities from the discharge of WBM drill cuttings, mud and cement at the proposed Abbey & Baker Development well locations is assessed in Section 7 (Seabed Disturbance).

Fish

The sensitivity of fish to the planned discharge of WBM drill cuttings and muds is considered to be **Low**. The receptor has a High value, as the SNS supports commercially important fish species and species of conservation importance, including those listed as UK BAP Priority Marine Species, species on the OSPAR List of Threatened and/or Declining Species, and species included on the IUCN Red List (see Section 4.3.3). However, the temporary effluent plume associated with the discharge of WBM drill cuttings and muds is expected to be highly localised and short-lived, with rapid dispersion under prevailing hydrodynamic conditions. Mobile fish species can avoid localised increases in turbidity, and exposure of early life stages would be limited due to the transient nature of elevated TSS concentrations. The receptor resistance and resilience are therefore considered to be Very High. The magnitude of impact is assessed as **Negligible**, as any increases in suspended solids concentrations are expected to be spatially limited and short-term. Any changes to the fish community are anticipated to be immeasurable / undetectable. Effects on fish due to the discharge of WBM drill cuttings and muds are therefore assessed as **Negligible**.

Marine Mammals

The sensitivity of marine mammals to the planned discharge of WBM drill cuttings and muds is considered to be **Medium**. Marine mammal species present in the SNS are typical of the wider region; however, all cetaceans are EPS under Annex IV of the Habitats Directive and are therefore of Very High value, with the proposed development also located within the Southern North Sea SAC designated for harbour porpoise (see Section 4.3.5). Despite this, receptor resistance and resilience are considered to be Very High, as the discharge is expected to result in only localised and transient increases in suspended solids concentrations. The magnitude of impact is assessed as **Negligible**, as rapid dilution and dispersion within the water column is anticipated. Any effects on marine mammals, including indirect effects via prey species, are expected to be immeasurable or undetectable. Effects on marine mammals due to the discharge of WBM drill cuttings and muds are therefore assessed as **Negligible**.

10.2.2 Discharge Chemicals

Chemical discharges associated with the Abbey & Baker Development will occur during a defined set of activities spanning drilling, cementing, hydraulic stimulation, completion, subsea commissioning, and routine production and maintenance operations. These activities are described in Section 3 and summarised below. In addition, chemicals may be used and discharged in future subsea maintenance programmes and during decommissioning activities.

Discharge of Drilling, Cementing, Hydraulic Stimulation, Completion and Rig Chemicals during Drilling Operations

Drilling operations will involve a number of planned chemical discharges which will be regulated under the relevant Drilling Operations MAT and Chemical Permit SAT, submitted via the UK Energy Portal in accordance with the Offshore Chemicals Regulations 2002 (as amended) (refer to Section 3.3). During riserless drilling of the 36 inch top-hole sections, seawater, sweeps, spud mud and associated WBM chemicals will be discharged directly to the seabed. For the subsequent 17½ inch sections, drill cuttings and associated WBM fluids will be returned to the MODU and discharged following processing at approximately 2 m below the sea surface. Minor volumes of residual WBM and associated chemicals may also be discharged during mud pit cleaning.

Further detail and assessment of WBM and cuttings discharge characteristics, including volumes and dispersion behaviour, are provided in Section 10.2.1.

In the deeper well sections (12¼ inch, 9½ x 8½ inch and 6 inch), LTOBM will be used; however, all LTOBM-contaminated cuttings will be returned to the rig, separated and shipped to shore for treatment, with mud recycled in a closed-loop system. Accordingly, no planned discharge of LTOBM or associated chemicals to the marine environment is anticipated.

Cementing activities will also give rise to chemical discharges. Excess cement and associated chemicals will be discharged to the seabed during cementing of the 30 inch conductor in order to confirm returns, with smaller volumes potentially also reaching the seabed during cementing of the 13⅜ inch casing. Additional discharges may occur during cleaning of the cementing unit, including wash water, spacers and residual cement slurry. In addition, a low likelihood contingent discharge may be required in the event of an aborted cement job, where a batch of cement slurry, spacer or mixwater chemicals cannot be pumped downhole and must be discharged rapidly to avoid flash setting within the cementing system (refer to Section 3.3.4).

During well completion and clean-up operations, completion brine and associated clean-up fluids may be discharged following treatment. At Baker, up to 200 m^3 of treated completion / clean-up brine may be discharged. At Abbey A1 and A3, up to 200 m^3 of treated completion / clean-up brine may be discharged per well. All fluids will be processed through the MODU slops treatment system and discharged in accordance with permit conditions. Other specialist clean-up fluids, such as surfactant pills and debris removal fluids, will be recovered and, where necessary, returned to shore for appropriate treatment and disposal rather than discharged offshore.

For the Abbey A1, A2 and A3 wells, hydraulic stimulation operations will also generate chemical discharges. Fracturing treatments and diagnostic injections will be pumped from a dedicated stimulation vessel using water, proppant and chemical additives. Following stimulation, flowback / return fluids will be recovered to the MODU during well clean-up. Up to 2,500 m^3 of returns per well may be discharged following treatment and monitoring in accordance with permit requirements. The chemicals associated with the hydraulic fracture operations and subsequent returns will therefore form an additional controlled discharge stream during the Abbey drilling and completion programme.

Routine rig chemicals, including detergents, lubricants and hydraulic fluids used for machinery maintenance and blowout preventer control, will also be used onboard the MODU. Any planned use and discharge of these materials will be subject to permitting controls. Collectively, these activities represent the principal drilling, cementing, completion, hydraulic fracture and rig-related chemical discharge streams associated with the proposed Abbey & Baker drilling operations.

Discharge of Subsea Commissioning Chemicals

During subsea installation and commissioning, a range of chemicals will be used to preserve infrastructure integrity, support hydrotesting and facilitate leak testing of the Abbey & Baker subsea production system (refer to Section 3.4). Where feasible, equipment will be pre-commissioned onshore prior to installation. The umbilicals will be pressure tested on completion of manufacture and installed with the control lines pre-filled with the appropriate hydraulic fluid and the chemical injection lines filled with MEG or a suitable spacer chemical.

Offshore, the production pipelines will be flooded with treated water and hydrostatically pressure tested. The hydrotest water will contain small quantities of chemicals such as biocide, oxygen scavenger and dye for leak detection and preservation purposes. Following completion of hydrotesting, the pipelines will be de-pressured and excess treated water discharged prior to commissioning of the system. The spool pieces will be hydrotested onshore and will be installed, pre-filled with chemicals to protect the infrastructure integrity typically MEG gel and potentially also dye, to facilitate leak testing. Following tie-in of all components, an overall leak test will be undertaken. For Start up the production pipeline will be pressurised backflowing with gas from the Easington terminal for start-up.

The use and discharge of chemicals during pipeline and subsea commissioning operations will be detailed and assessed within the Pipeline Operations MAT and associated Chemical Permit SAT, submitted via the UK Energy Portal in accordance with the Offshore Chemicals Regulations 2002 (as amended). Chemicals will be subject to environmental risk assessment, where applicable, and products with the most favourable environmental profile will be selected where technically practicable.

Discharge of Production Chemicals

During routine production operations, chemicals will be used to support flow assurance, corrosion management and subsea control of the Abbey & Baker production system (refer to Section 3.6). Hydrate inhibition and corrosion management will be achieved by injection of a methanol corrosion inhibitor mix at the Abbey and Baker trees continuously to provide pipeline protection. These chemicals

will be supplied from Dimlington terminal via York and delivered subsea through dedicated umbilical cores.

Additional spare cores will also be provided within the umbilicals to allow for future chemicals treatment, however there is no current requirement expected. There are no subsea processing facilities at Abbey or Baker and no processing will be undertaken on the York platform. Production fluids will instead be transported via the subsea export system to Dimlington terminal for onshore processing. Consequently, no routine offshore discharge of produced water is anticipated as part of normal production operations from the Abbey & Baker Development.

During operations, water / glycol-based control fluid will also be used within the subsea control system during periodic valve operation. The use and any discharge of operational chemicals, including control fluids, will be detailed and assessed in the appropriate MAT and associated Chemical Permit SAT in accordance with the Offshore Chemicals Regulations 2002 (as amended). Any such chemicals will be subject to environmental risk assessment, where applicable, and products with an improved environmental profile will be preferentially selected.

Subsea Maintenance and Future Decommissioning Chemical Discharges

In addition to the installation, commissioning and production phases described above, limited chemical discharges may occur during future subsea activities and eventual decommissioning of the Abbey & Baker wells and associated infrastructure.

Routine subsea inspection and maintenance activities are anticipated over field life. These activities, along with decommissioning works, may require the use of small volumes of intervention and control fluids, barrier testing chemicals, line flushing additives and cement slurries associated with plug and abandonment and pipeline decommissioning operations.

The detailed chemical inventories and any associated discharge volumes will be defined at the relevant stage of the project; however, based on comparable SNS developments, the scale of chemical use and potential discharge is expected to be minor relative to drilling, completion and commissioning activities.

All chemicals used during maintenance and decommissioning will be subject to separate environmental permitting under the Offshore Chemicals Regulations 2002 (as amended). Prior to decommissioning, the final approach will be informed by a comparative assessment and environmental appraisal to identify the optimum abandonment option and to minimise environmental effects as far as possible.

Assessment of Impacts

The discharge of drilling, cementing, completion, hydraulic fracture, commissioning, maintenance and operational chemicals associated with the Abbey & Baker Development has the potential to impact the marine environment. Chemical discharges can result in localised changes in water quality and chemistry, as well as potential toxicity effects depending on the properties of the substances used. The extent to which such effects occur is dependent on factors including the inherent toxicity of the chemicals, discharge volumes, resulting concentrations in the receiving environment, exposure duration and receptor sensitivity (OEUK, 2019).

In accordance with the Offshore Chemicals Regulations 2002 (as amended), Petrogas will seek to minimise environmental risk through the selection of chemicals with an improved environmental profile, in line with the OSPAR Harmonised Mandatory Control Scheme (HMCS). Where practicable, substances with substitution warnings will be avoided and preference will be given to PLONOR chemicals.

All CHARMable chemicals proposed for discharge will be subject to a CHARM assessment, including calculation of a Risk Quotient (RQ). Where RQ values exceed 1, further assessment will be undertaken to reduce risk through optimisation or substitution. The detailed risk assessment will be provided within the relevant Chemical Permit SAT.

Following discharge, chemicals are expected to undergo rapid dilution and dispersion within the water column due to the energetic hydrographic regime of the SNS, with further reduction in concentration

occurring through natural degradation processes. As such, exposure is expected to be localised and short-term.

Water Quality

The sensitivity of the water column to contamination from the planned, routine discharge of chemicals is considered to be **Low**. The receptor has a Low value, as only the water column in relatively close proximity to the discharge point will be affected and is therefore considered to be of local importance. The SNS is characterised by relatively shallow water depths, strong tidal currents and a well-mixed water column, resulting in high rates of dilution and dispersion. Consequently, water quality in the area is subject to rapid flushing and mixing processes. The receptor resistance and resilience are therefore considered to be Very High to planned, routine chemical discharges. The magnitude of impact is considered to be **Minor**, reflecting a short-term and localised deviation from baseline environmental conditions associated with temporary changes in water chemistry in the immediate vicinity of the discharge. Effects on water quality due to planned, routine chemical discharges are therefore assessed as **Minor**.

Plankton

The sensitivity of plankton to the planned, routine discharge of chemicals is considered to be **Low**. The receptor is of Medium value, as plankton communities are of regional importance within the SNS, forming a key component of the marine food web. However, the chemical discharge plumes are expected to be highly localised and short-lived, with rapid dilution and dispersion within the water column. Plankton communities are characterised by high reproductive rates and rapid turnover, enabling quick recovery from short-term disturbances. The receptor resistance and resilience are therefore considered to be Very High. The magnitude of impact is assessed as **Negligible**, as exposure concentrations are expected to reduce rapidly with distance from the discharge point and any effects would be transient. Any changes to plankton communities are anticipated to be immeasurable or undetectable. Effects on plankton due to planned, routine chemical discharges are therefore assessed as **Negligible** and not significant.

Fish

The sensitivity of fish to the planned, routine discharge of chemicals is considered to be **Low**. The receptor has a High value, as the SNS supports commercially important fish species and species of conservation importance, including those listed as UK BAP Priority Marine Species, OSPAR Threatened and/or Declining Species and species included on the IUCN Red List (see Section 4.3.3). However, the chemical discharge plumes are expected to be highly localised and short-lived, with rapid dispersion under prevailing hydrodynamic conditions. Mobile fish species can avoid localised areas of disturbance, and exposure of early life stages would be limited due to the transient nature of the discharge. The receptor resistance and resilience are therefore considered to be Very High. The magnitude of impact is assessed as **Negligible**, as exposure concentrations are expected to be low and short-term. Any changes to the fish community are anticipated to be immeasurable or undetectable. Effects on fish due to the planned, routine discharge of chemicals are therefore assessed as **Negligible** and not significant.

Marine Mammals

The sensitivity of marine mammals to the planned, routine discharge of chemicals is considered to be **Medium**. Marine mammal species present in the SNS are typical of the wider region; however, all cetaceans are EPS under Annex IV of the Habitats Directive and are therefore of Very High value, with the proposed development also located within the Southern North Sea SAC designated for harbour porpoise (see Section 4.3.5). Despite this, receptor resistance and resilience are considered to be Very High, as the discharge is expected to result in only localised and transient changes in water quality. Rapid dilution and dispersion within the water column is anticipated, and any indirect effects via prey species are expected to be negligible. The magnitude of impact is assessed as **Negligible**, as exposure would be short-term and spatially limited. Any effects on marine mammals are expected to be immeasurable or undetectable. Effects on marine mammals due to the planned, routine discharge of chemicals are therefore assessed as **Negligible**.

10.2.3 Discharge of Fluids Contaminated with Residual Hydrocarbons

Hydraulic Stimulation Operations

Prior to final well clean-up and testing of the Abbey A1, A2 and A3 wells, flowback fluids from hydraulic stimulation operations will be recovered to the MODU. These returns will comprise injected fracturing fluids, formation water and entrained solids and may contain low concentrations of residual reservoir hydrocarbons (refer to Section 3.3.4).

The total estimated maximum volume of hydraulic stimulation returns is up to 2,500 m^3 per well. Assuming a worst-case oil in water concentration of 30 mg/l, this equates to a maximum potential discharge of approximately 75 kg of hydrocarbons per well. For the three Abbey wells, this represents a combined worst-case discharge of 225 kg of hydrocarbons.

All returned fluids will be processed via the rig-based filtration and treatment system prior to discharge. Fluids will only be discharged where the oil in water concentration is equal to or less than 30 mg/l, in accordance with permit conditions. Any fluids exceeding this threshold will be recirculated and treated until compliant.

Discharges will be metered and monitored throughout, with representative samples collected at the point of discharge to verify compliance. Petrogas will seek consent for these discharges via submission of an Oil Discharge Permit (ODP) SAT through the UK Energy Portal, in accordance with the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended).

Well Testing and Clean-up Operations

As described in Section 3.3.5, prior to production, the Abbey and Baker wells will undergo clean-up and testing operations to remove drilling fluids, debris and residual completion materials and to establish stable flow conditions.

During initial clean-up, completion and interface fluids may contain low concentrations of residual reservoir hydrocarbons and will be routed to the rig-based treatment system prior to discharge. At Abbey, interface fluids may include up to 91 m^3 per well, which following treatment to 30 mg/l oil in water, corresponds to approximately 2.73 kg of hydrocarbons per well.

At Baker, up to 200 m^3 of treated completion / clean-up brine may be discharged, corresponding to approximately 6 kg of hydrocarbons following treatment.

Across all the Abbey & Baker Development wells (Abbey A1, Abbey A2, Abbey A3 and Baker), the total worst-case hydrocarbon discharge associated with well clean-up and testing operations is therefore estimated to be approximately 11.46 kg.

All returned fluids will be processed through the MODU slops treatment system and discharged only when compliant with the 30 mg/l oil in water limit.

Discharges will be monitored, and representative samples will be collected and analysed to verify compliance. Petrogas will seek consent for these discharges via submission of an ODP SAT through the UK Energy Portal, in accordance with the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended).

Assessment of Impacts

Hydrocarbons can cause toxicity in aquatic organisms primarily through a mechanism referred to as non-polar narcosis (or non-specific toxicity), which is generally reversible and occurs when organisms are exposed to sufficiently elevated concentrations. The potential for toxicity is influenced by the chemical composition of the hydrocarbon mixture, with lower molecular weight fractions typically exhibiting higher bioavailability and toxicity, while higher molecular weight fractions are less soluble and therefore less bioavailable.

The partitioning behaviour of hydrocarbons is commonly described by the octanol-water partition coefficient (log Pow), which provides an indication of a substance's tendency to partition into organic phases. Substances with higher log Pow values are less soluble in water and therefore less likely to contribute to dissolved-phase toxicity. Experimental evidence indicates that higher molecular weight

paraffinic hydrocarbons exhibit limited acute or chronic toxicity in aquatic systems (CONCAWE, 2001). In practice, following discharge to the marine environment, lighter hydrocarbon fractions may volatilise or degrade rapidly, whilst heavier fractions tend to have low bioavailability.

Certain hydrocarbon components, such as PAHs, are recognised for their potential toxicological effects, including mutagenicity and carcinogenicity. However, marine organisms possess physiological mechanisms to metabolise and detoxify PAHs at concentrations typically encountered in offshore environments (Stein et al., 2010; Tuvikene, 1995; Rust et al., 2004). In addition, hydrocarbons discharged to the marine environment are subject to natural attenuation processes, including volatilisation, dilution, dispersion, biodegradation and adsorption onto suspended particulates and sediments, which collectively reduce their concentration and bioavailability (OGP, 2005).

For the Abbey & Baker Development, discharges of residual reservoir hydrocarbons will be limited to treated flowback (hydraulic stimulation fluid), clean-up and testing fluids, with all discharges controlled to an oil in water concentration of 30 mg/l or less in accordance with permit requirements. The total worst-case hydrocarbon discharge associated with these activities is estimated to be approximately 168 kg across all wells, occurring over relatively short durations.

Given the relatively small discharge volumes, low concentrations, and the dynamic hydrographic conditions of the SNS characterised by strong tidal currents and a well-mixed water column, any hydrocarbons discharged are expected to dilute rapidly and be subject to natural degradation processes. As such, exposure concentrations are expected to be low and short-lived, with effects limited to the immediate vicinity of the discharge point.

Consistent with modelling and literature data, impacts from hydrocarbon discharges in open offshore environments are typically localised and transient. Studies undertaken for the Norwegian petroleum sector have demonstrated that while effects may be detectable at the level of individual organisms, no impacts are evident at the population or community scale (OGUK, 2014).

Water Quality

The sensitivity of the water column to contamination from the planned discharge of residual reservoir hydrocarbons from hydraulic stimulation, well clean-up and testing operations is considered to be **Low**. The receptor has a Low value, as only the water column in relatively close proximity to the discharge point will be affected and is therefore considered to be of local importance. The SNS is characterised by relatively shallow water depths, strong tidal currents and a well-mixed water column, resulting in high rates of dilution and dispersion. Consequently, water quality in the area is subject to rapid flushing and mixing processes. The receptor resistance and resilience are therefore considered to be Very High. The magnitude of impact is considered to be **Minor**, reflecting a short-term and localised deviation from baseline environmental conditions associated with low-level hydrocarbon concentrations in the immediate vicinity of the discharge. Effects on water quality due to the discharge of residual reservoir hydrocarbons are therefore assessed as **Minor**.

Plankton

The sensitivity of plankton to the planned discharge of residual reservoir hydrocarbons is considered to be **Low**. The receptor is of Medium value, as plankton communities are of regional importance within the SNS, forming a key component of the marine food web. However, residual hydrocarbons are not expected to persist within the marine environment due to rapid dilution and biodegradation. Plankton communities are characterised by high reproductive rates and rapid turnover, enabling quick recovery from short-term disturbances. The receptor resistance and resilience are therefore considered to be Very High. The magnitude of impact is considered to be **Negligible**, as exposure concentrations are expected to be low and short-term. Any changes to plankton communities are anticipated to be immeasurable or undetectable. Effects on plankton due to the discharge of residual reservoir hydrocarbons are therefore assessed as **Negligible.**

Fish

The sensitivity of fish to the planned discharge of residual reservoir hydrocarbons is considered to be **Medium**. The receptor has a High value, as the SNS supports commercially important fish species and species of conservation importance, including those listed as UK BAP Priority Marine Species, OSPAR

Threatened and/or Declining Species and cod which is classed as vulnerable on the IUCN Red List (see Section 4.3.3). However, residual hydrocarbons discharged during these operations are not expected to persist within the marine environment due to rapid dilution and natural degradation processes. Mobile fish species can avoid localised areas of disturbance, and exposure of early life stages would be limited due to the transient nature of the discharge. The receptor resistance and resilience are therefore considered to be Very High. The magnitude of impact is considered to be **Negligible**, as exposure will be spatially limited and short-term. Any changes to the fish community are anticipated to be immeasurable or undetectable. Effects on fish due to the discharge of residual reservoir hydrocarbons are therefore assessed as **Negligible**.

Marine Mammals

The sensitivity of marine mammals to the planned discharge of residual reservoir hydrocarbons is considered to be **Medium**. Marine mammal species present in the SNS are typical of the wider region; however, all cetaceans are EPS under Annex IV of the Habitats Directive and are therefore of Very High value, with the development located within the Southern North Sea SAC designated for harbour porpoise. Despite this, receptor resistance and resilience are considered to be Very High, as residual hydrocarbons are not expected to persist within the marine environment and exposure will be limited to localised and short-term changes in water quality. The magnitude of impact is considered to be **Negligible**, as rapid dilution and dispersion within the water column is anticipated. Any changes to marine mammal behaviour or prey availability are expected to be immeasurable or undetectable. Effects on marine mammals due to the discharge of residual reservoir hydrocarbons are therefore assessed as **Negligible**.

10.2.4 Impacts to the Southern North Sea SAC

The proposed Abbey & Baker Development is located within the Southern North Sea SAC, which is designated for the protection of harbour porpoise (*Phocoena phocoena*), an Annex II species. The site covers approximately 36,951 km² and supports an estimated 17.5 % of the UK North Sea Management Unit population. The northern extent of the site is recognised as important during the summer (April to September), whilst the southern area supports higher densities during the winter (October to March) (JNCC, 2023b).

The conservation objectives of the Southern North Sea SAC are to ensure site integrity and to contribute to maintaining favourable conservation status of harbour porpoise. This is achieved by ensuring that:

- harbour porpoise remains a viable component of the site;
- there is no significant disturbance of the species; and
- the condition of supporting habitats and prey availability is maintained.

As described in Section 10.2, marine discharges associated with the proposed development, including water-based drill cuttings and muds (and associated TSS), chemicals and limited volumes of residual reservoir hydrocarbons, are predicted to be highly localised, short-term and rapidly dispersed. These discharges do not present a pathway for injury or behavioural disturbance to harbour porpoise.

With respect to supporting habitats and prey species, fish communities in the vicinity include species known to form part of the harbour porpoise diet (e.g. sandeel, herring, mackerel, cod and whiting). However, as assessed in Section 10.2, impacts to fish are predicted to be negligible due to the limited spatial extent and short duration of discharges, together with rapid dilution and dispersion. Similarly, any increases in suspended solids concentrations are expected to be confined to the near-field and transient, and therefore will not affect habitat condition or prey availability at a scale relevant to the SAC.

All discharges will be subject to regulatory control under the Offshore Chemicals Regulations 2002 (as amended) and, where applicable, the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended), ensuring that environmental risks are minimised.

In view of the conservation objectives of the Southern North Sea SAC, and taking into account the localised and transient nature of the predicted effects, no likely significant effects on the Southern North Sea SAC are anticipated as a result of the proposed Abbey & Baker Development

10.3 Impacts to the East Offshore Marine Plan

The marine discharges generated by the proposed Abbey & Baker Development has the potential to impact the following East Offshore Marine Plan objectives:

- **SOC3 -** Proposals that may affect the terrestrial and marine character of an area should demonstrate, in order of preference:

  a) that they will not adversely impact the terrestrial and marine character of an area;

  b) how, if there are adverse impacts on the terrestrial and marine character of an area, they will minimise them;

  c) how, where these adverse impacts on the terrestrial and marine character of an area cannot be minimised they will be mitigated against;

  d) the case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts.

- **ECO1 -** Cumulative impacts affecting the ecosystem of the East marine plans and adjacent areas (marine, terrestrial) should be addressed in decision-making and plan implementation.

- **BIO1 -** Appropriate weight should be attached to biodiversity, reflecting the need to protect biodiversity as a whole, taking account of the best available evidence including on habitats and species that are protected or of conservation concern in the East marine plans and adjacent areas (marine, terrestrial).

- **MPA1 -** Any impacts on the overall MPA network must be taken account of in strategic level measures and assessments, with due regard given to any current agreed advice on an ecologically coherent network

The marine discharges generated by the proposed Abbey & Baker Development have the potential to interfere with the achievement of objectives ECO1, BIO1 and MPA1, however this is unlikely to occur following the implementation of the mitigation measures listed in Section 10.4, and for the reasons listed in Section 10.2. The objective SOC3 will be met through the mitigation measures listed in Section 10.4, and for the reasons listed in Sections 10.2.

10.4 Mitigation Measures

Impacts from marine discharges during the development of the Abbey & Baker field will be minimised by the implementation of the following mitigation measures:

- A chemical risk assessment will be undertaken to identify the risk profile of chemicals to be used and / or discharged in accordance with the requirements of the Offshore Chemicals Regulations 2002 (as amended). Where practicable, chemicals with a higher risk profile will be substituted out in favour of those with an improved environmental profile;
- Chemical use and discharge will be minimised to as low as practically possible;
- During drilling operations, cuttings / mud cleaning equipment will ensure optimal cuttings cleaning prior to discharge and recovered WBM will be reused/ re-circulated where practical. In addition, WBM will be mixed offshore to ensure that only what is required is used;
- During the drilling operations, any discharges of residual reservoir hydrocarbons will be treated to meet oil-in-water limits of less than or equal to 30 mg/l. The discharge stream will also be monitored and sampled in accordance with the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended).

10.5 Residual Effects

In summary, no significant residual effects on water quality or marine receptors are predicted as a result of routine marine discharges associated with the Abbey & Baker Development. Discharges from drilling operations, including water-based drill cuttings and muds, will result in short-lived and highly localised increases in water column suspended solids (TSS), with modelling confirming rapid attenuation to background levels within a short distance of the discharge location.

Chemical discharges associated with drilling, completion, commissioning and subsea operations will be subject to risk assessment and permitting under the Offshore Chemicals Regulations 2002 (as amended). Chemicals with acceptable environmental profiles will be selected, and discharges will be controlled to ensure rapid dilution, dispersion and biodegradation.

Limited discharges of fluids contaminated with residual reservoir hydrocarbons may occur during hydraulic stimulation, well clean-up and testing operations. These will be regulated under an ODP and will comply with the 30 mg/l oil in water standard. The total mass discharged is expected to be low, with any hydrocarbons rapidly diluted and naturally attenuated.

No routine offshore produced water discharges are expected during the operational phase, as production fluids will be exported to the Dimlington terminal for onshore processing. Any discharges associated with subsea maintenance activities will be infrequent and small in volume.

Overall, given the limited scale, short duration and regulated nature of discharges, residual effects are assessed as **Negligible** to **Minor** and not significant.

10.6 Transboundary Effects

The Abbey & Baker Development is located a substantial distance from the nearest international boundary, with the UK/Netherlands median line situated approximately 152 km to the northeast of the development area.

The planned marine discharges associated with the development, including water-based drill cuttings and muds (and associated TSS plumes), drilling and completion chemicals, commissioning fluids and residual reservoir hydrocarbons, are characterised by low volumes and are highly localised and transient in nature. Modelling of drill cuttings and mud discharges demonstrates that TSS elevations are confined to the near-field (on the order of hundreds of metres from the discharge location) and are short-lived due to rapid dispersion under the prevailing hydrodynamic conditions of the Southern North Sea.

Chemical and hydrocarbon discharges will be subject to regulatory control under the Offshore Chemicals Regulations 2002 (as amended) and, where applicable, the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended) via Chemical Permit SATs and ODP SATs, ensuring that discharge concentrations remain within acceptable limits. Following discharge, these substances are expected to dilute rapidly and undergo natural attenuation processes, including biodegradation.

Given the significant distance to the nearest transboundary line, combined with the limited spatial extent, short duration and rapid dispersion of all discharge types, there is no realistic pathway for discharges associated with the Abbey & Baker Development to reach international waters. Transboundary effects are therefore not anticipated.

10.7 Cumulative Effects

The Abbey & Baker Development will be undertaken over a relatively short and defined period, with drilling activities scheduled between Q4 2027 and Q3 2028, subsea installation between Q4 2028 and Q1 2029, and commissioning leading to first gas in the first half of 2029 (refer to Section 3.2). The principal marine discharges associated with the development will therefore occur over this limited timeframe and will be temporary, intermittent and highly localised in nature.

During the operational phase, discharges will be minimal and limited to small volumes associated with chemical injection systems and periodic subsea maintenance activities. Such activities are expected to be infrequent, short in duration and low in volume relative to drilling and commissioning operations.

At the end of field life, decommissioning activities may also result in limited, short-term discharges; however, these will be subject to separate environmental assessment and permitting. Overall, the scale, duration and regulated nature of discharges associated with the Abbey & Baker Development are limited, and therefore the potential for cumulative interaction with other activities is inherently low and not expected to result in significant effects.

The proposed Abbey & Baker Development is located within an area of established oil and gas activity (Section 4.4.4) and will tie back to the existing York platform, located approximately 8 km southwest of the Abbey drill centre. The nearest infrastructure is the Minerva platform, operated by Perenco, located approximately 5 km east-northeast. These facilities are currently in operation; however, routine production activities are not expected to result in significant offshore chemical or hydrocarbon discharges within the vicinity of the proposed development, with any discharges regulated under existing permits.

Potential cumulative effects associated with marine discharges are therefore limited to short-term, intermittent activities such as drilling or well intervention operations at nearby installations. The planned discharges associated with the Abbey & Baker Development (including water-based drill cuttings and muds, drilling and completion chemicals, commissioning fluids and residual reservoir hydrocarbons) are characterised by low volumes, are highly localised and transient in nature, and are subject to regulatory control under the Offshore Chemicals Regulations 2002 (as amended) and, where applicable, the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended) via Chemical Permit SATs and ODP SATs. Modelling of drill cuttings and mud discharges indicates that effects are confined to the near-field of the well location and are short-lived, with rapid dispersion under prevailing hydrodynamic conditions. Given the limited spatial extent and duration of these discharges, and the separation distances between installations, the potential for overlap with discharges from other oil and gas activities is considered to be negligible.

Petrogas is aware of the proposed Endurance carbon storage site located approximately 34 km northeast of the Abbey & Baker Development. Offshore construction and drilling activities for the Endurance project, including the 145 km pipeline installation and the five-well injection campaign, are scheduled to continue through 2027 and 2028. While these activities will coincide with the main offshore works for the Abbey & Baker Development, the significant spatial separation, combined with the localised and transient nature of discharges from both projects and the dispersive hydrodynamic conditions of the SNS, means there is no realistic pathway for interaction between discharge plumes. Consequently, significant cumulative impacts to the water column or marine receptors are not anticipated.

The proposed Hornsea Project Four Offshore Wind Farm cable corridor is located approximately 10 km from the Abbey & Baker Development. Installation activities are currently anticipated to commence from 2028 and may partially overlap with the proposed development. However, offshore wind installation activities do not typically involve routine discharges of chemicals or hydrocarbons to the marine environment, and therefore no cumulative effects with respect to marine discharges are predicted.

Other activities in the wider area, including commercial fishing, shipping, and aggregate extraction (detailed in Section 4.4), do not represent significant sources of chemical or hydrocarbon discharges that would interact with the planned discharges from the Abbey & Baker Development. These activities may contribute to localised increases in suspended solids (e.g. through seabed disturbance from fishing gear or dredging); however, the TSS plume associated with drill cuttings and mud discharges from the proposed development is highly localised and short-lived, with modelling demonstrating rapid dispersion and limited spatial extent (typically within a few hundred metres of the discharge location). Given the transient nature of both project-related and background sources of suspended solids, and the absence of sustained or overlapping plumes, there is no realistic potential for cumulative increases in TSS. As such, no significant cumulative effects on water quality or associated receptors are anticipated.

Overall, taking into account the scale, duration and regulated nature of the proposed marine discharges, the dispersive characteristics of the receiving environment, and the limited spatial and temporal overlap with other activities, significant cumulative effects on the marine environment are not anticipated.

11 Accidental Releases

11.1 Introduction

This section assesses the risk of a worst case release occurring from the Abbey & Baker Development and the potentially significant environmental and socio-economic effects that could occur as a result. It also details the control and mitigation measures that will be implemented to both reduce the risk of an incident occurring and limit the potential impacts in the event that a spill did occur. It should be noted that in planning its activities, a primary focus of Petrogas is to ensure that all practicable measures are taken to prevent the occurrence of accidental events and, should they occur, mitigate their effects. The risk of an accidental release of hydrocarbons occurring from the Abbey & Baker Development will be minimised through the implementation of physical barriers such as safety valves, maintenance to minimise leaks, and the implementation of handling and operational procedures and training to influence human behaviours. Measures to respond to a spill from the Abbey & Baker fields if an incident did occur will be covered in an Oil Pollution Emergency Plan (OPEP), approved by the Offshore Major Accident Regulator (OMAR) under The Merchant Shipping (Oil Pollution Preparedness, Response and Cooperation) Regulations 1998 (as amended) in advance of the proposed development operations commencing.

11.2 Sources and Likelihood of Accidental Releases

11.2.1 Historic UKCS Data for Hydrocarbon Releases

On the UKCS, all accidental oil releases to the marine environment, regardless of size, are reportable to the OPRED through submission of a Petroleum Operations Notice 1 (PON1). Analysis of long-term data over the past 30 years indicates a general trend towards smaller spill volumes and a reduction in the number of reported spill incidents. However, the total mass of oil accidentally released to the marine environment varies between years (2014–2024), reflecting the sensitivity of annual totals to isolated, low-frequency, higher-volume events (OEUK, 2025a).

In 2024, the mass of unintentional oil releases to the marine environment on the UKCS was reported as 56 tonnes. By comparison, approximately 1,500 tonnes of dispersed oil were discharged to sea in produced water under permit during the same year. Unintentional oil releases therefore represented approximately 4 % of the total oil entering the marine environment in 2024. For context, UK production of primary oils in 2024 was approximately 31 million tonnes, meaning accidental oil releases represented approximately 0.00018 % of total oil production (DESNZ, 2025e). OEUK (2025a) further reports that diesel accounted for the largest proportion of unintentional oil released in 2024 (71 %), followed by mineral oil (24 %) and hydraulic oil (3.5 %).

The historic UKCS dataset demonstrates that annual release totals are sensitive to relatively small numbers of atypical events. Consequently, year-on-year fluctuations in reported release mass do not necessarily indicate a broader deterioration in offshore environmental performance. Rather, the data illustrate that accidental hydrocarbon releases are generally infrequent in the context of overall offshore activities, although individual events can materially influence annual totals. This supports the need for a precautionary assessment of credible accidental release scenarios within the ES, notwithstanding the relatively low frequency of such events.

11.2.2 Abbey & Baker Development - Accidental Release Scenarios

It is considered that the following accidental release scenarios have the potential to result in significant environmental and socio-economic effects during development of the Abbey & Baker fields:

- Well blowout (releasing large quantities of condensate and gas) in the event of a loss of well control;
- MODU or vessel collision releasing the entire inventory of diesel;
- Pipeline rupture or vessel collision with the York platform, resulting in a subsequent release of condensate and gas to sea.

The likelihood of these unplanned events occurring is discussed below, using the Likelihood of Occurrence criteria defined in Section 5.3.2

Likelihood of a Well Blowout

A blowout is an extremely rare event where total failure of all pressure control systems and related processes can result in an uncontrolled flow of oil or natural gas (or a mixture of the two) at the rig floor as a result of BOP failure.

Following the 2009 Montara and the 2010 Deepwater Horizon/Macondo well control incidents, EU Directive 2013/30/EU on the safety of offshore oil and gas operations came into force, which is implemented in the UK through the Offshore Installations (Offshore Safety Directive) (Safety Case etc) Regulations 2015 (SCR 2015). The main aim of SCR 2015 is to reduce the risks from major accident hazards, such as a blowout, to the health and safety of the workforce employed on offshore installations or in connected activities. In addition, SCR 2015 also aims to increase the protection of the marine environment and coastal economies against pollution and ensure improved response mechanisms in the event of such an incident.

Table 11.1 presents North Sea blowout frequencies by operation type. This indicates that for development drilling (on average), the blowout frequency is extremely low at 3.9×10^{-5} per drilled well.

In summary, given the above, the likelihood of a blowout occurring at the Abbey & Baker Development is considered to be **Extremely Rare**.

An uncontrolled and unmitigated well blowout scenario is considered to result in the largest, i.e. worst case, volume of hydrocarbons to sea from the proposed Abbey & Baker Development (a cumulative release of 175,223.07 bbl (27,860.47 m^3) of condensate over a period of 79 days) and has therefore been subject to oil spill modelling and assessed in the proceeding sections below.

Table 11.1: Blowout Frequencies (data from IOGP, 2019)

Operation	Well Category	Frequency, Average Well	Frequency, Gas Well	Frequency, Oil Well	Unit [Note 3]
Development Drilling	Normal	3.9×10^{-5}	4.2×10^{-5}	3.4×10^{-5}	per drilled well
	HPHT [Note 1]	2.4×10^{-4}	2.6×10^{-4}	2.1×10^{-4}	per drilled well
Exploration Drilling	Normal	1.4×10^{-4}	1.5×10^{-4}	1.2×10^{-4}	per drilled well
Completion	-	2.1×10^{-4}	2.8×10^{-4}	1.4×10^{-4}	per operation
Wirelining	-	$6.7x\ 10^{-6}$	9.0×10^{-6}	4.4×10^{-6}	per operation
Coil Tubing	-	8.5×10^{-5}	1.1×10^{-4}	5.6×10^{-5}	per operation
Workover	-	3.0×10^{-4}	4.0×10^{-4}	2.0×10^{-4}	per operation
Producing Wells [Note 2]	-	3.7×10^{-5}	7.2×10^{-5}	2.1×10^{-5}	per well year

Note 1: HPHT – High Pressure, High Temperature.
Note 2: Excludes external causes such as ship collisions.
Note 3: Frequencies are presented on different exposure bases depending on the operation. Drilling frequencies are expressed per drilled well; completion, wireline, coil tubing and workover frequencies are expressed per operation; and producing well frequencies are expressed per well year. The values are therefore not directly comparable without considering the relevant activity duration or exposure period.

Likelihood of an MODU or Vessel Collision

During development of the Abbey & Baker fields there is the potential for a MODU and / or vessel collision, resulting in the entire loss of fuel inventory. The risk of collision will be highest when the MODU is jacked-up on location at Abbey & Baker and when the pipeline and umbilical are installed. A full collision risk assessment will therefore be undertaken by Petrogas to inform the CtL permit applications, required to site the MODU and subsea infrastructure at the Abbey & Baker locations.

In addition, information on the location of the drilling rig and associated anchor pattern (the MODU will only use anchors to move into position at the Abbey locations), 500 m safety zone, subsea

infrastructure and vessel operations will be communicated to other sea users (via the UKHO) through the standard communication channels including Kingfisher, Notice to Mariners and Radio Navigation Warnings.

Petrogas proposes to utilise guard vessels during the pipeline and umbilical installation activities, prior to the deposit of protection (rock) on top of the lines, to ensure that other sea users are aware of the ongoing operations. Vessels involved in installation operations will also update their marks, lights and navigational status broadcast on AIS to indicate to other vessels when they are restricted in manoeuvrability. This will assist any passing vessels that encounter the installation vessels.

Given the above mitigation measures, the likelihood of a MODU or vessel collision is considered to be **Unlikely**. As the loss of diesel inventory is small compared to the worst case well blow out scenario, it is not considered further in this assessment.

Likelihood of a Pipeline Rupture

Accidental releases of hydrocarbons or chemicals from subsea infrastructure (including pipelines, flowlines and umbilicals, plus the York platform) are most likely to occur as a result of structural failures of equipment, corrosion, impact damage or other third-party interaction. Releases due to impact damage are considered rare.

Table 11.2 details the number of Loss of Containment (LOC) events for hydrocarbon pipelines and risers on the UKCS during a 20-year period from 2001 to 2020, with an estimate of LOC frequencies for operating pipelines outside of the 500 m safety zone provided in Table 11.3.

Table 11.2: Number of LOC Events (2001-2020) (PARLOC, 2024)

Pipeline Type	Number of LOC Events 2001-2020		
	Pipeline (excluding jumpers)	Risers	Jumpers
Rigid	16	6	7
Flexible	9	4	11

Table 11.3: Estimated Pipeline Loss of Containment Frequencies (PARLOC, 2024)

Pipeline LOC frequencies outside the 500 m safety zone of a production installation for different pipeline lengths					
Pipeline length (per km.year)	0 km to 3 km	3 km to 10 km	10 km to 30 km	30 km to 100 km	>100 km
Rigid Pipeline	4.3E-04	4.3E-04	7.7E-05	1.8E-05	1.1E-05
Flexible Pipeline	1.1E-03				No data

Worst case release scenarios would involve the loss of containment of the entire inventory of the pipeline; however these types of events are rare. Data from the Worldwide Offshore Accident Database (WOAD) for the period from 1970 to 2007 indicates that worldwide there have only been two major accidents resulting in the total loss of inventory from a pipeline. Both of these events were recorded in the North Sea (Europe), during transfer operations and involved 'loss of buoyancy or sinking' (OGP, 2010).

The York platform has an existing 500m exclusion zone in place, which will remain the place for the duration of the Abbey & Baker Development. In the event of a vessel collision with the York platform, the hydrocarbon risk would be the same as the pipeline rapture discussed here and would not be considered to be worse case.

In summary, based on historical accidental loss of containment data, the likelihood of an accidental pipeline rupture is considered to be **Rare**.

The frequencies presented in Table 11.3 are based on historical accidental failure data and therefore provide a basis for assessing accidental loss of containment only; they do not provide a basis for quantifying intentional third-party interference or wider security-related threats to subsea infrastructure. The security and resilience of UKCS pipelines, cables and associated subsea infrastructure is addressed through wider UK critical national infrastructure protection and maritime security.

In the event of a significant leak from the Abbey & Baker Development production pipelines, the release is expected to be short-term, occurring over a period of day(s). The total volume of condensate released would be considerably less than the worst-case well blowout scenario, which has been modelled, and is therefore not considered further in the impact assessment.

It is acknowledged that gas could also be lost in the event the Abbey & Baker Development production pipelines are ruptured. An event such as this would result in the increased concentration of GHG emissions in the atmosphere, further contributing to the effects of climate change, and could cause short term air quality impacts. The potential environmental effects from GHG emissions generated from the Abbey & Baker Development are discussed in Section 9 of the ES and have not been considered further in this Section given the unlikely and one-off nature of a pipeline rupture event.

11.3 Fate of Spills in the Marine Environment

11.3.1 Oil Properties and Weathering Processes

When oil is spilled at sea it normally spreads out and moves on the sea surface with the wind and currents. At the same time, a number of natural processes take place; collectively termed weathering, these process change the physical and chemical properties of the oil and determine its fate in the marine environment. The weathering of oil depends on the chemical and physical properties of the oil (e.g. density, viscosity, wax content and pour point), the weather conditions (e.g. wind, waves, temperature and sunlight) and the properties of the seawater (e.g. salinity, temperature and bacterial flora).

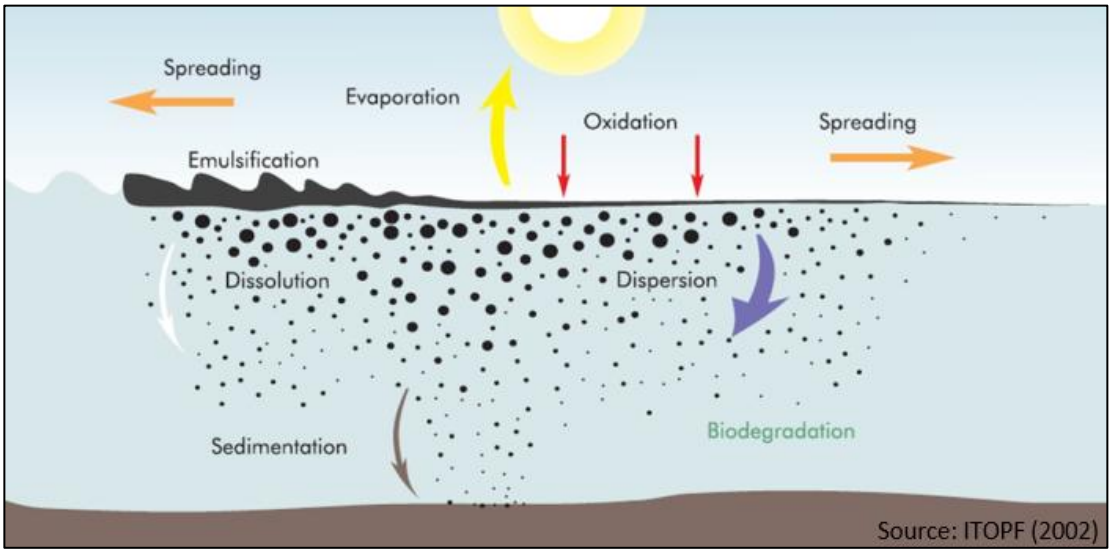
The International Tanker Owner Pollution Federation (ITOPF) has ranked oils according to their physical characteristics (API/SG) and likely spill behaviour (Table 11.4). The hydrocarbons present in the Abbey & Baker reservoirs are predominantly dry gas, with small amounts (circa. 9.4 bbl / million standard cubic foot) of associated light condensate (57.5˚ API; categorised as a Group 1 oil). Light oils such of these are more susceptible to evaporation and oxidation and consequently reduce faster over time compared to heavier oils.

Table 11.4: ITOPF Categories and Characteristics

Group	Specific Gravity	API	Viscosity (cSt)	Typical Examples	Scale
1	< 0.8	> 45˚	< 3	Gasoline products	Light
2	0.8 - 0.85	35˚ - 45˚	4 (semi solid)	Diesel-like products, light crude	
3	0.85 - 0.95	17.5˚ - 35˚	8 (semi solid)	Medium crude, North Sea crude (e.g. Forties)	
4	> 0.95	< 17.5˚	1,500 (semi solid)	Heavy crude and residual oils	Heavy

There are eight main oil weathering processes: spreading, evaporation, dispersion, emulsification, dissolution, sedimentation, oxidation, and biodegradation. The effects of spreading, evaporation, dispersion, emulsification and dissolution are most significant early on in a spill whilst oxidation, sedimentation and biodegradation are more significant later (Figure 11.1) (ITOPF, 2014a).

Figure 11.1: Oil Weathering Process



Over time, as a consequence of weathering, an oil spill will normally break up and begin to dissipate into the marine environment. Light products such as the Abbey & Baker Development condensate and diesel under most conditions, evaporate and dissipate quickly and naturally.

11.3.2 Oil Spill Modelling

Although extremely rare, a well blowout event is considered to be the worst case accidental release scenario that could occur as a result of the Abbey & Baker Development. Therefore, in order to gain an understanding of the fate of the Abbey & Baker condensate in the marine environment, the following scenario has been modelled:

- Subsurface blowout release from the Baker development well with a cumulative release of 175,223.07 bbl (27,860.47 m^3) of 57.5°API condensate, released over a period of 79 days.

This represents the worst case scenario for the Abbey & Baker Development in terms of both the volume of hydrocarbons which would be released and the duration of the spill (i.e. it assumes a relief well would need to be drilled to bring the well back under control). It should be noted that this is an extreme worst case that assumes the complete failure of all control and preventative measures. In a real situation, steps would immediately be taken to stem the flow of hydrocarbons and in the event of a well control incident bring the well back under control. A counter-pollution response strategy would also be developed and initiated, which would aim to prevent significant quantities of hydrocarbons beaching on the shoreline.

The oil spill modelling has been undertaken with the use of OILMAP (Version 7.7.218.1528), an advanced oil modelling tool developed and licensed by RPS ASA, which provides predictions of the fate and transport of spilled hydrocarbons and calculates the probability of key areas being impacted.

To simulate a range of possible metocean conditions, stochastic results were calculated from over 100 trajectory runs per season / 400 runs in total. This provides insight into the range of probable behaviours of a potential oil spill in response to varying meteorological and oceanographic conditions in the study area. Stochastic modelling computes surface trajectories for an ensemble of many individual cases for each spill scenario. Each individual simulation start time is selected randomly, thus sampling the variability in the wind and current forcing. The stochastic model results that have been reported in the assessment include the following:

- The probability and minimum time for surface oiling (with a minimum thickness threshold of 0.3 µm). A surface thickness 0.3 micrometres (µm) is the minimum threshold identified by the Bonn Agreement Oil Appearance Code (BAOAC) capable of producing a visible rainbow sheen. The 0.3 µm threshold value is required by the OPEP guidance notes (OPRED, 2022) and is the chosen value for when potential significant environmental impacts may begin to occur.

- The probability and minimum time for water column oiling (with a minimum concentration threshold of 1 ppb). A concentration of oil in water above 1 ppb is the minimum threshold identified for screening potential effects on sensitive organisms and socio-economic activity (e.g. seafood production).
- The probability and minimum time for shoreline oiling (with a minimum thickness threshold of 1.0 µm). A shoreline thickness 1.0 µm is the minimum threshold identified for potential effects on socio-economic resource uses, as this amount of oil may conservatively trigger the need for shoreline clean-up on amenity beaches (French-McCay, *et al*. 2011 and French-McCay, *et al*. 2012).

It is important to note that the stochastic modelling results **do not represent a single spill event**, and instead show the aggregation of results computed by running the spill scenario multiple times (i.e. 100 times) over different weather conditions.

To analyse single spill scenarios, trajectory modelling was undertaken for each season by extracting the worst case simulation run from the stochastic results. The worst case trajectory simulation was identified by the greatest mass of shoreline oiling at any one location after 89 days. The trajectory modelling enables fates analysis on the released condensate over time.

The input parameters and modelling results are presented in full in Appendix E. A summary of the key conclusions has been provided below.

Stochastic Modelling Results

Summary of Results

Table 11.7 summarises the stochastic results for a worst case subsea well blowout from the Abbey & Baker Development across all seasons, reporting the minimum arrival time and probability of oil to reach land and the territorial waters of nearby countries.

Table 11.5: Summary of Stochastic Modelling Results

Subsea Well Blowout from the Baker development well					
Spill Scenario / Descriptor: 175,223.07 bbl (27,860.47 m^3) of Condensate (57.5 °API) released over 79 days					
Season		Winter (December – February)	Spring (March – May)	Summer (June – August)	Autumn (September – November)
Median Crossing [Note 1]					
Identified Median Line	**Surface Oil: Probability and Shortest Time to Reach (Minimum Thickness of 0.3 µm)**				
Netherlands	*Maximum Probability*	14 %	N/A	3 %	17 %
	Shortest Arrival Time	222 hrs	N/A	882 hrs	410 hrs
Germany	*Maximum Probability*	5 %	N/A	N/A	2 %
	Shortest Arrival Time	457 hrs	N/A	N/A	1,196 hrs
Belgium	*Maximum Probability*	N/A	N/A	N/A	2 %
	Shortest Arrival Time	N/A	N/A	N/A	1,367 hrs
France	*Maximum Probability*	N/A	N/A	N/A	1 %
	Shortest Arrival Time	N/A	N/A	N/A	1,382 hrs
Denmark	*Maximum Probability*	2 %	N/A	N/A	1 %
	Shortest Arrival Time	785 hrs	N/A	N/A	2,099 hrs
Identified Median Line	**Subsurface Oil: Probability and Shortest Time to Reach (Minimum Water Column Concentration 1.0 ppb)**				
Netherlands	*Maximum Probability*	67 %	3 %	32 %	80 %
	Shortest Arrival Time	199 hrs	1,412 hrs	721 hrs	403 hrs
Germany	*Maximum Probability*	44 %	N/A	3 %	20 %
	Shortest Arrival Time	478 hrs	N/A	1,659 hrs	1,067 hrs
Belgium	*Maximum Probability*	10 %	1 %	11 %	25 %
	Shortest Arrival Time	897 hrs	1,418 hrs	1,078 hrs	757 hrs
France	*Maximum Probability*	5 %	1 %	12 %	20 %
	Shortest Arrival Time	933 hrs	1,352 hrs	986 hrs	743 hrs
Denmark	*Maximum Probability*	14 %	N/A	N/A	3 %

	Shortest Arrival Time	788 hrs	N/A	N/A	1,190 hrs
Norway	*Maximum Probability*	3 %	N/A	N/A	N/A
	Shortest Arrival Time	1,712 hrs	N/A	N/A	N/A
Sweden	*Maximum Probability*	4 %	N/A	N/A	N/A
	Shortest Arrival Time	1,396 hrs	N/A	N/A	N/A
Landfall [Note 1]					
Predicted Locations	**Shoreline Oil: Probability and Shortest Time to Reach (Minimum Thickness of 1.0 µm)**				
UK Counties					
East Riding of Yorkshire	*Maximum Probability*	40 %	58 %	34 %	13 %
	Shortest Arrival Time	157 hrs	119 hrs	101 hrs	115 hrs
North Yorkshire	*Maximum Probability*	33 %	26 %	22 %	7 %
	Shortest Arrival Time	149 hrs	191 hrs	118 hrs	335 hrs
Lincolnshire	*Maximum Probability*	9 %	11 %	4 %	2 %
	Shortest Arrival Time	350 hrs	272 hrs	320 hrs	525 hrs
Norfolk	*Maximum Probability*	7 %	3 %	N/A	2 %
	Shortest Arrival Time	628 hrs	394 hrs	N/A	447 hrs
Northumberland	*Maximum Probability*	N/A	1 %	N/A	N/A
	Shortest Arrival Time	N/A	932 hrs	N/A	N/A
Durham	*Maximum Probability*	10 %	1 %	N/A	1 %
	Shortest Arrival Time	573 hrs	570 hrs	N/A	2,023 hrs
Tyne and Wear	*Maximum Probability*	6 %	1 %	N/A	1 %
	Shortest Arrival Time	673 hrs	532 hrs	N/A	2,054 hrs
Suffolk	*Maximum Probability*	1 %	N/A	N/A	1 %
	Shortest Arrival Time	872 hrs	N/A	N/A	1,348 hrs
Essex	*Maximum Probability*	1 %	N/A	N/A	N/A
	Shortest Arrival Time	1,595 hrs	N/A	N/A	N/A
Kent	*Maximum Probability*	1 %	N/A	N/A	N/A

	Shortest Arrival Time	1,489 hrs	N/A	N/A	N/A
International					
Netherlands	*Maximum Probability*	1 %	N/A	N/A	1 %
	Shortest Arrival Time	1,120 hrs	N/A	N/A	2,018 hrs
Germany	*Maximum Probability*	2 %	N/A	N/A	N/A
	Shortest Arrival Time	1,242 hrs	N/A	N/A	N/A
Denmark	*Maximum Probability*	1 %	N/A	N/A	1 %
	Shortest Arrival Time	1,227 hrs	N/A	N/A	2,094 hrs
France	*Maximum Probability*	N/A	N/A	N/A	1 %
	Shortest Arrival Time	N/A	N/A	N/A	1,748 hrs

Note 1: Shortest arrival time and maximum probability values are not necessarily linked to the same run. The results represent a worst case scenario for each feature based on the analysis of all model runs.

Surface Oiling

Table 11.6 reports the maximum distance that the surface oil slick may extend from the Baker development well release location for each of the BAOAC 2–5 thresholds. The results are presented graphically in Figure 11.2. Higher-thickness surface oiling (BAOAC 4 and 5) is predicted to occur primarily in areas close to the release location where oil concentrations are greatest. In contrast, lower-thickness oiling (BAOAC 2 and 3) may extend over a wider area due to the spreading and weathering of the released condensate as it is transported away from the source.

Table 11.6: Surface Oiling by BAOAC Thresholds

Code	Description – Appearance	Layer Thickness Interval (µm)	Litres per km^2	Max Distance from the Release Location (excluding ≤10 % probability)
2	Rainbow	0.30 to 5.0	300 – 5000	282 km
3	Metallic	5.0 to 50	5000 – 50,000	67 km
4	Discontinuous True Oil Colour	50 to 200	50,000 – 200,000	18 km
5	Continuous True Oil Colour	More than 200	More than 200,000	6 km

The stochastic modelling results show that surface oiling is predicted to occur predominantly within UK waters. However, transboundary transport of surface oil is possible under certain meteorological and oceanographic conditions, although this is limited to the lowest thickness threshold modelled (BAOAC 2) (Figure 11.2). The highest probabilities of surface oil crossing into neighbouring waters occur towards the Netherlands, where a maximum probability of 17 % is predicted (Table 11.5; Figure 11.3). Lower probabilities are predicted for Germany (up to 5 %), Belgium (up to 2 %), France (up to 1 %), and Denmark (up to 2 %), depending on season.

The minimum predicted transit time for surface oil exceeding 0.3 µm thickness to reach neighbouring waters is approximately 222 hours (around 9 days) under winter conditions. Transit times in other seasons are generally longer, reflecting differences in prevailing wind and current patterns (Table 11.5).

Seasonal variability is evident in the stochastic modelling results, with autumn and winter simulations generally producing the greatest spatial extent of surface oiling, reflecting stronger winds and enhanced dispersion during these periods. Overall, the modelling indicates that while surface oil could disperse across a wide area of the SNS under a worst case scenario, the highest thickness oiling remains concentrated close to the release location in UK waters and decreases with distance as the oil spreads and weathers in the marine environment.

Figure 11.2: Maximum Surface Oil Thickness (Bonn Code)

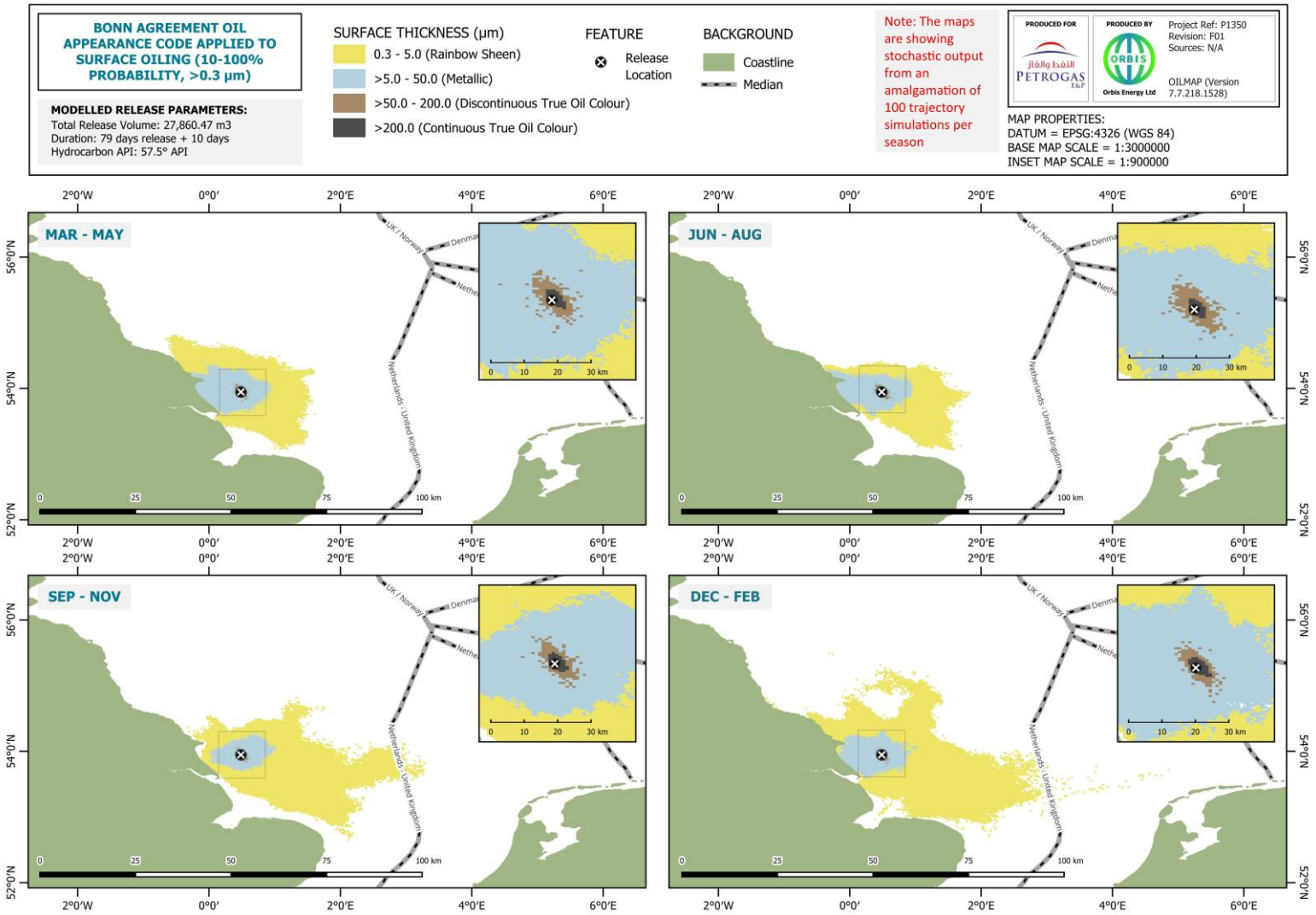
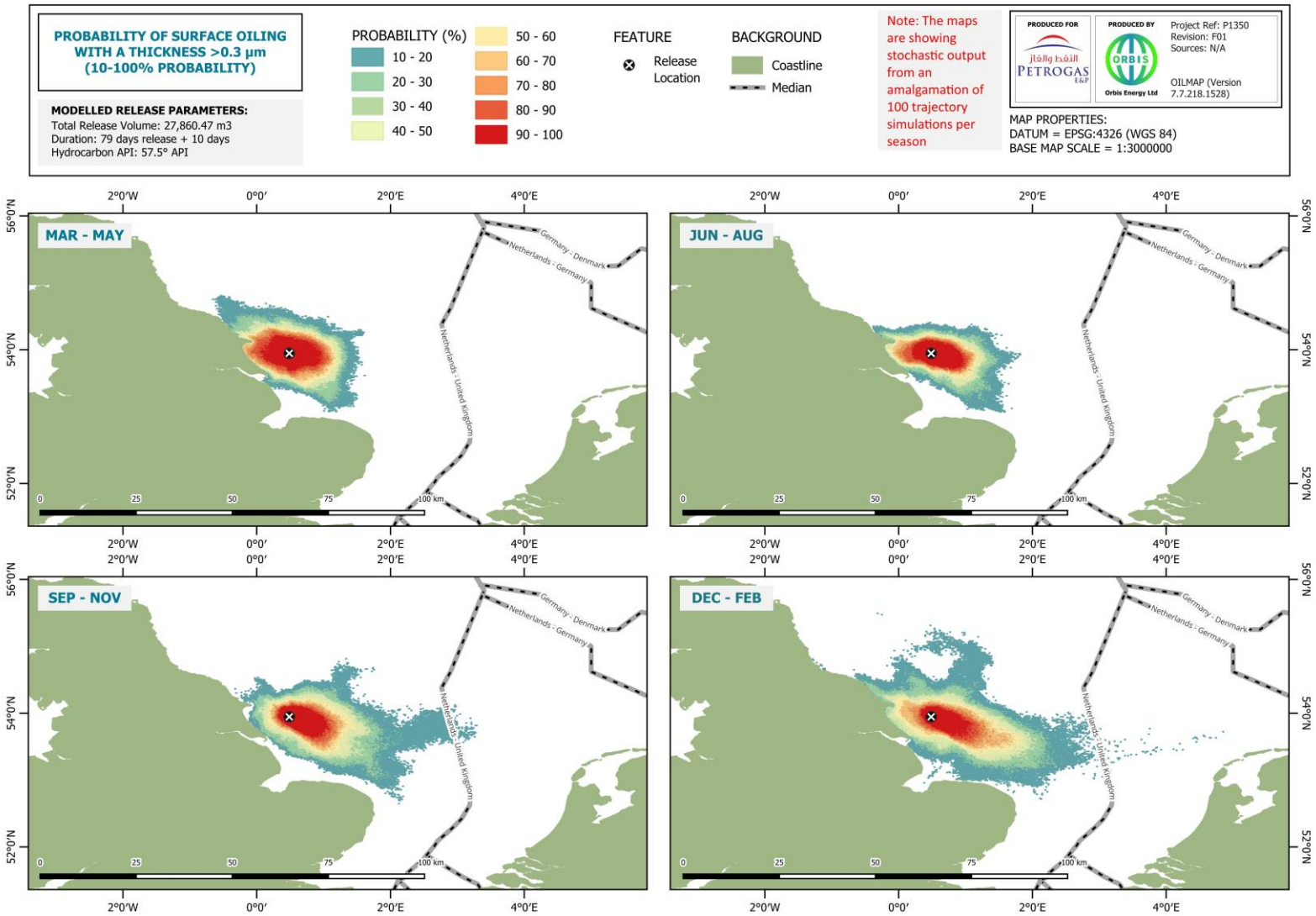


Figure 11.3: Probability of Surface Oiling



Subsurface Oiling

Table 11.7 presents the water column oil concentration thresholds that have been used in the modelling study to help determine subsurface oiling severity in the spatial context.

A minimum water column concentration of 1 ppb has been used in the modelling study to determine the probability and minimum arrival time for subsea oiling. This concentration is exceeded out to a maximum distance of 502 km from the release location (when excluding ≤10 % probability).

Model outputs indicate that the maximum predicted subsurface oil concentrations generally remain below the OSPAR predicted no-effect concentration (PNEC) of 70.5 ppb for most of the model domain. Concentrations exceeding this threshold are predicted only in areas close to the release location (up to 54 km) where oil droplet concentrations are highest immediately following the release (Figure 11.4).

Table 11.7: Water Column Oil Concentration Thresholds

Threshold for Water Column Oil Concentration (ppb)	Threshold Justification (refer to Appendix E for detailed justification)
1	Screening threshold (Minimum Water Column Concentration modelled) (Trudel, 1989; French-McCay, 2002; French-McCay, 2004; French-McCay, *et al.,* 2012).
70.5	OSPAR recommended PNEC threshold for marine fauna (Smit *et al*., 2009; OSPAR, 2014)

The stochastic modelling results indicate that subsurface oiling may occur across a wide area of the SNS, reflecting the natural dispersion and entrainment of small oil droplets within the water column following a subsea release. The modelled release parameters presented in Appendix E represent a high-energy blowout scenario with a large Gas to Oil Ratio (GOR) of 18,940 m^3/m^3. Under these conditions, the model predicts predominantly small oil droplet sizes (<200 µm), which are readily entrained within the water column and remain suspended for extended periods, resulting in a wider area of low-level hydrocarbon exposure. The smallest droplets (<70 µm), representing approximately 50 % of the released condensate, are predicted to remain in suspension and not surface. This behaviour is consistent with observations of subsea blowout dynamics (Spaulding et al., 2017) and experimental studies undertaken in the North Sea (Johansen et al., 2013; SINTEF, 2014).

The transboundary transport of subsurface oil is possible under certain meteorological and oceanographic conditions and is most pronounced during autumn and winter (Figure 11.5). The highest probabilities of subsurface oil crossing into neighbouring waters occur towards the Netherlands, with maximum probabilities of up to 80 % predicted depending on season. Lower probabilities are predicted for Germany (up to 44 %), Belgium (up to 25 %), France (up to 20 %), and Denmark (up to 14 %) (Table 11.5; Figure 11.5). The minimum predicted transit time for subsurface oil exceeding 1 ppb to reach neighbouring waters is approximately 199 hours (around 8 days) under winter conditions.

Seasonal variability is evident in the stochastic modelling results, with the greatest spatial extent of subsurface oiling generally predicted during autumn and winter, reflecting stronger wind-driven mixing and enhanced dispersion within the water column during these periods.

Overall, the modelling indicates that while dispersed oil droplets may be transported across a relatively wide area of the SNS under a worst case scenario, elevated concentrations remain largely confined to the vicinity of the release location and decrease rapidly with distance as the condensate disperses and degrades within the marine environment.

Figure 11.4: Maximum Total Water Column Oil Concentrations

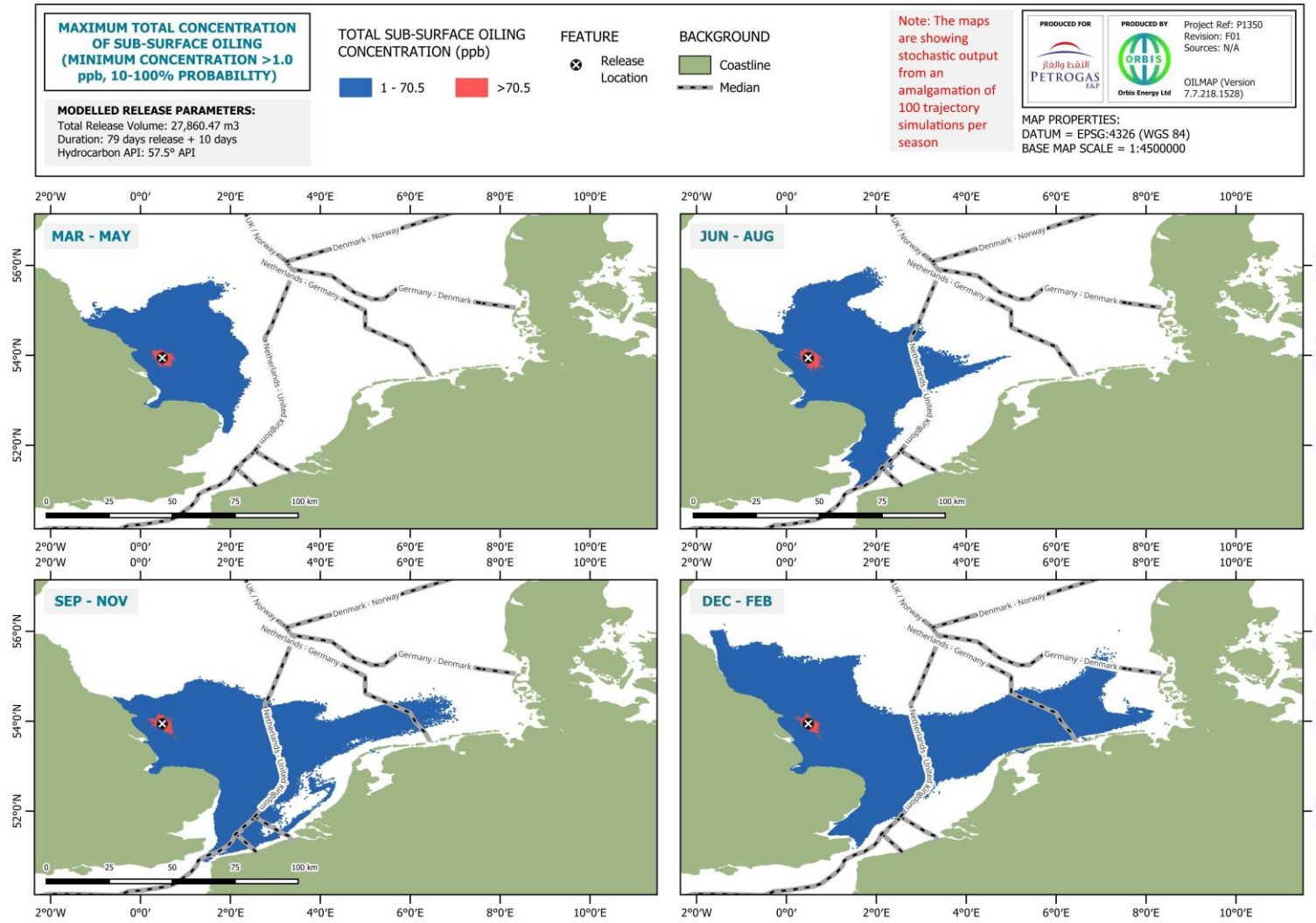
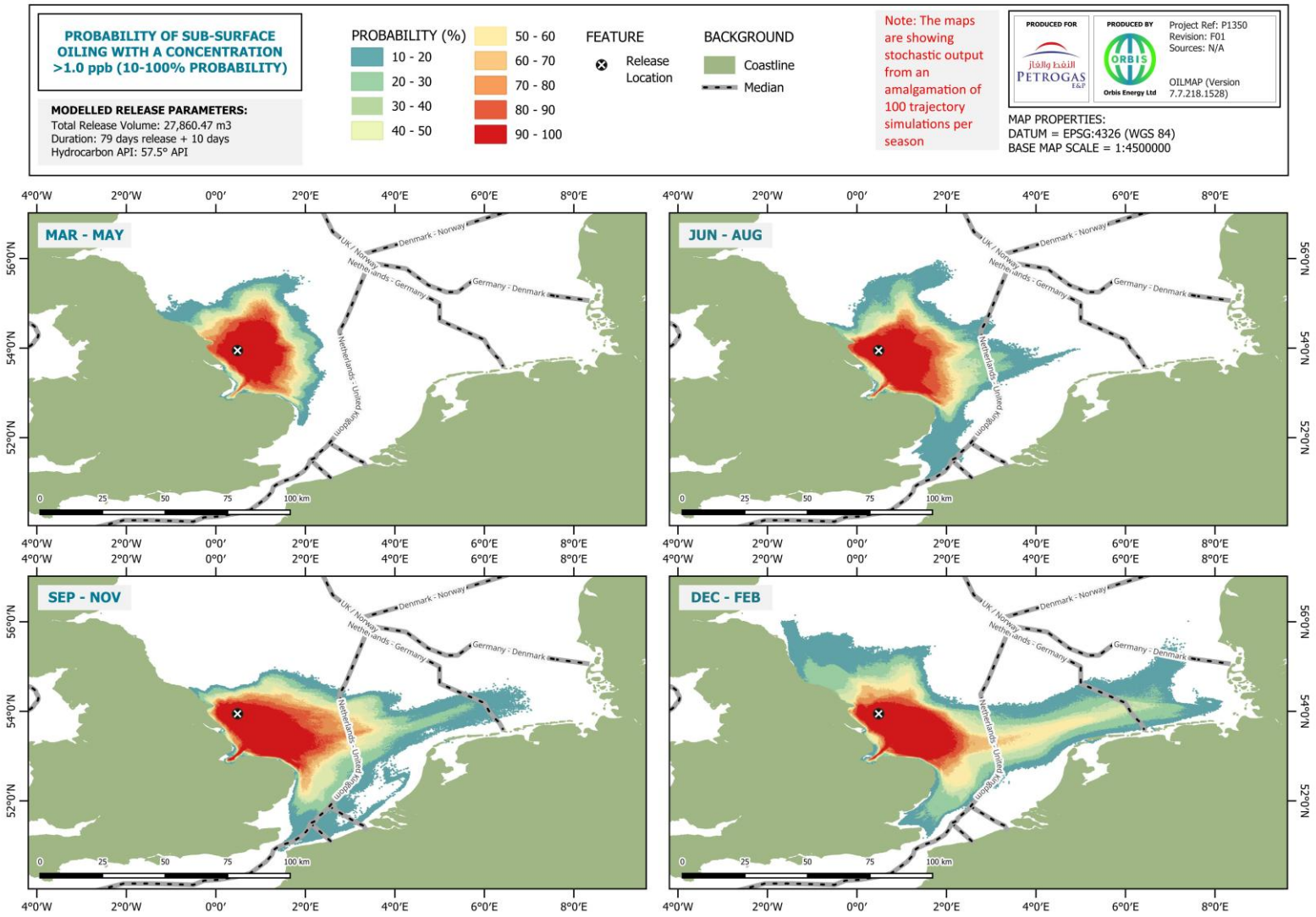


Figure 11.5: Probability of Subsurface Oiling



Shoreline Oiling

Table 11.8 presents the shoreline oiling thickness (and corresponding concentration) thresholds that have been used in the modelling study to help determine shoreline oiling severity in the spatial context. All modelled shoreline oiling, both along UK and international coastlines, falls within the 'Light Oiling' severity threshold, reflecting the progressive spreading, weathering and evaporation of condensate as it is transported away from the release location.

Table 11.8: Shoreline Oil Thickness Thresholds

Shoreline Oiling Severity (ITOPF, 2014b)	Thickness Threshold (mm)	Concentration
Light Oiling	0.001 – <1	0.001 – 1 litres/m^2
Moderate Oiling	1 – 10	1 – 10 litres/m^2
Heavy Oiling	>10	>10 litres/m^2

The stochastic modelling predicts that shoreline oiling could occur along parts of the UK east coast, with the highest probabilities along the Yorkshire and Humber coastline. The greatest likelihood of shoreline contact occurs along the East Riding of Yorkshire, where probabilities of shoreline oiling reach up to 58 % in spring, with minimum arrival times of approximately 101 hours (4 days) occurring in summer. Adjacent coastlines, including North Yorkshire, also show relatively high probabilities of shoreline oiling (up to 33%) (Table 11.5; Figure 11.6).

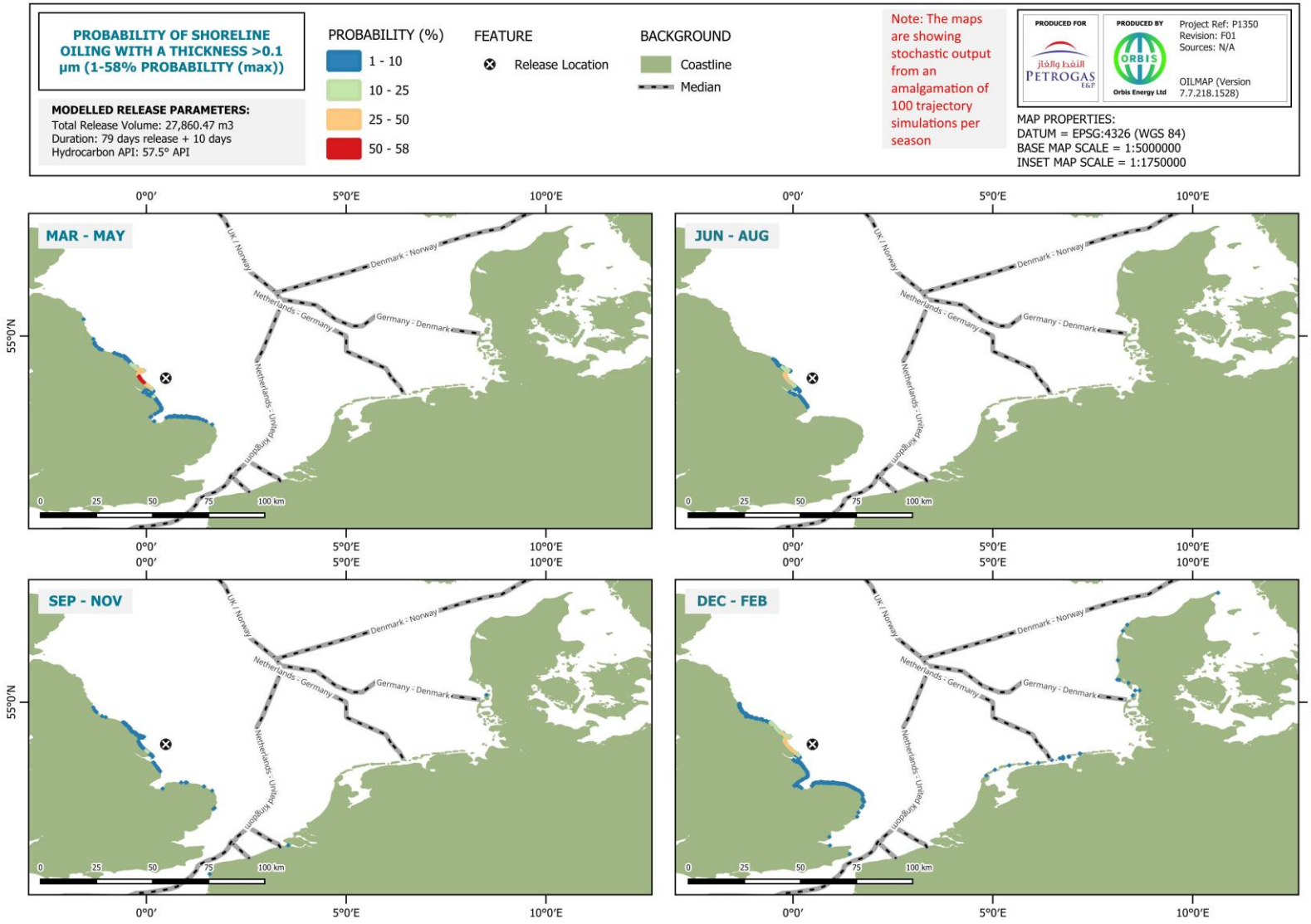
Further south, the probability of shoreline oiling decreases progressively along the English coastline. Lincolnshire shows lower probabilities of shoreline contact (up to 11 %), while Norfolk and Suffolk exhibit only limited probabilities of shoreline oiling, generally below 7 %, depending on seasonal conditions (Table 11.5; Figure 11.6).

To the north of the release location, the modelling indicates a lower probability of shoreline contact along the northeast England coastline, including Northumberland, Durham, and Tyne and Wear, where probabilities of shoreline oiling are generally below 10 % and minimum arrival times typically exceed 500 hours (approximately 21 days) (Table 11.5; Figure 11.6).

Outside the UK, the stochastic modelling predicts a very low probability of shoreline oiling along other North Sea coastlines. The highest transboundary shoreline oiling probabilities occur along the Netherlands coastline, where probabilities of up to 1% are predicted, with minimum arrival times of approximately 1,120 hours (47 days) depending on season. Similarly low probabilities are predicted for Germany and Denmark (up to 2 % and 1 %, respectively), with arrival times generally exceeding 1,200 hours (50 days) (Table 11.5; Figure 11.6).

Overall, the modelling indicates that while shoreline oiling could occur along parts of the UK east coast under a worst case scenario, all shoreline contact would be limited to light oiling severity. The probability of shoreline oiling beyond UK waters is low and associated with long transit times, meaning any oil reaching these coastlines would likely be highly weathered and patchy.

Figure 11.6: Probability of Shoreline Oiling



Worst Case Trajectory Results Summary

The worst case trajectory simulations were identified per season by the greatest volume of oil beached in any one location, as detailed in Table 11.9. The worst case trajectory simulations have been displayed graphically in Appendix E showing the total swept area of surface and shoreline oiling.

Table 11.9: Worst Case Trajectory Simulations Identified from Stochastic Results

Season	Run No	Greatest Volume of Oil Beached (in any one location)			Sim Start Date	Sim Start Time
		m^3	bbl	tonnes		
Winter	64	42.09	264.72	31.57	02/02/21	16:00
Spring	24	29.73	186.98	22.30	15/03/21	23:00
Summer	38	15.93	100.19	11.95	06/06/21	22:00
Autumn	84	6.03	37.92	4.52	17/11/20	10:00

Table 11.10 provides summary statistics for the worst case trajectory simulations. The predicted fate of released condensate after 89 days is broadly consistent across all seasons. The worst case trajectories identified from the stochastic modelling indicate that the maximum volume of oil predicted to beach at any single location varies seasonally, with the greatest deposition predicted during winter (31.57 tonnes), followed by spring (22.30 tonnes), summer (11.95 tonnes) and autumn (4.52 tonnes).

The modelling indicates that the released condensate does not persist in the marine environment. After 89 days, the majority of the released condensate is predicted to be evaporated (approximately 56–58 %) or degraded (approximately 37–39 %). Only a small proportion (approximately 3–4 %) remains within the water column at the end of the simulation period. The trajectory simulations predict no condensate deposition within sediments and negligible quantities remaining on the sea surface after 89 days.

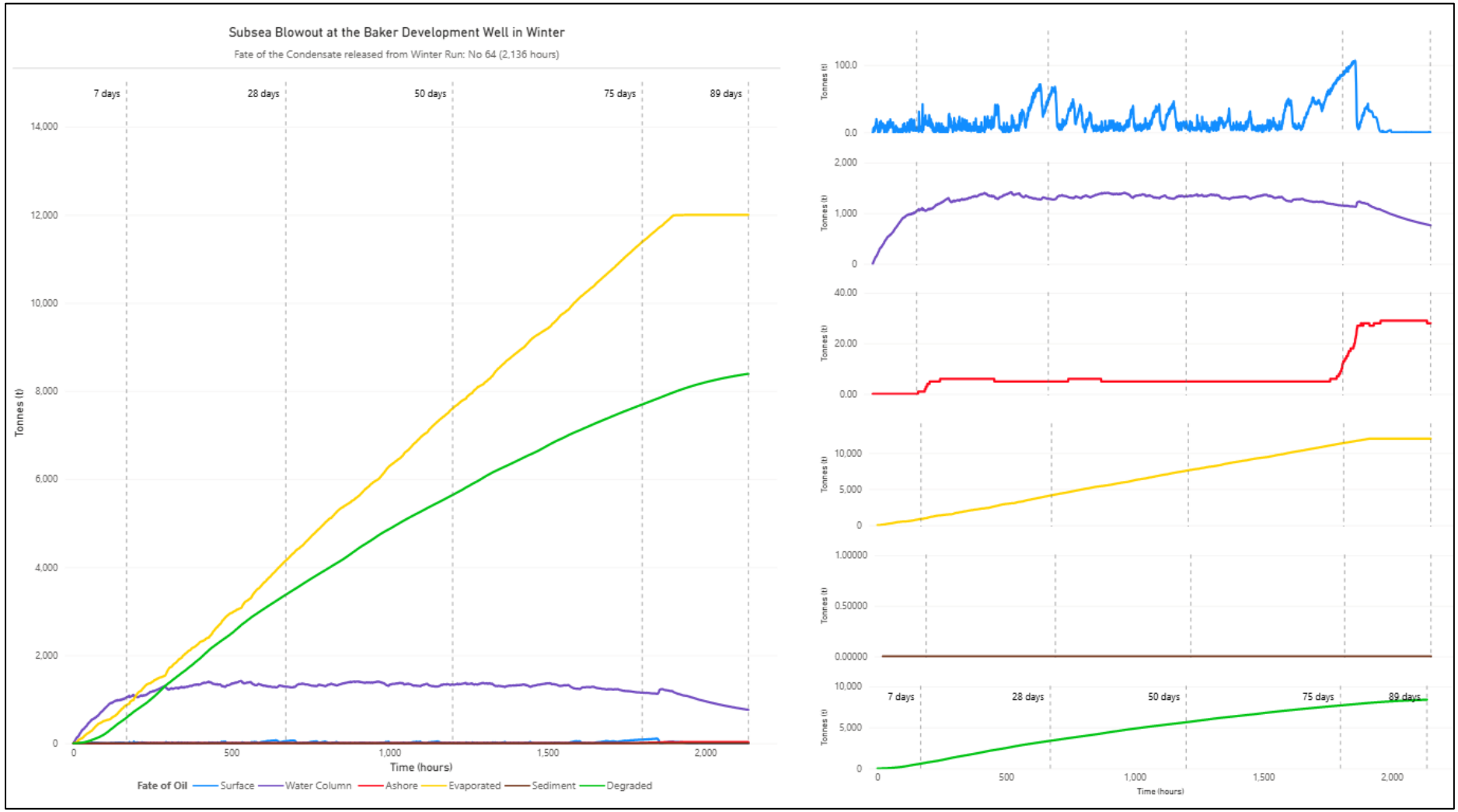
Table 11.10 indicates that the maximum surface slick area ranges between 88 km² and 357.94 km² across all seasons. However, these surface slick extents are short-lived due to the rapid evaporation and weathering characteristics of the released condensate.

Figure 11.7 illustrates the temporal fate (mass balance) of the released condensate for the winter trajectory, which represents the worst case season for shoreline oiling. At no point during the simulation does the mass of oil on the sea surface exceed 107 tonnes, while the water column fraction remains below 1,419 tonnes. After 79 days (1,896 hours) the blowout release ceases, and the subsequent 10-day simulation period shows a rapid decline in both surface oil (from 41 tonnes to approximately 0.5 tonnes) and subsurface oil (from 1,186 tonnes to 763 tonnes). This behaviour highlights the short persistence of released condensate within the marine environment.

Table 11.10: Fate Analysis Summary for Trajectory Simulations

Season	Trajectory Run No.	Minimum Time for Surface Oiling	Maximum Surface Slick Area	Minimum Time for Shoreline Oiling	Impacted Length of Coastline after 89 days	Fate of Released Condensate after 89 days (% of total release)					
						Ashore	Surface	Water Column	Evaporated	Degraded	Sediment
Winter	64	2 hrs	357.94 km^2	149 hrs	103.19 km	0.13	0.002	3.60	56.65	39.61	0.00
Spring	24	2 hrs	285.17 km^2	699 hrs	68.67 km	0.08	0.001	3.76	58.30	37.86	0.00
Summer	38	2 hrs	88 km^2	807 hrs	35.57 km	0.05	0.001	3.88	58.44	37.62	0.00
Autumn	84	2 hrs	96.27 km^2	1,203 hrs	30.32 km	0.02	0.000	3.73	56.75	39.50	0.00

Figure 11.7: Fate of the condensate released from Winter Run No. 64 (showing model duration 89 days)



11.4 Environmental and Socio-Economic Effects

The potential effects of spills on the marine environment depend on the nature and volume of the hydrocarbons spilt, the extent of weathering in the marine environment, and the sensitivity of the species exposed to the spill (ITOPF, 2014c). Oil spills can affect the marine environment directly through physical smothering of marine organisms and toxicity impacts, and also indirectly through loss of habitat, shelter, or key species in communities, altering community structure and loss of prey (ITOPF, 2014c). The marine environment is highly dynamic and complex. Many species are exposed to fluctuating environmental conditions and therefore have a degree of intrinsic tolerance to environmental stressors, including pollution. However, chronic stressors can reduce the resilience of individuals and communities.

In addition, economic losses can be experienced by industries and individuals dependent on offshore or coastal resources. Usually, the tourism and commercial fisheries sectors are where the greatest impacts are felt (ITOPF, 2014d).

Given the variety of factors that can affect the behaviour of spilt hydrocarbons, accurate predictions of effects before a spill has actually occurred are difficult to make. However, a summary of the potential effects that could occur in the event of a worst case condensate blowout release during drilling of the Baker development well has been provided below based on the oil spill modelling results (see Section 11.3 and Appendix E) and the known environmental and socio-economic sensitivities present in the area. In this assessment, to enable a worst case assessment, it is assumed that no response or clean-up activities are implemented to mitigate the spill, noting in reality that this would not be the case.

11.4.1 Water Quality

There is the potential that a worst case release of hydrocarbons from the Abbey & Baker Development could result in damage that would significantly adversely affect the ecological, chemical and/or quantitative status and/or ecological potential, as defined in Directive 2000/60/EC or the environmental status of marine waters as defined in Directive 2008/56/EC.

The Abbey & Baker Development fluid is a light condensate (57.5° API) with very low viscosity and high volatility. Under typical North Sea temperatures, the condensate remains highly fluid and readily dispersible within the marine environment. The modelled blowout scenario represents a high-energy subsea release characterised by a large GOR of 18,940 m^3/m^3, which promotes extensive droplet break-up and entrainment of oil droplets within the water column. The modelling predicts predominantly small droplet sizes (<200 µm), with approximately 50 % of droplets smaller than 70 µm, which typically remain suspended within the water column for extended periods rather than rapidly rising to the sea surface (refer to Appendix E).

As the released condensate rises through the water column, a proportion reaches the sea surface within approximately 2 hours of release, where it undergoes rapid weathering processes including spreading and evaporation. During the initial stages of the blowout, jet momentum and gas expansion within the release plume entrain seawater and transport oil droplets vertically through the water column, allowing droplets to be carried upwards despite extensive droplet break-up. As the plume transitions from a momentum-dominated jet to a buoyancy-driven plume, smaller droplets become increasingly dispersed and entrained within the upper water column. This behaviour is consistent with observations from experimental and modelling studies of subsea blowouts (Johansen et al., 2013; Spaulding et al., 2017; SINTEF, 2014).

The modelling indicates that evaporation represents the dominant removal pathway, with approximately 56–58 % of the released condensate predicted to evaporate over the 89-day simulation period. A further 37–39 % of the released condensate is predicted to degrade within the marine environment, with only a small proportion (approximately 3–4 %) remaining within the water column at the end of the simulation period. Negligible quantities remain on the sea surface and no condensate deposition to sediments is predicted after 89 days.

Modelling results indicate that the water column oiling could be affected over a relatively wide area, with the screening threshold of 1 ppb exceeded at considerable distances from the release location (Figure 11.4). The 1 ppb concentration threshold is used as a conservative screening level to identify

areas where hydrocarbon exposure to sensitive organisms or socio-economic receptors may occur (Trudel, 1989; French-McCay, 2002; French-McCay, 2004; French-McCay et al., 2012). However, concentrations at this level are not expected to result in mortality of marine fauna.

For the assessment of potential biological effects within the water column, the OSPAR PNEC of 70.5 ppb is adopted as a conservative oiling threshold. This PNEC is derived from a species sensitivity distribution approach (Smit et al., 2009) and represents a concentration protective of approximately 95 % of marine species. Modelling results indicate that subsurface oil concentrations exceeding this threshold are largely confined to areas close to the release location, where oil droplet concentrations are highest immediately following the release (Figure 11.4).

Overall, the modelling indicates that while the water column may be exposed to hydrocarbons over a relatively wide area during a worst case blowout scenario, the released condensate is rapidly dispersed, evaporated and degraded within the marine environment. Consequently, hydrocarbon concentrations decline rapidly following cessation of the release, with the modelling showing continued reduction in both surface and subsurface oil volumes during the 10-day period following termination of the blowout (Table 11.10).

In summary, the sensitivity of water quality to a worst case condensate blowout is considered to be **Medium**. The receptor has a Very High value, reflecting the international importance of maintaining good ecological and chemical status of offshore waters. However, the SNS characterised by energetic hydrodynamic conditions, including long-period swells propagating from the northern North Sea, strong tidal currents, complex circulation patterns and rapidly changing meteorological conditions. These factors promote rapid dilution, dispersion and mixing within the water column, together with strong wave action at the sea surface. Consequently, the receptor resistance and resilience is Very High to condensate pollution. The magnitude of impact is assessed as **Moderate**, as modelling indicates that the released condensate may disperse over relatively large distances (up to 282 km on the sea surface and 502 km within the water column when excluding ≤10 % probability). However, the released condensate does not persist within the marine environment, with modelling demonstrating rapid evaporation, dispersion and degradation, and a progressive return towards baseline conditions within the 10-day period following cessation of the blowout. Effects on water quality due to the worst case blowout scenario are therefore assessed as **Minor**. When combined with the likelihood of the event occurring (Extremely Rare), the risk to water quality from a well blowout is considered to be **Low**.

11.4.2 Sediment Quality

The Abbey & Baker Development condensate would be subject to rapid dispersion, evaporation and biodegradation following release, thereby limiting the mass of condensate that could reach and persist within seabed sediments. Modelling predicts no condensate deposition within seabed sediments during the simulation period (refer to Table 11.10 and Figure 11.7). The trajectory simulations indicate that the released condensate remains predominantly within the water column or at the sea surface before undergoing rapid weathering processes.

The condensate is very light (ITOPF Group 1 – 57.5° API) and remains significantly less dense than seawater. Consequently, oil droplets released during the subsea blowout remain positively buoyant and rise rapidly towards the sea surface, with a minimum predicted time to surface oiling of approximately 2 hours from the release depth of 46 m. The high-energy nature of the blowout release, characterised by a large GOR of 18,940 m^3/m^3, promotes droplet break-up and entrainment within the water column. The modelling predicts predominantly small droplet sizes (<200 µm), with approximately 50 % of droplets smaller than 70 µm, which remain suspended within the water column and are transported laterally by ambient currents rather than settling to the seabed.

As illustrated in Figure 11.7, the mass balance results show that the released condensate is progressively removed from the marine environment through evaporation and degradation, while no condensate is predicted to accumulate within seabed sediments during the modelled period. Consequently, there is no depositional pathway for condensate to persist within seabed sediments during the blowout scenario. In the unlikely event that trace quantities of condensate were to interact with seabed sediments outside of the model duration, concentrations would be expected to remain well below the OSPAR 50 ppm contamination threshold (OSPAR, 2006).

In summary, the sensitivity of sediment quality to a worst case condensate blowout is considered to be **High**. The receptor has a Very High value, reflecting the ecological importance of seabed habitats within the southern North Sea and the presence of designated marine protected areas in the wider region, including the nearby Holderness Offshore MCZ, which is designated for the protection of offshore seabed habitats and associated benthic communities. However, the modelling results indicate that the released condensate remains positively buoyant and does not accumulate within seabed sediments, with no sediment deposition predicted throughout the simulation period (Table 11.10; Figure 11.7). Any transient interaction with sediments in the immediate vicinity of the release location would be limited and subject to rapid dilution, dispersion and biodegradation. Therefore, the receptor resistance and resilience is High to condensate pollution. The magnitude of impact is therefore assessed as **Negligible**, as the worst case oil spill modelling predicts no persistent sediment oiling during the blowout scenario, and condensate is rapidly removed from the marine environment through evaporation and degradation. Effects on sediment quality resulting from the worst case blowout scenario are therefore assessed as **Negligible**. When combined with the Extremely Rare likelihood of such an event occurring, the overall risk to sediment quality from a well blowout is considered to be **Low**.

11.4.3 Plankton

Plankton play a fundamental role in marine food webs, forming the base of the trophic structure that supports higher organisms including fish, seabirds and marine mammals. Consequently, changes in plankton abundance or productivity can have indirect effects on higher trophic levels (Ozhan et al., 2014).

Phytoplankton and zooplankton predominantly occupy the upper layers of the water column and may therefore be exposed to hydrocarbons released during an oil spill. As hydrocarbons float at the sea surface and disperse through the water column during weathering processes, plankton may be exposed to both floating hydrocarbon slicks and dispersed oil droplets in the water column (Cormack, 1999; Almeda et al., 2013). Surface oiling may also influence plankton productivity through reductions in light penetration and inhibition of air–sea gas exchange, both of which are important for phytoplankton photosynthesis (González et al., 2009). Zooplankton near the sea surface may be particularly sensitive to oil spills due to their proximity to higher concentrations of dissolved hydrocarbons and the increased toxicity of photo-oxidised hydrocarbons at the air–sea interface (Bellas et al., 2013).

However, the modelling results indicate that surface oiling associated with the Baker Development blowout scenario would be transient and short lived, reflecting the rapid evaporation and weathering behaviour of the released condensate. The modelling predicts that the majority of the released condensate would evaporate (approximately 56–58%) or degrade (approximately 37–39%) within the marine environment, with negligible quantities remaining on the sea surface after the model simulation period (Table 11.10; Figure 11.7). Consequently, the duration of potential exposure of plankton communities to surface oil is expected to be limited.

The modelling also predicts that dispersed oil droplets may be transported within the water column over a relatively wide area of the SNS. The 1 ppb subsurface oiling concentration used in the modelling represents a conservative screening threshold for potential exposure of sensitive organisms and socio-economic receptors. Concentrations exceeding this threshold may occur over large distances from the release location due to natural dispersion and advection of small droplets within the water column. However, concentrations associated with potential biological effects are significantly higher. Laboratory studies have shown inhibition of phytoplankton growth at hydrocarbon concentrations of approximately 100,000 ppb, while concentrations around 100 ppb may stimulate growth (Harrison et al., 1986).

For the assessment of potential effects on marine organisms, the OSPAR PNEC of 70.5 ppb total hydrocarbons is adopted. This value represents a conservative threshold protective of the majority of marine species (Smit et al., 2009). The modelling indicates that concentrations exceeding this threshold are largely confined to the near-field area surrounding the release location, where oil droplet concentrations are highest during the early stages of the blowout. Beyond this zone, oil concentrations decline rapidly with distance and time as droplets rise, disperse and degrade within the water column.

Plankton communities are generally considered to be highly resilient to hydrocarbon exposure due to their short generation times and high reproductive rates (Abbriano et al., 2011). The widespread distribution of plankton across the North Sea means that any localised losses would be rapidly replenished through reproduction and advection from surrounding waters (ITOPF, 2014c; IPIECA-IOGP, 2015). In addition, some zooplankton species, particularly copepods, have been shown to detect and avoid hydrocarbon-contaminated waters, further reducing potential exposure (Seuront, 2010). Consequently, any impacts on plankton communities are expected to be localised and short-term, with rapid recovery once hydrocarbon concentrations return to background levels.

In summary, the sensitivity of plankton to a worst case condensate blowout is considered to be **Low**. The receptor is of Medium value, reflecting the importance of plankton communities as a food resource within the SNS ecosystem. However, the modelling indicates that hydrocarbon exposure would be transient, with the released condensate rapidly dispersed, evaporated and degraded within the marine environment. Therefore, the receptor resistance and resilience is Very High to condensate pollution. The magnitude of impact is assessed as **Moderate**, reflecting the potential for dispersed hydrocarbons to be transported over relatively large areas of the SNS. However, any effects on plankton communities would be short-term and temporary, with rapid recovery expected once hydrocarbon concentrations decline. Effects on plankton due to the worst case blowout scenario are therefore assessed as **Minor**. When combined with the Extremely Rare likelihood of such an event occurring, the overall risk to plankton from a well blowout is considered to be **Low**.

11.4.4 Seabed Communities

In response to hydrocarbon exposure, benthic fauna may avoid the pollutant, tolerate exposure (with associated effects on health and fitness), or, under more severe contamination, suffer mortality (Gray et al., 1988; Lee and Page, 1997). The response of seabed communities to hydrocarbons varies according to species life history, mobility, feeding mode and ability to metabolise toxic compounds, particularly PAHs. Severe oil pollution can result in reduced diversity and shifts in community composition, often followed by temporary increases in opportunistic species (Suchanek, 1993).

As discussed in Section 4.3.2, The Abbey & Baker Development area supports a diverse benthic assemblage characteristic of the SNS, comprising offshore circalittoral sand, offshore circalittoral coarse sediment and smaller areas of mixed sediment with sessile epifaunal assemblages. Macrofaunal survey data indicate generally high diversity across the development area, with annelids, crustaceans, molluscs and echinoderms forming the dominant faunal groups. Local ecological features of note include records of ocean quahog (*Arctica islandica*), which is listed by OSPAR as a threatened and/or declining species, and sparse occurrences of *Sabellaria spinulosa*, although no evidence of Annex I stony reef habitat was identified at the Baker site and the observed *Sabellaria* aggregations did not meet the criteria for biogenic reef (GEOxyz, 2023a).

As discussed in Sections 11.3 and 11.4.2, the modelling predicts no condensate deposition to seabed sediments during the simulation period (Table 11.10; Figure 11.7). The released condensate is very light (57.5° API) and remains positively buoyant following release. In addition, the high-energy blowout plume and associated droplet break-up promote entrainment within the water column, while the smallest droplets remain suspended rather than settling to the seabed. The condensate is also subject to rapid evaporation, dispersion and biodegradation, thereby limiting the mass of hydrocarbons reaching and persisting near the seabed. It is therefore anticipated that seabed communities would be exposed to negligible volumes of condensate during and after the spill duration, and mass mortality or a measurable reduction in community diversity is not expected.

Given the absence of a depositional pathway to sediment, any interaction between condensate and benthic communities would likely be limited to trace and highly localised exposure in the immediate vicinity of the release point, and would be short term in nature. Recovery, if required, would be supported by the widespread distribution of similar habitats and faunal assemblages in the surrounding area, together with natural recolonisation processes.

In summary, the sensitivity of seabed communities to a worst case condensate blowout is considered to be **High**. The receptors are of Very High value, reflecting the generally high diversity of the benthic communities recorded across the development area, the presence of habitats of ecological importance, and the recorded occurrence of ocean quahog within the wider survey area. However, the condensate

does not persist within seabed sediments, and the benthic community is expected to show a degree of tolerance to any trace hydrocarbon exposure, with recovery anticipated in the medium term. Therefore, the receptor resistance and resilience is High to condensate pollution.

The magnitude of impact is considered to be **Negligible**, as the worst case oil spill modelling predicts no persistent seabed oiling throughout the blowout scenario. Condensate does not persist within seabed sediments and the modelling indicates immeasurable / undetectable changes from baseline conditions following completion of the simulation period. Effects on seabed communities due to the worst case blowout scenario are therefore assessed as **Negligible**. When combined with the Extremely Rare likelihood of such an event occurring, the overall risk to seabed communities from a well blowout is considered to be **Low**.

11.4.5 Fish

Fish (including eggs and larvae) may be affected by hydrocarbon spills in a number of ways. Oil may contaminate gill surfaces, planktivorous and piscivorous fish may consume contaminated prey, and early life stages may be susceptible to toxic and volatile components of hydrocarbons (Neff, 1990). Free-swimming adult fish are generally less susceptible to the effects of oil spills because they are mobile and can detect and avoid contaminated waters (ITOPF, 2014c). In addition, many fish species possess physiological mechanisms that enable them to metabolise and excrete aromatic hydrocarbons, meaning that petroleum compounds rarely accumulate in high concentrations within fish tissues, even in contaminated environments (Neff, 1990). However, studies have shown that hydrocarbons may persist within fish bile following large spill events, indicating that temporary contamination of adult fish can occur (Murawski et al., 2014).

Early life stages of fish are generally considered more sensitive to hydrocarbon exposure. Eggs and larvae are relatively immobile and therefore may be exposed to elevated hydrocarbon concentrations for longer periods of time compared with adult fish. Laboratory and field studies have shown that exposure to hydrocarbons can cause larval mortality, developmental abnormalities and sub-lethal effects such as reduced growth or impaired swimming ability (Abbriano et al., 2011). Large spill events have demonstrated the potential scale of such effects, with estimates suggesting that trillions of fish larvae were lost following the Deepwater Horizon oil spill (Joye et al., 2016).

Fish may also be affected by tainting, whereby hydrocarbons absorbed into tissues alter the taste or odour of fish flesh. Studies indicate that fish tainting may occur at hydrocarbon concentrations as low as 10 ppb (GESAMP, 1993). The stochastic oil spill modelling predicts that water column concentrations exceeding this threshold may extend up to approximately 60 km from the release location, depending on seasonal conditions (Figure 11.8). These concentrations represent a conservative threshold for potential sensory effects rather than toxicological impacts. Although fish within this area could potentially be exposed to hydrocarbons at levels capable of causing temporary tainting, such effects would likely be short-term because hydrocarbons are rapidly metabolised and eliminated from fish tissues once exposure ceases (Krahn et al., 1993).

For the assessment of potential toxicological effects, the OSPAR PNEC of 70.5 ppb total hydrocarbons is adopted as a conservative threshold for marine fauna (Smit et al., 2009). Model results indicate that concentrations exceeding this threshold are largely confined to areas close to the release location where oil droplet concentrations are highest immediately following the release. Beyond this near-field area, hydrocarbon concentrations decline rapidly with distance as droplets disperse, rise and degrade within the water column. As discussed in Sections 11.3 and 11.4.1, the released condensate is very light (57.5° API) and undergoes rapid evaporation, dispersion and biodegradation. Consequently, hydrocarbon exposure within the water column is transient and concentrations are predicted to decline rapidly once the blowout release ceases.

The Abbey & Baker Development area lies within ICES Rectangle 36F0, which supports spawning and nursery grounds for a number of commercially important fish species including cod, herring, lemon sole, plaice, sandeels, sole, sprat and whiting (Coull et al., 1998; Ellis et al., 2012). Of particular ecological importance in the SNS are sandeels, which spawn within sandy sediments and are an important prey species for a range of fish, seabirds and marine mammals. Site-specific sediment analyses indicate that parts of the development area contain sediments suitable for sandeel spawning (refer to Section 4.3.2). However, the modelling predicts no condensate deposition to seabed

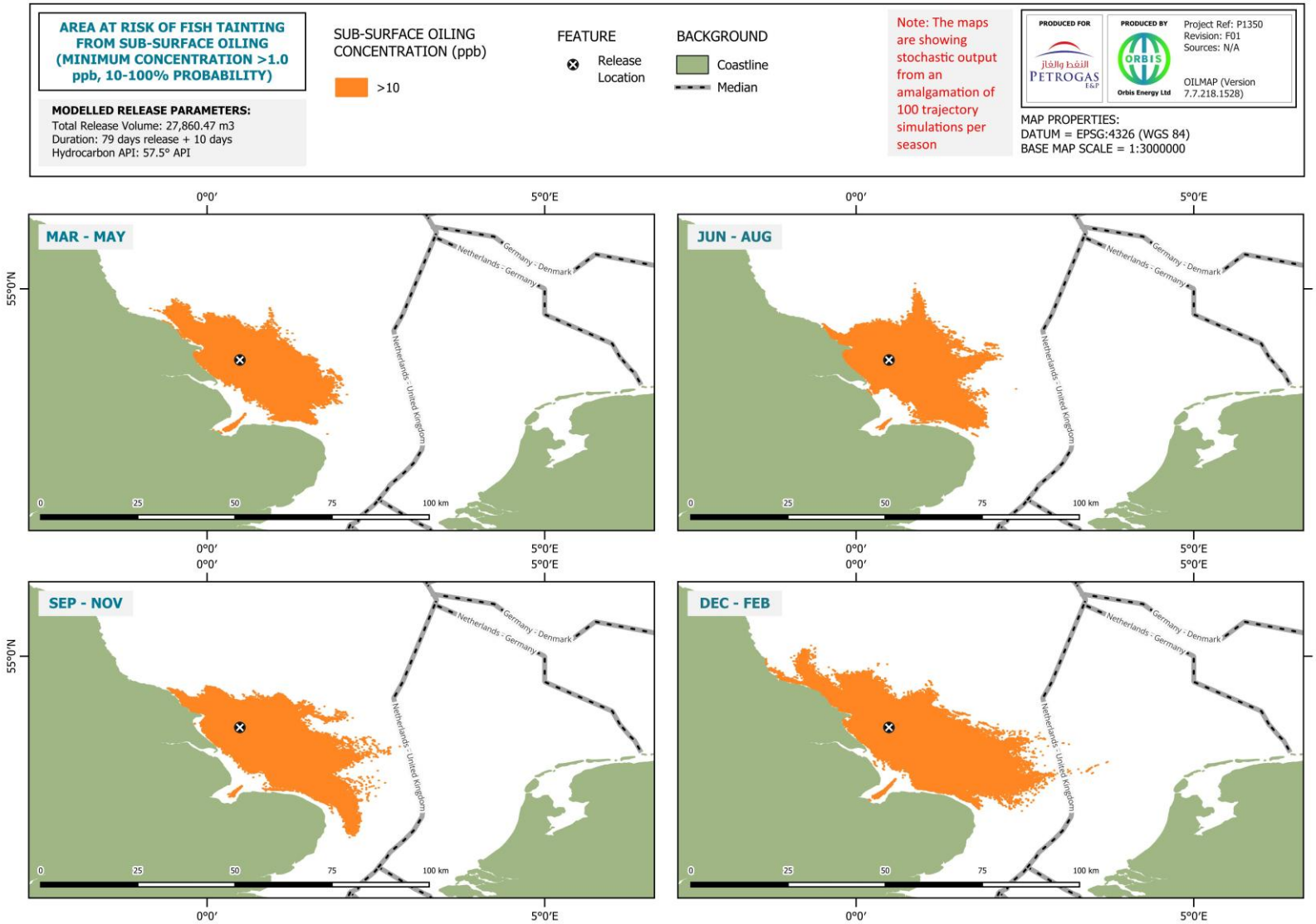
sediments, and therefore the eggs of demersal spawning species such as sandeels are unlikely to be exposed to significant hydrocarbon contamination.

Pelagic spawning species such as herring and sprat release eggs and larvae into the water column and could therefore be exposed to dispersed hydrocarbons during a spill event. Nevertheless, spawning and nursery grounds for these species are widespread throughout the SNS, and the modelling indicates that hydrocarbon concentrations decline rapidly with distance and time as the condensate disperses and degrades. Any mortality of eggs or larvae resulting from localised hydrocarbon exposure is therefore unlikely to affect wider fish populations. Marine organisms are adapted to episodic disturbances through the production of large numbers of eggs and larvae and recruitment from unaffected areas (ITOPF, 2014c; IPIECA-IOGP, 2015).

Elasmobranch species including spiny dogfish, thornback ray and starry smoothhound may also occur within the wider Abbey & Baker Development area. These species are generally mobile and widely distributed across the SNS and would be expected to avoid contaminated waters during a spill event. Consequently, direct effects on elasmobranch populations are considered unlikely.

In summary, the sensitivity of fish to a worst case condensate blowout is considered to be **Medium**. The receptor has a High value, reflecting the commercial and ecological importance of fish species present in the SNS and the presence of spawning and nursery grounds within the wider region. However, the released condensate is light and does not persist in the marine environment, and fish have a demonstrated ability to avoid contaminated waters and metabolise hydrocarbons rapidly. Therefore, the receptor resistance and resilience is High to condensate pollution. The magnitude of impact is assessed as **Minor**, as hydrocarbon exposure within the water column is predicted to be transient and localised, with rapid recovery towards baseline conditions following cessation of the blowout. Effects on fish due to the worst case blowout scenario are therefore assessed as **Minor**. When combined with the Extremely Rare likelihood of such an event occurring, the overall risk to fish from a well blowout is considered to be **Low**.

Figure 11.8: Area at Risk of Fish Tainting (Subsurface Oil Concentration >10 ppb)



11.4.6 Seabirds

The effects of oil on seabirds have been widely studied and include both immediate impacts that can result in mortality as well as longer-term sub-lethal effects that may influence individual fitness and population recovery over extended periods (Camphuysen et al., 2005; Perez et al., 2009). Seabird species that raft together or spend a significant proportion of their time on the sea surface, such as auks, are particularly vulnerable to oil pollution. Even relatively small spills can cause significant mortality, if they occur during sensitive periods such as the breeding or moulting seasons, when birds may be concentrated in large numbers or temporarily unable to fly. Oiling of plumage can result in mortality through hypothermia, loss of buoyancy and drowning, and may also reduce a bird's ability to fly and forage effectively (ITOPF, 2014c). Seabirds also instinctively attempt to clean oiled plumage through preening, which can result in the ingestion of hydrocarbons and subsequent toxic effects. Seabirds may also be exposed to toxic volatile fractions of hydrocarbons when resting on the surface. Seabirds may additionally be indirectly affected through the ingestion of contaminated prey.

The offshore waters of the SNS are primarily used by seabirds for foraging, particularly around shallow sandbanks where prey species such as sandeels occur. Seabirds present in the proposed Abbey & Baker Development area may originate from coastal breeding colonies along the east coast of England, including those protected within nearby SPAs. The Greater Wash SPA, located approximately 20 km southwest of the development area, protects important foraging areas for little tern, sandwich tern and common tern. In addition, the Flamborough and Filey Coast SPA, located approximately 39 km northwest of the development area, supports internationally important breeding populations of species including northern gannet, black-legged kittiwake, common guillemot, razorbill and Atlantic puffin. Individuals from these colonies may forage within the offshore waters surrounding the proposed development during the breeding season.

As discussed in Section 4.3.4, data from ESAS database indicates that seabird densities in the Abbey & Baker Development area during the breeding season (March to September) are generally moderate (<50 birds per km²), with species such as kittiwake, guillemot and puffin considered to be of particular importance in the wider region (JNCC, 2019; Kober et al., 2010). During the winter months seabird densities are typically lower (<23 birds per km²), with species such as northern gannet, great black-backed gull and herring gull occurring more frequently offshore. An assessment of the SOSI for UKCS Block 47/3, within which the Abbey & Baker Development is located, indicates that seabird sensitivity to oil pollution is generally high to very high between February and November, with medium sensitivity during December and January (Webb et al., 2016).

An oil sheen thickness of 0.3 µm (BAOAC 2 – Rainbow) represents the minimum surface oiling threshold modelled and has the potential to affect seabirds encountering hydrocarbons at the sea surface. As discussed in Section 11.3, stochastic modelling indicates that surface oiling may extend over a wide area of the SNS under the worst case blowout scenario. The most severe surface oiling (BAOAC 5 – Continuous True Oil Colour) is predicted to occur primarily in areas close to the release location, with the extent of lower-thickness oiling decreasing with distance as the condensate spreads and weathers. Consequently, seabirds rafting on the sea surface within the vicinity of the release could be exposed to hydrocarbons during the blowout scenario.

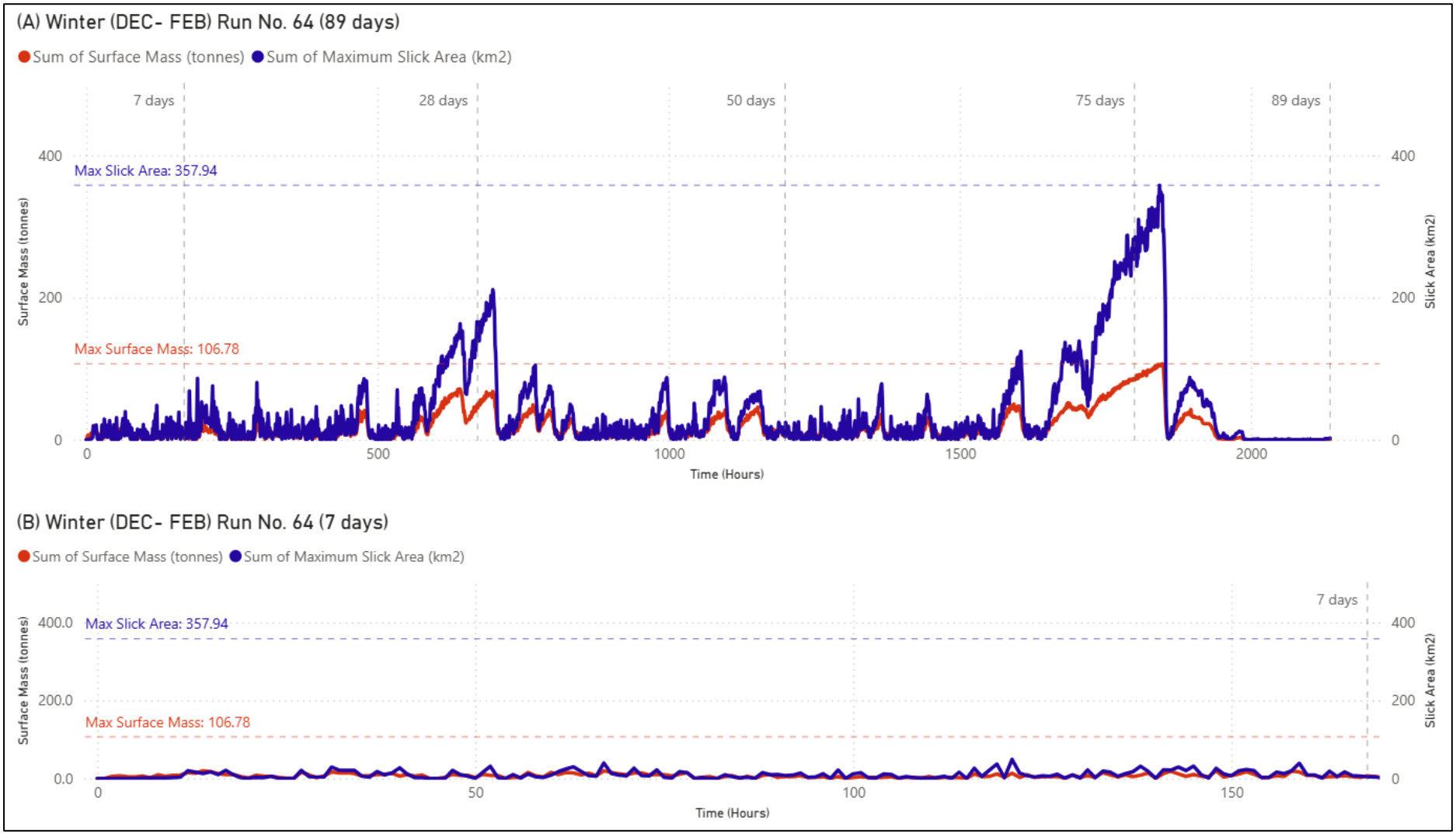
However, the modelling also demonstrates that surface oil associated with the released condensate is highly transient. As described in Section 11.3, the condensate is very light (57.5° API) and undergoes rapid evaporation and weathering once it reaches the sea surface. Time-series analysis of the surface oil mass and slick area (Figure 11.9) shows that the surface slick fluctuates in a pattern of peaks and troughs throughout the blowout scenario. These fluctuations reflect the episodic nature of oil surfacing, as droplets released at depth require time to rise through the water column before reaching the surface, combined with rapid evaporation and weathering once the condensate reaches the sea surface. As a result, the surface slick does not remain constant but instead forms and dissipates repeatedly during the release, with periods of increasing slick area followed by rapid decline. This pulsed behaviour limits the duration of peak surface exposure and therefore reduces the time window for interaction with rafting seabirds. Although it must be recognised that even short periods of exposure may still pose a risk to individual birds.

In addition to surface oiling, diving seabirds may also be exposed to hydrocarbons present within the upper water column during foraging activity. Species such as common guillemot (*Uria aalge*), razorbill (*Alca torda*) and Atlantic puffin (*Fratercula arctica*) regularly dive beneath the sea surface to capture pelagic prey such as sandeels and other small fish. Consequently, there is potential for these species to encounter hydrocarbons dispersed within the water column during a spill event. However, modelling indicates that subsurface condensate concentrations are largely confined to the upper water column and the vicinity of the release location, and are transient due to rapid dilution, advection and biodegradation (refer to Section 11.4.1 and 11.3.2). Concentrations above the OSPAR PNEC of 70.5 ppb total hydrocarbons are predicted to occur only locally and decrease rapidly with distance from the release source. As such, while a short-term exposure pathway exists for diving seabirds foraging close to the release location, widespread or prolonged exposure of seabird populations within designated MPAs is not anticipated.

The modelling predicts that light shoreline oiling could occur along parts of the UK east coast under the worst case scenario; however, oil reaching the shoreline would be highly weathered and limited to light oiling severity. Consequently, seabirds present on coastal habitats would not be exposed to large volumes of oil and the potential for widespread shoreline seabird mortality is considered low.

In summary, the sensitivity of seabirds to a worst case condensate blowout is considered to be **Very High**. The receptor has a Very High value, reflecting the international importance of seabird assemblages associated with nearby SPAs and the wider southern North Sea ecosystem. Seabirds have limited tolerance to oil pollution and individuals exposed to oil may experience significant mortality or sub-lethal impacts. Therefore, the receptor resistance and resilience is Low to condensate pollution. The magnitude of impact is assessed as **Moderate**, as surface oiling has the potential to affect seabirds within the vicinity of the release location, although the released condensate is not predicted to persist in the marine environment and exposure is likely to be intermittent and short-lived. Effects on seabirds due to the worst case blowout scenario are therefore assessed as **Major**. When combined with the Extremely Rare likelihood of such an event occurring, the overall risk to seabirds from a well blowout is considered to be **Medium**.

Figure 11.9: Surface Slick Area (with a concentration >100 kg / km^2) and Surface Oil Mass over Time during Winter Run No. 64 (Graph A: x-axis scale 0-2,136 hours (showing model duration 89 days); Graph B: x-axis scale 0-168 hours (showing first 7 days of spill scenario))



11.4.7 Marine Mammals

Although marine mammals also use the sea surface in a similar manner to seabirds (refer to Section 11.4.6), they are generally less affected by spills of oil as they can detect and move away from oiled areas (Abbriano et al., 2011). Unlike fish or seabirds, oil is also unlikely to adhere to or permeate through the skin of marine mammals where it could accumulate in tissues and have toxicological effects (Neff, 1990). Additionally, marine mammals do not drink large volumes of seawater and therefore accumulation of hydrocarbons via this route is unlikely (Neff, 1990). Baleen whales, such as the minke whale, may however ingest oil whilst filter feeding. Marine mammals may also be exposed to toxic volatile fractions of hydrocarbons when surfacing to breathe. Although mortality as a direct result of contact with condensate is considered unlikely, there remains potential for sub-lethal impacts on individuals, such as physiological stress associated with inhalation of hydrocarbon vapours (Takeshita et al., 2017).

As discussed in Section 4.3.5, cetacean species most likely to be present in the vicinity of the proposed Abbey & Baker Development include harbour porpoise, bottlenose dolphin, common dolphin, minke whale, white-beaked dolphin and white-sided dolphin (Reid et al., 2003; DESNZ, 2022). Harbour porpoise are the most abundant cetacean species in the North Sea and are present in relatively high densities throughout the SNS. The proposed Abbey & Baker Development lies within the Southern North Sea SAC, which has been designated for the protection of harbour porpoise populations. All cetaceans are listed as EPS under Annex IV of the Habitats Directive, while harbour porpoise and bottlenose dolphin are also listed under Annex II of the Habitats Directive. Harbour porpoise is additionally listed on the OSPAR List of Threatened and/or Declining Species (OSPAR, 2021). While cetacean skin is not thought to be particularly sensitive to oil, accidental ingestion or inhalation of hydrocarbons may cause physiological stress in exposed individuals. Notably, following the Deepwater Horizon oil spill in 2010, significant health issues were identified in a resident bottlenose dolphin population located in heavily oiled areas, including pulmonary disease and reduced reproductive success (Lane et al., 2015; Takeshita et al., 2017), although the direct causal link to oil exposure remains uncertain.

Two species of pinnipeds, grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*), occur along the east coast of England. Important colonies occur at haul-out sites such as Donna Nook, Blakeney Point, Horsey and The Wash (SCOS, 2022). Grey seals undertake extensive foraging trips offshore, often travelling distances of up to 100 km from haul-out sites. The at-sea distribution of grey seals indicates relatively high densities within the vicinity of the proposed Abbey & Baker Development (0.01–0.05 % of the population per 25 km^2) (Carter et al., 2022). In contrast, harbour seals generally forage closer to shore and densities in the offshore development area are low (<0.005 % of the population per 25 km^2). Seals utilising coastal waters, particularly those at haul-out and breeding sites, may be impacted in the event of shoreline oiling. These species rely on their fur for thermoregulation, which can be compromised if fur becomes coated in oil, potentially resulting in hypo- or hyperthermia. Individuals may also ingest oil during grooming behaviour (ITOPF, 2014c).

As discussed in Section 11.3, the worst case condensate blowout modelling indicates that released hydrocarbons are subject to rapid evaporation and biodegradation. Although surface oiling may occur intermittently throughout the duration of the release, the modelling demonstrates that oil does not persist within the marine environment. The modelling predicts that the east coast of England may be subject to light shoreline oiling (maximum thickness <1 mm), with the greatest mass of beached condensate predicted at any one location at 31.57 tonnes during winter. Consequently, seal haul-out sites along the coastline are not considered to be at risk from a large-scale oiling event.

In summary, the sensitivity of marine mammals to a worst case condensate blowout is considered to be **Medium**. The receptor has a Very High value, as marine mammals are protected under international and European legislation and the development area lies within the Southern North Sea SAC designated for harbour porpoise. However, the condensate does not persist in the marine environment and marine mammals are highly mobile and capable of avoiding contaminated areas. Therefore, the receptor resistance and resilience is Very High to condensate pollution. The magnitude of impact is considered to be **Minor**, as modelling indicates that condensate concentrations would be transient and rapid recovery towards baseline conditions would occur within approximately ten days following cessation

of the blowout. Effects on marine mammals due to the worst case blowout scenario are therefore assessed as **Minor**. When combined with the likelihood of the event occurring (Extremely Rare), the overall risk to marine mammals from a well blowout is considered to be **Low**.

11.4.8 Marine Protected Areas

Modelling indicates that a total of 51 UK designated MPAs are at risk from oiling under the Baker & Abbey Development worst case blowout scenario. Of these, 30 sites are predicted to be at risk from surface oiling, 19 sites from shoreline oiling, and 51 sites from subsurface oiling within the model domain (Table 11.11). The greatest number of potentially affected sites are MCZs, SACs and SPAs, reflecting the density of designated sites along the east coast of England and within the SNS.

All MPAs potentially at risk from surface, shoreline and subsurface oiling are presented in Appendix E (Section E.3.3 / Table E.7), where the maximum probability, shortest arrival time and maximum predicted severity are reported for each site. These results provide the detailed basis for the assessment of potential effects on qualifying features under the worst case spill scenario.

Table 11.11: Summary of MPAs at risk from Oiling [Note 1]

MPA Designation Type	Total number of sites at risk from Oiling	Number of sites at risk from Surface Oil	Number of sites at risk from Shoreline Oil	Number of sites at risk from Subsurface Oil
SPA	9	8	8	9
SAC	11	4	4	11
RAMSAR	3	2	2	3
NC MPA	2	1	0	2
MCZ	26	15	5	26
Total	**51**	**30**	**19**	**51**

Note 1: Internationally designated MPAs are excluded, as they lie outside UK jurisdiction and conservation obligations, and there is no regulatory requirement to assess feature-level impacts on non-UK conservation designations. Transboundary considerations are addressed separately in Section 11.8.

The assessment of MPAs has been informed by the receptor-level impact assessments presented in Sections 11.4.1 to 11.4.7. These sections concluded that the predicted effects of the worst case condensate blowout scenario are **Low** risk for the majority of environmental receptors, including plankton, seabed communities, fish and marine mammals. The only receptor assessed as having a **Medium** risk is seabirds, reflecting their Very High sensitivity to oil contamination at the sea surface (refer to Section 11.4.6). Seabirds are particularly vulnerable because they spend prolonged periods resting or foraging at the sea surface where oil accumulates, and even short-term exposure to surface oil sheens (>0.3 µm; equivalent to BAOAC 2 or greater) can compromise plumage integrity, buoyancy and thermoregulation.

On this basis, the MPA assessment focuses primarily on sites designated for seabird species where surface oiling represents a credible exposure pathway. MPAs designated for benthic habitats, seabed features, fish or marine mammals are generally not taken forward for detailed assessment, as these receptors were assessed as Low risk in the preceding sections and the modelling predicts negligible oil deposition to seabed sediments. Consequently, there is no credible exposure pathway for hydrocarbon contamination of benthic qualifying features.

In addition, the modelling indicates that all predicted shoreline oiling is limited to light oiling severity, with no moderate or heavy shoreline oiling predicted for UK designated sites. As such, shoreline oiling is not considered to represent a significant impact pathway for coastal MPAs. Similarly, although subsurface oiling intersects a number of MPAs within the model domain, the majority of predicted concentrations remain below the OSPAR PNEC threshold (70.5 ppb), indicating a low likelihood of toxic effects to marine organisms.

An exception to this screening approach is the Southern North Sea SAC, which is designated for the protection of harbour porpoise (*Phocoena phocoena*). The proposed release location lies within this

SAC and the modelling predicts surface oiling at 100 % probability (BAOAC 5 – Continuous True Oil Colour) and subsurface oiling above the OSPAR PNEC (>70.5 ppb) also at 100 % probability within the site. Harbour porpoise are sensitive to disturbance from hydrocarbon contamination and elevated hydrocarbon concentrations in the water column may cause behavioural disturbance or temporary displacement of individuals. Given the predicted oiling severity and the site's conservation objectives for harbour porpoise, the Southern North Sea SAC is therefore taken forward for detailed assessment under the worst case spill scenario.

The detailed assessment therefore focuses on MPAs designated for seabird features that may be exposed to surface oiling, together with the Southern North Sea SAC, as these represent the receptors with the greatest sensitivity and the most credible pathways for ecological impact under the worst case blowout scenario (refer to Table 11.12 for the summary of receptor sensitivities and risk scores).

Assessment Summary

In summary, the seabird and waterbird protected features / qualifying species from 11 MPAs (8 x SPA, 2 x RAMSAR sites & 1 x MCZ) are considered to be at **Medium** risk from a large-scale oiling event under the Abbey & Baker Development worst case blowout scenario (Table 11.12). This reflects the Very High sensitivity of seabirds and waterbirds to hydrocarbon contamination, particularly from surface oiling, which represents the most credible exposure pathway for these receptors. Although modelling predicts that surface oiling may occur across a wide area, the probability of exposure varies between sites and the predicted oiling severity is generally limited to thin sheens (BAOAC 2–4) that are transient and subject to rapid weathering and dispersion.

The Southern North Sea SAC is also taken forward for detailed assessment, as the proposed release location lies within the site and modelling predicts 100 % probability of both surface oiling (BAOAC 5 – Continuous True Oil Colour) and subsurface oiling above the OSPAR PNEC threshold (>70.5 ppb). While harbour porpoise are capable of avoiding contaminated areas, elevated hydrocarbon concentrations within the water column may cause temporary behavioural disturbance or displacement of individuals within the site. However, given the Extremely Rare likelihood of a blowout event, the overall risk to the SAC conservation objectives identified in Table 11.12 remain **Medium**.

All other MPAs identified in Appendix E (Section E.3.3 / Table E.7) are considered to be at **Low** risk, either because predicted oiling severities are low, concentrations remain below the OSPAR PNEC threshold, or there is no credible exposure pathway to their designated benthic or habitat features.

Table 11.12: Assessment of MPAs with Protected Features / Qualifying Species at Risk from Oiling

Protected Area	Surface Oil		Subsurface Oil		Protected Features / Qualifying Species at Risk from Oiling	Impact Assessment [Note 1]		
	Maximum Probability	Maximum Severity	Probability	Maximum Severity		Sensitivity to Oiling	Magnitude of Oiling Impact	Significance Evaluation (Consequence x Likelihood)
Special Protected Areas (SPA) with Marine Components								
Dungeness, Romney Marsh and Rye Bay SPA	1 %	BAOAC 2	7 %	Below OSPAR PNEC	**Qualifying Species:** Bewick's swan (*Cygnus columbianus bewickii*), Bittern (*Botaurus stellaris*), Hen harrier (*Circus cyaneus*), Golden plover (*Pluvialis apricaria*), Ruff (*Philomachus pugnax*), Aquatic warbler (*Acrocephalus paludicola*), Marsh harrier (*Circus aeruginosus*), Avocet (*Recurvirostra avosetta*), Mediterranean gull (*Larus melanocephalus*), Sandwich tern (*Sterna sandvicensis*), Common tern (*Sterna hirundo*), Little tern (*Sterna albifrons*), Shoveler (*Anas clypeata*). **Assemblage:** the site regularly supports >20,000 waterbirds during the non-breeding season.	Very High	Major	Major x Extremely Rare = **MEDIUM**
Flamborough and Filey Coast SPA	75 %	BAOAC 3	91 %	Below OSPAR PNEC	**Qualifying Species:** Black-legged kittiwake (*Rissa tridactyla*), Northern gannet (*Morus bassanus*), Common guillemot (*Uria aalge*), Razorbill (*Alca torda*). **Assemblage:** Breeding seabird assemblage (>20,000 individuals).	Very High	Major	Major x Extremely Rare = **MEDIUM**
Greater Wash SPA	93 %	BAOAC 4	100 %	Below OSPAR PNEC	**Qualifying Species:** Red-throated diver (*Gavia stellata*), Little gull (*Hydrocoloeus minutus*), Common scoter (*Melanitta nigra*), Sandwich tern (*Sterna sandvicencis*), Little tern (*Sternula albifrons*), Common tern (*Sterna hirundo*).	Very High	Major	Major x Extremely Rare = **MEDIUM**
Humber Estuary SPA	19 %	BAOAC 2	50 %	Below OSPAR PNEC	**Qualifying Species:** Great bittern (*Botaurus stellaris*), Common shelduck (*Tadorna tadorna*), Eurasian marsh harrier (*Circus aeruginosus*), Hen harrier (*Circus cyaneus*), Pied avocet (*Recurvirostra avosetta*), European golden plover (*Pluvialis apricaria*), Red knot (*Calidris canutus*), Dunlin (*Calidris alpina alpina*), Ruff (*Philomachus pugnax*), Black-tailed godwit (*Limosa limosa islandica*), Bar-tailed godwit (*Limosa lapponica*), Common redshank (*Tringa totanus*), Little tern (*Sterna albifrons*). **Assemblage:** Internationally important waterbird assemblage (>20,000 birds).	Very High	Major	Major x Extremely Rare = **MEDIUM**
Northumberland Marine SPA	1 %	BAOAC 2	15 %	Below OSPAR PNEC	**Qualifying Species:** Sandwich tern (*Sterna sandvicensis*), Roseate tern (*Sterna dougallii*), Common tern (*Sterna hirundo*), Arctic tern (*Sterna paradisaea*), Little tern (*Sternula albifrons*), Common guillemot (*Uria aalge*), Atlantic puffin (*Fratercula arctica*). **Assemblage:** the site regularly supports >20,000 in any season.	Very High	Major	Major x Extremely Rare = **MEDIUM**
Outer Thames Estuary SPA	9 %	BAOAC 2	72 %	Below OSPAR PNEC	**Qualifying Species:** Red-throated diver (*Gavia stellata*), Common tern (*Sterna hirundo*), Little tern (*Sternula albifrons*).	Very High	Major	Major x Extremely Rare = **MEDIUM**

Protected Area	Surface Oil		Subsurface Oil		Protected Features / Qualifying Species at Risk from Oiling	Impact Assessment [Note 1]		
	Maximum Probability	Maximum Severity	Probability	Maximum Severity		Sensitivity to Oiling	Magnitude of Oiling Impact	Significance Evaluation (Consequence x Likelihood)
Teesmouth and Cleveland Coast SPA	12 %	BAOAC 2	22 %	Below OSPAR PNEC	**Qualifying Species:** Pied avocet (*Recurvirostra avosetta*), Red knot (*Calidris canutus*), Ruff (*Calidris pugnax*), Common redshank (*Tringa totanus*), Sandwich tern (*Sterna sandvicensis*), Common tern (*Sterna hirundo*), Little tern (*Sterna albifrons*). **Assemblage:** the site supports >20,000 wintering waterfowl.	Very High	Major	Major x Extremely Rare = **MEDIUM**
The Wash SPA	11 %	BAOAC 2	100 %	Below OSPAR PNEC	**Qualifying Species:** Bewick's swan (*Cygnus columbianus bewickii*), Pink-footed (*Anser brachyrhynchus*), Dark-bellied brent goose (*Branta bernicla bernicla*), Common shelduck (*Tadorna tadorna*), Eurasian wigeon (*Anas penelope*), Gadwall (*Anas strepera*), Northern pintail (*Anas acuta*), Black (common) scoter (*Melanitta nigra*), Common goldeye (*Bucephala clangula*), Eurasian oystercatcher (*Haematopus ostralegus*), Grey plover (*Pluvialis squatarola*), Red knot (*Calidris canutus*), Sanderling (*Calidris alba*), Dunlin (*Calidris alpina alpina*), Black-tailed godwit (*Limosa limosa islandica*), Bar-tailed godwit (*Limosa lapponica*), Eurasian curlew (*Numenius arquata*), Common redshank (*Tringa totanus*), Ruddy turnstone (*Arenaria interpres*), Common tern (*Sterna hirundo*), Little tern (*Sterna albifrons*). **Assemblage:** waterbird assemblage.	Very High	Major	Major x Extremely Rare = **MEDIUM**
RAMSAR								
Humber Estuary RAMSAR	19 %	BAOAC 2	11 %	Below OSPAR PNEC	**Protected features:** • Criterion 1: The site is a representative example of a near-natural estuary with the following component habitats: dune systems and humid dune slacks, estuarine waters, intertidal mud and sand flats, saltmarshes, and coastal brackish/saline lagoons. • Criterion 3 - The Humber Estuary Ramsar site supports a breeding colony of grey seals (*Halichoerus grypus*) at Donna Nook, and the most north-easterly breeding site in Great Britain of the natterjack toad (*Bufo calamita*). • Criterion 5 – Waterfowl Assemblage. • Criterion 6 – Eurasian golden plover (*Pluvialis apricaria*), Red knot (*Calidris canutus islandica*), Dunlin (*Calirdris alpina*), Black-tailed godwit (*Limosa limosa*), Common redshank (*Tringa totanus bittanicca*), Common shelduck (*Tadorna tadorna*), Bar-tailed godwit (*Limosa lapponica lapponica*).	Very High	Major	Major x Extremely Rare = **MEDIUM**

Protected Area	Surface Oil		Subsurface Oil		Protected Features / Qualifying Species at Risk from Oiling	Impact Assessment Note 1		
	Maximum Probability	Maximum Severity	Probability	Maximum Severity		Sensitivity to Oiling	Magnitude of Oiling Impact	Significance Evaluation (Consequence x Likelihood)
The Wash RAMSAR	11 %	BAOAC 2	2 %	Below OSPAR PNEC	**Protected features:** • Criterion 1 – The wetland contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region. • Criterion 3 - the inter-relationship between its various components including saltmarshes, intertidal sand and mud flats and the estuarine waters. The saltmarshes and the plankton in the estuarine water provide a primary source of organic material which, together with other organic matter, forms the basis for the high productivity of the estuary. • Criterion 5 - Waterfowl Assemblage. • Criterion 6 – Eurasian oystercatcher (*Haemotopus ostralegus*), Grey plover (*Pluvialis squatarola*), Red knot (*Calidris canutus islandica*), Sanderling (*Calidris alba*), Eurasian curlew (*Numenius arquata arquata*), Common redshank (*Tringa totanus totanus*), Ruddy turnstone (*Arenaria interpres interpres*), Pink-footed goose (*Anser brachyrhynchus*), Dark-bellied brent goose (*Branta bernicla*), Common shelduck (*Tadorna tadorna*), Northern pintail (*Anas acuta*), Dunlin (*Calidris alpina alpina*), Bar-tailed godwit (*Limosa lapponica lapponica*).	Very High	Major	Major x Extremely Rare = **MEDIUM**
Marine Conservation Zones (MCZ)								
Berwick to St Mary's MCZ	2 %	BAOAC 2	15 %	Below OSPAR PNEC	**Protected features:** Common Eider (*Somateria mollissima*).	Very High	Major	Major x Extremely Rare = **MEDIUM**
Special Area of Conservation (SAC) with Marine Components								
Southern North Sea SAC	100 %	BAOAC 5	100 %	Above OSPAR PNEC	**Protected features:** Harbour porpoise (*Phocoena phocoena*). **Conservation Objectives:** Ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining Favourable Conservation Status (FCS) for harbour porpoise in UK waters. In the context of natural change, this will be achieved by ensuring that: • CO 1. Harbour porpoise is a viable component of the site. • CO 2. There is no significant disturbance of the species. • CO 3. The condition of supporting habitats and processes, and the availability of prey is maintained.	Medium	Major	Moderate x Extremely Rare = **MEDIUM**

Note 1: Refer to Section 5.3 for impact assessment methodology.

11.4.9 Socio-economic Receptors

Commercial Fisheries

Major oil spills can have the potential to impact commercial fishing activities through a range of mechanisms, including contamination of target species, oiling of fishing vessels and gear, temporary displacement of fishing vessels from fishing grounds, and reduced consumer confidence in seafood products (ITOPF, 2014d).

The proposed Abbey & Baker Development is located within ICES Rectangle 36F0, an area of relatively high fishing activity in the southern North Sea (refer to Section 4.4.1). Fishing effort in this rectangle has increased since 2015 and is dominated by static gears, particularly pots and traps, reflecting the importance of shellfish fisheries targeting crab, lobster and scallops. These shellfish species account for the majority of landings by both weight and value within the rectangle, confirming that the area supports an active commercial fishery. Spatial fishing activity data derived from VMS and AIS vessel tracks indicate that the proposed Abbey & Baker Development lies on the eastern edge of a heavily fished coastal area, with moderate to high intensity shellfish fishing activity in the wider region (MMO, 2025; Anatec, 2024). Fishing vessels have been recorded actively fishing in close proximity to the Abbey & Baker Development, although activity is more concentrated closer to the coast.

Modelling undertaken for the worst case condensate blowout scenario indicates that subsurface hydrocarbons in the water column may exceed the OSPAR PNEC threshold (70.5 ppb) only within a relatively limited area close to the release location (up to 54 km), with concentrations decreasing rapidly with distance due to dilution and dispersion processes (refer to Section 11.3.2). The modelling indicates that elevated concentrations are transient and confined primarily to the upper water column, and therefore widespread mortality of commercial fish or shellfish stocks is not predicted.

Surface oiling may temporarily affect fishing operations through displacement of vessels from areas where surface slicks occur. However, modelling indicates that the surface condensate slick remains relatively small and transient, fluctuating in size over time and typically covering a limited area at any one time. The condensate is predicted to weather and disperse rapidly, with modelling showing that surface oiling does not persist following cessation of the blowout and returns to baseline conditions within approximately 10 days (refer to Section 11.3.2). As a result, any disruption to fishing activities is expected to be short-term and localised, and fishing vessels would be able to operate in adjacent fishing grounds within the wider North Sea.

In summary, the sensitivity of commercial fisheries to a worst case blowout is considered to be **High**, reflecting the importance of shellfish fisheries within ICES Rectangle 36F0 and the wider SNS. The receptor has a Very High value, given the economic importance of the fishery and the relatively high levels of fishing activity recorded in the area. However, the condensate is non-persistent and predicted hydrocarbon concentrations above the OSPAR PNEC are limited to a relatively small area close to the release location. Furthermore, the presence of extensive alternative fishing grounds within the wider North Sea means that fishing vessels could temporarily relocate if required. Therefore, receptor resistance and resilience is High to condensate pollution and the magnitude of impact is assessed as **Minor**. When combined with the Extremely Rare likelihood of a blowout event, the overall risk to commercial fisheries is considered to be **Low**.

Commercial Shipping

The proposed Abbey & Baker Development lies within an area of relatively high shipping density in the southern North Sea, reflecting the proximity of major ports along the east coast of England and the presence of cargo vessels, fishing vessels, ferries and offshore support vessels (refer to Section 4.4.3). Vessel traffic analysis indicates that approximately 8,424 vessels per year transit within 10 nautical miles of the Abbey and Baker locations, equating to an average of around 23 vessels per day. Several established shipping routes pass within close proximity of the proposed development area.

A large hydrocarbon release could potentially affect commercial shipping through temporary navigational hazards associated with surface oiling, or through the need for vessels to avoid contaminated areas. However, modelling undertaken for the worst case condensate blowout scenario indicates that the surface condensate slick would remain relatively small and transient, fluctuating in

size throughout the spill duration and covering only a limited area of sea surface at any one time. The condensate is predicted to weather and disperse rapidly, with no persistent surface oil predicted approximately 10 days following cessation of the blowout. As a result, any displacement of vessels would likely be short-term and localised, with ships able to navigate around the affected area using the extensive sea space available within the wider North Sea.

In summary, the sensitivity of commercial shipping to a worst case blowout is considered to be **Medium**, reflecting the relatively high vessel traffic density in the vicinity of the proposed Abbey & Baker Development. The receptor has a Very High value due to the economic and logistical importance of shipping routes in the SNS. However, the condensate slick is predicted to remain limited in spatial extent and non-persistent, and vessels would be able to alter course to avoid the affected area if necessary. Therefore, receptor resistance and resilience is Very High to condensate pollution, particularly given the availability of alternative navigational routes. The magnitude of impact is assessed as **Minor**, as modelling indicates rapid weathering and dispersion of the released condensate and recovery of conditions to baseline levels within approximately 10 days following cessation of the blowout. When combined with the Extremely Rare likelihood of a blowout event, the overall risk to commercial shipping is therefore considered to be **Low**.

Recreational Activity and Tourism

In coastal areas, oil spills can result in economic impacts associated with shoreline clean-up operations, temporary closure of recreational facilities, and financial losses to sectors that rely on clean coastal environments, such as tourism and leisure industries (ITOPF, 2014d). The presence of stranded oil or hydrocarbon residues on beaches and coastal habitats can also create nuisance effects for local communities and visitors due to the visual appearance and odour of contaminated shorelines.

Leisure and tourism activities are widespread along the east coast of England and include activities such as coastal walking, bird watching, recreational boating, sailing, and beach-based tourism (refer to Section 4.4.9). Several coastal towns in the region have a long association with the tourism industry, and a number of beaches along the east coast are designated bathing waters. The proposed Abbey & Baker Development is located approximately 40 km offshore, and therefore any impacts to recreational activities would occur primarily through potential shoreline oiling rather than direct offshore disturbance.

Modelling indicates that shoreline oiling could occur along parts of the east coast of England, with the highest probabilities predicted for East Riding of Yorkshire (up to 58 %), followed by North Yorkshire (up to 33 %) and Lincolnshire (up to 11 %) (refer to Table 11.5 and Figure 11.6). Probabilities are lower elsewhere along the coast, and all predicted shoreline oiling is limited to light oiling severity (0.001–1 litres/m²). Light shoreline oiling represents thin and patchy deposits that are typically subject to rapid weathering and natural dispersion processes. In addition, modelling indicates that surface oiling is transient and does not persist following cessation of the blowout, with recovery towards baseline conditions predicted within approximately 10 days. Consequently, any effects on recreational activities and tourism would likely be short-term and localised.

In summary, the sensitivity of recreational activity and tourism to a worst case blowout is considered to be **Low**, reflecting the limited direct exposure pathway and the transient nature of predicted shoreline oiling. The receptor has a **High value**, as tourism and leisure activities contribute to the local economy along the east coast of England. However, the condensate is non-persistent and predicted shoreline oiling severity is low, meaning that recreational activities would be expected to recover quickly following any short-term disturbance. Therefore, the receptor resistance and resilience is very high to condensate pollution and the magnitude of impact is assessed as **Minor**. When combined with the Extremely Rare likelihood of a blowout event, the overall risk to recreational activity and tourism is considered to be **Low**.

11.5 Potential for a Major Environmental Incident

A MEI is defined as "*an incident which results, or is likely to result, in significant adverse effects on the environment in accordance with Directive 2004/35/EC of the European Parliament and the Council on environmental liability with regard to the prevention and remedying of environmental damage*".

Under Directive 2004/35/EC, "*environmental damage*" is defined as:

- *"Damage to protected species and natural habitats, which is any damage that has significant adverse effects on reaching or maintaining the favourable conservation status of such habitats or species. The significance of such effects is to be assessed with reference to the baseline condition, taking account of the criteria set out in Annex I";*
- *"Water damage, which is any damage that significantly adversely affects the ecological, chemical and/or quantitative status and/or ecological potential, as defined in Directive 2000/60/EC, of the waters concerned, with the exception of adverse effects where Article 4(7) of that Directive applies";*
- *"Land damage, which is any land contamination that creates a significant risk of human health being adversely affected as a result of the direct or indirect introduction, in, on or under land, of substances, preparations, organisms or micro-organisms".*

For an event to be considered as a MEI, a major accident (as defined under SCR 2015) must be a precursor (BEIS, 2017). For the proposed Abbey & Baker Development, the major accident scenario that would result in the worst case release of hydrocarbons is:

- Loss of well control and subsequent blowout that can only be stopped by drilling a relief well.

Based on the results of the oil spill modelling (Section 11.3.2 and Appendix E) and the assessment of environmental and socio-economic effects presented in Section 11.4, it is considered possible that a worst case condensate release could result in significant adverse effects on certain protected species and habitats, and therefore has the potential to constitute a MEI.

As discussed in Sections 11.4.6 and 11.4.8, surface oiling represents the most credible pathway for ecological impact, particularly for seabirds which are highly sensitive to oil contamination at the sea surface. Several MPAs designated for seabird species or internationally important waterbird assemblages are predicted to be exposed to surface oiling under the worst case scenario. These sites include eight SPAs, two RAMSAR sites and one MCZ with qualifying seabird features (refer to Table 11.12). Exposure of these receptors to surface oiling could result in adverse effects on seabird populations and therefore represents the most plausible mechanism through which a MEI could occur.

In addition, the Southern North Sea SAC, which is designated for harbour porpoise (*Phocoena phocoena*), lies directly within the modelled release area. The modelling predicts surface oiling at 100 % probability (BAOAC 5 – Continuous True Oil Colour) and subsurface oiling above the OSPAR PNEC threshold (>70.5 ppb) within this site. This level of exposure could result in behavioural disturbance or temporary displacement of harbour porpoise, and therefore this site is also considered to represent a potential pathway for a MEI.

Conversely, as discussed in Section 11.4, the predicted severity of shoreline oiling and subsurface oiling across the wider model domain is generally low, with shoreline contamination limited to light oiling severity and water column concentrations exceeding the OSPAR PNEC threshold confined to areas close to the release location within UK waters. As such, these pathways are unlikely to result in impacts of sufficient magnitude to constitute a MEI.

It should be emphasised that the identified major accident scenario represents an extreme worst case, assuming the complete failure of all preventative and control measures. In practice, a range of well control and spill response measures would be implemented immediately to stem the flow of hydrocarbons and bring the well back under control (refer to Section 11.6). These measures would substantially reduce both the duration and extent of any potential environmental effects.

11.6 Mitigation Measures

11.6.1 Spill Prevention Measures

It is Petrogas policy that the Abbey & Baker Development will be designed and operated in a manner that minimises the risk of accidental releases. Onshore design reviews, risk assessments and operations planning are used to identify potential risks and to ensure that, where possible, risks are minimised at the design stage. Where residual risks remain, mitigation procedures will be put in place to prevent accidental spills as summarised in Table 11.13. These take into account relevant learnings from both the Montara and Macondo well control incidents.

MODU and vessel contractors will be required to demonstrate that they have control processes in place to minimise environmental impacts. Training, competency and maintenance of safety and environmentally critical equipment all play vital roles in ensuring the risks of pollution are as low as reasonably practicable.

An approved OPEP will be in place, prepared in advance of activities commencing offshore, which will detail the spill prevention measures, response procedures and resources available to Petrogas in the event of a spill. All supporting vessels will also have a shipboard oil pollution emergency plan (SOPEP) onboard.

Table 11.13: Spill Prevention Measures for the Abbey & Baker Development

Source	Spill Prevention Measures
Loss of chemicals, fuel or utility hydrocarbons during bunkering and general operations	• Liquid storage areas and areas that might be contaminated with oil are segregated from other deck areas; • Permanent drip trays will be located under process plant, pumps and vessels (on grated decks); • Bunding or additional containment will be provided around plated areas beneath equipment with significant hydrocarbon inventories; • Chemicals will be stored in bunded areas where any spillages can be routed to the closed drainage system; • Chemical, utility and fuel storage tanks will be equipped with alarm systems and procedure will be in place to minimise and prevent spills overfilling these storage tanks; • Small spill kits will be on board the MODU to clean up deck spills and prevent spilt hydrocarbons and chemicals from reaching the sea; • Non-return valves will be installed on transfer hoses and hoses to be tested and inspected as a part of a regular maintenance programme; • Bunkering procedures will be put in place to include measures such as transfer operations to be supervised at all times from both the supply vessel and MODU; • Crews will be adequately trained, supervised and regular exercises held to contain and clean-up deck spills; • Routine equipment maintenance programme will be in place with specific emphasis on environmentally critical equipment; • Effective management of chemicals to endeavour to reduce the volumes required and therefore the frequency of bunkering; • Use of floating hoses; • Where feasible, bunkering operations will be undertaken in daylight and in good weather conditions.
Loss of containment on MODU due to collision or other major event	• Consent to Locate will be in place for the MODU under Part 4A of the Energy Act 2008; • 500m safety exclusion zone will be designated around the MODU; • Dedicated ERRV present during drilling to monitor movements of other vessels in the area and prevent them entering the exclusion zones; • Notifications made to ‘regular runners’ and local fisheries organisations via Notices to Mariners, NAVTEX / NAVAREA warnings and fisheries notices.

Source	Spill Prevention Measures
Well Blowout	• Undertake shallow gas survey prior to drilling; • Crews will be adequately experienced, trained in well control techniques and supervised; • Weighted drilling fluids will provide the primary barrier and the downhole pressures will be carefully controlled and monitored; • The secondary barrier will be the BOP which will be regularly maintained and tested; • Well design and construction reviewed by an independent well examiner; • Safety and Environmental critical elements related to drilling operations will be identified, and a suitable maintenance and testing schedule applied to each; • Emergency drills will be held regularly; • Emergency response plans and equipment will be in place; • Review spill mitigation measures of all contractors as part of the contractor selection process.
Loss of pipeline, flowline or umbilicals	• Facilities will be subject to stringent design specifications; • Pressure and leak testing will be undertaken onshore prior to infrastructure being installed and all pipelines, flowlines and risers pressure tested to above the planned operating pressure; • The pipeline will be protected against corrosion by the continuous injection of corrosion inhibitor, supplied as a cocktail with the hydrate inhibitor at the subsea xmas tree. • The pipeline and umbilical will be protected from physical damage by fishing gear or anchors by rock protection; • Routine monitoring of pipeline pressure and temperature will be undertaken. Automatic and manual shutdown systems in place; • Regular ROV inspection of all pipelines will be undertaken.

11.6.2 Oil Spill Response Strategy

With respect to accidental spills, the greatest importance lies with preventing their occurrence in the first instance. However, in the unlikely event of a spill incident occurring, a suitable response strategy must be in place to manage and control a spill.

Response Options

Based on a review of data within OEUK's Oil Spill Response Effectiveness in UK Waters Guidelines (January 2019), the only viable response options available to Petrogas for the Abbey & Baker Development, given the type of hydrocarbons that would be released (i.e. ITOPF Group 1), are as follows (see Figure 11.10):

- **Natural Dispersion:** the natural processes by which the condensate reacts to when in the environment;
- **Monitor and Evaluate:** monitoring the fate of the oil and quantifying the size of the slick.

Given the nature of these response options, a 100 % response effectiveness is therefore available throughout the year.

Petrogas will ensure that a contract is in place with an established oil spill response contractor, prior to commencing field development operations offshore. The oil spill response contractor will be able to provide aerial surveillance, if required in the event of an incident. This is the method of choice for observing and monitoring oil spills in the field as it allows visibility over a wide area. Aerial surveillance can be supplemented with the use of satellite imagery and real-time oil spill modelling, both of which can be mobilised through the oil spill response contractor.

Figure 11.10: Response Options for ITOPF Group 1 Oils in the Southern North Sea (OEUK, 2019)

	Aerial Dispersant	In-situ Burn	Monitor & Evaluate	Natural Dispersion
Wind Speed	N/A Ariel dispersant is not an option for Non-persistent Group 1 oil as it will naturally disperse.	N/A In-situ burning is not an option for Non-persistent Group 1 oil as it will naturally disperse.	**Between 0 – 45 kts**	**All wind speeds**
Visibility			Doesn't affect response	Doesn't affect response
Precipitation			Doesn't affect response	Doesn't affect response
Temperature			Doesn't affect response	Doesn't affect response
Tidal State			Doesn't affect response	Doesn't affect response
Current Speed			Doesn't affect response	Doesn't affect response
Ice & Debris			N/A in UK Climate	N/A in UK Climate
Daylight			**Available 24 hrs**	Doesn't affect response
Wave Height			Doesn't affect response	**All wave heights**

	Contain & Recover	Shoreline Response	Vessel Dispersant
Wind Speed	N/A Containment and Recovery is not an option for Non-persistent Group 1 oil as it will naturally disperse.	N/A Shoreline response is not an option for Non-persistent Group 1 oil as it will naturally disperse.	N/A is not an option for Non-persistent Group 1 oil as it will naturally disperse.
Visibility			
Precipitation			
Temperature			
Tidal State			
Current Speed			
Ice & Debris			
Daylight			
Wave Height			

Source Control Options

In the event of a well control incident, source control will be prioritised, where possible, to stop the flow as quickly as possible in a manner that does not expose the environment to an extended release of hydrocarbons. If primary and secondary well control is lost by way of a blowout and oil flows uncontrollably from the well to the marine environment, then deployment of a capping device and / or a relief well may be required to stop the flow and bring the well under control.

Petrogas estimates that it would take up to 79 days to drill a relief well. This represents a worst-case scenario and includes the time required to survey the proposed relief well location, as well as to source and mobilise a suitable drilling rig.

Note, as the Abbey & Baker Development wells are not at high pressure/high temperature and are not being drilled in deep water. Therefore, it is not anticipated that a specialist drilling rig configuration would be required and a heavy duty jack-up drilling rig would be suitable to drill a relief well.

11.7 Residual Risk

Based on historical data and taking into account the spill prevention measures that will be in place, the most probable accidental releases from the proposed Abbey & Baker Development will be small in volume. It is considered to be extremely rare for a major event, such as a blowout, to occur, particularly given the measures that will be in place to reduce the probability of a failure of well control. The consequences of an accidental release from the Abbey & Baker Development will vary depending on the quantity and type of oil or chemical spilt, the wind speed and direction and sea state and the sensitivity of receptors depending on the time of year. A small spill of condensate, diesel or chemicals would be subject to rapid dilution and dispersion and any impact on receptors in the marine environment would be short term and localised.

The Abbey & Baker Development condensate is an ITOPF Group 1 (57.5° API) which is subject to rapid evaporation and biodegradation rates upon release. The condensate does not persist in the water column, on the sea surface or at the shoreline. The residual risk to the marine environment from a worst case accidental release is considered to range from **Medium** to **Low**, depending on the receptor impacted, but in all cases the risk has been reduced to ALARP through mitigation measures and good industry practice and is therefore not considered to be significant.

11.8 Transboundary Impacts

The modelling indicates that, under the Abbey & Baker Development worst case blowout scenario, transboundary transport of condensate could occur under certain meteorological and oceanographic conditions. However, the majority of predicted oiling remains within UK waters, with concentrations decreasing with distance from the release location as the condensate spreads, evaporates and disperses within the marine environment.

The probability of surface oil crossing international median lines is low and limited to thin surface sheens (BAOAC 2 – Rainbow). The highest probability occurs towards the Netherlands (up to 17 %), with lower probabilities predicted for Germany (up to 5 %), Belgium (up to 2 %), Denmark (up to 2 %) and France (up to 1 %) depending on season (Table 11.5; Figure 11.3). The minimum predicted transit time for surface oil to reach neighbouring waters is approximately 222 hours (around 9 days) towards the Netherlands under winter conditions, with longer transit times predicted for other countries.

Dispersed oil droplets within the water column may extend across a wider area of the SNS due to entrainment of small droplets during the subsea release (refer to Section 11.3.2). The highest probabilities of subsurface oil crossing international median lines occur towards the Netherlands (up to 80 %), followed by Germany (up to 44 %), Belgium (up to 25 %), France (up to 20 %) and Denmark (up to 14 %) (Table 11.5; Figure 11.5). The minimum predicted transit time for subsurface oil concentrations exceeding 1 ppb to reach neighbouring waters is approximately 199 hours (around 8 days) under winter conditions. However, concentrations exceeding the OSPAR PNEC threshold (70.5 ppb) are only predicted within UK waters close to the release location, indicating that toxicologically relevant exposure levels are not expected to occur beyond UK jurisdiction.

The probability of shoreline oiling outside UK waters is very low, with maximum probabilities of up to 1 % for the Netherlands, up to 2 % for Germany, and up to 1 % for Denmark and France, with minimum predicted arrival times generally exceeding 1,100 hours (approximately 45 days). All predicted shoreline oiling is limited to light oiling severity (0.001–1 litres/m²).

Overall, the modelling indicates that although small quantities of surface oil or dispersed droplets could cross international median lines under certain conditions, the most significant oiling remains confined to UK waters close to the release location. Given the low probabilities of shoreline oiling outside the UK, the long transit times involved, and the rapid weathering and dispersion of condensate, the potential for significant transboundary environmental impacts is considered to be **Low** and not significant.

In the event of an oil spill entering Norwegian waters it may be necessary to implement the NORBRIT Agreement (the Norway-UK Joint Contingency Plan). The NORBRIT Agreement sets out command and control procedures for pollution incidents likely to affect both parties, as well as channels of communication and resources available. The Agreement is largely oriented towards major spills; however, it is not confined to such events and will apply as necessary to any spills within the NORBRIT regions, which are of sufficient severity to warrant joint action. The NORBRIT Agreement becomes

operational when agreement to the request for its implementation is reached. Responsibility for implementing joint action rests with the Action Co-ordinating Authority (ACA) of the country on whose side of the median line a spill originated. In this case, Petrogas would immediately inform the MCA (and OPRED) once they have any indication that an oil spill will encroach into Norwegian waters. The MCA would assume the role of the ACA and request Norwegian resources if required.

11.9 Cumulative Impacts

Cumulative effects from accidental releases are not anticipated. Any impact to the marine environment from a small hydrocarbon spill would be short term and localised. The probability of a major hydrocarbon release occurring from the proposed Abbey & Baker Development is extremely rare given the mitigation measures that will be in place.

12 Waste Management

12.1 Introduction

The management of waste produced offshore on the UKCS is regulated through a framework of international and national legislation. Waste generated on offshore installations and vessels is primarily regulated by the Merchant Shipping (Prevention of Pollution by Sewage from Ships) Regulations 2020 (as amended) and Merchant Shipping (Prevention of Pollution by Garbage from Ships) Regulations 2020 (as amended). These Regulations implement Annex IV (Prevention of pollution by sewage from ships) and Annex V (Prevention of pollution by garbage from ships) of MARPOL 73/78 (The International Convention for the Prevention of Pollution from Ships).

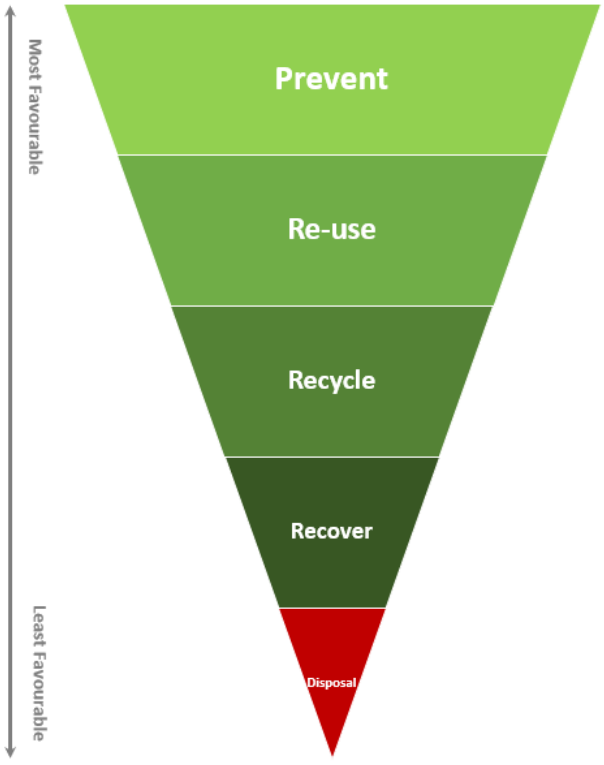
MARPOL Annex IV and V prohibit the discharge of all garbage (including plastics) and galley waste (except for comminuted or ground food waste to < 25 mm and treated sewage) into sea from offshore installations or vessels. Once transported onshore, waste management is regulated by the Environment Protection Act 1990 (as amended), which sets out Duty of Care requirements for the containment, transfer, handling, and recording of all onshore waste through appropriately licensed carriers holding a Waste Carrier Registration.

Given the subsea nature of the Abbey & Baker Development, the majority of waste associated with the Project will be generated onboard the vessels, including the MODU, contracted by Petrogas to undertake the development operations. Waste handling onboard the vessels, including the MODU, will therefore be the responsibility of vessel/MODU contractors. However, Petrogas will produce some waste on York during the annual maintenance visits. Petrogas has a Duty of Care to ensure that the collection, handling, and disposal of all waste generated by the Abbey & Baker Development is achieved, in compliance with current environmental legislation, as well as in accordance with Petrogas Waste Management Procedures.

12.2 The Waste Hierarchy

Petrogas is committed, and has a legal duty, to take all reasonable steps to apply the waste hierarchy (as illustrated in Figure 12.1) and promote 'high quality' recycling.

Figure 12.1: Waste Hierarchy



The waste hierarchy ranks waste management options according to the best environmental outcome, taking into consideration the lifecycle of the material. The lifecycle of a material is an environmental assessment of all the stages of a product's life from-cradle-to-grave (i.e. from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling). Waste will only be disposed of if it cannot be prevented, re-used, recycled or recovered.

In its simplest form, the waste hierarchy gives top priority to preventing waste. When waste is created, it gives priority to preparing it for reuse, then recycling, then other recovery, and last of all disposal (i.e. landfill). For example, one tonne of food waste in landfill produces 450 kg CO_2e, whereas preventing one tonne of food waste saves 3,590 kg CO_2e. The benefits of selecting options higher up the hierarchy also extend beyond carbon savings and include reduced water consumption, protection of important raw materials, creation of jobs, and other economic opportunities (Scottish Government, 2017).

12.3 Duty of Care

Anyone who produces, transports, manages and treats waste has a legal Duty of Care to ensure that waste is managed correctly. This includes proper storage, only transferring it to an appropriate person and ensuring that when it is transferred it is sufficiently well described to enable its safe recovery or disposal without harming the environment.

Petrogas will ensure that all waste produced from the Abbey & Baker Development operations will be minimised through appropriate procurement controls and will be properly segregated for recycling, treatment or disposal. Bulk wastes generated offshore will be segregated by type and periodically transported to shore in an auditable manner through authorised and licenced waste contractors.

Petrogas is responsible for ensuring that waste is transferred to waste contractors in possession of a Waste Carrier Registration. All controlled waste being transferred onshore is required to have a completed Transfer Note, whilst special waste requires a Consignment Note. These Notes provide details on the type and quantity of waste that is being transferred, the parties involved in the transfer of waste, the category of authorised person in receipt of the waste, licence numbers, and time, place and date of transfer. Once onshore, waste will be managed in accordance with the waste hierarchy and will be recovered or disposed of at appropriate licensed sites by properly licensed waste disposal contractors.

12.4 Waste Streams

The types of wastes likely to be generated during the life of the Abbey & Baker Development are summarised in Table 12.1 and include both non-hazardous waste and hazardous waste.

Table 12.1: Types of Waste Likely to Generated from the Abbey & Baker Development

Special Waste	General Waste	Other Waste	Backloaded Cuttings [1]	NORM [2]
Oils, paints, adhesives, solvents, hazardous chemicals and brines, batteries, oily rags	Non-hazardous workover / completion / drilling fluids, brines Segregated recyclables (e.g. scrap metal, plastics, aluminium cans, aerosols, paper / cardboard, glass etc.) Non-hazardous, galley waste, accommodation waste, compactor waste	Clinical materials Explosives	LTOBM cuttings Solid material (e.g. powder or stabilised products), oil and water generated by the treatment process. These will be skip and shipped back to shore for onshore processing and disposal	Naturally occurring radioactive material (NORM) from mineral scales which build up in pipework

[1] The use of thermal treatment technology to remove oil contamination and allow the discharge of cuttings to sea was considered, but this option was not considered to be commercially viable. The recovered LTOBM will be recycled downhole by the mud pump in a closed loop system, ensuring that the mud is continuously recycled during the drilling programme.
[2] May be applicable during Abbey & Baker decommissioning operations. Where NORM readings are found, the infrastructure would be subject to specific identification, handling and waste disposal at an authorised site in accordance with legislative requirements.

Given the subsea nature of the Abbey & Baker Development, the majority of waste will be generated onboard the MODU during development drilling operations and, on cessation of production, when the Abbey & Baker infrastructure is decommissioned. See further detail below.

The quantities and disposal routes of waste arising from offshore operations associated with the Abbey & Baker Development will be reported by Petrogas via the OPRED EEMS, which records measured and calculated data relating to emissions and discharges from offshore installations.

12.4.1 Vessel Waste

Waste will be generated onboard all vessels associated with the proposed Abbey & Baker Development activities including the MODU and support vessels, subsea installation vessels and any vessels used during inspection and maintenance activities and decommissioning. All vessel waste will be managed in compliance with the framework of Regulations discussed above and in line with individual vessel specific Waste Management Plans (WMPs). Generally, waste will either be discharged in line with MARPOL 73/78 requirements, if appropriate, or it will be segregated and stored in suitable, labelled containers for subsequent transfer to shore, where it will be treated or disposed of in accordance with the waste hierarchy.

Offshore vessels of 100 gross tonnage and above, and every ship certified to carry 15 or more persons, must have a Garbage Management Plan and maintain a Garbage Record Book (as per MCA Marine Guidance Note 632 (M+F) Amendment 2). Solid domestic waste will normally be compacted with a garbage compactor, placed in disposal bags and returned to the mainland in waste skips. Open skips will be netted. Separate storage areas will be provided for solid and liquid waste that can be reused. Waste storage areas will be well ventilated and bunded with drainage to appropriate storage or treatment areas. Hazardous waste containers will be covered to reduce rainwater contact in the containment structure. Furthermore, segregation of recyclable materials will be implemented to avoid contamination and consequent reduction of the quality of recycled products.

In summary, due to the strict regulations associated with vessel waste it is assumed that vessel waste will have a **Negligible** impact on the marine environment.

12.4.2 Drilling Waste

MODUs generate various waste products during routine drilling operations (e.g. excess cement, used drilling fluids and chemicals etc.), in addition to waste generated from the everyday running of the MODU (e.g. general waste, food waste and sewage).

Wastes will be minimised by use of appropriate procurement controls, and all wastes will be segregated for recycling, disposal, and / or treatment. The appointed waste management contractor will supply monthly reports of all waste sent to shore and will complete Controlled Waste Transfer Notes as required, and records of monthly disposals will be maintained. Waste Management Duty of Care audits will also be carried out.

Oily waste will be generated on the MODU by a variety of sources, including waste engine oil and hydraulic oil. All waste oil will be held in designated storage tanks. The volumes of waste oils kept onboard the MODU will be kept to a minimum before being transferred to shore, keeping the possibility of spillages to a minimum. No sludge or waste oil will be discharged to sea. Lidded skips will be used for LTOBM contaminated drill cuttings (if required).

In summary, due to the strict regulations associated with MODU waste it is assumed that vessel waste will have a **Negligible** impact on the marine environment. In addition, all the aforementioned waste will be shipped to and processed on shore.

12.4.3 Decommissioning Waste

Onshore waste management will be in an important consideration during the decommissioning phase of the Abbey & Baker Development. A dedicated decommissioning WMP will be produced to identify all waste streams and the most appropriate removal and disposal method. All recovered waste will be brought to shore to a licenced specialist decommissioning waste facility. Where possible, materials will be sold for reuse or recycled in accordance with the waste hierarchy. Therefore, it is anticipated that waste associated with decommissioning will have a **Negligible** impact on the marine environment.

12.5 Mitigation Measures

The management of offshore waste generated on the UKCS is strictly regulated, ensuring a high level of mitigation from the outset, as described above. Petrogas will ensure successful implementation of the mitigation measures regarding waste management by:

- Application of the Waste Hierarchy to all produced waste;
- Compliance with Petrogas WMP and use of Garbage Management Plans for the management of waste produced from vessels;
- Compliance with Petrogas Waste Management Procedures for waste produced during the proposed development activities;
- Segregation, transfer onshore and disposal of waste through licensed contractors and sites.

12.6 Conclusion

Several different waste streams will be generated throughout the lifespan of the Abbey & Baker Development. Waste management will be undertaken in compliance with current environmental legislation and applicable waste procedures which includes the waste hierarchy, as described above. The management of offshore waste generated on the UKCS is strictly regulated and the UK has well-established infrastructure in place to manage this waste effectively. Therefore, no significant impacts (including cumulative or transboundary impacts) are expected as a result of the Abbey & Baker Development.

13 Environmental Management

13.1 Introduction

The identification and control of potential environmental impacts associated with all Petrogas activities forms an integral part of managing the business. Impacts are identified during the planning stages of all operations and the risks evaluated and managed through an integrated Business Excellence Management System (BEMS). This system provides the structured management framework within which environmental impacts are identified, assessed, controlled, and monitored.

As the offshore licensee, Petrogas is responsible for the Abbey & Baker Development during all lifecycle phases of the project.

Petrogas is planning to be the well operator, installation operator (York) and a pipeline operator, subject to approval by the NSTA under The Offshore Petroleum Licensing (Offshore Safety Directive) Regulations 2015. Petrogas will manage the development drilling and well completion operations, as well as any future well intervention (maintenance) and subsequent well abandonment operations. Petrogas will also manage any pipeline interventions once the field goes into production and subsequent pipeline abandonment activities.

Petrogas will ensure that the activities comply with the OSPAR Recommendation 2003/5 to Promote the Use and Implementation of Environmental Management Systems by the Offshore Industry. Petrogas will also monitor and evaluate the performance of the contractors, either directly or via the appointed operators, particularly with respect to safety and environmental performance.

The remainder of this section describes the main components of the Petrogas BEMS, how it will be integrated with the management systems of other entities and explains how the potential impacts identified within this ES will be managed throughout the proposed Abbey & Baker development operations.

13.2 Petrogas BEMS

13.2.1 HSE Policy

Petrogas HSE Policy defines and documents the Company's commitment to the health and safety of individuals, integrity of company property, protection of the environment and continual company improvement. Petrogas policy objectives and statements are listed below:

- Our primary objective is to minimise all occupational health, safety, security and environmental risks to as low as reasonably practicable, by engaging Workers to look for the elimination of hazards and when not possible, substitution or control of those hazards.
- We ensure to effectively respond to any emergencies prioritising the health and safety of all individuals involved and minimising the impact to the environment. We make all required efforts to prevent or mitigate crisis situations.
- We are dedicated to creating and maintaining a working environment where we minimise impact to the physical and mental health and safety of the Workers. We always look at initiatives aimed at enhancing the overall health, safety, and wellbeing of the Workers. We work with our Value Chain to ensure fair and equitable treatment for their workers.
- We ensure to effectively respond to any emergencies prioritising the health and safety of all individuals involved and minimising the impact to the environment. We make all required efforts to prevent or mitigate crisis situations.
- We ensure our workforce is trained and competent to perform their duties safely and effectively.
- We work together in fostering an environment where every individual feels safe to start the job and feels free to stop the job, when it is judged to be unsafe for people and / or

the environment. We will never penalise anyone to stop a job or speaking up about hazards, injuries or undesirable behaviour.

- We are committed to be a diverse, equitable and inclusive workplace, where the human rights of everyone, including the workers in value chain, are respected. We strive for a place where every voice is heard, and cultural differences are valued.
- We design, build, operate, apply the latest technologies and maintain facilities with the highest integrity standards to prevent and mitigate undesirable events and proactively address climate change related impacts within our control.
- We are dedicated to preventing pollution and mitigating environmental impacts stemming from our operations throughout their whole lifecycle, by improving the energy efficiency of our assets, minimising and/or eliminating emissions, including greenhouse gasses, waste, water discharges, and the use of environmentally harmful substances.
- We are committed to preventing pollution and reducing environmental impacts across the full lifecycle of our operations. This includes improving energy efficiency, minimising or eliminating emissions (including greenhouse gases), waste, water discharges, and the use of environmentally harmful substances.
- We embrace circularity extending the lifespan of the resources we employ by maximising recycling and upcycling opportunities, through innovation and ingenuity.
- Our ambition extends to have a no negative impact on biodiversity of the areas, and on ecosystems, where we operate.
- We endeavour to create more sustainable business to minimise the negative impact and maximise the positive impact of our operations to the community we work and live in, by applying thorough due diligence to us and our value chain.
- We are committed to a culture of continuous learning and improvement, where we actively seek to understand both our successes and our shortcomings. Through the analysis of normal work, best practices, incident investigations and audits, we extract valuable insights to enhance our operations. We share learnings across our organisation to facilitate continuous improvement in all aspects of our work.
- We enable, promote, and verify compliance with applicable stipulated legal and corporate HSE related requirements.
- We ensure transparency and we engage with all our stakeholders on all our positive and negative impacts, and we work with them to maximise and minimise these impacts.

The implementation of the HSE Policy is achieved through application of Petrogas BEMS. Achieving the policy goals depends on the commitment of everybody who works for Petrogas, including contractors, suppliers and consultants. It is therefore the responsibility of everyone to ensure that the system is understood and followed.

Petrogas HSE Policy is regularly reviewed and, if necessary, modified and revisited following any material changes in the company. It is made available to the public and those working for and on behalf of Petrogas as necessary.

13.2.2 BEMS

Petrogas operates an ISO14001:2015 certified management system: the BEMS. The system was certified according to ISO 14001:2015 on 22 September 2021, prior to the commencement of offshore drilling activities on the UKCS. The management system therefore meets the requirements of OSPAR Recommendation 2003/5 to Promote the Use and Implementation of Environmental Management Systems by the Offshore Industry. An annual verification audit has been successfully executed since September 2022, following a three-year revalidation cycle. BEMS was successfully recertified in 2024, starting the new three-year revalidation cycle. Petrogas is planning to conduct a gap assessment on the newly released ISO14001:2026 and, where relevant, initiate a management system update.

The basis for the management system is the concept of "Plan Do Check Act", which provides an iterative process to achieve continual improvement in performance. Figure 13.1 reflects the elements of this process and the relationship to the ISO High Level Structure requirements.

Figure 13.1: Plan-Do-Check-Act Loop

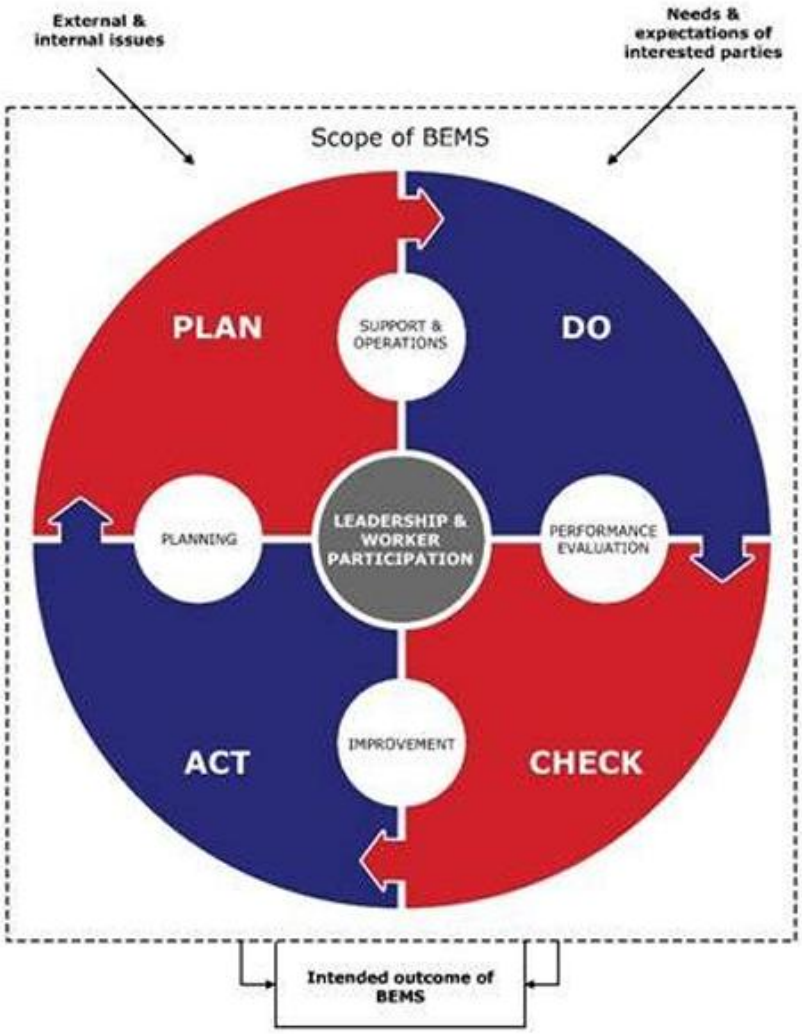
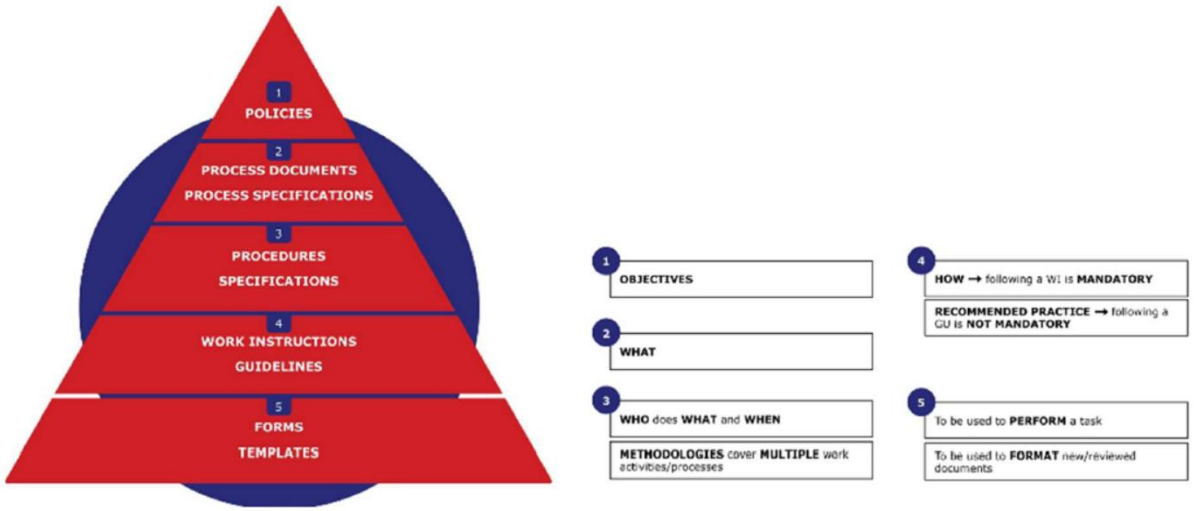


Figure 13.2 illustrates the overall documentation structure for the BEMS.

Figure 13.2: BEMS Document Structure



The BEMS includes an HSE Policy and (Corporate) Major Accident Prevention Policy (MAPP), as well as relevant safety and environmental processes and procedures as required by the ISO standards.

Key safety and environmental documents in the BEMS are listed in Table 13.1.

Table 13.1: Key safety and environmental documents for the BEMS

Document Title
HSE Policy
Major Accident Prevention Policy (MAPP)
Business Ethics Policy
BEMS Manual
General Management Process Document
Management System Process Specification
Health, Safety, Environment and Quality (HSEQ) Process Document
Incident Investigation and Reporting Process Specification
HSE Risk Management Process Specification
Environmental Stewardship Process Specification
Emergency Management Process Specification
Compliance Assurance Process Specification
HSE Compliance Register
Project Compliance Plan
Environmental Aspects and Planning Procedure
Petrogas Environmental Aspects Register
Management of Contractors Procedure
Management of Change Procedure – Drilling and Well Engineering
Competence Assurance Procedure
Well Engineering Process Document
Logistics Process Document

The BEMS is dynamic. Although Figure 13.1 above shows a defined sequence of events, the system elements operate across the business and at various levels within the organisation and therefore may not strictly follow the sequence shown. The BEMS is currently under update to cater for becoming an operator of the York facility.

13.2.3 HSE Compliance

The overall responsibility for the BEMS lies with the General Manager, who, on behalf of the Petrogas Directors, has committed to its development, implementation and continual improvement. The General Manager shall demonstrate leadership and commitment with respect to BEMS by:

- Taking accountability for the effectiveness of BEMS;
- Ensuring that health, safety and environmental policies and objectives are established and are compatible with the strategic direction and the context of the organization;
- Ensuring that the resources needed for BEMS are available;
- Communicating the importance of effective safety and environmental management and of conforming to BEMS requirements;
- Engaging, directing and supporting persons to contribute to the effectiveness of BEMS;
- Promoting continual improvement.

The HSE standards adopted by Petrogas are those specified in the relevant legislation, codes of practice and guidance notes, together with those contained in recognised industry standards and practices. Applicable standards are generally defined within Contractor Operating Procedures.

Petrogas anticipates being the "operator" for drilling wells, the installation of pipelines and other subsea equipment and the York facility, therefore, the Directors and advisors to the company have experience of such operational activity in the UK and internationally in senior positions. The team are also aware of the health, safety and environmental requirements for exploration and production activities. The General Manager has delegated the operational management of the company HSE aspects to the HSEQ Manager; the HSEQ Manager is managing a team of specialist who are supporting the companies throughout the design, construction and operational phases of Abbey and Baker.

13.2.4 Contractor Selection

Temporary Workers and Value Chain Workers will be employed throughout the proposed Abbey & Baker development operations. The Petrogas BEMS includes a requirement to assess HSE capability and performance as an integral part of the contractor selection process. The selection process is dependent on the HSE risks associated with each contract and include:

- Ensuring an effective health, safety and environmental management system is in place;
- Reviewing HSE Performance;
- Reviews of regulatory compliance and inspections;
- Ensuring contractors operate an effective competence system;
- Reviewing audit findings and action tracking;
- Maintenance management (where appropriate);
- Review of previous audit reports (certification, internal, external) and outstanding actions;
- Undertaking or commissioning pre-contract health, safety and environmental audits.

Every effort is made to select contractors with strong HSE performance and processes.

13.2.5 Contractor Management

BEMS Interface/Bridging Documents will be produced, which describe how the various parties will work together in the execution of this project. It will document clear lines of communications and responsibilities between Petrogas, the appointed operators and the various contractors throughout the proposed operations, including designation of responsibilities for environmental management and regulatory compliance.

Steps will be taken to ensure that all parties engaged in the proposed Abbey & Baker operations understand the potential environmental impacts and commitments as outlined in this ES and the importance of environmental compliance. This will be achieved through meetings prior to the commencement of operations and inductions. Oil spill training and emergency management exercises / drills will also be undertaken as defined within the future OPEP for the Abbey & Baker wells and general Petrogas Emergency Management Process Specification.

13.2.6 Audit, Monitoring and Reporting

Environmental audits of the drilling rig and the main subsea installation vessels will be carried out prior to Petrogas accepting the vessels for the Abbey & Baker development activities. Further environmental audits may be conducted during the proposed work programme as part of the annual audit plan as defined by the Petrogas Audit Process Specification.

In addition, contractor safety and environmental related performance will be monitored and reviewed throughout the proposed operations, with emissions and discharges monitored and reported in accordance with the HSE MS Interface/Bridging Document. All environmental incidents will be subject to joint investigation and dual reporting.

All environmental emissions data recorded during the proposed Abbey & Baker operations will be submitted to OPRED via the dedicated EEMS. This includes data on the following:

- Atmospheric emissions;
- Chemicals;
- Drill fluids;
- OPPC returns;
- Waste.

13.3 ES Commitments

Table 13.2 summarises the mitigation measures and commitments identified within this ES. As described above, Petrogas will ensure these are taken into account and implemented as the proposed Abbey & Baker field development project progresses.

Table 13.2: Mitigation Measures and Commitments Register

Ref	Theme	Mitigation Measure / Commitment	ES Section
1	Physical Presence	a. Up to three separate 500 m safety zones (are and) will be designated around the MODU and a dedicated ERRV, equipped with AIS and/or ARPA will be present during the drilling operations to monitor movements of other vessels in the area and prevent them entering the safety zone. b. A Vessel Traffic Survey was conducted in 2024 prior to the drilling of the Abbey Appraisal and Baker Exploration well. However, this survey only has a validity of one year and thus a new study will be required along with a Collision Risk Assessment. These will be prepared to support the CtL permit applications required to site the MODU and subsea infrastructure at the Abbey & Baker Development locations and all vessels will comply with the COLREGs. c. Information on the location of the MODU, MODU anchor positions, 500m safety zones, subsea infrastructure (i.e. wellhead/tree, WHPS and pipelines) and vessel operations will be communicated to other sea users via the UKHO, MCA, FishSAFE, Kingfisher Information Services, Notices to Mariners and Radio Navigation Warnings. d. Petrogas will continue to consult with NFFO during the detailed design phase and planning process for the subsea infrastructure installation activities. A FLO will be appointed to maintain good communication with local fisheries and co-ordinate activities, particularly during installation of the pipelines and umbilicals. e. Through careful planning, the number of vessels and length of time they are required on site for installation operations, will be reduced as far as practicably possible. f. Where boulders (>0.5 m) are required to be removed from the pipeline lay corridors, the as-left position of any relocated boulders will be recorded and reported via Kingfisher. g. Vessels involved in subsea infrastructure installation operations will update their marks, lights and navigational status broadcast on AIS to indicate when they are restricted in manoeuvrability. This will assist any passing vessels that encounter the installation vessels. h. Up to three guard vessels will be present to guard partly constructed facilities when the installation vessels are not on location, prior to the deposit of protection (rock) on top of the lines, to ensure that other sea users are aware of the ongoing operations. i. Pipeline working corridors will be minimised, as far as possible. j. Prior to installation, Petrogas will apply for 500 m subsea exclusion zones to be in place around the subsea infrastructure at the Abbey A1 and A3 and Baker well locations.	6

Ref	Theme	Mitigation Measure / Commitment	ES Section
		k. Maintenance inspection surveys will be undertaken throughout the life of the Abbey & Baker fields to ensure the seabed infrastructure and associated protection material remain in a favourable condition.	
2	Seabed Disturbance	a. Use the minimum appropriate number of drilling rig anchors and length of anchor chains to maintain stability and integrity. b. MODU anchors will be set at the optimum angle for the local seabed sediments, reducing the potential drag across the seabed and helping them to become suitably embedded. c. The MODU anchoring system (anchors and chains) will be placed in accordance with site survey results so as to prevent damage to sensitive seabed habitats. d. A full CHARM assessment of the proposed chemicals to be used and discharged, as required under the Offshore Chemicals Regulations 2002 (as amended), will be undertaken during the permitting process prior to drilling operations commencing and, as part of chemical selection and assessment process, less hazardous alternatives will be sought in preference for any chemicals identified to be high risk (e.g. those with substitution warnings). e. A ROV will be used to monitor cement returns when cementing the 30 inch conductor and 13 3/8 inch casing to help ensure the volume of cement discharged to the seabed is kept at a minimum. f. Route selection and optimisation will be based on acquired Environmental, Geophysical, and Geotechnical survey data. g. Petrogas commit to the microrouting of the production pipelines and umbilicals in order to avoid affecting the predicted Annex I stony reef habitats. h. Working corridors will be minimised as far as possible. i. Any boulders removed from the pipeline and umbilical lay corridors will be placed appropriately on the seabed to avoid a snag hazard and their as-left position recorded. j. Use of DP installation vessels as opposed to anchored vessels. k. Rock will be deployed from a DP rock dumping vessel using a fall pipe and the rate and locations of deployment will be controlled on board the vessel and monitored using high resolution survey / sonar equipment. l. Size of subsea infrastructure will be optimised for the Abbey & Baker Development. m. Subsea infrastructure layout and pipeline crossing designs optimised to minimise material deposited. n. Concrete mattresses will be deployed from a vessel with a ROV and acoustic positioning to monitor placement of material and ensure that it is directed to the required area.	7

Ref	Theme	Mitigation Measure / Commitment	ES Section
		o. Minimise amount of deposited material whilst still achieving the required level of stabilisation / protection. p. Monitoring of integrity of subsea infrastructure, including the pipeline / umbilical and stabilisation material throughout production operations and taking remedial action, if required.	
3	Noise	a. Operational and maintenance procedures on vessels will aim to optimise the efficiency of equipment; and b. Vessel use will be optimised where possible by minimising the number of vessels required and vessel movements.	8
4	Atmospheric Emissions	a. The drilling rig selection process will factor in whether an energy control system is installed. The rig operator will be required to be ISO 140001 (Environmental Management) and ISO 50001 (Energy Management) certified; b. Electrical powerpacks, instead of diesel powerpacks, will be used for all services on the rig where these are compatible and available; c. • The contracts evaluation process will include emissions information from potential suppliers; d. Compliance with International Maritime Organisation requirements on fuels; e. Optimise drilling, installation, maintenance and repair and decommissioning activities, including vessel movements, by careful planning to optimise fuel use holistically. f. Well test and clean-up durations will be optimised and permitted appropriately.	9
5	Marine Discharges	a. A chemical risk assessment will be undertaken to identify the risk profile of chemicals to be used and / or discharged in accordance with the requirements of the Offshore Chemicals Regulations 2002 (as amended). Where practicable, chemicals with a higher risk profile will be substituted out in favour of those with an improved environmental profile; b. Chemical use and discharge will be minimised to as low as practically possible; c. During drilling operations, cuttings / mud cleaning equipment will ensure optimal cuttings cleaning prior to discharge and recovered WBM will be reused/ re-circulated where practical. In addition, WBM will be mixed offshore to ensure that only what is required is used; d. During the drilling operations, any discharges of residual reservoir hydrocarbons will be treated to meet oil-in-water limits of less than or equal to 30 mg/l. The discharge stream will also be monitored and sampled in accordance with the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended).	10
6	Accidental Discharges	a. Liquid storage areas and areas that might be contaminated with oil are segregated from other deck areas; b. Permanent drip trays will be located under process plant, pumps and vessels (on grated decks);	11

Ref	Theme	Mitigation Measure / Commitment	ES Section
		c. Bunding or additional containment will be provided around plated areas beneath equipment with significant hydrocarbon inventories; d. Chemicals will be stored in bunded areas where any spillages can be routed to the closed drainage system; e. Chemical, utility and fuel storage tanks will be equipped with alarm systems and procedure will be in place to minimise and prevent spills overfilling these storage tanks; f. Small spill kits will be on board the MODU to clean up deck spills and prevent spilt hydrocarbons and chemicals from reaching the sea; g. Non-return valves will be installed on transfer hoses and hoses to be tested and inspected as a part of a regular maintenance programme; h. Bunkering procedures will be put in place to include measures such as transfer operations to be supervised at all times from both the supply vessel and MODU; i. Crews will be adequately trained, supervised and regular exercises held to contain and clean-up deck spills; j. Routine equipment maintenance programme will be in place with specific emphasis on environmentally critical equipment; k. Effective management of chemicals to endeavour to reduce the volumes required and therefore the frequency of bunkering; l. Use of floating hoses; m. Where feasible, bunkering operations will be undertaken in daylight and in good weather conditions. n. Consent to Locate will be in place for the MODU under Part 4A of the Energy Act 2008; o. 500m safety exclusion zone will be designated around the MODU; p. Dedicated ERRV present during drilling to monitor movements of other vessels in the area and prevent them entering the exclusion zones; q. Notifications made to 'regular runners' and local fisheries organisations via Notices to Mariners, NAVTEX / NAVAREA warnings and fisheries notices. r. Undertake shallow gas survey prior to drilling; s. Crews will be adequately experienced, trained in well control techniques and supervised;	

Ref	Theme	Mitigation Measure / Commitment	ES Section
		t. Weighted drilling fluids will provide the primary barrier and the downhole pressures will be carefully controlled and monitored; u. The secondary barrier will be the BOP which will be regularly maintained and tested; v. Well design and construction reviewed by an independent well examiner; w. Safety and Environmental critical elements related to drilling operations will be identified, and a suitable maintenance and testing schedule applied to each; x. Emergency drills will be held regularly; y. Emergency response plans and equipment will be in place; z. Review spill mitigation measures of all contractors as part of the contractor selection process. aa. Facilities will be subject to stringent design specifications; bb. Pressure and leak testing will be undertaken onshore prior to infrastructure being installed and all pipelines, flowlines and risers pressure tested to above the planned operating pressure; cc. The pipeline will be protected against corrosion by the continuous injection of corrosion inhibitor, supplied as a cocktail with the hydrate inhibitor at the subsea xmas tree. dd. The pipeline and umbilical will protected from physical damage by fishing gear or anchors by rock protection; ee. Routine monitoring of pipeline pressure and temperature will be undertaken. Automatic and manual shutdown systems in place; ff. Regular ROV inspection of all pipelines will be undertaken.	
7	Waste Management	a. Application of the Waste Hierarchy to all produced waste; b. Compliance with Petrogas WMP and use of Garbage Management Plans for the management of waste produced from vessels; c. Compliance with Petrogas Waste Management Procedures for waste produced during the proposed development activities; d. Segregation, transfer onshore and disposal of waste through licensed contractors and sites.	12

14 Conclusions

Petrogas is proposing to develop the Abbey & Baker fields via four subsea gas wells (three at Abbey and one at Baker). The Baker Well is approximately 4 km (3.8 km) from the Abbey location. Baker will have a 8-inch pipeline and electro-hydraulic umbilical tied into a production manifold at the Abbey location and then commingled with the Abbey wells. The combined Abbey & Baker production will be tied back via a new 8 km 8-inch production pipeline and electro-hydraulic umbilical to the York NPAI platform, hereafter referred to as the York platform. From York, Abbey & Baker production would be exported onshore via the existing 16-inch export pipeline to Perenco UK Limited's Dimlington Terminal via the Easington Terminal for processing.

Under The Offshore Oil and Gas Exploration, Production, Unloading and Storage (EIA) Regulations 2020, as the proposed Abbey & Baker Development will extract more than 500,000 cubic metres of gas per day, there is a mandatory requirement for Petrogas to conduct an EIA to determine if the proposed Abbey & Baker Development is likely to have any significant effects on the environment, the results of which have been documented in this ES.

The key findings of the EIA undertaken for the Abbey & Baker Development are summarised below.

14.1 Physical Presence

No significant residual effects on other sea users (shipping and commercial fishing) are predicted as a result of the physical presence of the jack up MODU and / or vessels during drilling, installation, inspection and maintenance and decommissioning activities or the long-term presence of the Abbey & Baker subsea infrastructure and associated protection / stabilisation material.

The Abbey & Baker Development has the potential to interact with shipping through the temporary presence of the MODU and / or vessels resulting in the displacement of vessel traffic and increased risk of a vessel collision. The greatest impact will be before and during drilling operations, during installation of the subsea infrastructure and, following cessation of production, during decommissioning operations. However, any discernible increase in vessel presence in the area will be temporary in nature. The risk of a collision will be minimised by implementing measures, including temporarily establishing a 500 m safety zone around the MODU during the proposed drilling operations, which will be patrolled by an ERRV equipped with an AIS and/or ARPA. Notifications to other sea users will also be issued via Notices to Mariners and Kingfisher Bulletin to communicate the location of the works. An updated VTS will be undertaken to inform the CtL permit applications, required to site the MODU and subsea infrastructure at the Abbey & Baker locations. If necessary, a Collision Risk Assessment may also be undertaken. Residual effects on shipping from the physical presence of the MODU and vessels during drilling, installation, inspection and maintenance and decommissioning activities, are therefore **Minor** and not significant.

Fishing vessels may be temporarily displaced from the Abbey & Baker Development area during the drilling and installation phases of the Project, with an area of 1.6 km^2 at the Abbey drill centre and 0.8 km^2 at the Baker well location also lost for the life of the field development. This is a very small area in comparison to the alternative fishing grounds available in the wider SNS area. During the installation of the pipelines and umbilicals, fishing vessels will be temporarily displaced from the working corridors, with the area remaining unavailable to commercial fisheries until rock has been placed over the lines for protection and upheaval buckling mitigation. In the case that the trench and burial method is used for the pipeline and umbilical installations, the buried pipelines will be overtrawlable. In addition, the profile of any rock berms once deposited will be overtrawlable. to minimise the risk to fishing vessels, Petrogas proposes to use up to three guard vessels to guard partly constructed facilities when the installation vessels are not on location. This approach has been discussed with the NFFO and Petrogas will continue to consult with the NFFO during the detailed design phase and planning process for the subsea infrastructure installation activities. To ensure the integrity of the Abbey and Baker infrastructure at the seabed and prevent damage in the event of contact with fishing gears, the Abbey and Baker WHPS's will all be designed to be fishing friendly. Concrete mattresses will be placed over the tie-in spools and control jumpers located within the 500 m safety zones at Abbey, Baker and York Residual effects on commercial fishing from the physical presence of the MODU and vessels during

drilling, installation, inspection and maintenance and decommissioning activities, are therefore **Minor** and not significant.

The proposed Abbey & Baker Development is located within a region of established oil and gas activity. Other oil and gas developments in the area will utilise vessels which have the potential to act cumulatively in increasing vessel collision risk. However, given the mitigation measures which will be in place for the Abbey & Baker Development and other oil and gas operations, increased vessel presence should not act in combination with any other development to increase collision risk.

A significant cumulative increase in snagging risk with other oil and gas development in the area is also not anticipated as the Abbey & Baker subsea infrastructure will be designed to be 'fishing friendly'; the pipelines and umbilical will be trenched and buried, and the berm profile of any rock placement will be designed to be overtrawlable. In addition, any mattresses or grout bags will only be placed within designated 500 m subsea exclusion zones.

14.2 Seabed Disturbance

No significant residual effects on water quality, seabed sediments, seabed communities, fish or protected areas are predicted as a result of disturbance to the seabed during the life of the Abbey & Baker Development. The worst case total area of seabed that will be impacted temporarily by the Abbey & Baker Development is estimated at around 0.697 km^2, and the worst case total area of seabed that will be impacted in the long term by the Abbey & Baker Development is estimated at around 0.0399 km^2. These are relatively small areas in comparison to the seabed available in the SNS region, with similar water depths, sediment types and benthic communities. In addition, while aspects of the Abbey & Baker Development will be located within the SNS SAC and Holderness Offshore MCZ, it has been concluded that no significant impacts will occur to the conservation objectives of these sites.

Temporary disturbance of the seabed is attributed to the siting of the MODU, siting of the accommodation unit at York, discharge of drill cuttings, muds and cement and installation of the Abbey & Baker subsea infrastructure, including the pipelines and umbilical.

Siting of the jack-up rig (three times, with anchors and anchor chains used at the Abbey wells) at the Abbey and Baker locations and the accommodation unit at York will impact an area of seabed totalling circa. 0.0344 km^2; the three rig moves will impact ca. 0.0234 km^2, and the siting of the accommodation unit at York will impact ca. 0.011 km^2. The spudcans, legs and anchors will cause a physical disturbance to the subsurface of the local environment and the use of anchor chains will cause a physical disturbance via abrasion of the surface of the local environment. In the case of the local sediments, habitats with a naturally high rate of disturbance, such as wave or current exposed unconsolidated fine grained sediments in shallow water, tend to recover from disturbance within months (Foden et al. 2009). This is likely to be the case for the proposed Abbey & Baker development given its location in the Southern North Sea (SNS). Permanent scarring of the seabed is therefore also unlikely. Sessile epifauna, and a proportion of the infauna (animals that burrow into the sediment or form tubes within it) such as polychaete worms in the direct footprint area of the drilling rig and accommodation unit (ca. 0.00341 km^2) may experience injury and mortality from compression and abrasion. However, recovery is expected to occur once the drilling rig and accommodation unit have moved off location.

The discharge of drill cuttings, muds and cement will initially alter the seabed topography and sediment structure of a small area in close proximity to the proposed Abbey and Baker wells (0.37 km^2). The accumulation of drill cuttings and mud at the Abbey & Baker well locations is likely to change the benthic community in the immediate area by burying some animals and impairing the feeding and respiration of others. It is expected that any communities in the immediate vicinity of the well will be lost, and that increased concentrations of suspended particles near the seabed may also impair respiratory and feeding processes, inducing metabolic stress and reducing growth and survival rates. Field studies have shown however that recovery of benthic communities impacted with water based drilling discharges (which will be discharged to the seabed from the top two hole sections of the Abbey & Baker wells) is likely to be very rapid (i.e. within a few months). The deeper wells sections of the Abbey & Baker wells will be drilled with LTOBM, the LTOBM will be shipped back to shore and therefore is not subject to any discharges.

Installation of the Abbey & Baker subsea infrastructure, particularly the trenching and backfill operations during pipeline and umbilical installation, will also result in temporary disturbance to seabed from sediment suspension and re-settlement within an area of ca. 0.293 km^2. However, given the relatively coarse (sandy and gravelly) nature of the sediment at Abbey & Baker any sediment plumes or re-suspended sediment will tend to settle quickly and will not be prolonged or affect large areas.

The habitat assessment results for the Abbey & Baker Development highlighted the presence of the EUNIS biotope complex 'Offshore Circalittoral Sand' (MD52 / SS.SSa.OSa) within the Abbey site survey area, and the presence of 'Offshore Circalittoral Coarse Sediment' (MD32 / SS.SCS.OCS) through the Abbey & Baker Development. Both of these habitat types are encompassed within the UK BAP 'Offshore subtidal sands and gravels' (BRIG, 2011). Due to the dynamic environment within which the Abbey & Baker Development is located, recovery of this habitat is expected in the short to medium term.

The habitat assessment results for the Abbey & Baker Development also highlighted the presence of the habitat type '*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment' (MC4214) in the at the proposed Abbey drill centre. The biotope is likely to be exposed to at least seasonal movement of substrata and this movement and scour maintains this biotope by preventing species that require more stable habitats from colonizing and developing stable populations. The Marine Life Information Network (MarLIN) Sensitivity Assessment indicates a Low sensitivity to heavy smothering and siltation rate changes, and Medium sensitivity to penetration or disturbance of the substratum subsurface and to the abrasion / disturbance to the surface of the substratum (Readman and Watson, 2024).

There was no evidence to indicate the presence of Annex I 'Stony Reef' habitats within the vicinity of the Baker well location, Abbey to York pipeline route or Baker to Abbey pipeline route. The Abbey drill centre is, however, situated in an area identified as having the potential for Annex I 'stony reef' habitats. As a consequence, the drill site underwent a move 70 m northeast to aim to reduce the likeliness that the installation of subsea infrastructure at Abbey, the installation of the pipelines and umbilicals, or the installation of any protection materials (rock, concrete mattresses, grout bags) will significantly impact the stony reef habitat.

Ocean quahog (*A. islandica*) has been recorded to be present within the Abbey & Baker Development area. The ocean quahog is highly sensitive to physical pressures such as surface abrasion and subsurface disturbance, but not sediment deposition. Therefore, while the installation of the Abbey & Baker development subsea infrastructure has the potential to cause direct mortality; any sedimentation arising from the installation of the infrastructure is unlikely to affect *A. islandica*.

Exposure to increased turbidity caused by the proposed Abbey & Baker Development operations may also reduce the visual acuity of fish utilising the area potentially affecting foraging behaviour. Fish may also be temporarily displaced from their spawning and nursery areas. However, given the localised area of impact and the mobile nature of the species, any displaced fish are likely to find foraging opportunities, as well as suitable spawning and nursery areas in adjacent locations. The Abbey & Baker Development area contained areas of low to moderate potential ('Unsuitable', 'Suitable', 'Preferred' or 'Sub-prime') for sandeel spawning grounds. In addition, the herring spawning ground assessment undertaken for the proposed Abbey & Baker Development did not indicate high potential (i.e. 'Prime' or 'Preferred' classification) for herring spawning grounds. Notwithstanding this, any potential spawning grounds identified within the vicinity of the Abbey & Baker development are part of wider spawning grounds around the Southern North Sea and this area is not considered to be a critical habitat for these species.

It is, however, recognised that some aspects of the Abbey & Baker Development (i.e. installation of the subsea structures, pipeline and umbilical, as well as associated rock and concrete mattresses for protection / stability / trench transitions) will have long term impacts on sediment communities, due to permanent habitat change, although direct physical injury of benthic species will only occur when the infrastructure or material is first placed on the seabed. This impact will last the duration of the Abbey & Baker development (ca. 11 to 16 years) and beyond depending on how the infrastructure is decommissioned. The area beneath the subsea infrastructure and protection / stabilisation material will become unavailable for re-colonisation by sandy and gravelly sediment inhabiting infauna and over time a new rocky substrate habitat will become established; all protected species habitats within the

Abbey & Baker Development have a high sensitivity to this. Ultimately, it is expected that this new habitat will be colonised by the same types of mobile and encrusting epifaunal animals already present on cobbles and boulders in the wider area. As such, any long term change to the benthic environment will be localised and is not expected to cause any widespread changes to the marine life present in the wider area.

The proposed Abbey & Baker development is wholly located within the winter area of the SNS SAC, which is designated for the protection of the Annex II species harbour porpoise. While no direct impacts to the harbour porpoise are expected, the Abbey & Baker development area is located within the nursery and spawning grounds for a number of prey species. The spawning grounds within which the Abbey & Baker development area is located are part of wider spawning grounds within the SNS and, as such, is not considered to be a key habitat for these fish species. Any impacts to fish species, including those used by harbour porpoise as prey, will be negligible. This is both due to the relatively small magnitude of impact, and fish species' Very High resistance and resilience to seabed disturbance.

The proposed Abbey & Baker Development, more specifically, approximately 4.8 km of the Abbey to York pipeline corridor route, and the York platform are located within the Holderness Offshore MCZ. The MCZ is designated for the following five features: Subtidal coarse sediment; Subtidal sand; Subtidal mixed sediments; Ocean quahog (*Arctica islandica*); and North Sea glacial tunnel valleys (inner Silver Pit). Due to the dynamic environment within which the Abbey & Baker Development is located, recovery of the subtidal coarse sediment, subtidal sand and subtidal mixed sediment habitats to temporary disturbance is expected in the short to medium term. In addition, the temporary and long term disturbance within the MCZ is also limited in scale, and therefore is unlikely to significantly impact the conservation objectives set for the protected habitat types or Ocean Quahog. The Abbey & Baker Development is not located in proximity to the North Sea glacial tunnel valley (Inner Silver Pit) protected by the MCZ (the feature lies approximately 30 km southeast of the proposed development), so is unlikely to have an effect on the feature or significantly impact the conservation objectives associated with this feature.

In summary, residual effects on water quality, seabed sediments, seabed communities and fish as a result of seabed disturbance during the life of the Abbey & Baker Development are predicted to be **Negligible** to **Minor** and not significant.

Effects of seabed disturbance resulting from the proposed Abbey & Baker Development will be cumulative to those of other activities in the area. The proposed Abbey & Baker development lies within an area of moderate oil and gas activity and may overlap with other projects both for oil and gas development and other industries. However, the Abbey & Baker development is estimated to have a relatively small temporary impact area (0.697 km^2), and a relatively small long term impact area (0.0399 km^2). This coupled with the mitigation measures that will be implemented, means that significant cumulative impacts with respect to seabed disturbance are therefore not predicted.

14.3 Underwater Noise Emissions

Underwater noise emissions generated during the proposed Abbey & Baker Development have the potential to disturb, or cause injury to, a number of species in the marine environment, particularly marine mammals. However, the only Abbey & Baker Development activity which results in underwater noise emissions with the potential to result in significant effects on marine fauna are the DP vessels used for drilling and subsea installation, together with noise from equipment operating on both the DP vessels and the MODU. All other potential noise sources have been scoped out as their underwater acoustic output is minimal and not considered relevant for further assessment.

Marine mammals will not be injured by the noise generated from the DP vessels, and vessel equipment but reported responses of behavioural disturbance include avoidance, changes in swimming speed, direction and surfacing patterns, alteration of the intensity and frequency of calls.

For marine mammals, it is acknowledged that the maximum anticipated underwater SELcum criteria from the DP vessels is below the thresholds for potential injury of marine mammals in terms of PTS to LF cetaceans, HF cetaceans and PCWs. However, the underwater noise generated by the DP vessels may exceed the PTS for VHF cetaceans (e.g. harbour porpoise). Based on a simple spherical spreading sound propagation model, this threshold is potentially exceeded approximately 3 m from the noise

source. However, it is extremely unlikely that marine mammals would venture this close to the vessel and therefore they are not expected to be injured by the proposed Abbey & Baker Development operations.

The proposed Abbey & Baker Development is located within the Southern North Sea SAC, which has conservation objectives to ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining FCS for harbour porpoise in UK waters. In view of the conservation objectives of the SAC, no LSEs on the SNS SAC are predicted as a result of the proposed drilling and subsea installation operations. In addition, the proposed Abbey & Baker Development will therefore not constitute an offence under The Conservation of Offshore Marine Habitats and Species Regulations 2017.

To reduce the risk of injury or behavioural disturbance to marine mammals and fish from the proposed operations, Petrogas will follow these measures: operational and maintenance procedures on vessels will aim to optimise the efficiency of equipment; and vessel use will be optimised where possible by minimising the number of vessels required and vessel movements.

In summary, it is possible that short term behavioural effects may be observed among marine mammals as a result of the underwater noise emissions generated from the proposed Abbey & Baker Development, but any impacts will be mitigated such that residual effects are predicted to be **Negligible** and not significant.

Given the mitigation measures which will be in place for the Abbey & Baker Development, significant cumulative effects are not predicted in the event that other noisy activities are occurring nearby in the marine environment at the same time as the proposed operations.

14.4 Greenhouse Gas Emissions

GHG emissions will be produced from the Abbey & Baker Development contributing to global GHG emissions in the atmosphere. The worst-case total gross GHG emissions generated over the life of the Abbey & Baker Development are estimated to be ca. 16,509.35 kt of CO_2e, based on the High (P10) production case. These emissions will be generated upstream from the combustion of hydrocarbons for power generation on the MODU, vessels, and helicopters during the development of the Abbey & Baker field, as well as flaring of hydrocarbons during the well flow test (pre-production). Upstream emissions will also be produced during Abbey & Baker's operational lifetime from the operation of the York platform, namely diesel combustion for power generation. Furthermore, during the production phase, indirect downstream (scope 3) emissions will be generated from processing, transportation and distribution of the Abbey & Baker hydrocarbons, as well as from the end use of the sold product. To ensure a worst-case scenario has been assessed, it is assumed that all Abbey & Baker hydrocarbons are eventually combusted, although in reality the actual end use and fate of the Abbey & Baker hydrocarbons may vary. Scope 3 end-use emissions represent by far the largest component of the total GHG emissions which will be generated by the Abbey & Baker Development over the life of the field (ca. 85%), although Petrogas as the developer does not have direct control over these emissions.

In a global context, GHG emissions generated from the Abbey & Baker Development represent a negligible share of median global GHG emissions projected under the IPCC's Shared Socio-economic Pathways, between ca. 0.00304% and 0.0066% of median global emissions in 2030, and between ca. 0.0007% to 0.0029% in 2040, depending on the pathway. Against a single year of global energy-related emissions (IEA, 2026), the development's lifetime downstream (Scope 3) emissions equate to ca. 0.19639% of the natural gas share and 0.00936% of the oil share.

From a cumulative perspective, it is acknowledged that Trout et al. (2022) have concluded that combustion of fossil fuel reserves within already operating or under-development infrastructure will generate approximately 936 Gt CO_2, which exceeds the remaining global carbon budget under a 1.5°C-compatible scenario (170 Gt CO2e; GCP, 2025), but remains within the global carbon budget for a 2.0°C scenario (1,055 GtCO2e; GCP, 2025). The combustion of hydrocarbons from the Abbey & Baker Development (i.e. the total Scope 3 end use emissions), would account for just 0.01089% of the remaining global carbon budget under a 2˚ C scenario.

The Global Oil and Gas Extraction Tracker (GOGET) (GEM, 2026) also provides comprehensive data on oil and gas projects worldwide, including production volumes and reserves from active extraction areas,

areas under development and oil and gas discoveries. Abbey & Baker's P10 field reserves (8,206 Mm^3 of gas and 2.14 MMbbl of condensate) add only a very small fraction towards the global reserves recorded within GOGET; increasing global gas reserves by 0.0058% and global condensate reserves by 0.0096%.

Given the above, it is clear that the Abbey & Baker Development on its own would not significantly affect a GHG emissions reduction trajectory towards achieving net zero by 2050, particularly as the Abbey & Baker Development is scheduled to cease production prior to 2050. However, regardless of whether the Project goes ahead, given the range of possible global emissions reduction pathways available, which are dependent on the scale of effort different countries make to reduce their national emissions, it is uncertain whether net zero on a global basis will be achieved by ca. 2050. However, the effect of the proposed Abbey & Baker Development on this uncertain baseline is not significant given the negligible proportional impact of the Project.

At a national level, the Abbey & Baker Development is aligned with UK oil and gas sector specific net zero policies and plans. To minimise the amount of GHG emissions generated, during drilling and installation operations, vessel days and fuel consumption will be reduced, as far as practicable. The well test and well clean-up activities will be designed not only to achieve their goals but to provide an optimal duration and reduce flaring to minimise the GHG emissions produced.

The GHG emissions generated from the Abbey & Baker Development represent a small proportion of GHG emissions typically arising from oil and gas developments in the UKCS and will contribute a small fraction of CO_2e emissions towards future UK carbon budget targets (ca. 0.45410% of carbon budget 5, 0.55689% of carbon budget 6 and 0.49301% of the proposed carbon budget 7) and the UK's NDC targets (ca. 0.82688% of the 2030 NDC allowance and ca. 0.66278% of the 2035 NDC allowance). As such, the GHG emissions generated by the Abbey & Baker Development would have no material influence on the UK's ability to meet its statutory carbon budget targets or NDC emissions reduction targets, resulting in a minor adverse magnitude of impact which is determined to be not significant.

All gas produced from the Abbey & Baker fields will flow into the NTS via the DGT and will be used domestically and not exported, thereby helping contribute to energy security during the UK's transition to net zero. Responsible stewardship of remaining offshore reserves ensures that the UK meets its energy demand while retaining control over GHG emissions.

14.5 Marine Discharges

No significant residual effects on water quality, plankton, fish or marine mammals are predicted as a result of routine marine discharges during the development of the Abbey & Baker development.

The main operational discharges into the marine environment from the proposed Abbey & Baker Development will occur as a result of the discharge of drill cuttings, muds and cement during drilling; the discharge of chemicals during drilling operations, hook-up and commissioning of subsea infrastructure, production, subsea maintenance activities and decommissioning operations; as well as the discharge of fluids contaminated with hydrocarbons following hydraulic stimulation, well testing and clean-up of the Abbey & Baker wells.

Upon release, these discharges will be subject to rapid dilution and dispersion and are not expected to persist within the marine environment. Additionally, a number of studies have shown that any impacts will be limited to the local area in the immediate vicinity of the discharge locations and therefore no significant adverse residual effects are predicted.

Petrogas will implement a range of measures to mitigate any potential impacts including undertaking a chemical risk assessment to identify the risk profile of chemicals being used and / or discharged in accordance with the requirements of the Offshore Chemicals Regulations 2002 (as amended). Where practicable, chemicals with a higher risk profile will be substituted out in favour of those with an improved environmental profile.

During the drilling operations, any discharges of residual reservoir hydrocarbons in the chemicals will be treated to meet oil in water limits of the relevant Oil Discharge Permit SAT. The discharge streams will also be monitored and sampled in accordance with the permit conditions.

Residual effects on water quality, plankton, fish or marine mammals from operational discharges into the marine environment from the proposed Abbey & Baker Development are therefore predicted to be **Minor** to **Negligible** are not significant.

Marine discharges from the proposed Abbey & Baker Development will occur within a region of established oil and gas activity, however, the closest neighbouring assets are located at sufficient distances such that cumulative effects on the wider marine environment are not anticipated.

14.6 Accidental Releases

All offshore activities associated with the Abbey & Baker Development will carry a potential risk of hydrocarbon pollution to sea; however, hydrocarbon spills from normal oil and gas operations are uncommon and can be effectively mitigated against. In planning its activities, Petrogas' primary focus is to ensure that all practicable measures are taken to prevent the occurrence of such accidental events and, should they occur, mitigate their effects. The consequences of an accidental release will vary depending on the quantity and type of hydrocarbon released, the wind speed and direction and sea state and the sensitivity of receptors depending on the time of year.

The worst-case spill scenario from the Abbey & Baker Development would be an uncontrolled and unmitigated subsea blowout scenario from the Baker well, releasing ca. 27,860.47 m^3 of condensate to the marine environment over 79 days (time taken to drill a relief well). Oil spill modelling has been conducted to determine the fate of Abbey & Baker hydrocarbons released from this worst case scenario. Given the lack of proximity to the UK/Netherlands median line, located approximately 152 km east of Abbey & Baker, there is a small probability for a surface slick of oil to cross the median line in all seasons (up to 17%). Other median lines which could be crossed include Germany (up to 5 %), Belgium (up to 2 %), Denmark (up to 2 %) and France (up to 1 %). The highest probability of shoreline oiling on the UK mainland is 58% in spring, with the shortest arrival time after 101 hours in summer. However, the Abbey & Baker condensate is an ITOPF Group 1 (57.5° API) oil that undergoes rapid evaporation, dispersion and biodegradation upon release, and concentrations decline quickly following cessation of the blowout, and if this event were to occur, the oil is not predicted to persist in the water column, at the sea surface, or on the shoreline.

The risk of an accidental release occurring from the Abbey & Baker Development will be minimised through the implementation of physical barriers such as downhole safety valves, maintenance to minimise leaks, and the development and implementation of handling and operational procedures and training. Measures to respond to a spill from the MODU or the Abbey & Baker subsea facilities once operational will be covered in approved oil pollution emergency plans, which will be prepared in advance of drilling operations commencing offshore. As such, the overall risk to the marine environmental from an accidental release of hydrocarbons from the Abbey & Baker development is considered to range from **Medium** to **Low**, depending on the receptor impacted, but in all cases the risk has been reduced to ALARP through mitigation measures and good industry practice and is therefore not considered to be significant.

Cumulative effects from accidental releases are not anticipated. As indicated by historical data, the likelihood of one major accidental release occurring is remote or extremely remote, limiting the cumulative impact from the Abbey & Baker Development and other existing installations.

14.7 Overall Conclusions

In summary, it is concluded that the proposed Abbey & Baker Development will not result in any significant environmental effects, including transboundary and cumulative effects.

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16 Glossary

Term	Description
Annex I habitat	A habitat type listed under the EU Habitats Directive whose conservation requires the designation of Special Areas of Conservation offshore under The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended).
Annex II species	Animal or plant species of community interest whose conservation requires the designation of Special Areas of Conservation offshore under The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended).
Atmospheric Emissions	A collective term for gases and particulates released to the atmosphere.
Automatic Identification System	A marine navigation safety system that uses transponders on ships and shore-based stations to automatically transmit and receive real-time data about a vessel's identity, position, course, and speed to aid collision avoidance and vessel tracking.
Barrel of Oil Equivalent	A standardised unit of energy measurement used in the oil and gas industry. It equates different types of energy product, i.e. oil, gas, etc into a single comparable unit.
Bioaccumulation	The process where a substance, such as a pesticide or heavy metal, builds up in the tissues of an individual organism over its lifetime because the rate of intake and storage (from the environment, food, and water) is faster than the rate at which the organism can break it down and excrete it.
Blowout	A blowout occurs when gas/ oil escapes in an uncontrolled manner from a well.
Blowout Preventer (BOP)	A high-pressure safety valve or series of valves installed at the wellhead that is designed to seal the wellbore to prevent uncontrolled flow of oil, gas (blowout), or drilling fluid from the well
Carbon Budget	Legally binding milestone of anthropogenic CO_2 emissions proposed every 5 years to achieve Net Zero targets.
Casing	Steel pipe cemented in place during the construction process to stabilise the wellbore.
Carbon Dioxide Equivalent	A metric used to compare the climate impact of different greenhouse gases by converting the amount of each gas into the amount of carbon dioxide that would have the equivalent global warming potential.
Conductor	The casing string that is usually put into the well first to prevent the sides of the hole from caving into the wellbore.
Cease of Production	The point at which an oil or gas well, field, or facility stops producing hydrocarbons, either temporarily or permanently.
Cumulative Weighted Sound Exposure Level	An advanced measure of the total received acoustic energy over a specified period where the sound levels are weighted according to the hearing sensitivity of the specific marine species being studied.
Cuttings	Rock chips produced by chipping and crushing action of the drill bit.
Decibel	Denoted by dB, a logarithmic unit used to express the ratio of two values of a physical quantity used to measure the intensity of sound.
Decibels relative to one micro-Pascal	Denoted by dB re 1µPa @ 1 m, a specialized unit of measurement for underwater acoustics that defines the sound pressure level by comparing the measured acoustic pressure to a standard reference pressure of one micropascal.
Degrees Latitude	The angular distance, measured in degrees North or South of the Equator, used as the primary geographical coordinate to specify the north-south position of a point on the Earth's surface
Degrees Longitude	The angular distance, measured in degrees East or West of the Prime Meridian (Greenwich, UK), used as the primary geographical coordinate to specify the east-west position of a point on the Earth's surface.

Term	Description
Demersal	Organisms (primarily fish like cod or haddock) that live on or near the seabed (the benthic zone) and often feed on benthic invertebrates, contrasting with organisms that live entirely in the open water.
Drill Bit	The cutting tool at the very end of the drill string that rotates to grind, shear, or crush rock, creating the wellbore.
Dynamic Positioning	A computer-controlled system that automatically maintains a vessel's heading and position solely by using its own thrusters and propellers, without the need for anchors.
Effects Range Low	A sediment quality guideline concentration that represents the level below which adverse biological effects are rarely observed.
Effects Range Median	A sediment quality guideline concentration that represents the median level in which adverse biological effects have been observed.
Emissions Reduction Action Plan	A company's specific strategies, targets, and scheduled activities designed to measure, manage, and significantly reduce greenhouse gas emissions and other atmospheric pollutants across its operations.
Environmental Aspect	An element of an organization's activities, products, or services that can interact with the environment.
Environmental Baseline Survey	A systematic collection and analysis of physical, chemical, and biological data in a specific area to establish the existing environmental conditions.
Environmental Effect	Consequences of environmental impacts upon receptors.
Environmental Impact	Changes to the environment as result of environmental aspects.
Environmental Impact Assessment	A systematic process of evaluating the likely environmental consequences of a proposed project or development, aiming to ensure that environmental considerations are integrated into decision-making.
Environmental Impact Identification (ENVID)	A structured, systematic review process used to identify potential environmental hazards, impacts, and risks associated with all phases of a development project or activity.
Environmental Statement	The report on the environmental impact assessment for proposed project or development.
Epifauna	Benthic organisms that live on the surface of the seabed, either sessile or free moving.
European Protected Species	Animal and plant species listed in the Habitats Directive of the European Union, afforded strict legal protection against deliberate capture, injury, killing, or disturbance, and the damage or destruction of their breeding and resting sites
Far-field	The region of a propagating wave distant enough from the source that the waves behave as planar, and the intensity falls off predictably (e.g., inversely with the square of the distance from the source).
Favourable Reference Population	The ideal minimum population size for a species within a given region that is needed to ensure its long-term survival and healthy status, as defined for conservation under the EU Habitats Directive.
Field	An accumulation of hydrocarbons in the subsurface. Consists of a reservoir in a shape that will trap hydrocarbons and that is covered by an impermeable, sealing rock.
Finch Judgment, 2024	UK's Supreme Court ruling in 2024 that a decision to grant planning permission for an onshore oil development project at a site in Surrey was unlawful, because downstream GHG emissions from the combustion of the oil produced were not assessed in the EIA as part of the planning decision.
Flare	A controlled vent system to safely and quickly burn off unwanted or excess combustible gases to the atmosphere.
Global Warming Potential	An index that measures how much a specific mass of a greenhouse gas will warm the Earth over a defined time period (usually 100 years) relative to the

Term	Description
	warming caused by the same mass of carbon dioxide, which is set as the baseline with a GWP of 1.
Greenhouse Gas	Any gaseous compound in the atmosphere, such as carbon dioxide, methane, or nitrous oxide, that is capable of absorbing and re-emitting infrared radiation, thereby trapping heat and contributing to the warming of the Earth's surface known as the 'Greenhouse Effect'
Habitat Assessment	A survey and evaluation process used to determine the type, quality, condition, and distribution of habitats present in a specific area.
Harmonised Mandatory Control Scheme	A regulatory framework established by the OSPAR Commission to protect the marine environment requiring all chemicals used and discharged during offshore oil and gas operations to be tested, risk-assessed, and authorised.
High Frequency	A wave or periodic event that repeats a large number of times within a specific period.
Hydraulic Stimulation / Fracturing (Fracking)	The underground petroleum extraction process that involves the injection of fluids under high pressure into low permeability rock to induce fractures in order to increase hydrocarbon flow rates.
International Council for the Exploration of the Seas (ICES) Rectangle	A standard geographical unit defined by the International Council for the Exploration of the Sea used primarily for the reporting and management of fisheries, environmental monitoring, and research within the North Atlantic and adjacent seas, with each rectangle typically measuring 1˚of longitude by 0.5˚of latitude.
Intergovernmental Panel on Climate Change (IPCC)	The United Nations body that regularly assesses the scientific basis of climate change, its impacts, future risks, and options for adaptation and mitigation, providing policymakers with comprehensive and authoritative scientific reports.
IPCC Assessment Report	A comprehensive scientific evaluation of the state of knowledge on climate change, its physical science basis, impacts, adaptation, vulnerability, and options for mitigation, published every five to seven years by the IPCC.
International Union for the Conservation of Nature	A global authority and membership union composed of both governmental and civil society organisations dedicated to addressing the world's most pressing environment and development challenges.
Joint Nature Conservation Committee	UK public body that advises the UK Government and the devolved administrations on UK-wide and international nature conservation, providing scientific evidence and data on biodiversity status and trends.
Liquified Natural Gas	Natural gas that has been cooled to minus 162°c, turning it into a liquid for easier, safer, and more economical storage and transportation.
Low Frequency	A wave or periodic event that repeats a low number of times within a specific period.
Lowest Astronomical Tide	The lowest predictable water level that can occur under any combination of astronomical conditions (Sun, Moon, and Earth alignment), excluding extreme meteorological effects like storms.
Low Toxicity Oil Based Mud	An invert emulsion mud with synthetic oil as the external phase instead of oil
Marine Conservation Zone	A type of Marine Protected Area in English waters designated under the Marine and Coastal Access Act (2009) to protect nationally important species, habitats, ecological processes and features of geological/geomorphological importance.
Marine Mammal Management Units	Specific geographical areas defined by UK conservation bodies to represent distinct population segments of highly mobile marine mammals (i.e. dolphins, seals and porpoises).
Marine Protected Area	A clearly defined geographical zone in the sea that receives long-term protection of its marine life, habitats, and cultural heritage.
Measured Depth	Depth of the well as measured from the rotary table on the drilling rig, therefore includes the distance between the drilling rig and the seabed.

Term	Description
Mobile Offshore Drilling Unit	Any vessel or structure, such as a jack-up rig or semi-submersible, capable of engaging in drilling operations for exploring or developing offshore oil and gas reserves.
Multibeam Echosounder	An advanced sonar system that transmits multiple beams of sound waves in a fan shape perpendicular to the vessel's movement, allowing it to measure and map a wide area of the seafloor simultaneously to create high-resolution, 3D bathymetric maps.
National Transmission System	The high-pressure gas pipeline network that transmits natural gas throughout Great Britain, connecting terminals and storage facilities to the regional distribution networks.
Nationally Determined Contribution	A country's self-defined national climate action plan under the Paris Agreement, outlining its specific commitments and policies to reduce greenhouse gas emissions.
Natural Gas	A naturally occurring mixture of gaseous hydrocarbons, primarily methane, often found in underground reservoirs and used as a major source of energy
Nature Conservation Marine Protected Area	A type of Marine Protected Area in Scottish waters designated under the Marine (Scotland) Act 2010 to protect nationally important marine flora, fauna, habitats, and geological or geomorphological features.
Nautical Mile	A unit used for measuring distances at sea.
Net Zero	A state where the amount of greenhouse gases emitted is balanced by the amount removed from the atmosphere.
North Sea Transition Authority	Previously known as the Oil and Gas Authority (OGA) until March 2022, it is the UK government body responsible for regulating and enabling the effective and responsible development of oil, gas, and carbon storage within the UK Continental Shelf, while driving the transition to net zero.
Octanol-water partition coefficient	A ratio used to describe how a chemical distributes itself between two immiscible phases, providing a critical indicator of a chemical's potential to bioaccumulate in organisms.
Offshore Petroleum Regulator for Environment and Decommissioning	UK Government regulator responsible for regulating the environmental and decommissioning aspects of offshore oil and gas operations and carbon capture and storage in the UK.
OSPAR Commission	An intergovernmental body formed by 15 Governments and the European Union to implement the OSPAR Convention and cooperate on measures to protect the marine environment of the North-East Atlantic Ocean
Paris Agreement	Adopted at COP21 in 2015 and requires all major greenhouse gas emitting countries to reduce their emissions. The aim of the Paris Agreement is to restrict global temperature change to well under 2°C above pre-industrial levels and pursue efforts to keep it below 1.5°C.
Particle Size Analysis	A laboratory technique used to determine the distribution of different sized grains within a sample of sediment, which is crucial for understanding the material's properties.
Particle Size Distribution	A fundamental characteristic of any material composed of particles, such as powders, granules, or particles dispersed. It is a statistical description that defines the relative amount of particles present according to their size.
Pelagic	The zone of the water column in a sea or ocean that is neither near the shore nor close to the seabed.
Permanent Threshold Shift	An irreversible, long-term or permanent reduction in hearing sensitivity caused by exposure to sufficiently loud noise
Pipeline Integrity Gauge (PIG)	A tool sent through a pipeline to perform various tasks such as cleaning, inspecting, ensuring the line's structural integrity and operational efficiency.

Term	Description
Plankton	Any aquatic organisms, including tiny plants, animals, and bacteria, that drift in the water column and cannot swim strongly enough to counteract currents, forming the base of most marine and freshwater food webs.
Polycyclic Aromatic Hydrocarbons	A group of organic chemical compounds that are naturally present in fossil fuels, a leading indicator to monitor environmental pollutants of this nature.
Production Manifold	A system of pipes and valves used to control the flow of produced fluids from all wells on location to a common gathering point or processing facility.
Representative Concentration Pathway	A greenhouse gas concentration trajectory adopted by the IPCC for climate modelling, representing a possible future level of carbon dioxide emissions and resulting climate change.
Reservoir	The underground formation where oil and gas has accumulated. It consists of a porous rock to hold the oil or gas, and a cap rock that prevents its escape.
Scope 1 Emissions	Greenhouse gas emissions categorised as Scope 1 emissions are those that a company makes directly.
Scope 2 Emissions	Greenhouse gas emissions categorised as Scope 2 emissions are those that a company makes indirectly such as the purchase of energy for heating buildings
Scope 3 Emissions	Greenhouse gas emissions which include all other indirect emissions that occur in the upstream and downstream activities of an organisation
Shellfish	Any aquatic invertebrate with a shell or shell-like exoskeleton.
Sidescan Sonar	An acoustic device towed behind a vessel that transmits sound pulses to the seafloor on both sides, creating a photographic-like, high-resolution image of the seabed surface that highlights variations in texture and features
Similarity Profile Analysis (SIMPROF)	A statistical permutation test used in ecology to objectively determine if a set of samples, which are not grouped beforehand, contain any genuine structure or statistically distinct groups.
Sound Exposure Level	A cumulative measure of the total acoustic energy of a sound event over a given time period.
Special Area of Conservation	Protected areas for important marine habitats and species designated under The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) in the UK offshore area. Special Areas of Conservation, together with Special Protected Areas, form the UK's national site network.
Special Protected Area	Protected areas for wild birds designed under The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) in the UK offshore area. Special Protected Areas, together with Special Areas of Conservation, form the UK's national site network.
Spool	Short segment of rigid pipe with a flange or other connecting fitting at either end and is commonly used to connect flowlines and / or subsea facilities together, e.g. a subsea tree to a subsea manifold.
Subsea Isolation Valve (SSIV)	A safety device used in subsea oil and gas production systems, designed to isolate and shut off the flow of oil and gas in the event of an emergency or unplanned shutdown.
Statutory Nature Conservation Bodies	Public sector organizations in the UK and its devolved nations that advise the government and enforce laws concerning nature and wildlife protection.
Sub-bottom Profiler	A geophysical sonar system used to map and image the geological structure of the material below the seafloor, providing detailed cross-sectional views of the shallow layers of sediment and rock.
Tie-in	A tie-in is the process of connecting a new pipeline, facility, or equipment to an existing oil and gas system.
Tie-back	A tie-back is the connection of a new well or subsea facility to an existing production system or infrastructure.
Total Hydrocarbon Concentration	The sum measurement of all individual hydrocarbon compounds present in a sample.

Term	Description
Total Organic Carbon	The amount of carbon found in an organic compound within a sample (e.g., soil or water.
Total Organic Matter	A measurement of the organic material in a soil or sediment sample, typically derived using a loss on ignition technique.
Total Suspended Solids	A measurement of the dry weight of solid particles (i.e. sediment, organic matter) that remain suspended in a water sample.
Transboundary Impacts	Potential environmental impacts on the seabed, water column and/or atmosphere, which extend beyond the boundaries of the United Kingdom Continental Shelf.
Transboundary line	The officially established line separating the Exclusive Economic Zones or Continental Shelves of two adjacent or opposing countries in a shared sea area, such as the North Sea.
True Vertical Depth Sub Sea	The vertical distance measured from a fixed reference point down to a specific point within the wellbore.
Umbilical	Connections used between the subsea equipment and/or surface installation enabling the provision of control, power, communications and chemical services.
United Kingdom Continental Shelf	The area of the continental shelf over which the United Kingdom exercises sovereign rights for the purpose of exploring it and exploiting its natural resources, primarily oil and gas.
United Kingdom Continental Shelf Block	Sub-division of territorial seas for the purpose of licensing to a company or group of companies for exploration and production rights. Each block has a standard size of 10 minutes of Latitude by 12 minutes of Longitude, ~200 – 250 km^2.
Venting	The discharge of un-burnt, unwanted gases or hydrocarbons.
Volatile Organic Compounds	A large group of carbon-containing chemicals that easily become vapours or gases at room temperature that largely contribute to air pollution, smog formation, and have adverse effects on human health.
Water Based Mud	A drilling fluid that uses water as the continuous phase, mixed with various clays, polymers, and chemical additives to control well pressure, cool and lubricate the drill bit, and carry rock cuttings to the surface
Wellbore	The drilled hole that extends from the surface or seabed into the earth, used to access and produce hydrocarbons from a subsurface reservoir.
Wellhead	The unit at the surface of a well which controls pressure and connects to drilling and production equipment. The wellhead is the upper part of the well, located above the casing and under the drilling floor.
Wellhead Protection Structure (WHPS)	A steel frame or structure installed over a subsea or surface wellhead to protect it from external damage, such as impact from fishing gear, dropped objects, or vessel interference.
Xmas Tree	A complex arrangement of valves, spools, and fittings installed at the wellhead of an oil or gas well to control the flow of fluids from the wellbore, manage pressure, and allow access for monitoring and intervention
Zooplankton	The animal components of the plankton community, consisting mostly of tiny crustaceans, protozoans, and the eggs and larvae of larger animals, which feed on phytoplankton and are themselves prey for fish and larger animals

Appendix A: Legislation and Marine Policy

A.1 Applicable Environmental Legislation

Table A.1 identifies some of the key environmental legislation pertinent to the proposed Abbey & Baker field development operations.

Table A.1. Key Legislation Pertinent to the Proposed Abbey & Baker Field Development

Legislation	Summary of Requirements	Relevance to Abbey & Baker Development
The Petroleum Act 1998	The Petroleum Act 1998 vests all rights to the UK's petroleum resources in the Crown and provides the NSTA with the power to grant licences that confer exclusive rights to 'search and bore for and get' petroleum. The Act provides the legislative basis for the OGA Strategy (OGA, 2020) and the requirement for the NSTA and industry to act in accordance with the Strategy, which sets out how, in practice, the principal objective should be achieved by the NSTA and industry. It is supplemented by the Energy Act 2016, the Infrastructure Act 2015 and various environmental and health and safety legislative provisions.	The proposed Abbey & Baker Development concept has been selected and defined with consideration to the central obligation of the OGA Strategy (refer to Section 2). All consents and permits relevant to the proposed Abbey & Baker field development will be in place prior to the commencement of operations.
Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 and associated guidance July 2021	There is a mandatory requirement for an EIA and the application for consent must be supported by an ES where the Development falls within the scope of a Schedule 1 project, namely where the extraction of oil and natural gas for commercial purposes exceeds 500 tonnes per day in the case of oil and 500,000 cubic metres per day in the case of natural gas and/or where the project involves a pipeline with a diameter of more than 800 mm and a length of more than 40 km.	The Abbey & Baker production rates exceed the 500,000 cubic metres per day in the case of natural gas threshold therefore falls within the scope of a Schedule 1 project and triggers the requirement for an Environmental Statement.

Legislation	Summary of Requirements	Relevance to Abbey & Baker Development
The Offshore Chemicals Regulations 2002 (as amended)	These regulations implement OSPAR Decision 2000/2 and a number of subsidiary OSPAR Recommendations and Agreements relating to the adoption of a harmonised mandatory control system for the use and discharge of offshore chemicals. All activities that involve the use and/or discharge of chemicals during the course of offshore operations require a Chemical Permit issued under the regulations	Applications for the required Chemical Permits will be made via the DESNZ UK Energy Portal in advance of the proposed Abbey & Baker Development drilling operations, pipeline operations, well intervention (if applicable) and plug and abandonment activities commencing.
The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended)	Prohibits the discharge of oil to sea other than in accordance with the terms and conditions of a permit. Operators of offshore installations must identify all planned oil discharges to relevant waters and apply for the appropriate permits. Oil Discharge Permits will not be required for those chemicals already covered by the Offshore Chemicals Regulations (2002) as amended (i.e. base oils, lubricants etc.). The 2011 amendment redefined the term 'offshore installation' to encompass all pipelines and the term 'release' to cover all unintentional oil emissions. Intentional emissions are referred to as 'discharges'.	Produced water from the Abbey & Baker Development shall be treated by the existing DGT produced water system where it will be discharged in accordance with the DGT Oil Discharge Permit.
The Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation) Regulations 1998 (as amended)	These Regulations require that every offshore installation and oil-handling facility must have an approved oil pollution emergency plan (OPEP) in place, setting out arrangements for responding to incidents that cause or may cause a hydrocarbon pollution incident at sea. The OPEP must detail methods to prevent such pollution or reducing or minimising its effect. The 2015 Amendment Regulations implement the EU Offshore Safety Directive (2013/30/EU).	Approved OPEPs will be in place for all lifecycle phases of the Abbey & Baker Development in advance of operations commencing offshore.
The Climate Change Act 2008 (as amended)	The Climate Change Act (2008) establishes a legally binding target for the UK to reduce greenhouse gas (GHG) emissions by at least 80% by 2050 from 1990 levels. In 2019 this target was revised with the UK planning to reduce all GHG emissions to net zero by 2050. The Act also provides a system of carbon budgeting, to help the UK meet its targets through a series of five-year carbon budgets.	The potentially significant effects on climate from GHG emissions generated by the proposed Abbey & Baker Development are assessed in Section 9. The GHG emissions have been evaluated in the context of a global baseline scenario of GHGs, with consideration given to the impact the emissions will have on global climate change agreements, UK carbon policies and targets and associated

Legislation	Summary of Requirements	Relevance to Abbey & Baker Development
		emissions reduction pathways. The assessment has been undertaken with reference to the new DESNZ supplementary guidance for assessing the effects of downstream Scope 3 emissions on climate from offshore oil and gas projects (DESNZ, 2025), published following the Finch judgment, 2024 and the Jackdaw / Rosebank judgment, 2025.
The Offshore Petroleum Licensing (Offshore Safety Directive) Regulations 2015	These Regulations introduce the specific licensing requirements of the EU Offshore Safety Directive. The Regulations stipulate that the licensee cannot appoint an installation or well operator without giving written notice to the licensing authority and place a duty on the licensee to ensure that there are adequate provisions to cover any liabilities that may arise from the offshore operations.	PNS will be the appointed Well and Pipeline Operator for the Abbey & Baker Development, subject to approval by the NSTA.
The Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015	These Regulations aim to reduce the risks from major accident hazards to the health and safety of the workforce employed on offshore installations or in connected activities. The Regulations also aim to increase the protection of the marine environment and coastal economies against pollution and ensure improved response mechanisms in the event of such an incident	The risk of a major environmental incident occurring from the Abbey & Baker Development has been identified and its environmental consequence assessed in Section 11.
OSPAR Recommendation 2003/5 to Promote the Use and Implementation of Environmental Management Systems by the Offshore Industry	In line with the convention and reporting requirements, all operators controlling the operation of offshore installations on the UKCS should have in place an independently verified environmental management system (EMS) designed to: • Achieve the general objectives of the OSPAR Offshore Strategy; • Achieve the environmental goals of the prevention and elimination of pollution from offshore sources and of the protection and conservation of the maritime area against other adverse effects of offshore activities, and Maintain continual improvement in environmental performance.	The Abbey & Baker fields will be developed in accordance with PNS's EMS, which was successfully verified against the requirements of OSPAR 2003/5 in June 2024 (refer to Section 13).
OSPAR Decision 98/3 on the disposal of Disused Offshore Installations	This decision prohibits the dumping and leaving wholly or partially in place of disused offshore installations with some exceptions for large structures (derogation cases).	On cessation of production, the Abbey & Baker fields will be decommissioned in accordance with

Legislation	Summary of Requirements	Relevance to Abbey & Baker Development
		the requirements of the prevailing UK and international law (refer to Section 3.7).
The Energy Act 2008	Part 4A of the Energy Act 2008 administers control for Section 34 of the Coastal Protection Act which requires a permit for the placement of surface and some subsurface structures deemed to pose a navigation risk. It allows OPRED to insist upon the provision of navigational markings that are considered appropriate for the proposed offshore structure or operations.	Applications for Consent to Locate permits will be made via the DESNZ UK Energy Portal in advance of the proposed Abbey & Baker drilling operations commencing and installation of the Abbey & Baker subsea infrastructure and pipelines.
The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)	The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships. It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments through the years. The Convention is made up of six annexes: • Annex I – sets out regulations regarding the discharge of oil into the sea and requires ships to have efficient oil separation and removal equipment onboard (transposed into UK legislation through the Merchant Shipping (Prevention of Oil Pollution) Regulations 2019 (as amended) and Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulation 2005 as amended; • Annex II – addresses the prevention of pollution by noxious liquid substances carried in bulk on ships (transposed into UK legislation through The Merchant Shipping (Dangerous or Noxious Liquid Substances in Bulk) Regulations 2018); • Annex III – addresses the prevention of pollution by harmful substances carried in packaged form (transposed into UK legislation through Merchant Shipping (Carriage of Dangerous Goods and Harmful Substances) Regulations 2024); • Annex IV – concerned with the prevention of pollution by sewage from ships (transposed into UK legislation through The Merchant Shipping (Prevention of Pollution by Sewage from Ships) Regulations 2020) (as amended); • Annex V – concerned with the prevention of pollution by garbage from ships (transposed into UK legislation through The Merchant Shipping (Prevention of Pollution by Garbage from Ships) Regulations 2020) (as amended);	The MODU and all other contracted vessels will meet MARPOL requirements throughout all stages of the Project. Further information on PNS's Waste Management strategy for the Abbey & Baker Development is provided in Section 12.

Legislation	Summary of Requirements	Relevance to Abbey & Baker Development
	• Annex VI – covers prevention of air pollution from ships setting limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibiting deliberate emissions of ozone depleting substances (transposed into UK legislation by The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008 (as amended)).	
Marine and Coastal Access Act 2009 (as amended)	This Act covers inshore and offshore waters and provides a framework to help balance the competing demands on UK Territorial Waters. It introduced a number of measures to deliver its vision of 'clean, healthy, safe, productive, and biologically diverse oceans and seas'. This included the introduction of a new marine planning system with the Marine Management Organisation (MMO) being delegated a number of marine planning functions, although the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) manage a number of licencing functions pertaining to offshore energy activities rather than the MMO. In line with the MCAA, a number of marine plans have been developed for inshore and offshore waters around the UK. Marine plans, together with the overarching Marine Policy Statement (MPS), underpin the planning system for inshore and offshore activities and contribute to the achievement of sustainable development in the UK marine area.	The proposed Abbey & Baker Development, as described in this ES, has been assessed against all relevant East Offshore Marine Plan objectives and policies to confirm that the Project will not adversely impact them (refer to Section A.2 below).
The Conservation of Offshore Marine Habitats and Species Regulations 2017	These Regulations implement the species protection requirements of the Habitats and Birds Directives offshore (12-200 nautical miles from the coast). The Regulations also include provisions for the designation and protection of areas that	This ES has concluded that the Abbey & Baker Development activities will not injure an EPS or deliberately disturb EPS in such a way as to be likely

Legislation	Summary of Requirements	Relevance to Abbey & Baker Development
	host important habitats and species in the offshore marine area (i.e. SACs and SPAs). Part 5 provides powers to OPRED to issue licences for specific activities that could result in the injury or disturbance of European Protected Species (EPS injury or disturbance licences) and the potential to issue wild birds licences (providing certain licensing tests are met).	to impair their ability to survive, breed, or rear or nurture their young, or significantly affect the local distribution or abundance of EPS.
The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended)	These Regulations require consent for geological surveys related to oil and gas activities. In addition, under these Regulations. It is the responsibility of the Competent Authority (OPRED) to make an appropriate assessment of the implications of any activity that might be undertaken pursuant to a UKCS licence, consent, authorisation, or approval, on a relevant site's conservation objectives, where this is likely to have a significant effect on a relevant site, alone or in combination with any other plan or project. A relevant site is any Special Area of Conservation (SAC) or Special Protection Area (SPA).	An application for a Marine Survey Consent will be made via the DESNZ UK Energy Portal in advance of future survey operations commencing.

A.2 East Offshore Marine Plan

Through the Marine and Coastal Access Act (MCAA) 2009, the UK Government introduced several measures to deliver its vision of 'clean, healthy, safe, productive, and biologically diverse oceans and seas'. This included the introduction of a marine planning system with the Marine Management Organisation (MMO) being delegated a number of marine planning functions, although the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) manage a number of licensing functions pertaining to offshore energy activities relating to oil and gas exploration and production, gas unloading and storage, and carbon dioxide storage rather than the MMO.

In line with the MCAA, a number of marine plans have been developed for inshore and offshore waters around the UK. Marine plans, together with the overarching Marine Policy Statement, underpin the new planning system for inshore and offshore activities. The proposed Abbey & Baker field development is located within the East Offshore Marine Plan area. The key policies contained within the Plan that are relevant to the proposed Abbey & Baker field development and how these have been incorporated into the proposed operations are provided in Table A.2 below (MMO, 2014).

Table A.2. General Policies Contained within the East Offshore Marine Plan that are of Relevance to the Proposed Abbey & Baker Field Development

Relevant Objectives	Associated Policies	Addressed by the Abbey & Baker Development Project
Economic Productivity - To promote the sustainable development of economically productive activities, taking account of spatial requirements of other activities of importance to the East marine plan areas.	**EC1** - Proposals that provide economic productivity benefits which are additional to Gross Value Added currently generated by existing activities should be supported.	It is widely acknowledged that on the pathway to Net Zero emissions, oil and gas will continue to play an important part of the energy mix for the foreseeable future. Moreover, according to the Climate Change Committee (CCC), the UK will require 13–15 billion barrels of oil and gas equivalent in the period 2025 to 2050 but is currently only forecast to produce 4 billion (CCC, 2025; NSTA, 2025a). In a time of historically low domestic energy production with more than 40% of the UK's energy now imported, responsible development of UKCS oil and gas fields ensures that the UK meets its energy demand while retaining control over emissions. The selected Development concept for Abbey & Baker makes maximum use of existing oil and gas infrastructure. While residual operational emissions are unavoidable, the Development represents one of the lowest carbon intensity means of recovering remaining hydrocarbons in the Abbey & Baker fields. Opportunities for further emissions reductions, including electrification of offshore assets and low-carbon logistics, will be assessed as part of ongoing asset stewardship and future investment planning. In addition, the Project aligns with the UK Government's strategy to maintain domestic production to preserve critical infrastructure, skills, and supply chain capacity for the energy transition.
Employment and Skill Levels - To support activities that create employment at all skill levels, taking	**EC2** - Proposals that provide additional employment benefits should be supported, particularly where these benefits have the potential to meet employment needs in localities close to the marine plan areas.	The Abbey & Baker field development will utilise local contractors in the area, where possible, and a support base close to the proposed operations.

Relevant Objectives	Associated Policies	Addressed by the Abbey & Baker Development Project
account of the spatial and other requirements of activities in the East marine plan areas.		
Heritage Assets - To conserve heritage assets, nationally protected landscapes and ensure that decisions consider the seascape of the local area.	**SOC2** - Proposals that may affect heritage assets should demonstrate, in order of preference: a) that they will not compromise or harm elements which contribute to the significance of the heritage asset; b) how, if there is compromise or harm to a heritage asset, this will be minimised; c) how, where compromise or harm to a heritage asset cannot be minimised it will be mitigated against, or; d) the public benefits for proceeding with the proposal if it is not possible to minimise or mitigate compromise or harm to the heritage asset. **SOC3** - Proposals that may affect the terrestrial and marine character of an area should demonstrate, in order of preference: a) that they will not adversely impact the terrestrial and marine character of an area; b) how, if there are adverse impacts on the terrestrial and marine character of an area, they will minimise them;	There are no wrecks designated as historic Marine Protected Areas (hMPAs), scheduled monuments (including wrecks) or war graves within the vicinity of the proposed Abbey & Baker Development area (NMPi, 2026), however there are three non-dangerous wrecks located approximately 1 km from the proposed Abbey & Baker Development area (UKHO, 2025). No wrecks were observed during the 2024 survey operations (refer to Section 4.4.8).

Relevant Objectives	Associated Policies	Addressed by the Abbey & Baker Development Project
	c) how, where these adverse impacts on the terrestrial and marine character of an area cannot be minimised they will be mitigated against; d) the case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts.	
Healthy Ecosystem - To have a healthy, resilient and adaptable marine ecosystem in the East marine plan areas.	**ECO1** - Cumulative impacts affecting the ecosystem of the East marine plans and adjacent areas (marine, terrestrial) should be addressed in decision-making and plan implementation.	Cumulative impacts have been considered during the EIA process and are assessed in the Sections 6 to 11 of this ES. No significant cumulative impacts are predicted provided that all identified mitigation measures are implemented.
	ECO2 - The risk of release of hazardous substances as a secondary effect due to any increased collision risk should be taken account of in proposals that require an authorisation.	The risk of collision will be mitigated as detailed in the impacts sections of the ES (Sections 6 – 11). In the unlikely event of an accidental release of diesel, the impact would be minor as diesel is a light oil; once spilt it is likely to remain on the sea surface and be subject to high rates of evaporation as it has a large percentage of light and volatile compounds (ITOPF, 2011).
Biodiversity - To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East marine plan areas.	**BIO1** - Appropriate weight should be attached to biodiversity, reflecting the need to protect biodiversity as a whole, taking account of the best available evidence including on habitats and species that are protected or of conservation concern in the East marine plans and adjacent areas (marine, terrestrial).	The environmental baseline and potential presence of protected species or habitats, including BAPs has been fully characterised in Section 4 of the ES. The ES has concluded that the Abbey & Baker Development will not result in any significant environmental effects to the marine environment provided that all identified mitigation measures are implemented (refer to assessment detailed in Sections 6 – 11).
Climate Change - To facilitate action on climate change adaptation and mitigation in the East marine plan	**CC1 -** Proposals should take account of: • how they may be impacted upon by, and respond to, climate change over their lifetime and;	The potentially significant effects on climate from GHG emissions generated by the proposed Abbey & Baker Development are assessed in Section 9. The GHG emissions have been evaluated in the context of a global baseline scenario of GHGs, with consideration given to the impact the emissions will have on global climate change agreements, UK carbon policies and targets and associated emissions reduction pathways. The assessment has been undertaken with reference to the new DESNZ supplementary guidance for assessing the effects of downstream

Relevant Objectives	Associated Policies	Addressed by the Abbey & Baker Development Project
areas.	• how they may impact upon any climate change adaptation measures elsewhere during their lifetime Where detrimental impacts on climate change adaptation measures are identified, evidence should be provided as to how the proposal will reduce such impacts.	scope 3 emissions on climate from offshore oil and gas projects (DESNZ, 2025), published following the Finch judgment, 2024.
	CC2 - Proposals for development should minimise emissions of greenhouse gases as far as is appropriate. Mitigation measures will also be encouraged where emissions remain following minimising steps. Consideration should also be given to emissions from other activities or users affected by the proposal.	
Marine Protected Areas (MPAs) - To support the objectives of MPAs (and other designated sites around the coast that overlap or are adjacent to the East marine plan areas), individually and as part of an ecologically coherent network.	**MPA1** - Any impacts on the overall MPA network must be taken account of in strategic level measures and assessments, with due regard given to any current agreed advice on an ecologically coherent network	The environmental baseline and potential presence of protected species or habitats have been fully characterised in Section 4 of the ES. The ES has concluded that the Abbey& Baker Development will not result in any significant environmental effects to the marine environment provided that all identified mitigation measures are implemented (refer to assessment detailed in Sections 6 – 11).

Relevant Objectives	Associated Policies	Addressed by the Abbey & Baker Development Project
Governance - To ensure integration with other plans, and in the regulation and management of key activities and issues, in the East marine plans, and adjacent areas.	**GOV2** - Opportunities for co-existence should be maximised wherever possible.	Currently, there are no planned, consented or operational offshore wind farms or carbon capture and storage sites that would be adversely impacted by the Abbey & Baker Development. In addition, there are no commercial or capital dredging activities undertaken in the area or any sites licenced for disposal of dredged material. Shipping activity in the waters SNS is relatively high, however there is ample sea room for shipping to re-route or avoid the Abbey & Baker Development location (refer to Section 4.4). One active pipeline cross with the proposed route of the Abbey to Baker pipeline and umbilical, the active Cleeton CP to Dimlington gas pipeline (PL447) operated by Perenco. Crossing designs are not yet matured, but are likely to entail rock placement, as described in Section 3.4.3. PNS has undertaken a scoping exercise with key stakeholders to ensure that the expectations of concerned parties have been incorporated into the Project at an early stage. The feedback received and how this has been considered by the Project is detailed in Section 1.7 of this ES. Continued liaison with other users of the area will be undertaken throughout the Project to achieve a synergistic approach to the Development of the area.
	GOV3 - Proposals should demonstrate in order of preference: a) that they will avoid displacement of other existing or authorised (but yet to be implemented) activities; b) how, if there are adverse impacts resulting in displacement by the proposal, they will minimise them; c) how, if the adverse impacts resulting in displacement by the proposal, cannot be minimised, they will be mitigated against or; d) the case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts of displacement.	
	FISH1 - Within areas of fishing activity, proposals should demonstrate in order of preference: a) that they will not prevent fishing activities on, or access to, fishing grounds b) how, if there are adverse impacts on the ability to undertake fishing activities or access to	An assessment into the potential impacts to fisheries has been undertaken in Section 6. Whilst it is acknowledged that there could be some temporary access restrictions during pipeline installation and drilling at the Abbey to York location and Abbey to Baker location, any long-term exclusion will be localised to any permanent 500 m subsea exclusion zones. Mitigation measures are proposed to minimise any disturbance to the fishing industry. PNS will continue to consult the fishing industry throughout the Development to minimise any potential impacts. As noted in the impact assessment in Section 6, temporary and long-term exclusion is not expected to significantly impact the fishing industry.

Relevant Objectives	Associated Policies	Addressed by the Abbey & Baker Development Project
	fishing grounds, they will minimise them c) how, if the adverse impacts cannot be minimised, they will be mitigated d) the case for proceeding with their proposal if it is not possible to minimise or mitigate the adverse impacts	
	FISH2 - Proposals should demonstrate, in order of preference: a) that they will not have an adverse impact upon spawning and nursery areas and any associated habitat b) how, if there are adverse impacts upon the spawning and nursery areas and any associated habitat, they will minimise them c) how, if the adverse impacts cannot be minimised they will be mitigated d) the case for proceeding with their proposals if it is not possible to minimise or mitigate the adverse impacts	The potential impact on nursery and spawning areas has been considered in the seabed impacts impact assessment (See Section 4). Although the Development area is considered to be within spawning and nursery grounds for some species, as discussed in the environmental baseline (see Section 4), the greatest potential for impact is during installation of the pipelines. These activities will be short-lived and cover only a small area of the available spawning habitat. The Development is not expected to have any long-term impacts.
	OG1 - Proposals within areas with existing oil and gas production should not be authorised except where compatibility with oil and gas production and	The Development is within an area of past and present oil and gas exploration and production. Given the nature of the Development, which will involve the drilling of wells, installation of subsea facilities and the installation of the pipelines, it is deemed to be wholly compatible with oil and gas activity in the area.

Relevant Objectives	Associated Policies	Addressed by the Abbey & Baker Development Project
	infrastructure can be satisfactorily demonstrated.	PNS will remain in consultation with oil and gas developers in the vicinity of the Development to minimise any potential impacts.
	TR1 - Proposals for development should demonstrate that during construction and operation, in order of preference: 1. They will not adversely impact tourism and recreation activities; 2. How, if there are adverse impacts on tourism and recreation activities, they will minimise them; 3. How, if the adverse impacts cannot be minimised, they will be mitigated; or 4. The case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts.	Recreation and tourism in the area is described as part of the baseline (Section 4). No potential impact to tourism and recreation is predicted due to the offshore location of the Development (York platform located approximately 31 km from Yorkshire coast, Abbey drill centre approximately 40 km from the coast and the Baker well approximately 38 km from the coast) (see Sections 6 - 11).

References

MMO (Marine Management Organisation) (2014) East Inshore and East Offshore Marine Plans. [Online] Available at: https://www.gov.uk/government/publications/east-inshore-and-east-offshore-marineplans [Accessed May 2026].

OGA (2020) The OGA Strategy. December 2020. Available from: https://www.ogauthority.co.uk/media/7105/the-oga-strategy.pdf [Accessed May 2026].

Appendix B: ENVID Registers

To inform the Abbey & Baker Development EIA, an ENVironmental and socio-economic impact IDentification (ENVID) workshop was undertaken to identify those Project activities (or aspects) which should be subject to detailed assessment in the ES.

The ENVID used the Evaluation of Significance Criteria (as documented in Section 5 of the ES) to determine the likely significance of effects on the environment.

For planned activities, the significance of environmental effects has been evaluated by considering the sensitivity of the receptor affected in combination with the magnitude of impact. For the purposes of this assessment, aspects with a significance score of Minor / Moderate, Moderate, Moderate / Major or Major have been taken forward for detailed assessment in the ES.

For unplanned events, significance has been determined using a risk assessment approach, where the likelihood (probability) of the unplanned event occurring is considered against the consequence (significance of effect) if the event was to occur. For the purposes of this assessment, unplanned events with a significance score of Medium or High have been taken forward for detailed assessment in the ES.

The results of the ENVID workshop (which took place on the 30th September 2025) are documented in the ENVID Registers provided in this Appendix, refer to Tables B.1 to B.4.

Table B.1: Drilling ENVID Matrix

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
1.1	Physical Presence	Presence of Jack-up MODU and supply / support vessels during drilling operations	Shipping	High	High	**Medium**	Moderate	**Minor/ Moderate**	Vessels will present a navigational hazard and cause displacement of commercial fisheries.	A 500 m safety exclusion zone will be in place, which will be patrolled by a dedicated ERRV; Reporting of the rig move will take place in line with the requirements of Part 4a of the Energy Act and HSE Operations Notice 6 guidance; Site-specific collision risk management plan to be developed; Subsea beacons will need to be put in place; Consent to Locate will be in place.	**Yes**
			Commercial Fishing	High	High	**Medium**	Moderate	**Minor/ Moderate**			
			Marine Mammals	High	Very High	**High**	Negligible	**Negligible**	Potential for collision between moving vessels and marine mammals.		**No**
			Seabirds	High	Very High	**High**	Negligible	**Negligible**	Potential for disturbance / displacement from foraging areas.		
			Marine Protected Areas	High	Very High	**High**	Negligible	**Negligible**	SNS SAC - Potential for collision between moving vessels and marine mammals.		
			Military Activity	Very High	Very High	**Medium**	Negligible	**Negligible**	Vessels will present a navigational hazard.		
1.2	Physical Presence	Artificial light emitted from the MODU and support vessels	Seabirds	High	Very High	**High**	Negligible	**Negligible**	Seabirds are easily disorientated by intense sources of artificial light.	Researching the possibility of reducing time lights are switched on.	**No**
1.3		Physical presence of wellhead and xmas tree	Commercial Fishing	High	Medium	**Medium**	Major	**Moderate**	Potential snagging hazard to fishing gears towed along the seabed.	Wellhead will be located within 500 m safety zone and will be marked as a hazard on admiralty charts and entered into the FishSafe system;	**Yes**

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
		following rig departure								Wellhead will be covered with a 'fishing friendly' Wellhead Protection Structure Consent to Locate will be in place.	
1.4	Seabed Disturbance	The siting of spudcans onto the seabed	Seabed Sediments	High	Very High	**High**	Moderate	**Moderate**	The presence of new infrastructure may disturb seabed sediments through scouring.	- Siting of the spud cans will take into account the results of the rig site survey, environmental survey and herring spawning survey	**Yes**
			Water Quality	Very High	Medium	**Low**	Negligible	**Negligible**	The siting of the spudcans may cause suspension of seabed sediments causing a reduction in Water Quality.		**No**
			Benthic Communities	High	Very High	**High**	Major	**Moderate / Major**	Direct loss of benthic habitat beneath spudcans.		**Yes**
			Fish & Shellfish	High	Very High	**High**	Moderate	**Moderate**	Direct loss of fish and shellfish habitat beneath spudcans.		
			Marine Protected Areas	High	Very High	**High**	Negligible	**Negligible**	SNS SAC - Direct loss of benthic habitat and species beneath spudcans.		**No**

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
1.5		Deposit of drill cuttings and cement on the seabed.	Seabed Sediments	High	Low	**Low**	Major	**Minor**	Cuttings pile will alter the seabed topography and sediment structure. Physical disturbance and smothering of benthic communities. Impacts to foraging behaviour of fish and displacement from spawning and nursery areas.	Minimise chemical use, use less hazardous chemicals; No discharge of LTOBM chemicals.	**Yes**
			Water Quality	Very High	Medium	**Low**	Negligible	**Negligible**			**No**
			Benthic Communities	High	Very High	**High**	Major	**Moderate / Major**			**Yes**
			Fish & Shellfish	High	Very High	**High**	Major	**Moderate / Major**			
			Marine Protected Areas	High	Very High	**High**	Major	**Moderate / Major**			
1.6	Underwater Noise Emissions	Use of propellers / DP thrusters on vessels	Marine Mammals	High	Very High	**High**	Minor	**Minor**	Potential behavioural disturbance or physiological impacts to sensitive marine fauna species.	Optimise vessel movements by careful planning	**Yes**
			Fish & Shellfish	High	Very High	**High**	Negligible	**Negligible**			**No**
			Seabirds	High	Very High	**High**	Negligible	**Negligible**			
			Marine Protected Areas	High	Very High	**High**	Minor	**Minor**			**Yes**
			Commercial Fishing	Very High	High	**Low**	Negligible	**Negligible**			**No**
1.7		Operation of equipment on MODU (e.g.	Marine Mammals	High	Very High	**High**	Minor	**Negligible**	Potential behavioural disturbance or physiological impacts to	Operational and maintenance procedures will aim to optimise the efficiency of equipment.	**No**
			Fish & Shellfish	High	Very High	**High**	Negligible	**Negligible**			**No**

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
		rotating machinery)	Seabirds	High	Very High	**High**	Negligible	**Negligible**	sensitive marine fauna species.		
			Marine Protected Areas	High	Very High	**High**	Minor	**Negligible**			**No**
			Commercial Fishing	Very High	High	**Low**	Negligible	**Negligible**			**No**
1.8	Airborne noise emissions	Use of helicopters	Seabirds	High	Very High	**High**	Negligible	**Negligible**	Potential for disturbance / displacement from foraging areas.	Optimise helicopter movements by careful planning	**No**
1.9	Atmospheric Emissions	Fuel burnt for power generation on the MODU, vessels and helicopters	Air Quality	Very High	Low	**Low**	Negligible	**Negligible**	Emissions of combustion products (particularly CO_2, CH_4, N_2O) contribute to the pool of greenhouse gases in the atmosphere resulting in global warming and potential climate change. Inputs of contaminants (particulate matter, CO,	Maintenance regime will ensure all equipment will operate at optimum efficiency, minimising the overall fuel consumption; The combustion plants onboard the MODU will be built to be fuel efficient and to meet all current emission standards; Use of low sulphur fuels according to IMO requirements;	**No**

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
1.10			Climate	Medium	Very High	**Very High**	Substantial	**Major**	NOx, SO_2, VOCs) can contribute to the formation of local tropospheric ozone and photochemical smog, resulting in a reduction in local air quality.	Petrogas will investigate the use of HVOs and SAFs during operations; Optimise drilling programme including vessel movements by careful planning to minimise fuel use.	**Yes**
1.11		Well Clean Up	Air Quality	Very High	Low	**Low**	Negligible	**Negligible**	Emissions of combustion products (particularly CO2, CH4, N2O) contribute to the pool of greenhouse gases in the atmosphere resulting in global warming and potential climate change. Inputs of contaminants (particulate matter, CO, NOx, SO2, VOCs) can contribute to the formation of local tropospheric ozone and	Using a special completion design which will reduce clean up times and flaring times, using high efficiency flares, start flares during daylight, bird migration modelling	**No**
1.12			Climate	Medium	Very High	**Very High**	Substantial	**Major**			**Yes**

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
1.13			Seabirds	Medium	Very High	**High**	Negligible	**Negligible**	photochemical smog, resulting in a reduction in local air quality. Illumination from the flare can impact bird movements during migration.		**No**
1.14	Marine Discharges	Discharge of cuttings at the sea surface	Water Quality	Very High	Low	**Low**	Moderate	**Minor**	Decline in water quality, including temporary increase in suspended sediment levels and turbidity in the water column, which could have toxic effects on marine biota particularly phytoplankton, zooplankton and fish.	Screening Direction and Chemical Permit will be in place; No LTOBM to be discharged.	**Yes**
			Plankton	High	Medium	**Medium**	Moderate	**Minor / Moderate**			
			Fish & Shellfish	High	Very High	**Medium**	Moderate	**Minor / Moderate**			
			Marine Mammals	Very High	Very High	**Medium**	Moderate	**Minor / Moderate**			
			Marine Protected Areas	Very High	Very High	**Medium**	Moderate	**Minor / Moderate**			
1.14		Discharge of drilling, cementing, completion (including fracking/ stimulation) and rig chemicals	Water Quality	Very High	Low	**Low**	Moderate	**Minor**	Decline in water quality which could have toxic effects on marine biota particularly phytoplankton, zooplankton and fish.	Chemical use and discharge will be minimised to as low as practically possible; Where practicable, chemicals with a higher risk profile will be substituted out in favour of those with an improved environmental profile. A Chemical Risk Assessment will	**Yes**
			Plankton	High	Medium	**Medium**	Moderate	**Minor / Moderate**			

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
			Fish & Shellfish	High	Very High	**Medium**	Moderate	**Minor / Moderate**		be undertaken in advance of drilling ops to support the Chemical Permit as per the requirements of the Offshore Chemicals Regulations 2002 (as amended).	
			Marine Mammals	Very High	Very High	**Medium**	Moderate	**Minor / Moderate**			
			Marine Protected Areas	Very High	Very High	**Medium**	Moderate	**Minor / Moderate**			
1.16		MODU and support vessels - discharge of grey/blackwater	Water Quality	Very High	Low	**Low**	Negligible	**Negligible**	Increased BOD (from organic and other nutrient matter in detergents and human waste) may ultimately lead to an increase in opportunistic species. Some marine avoid contaminated areas.	Waste water will be disposed of in accordance with the requirements of the MARPOL convention and UK regulations	**No**
			Plankton	Very High	Medium	**Low**	Negligible	**Negligible**			
			Fish & Shellfish	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Marine Mammals	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Marine Protected Areas	Very High	Very High	**Medium**	Negligible	**Negligible**			
1.17		MODU and support vessels - release of food waste	Water Quality	Very High	Low	**Low**	Negligible	**Negligible**	Increased BOD (from organic and other nutrient matter) may ultimately lead to an increase in opportunistic species.	Food waste will be disposed of to meet the requirements of MARPOL convention and UK regulations.	**No**
			Plankton	Very High	Medium	**Low**	Negligible	**Negligible**			
			Fish & Shellfish	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Seabirds	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Marine Mammals	Very High	Very High	**Medium**	Negligible	**Negligible**			

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
			Marine Protected Areas	Very High	Very High	**Medium**	Negligible	**Negligible**			
1.18		Oily water discharges from deck drains on MODU	Water Quality	Very High	Low	**Low**	Negligible	**Negligible**	Decline in water quality which could have toxic effects on marine biota particularly phytoplankton, zooplankton and fish.	Deck drainage water will be sampled prior to discharge to ensure the oil in water concentration is <40 mg/l; An Oil Discharge Permit will be in place.	**No**
			Plankton	Very High	Medium	**Low**	Negligible	**Negligible**			
			Fish & Shellfish	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Seabirds	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Marine Mammals	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Marine Protected Areas	Very High	Very High	**Medium**	Negligible	**Negligible**			
1.19		MODU and support vessels - discharge of ballast water	Water Quality	Very High	Low	**Low**	Negligible	**Negligible**	Potential to introduce alien species, which could alter the local and possibly the wider ecosystem.	Compliance with the IMO Ballast Water Management Convention	**No**
			Plankton	Very High	Medium	**Low**	Negligible	**Negligible**			
			Fish & Shellfish	Medium	Very High	**Very High**	Negligible	**Negligible**			
			Seabirds	High	Very High	**High**	Negligible	**Negligible**			
			Marine Mammals	High	Very High	**High**	Negligible	**Negligible**			

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
			Marine Protected Areas	High	Very High	**High**	Negligible	**Negligible**			
1.20	Solid Waste	General operational waste - non-hazardous & hazardous	Population & Human Health	Very High	Very High	**Medium**	Negligible	**Negligible**	Effects of onshore disposal of waste depends on the nature of waste and disposal site. Potential effects on future land use options for waste disposal sites. Potential for localised land and air contamination.	Waste will be dealt with in accordance with regulatory requirements. The principles of the Waste Management Hierarchy will be followed, licensed waste contractors will be used and Waste Management Duty of Care audits will be carried out. Vessels will conform to their own Waste Management Plans. A project Waste Management Plan will be put in place and followed.	**No**
1.21	Use of Resources	Resource use during drilling operations	Population & Human Health	Medium	Very High	**Very High**	Negligible	**Negligible**	Depletion of natural resources leading to climate change, biodiversity loss and pollution, as well as socio-economic consequences for the world-wide population	Minimise the use of natural resources, as far as practicable	**No**

Table B.2: Subsea Installations and Commissioning ENVID Matrix

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
2.1	Physical Presence	Physical presence of DP installation and commissioning vessels	Shipping	High	Medium	**Medium**	Moderate	**Minor / Moderate**	Potential for the vessels to be a navigational hazard as during installation activities, vessel manoeuvrability will be restricted	Adherence to Marine law, vessel radar and AIS, Notices to Mariners, Kingfisher Bulletin.	**Yes**
			Commercial Fishing	High	Medium	**Medium**	Moderate	**Minor / Moderate**			
2.2			Marine Mammals	High	Very High	**High**	Negligible	**Negligible**	Potential for collision between moving vessels and marine mammals.		**No**
			Marine Protected Areas	High	Very High	**High**	Negligible	**Negligible**	SNS SAC - Potential for collision between moving vessels and marine mammals.		
			Seabirds	High	Very High	**High**	Negligible	**Negligible**	Potential for disturbance / displacement from foraging areas.		
			Military Activity	Very High	Very High	**Medium**	Negligible	**Negligible**	Potential for the vessels to be a navigational hazard as during installation activities, vessel manoeuvrability will be restricted		
2.3		Presence of subsea	Commercial Fishing	High	Medium	**Medium**	Major	**Moderate**	Loss of sea area for other users (i.e. loss of access to	There will be separate Abbey and Baker subsea safety exclusion	**Yes**

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
		infrastructure and associated protection material (rock, mattresses)							fishing grounds) and potential snagging hazard.	zones around the subsea infrastructure and seabed infrastructure will be clearly marked on navigation charts.	
2.4		Artificial light emitted from DP installation and commissioning vessels	Seabirds	High	Very High	**High**	Negligible	**Negligible**	Seabirds are easily disorientated by intense sources of artificial light.	Temporary disturbance, metocean conditions drive operations to target summer weather (when hours of darkness are shorter).	**No**
2.5	Seabed Disturbance	Laying of production pipelines and umbilical on the seabed followed by trenching and burial of pipelines and umbilical	Water Quality	Very High	Low	**Low**	Minor	**Minor**	Potential to disturb seabed sediments and affect benthic communities	Route selection and optimisation based on acquired Environmental, Geophysical, and Geotechnical survey data; Minimise working corridors, as far as possible.	**Yes**
			Seabed Sediments	High	Very High	**High**	Major	**Moderate / Major**			
			Benthic Communities	High	Very High	**High**	Major	**Moderate / Major**			
			Fish & Shellfish	High	Very High	**High**	Major	**Moderate / Major**			
			Marine Protected Areas	High	Very High	**High**	Major	**Moderate / Major**			
2.6		Installation of tie-in spools & jumpers at Abbey, Baker and York	Water Quality	Very High	Low	**Low**	Minor	**Minor**	Potential to disturb seabed sediments and affect benthic communities	Subsea infrastructure layout optimised to minimise footprint/seabed disturbance	**Yes**
			Seabed Sediments	High	Very High	**High**	Major	**Moderate / Major**			

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
			Benthic Communities	High	Very High	**High**	Major	**Moderate / Major**			
			Fish & Shellfish	High	Very High	**High**	Major	**Moderate / Major**			
			Marine Protected Areas	High	Very High	**High**	Major	**Moderate / Major**			
2.7	Seabed Disturbance	Installation of Abbey and Baker Subsea Infrastructure	Water Quality	Very High	Low	**Low**	Minor	**Minor**	Potential to disturb seabed sediments, including contaminated sediments at Abbey and Baker from prior drilling operations and affect benthic communities	Subsea infrastructure layout optimised to minimise footprint/seabed disturbance.	**Yes**
			Seabed Sediments	High	Very High	**High**	Major	**Moderate / Major**			
			Benthic Communities	High	Very High	**High**	Major	**Moderate / Major**			
			Fish & Shellfish	High	Very High	**High**	Major	**Moderate / Major**			
			Marine Protected Areas	High	Very High	**High**	Major	**Moderate / Major**			
2.8	Seabed Disturbance	Laying of rock, concrete mattresses for protection / stability / trench transitions	Water Quality	Very High	Low	**Low**	Minor	**Minor**	Potential to disturb seabed sediments, affect benthic communities with rock / mattresses / grout bags introducing a novel hard substrata.	Minimise amount of deposited material whilst still achieving the required level of stabilisation / protection.	**Yes**
			Seabed Sediments	High	Very High	**High**	Major	**Moderate / Major**			
			Benthic Communities	High	Very High	**High**	Major	**Moderate / Major**			

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
			Fish & Shellfish	High	Very High	**High**	Major	**Moderate / Major**			
			Marine Protected Areas	High	Very High	**High**	Major	**Moderate / Major**			
2.9		Construction of pipeline crossings (PL447 - Cleeton CP to Dimlington)	Water Quality	Very High	Low	**Low**	Minor	**Minor**	Potential to disturb seabed sediments, affect benthic communities with rock, plinths and mattresses introducing a novel hard substrata.	Minimise amount of rock required to achieve safe crossing of the pipeline.	**Yes**
			Seabed Sediments	High	Very High	**High**	Major	**Moderate / Major**			
			Benthic Communities	High	Very High	**High**	Major	**Moderate / Major**			
			Fish & Shellfish	High	Very High	**High**	Major	**Moderate / Major**			
			Marine Protected Areas	High	Very High	**High**	Major	**Moderate / Major**			
2.10	Underwater Noise Emissions	Use of propellers / DP thrusters on installation and commissioning vessels, including general noise and vibration of equipment whilst operating	Fish & Shellfish	High	Very High	**High**	Negligible	**Negligible**	Potential behavioural disturbance or physiological impacts to sensitive marine fauna species.	Optimise vessel movements by careful planning; Operational and maintenance procedures on vessels will aim to optimise the efficiency of equipment.	**No**
			Marine Mammals	High	Very High	**High**	Negligible	**Negligible**			
			Marine Protected Areas	High	Very High	**High**	Negligible	**Negligible**			

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
		(trench and burial)	Seabirds	High	Very High	**High**	Negligible	**Negligible**			
2.12	Atmospheric Emissions	Fuel burnt for power generation on installation and commissioning vessels	Air Quality	Very High	Low	**Low**	Negligible	**Negligible**	Emissions of combustion products (particularly CO_2, CH_4, N_2O) contribute to the pool of greenhouse gases in the atmosphere resulting in global warming and potential climate change. Inputs of contaminants (particulate matter, CO, NOx, SO_2, VOCs) can contribute to the formation of local tropospheric ozone and photochemical smog, resulting in a reduction in local air quality.	Supplier's environmental footprints will be factored into the tender evaluation process; Maintenance regime will ensure all equipment will operate at optimum efficiency, minimising the overall fuel consumption; Use of low sulphur fuels according to IMO requirements; Optimise subsea installation and commissioning programme including vessel movements by careful planning to minimise fuel use.	**No**
2.13			Climate	Medium	Very High	**Very High**	Substantial	**Major**			**Yes**
2.14	Marine Discharges	Use and discharge of chemicals during hook-up and commissioning of subsea infrastructure, including commissioning and preservation fluids	Water Quality	Very High	Low	**Low**	Moderate	**Minor**	Decline in water quality which could have toxic effects on marine biota particularly phytoplankton, zooplankton and fish.	Chemical use and discharge will be minimised to as low as practically possible; Where practicable, chemicals with a higher risk profile will be substituted out in favour of those with an improved environmental profile. A Chemical Risk Assessment will be undertaken in advance of pipeline installation ops to support the Chemical Permit as per the requirements of the Offshore Chemicals Regulations 2002 (as amended).	**Yes**
			Plankton	High	Medium	**Medium**	Moderate	**Minor / Moderate**			
			Fish & Shellfish	High	Very High	**Medium**	Moderate	**Minor / Moderate**			
			Seabirds	Very High	Very High	**Medium**	Negligible	**Negligible**			**No**
			Marine Mammals	Very High	Very High	**Medium**	Moderate	**Minor / Moderate**			**Yes**

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
			Marine Protected Areas	Very High	Very High	**Medium**	Moderate	**Minor / Moderate**			
			Commercial Fishing	Very High	High	**Medium**	Negligible	**Negligible**			**No**
2.15		Production chemical discharge of hydraulic fluid from subsea infrastructure	Water Quality	Very High	Low	**Low**	Moderate	**Minor**	"Decline in water quality which could have toxic effects on marine biota particularly phytoplankton, zooplankton and fish."	"Chemical use and discharge will be minimised to as low as practically possible; Where practicable, chemicals with a higher risk profile will be substituted out in favour of those with an improved environmental profile. A Chemical Risk Assessment will be undertaken in advance of pipeline installation ops to support the Chemical Permit as per the requirements of the Offshore Chemicals Regulations 2002 (as amended). "	**Yes**
			Plankton	High	Medium	**Medium**	Moderate	**Minor / Moderate**			
			Fish & Shellfish	High	Very High	**Medium**	Moderate	**Minor / Moderate**			
			Seabirds	Very High	Very High	**Medium**	Negligible	**Negligible**			**No**
			Marine Mammals	Very High	Very High	**Medium**	Moderate	**Minor / Moderate**			**Yes**
			Marine Protected Areas	Very High	Very High	**Medium**	Moderate	**Minor / Moderate**			
			Commercial Fishing	Very High	High	**Medium**	Negligible	**Negligible**			**No**
2.16		Installation and commissioning vessels - discharge of grey/blackwater	Water Quality	Very High	Low	**Low**	Negligible	**Negligible**	Increased BOD (from organic and other nutrient matter in detergents and human waste) may ultimately lead to an increase in opportunistic species.	Waste water will be disposed of in accordance with the requirements of the MARPOL convention and UK regulations	**No**
			Plankton	Very High	Medium	**Low**	Negligible	**Negligible**			
			Fish & Shellfish	Very High	Very High	**Medium**	Negligible	**Negligible**			

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
			Marine Mammals	Very High	Very High	**Medium**	Negligible	**Negligible**			
2.17		Installation and support vessels - release of food waste	Water Quality	Very High	Low	**Low**	Negligible	**Negligible**	Increased BOD (from organic and other nutrient matter) may ultimately lead to an increase in opportunistic species.	Food waste will be disposed of to meet the requirements of MARPOL convention and UK regulations.	**No**
			Plankton	Very High	Medium	**Low**	Negligible	**Negligible**			
			Fish & Shellfish	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Seabirds	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Marine Mammals	Very High	Very High	**Medium**	Negligible	**Negligible**			
2.18	Marine Discharges	Installation and commissioning vessels - discharge of ballast water	Water Quality	Very High	Low	**Low**	Negligible	**Negligible**	Potential to introduce alien species, which could alter the local and possibly the wider ecosystem.	Compliance with the IMO Ballast Water Management Convention	**No**
			Plankton	Very High	Medium	**Low**	Negligible	**Negligible**			
			Fish & Shellfish	Medium	Very High	**Very High**	Negligible	**Negligible**			
			Seabirds	High	Very High	**High**	Negligible	**Negligible**			
			Marine Mammals	High	Very High	**High**	Negligible	**Negligible**			
2.19	Solid Waste	General operational waste - non-hazardous & hazardous	Population & Human Health	Very High	Very High	**Medium**	Negligible	**Negligible**	Effects of onshore disposal of waste depends on the nature of waste and disposal site. Potential effects on future land use options for waste disposal sites. Potential for	Waste will be dealt with in accordance with regulatory requirements. The principles of the Waste Management Hierarchy will be followed, licensed waste contractors will be used and Waste Management Duty of Care audits will be carried	**No**

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
									localised land and air contamination.	out. Vessels will conform to their own Waste Management Plans. A project Waste Management Plan will be put in place and followed.	
2.20	Use of Resources	Resource use during installation and commissioning operations	Population & Human Health	Medium	Very High	**Very High**	Negligible	**Negligible**	Depletion of natural resources leading to climate change, biodiversity loss and pollution, as well as socio-economic consequences for the worldwide population	Minimise the use of natural resources, as far as practicable	**No**

Table B.3: Production, Inspection and Maintenance ENVID Matrix

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
3.1	Physical Presence	Ongoing presence of subsea infrastructure and protection material (rocks and mattresses)	Commercial Fishing	High	Medium	**Medium**	Major	**Moderate**	Loss of sea area for other users (i.e. loss of access to fishing grounds) and potential snagging hazard.	Abbey and Baker safety exclusion zones and seabed infrastructure will be clearly marked on navigation charts.	**Yes**
			Shipping	Very High	High	**Low**	Negligible	**Negligible**			**No**
3.2	Seabed Disturbance	Inspection, maintenance and repair of subsea infrastructure	Water Quality	Very High	Low	**Low**	Negligible	**Negligible**	Potential to disturb seabed sediments and affect benthic communities		**No**
			Seabed Sediments	High	Very High	**High**	Negligible	**Negligible**			
			Benthic Communities	High	Very High	**High**	Negligible	**Negligible**			
			Fish & Shellfish	High	Very High	**High**	Negligible	**Negligible**			
			Marine Protected Areas	Low	Very High	**Very High**	Negligible	**Negligible**			

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
3.3	Atmospheric Emissions	Reintroduction of atmospheric emissions at the York platform (host facility) as a result of Abbey and Baker coming online	Air Quality	Very High	Low	**Low**	Negligible	**Negligible**	Emissions of combustion products (particularly CO_2, CH_4, N_2O) contribute to the pool of greenhouse gases in the atmosphere resulting in global warming and potential climate change. Inputs of contaminants (particulate matter, CO, NOx, SO_2, VOCs) can contribute to the formation of local tropospheric ozone and photochemical smog, resulting in a reduction in local air quality.		**No**
3.4			Climate	Medium	Very High	**Very High**	Substantial	**Major**			**Yes**
3.5		Atmospheric emissions at York due to gas cold vented from pig launcher as a result of Abbey and Baker production	Air Quality	Very High	Low	**Low**	Negligible	**Negligible**	Emissions of combustion products (particularly CO_2, CH_4, N_2O) contribute to the pool of greenhouse gases in the atmosphere resulting in global warming and potential climate change. Inputs of contaminants (particulate matter, CO, NOx, SO_2, VOCs) can contribute to the formation of local tropospheric ozone and photochemical smog, resulting in a reduction in local air quality.		**No**
3.6			Climate	Medium	Very High	**Very High**	Substantial	**Major**			**Yes**

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
3.7		End use emissions from burning the extracted hydrocarbons	Air Quality	Very High	Low	**Low**	Negligible	**Negligible**	Emissions of combustion products (particularly CO_2, CH_4, N_2O) contribute to the pool of greenhouse gases in the atmosphere resulting in global warming and potential climate change. Inputs of contaminants (particulate matter, CO, NOx, SO_2, VOCs) can contribute to the formation of local tropospheric ozone and photochemical smog, resulting in a reduction in local air quality.		**No**
3.8			Climate	Medium	Very High	**Very High**	Substantial	**Major**			**Yes**
3.9	Marine Discharges	Discharge of chemicals or hydrocarbons during subsea intervention activities (IRM), including well intervention operations	Water Quality	Very High	Low	**Low**	Moderate	**Minor**	Decline in water quality which could have toxic effects on marine biota particularly phytoplankton, zooplankton and fish.	"Chemical use and discharge will be minimised to as low as practically possible; Chemicals with a higher risk profile will be substituted out in favour of those with an improved environmental profile, where possible; A Chemical Risk Assessment will be undertaken in advance of IRM ops to support the Chemical Permit as	**Yes**
			Plankton	High	Medium	**Medium**	Moderate	**Minor/ Moderate**			
			Fish & Shellfish	High	Very High	**Medium**	Moderate	**Minor/ Moderate**			

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
										per the requirements of the Offshore Chemicals Regulations 2002 (as amended); A term Oil Discharge Permit will be in place for the discharge of hydrocarbons as per the requirements of Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended)."	
3.10		York Platform - discharge of grey / blackwater and food waste	Water Quality	Very High	Low	**Low**	Negligible	**Negligible**	Increased BOD (from organic and other nutrient matter in detergents, human waste and food) may ultimately lead to an increase in opportunistic species.	Waste water and food waste will be disposed of in accordance with the requirements of the MARPOL convention and UK regulations	**No**
			Plankton	Very High	Medium	**Low**	Negligible	**Negligible**			

Ref No.	Environmental Issue	Project Activity	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Significance	Potential Impacts	Mitigation Measures	Scoped into EIA
			Fish & Shellfish	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Seabirds	Very High	Very High	**Medium**	Negligible	**Negligible**			
			Marine Mammals	Very High	Very High	**Medium**	Negligible	**Negligible**			

Table B.4: Unplanned Events ENVID Matrix

Ref No.	Unplanned Event	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Consequence	Likelihood	Risk	Potential Impacts	Mitigation Measures	Scoped into EIA
4.1	Dropped Objects	Oil & Gas	Very High	Medium	**Low**	Negligible	**Negligible**	Possible	Low	Dropped objects may pose a risk to subsea infrastructure or present a snagging risk to trawlers.	"Any dropped objects to be immediately reported to the regulator (via a PON2) and procedures will be in place to recover objects, where possible; Debris will be identified during post work surveys and anything that cannot be recovered will be reported to the relevant authorities to be included on navigation charts; Subsea infrastructure to be designed for dropped objects as applicable."	**No**
		Commercial Fishing	High	Medium	**Medium**	Negligible	**Negligible**	Possible	Low			

Ref No.	Unplanned Event	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Consequence	Likelihood	Risk	Potential Impacts	Mitigation Measures	Scoped into EIA
4.2	Small release of hydrocarbons / chemicals to sea (e.g. from drains, bunkering operations etc.) during drilling, installation and commissioning or maintenance and well intervention activities	Water Quality	Very High	Low	**Low**	Minor	**Minor**	Possible	Low	May temporarily affect water quality and impact species within the water column.	MODU / vessels will be designed, managed and maintained to prevent spills; Crews will be adequately trained and regular exercises held; Bunkering procedures will be put in place.	**No**
		Seabed Sediments	Very High	Low	**Low**	Minor	**Minor**	Possible	Low			
		Benthic Communities	High	Very High	**High**	Minor	**Minor**	Possible	Low			
		Fish & Shellfish	High	Very High	**High**	Minor	**Minor**	Possible	Low			
		Marine Mammals	High	Very High	**High**	Minor	**Minor**	Possible	Low			
		Marine Protected Areas	High	Very High	**High**	Minor	**Minor**	Possible	Low			
4.3	Small release of hydraulic fluid, e.g. from ROV operations / hydraulic equipment / subsea control system failure	Water Quality	Very High	Low	**Low**	Minor	**Minor**	Possible	Low	May temporarily affect water quality and impact species within the water column.	Appropriate maintenance, and pre-use checks on hydraulic equipment and ROVs PON1 reporting systems in place in the case of a release. CEFAS registered hydraulic chemicals in use. Closed loop control system in place for subsea facilities.	**No**
		Plankton	Very High	Low	**Low**	Minor	**Minor**	Possible	Low			
		Fish & Shellfish	High	Very High	**High**	Minor	**Minor**	Possible	Low			
		Seabirds	High	Very High	**High**	Minor	**Minor**	Possible	Low			

Ref No.	Unplanned Event	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Consequence	Likelihood	Risk	Potential Impacts	Mitigation Measures	Scoped into EIA
		Marine Mammals	High	Very High	**High**	Minor	**Minor**	Possible	Low			
		Marine Protected Areas	High	Very High	**High**	Minor	**Minor**	Possible	Low			
4.4	MODU or vessel collision (loss of diesel inventory) (MAH)	Water Quality	Very High	Low	**Low**	Moderate	**Minor**	Rare	Low	Release of fuel oil to sea may impact species within the water column, on the sea surface and in coastal habitats.	Consent to Locate will be in place for the MODU; 500m safety zone will be designated around the MODU and dedicated ERRV present; Notifications made to 'regular runners' and local fisheries organisations via Notices to Mariners, NAVTEX / NAVAREA warnings and fisheries notices; Adherence to Marine law; Vessel radar and AIS; Approved OPEP and CIP in place.	**Yes**
		Seabed Sediments	High	Very High	**High**	Moderate	**Moderate**	Rare	Medium			
		Plankton	Very High	Low	**Low**	Moderate	**Minor**	Rare	Low			
		Benthic Communities	High	Very High	**High**	Moderate	**Moderate**	Rare	Medium			
		Fish & Shellfish	Medium	Very High	**Very High**	Moderate	**Moderate / Major**	Rare	Medium			
		Seabirds	Medium	Very High	**Very High**	Moderate	**Moderate / Major**	Rare	Medium			
		Marine Mammals	Medium	Very High	**Very High**	Moderate	**Moderate / Major**	Rare	Medium			
		Marine Protected Areas	Medium	Very High	**Very High**	Moderate	**Moderate / Major**	Rare	Medium			
		Shipping	High	Very High	**High**	Moderate	**Moderate**	Rare	Medium			
		Commercial Fishing	High	Very High	**High**	Moderate	**Moderate**	Rare	Medium			

Ref No.	Unplanned Event	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Consequence	Likelihood	Risk	Potential Impacts	Mitigation Measures	Scoped into EIA
		Tourism & Leisure	High	Medium	**Medium**	Moderate	**Minor / Moderate**	Rare	Medium			
		Population & Human Health	Medium	Very High	**Very High**	Moderate	**Moderate / Major**	Rare	Medium			
4.5	Well blowout (releasing large quantities of hydrocarbons) in the event of a loss of well control (MAH)	Water Quality	Very High	Low	**Low**	Substantial	**Minor / Moderate**	Rare	Low	Release of hydrocarbons to sea may impact species within the water column, on the sea surface and in coastal habitats.	Well design and construction reviewed by an independent well examiner; Safety and Environmental Critical Elements will be identified, and a suitable maintenance and testing schedule applied to each; Crews will be adequately experienced, trained in well control techniques and supervised; During drilling ops, weighted drilling fluids will provide the primary barrier and the downhole pressures will be carefully controlled and monitored, with the secondary barrier, the BOP, regularly maintained and tested; Emergency drills will be held regularly; An approved OPEP, emergency response plans	**Yes**
		Seabed Sediments	High	Very High	**High**	Substantial	**Major**	Rare	Medium			
		Plankton	Very High	Low	**Low**	Substantial	**Minor / Moderate**	Rare	Low			
		Benthic Communities	High	Very High	**High**	Substantial	**Major**	Rare	Medium			
		Fish & Shellfish	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
		Seabirds	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
		Marine Mammals	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
		Marine Protected Areas	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
		Shipping	High	Very High	**High**	Substantial	**Major**	Rare	Medium			
		Commercial Fishing	High	Very High	**High**	Substantial	**Major**	Rare	Medium			

Ref No.	Unplanned Event	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Consequence	Likelihood	Risk	Potential Impacts	Mitigation Measures	Scoped into EIA
		Tourism & Leisure	High	Medium	**Medium**	Substantial	**Moderate / Major**	Rare	Medium		and equipment will be in place; OSRL Tier 2/3 support and capping device available.	
		Population & Human Health	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
4.6	Production pipeline rupture, releasing large quantities of hydrocarbons to sea	Water Quality	Very High	Low	**Low**	Substantial	**Minor / Moderate**	Rare	Medium	Release of hydrocarbons to sea may impact species within the water column, on the sea surface and in coastal habitats.	Facilities will be subject to stringent design specifications; Routine monitoring of pipeline pressure and temperature will be undertaken; Automatic and manual shutdown systems in place; Periodic ROV inspection of the pipeline will be undertaken; Maintaining pipeline integrity KPIs.	**Yes**
		Seabed Sediments	High	Very High	**High**	Substantial	**Major**	Rare	Medium			
		Plankton	Very High	Low	**Low**	Substantial	**Minor / Moderate**	Rare	Medium			
		Benthic Communities	High	Very High	**High**	Substantial	**Major**	Rare	Medium			
		Fish & Shellfish	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
		Seabirds	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
		Marine Mammals	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
		Marine Protected Areas	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
		Shipping	High	Very High	**High**	Substantial	**Major**	Rare	Medium			
		Commercial Fishing	High	Very High	**High**	Substantial	**Major**	Rare	Medium			

Ref No.	Unplanned Event	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Consequence	Likelihood	Risk	Potential Impacts	Mitigation Measures	Scoped into EIA
		Tourism & Leisure	High	Medium	**Medium**	Substantial	**Moderate / Major**	Rare	Medium			
		Population & Human Health	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
4.7	Production pipeline rupture, releasing large quantities of gas	Air Quality	Very High	Low	**Low**	Minor	**Minor**	Rare	Low	Atmospheric emissions due to gas release	Facilities will be subject to stringent design specifications; Routine monitoring of pipeline pressure and temperature will be undertaken; Automatic and manual shutdown systems in place; Periodic ROV inspection of the pipeline will be undertaken; Maintaining pipeline integrity KPIs.	**Yes**
		Climate	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			
4.8	Well Blowout (Gas)	Air Quality	Very High	Low	**Low**	Minor	**Minor**	Rare	Low	Atmospheric emissions due to gas release	Well design and construction reviewed by an independent well examiner; Safety and Environmental Critical Elements will be identified, and a suitable maintenance and testing schedule applied to each;	**Yes**

Ref No.	Unplanned Event	Receptor	Resistance & Resilience	Value	Receptor Sensitivity	Magnitude of Impact	Consequence	Likelihood	Risk	Potential Impacts	Mitigation Measures	Scoped into EIA
		Climate	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium		Crews will be adequately experienced, trained in well control techniques and supervised; During drilling ops, weighted drilling fluids will provide the primary barrier and the downhole pressures will be carefully controlled and monitored, with the secondary barrier, the BOP, regularly maintained and tested; Emergency drills will be held regularly; An approved OPEP, emergency response plans and equipment will be in place; OSRL Tier 2/3 support and capping device available.	
4.9	Emergency Gas Venting at the York Platform	Air Quality	Very High	Low	**Low**	Minor	**Minor**	Rare	Low	Atmospheric emissions due to gas release		**Yes**
		Climate	Medium	Very High	**Very High**	Substantial	**Major**	Rare	Medium			

Appendix C: Drill Cuttings Modelling

MAKING COMPLEX EASY

A TETRA TECH COMPANY

ABBEY AND BAKER FIELDS

Drill Cuttings and Muds Dispersion Modelling

GOC437855
24 July 2026
Rev 1

rpsgroup.com

REPORT

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
Rev A	Internal Draft	R. Dunn N. Benfer	N. Benfer	N. Benfer	13/03/2026
Rev 0	Draft issued to client		N. Benfer	N. Benfer	13/03/2026
Rev 1	Issue to client		N. Benfer	N. Benfer	24/07/2026

Approval for issue

Nathan Benfer		24 July 2026

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EXECUTIVE SUMMARY

Project Background

Petrogas E&P (Petrogas) is the owner of the Abbey and Baker Fields in the southern North Sea. The Abbey Gas Development is located within Block 47/3i, located approximately 40 km east of Yorkshire, whilst the Baker prospect is located within Block 47/3f, positioned approximately 5 km west of the Abbey Field.

To support the environmental permitting process for proposed drilling activities within the Abbey and Baker Fields, Orbis Energy Limited (on behalf of Petrogas) commissioned RPS to undertake a detailed drill cuttings and muds dispersion modelling study to quantify the distribution and sediment thicknesses on the seabed and the total suspended solids (TSS) concentrations in the water column resulting from the associated discharge programs. Drilling and discharges are proposed for three wells (release locations) and will potentially include re-spud drilling and discharge practices, which has been included as part of the modelling assessment.

The purpose of the modelling is to provide an understanding of a conservative 'outer envelope' of the potential area of deposited cuttings and muds on the seabed and TSS concentrations (TSS) resulting from the proposed drilling and discharge programs.

Methodology

The modelling study was conducted in stages. Firstly, 10-years of three-dimensional current data (2010–2019) for the study region was generated to represent the combined influence of ocean drift currents and tidal currents. Secondly, the current data and discharge characteristics for each of the well drilling and discharge programs were input into a three-dimensional sediment dispersion model, MUDMAP, to predict the movement and initial settlement of cuttings and drilling muds based on the proposed discharge programs, which include three wells, Abbey–A1, Abbey–A3 and Baker and corresponding volumes of discharged cuttings and drilling muds solids into the marine environment of 410 m^3 and 76 m^3, 406 m^3 and 75.2 m^3, and 374 m^3 and 68.8 m^3, respectively. Thirdly, as the spud date can vary, 50 simulations were modelled per well with varying start dates to assess a range of current conditions for each well. Results from the combined 100 simulations for Abbey–A1 and Abbey – A2 wells were overlayed and the 50 simulations for Baker well were also overlayed the to determine the maximum sediment deposition, and total TSS concentrations based on acute (1-hr averaged concentration) and chronic (24-hr averaged concentration) exposure thresholds, in each grid cell for the combined Abbey–A1 and Abbey–A3 discharges and the Backer well discharges, respectively.

Key Results

Deposition

- The maximum predicted thickness of deposited cuttings and muds from the combined Abbey–A1 and Abbey–A3 wells was associated with the drilling of the riserless discharge (i.e., 26" x 36" x 42" bore diameter well interval), which were returned directly to seafloor from a discharge height of 2 m above the seafloor. A maximum thickness of 1.05 m was predicted within 20 m of the discharge location.
- The maximum predicted thickness of deposited cuttings and muds from the Baker well was associated with the drilling of the riserless discharge (i.e., 26" x 36" x 42" bore diameter well interval), which were returned directly to seafloor from a discharge height of 2 m above the seafloor. A maximum thickness of 0.59 m was predicted within 20 m of the discharge location.
- Based on the assessment of 100 simulations for the Abbey–A1 and Abbey–A3 wells, the maximum distances from the release locations (mid-point between wells) to the edge of the low exposure (10 mg/cm²/day [1.11 mm]) , moderate exposure (30 mg/cm²/day [3.33 mm]) and high exposure (100 mg/cm²/day [11.1 mm]) thresholds were 0.41 km, 0.28 km and 0.12 km, respectively.
- Based on the assessment of 50 simulations for Baker well, the maximum distances from the release location to the edge of the low exposure (10 mg/cm²/day [0.44 mm]) , moderate exposure

(30 mg/cm²/day [1.33 mm]) and high exposure (100 mg/cm²/day [4.44 mm]) thresholds were 0.42 km, 0.28 km and 0.18 km, respectively.

Acute (1-hr averaged concentrations) Total Suspended Solids Exposure

- Based on the assessment of 100 simulations for the Abbey–A1 and Abbey–A3 wells, the maximum distance from the release locations (mid-point between wells) to the edge of the low exposure TSS concentration threshold (10 mg/L) for acute exposure (1-hr averaged concentration) was 0.34 km. Additionally, the maximum distance from the release location to the edge of the moderate exposure TSS concentration threshold (50 mg/L) for acute exposure (1-hr averaged concentration) was 0.04 km. High exposure (100 mg/L) TSS concentrations did not exceed 0.02 km from the release location. The total area of coverage for the low exposure threshold, or greater, was 0.26 km^2.
- Based on the assessment of 50 simulations for the Baker well, the maximum distance from the release location to the edge of the low exposure TSS concentration threshold (10 mg/L) for acute exposure (1-hr averaged concentration) was 0.43 km. Additionally, the maximum distance from the release location to the edge of the moderate exposure TSS concentration threshold (50 mg/L) for acute exposure (1-hr averaged concentration) was 0.04 km. High exposure (100 mg/L) TSS concentrations did not exceed 0.02 km from the release location. The total area of coverage for the low exposure threshold, or greater, was 0.35 km^2.

Chronic (24-hr averaged concentrations) Total Suspended Solids Exposure

- The maximum distance from the release location to the edge of the low exposure TSS concentration threshold (5 mg/L) for chronic exposure (24-hr averaged concentration) was 0.35 km. Additionally, the maximum distance from the release location to the edge of the chronic moderate exposure TSS concentration threshold (15 mg/L) was 0.10 km. Chronic high exposure (50 mg/L) TSS did not exceed 0.03 km from the release location. The total area of coverage for the low exposure threshold was 0.23 km^2.
- The maximum distance from the release location to the edge of the low exposure TSS concentration threshold (5 mg/L) for chronic exposure (24-hr averaged concentration) was 0.36 km. Additionally, the maximum distance from the release location to the edge of the chronic moderate exposure TSS concentration threshold (15 mg/L) was 0.12 km. Chronic high exposure (50 mg/L) TSS did not exceed 0.03 km from the release location. The total area of coverage for the low exposure threshold was 0.26 km^2.

1 INTRODUCTION

Petrogas E&P (Petrogas) is the owner of the Abbey and Baker Fields in the southern North Sea. The Abbey Gas Development is located within Block 47/3i, located approximately 40 km east of Yorkshire, whilst the Baker prospect is located within Block 47/3f, positioned approximately 5 km west of the Abbey Field.

To support the environmental permitting process for proposed drilling activities within the Abbey and Baker Fields, Orbis Energy Limited (on behalf of Petrogas) commissioned RPS to undertake a detailed drill cuttings and muds dispersion modelling study to quantify the distribution and sediment thicknesses on the seabed and the total suspended solids (TSS) concentrations in the water column resulting from the associated discharge programs. Drilling and discharges are proposed for three wells (release locations) and will potentially include re-spud drilling and discharge practices, which has been included as part of the modelling assessment.

The coordinates for the modelled Abbey–A1, Abbey–A3 and Baker wells are presented in Table 1.1 and illustrated in Figure 1.1.

The purpose of the modelling is to provide an understanding of a conservative 'outer envelope' of the potential area of deposited cuttings and muds on the seabed and TSS concentrations (TSS) resulting from the proposed drilling and discharge programs.

Modelling was performed using an advanced three-dimensional dispersion model; MUDMAP. The MUDMAP model calculates the transport, spreading, and deposition of discharged cuttings and muds solids over time, based on the prevailing current conditions, the proposed drilling and discharge program, and physical properties of the discharged cuttings and muds solids.

As the spud date may vary, 50 simulations were modelled, per well, with varying start dates to assess a range of current conditions.

Table 1.1 Coordinates for the drill cuttings and muds discharge modelling release locations.

Well name	Latitude*	Longitude*	Water depth (m)
Abbey–A1	53° 56' 4.8266" N	0° 31' 20.9108" E	~40
Abbey–A3	53° 56' 4.6521" N	0° 31' 21.1121" E	~40
Baker	53° 57' 13.7631" N	0° 28' 29.1766" E	~36

*Datum: WGS84

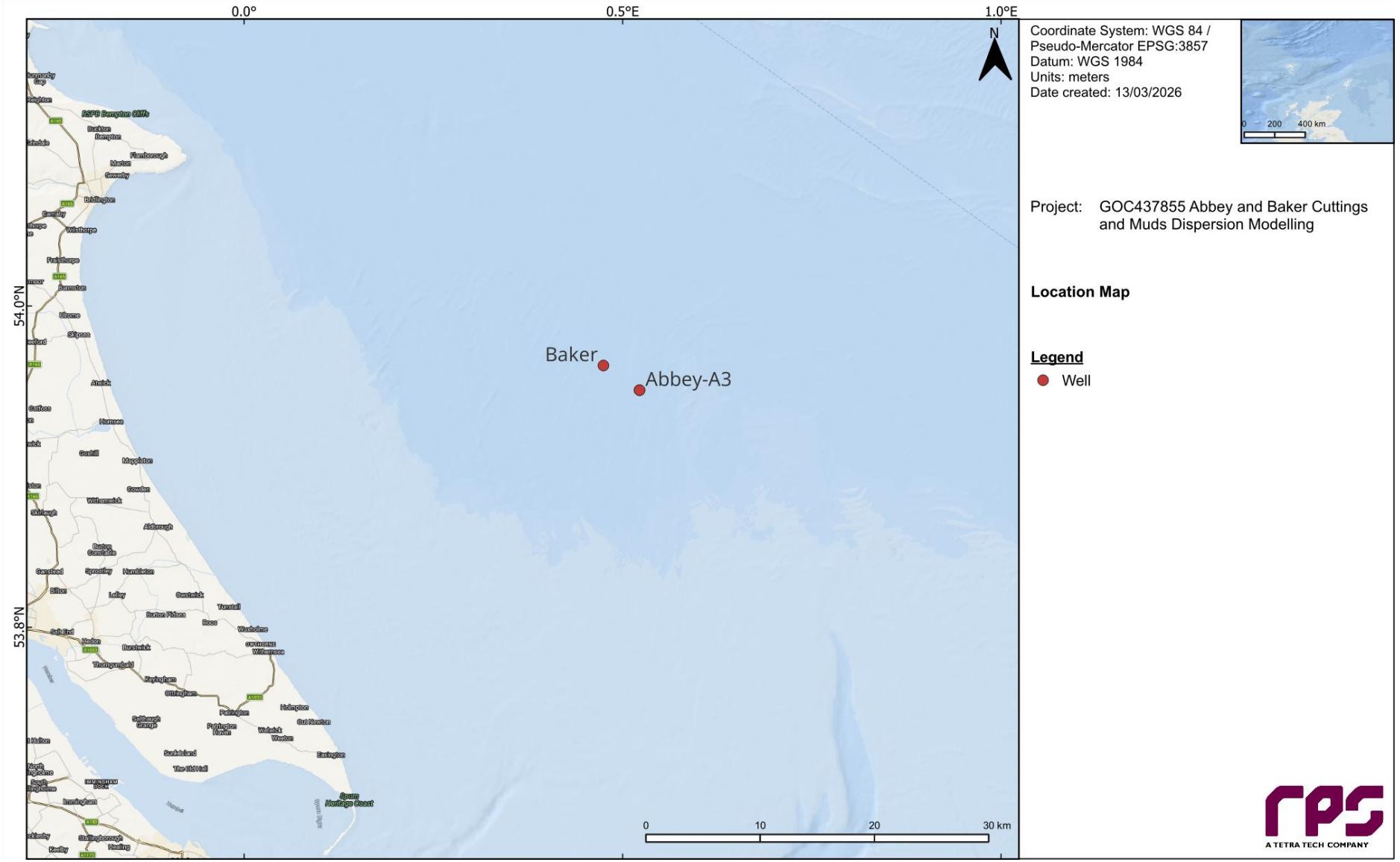

Figure 1.1 Drill cuttings and muds discharge modelling release locations.

2 SCOPE OF WORK

The scope of work included the following components:

1. Ten years (2010 to 2019 (inclusive)) of current data were generated, which included the combined influence of ocean and tidal currents. The current data are suitably long enough to be indicative of interannual variability in ocean currents;

2. The current data and the defined discharge program specifics for each well (release location) were input into the three-dimensional dispersion model (MUDMAP) with a total of 50 simulations modelled per well that included discharges at the seafloor and sea surface. Each well-specific simulation had different start times to ensure a range of current conditions were assessed;

3. Present example deterministic modelling results of the near-seabed and near- surface discharges for the drilling programs for the Abbey–A1 well and Baker well; and

4. Results from the combined 100 simulations for Abbey–A1 and Abbey – A2 wells were overlayed and the 50 simulations for Baker well were also overlayed the to determine the maximum sediment deposition, and total TSS concentrations based on acute (1-hr averaged concentration) and chronic (24-hr averaged concentration) exposure thresholds, in each grid cell for the combined Abbey–A1 and Abbey–A3 discharges and the Backer well discharges, respectively.

3 REGIONAL CURRENTS

Several water mass classifications exist for the North Sea, based on (i) temperature and salinity distributions, (ii) residual current patterns, or (iii) stratification (OSPAR, 2000). The North Sea is a shallow sea that lies between Norway, the United Kingdom and the European Continent. Up to two thirds of the Sea is characterised by a depth shallower than 100 m. The Norwegian Trench being the one exception, with depths exceeding 700 m, which is a feature that has a strong influence on the circulation within the North Sea.

The variability of the general circulation in the North Sea is determined by varying local wind conditions and their interaction with the inflow of Atlantic water masses through the northern and southern boundaries (Mathis et al., 2015). The warm and saline Atlantic waters enter the North Sea through the English Channel and northern boundary (Winther and Johannessen, 2006). Waters entering through the northern boundary can be divided into three different inflow sites; the Orkneys-Shetland section (Fair Isle Current), the Shetland shelf area and the western section of the Norwegian Trench.

General circulation patterns in the North Sea are predominantly cyclonic (Winther and Johannessen, 2006). The Atlantic water flow entering the North Sea is primarily southward and is steered by the local topography. Southern flows adjacent to the Norwegian mainland then proceed eastward through Skagerrak, the strait running between the Jutland peninsula of Denmark, the east coast of Norway and the west coast of Sweden, connecting the North Sea and the Kattegat Sea. This flow continues eastward, and when it reaches the inner part of Skagerrak, the area between Denmark, Sweden and Norway, it meets brackish water from the Baltic Sea and turns northward (Winther and Johannessen, 2006).

Figure 3.1 presents a schematic of the regional currents in the North Sea.

Readers are referred to Lee (1980), Huthnance (1991) and Mathis et al., (2015) for details reviews of the physical oceanography of the North Sea.

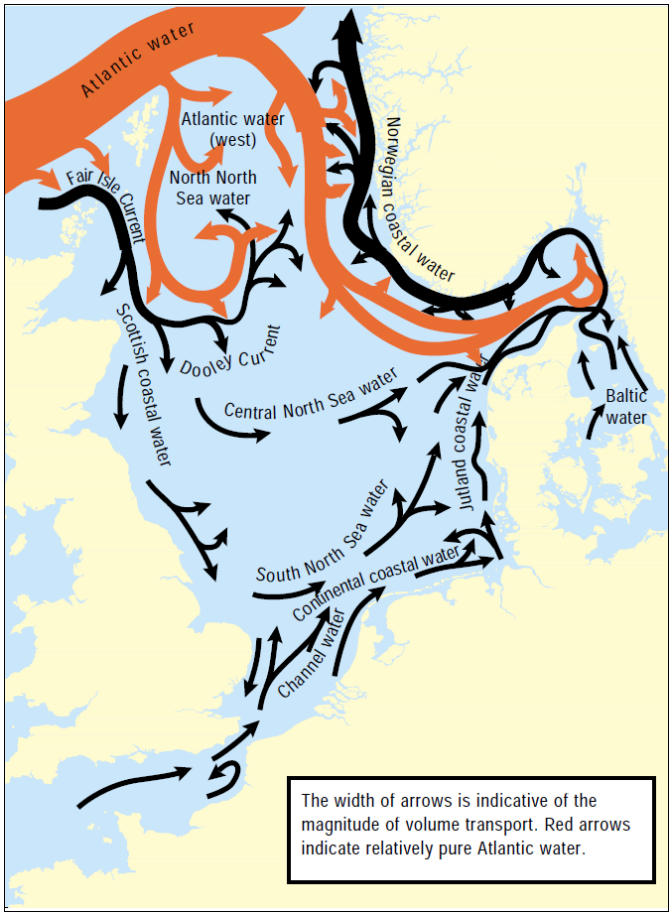

Figure 3.1 Schematic showing the oceanic current circulation in the study region (Image source: OSPAR, 2000).

To accurately describe the variability in currents both horizontally and vertically, data based on the combination of ocean currents and tides were included as part of this study. Below is a summary of the combined datasets.

3.1 Tidal currents

Tidal current data was generated using RPS's advanced ocean/coastal model, HYDROMAP. The HYDROMAP model has been thoroughly tested and verified through field measurements throughout the world for over 35 years (Isaji and Spaulding, 1984; Isaji et al., 2001; Zigic et al., 2003; Makarynskyy et al., 2010), whilst being used for a wide variety of disciplines within marine environments (e.g. Zigic et al., 2003, 2009; Talouli et al., 2009; King et al., 2010; Makarynskyy et al., 2010; 2015). HYDROMAP tidal current data has been used as input to forecast (in the future) and hindcast (in the past) pollutant spills in Australian waters and forms part of the Australian National Oil Spill Emergency Response System operated by AMSA (Australian Maritime Safety Authority).

HYDROMAP employs a sophisticated sub-gridding strategy, which supports up to six levels of spatial resolution, halving the grid cell size as each level of resolution is employed. The sub-gridding allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, and/or of interest to a study.

The numerical solution methodology follows that of Davies (1977a and 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji and Spaulding (1984) and Isaji et al. (2001).

3.1.1 Grid Setup

RPS has a seamless global tidal model. The tidal domains are sub-gridded to a resolution of 500 m for shallow and coastal regions, starting from an offshore (or deep water) resolution of 8 km. The finer grid cells are allocated in a step-wise fashion to more accurately resolve flows along the coastline, around islands and over regions with more complex bathymetry. Figure 3.2 shows a zoomed in image of the North Atlantic Ocean and North Sea model regions.

A combination of datasets was used to describe the shape of the seabed within the high-resolution grid. Depths for the region were extracted from nautical charts and the SRTM30_PLUS dataset (see Becker et al., 2009), which provides a 30-arc second, or approximately 1 km, resolution.

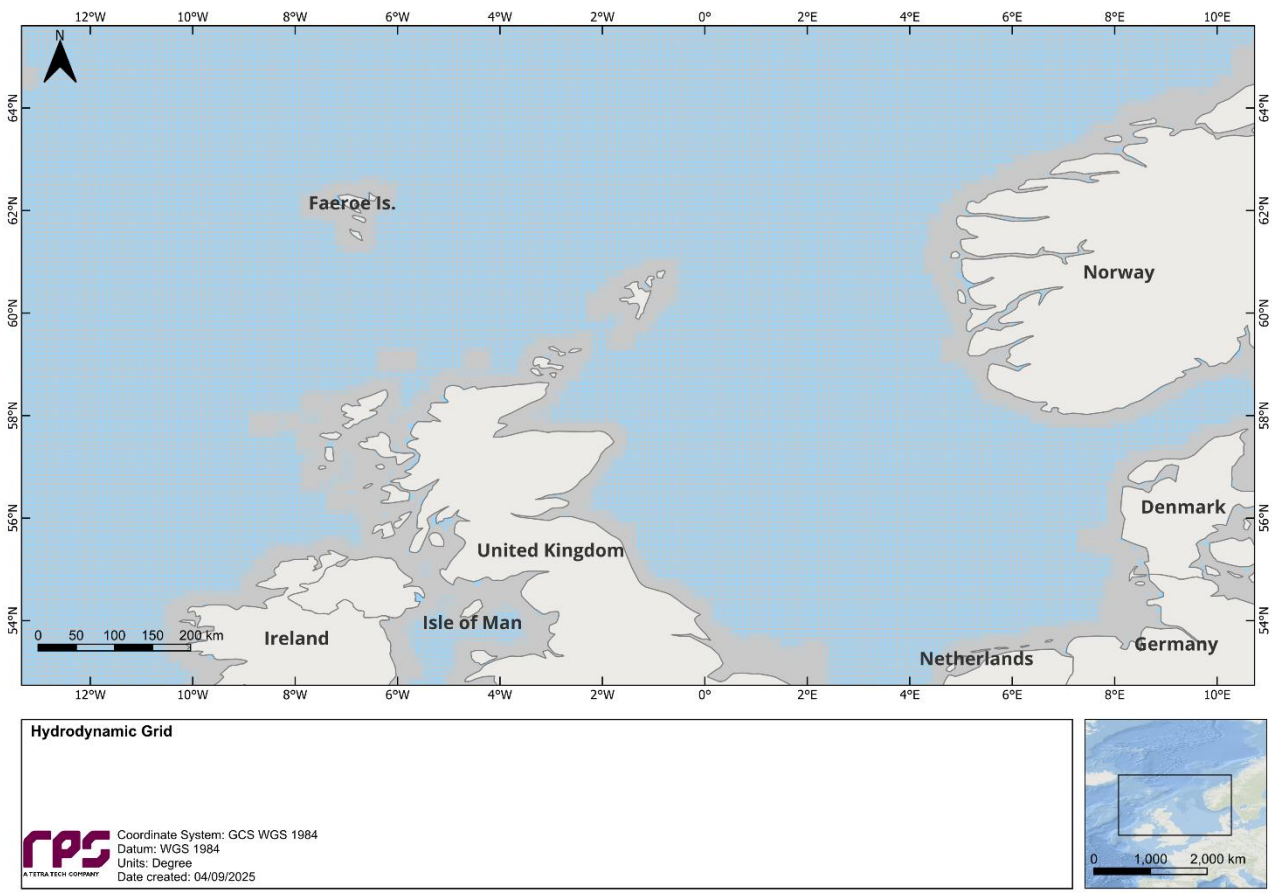

Figure 3.2 Map showing the regions of sub-gridding for the study area and example nearshore resolution.

3.1.2 Tidal Conditions

The ocean boundary data for the regional model was obtained from satellite measured altimetry data (TOPEX/Poseidon 8.0) which provided estimates of the eight dominant tidal constituents at a horizontal scale of approximately 0.25 degrees. The eight major tidal constituents used were K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1. Using the tidal data, time series surface heights were calculated along the open boundaries for the simulation period.

The Topex/Poseidon satellite data has a resolution of 0.25 degrees globally, with higher resolution in coastal regions, and is produced and quality controlled by NASA (National Aeronautics and Space Administration). The data capturing satellites, equipped with two altimeters capable of taking sea level measurements accurate to less than ± 5 cm, measured oceanic surface elevations (and the resultant tides) for the period 1992–2005. In total these satellites carried out 62,000 orbits of the planet. The Topex-Poseidon tidal data has been widely used amongst the oceanographic community, being referenced in more than 2,100 research publications (e.g. Andersen, 1995; Ludicone et al., 1998; Matsumoto et al., 2000; Kostianoy et al., 2003; Yaremchuk and Tangdong, 2004; Qiu and Chen 2010). The Topex/Poseidon tidal data is considered suitably accurate for this study.

3.1.3 Surface Elevation Validation

To ensure that tidal predictions were accurate, predicted surface elevations were compared to data observed at twelve (12) locations situated across the study region (Figure 3.3).

Figure 3.4 to Figure 3.7 illustrate a comparison of the predicted and observed surface elevations for each location for January 2014. As shown on the graph, the model accurately reproduced the phase and amplitudes throughout the spring and neap tidal cycles well.

To provide a statistical measure of the model's performance, the Index of Agreement (IOA – Willmott, 1981) and the Mean Absolute Error (MAE – Willmott, 1982; Willmott and Matsuura, 2005) were used.

The MAE is the average of the absolute values of the difference between the model-predicted (P) and observed (O) variables. It is a more natural measure of the average error and more readily understood (Willmott and Matsuura, 2005).

$$MAE = N^{-1}\sum_{i=1}^{N}|P_i - O_i|$$

The Index of Agreement (IOA) is determined by:

$$IOA = 1 - \frac{\sum|X_{model} - X_{obs}|^2}{\sum(|X_{model} - \overline{X_{obs}}| + |X_{obs} - \overline{X_{obs}}|)^2}$$

Where: *X* represents the variable being compared and the time mean of that variable. A perfect agreement exists between the model and field observations if the index gives an agreement value of 1 and complete disagreement will produce an index measure of 0 (Wilmott, 1981). Willmott et al., (1985) also suggests that values meaningfully larger than 0.5 represent good model performance. Clearly, a greater IOA and lower MAE represent a better model performance.

Table 3.1 shows the IOA and MAE values for the selected locations.

Figure 3.3 Location of the tide stations around used to demonstrate the accuracy of the tidal model.

Table 3.1 Statistical comparison between the observed and HYDROMAP predicted surface elevations data from the 1st to 31st January 2014.

Tide Station	IOA	MAE (m)
Aberdeen	0.99	0.13
Arendal	0.92	0.03
Belfast	0.99	0.15
Concarneau	1.00	0.09
Dover	0.95	0.50
Galway	0.99	0.14
Hvalba	0.99	0.32
Immingham	0.91	0.66
Kristiansund	0.96	0.91
Lerwick, Shetland Islands	0.99	0.06
Milford Haven	0.98	0.32
Wierumergronden	0.92	0.28
Average	**0.97**	**0.30**

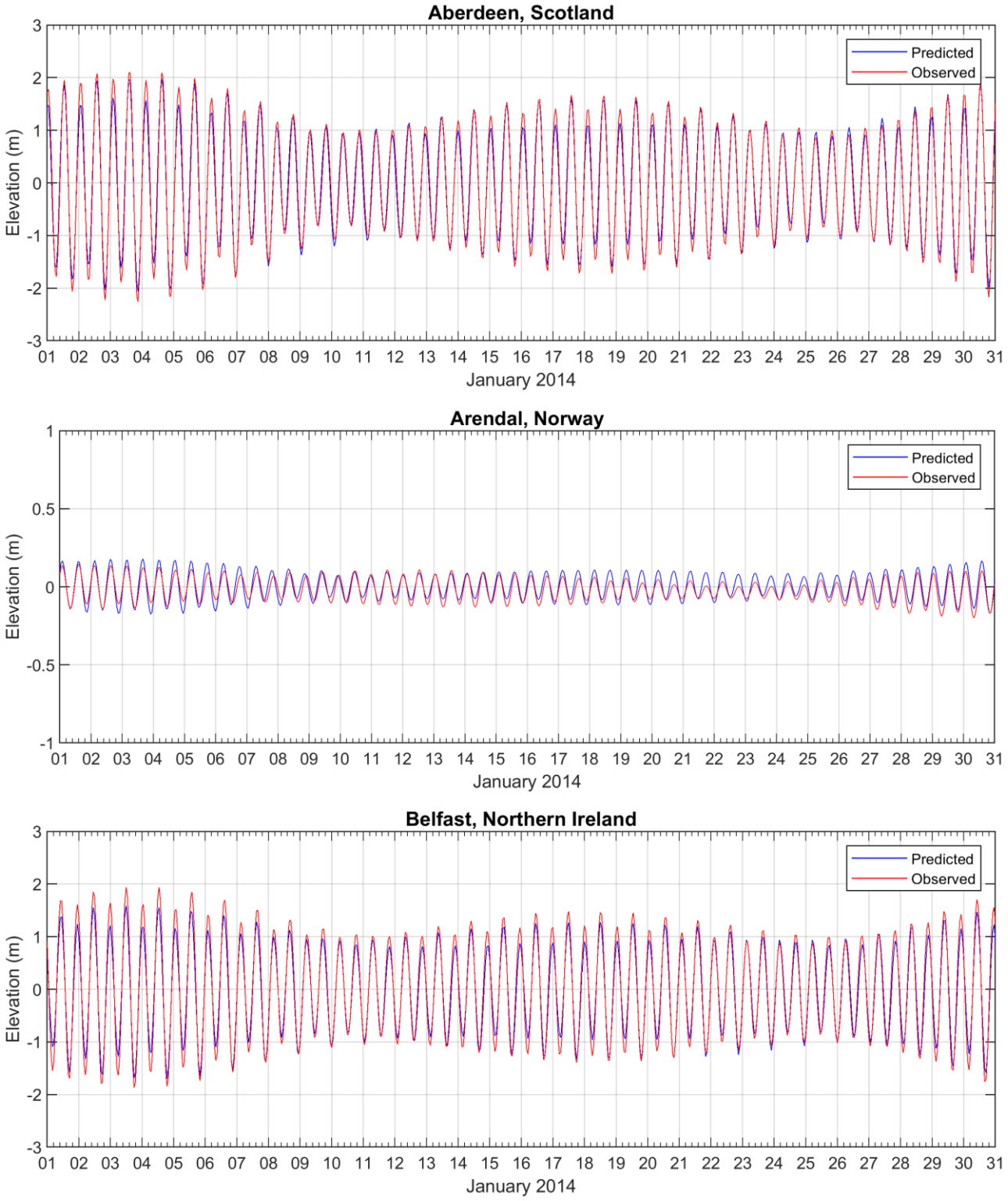

Figure 3.4 Comparison between predicted (blue line) and observed (red line) surface elevation variation at Aberdeen (top), Arendal (middle) and Belfast (bottom), between the 1st and the 31st of January 2014.

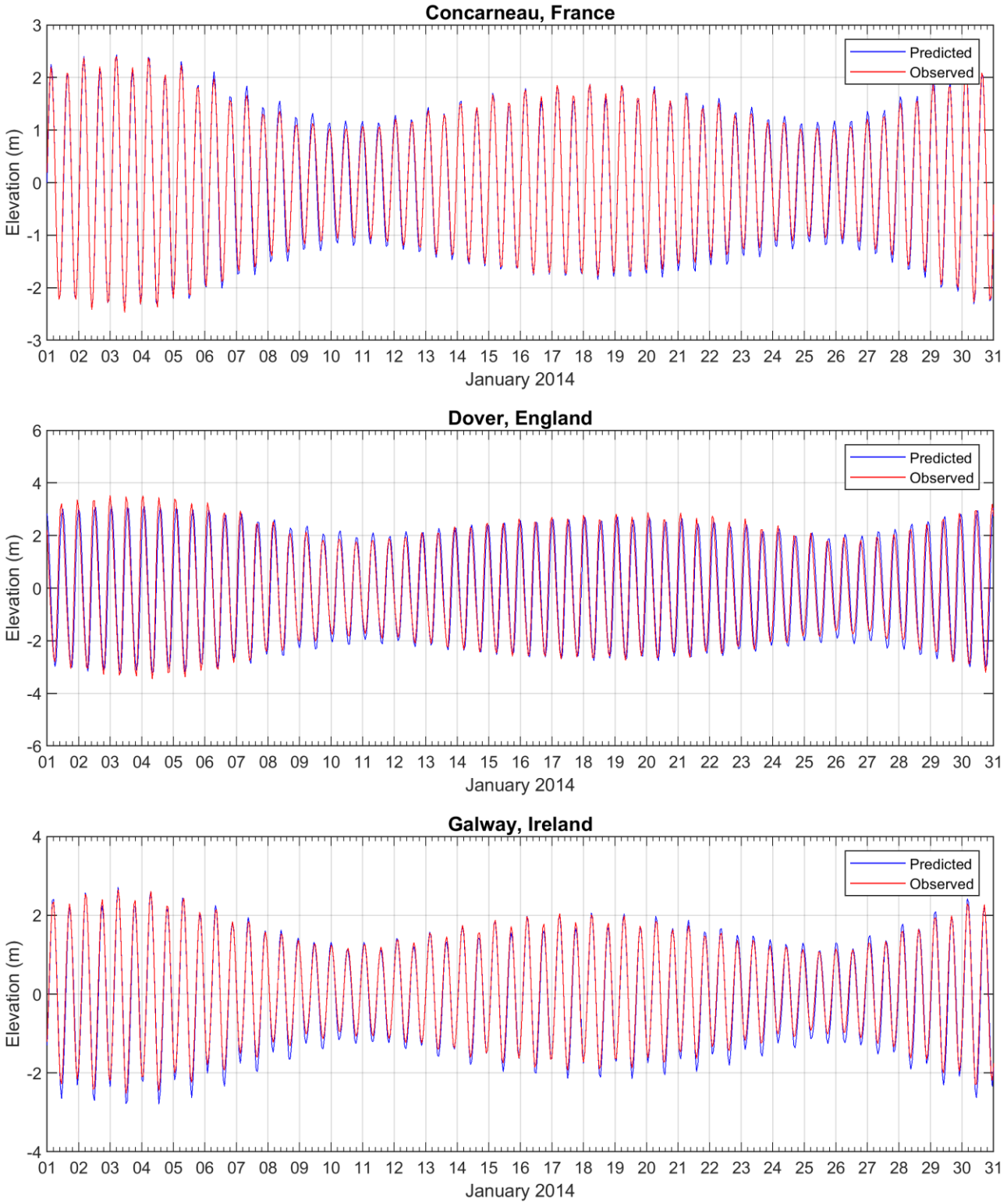

Figure 3.5 Comparison between predicted (blue line) and observed (red line) surface elevation variation at Concarneau (top), Dover (middle) and Galway (bottom), between the 1st and the 31st of January 2014.

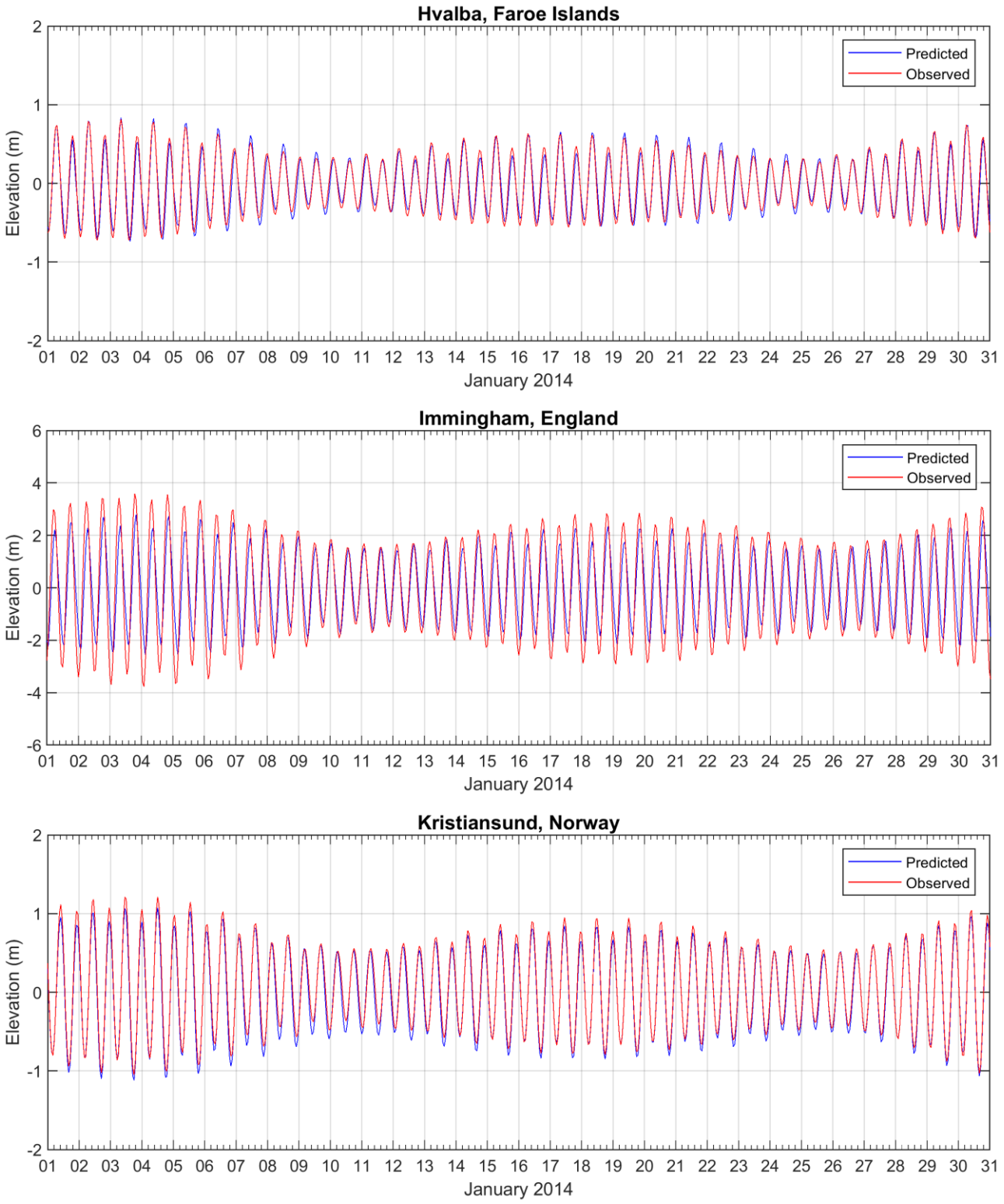

Figure 3.6 Comparison between predicted (blue line) and observed (red line) surface elevation variation at Hvalba (top), Immingham (middle) and Kristiansund (bottom), between the 1st and the 31st of January 2014.

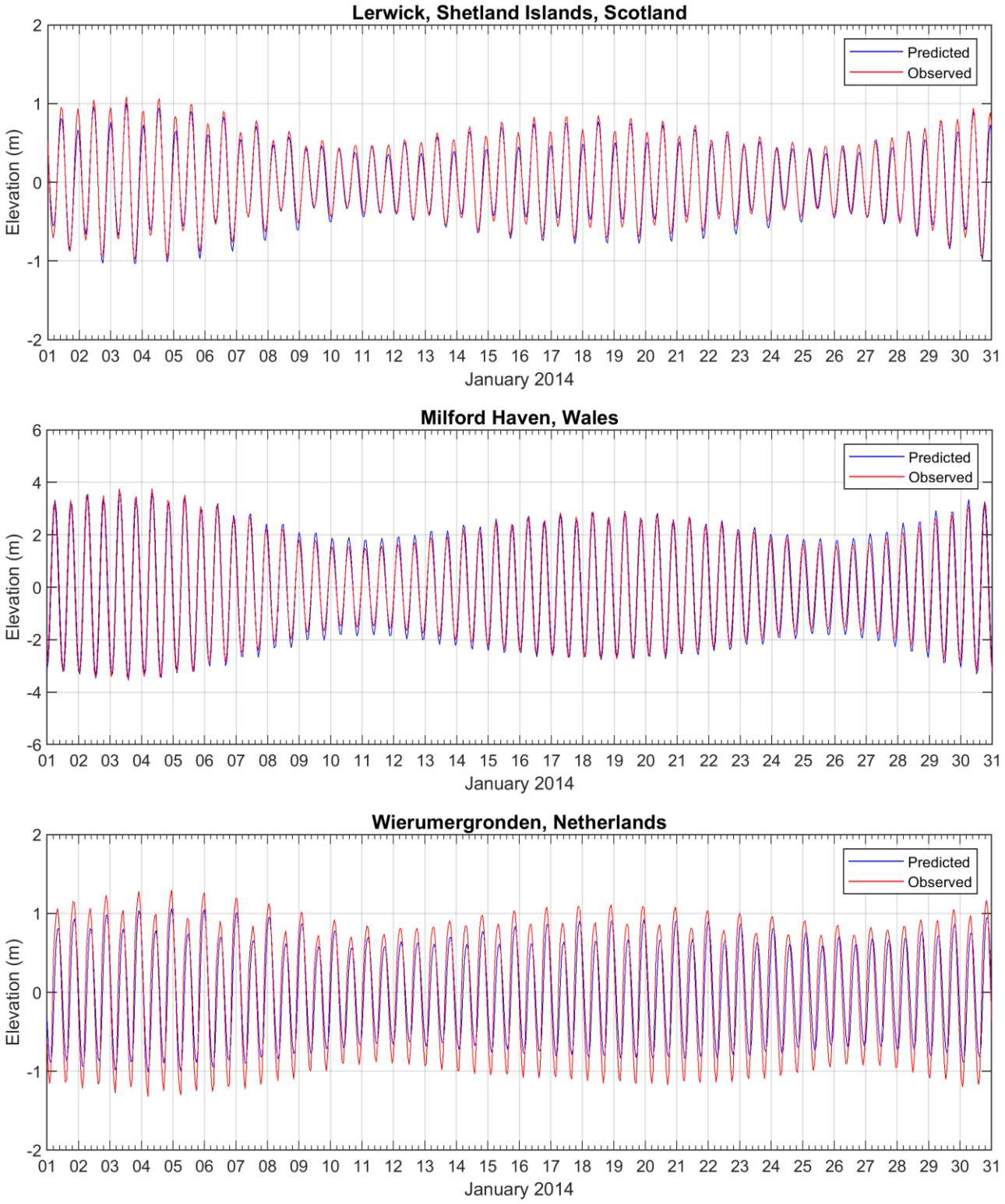

Figure 3.7 Comparison between predicted (blue line) and observed (red line) surface elevation variation at Lerwick (top), Milford Haven (middle) and Wierumergronden (bottom), between the 1st and the 31st of January 2014.

3.2 Three-Dimensional Ocean Currents – HYCOM

Data describing the flow of ocean currents were for the years 2010 to 2019 (inclusive) obtained from HYCOM (Hybrid Coordinate Ocean Model) (Chassignet et al., 2007), which is operated by the HYCOM Consortium, sponsored by the Global Ocean Data Assimilation Experiment (GODAE). HYCOM is a data-assimilative, three-dimensional ocean model that is run as a hindcast (for a past period), assimilating time-varying observations of sea surface height, sea surface temperature and in-situ temperature and salinity measurements (Chassignet et al., 2009). The HYCOM predictions for drift currents are produced at a horizontal spatial resolution of approximately 8.25 km (1/12th of a degree) over the region, at a frequency of every 3 hours. HYCOM uses isopycnal layers in the open, stratified ocean, but uses the layered continuity equation to make a dynamically smooth transition to a terrain following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or unstratified seas.

The HYCOM model has been extensively documented through many publications which are available online[1]. The HYCOM data have also been used within the North Sea region for various application (e.g., Melsom, 2005; Winther and Johannessen, 2006; Winther and Evensen, 2006; Akinbamini et al., 2022).

For this study, the HYCOM hindcast currents were obtained for the year 2010-2019. Figure 3.8 provides an example of the modelled surface ocean currents (HYCOM) for the region.

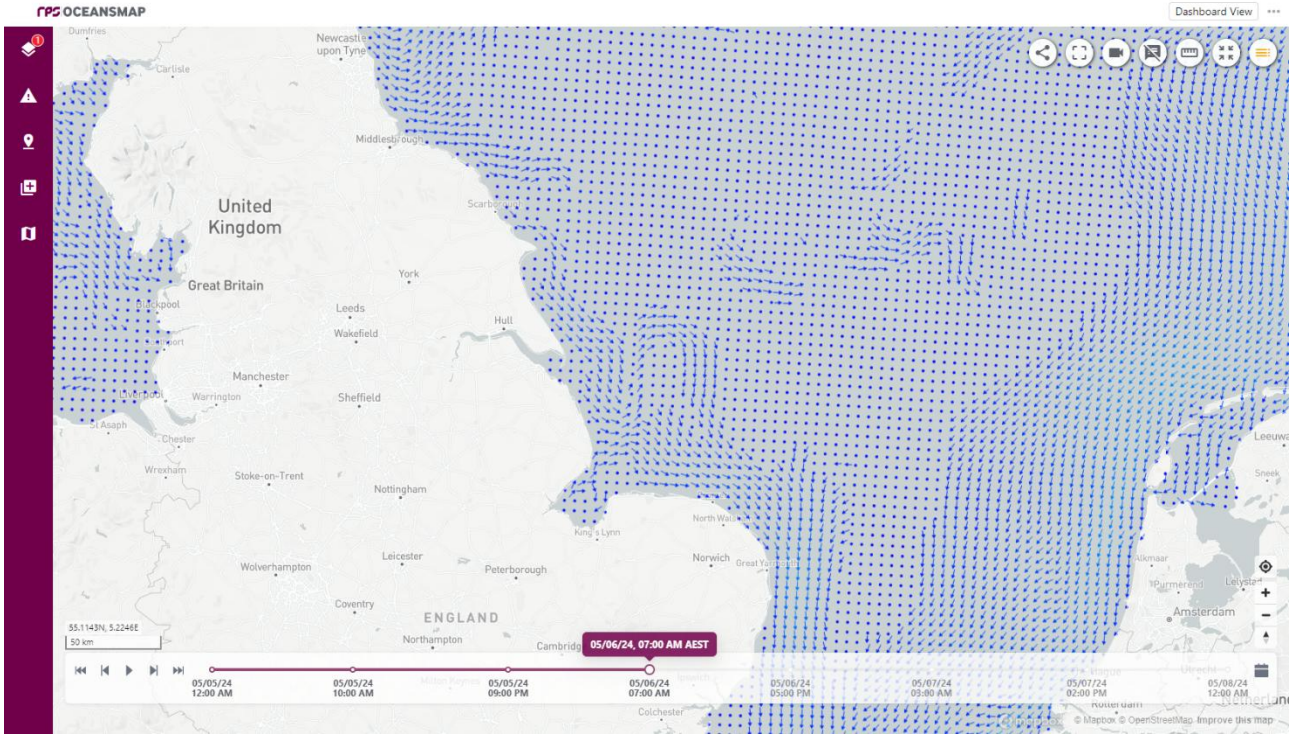

Figure 3.8 Snapshot example of the predicted HYCOM ocean surface currents in the region. Colour and size of individual arrows indicate current speed (m/s).

[1] https://hycom.org/publications

3.3 Surface and Near-Bottom Currents

Figure 3.9 and Figure 3.10 present the monthly surface and near-bottom current roses nearby the three release locations, respectively. Note the convention for defining current direction is the direction the current flows towards, which is used to reference current direction throughout this report. Each branch of the rose represents the currents flowing to that direction, with north to the top of the diagram. Sixteen directions are used. The branches are divided into segments of different colour, which represent the current speed ranges for each direction. Speed intervals of 0.1 m/s are predominantly used in these current roses. The length of each coloured segment is relative to the proportion of currents flowing within the corresponding speed and direction.

Table 3.2 and Table 3.3 present the surface and near-bottom monthly current speeds and directions nearby the three release locations, respectively.

The monthly average surface current speeds ranged from 0.11 m/s (April–September) to 0.16 m/s (December). Additionally, the monthly maximums reached speeds ranging between 0.46 m/s (July) to 1.01 m/s (December; Table 3.2). Surface current directions were predominantly east-southeast followed by a trend towards the northwest (Figure 3.9).

In comparison, the monthly average near-bottom current speeds were relatively consistent ranging from 0.06 m/s (May–July) to 0.09 m/s (December), whilst near-bottom monthly maximum current speeds ranged between 0.23 m/s (July) and 0.52 m/s (December; Table 3.3). Additionally, the near-bottom current directions predominantly occurred along the northwest–southwest axis (Figure 3.10).

Table 3.2 Monthly average and maximum surface current speeds nearby the three release locations. The data was derived by combining the HYCOM ocean data and HYDROMAP tidal data for 2010-2019.

Month	Average current speed (m/s)	Maximum current speed (m/s)	General direction(s)
January	0.15	0.87	Southeast
February	0.14	0.65	East-southeast
March	0.13	0.74	Northwest–Southeast
April	0.11	0.55	Northwest–Southeast
May	0.11	0.52	Northwest–Southeast
June	0.11	0.63	Northwest–Southeast
July	0.11	0.46	Northwest–Southeast
August	0.11	0.56	East-southeast
September	0.11	0.66	East-southeast
October	0.13	0.59	Northwest–Southeast
November	0.14	0.82	Northwest–Southeast
December	0.16	1.01	Southeast
Minimum	**0.11**	**0.46**	-
Maximum	**0.16**	**1.01**	

Table 3.3 Monthly average and maximum near-bottom current speeds nearby the three release locations. The data was derived by combining the HYCOM ocean data and HYDROMAP tidal data for 2010-2019.

Month	Average current speed (m/s)	Maximum current speed (m/s)	General direction(s)
January	0.09	0.46	Northwest-southeast
February	0.08	0.35	
March	0.08	0.34	
April	0.07	0.29	
May	0.06	0.31	
June	0.06	0.26	
July	0.06	0.23	
August	0.07	0.25	
September	0.07	0.32	
October	0.08	0.28	
November	0.08	0.43	
December	0.09	0.52	
Minimum	**0.06**	**0.23**	-
Maximum	**0.09**	**0.52**	

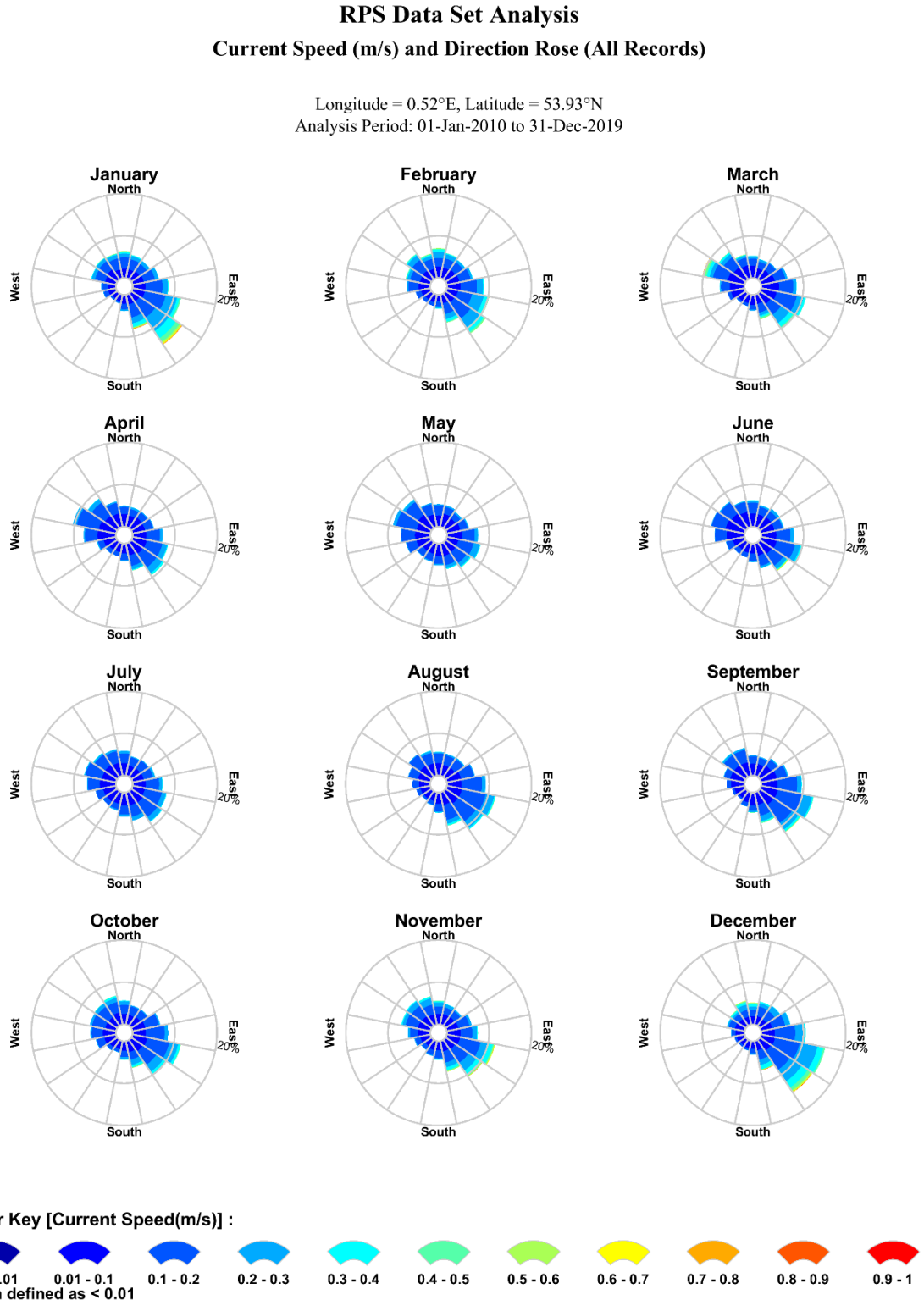

Figure 3.9 Monthly surface current rose distributions nearby the three release locations, derived from the 2010 to 2019 modelled dataset.

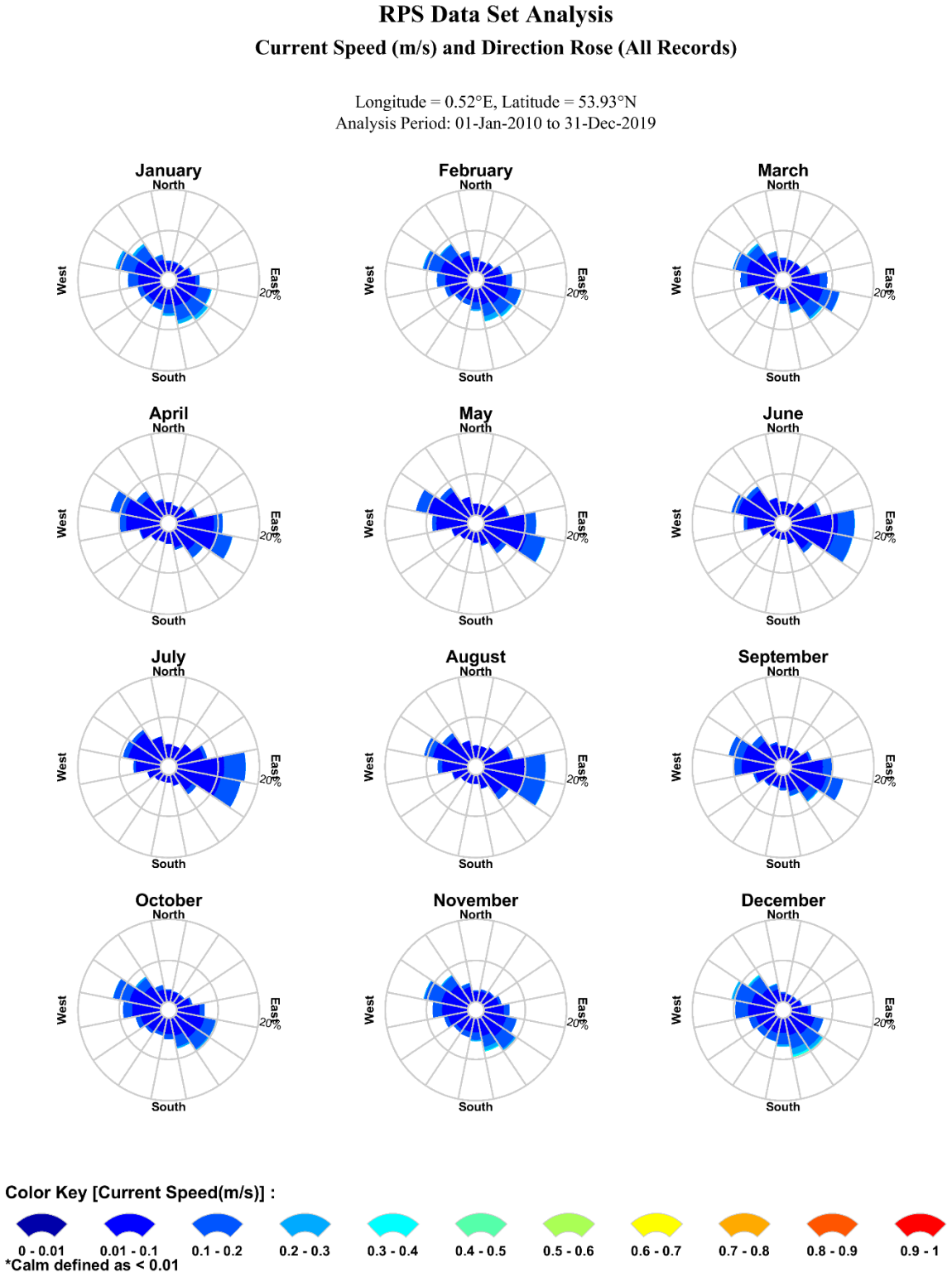

Figure 3.10 Monthly near-bottom current rose distributions nearby the three release locations, derived from the 2010 to 2019 modelled dataset.

4 WATER TEMPERATURE AND SALINITY

The monthly depth-varying water temperature and salinity profiles nearest to the release location were obtained from the HYCOM dataset (see Section 3.2).

The three-dimensional salinity and temperature datasets are used in the model domain to inform water density in through the water column layers.

Table 4.1 presents the monthly average sea temperature and salinity of the surface layer nearby the release location. Monthly average surface water temperature ranged from 5.6°C (March) to 15.5°C (August). In contrast, near-bottom waters ranged from 6.3°C (March) to 12.8°C (September). Salinity remained relatively consistent through the water column ranging between 33.8 psu to 34.8 psu.

Figure 4.1 presents depth profiles of water temperature and salinity nearby the release location.

Table 4.1 Monthly average sea surface temperature and salinity nearby the three release locations.

Month	Temperature (°C)		Salinity (psu)	
	Surface	Near-bottom	Surface	Near-bottom
January	6.2	6.7	34.2	34.5
February	6.1	6.5	34.3	34.7
March	5.6	6.3	34.6	34.8
April	7.4	7.2	34.7	34.8
May	8.4	7.2	34.6	34.4
June	14.8	10.5	34.3	34.5
July	15.2	10.3	34.5	34.6
August	15.5	11.1	34.5	34.6
September	13.9	12.8	34.4	34.4
October	13.6	12.5	34.3	34.7
November	9.1	8.9	34.7	34.8
December	9.9	11.4	33.8	34.6
Minimum	**5.6**	**6.3**	**33.8**	**34.4**
Maximum	**15.5**	**12.8**	**34.7**	**34.8**

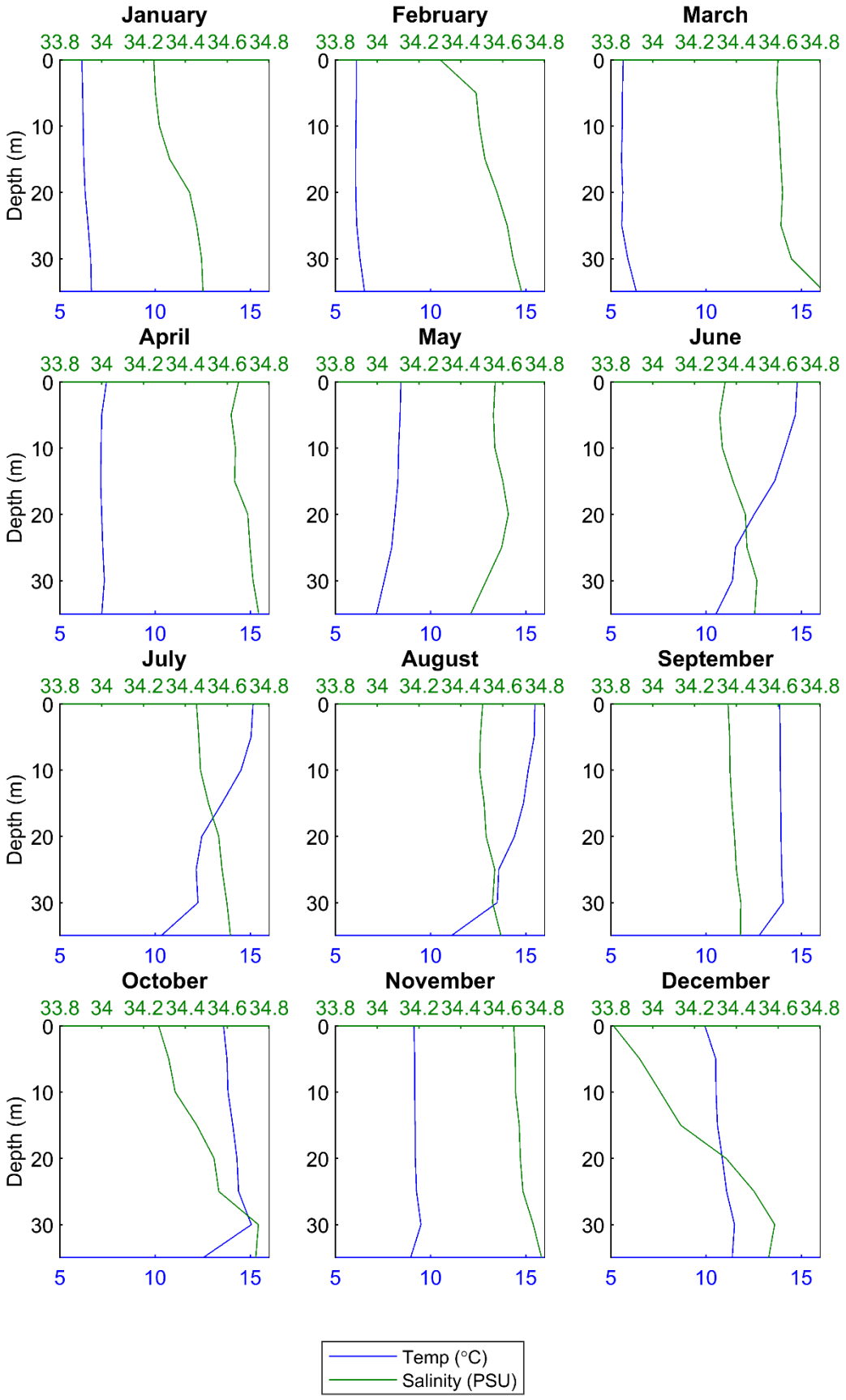

Figure 4.1 Monthly average depth profiles of water temperature and salinity nearby the three release locations.

5 SEDIMENT DISPERSION MODELLING

5.1 Sediment Dispersion Model Description – MUDMAP

MUDMAP is a three-dimensional plume model used by industry and regulators to aid in assessing the potential environmental effects from operational discharges such as drill cuttings, drilling fluids (muds) and produced water. The model has been applied to hundreds of assessments in over 35 countries.

The far-field calculation (passive dispersion stage) employs a particle-based, random walk procedure. The model predicts the dynamics of the discharge material and resulting seabed concentrations and bottom thicknesses over the near-field (i.e. the immediate area of the discharge) and the far-field (the wider region). Figure 5.1 shows a conceptual diagram of the dispersion and fates of drill cuttings and muds discharge to the ocean and an idealized representation of the three discharge phases.

Settling under currents is selective for particle size, with the larger particles (rock chips to sand) tending to settle quickly, forming a pile that aligns with the predominant current axis. Smaller particles (especially silts and clays) will remain suspended for longer periods and will therefore be dispersed more widely by the ambient current conditions. Dispersion of the finer discharged material will tend to be enhanced with increased current speeds and water depth and with greater variation in current direction over time and depth.

Along with the advanced analyses tools, MUDMAP can simulate six classes of material (or 36 sub-categories), each with unique density and particle-size distribution. During the dispersion stage, the model particles are transported in three-dimensions according to the current data and horizontal and vertical mixing coefficients at each time step according to the governing equations.

MUDMAP has been extensively reported, validated and applied for discharge operations (e.g. Burns et. al., 1999; King and McAllister, 1997, 1998; Spaulding, 1994; Albert and Prosser, 2023).

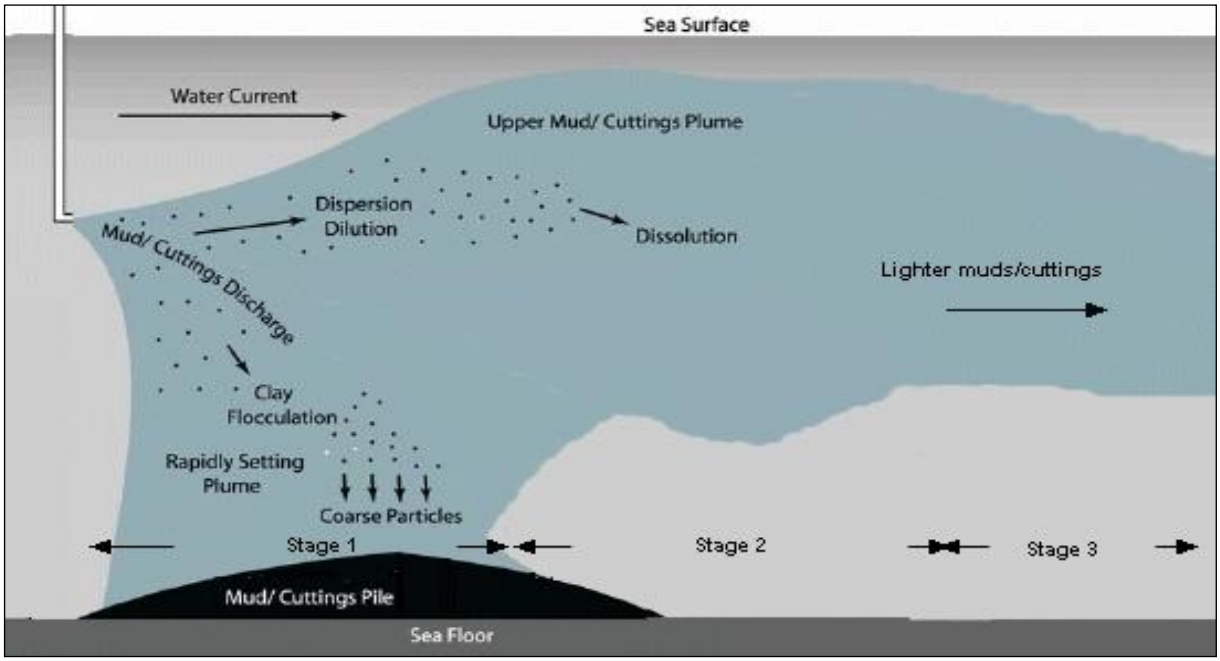

Figure 5.1 Conceptual diagram showing the general behaviour of cuttings and muds following the discharge to the ocean (Neff, 2005) and the idealised representation of the three discharge phases.

5.2 Drilling and Discharge Program

Petrogas has indicated that a conventional drilling design will be used for the proposed drilling programs for the Abbey–A1, Abbey–A3 and Baker wells. The following is the description of the proposed drilling and discharge programs.

Table 5.1 to Table 5.3 presents a summary of the estimated discharge of volume of drill cuttings and unrecoverable mud solids for the proposed drilling and discharge programs for the Abbey–A1, Abbey–A3 and Baker wells, respectively. To account for any unforeseen mechanical or geological issues, a re-spud scenario has been added to each of the well intervals for each well to represent a worst-case scenario.

Drilling of each of the wells will commence with a 26" x 36" x 42" bore diameter well interval followed by a 17 ½" bore diameter well interval that may require a re-spud scenario. The 26" x 36" x 42" bore diameter well interval will be drilled using seawater and hi-vis sweeps with the cuttings being returned (discharged) directly to the seafloor (riser-less discharge) over 1 day.

Following the near-seabed discharge, the 17 ½" bore diameter well interval will be drilled using spud mud (water-based mud) with KCl inhibitor that may also require a re-spud scenario. The cuttings and unrecoverable muds from this interval will be brought to the rig via a 30" environmental riser and returned to 1 m below the sea surface from a vertically orientated pipe over 4 days (Abbey–A1), 4 days (Abbey–A3) and 3 days (Baker).

The anticipated total discharge duration for the Abbey–A1, Abbey–A3 and Baker wells (including re-spud scenario) is 10 days, 10 days and 8 days, respectively.

Table 5.1 Summary of the estimated discharge of volume of drill cuttings and unrecoverable mud solids for each well interval for the Abbey–A1 well, including the potential for a re-spud scenario.

Bore Diameter (inches)	Discharge method	Volume of cuttings solids discharged (m^3)	Fluid Type	Volume of muds liquid and solids (m^3)	Volume of solids in the muds (m^3)	Discharge Duration (days)
26" x 36" x 42"	To seabed (riserless drilling)	60 (20% washout included)	Seawater and hi-vis sweeps displace to spud mud at TD	90	9	1
17 ½"	From rig (30" environmental riser back to rig installed)	145 (20% washout included)	Spud mud, displace to KCl inhibited mud system during drilling	290	29	4
26" x 36" x 42" (re-spud)	To seabed (riserless drilling)	60 (20% washout included)	Seawater and hi-vis sweeps displace to spud mud at TD	90	9	1
17 ½" (re-spud)	From rig (30" environmental riser back to rig installed)	145 (20% washout included)	Spud mud, displace to KCl inhibited mud system during drilling	290	29	4
Total		**410**		**760**	**76**	**10**

Table 5.2 Summary of the estimated discharge of volume of drill cuttings and unrecoverable mud solids for each well interval for the Abbey–A3 well, including the potential for a re-spud scenario.

Bore Diameter (inches)	Discharge method	Volume of cuttings solids discharged (m^3)	Fluid Type	Volume of muds liquid and solids (m^3)	Volume of solids in the muds (m^3)	Discharge Duration (days)
26” x 36” x 42”	To seabed (riserless drilling)	60 (20% washout included)	Seawater and hi-vis sweeps displace to spud mud at TD	90	9	1
17 ½”	From rig (30” environmental riser back to rig installed)	143 (20% washout included)	Spud mud, displace to KCl inhibited mud system during drilling	286	28.6	4
26” x 36” x 42” (re-spud)	To seabed (riserless drilling)	60 (20% washout included)	Seawater and hi-vis sweeps displace to spud mud at TD	90	9	1
17 ½” (re-spud)	From rig (30” environmental riser back to rig installed)	143 (20% washout included)	Spud mud, displace to KCl inhibited mud system during drilling	286	28.6	4
Total		**406**		**752**	**75.2**	**10**

Table 5.3 Summary of the estimated discharge of volume of drill cuttings and unrecoverable mud solids for each well interval for the Baker well. , including the potential for a re-spud scenario

Bore Diameter (inches)	Discharge method	Volume of cuttings solids discharged (m^3)	Fluid Type	Volume of muds liquid and solids (m^3)	Volume of solids in the muds (m^3)	Discharge Duration (days)
26” x 36” x 42”	To seabed (riserless drilling)	60 (20% washout included)	Seawater and hi-vis sweeps displace to spud mud at TD	90	9	1
17 ½”	From rig (30” environmental riser back to rig installed)	127 (20% washout included)	Spud mud, displace to KCl inhibited mud system during drilling	254	25.4	3
26” x 36” x 42” (re-spud)	To seabed (riserless drilling)	60 (20% washout included)	Seawater and hi-vis sweeps displace to spud mud at TD	90	9	1
17 ½” (re-spud)	From rig (30” environmental riser back to rig installed)	127 (20% washout included)	Spud mud, displace to KCl inhibited mud system during drilling	254	25.4	3
Total		**374**		**688**	**68.8**	**8**

5.3 Discharge Input Data

The input data used to setup the dispersion model included:

- Volume and discharge duration of the cuttings and unrecovered muds solids;
- Particle size distributions (PSD) and associated settling velocities of discharged cuttings and unrecoverable muds solids;
- Bulk density of the discharged cuttings and unrecoverable muds solids;
- Temperature and salinity profile of the receiving waters;
- The size and orientation of the discharge pipe;
- The height/depth of the discharge point relative to mean sea level; and
- Depth-varying current data to represent local physical forcing.

Table 5.4 provides a summary of the discharge configuration and the estimated volume of cuttings and muds solids input into the discharge model. Simulations were run for an additional period after the completed discharges to allow sediments to disperse through the water column and potentially deposit on the seafloor (see Table 5.4).

Table 5.4 Input data used for the drill cuttings and muds modelling.

Parameter/description	Abbey–A1	Abbey–A3	Baker
Total volume of cuttings discharged (m^3)	410	406	374
Total volume of muds solids discharged (m^3)	76	75.2	68.8
Discharge duration (days) [model duration (days)]	10 [12]	10 [12]	8 [10]
Depth of surface discharge (m)	1	1	1
Height of riserless discharge above seafloor (m)	2	2	2
Water depth (m)	40	40	36
Discharge pipe orientation	Vertically downwards	Vertically downwards	Vertically downwards
Number of simulations	50 (randomly selected start simulation dates and times between 2010–2019, inclusive)	50 (randomly selected start simulation dates and times between 2010–2019, inclusive)	50 (randomly selected start simulation dates and times between 2010–2019, inclusive)
Seasonal or Annual assessment	Annual	Annual	Annual

It is anticipated that all wells will be drilled using a conventional drilling approach. Model input included particle sizes for cuttings and drilling muds returned to the seafloor varying in diameter between 0.016 mm and 6 mm (Table 5.5). The PSD is representative of data previously used for well intervals drilled using water based muds (e.g. Koh & Teh, 2011; IOGP, 2016). The PSD are based on the relative contribution of cuttings and drilling muds discharge volumes.

It is important to note that grain size has a greater influence on the rate of settling than density (Neff, 2005). The fall velocities for the various size classes were derived from empirical data provided by Dyer (1986).

Table 5.5 Cuttings and muds sediment grain sizes, settling velocities and percentage distributions applicable for each well.

Class	Grain size (mm)	Settling velocity (cm/s)	Percentage Distributions
Medium cuttings	6	53.62	8.6
	5	49.46	8.6
	2	28.55	8.6
	1	12.73	5.8
	0.5	7.5	5.8
	0.45	6.6	2.9
Light cuttings	0.4	6	2.9
	0.35	5	2.8
	0.3	4	2.8
	0.25	3.1	2.8
	0.2	2.3	2.8
	0.15	1.6	2.8
Very light cuttings	0.1	0.8	2.8
	0.05	0.22	2.8
	0.04	0.15	2.9
	0.03	0.08	2.9
	0.02	0.04	2.9
Drilling mud solids	0.063	0.34	0.4
	0.05	0.22	1.6
	0.035	0.11	3.7
	0.026	0.06	6
	0.02	0.038	7.4
	0.016	0.026	9.4

5.4 Grid Configuration

Individual grids covering 20 km (longitude, x-direction) by 20 km (latitude, y-direction) region with varying depths waere employed for the discharge modelling of the respective wells. The grids consisted of cells with a horizontal resolution of 20 m to calculate the deposition of drill cuttings and muds on the seabed and a vertical resolution of 5 m to estimate the TSS concentrations.

5.5 Mixing Parameters

The horizontal and vertical dispersion coefficients are used in dispersion modelling to represent the mixing and diffusion processes caused by turbulence, which are sub-grid processes at the scale of the hydrodynamic model drivers. The dispersion coefficients are expressed in units of rate of area change (m^2/s). Increasing the horizontal dispersion coefficient will increase the horizontal spread of the discharge plume and decrease the centreline concentrations. Increasing the vertical dispersion coefficient spreads the discharge further across the vertical layers.

The horizontal turbulent diffusion of the plume is dependent on the hydrodynamic conditions (i.e. wind, wave and current) and the physical scale of the plume compared to the scales of the oceanic processes that

disperse the plume. For a plume of approximately 10-100 m width, dispersion occurs primarily through small-scale horizontal swirling motions and vertical mixing, with a horizontal dispersion rate of the order of 0.1 m^2/s. As the plume grows to a scale of 1-10 km, it begins to be subject to mesoscale eddies and horizontal dispersion rate becomes of the order of a few to tens m^2/s.

For both modelled fields, a horizontal coefficient value of 0.25 m^2/s was used to account for the turbulence as the discharged solids are transported from the release locations for the near-bottom discharges. Additionally for the near-bottom discharges a low vertical coefficient value was employed (0.0001 m^2/s). In comparison, sea surface discharges employed horizontal and vertical coefficients of 1.0 m^2/s and 0.001 m^2/s, respectively.

5.6 Reporting Thresholds

The MUDMAP model is capable of predicting sediment deposition and TSS concentrations at levels below ecological relevance. To ensure that model results are both meaningful and interpretable, carefully selected thresholds for reporting are applied. Among the various sensitive marine ecosystems affected by sediment and turbidity stress, corals are recognised as the most vulnerable. Although cold-water corals have not been recorded in this area of the North Sea, by applying thresholds based on coral responses, this assessment adopts a worst-case conservative benchmark that ensures the protection of the most sensitive ecosystem components.

5.6.1 Deposition

Sediment impact is usually assessed by total sedimentation rate (mass of sediment settling per unit area per day), deposition thickness, or both.

Coral species vary widely regarding their tolerance to sediment deposition, ranging from less than 10 $mg/cm^2/day$ to over 400 $mg/cm^2/day$ (Erftemeijer et al., 2012). A conservative low exposure threshold of 10 $mg/cm^2/day$ has been applied for this study (see Table 5.6 and Table 5.7). Sustained high sedimentation rates of 30 $mg/cm^2/day$ (Hodgson, 1990; Browne et al., 2015) and above 100 $mg/cm^2/day$ over several weeks can lead to coral smothering, tissue necrosis, and long-term declines in coral cover (MScience, 2011). These impacts result from multiple interacting stressors, including the physical burden of sediments, shading and light limitation, and nutrient and contaminant loads associated with suspended material (Fabricius, 2005).

Accordingly, moderate and high exposure thresholds are set at ≥30 $mg/cm^2/day$ and ≥100 $mg/cm^2/day$, respectively, as shown in Table 5.6 and Table 5.7.

Equivalent sediment thicknesses were calculated based on the anticipated total discharge periods of 24 days (Combined Abbey well discharges) and 9 days (Baker well discharges) and an assumed in-situ bulk density of 2,600 kg/m^3. Based on the combined Abbey well discharge duration the low exposure threshold of 10 $mg/cm^2/day$ corresponds to 1.11 mm of sediment accumulation over this period. Additionally, moderate and high exposure thickness thresholds would equate to 3.33 mm to 11.11 mm, respectively (Table 5.6).

Regarding the Baker well discharges, the low exposure threshold of 10 $mg/cm^2/day$ corresponds to 0.44 mm of sediment accumulation over this period. Additionally, moderate and high exposure thickness thresholds would equate to 1.33 mm and 4.44 mm, respectively (Table 5.7).

These align with literature findings such as Gilmour (2002), who observed that older corals suffer injury from 2 mm sediment layers applied every two days, with larger polyps showing damage at 5 mm and 10 mm sediment layers. Mesocosm experiments by Trannum et al. (2010) showed that cuttings layers as thin as 3 mm cause gradual community declines over six months in soft-sediment communities.

Table 5.6 Reporting thresholds for sediment deposition for the drill cuttings and unrecoverable muds discharge modelling for the combined Abbey wells 20-day drilling operations.

Impact level	Sedimentation rates (mg/cm²/day)	Equivalent sediment bottom thickness thresholds (mm)^	Notes/Comments
No Impact	<10	–	No measurable effect; natural sediment fluxes tolerated
Low Exposure	10	1.11	Minor effects; some sediment accumulation but corals tolerate
Moderate Exposure	30	3.33	Sub-lethal effects; reduced larval settlement (Babcock and Davies 1991), tissue stress
High Exposure	>100	>11.11	Smothering, mortality risk; long-term coral cover decline

^ Based on anticipated total discharge duration of 26.4 days and assuming final settled in-situ bulk density of 1,800 kg/m^3

Table 5.7 Reporting thresholds for sediment deposition for the drill cuttings and unrecoverable muds discharge modelling for the 8-day Baker well drilling operation.

Impact level	Sedimentation rates (mg/cm²/day)	Equivalent sediment bottom thickness thresholds (mm)^	Notes/Comments
No Impact	<10	–	No measurable effect; natural sediment fluxes tolerated
Low Exposure	10	0.44	Minor effects; some sediment accumulation but corals tolerate
Moderate Exposure	30	1.33	Sub-lethal effects; reduced larval settlement (Babcock and Davies 1991), tissue stress
High Exposure	>100	>4.44	Smothering, mortality risk; long-term coral cover decline

^ Based on anticipated total discharge duration of 26.4 days and assuming final settled in-situ bulk density of 1,800 kg/m^3

5.6.2 TSS Concentration

A fundamental principle in assessing the effects of TSS is the relationship between intensity (or TSS concentrations) and duration of exposure (Figure 5.2). High TSS concentrations over a short duration may cause immediate stress or mortality, while prolonged exposures at lower concentrations can generate similar cumulative impacts. To address this relationship, TSS thresholds are expressed using both 1-hour averages (representing acute exposure) and 24-hour averages (representing chronic exposure).

The durations used here are intentionally conservative compared to those reported in experimental studies. Typically, acute effects are measured over periods of 1 to 7 days, while chronic effects are assessed over weeks to months (Brown et al., 2015; Stump et al., 2019). By comparison, this assessment adopts durations of just 1 hour (acute) and 24 hours (chronic), which is more appropriate given the operational context of drill cuttings and mud discharges, where TSS levels can rise sharply within minutes to days, significantly exceeding background levels. By applying shorter durations, the thresholds remain protective and precautionary.

In pristine offshore environments, background TSS levels are typically less than 10 mg/L, whereas naturally turbid nearshore reefs can experience levels exceeding 100 mg/L (Erftemeijer et al., 2012). Studies have shown that short-term spikes between 50 and 100 mg/L can cause acute sub-lethal stress, such as increased mucus production and reduced photosynthesis (Browne et al., 2015; Stump et al., 2019). Chronic exposures between 15 to 50 mg/L are linked to long-term physiological impairment, reduced reproductive

success and higher mortality rates (Browne et al., 2015; Erftemeijer et al., 2012). The final reporting TSS thresholds are presented in Table 5.8.

Table 5.8 Reporting thresholds for TSS concentrations for the drill cuttings and unrecoverable muds discharge modelling.

Impact level	Acute Exposure (1-hour averaged concentration) (mg/L)	Chronic Exposure (24-hour averaged concentration) (mg/L)	Notes/Comments
No Impact	<10	<5	Background or natural variability; corals tolerate well
Low Exposure	10	5	Minor physiological stress; corals acclimate to short pulses
Moderate Exposure	50	15	Sub-lethal effects; mucus production, reduced photosynthesis
High Exposure	> 100	> 50	Tissue damage, mortality risk; chronic exposure particularly harmful

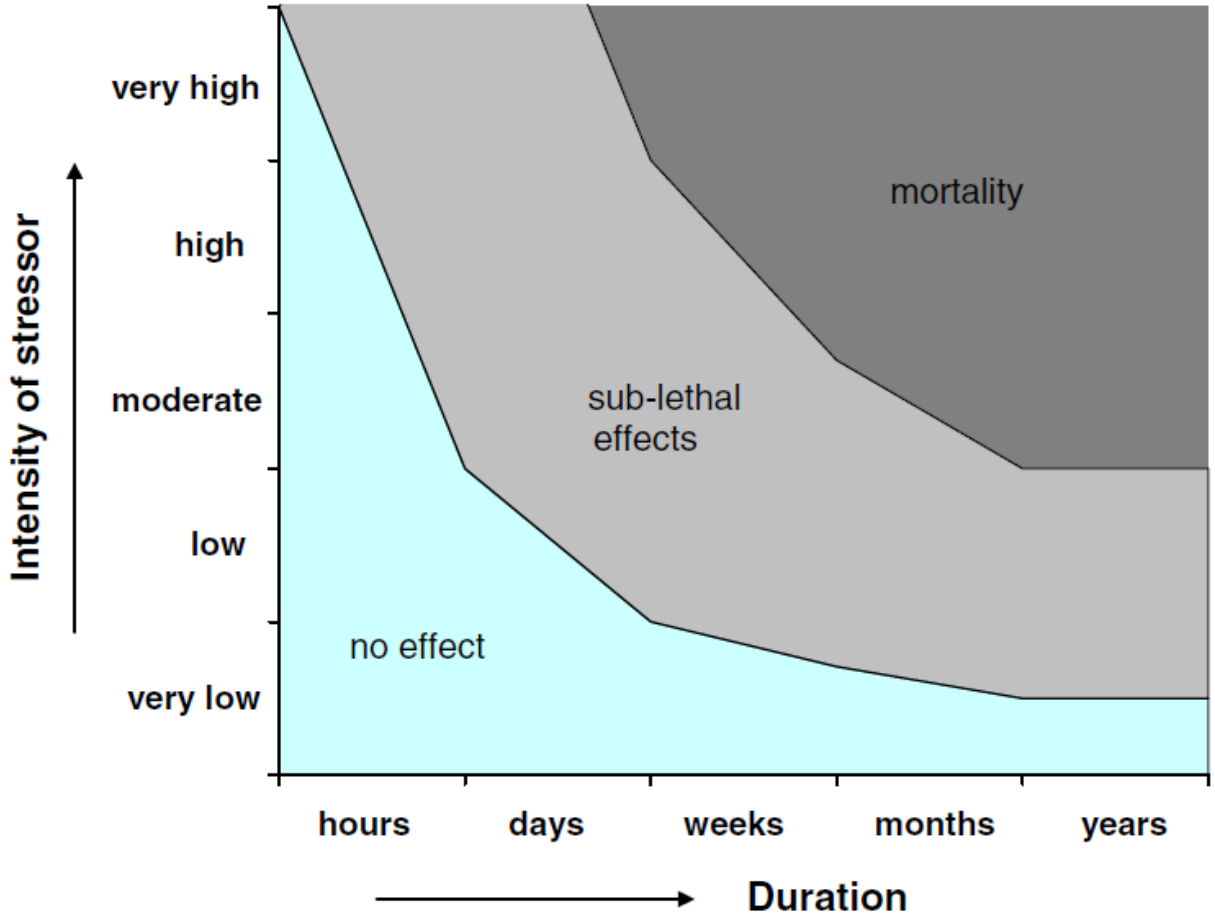

Figure 5.2 Conceptual relationship between the intensity and duration of a stress event and the risk of sublethal and lethal effects on corals. The figure illustrates the general relationship between the magnitude of an increase in turbidity or sedimentation above background levels (vertical axis), how long it lasts (horizontal axis) and the onset of effects on corals (Source: Erftemeijer et al., 2012).

5.7 Analysis of Output

During each individual simulation the MUDMAP model recorded the final mass on the seafloor in each grid cell over the entire model domain. Once all simulations were complete all model outputs were compared to determine the maximum deposition that occurred in each grid cell across all of the runs, per well.

Additionally, during each simulation a timeseries of the TSS concentrations through the water column were recorded at 5-minute intervals within each grid cell. This time series was used to calculate the highest 1-hour moving averaged (acute exposure) and 24-hour moving averaged (chronic exposure) TSS concentrations for the simulation. Thereafter, once all the simulations were run, the moving averages from each individual simulation were compared to determine the maximum acute and chronic exposure concentrations.

It's important to note that the reported TSS concentrations are above background TTS concentrations.

6 Results

6.1 Deterministic Modelling Results: Abbey–A1

Deterministic modelling (single simulation) results of near-seabed and near-sea surface discharges for the drilling and discharge program from Abbey–A1 are presented below. Note, due to the near-identical nature and proximity of drilling and discharge programs and locations for the Abbey well discharges (see Section 5.2), a single representative field example of the deterministic modelling results from Abbey–A1 is provided.

6.1.1 Deposition

Figure 6.1 to Figure 6.4 present model screenshots of the sedimentation rate during the modelled drilling and discharge operation during example near-seabed and near-surface discharges from a single simulation at Abbey–A1.

The model screenshots illustrate the evolution of the deposition. These images have been included to provide an example “snapshot” of the predicted orientation and size of depositional footprint influenced by the time-varying current directions and speeds.

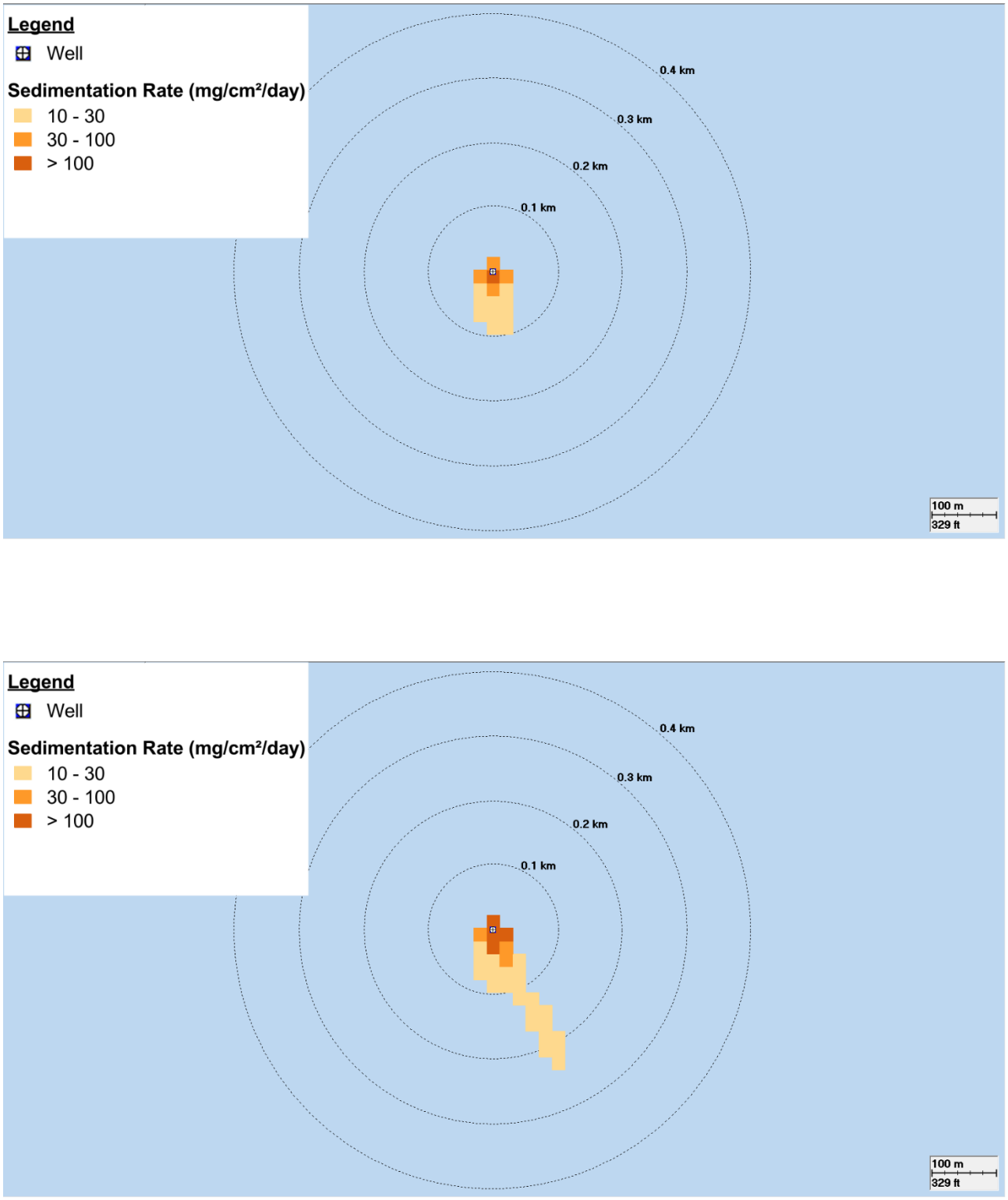

Figure 6.1 **Example plan-view screenshots of the predicted sedimentation rate (in each grid cell) 12 hours (top image) and 24 hours (bottom image) after the commencement of the near seabed discharges of drilling cuttings and muds from Abbey–A1. Screenshot results are from 1 simulation of the 100 modelled as part of the study.**

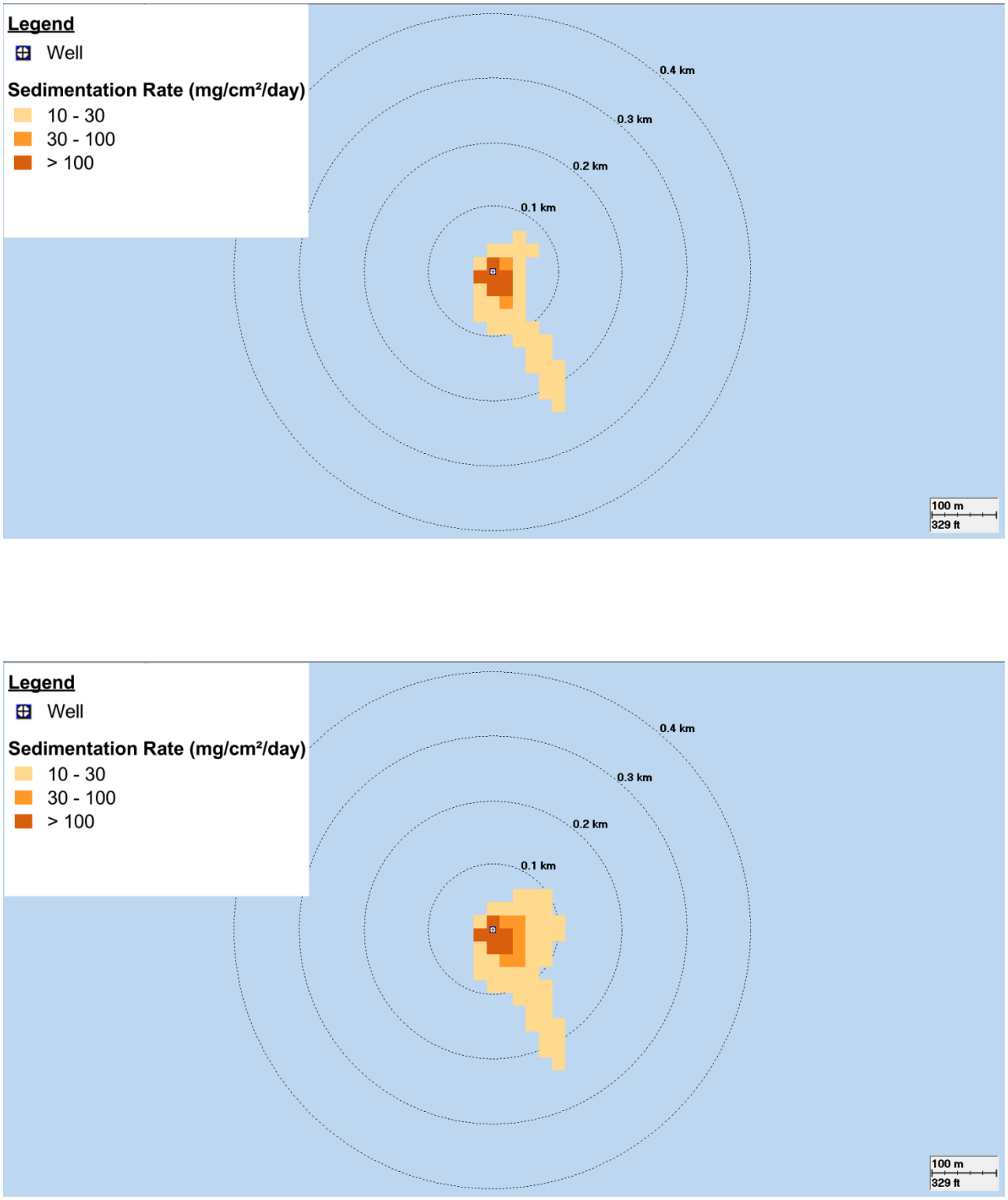

Figure 6.2 **Example plan-view screenshots of the predicted sedimentation rate (in each grid cell) 36 hours (top image) and 48 hours (bottom image) after the commencement of the near-seabed discharges of drilling cuttings and muds from Abbey–A1. Screenshot results are from 1 simulation of the 100 modelled as part of the study.**

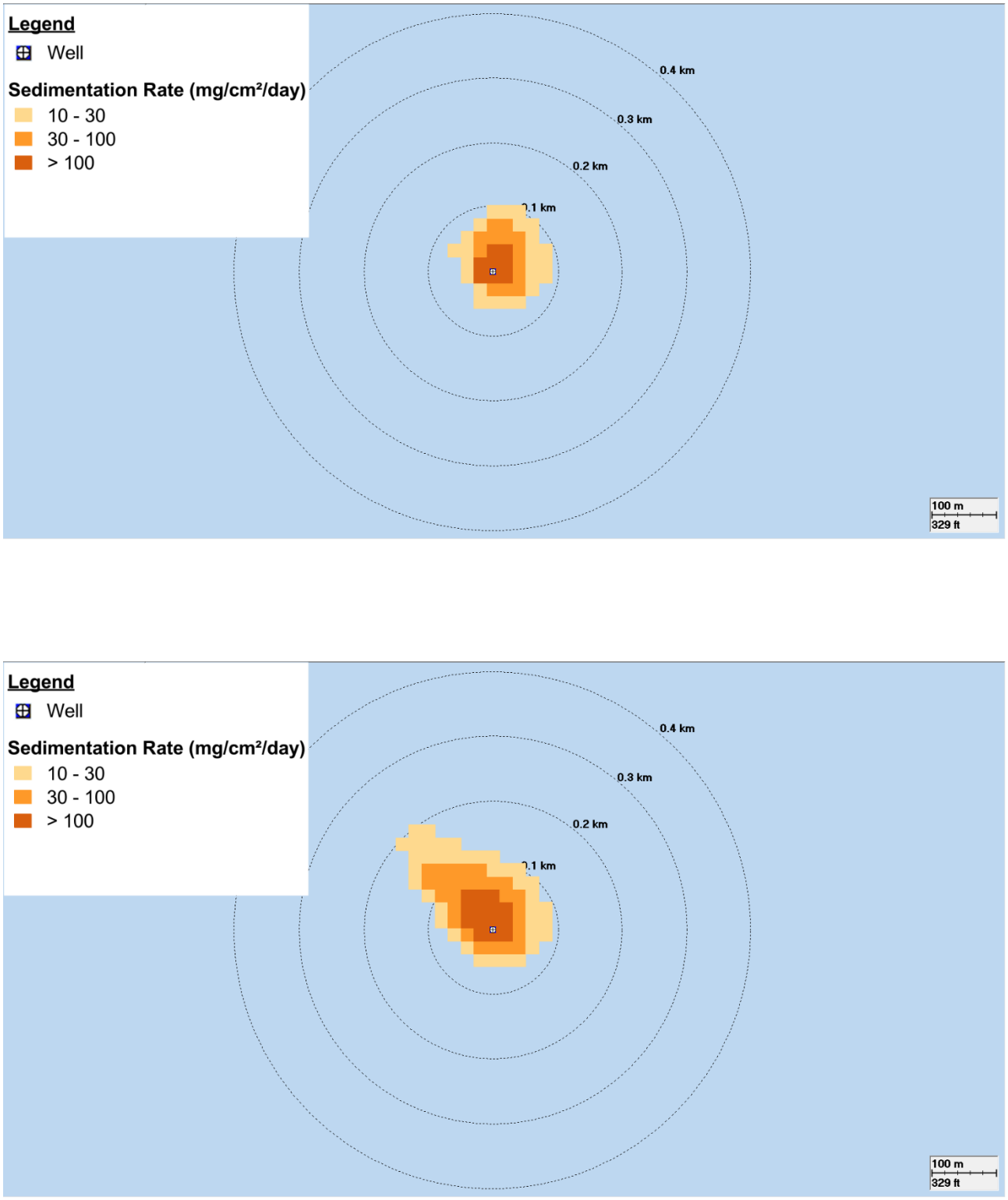

Figure 6.3 **Example plan-view screenshots of the predicted sedimentation rate (in each grid cell) 48 hours (top image) and 96 hours (bottom image) after the commencement of the near-surface discharges of drilling cuttings and muds from Abbey–A1. Screenshot results are from 1 simulation of the 100 modelled as part of the study.**

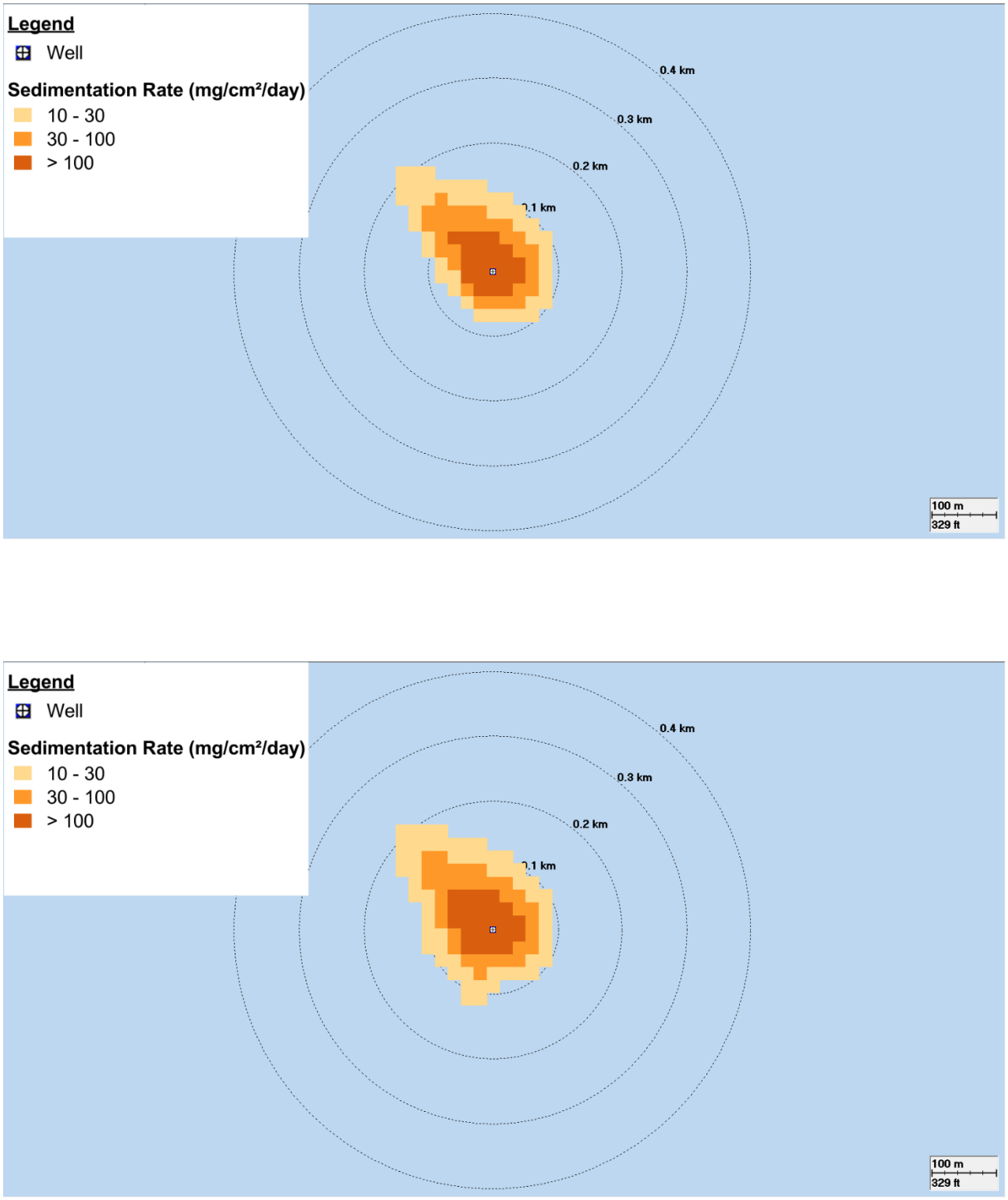

Figure 6.4 **Example plan-view screenshots of the predicted sedimentation rate (in each grid cell) 144 hours (top image) and 192 hours (bottom image) after the commencement of the near-surface discharges of drilling cuttings and muds from Abbey–A1. Screenshot results are from 1 simulation of the 100 modelled as part of the study.**

6.1.2 Total Suspended Solids

Figure 6.5 and Figure 6.6 present model screenshots of the TSS concentrations during the modelled drilling and discharge operation during the near-seabed discharges from a single simulation at Abbey–A1. Additionally, Figure 6.7 and Figure 6.8 present the associated TSS concentration during the near-surface discharges also during a single simulation at Abbey–A1.

The model screenshots illustrate the dynamic nature of the TSS plume and provide both an aerial (plan) view illustrating the predicted TSS concentrations within the water column (cross section) along a given transect.

These images have been included to provide an example “snapshot” of the predicted orientation and size of the TSS plume influenced by the time-varying current directions and speeds.

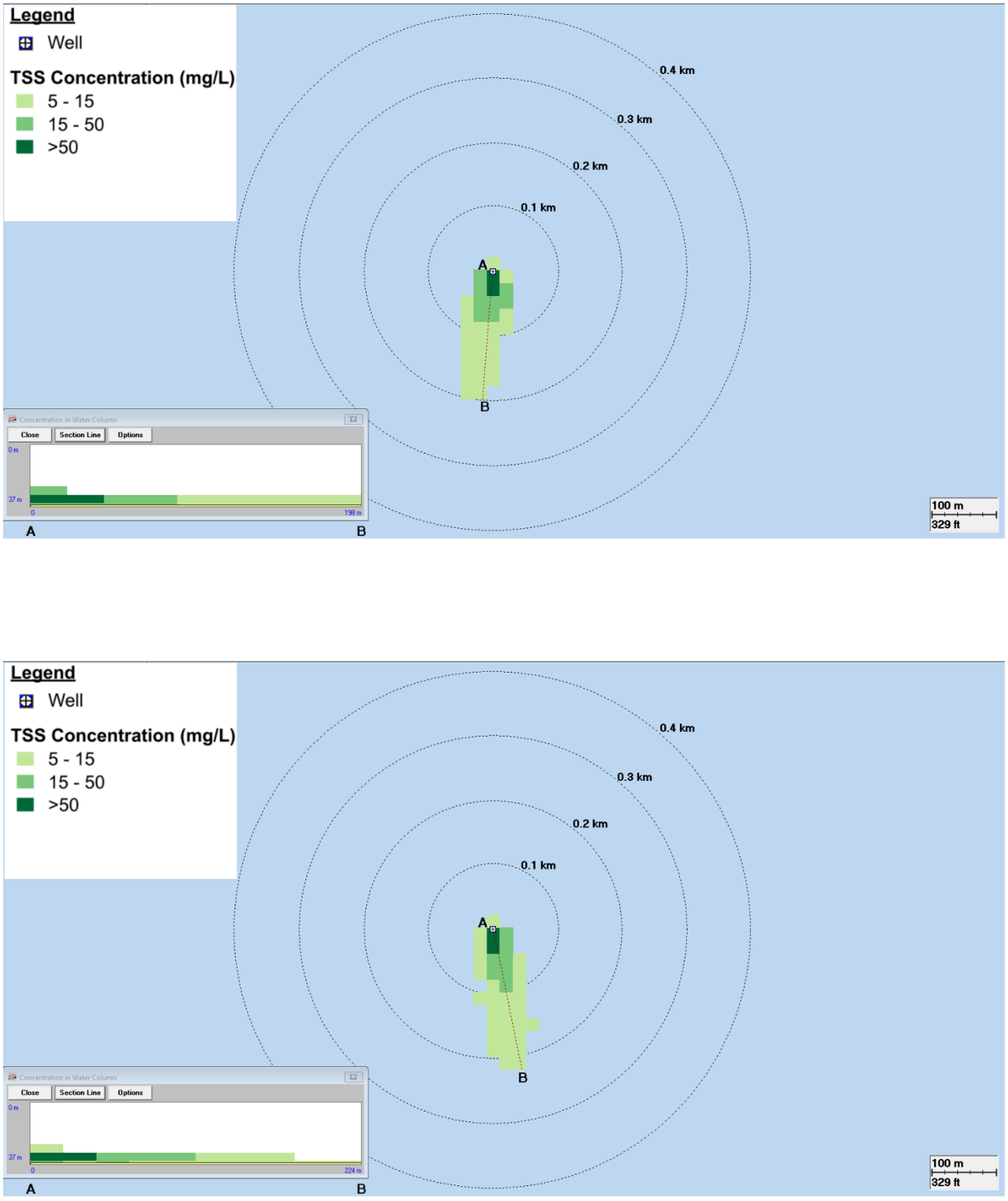

Figure 6.5 Example plan-view and water column (cross section) screenshots of the predicted TSS concentrations (in each grid cell) 3 hours (top image) and 6 hours (bottom image) after the commencement of the near-seabed discharges of drilling cuttings and muds from Abbey–A1. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

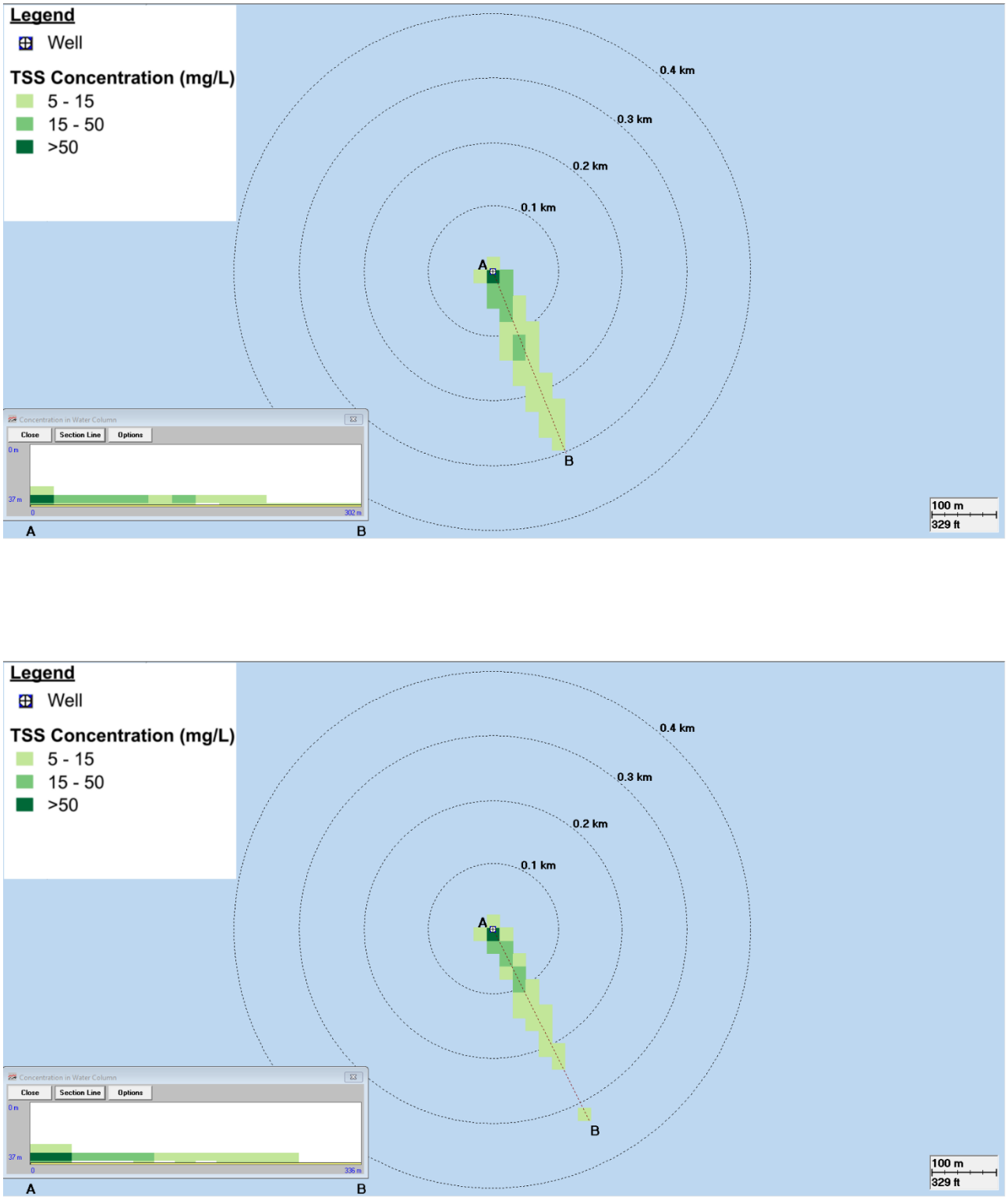

Figure 6.6 Example plan-view and water column (cross section) screenshots of the predicted TSS concentrations (in each grid cell) 9 hours (top image) and 12 hours (bottom image) after the commencement of the near-seabed discharges of drilling cuttings and muds from Abbey–A1. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

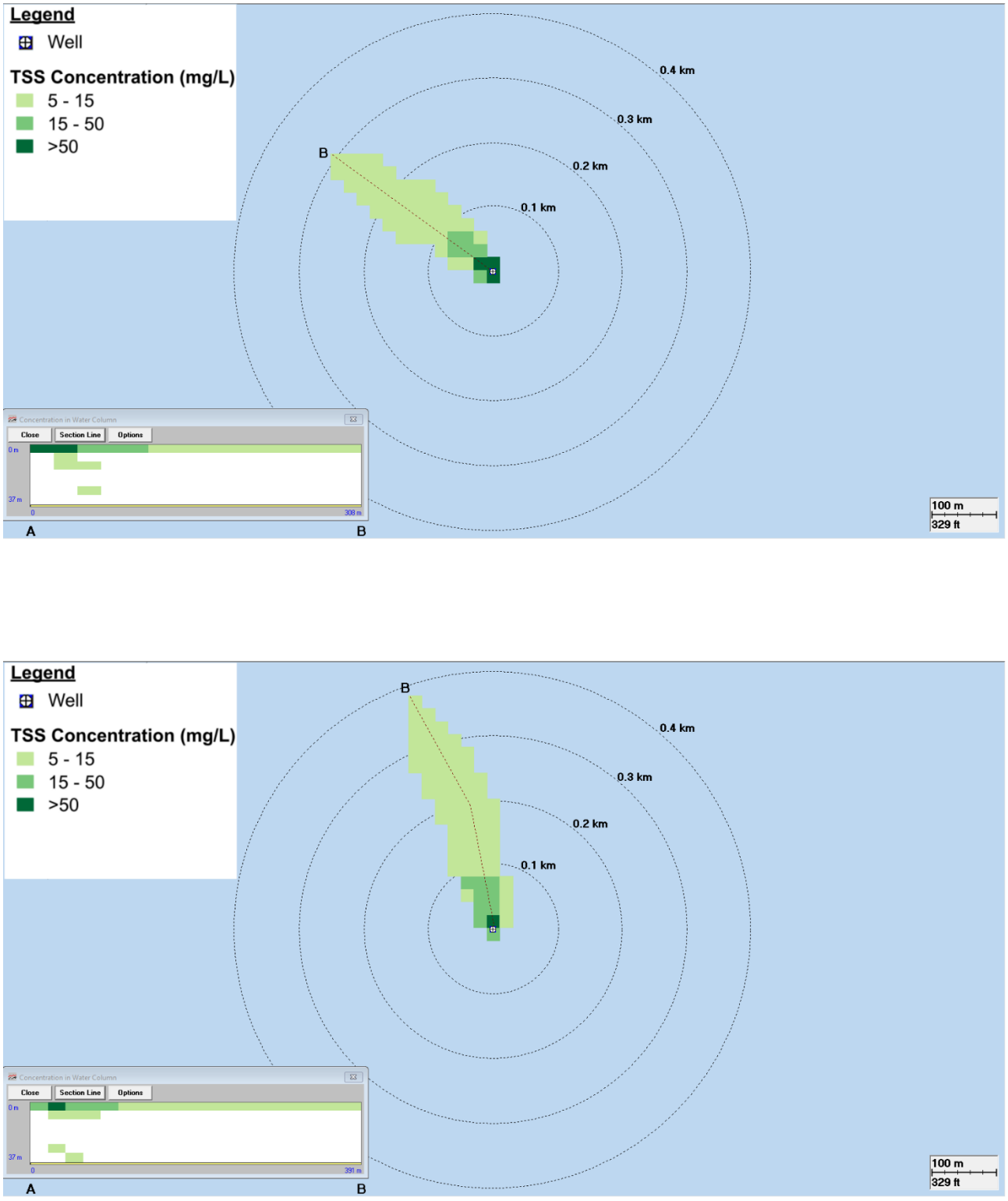

Figure 6.7 Example plan-view and water column (cross section) screenshots of the predicted TSS concentrations (in each grid cell) 3 hours (top image) and 6 hours (bottom image) after the commencement of the near-surface discharges of drilling cuttings and muds from Abbey–A1. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

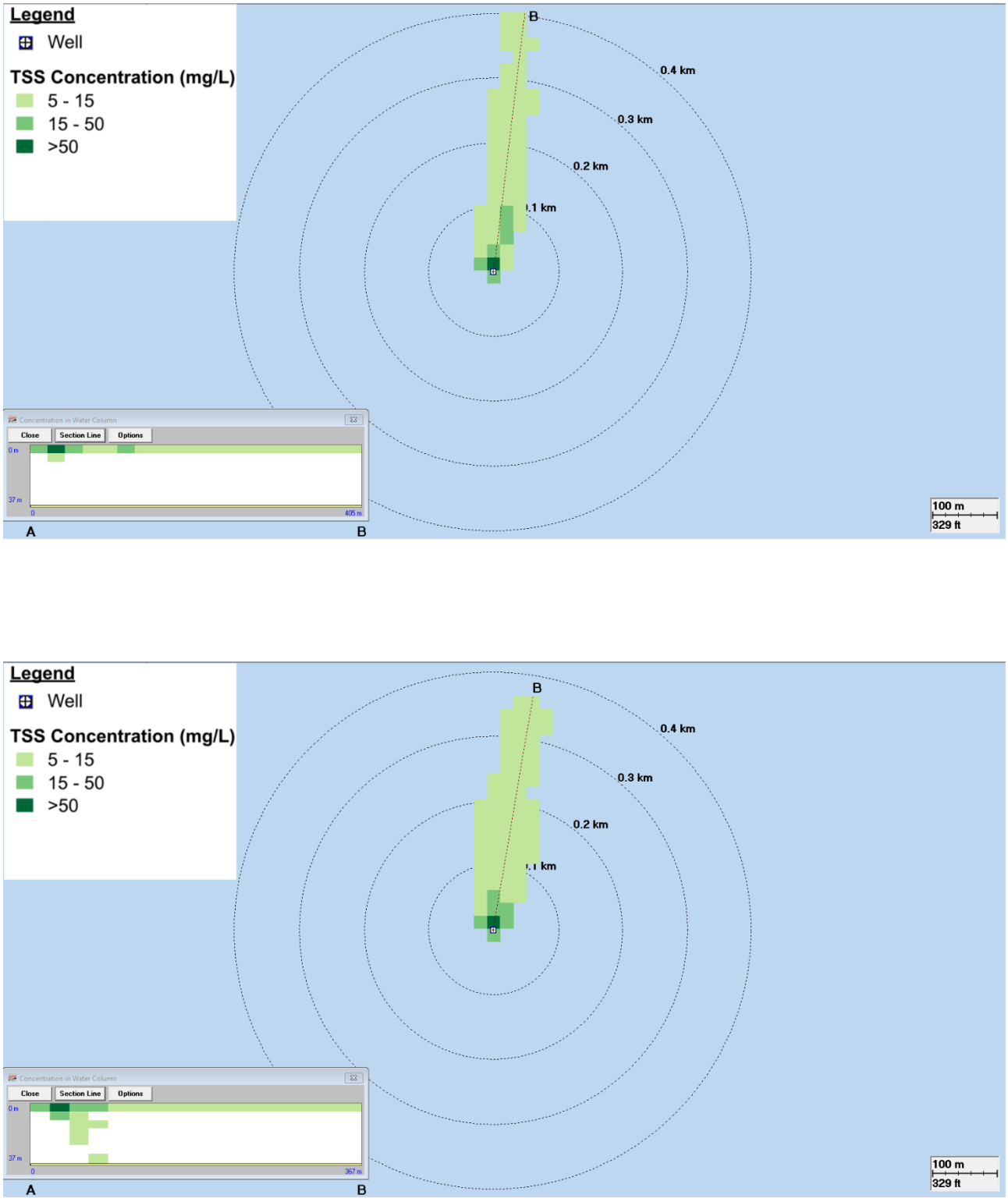

Figure 6.8 Example plan-view and water column (cross section) screenshots of the predicted TSS concentrations (in each grid cell) 9 hours (top image) and 12 hours (bottom image) after the commencement of the near-surface discharges of drilling cuttings and muds from Abbey–A1. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

6.2 Deterministic Modelling Results: Baker Well

Deterministic modelling (single simulation) results of the near-seabed and near-sea surface discharges for the drilling and discharge program from Baker are presented below.

6.2.1 Deposition

Figure 6.13 to Figure 6.16 present model screenshots of the sedimentation rate during the modelled drilling and discharge operation during example near-seabed and near-surface discharges from a single simulation at Baker.

The model screenshots illustrate the evolution of the deposition. These images have been included to provide an example “snapshot” of the predicted orientation and size of depositional footprint influenced by the time-varying current directions and speeds.

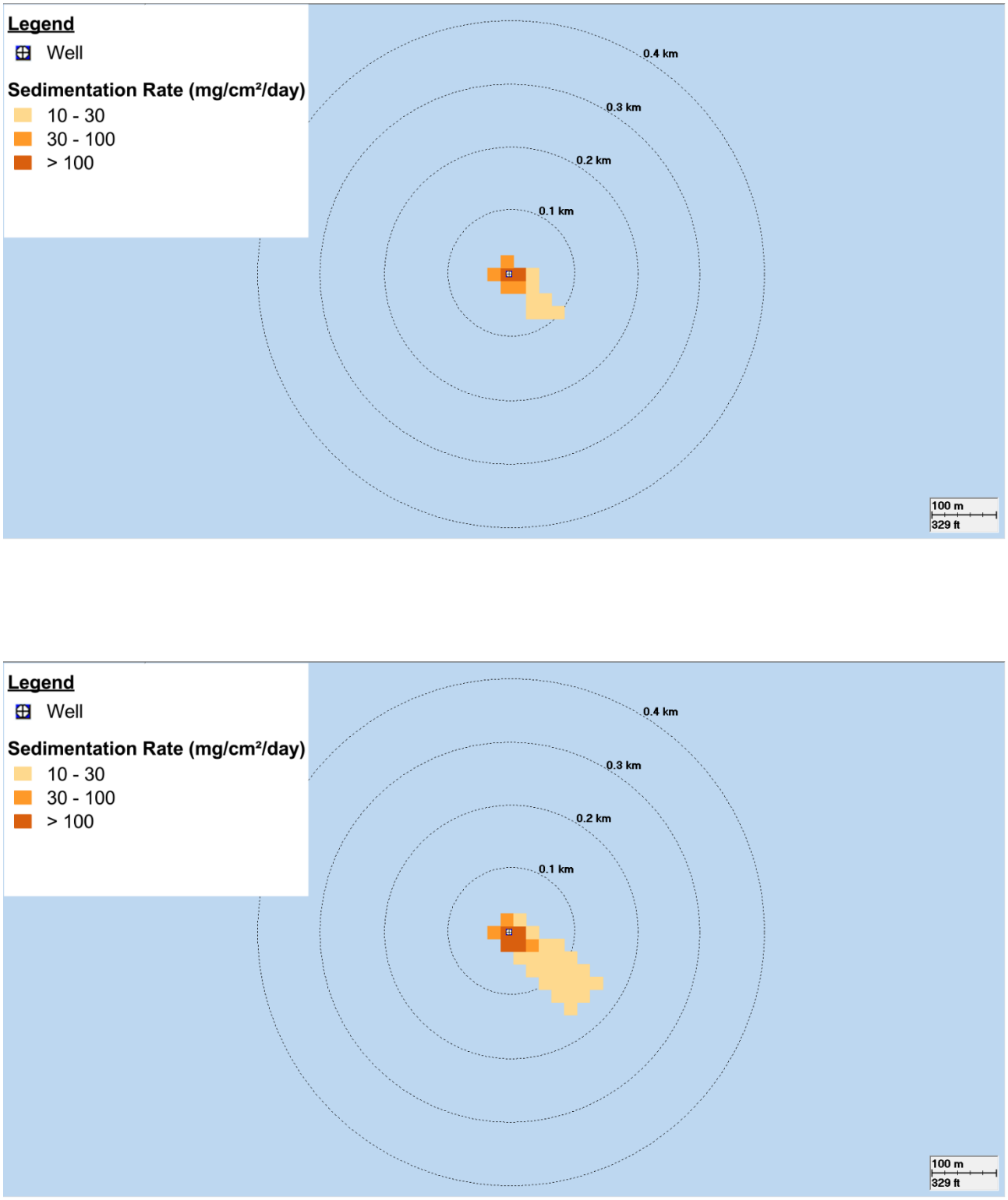

Figure 6.9 **Example plan-view screenshots of the predicted sedimentation rate (in each grid cell) 12 hours (top image) and 24 hours (bottom image) after the commencement of the near-seabed discharges of drilling cuttings and muds from Baker. Screenshot results are from 1 simulation of the 100 modelled as part of the study.**

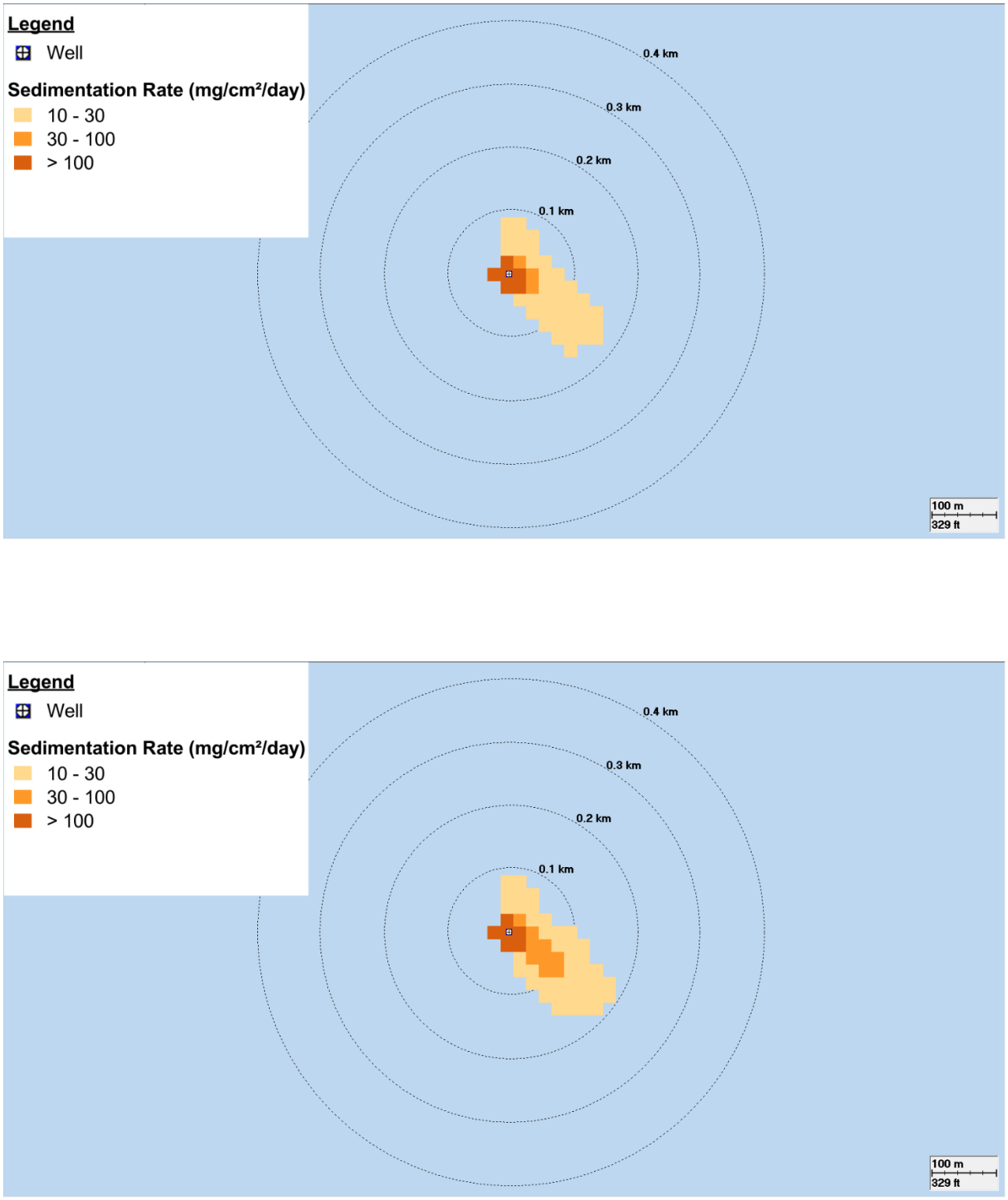

Figure 6.10 Example plan-view screenshots of the predicted sedimentation rate (in each grid cell) 36 hours (top image) and 48 hours (bottom image) after the commencement of the near-seabed discharges of drilling cuttings and muds from Baker. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

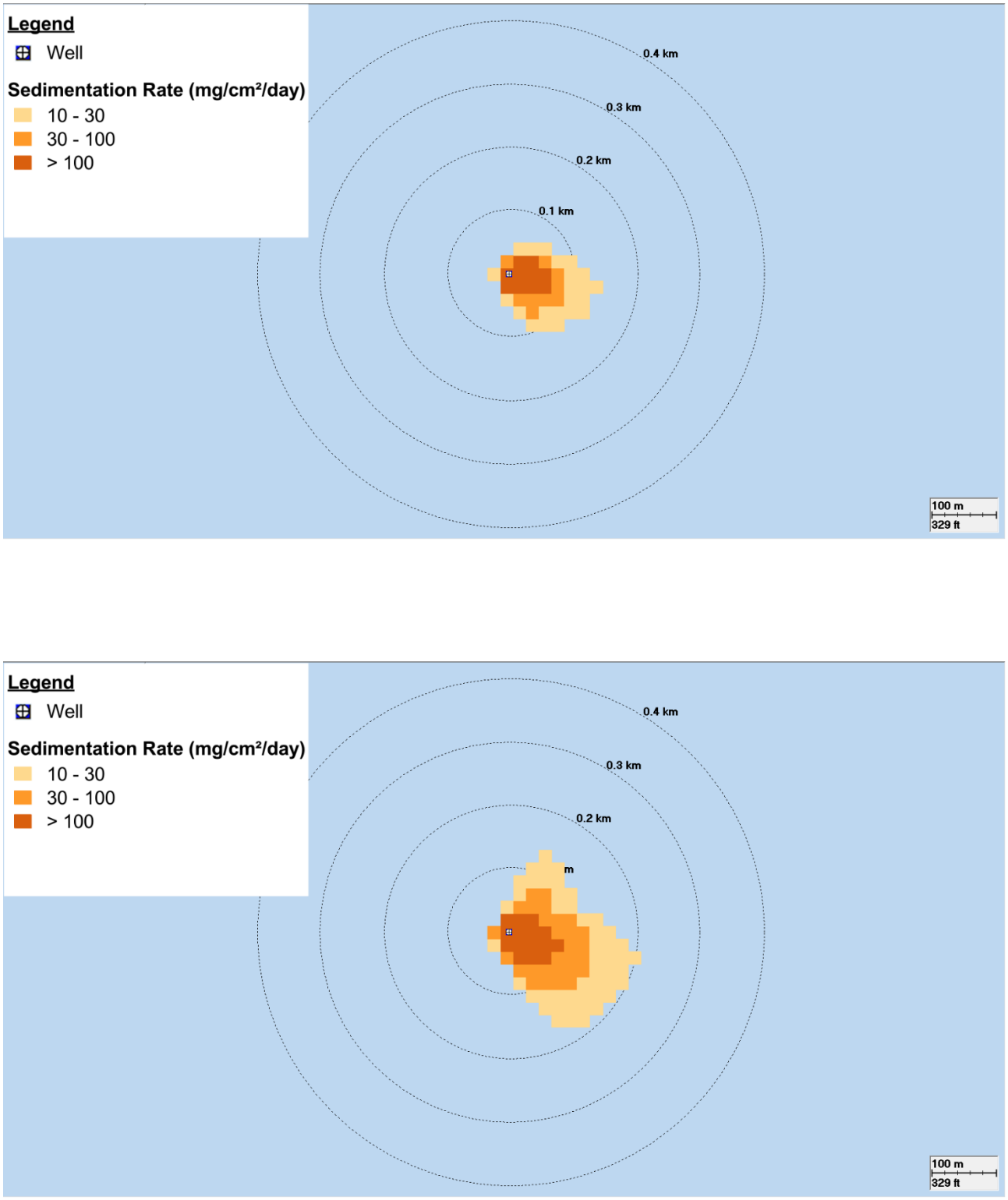

Figure 6.11 Example plan-view screenshots of the predicted sedimentation rate (in each grid cell) 36 hours (top image) and 72 hours (bottom image) after the commencement of the near-surface discharges of drilling cuttings and muds from Baker. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

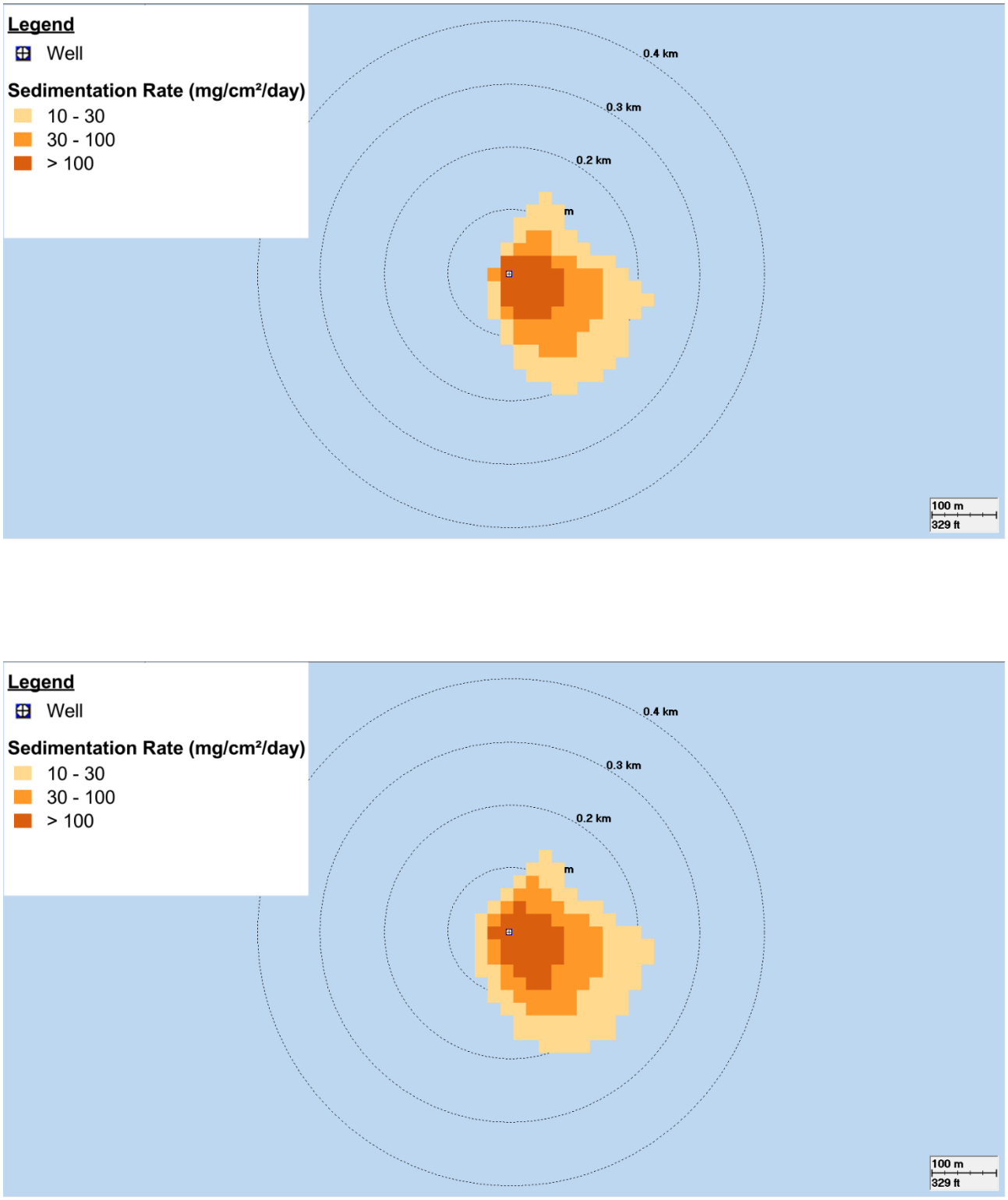

Figure 6.12 Example plan-view screenshots of the predicted sedimentation rate (in each grid cell) 108 hours (top image) and 144 hours (bottom image) after the commencement of the near-surface discharges of drilling cuttings and muds from Baker. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

6.2.2 Total Suspended Solids

Figure 6.13 and Figure 6.14 present model screenshots of the TSS concentrations during the modelled drilling and discharge operation during the near-seabed discharges from a single simulation at Baker. Additionally, Figure 6.15 and Figure 6.16 present the associated TSS concentration during the near-surface discharges also during a single simulation at Baker.

The model screenshots illustrate the dynamic nature of the TSS plume and provide both an aerial (plan) view illustrating the predicted TSS concentrations within the water column (cross section) along a given transect.

These images have been included to provide an example “snapshot” of the predicted orientation and size of the TSS plume influenced by the time-varying current directions and speeds.

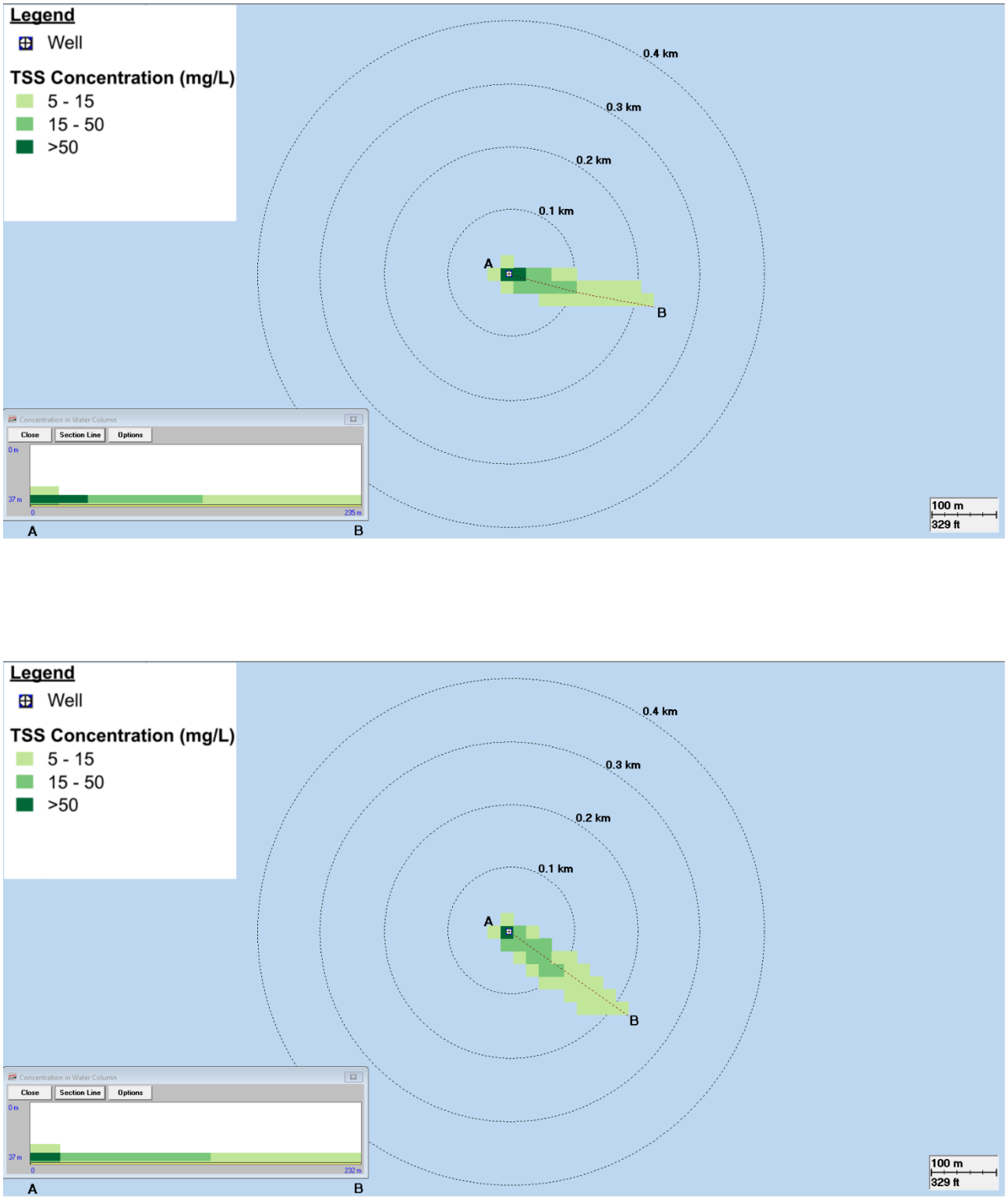

Figure 6.13 Example plan-view and water column (cross section) screenshots of the predicted TSS concentrations (in each grid cell) 3 hours (top image) and 6 hours (bottom image) after the commencement of the near-seabed discharges of drilling cuttings and muds. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

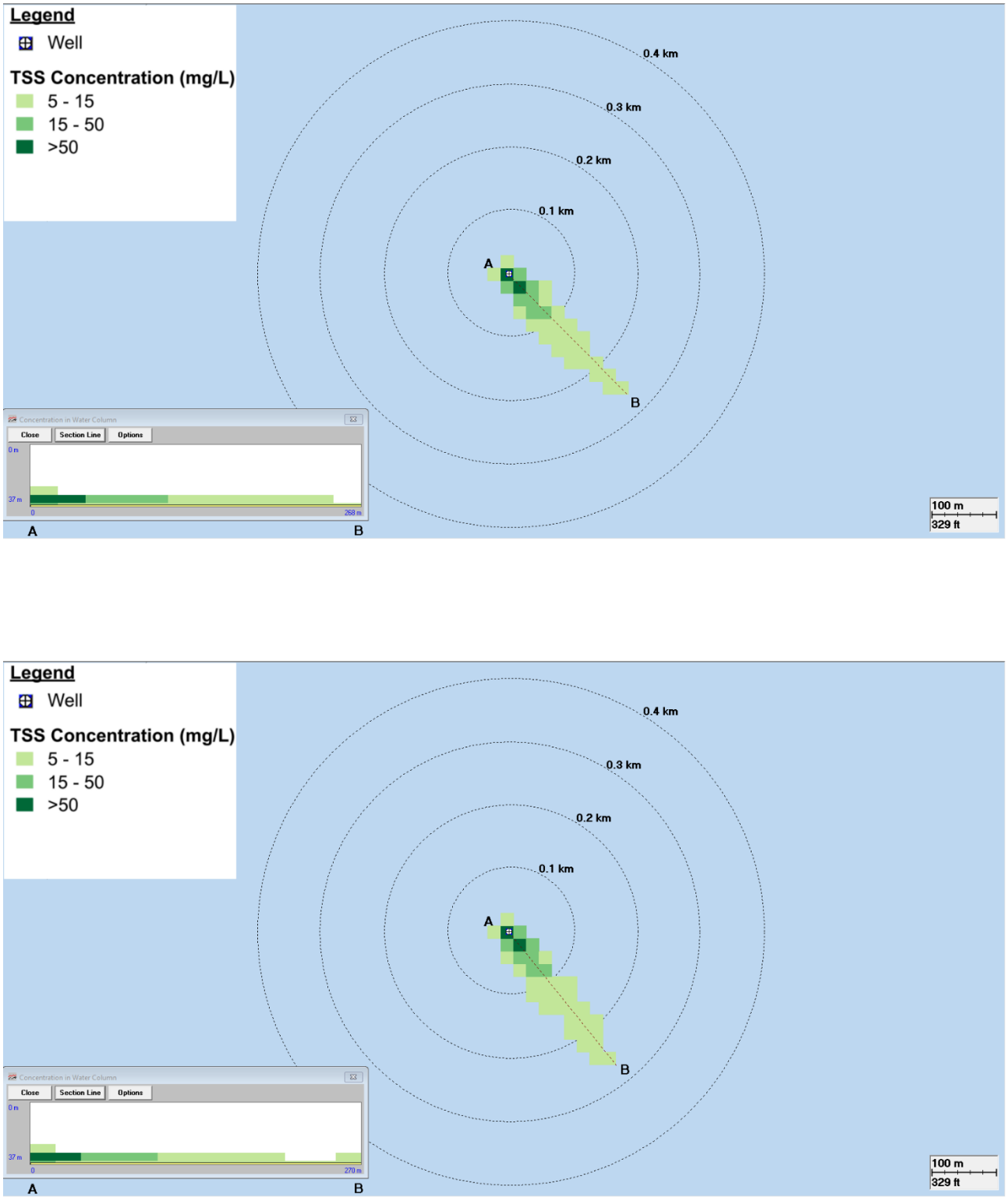

Figure 6.14 Example plan-view and water column (cross section) screenshots of the predicted TSS concentrations (in each grid cell) 9 hours (top image) and 12 hours (bottom image) after the commencement of the near-seabed discharges of drilling cuttings and muds from Baker. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

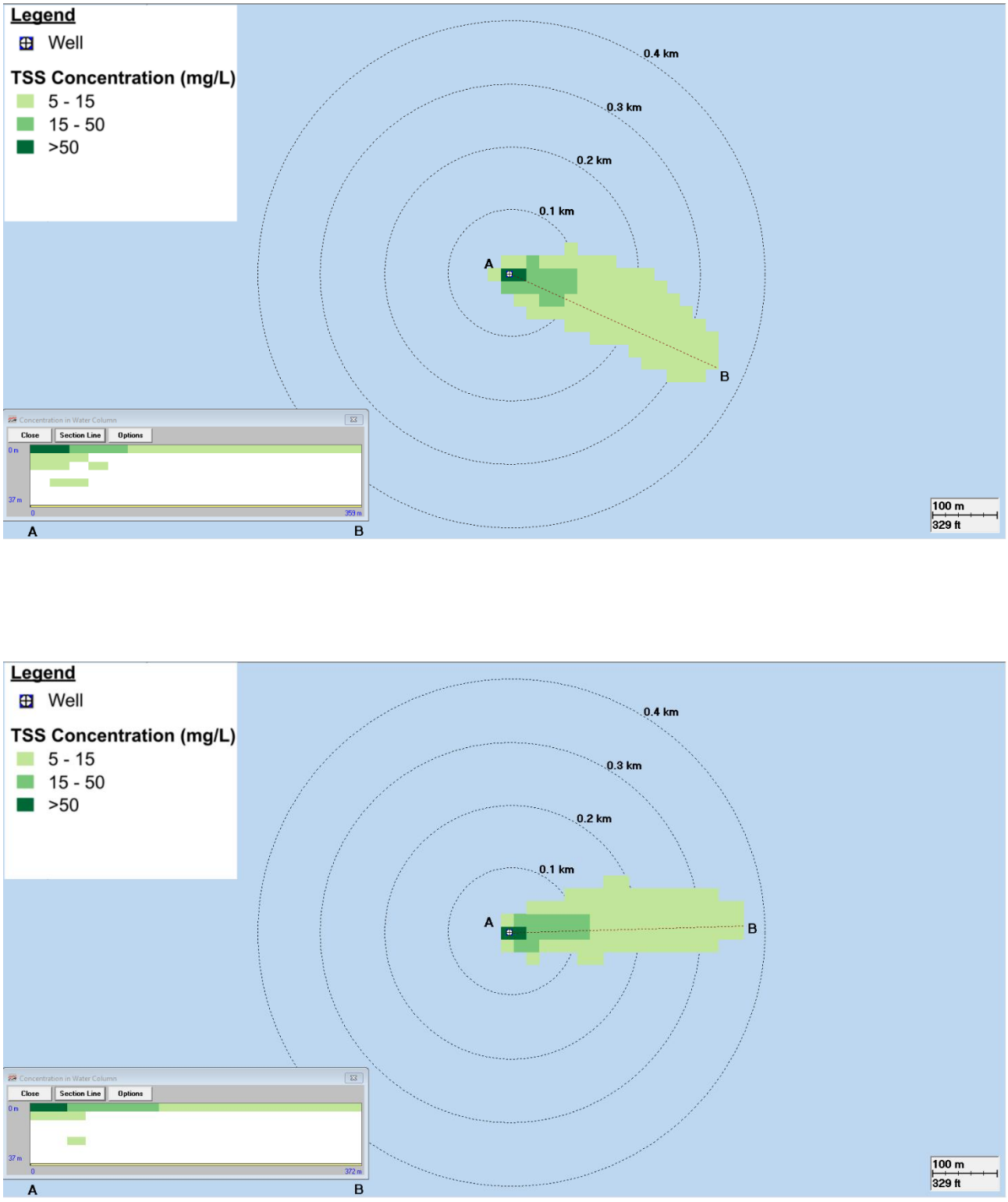

Figure 6.15 Example plan-view and water column (cross section) screenshots of the predicted TSS concentrations (in each grid cell) 3 hours (top image) and 6 hours (bottom image) after the commencement of the near-surface discharges of drilling cuttings and muds from Baker. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

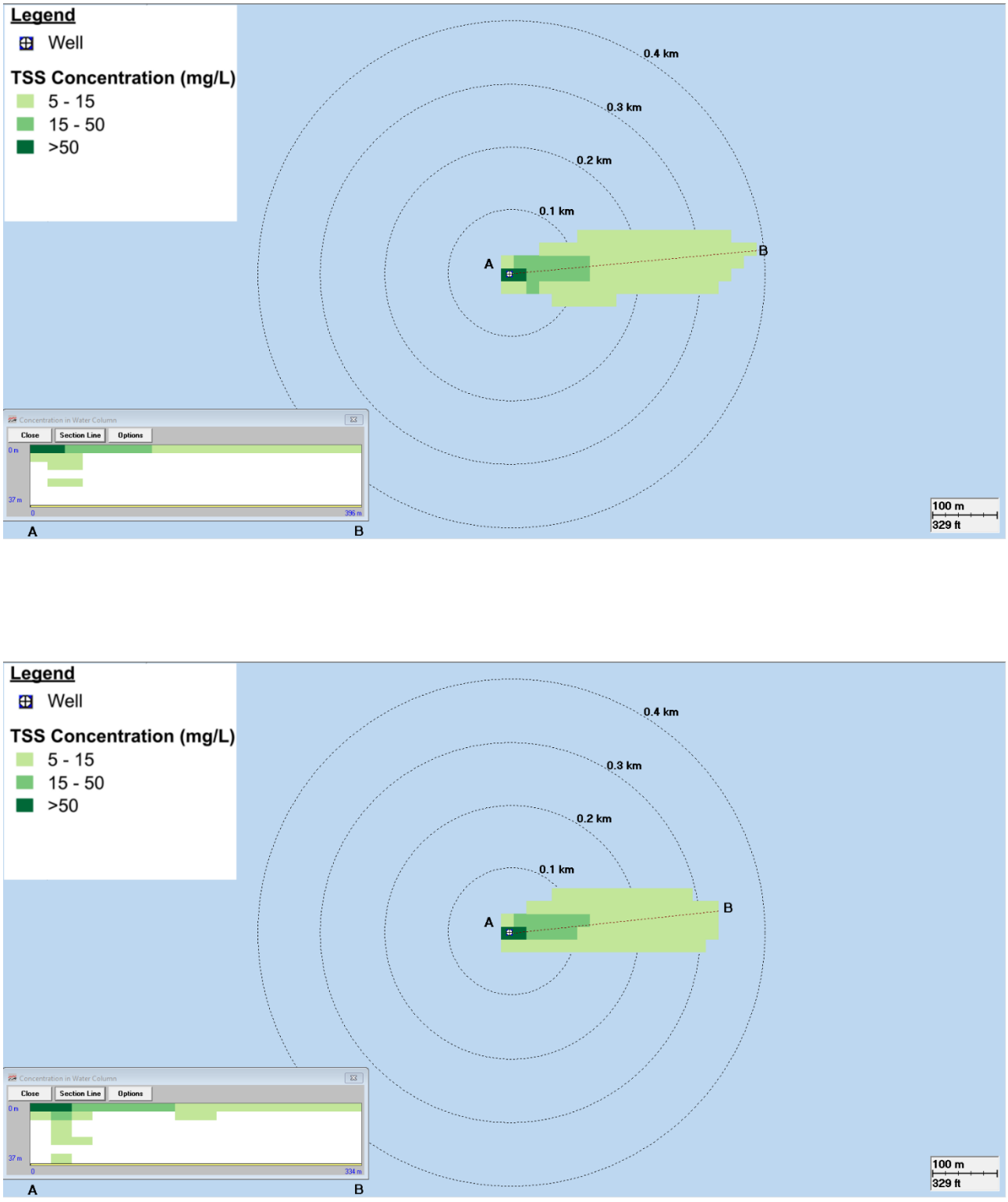

Figure 6.16 Example plan-view and water column (cross section) screenshots of the predicted TSS concentrations (in each grid cell) 9 hours (top image) and 12 hours (bottom image) after the commencement of the near-surface discharges of drilling cuttings and muds from Baker. Screenshot results are from 1 simulation of the 100 modelled as part of the study.

6.3 Stochastic Modelling Results: Abbey–A1 and Abbey–A3

6.3.1 Deposition

Figure 6.17 presents the maximum sedimentation rates and equivalent total bottom thickness in each grid cell from all Abby well simulations (50 per well) to define the potential exposure from the discharge of cuttings and muds for the combined Abbey–A1 and Abbey–A3 drilling and discharge programs.

The maximum predicted thickness of deposited cuttings and muds was associated with the drilling of the riserless discharge (i.e., 26” x 36” x 42” bore diameter well interval), which were returned directly to seafloor from a discharge height of 2 m above the seafloor. A maximum thickness of 1.05 m was predicted within 20 m of the discharge location.

Table 6.1 summarises the total area of coverage and the maximum distances from the release location for each sedimentation rate (and equivalent total bottom thickness) of 10 mg/cm²/day (1.11 mm), 30 mg/cm²/day (3.33 mm) and 100 mg/cm²/day (11.1 mm; Table 6.1) for the modelled combined 20-day discharge program for the Abbey–A1 and Abbey–A3 wells.

Based on the assessment of 100 simulations for the Abbey–A1 and Abbey–A3 wells, the maximum distances from the release locations (mid-point between wells) to the edge of the low exposure (10 mg/cm²/day [1.11 mm]) , moderate exposure (30 mg/cm²/day [3.33 mm]) and high exposure (100 mg/cm²/day [11.1 mm]) thresholds were 0.41 km, 0.28 km and 0.12 km, respectively.

The total area of coverage for the low exposure threshold, or greater, was 0.16 km^2 (Table 6.1).

Table 6.1 Predicted areas of coverage and maximum distances from the release location for each reporting threshold based on the results of all 100 simulations for the Abbey–A1 and Abbey–A3 wells.

Annual assessment			
Sedimentation rate (mg/cm^2/day)	**Equivalent total sediment bottom thickness* (mm)^**	**Total area of coverage (km^2)**	**Maximum distance (km) from the release location**
10	1.11	0.16	0.41
30	3.33	0.07	0.28
100	11.1	0.03	0.12

* Based on anticipated total discharge duration and assuming final settled in-situ bulk density of 1,800 kg/m^3

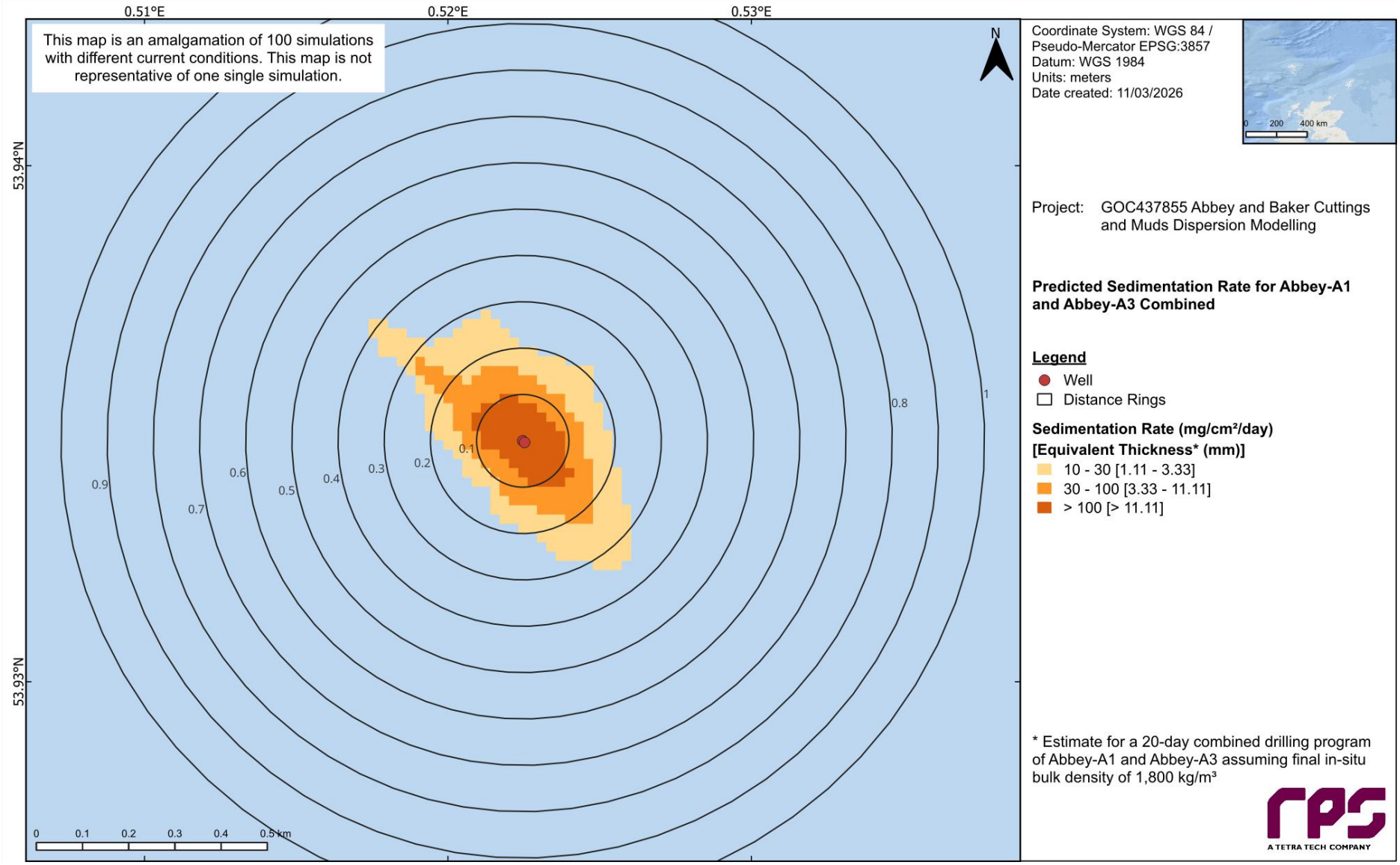

Figure 6.17 Predicted maximum sedimentation rate and equivalent thickness from the discharge of drill cuttings and muds. Results are based on 100 simulations for the Abbey–A1 and Abbey–A3 wells and represent annual conditions.

6.3.2 Total Suspended Solids

Figure 6.18 and Figure 6.19 illustrate the maximum moving average concentrations computed over 1-hr and 24-hr in each grid cell for the combined Abbey–A1 and Abbey–A3 drilling and discharge programs, representing acute and chronic exposures respectively, to define the potential exposure from the discharge of cuttings and muds.

Table 6.2 summarises the total area of coverage and maximum distances from the release locations (mid-point between wells) for each TSS concentration threshold based on acute and chronic exposures.

Based on the assessment of 100 simulations for the Abbey–A1 and Abbey–A3 wells, the maximum distance from the release locations (mid-point between wells) to the edge of the low exposure TSS concentration threshold (10 mg/L) for acute exposure (1-hr averaged concentration) was 0.34 km. Additionally, the maximum distance from the release location to the edge of the moderate exposure TSS concentration threshold (50 mg/L) for acute exposure (1-hr averaged concentration) was 0.04 km. High exposure (100 mg/L) TSS concentrations did not exceed 0.02 km from the release location. The total area of coverage for the low exposure threshold, or greater, was 0.26 km^2 (Table 6.2).

The maximum distance from the release location to the edge of the low exposure TSS concentration threshold (5 mg/L) for chronic exposure (24-hr averaged concentration) was 0.35 km. Additionally, the maximum distance from the release location to the edge of the chronic moderate exposure TSS concentration threshold (15 mg/L) was 0.10 km. Chronic high exposure (50 mg/L) TSS did not exceed 0.03 km from the release location. The total area of coverage for the low exposure threshold was 0.23 km^2 (Table 6.2).

The discharge of cuttings and muds will lead to relatively short-lived increased TSS concentrations, which dilute and reduce with distance from the release location to concentrations below the reporting thresholds. Based on the temporary elevated concentrations of TSS concentrations at the low exposure threshold, and the limited occurrence of the very localised high exposure, the impact likelihood is thus considered low.

Table 6.2 Predicted total areas of coverage and maximum distances to acute and chronic exposure from the release location to each reporting threshold based on the results of all 100 simulations for the Abbey–A1 and Abbey–A3 wells.

	Annual	
Reporting threshold (mg/L)	**Total area of coverage (km^2)**	**Maximum distance (km) from the release location**
	Acute Exposure (1-hr averaged concentration)	
10	0.26	0.34
50	<0.01	0.04
100	<0.01	0.02
	Chronic Exposure (24-hr averaged concentration)	
5	0.23	0.35
15	0.03	0.10
50	<0.01	0.03

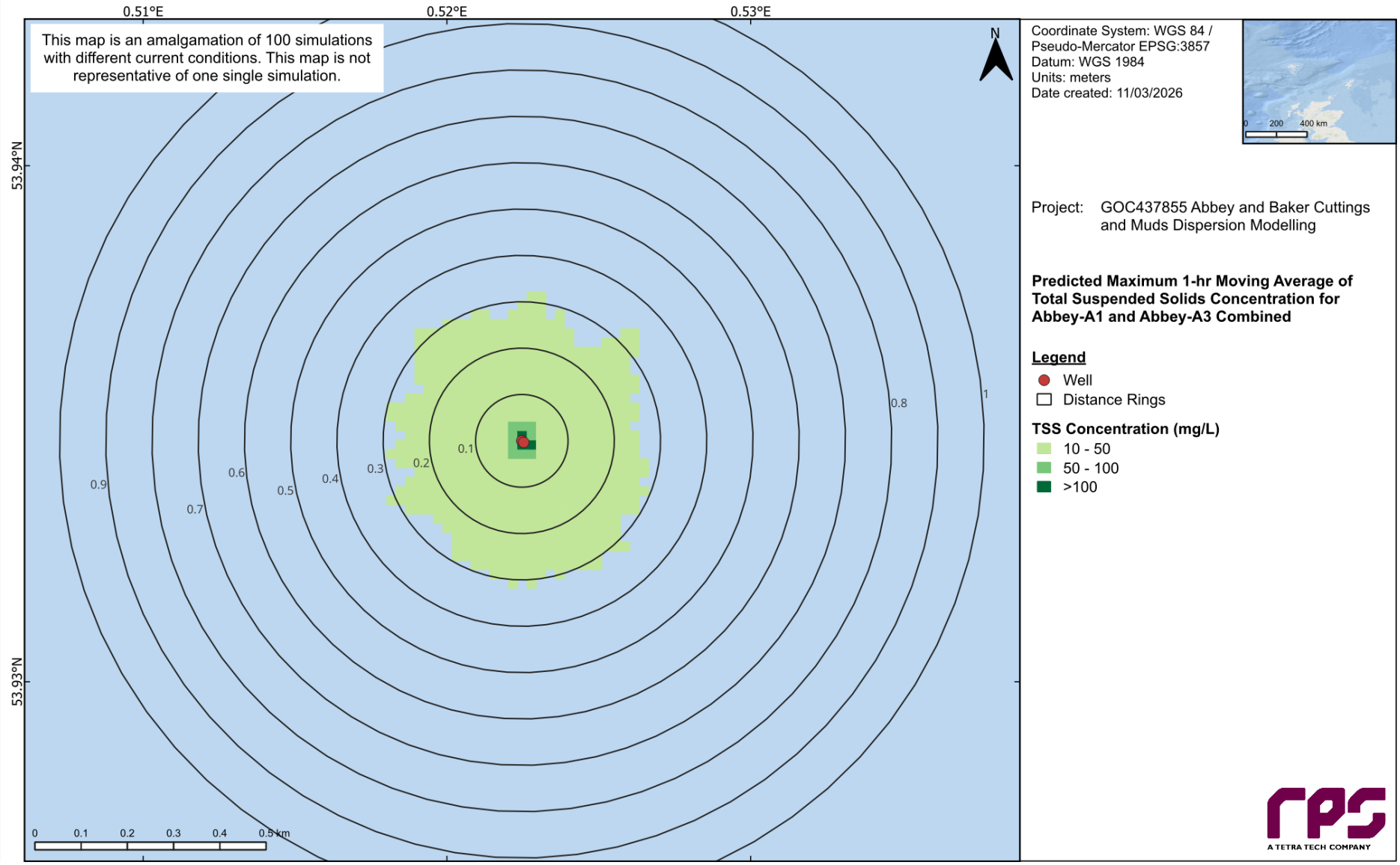

Figure 6.18 Predicted maximum 1-hr moving average of TSS concentrations, representing acute exposure, from the discharge of drill cuttings and muds. Results are based on 100 simulations and represent annual conditions for the Abbey–A1 and Abbey–A3 wells.

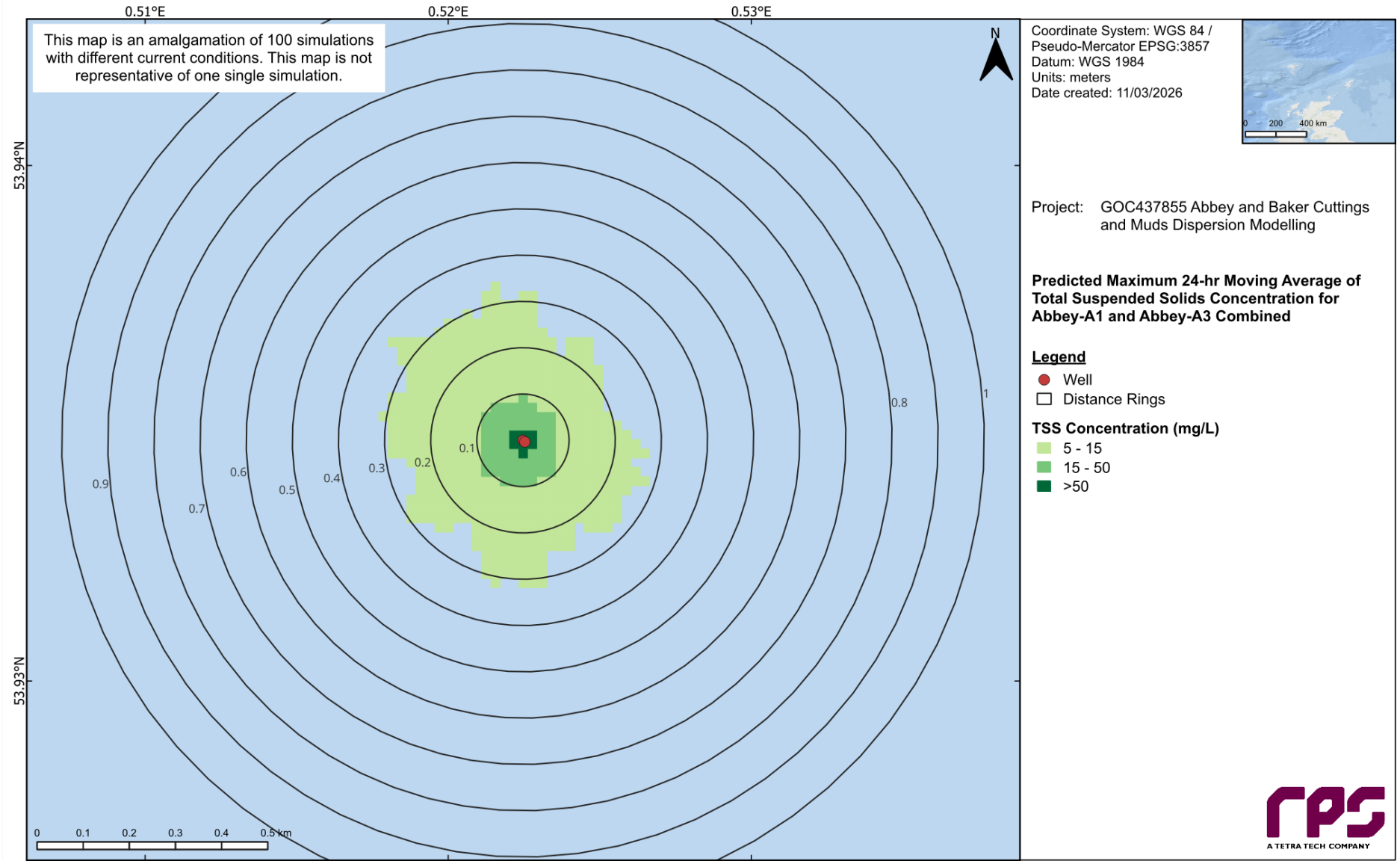

Figure 6.19 Predicted maximum 24-hr moving average of TSS concentrations, representing chronic exposure, from the discharge of drill cuttings and muds. Results are based on 100 simulations and represent annual conditions for the Abbey-A1 and Abbey–A3 wells.

6.4 Stochastic Modelling Results: Baker

6.4.1 Deposition

Figure 6.20 presents the maximum sedimentation rates and equivalent total bottom thickness in each grid cell from all simulations (50) to define the potential exposure from the discharge of cuttings and muds for the Baker well drilling and discharge program.

The maximum predicted thickness of deposited cuttings and muds was associated with the drilling of the riserless discharge (i.e., 26” x 36” x 42” bore diameter well interval), which were returned directly to seafloor from a discharge height of 2 m above the seafloor. A maximum thickness of 0.59 m was predicted within 20 m of the discharge location.

Table 6.1Table 6.3 summarises the total area of coverage and the maximum distances from the release location for each sedimentation rate (and equivalent total bottom thickness) of 10 mg/cm²/day (0.44 mm), 30 mg/cm²/day (1.33 mm) and 100 mg/cm²/day (4.44 mm; Table 6.3) for the modelled 8-day discharge program for the Baker well.

Based on the assessment of 50 simulations for Baker well, the maximum distances from the release location to the edge of the low exposure (10 mg/cm²/day [0.44 mm]) , moderate exposure (30 mg/cm²/day [1.33 mm]) and high exposure (100 mg/cm²/day [4.44 mm]) thresholds were 0.42 km, 0.28 km and 0.18 km, respectively.

The total area of coverage for the low exposure threshold, or greater, was 0.21 km^2 (Table 6.3).

Table 6.3 Predicted areas of coverage and maximum distances from the release location for each reporting threshold based on the results of all 50 simulations for the Baker well.

Annual assessment			
Sedimentation rate (mg/cm^2/day)	**Equivalent total sediment bottom thickness* (mm)^**	**Total area of coverage (km^2)**	**Maximum distance (km) from the release location**
10	0.44	0.21	0.42
30	1.33	0.09	0.28
100	4.44	0.04	0.18

* Based on anticipated total discharge duration and assuming final settled in-situ bulk density of 1,800 kg/m^3

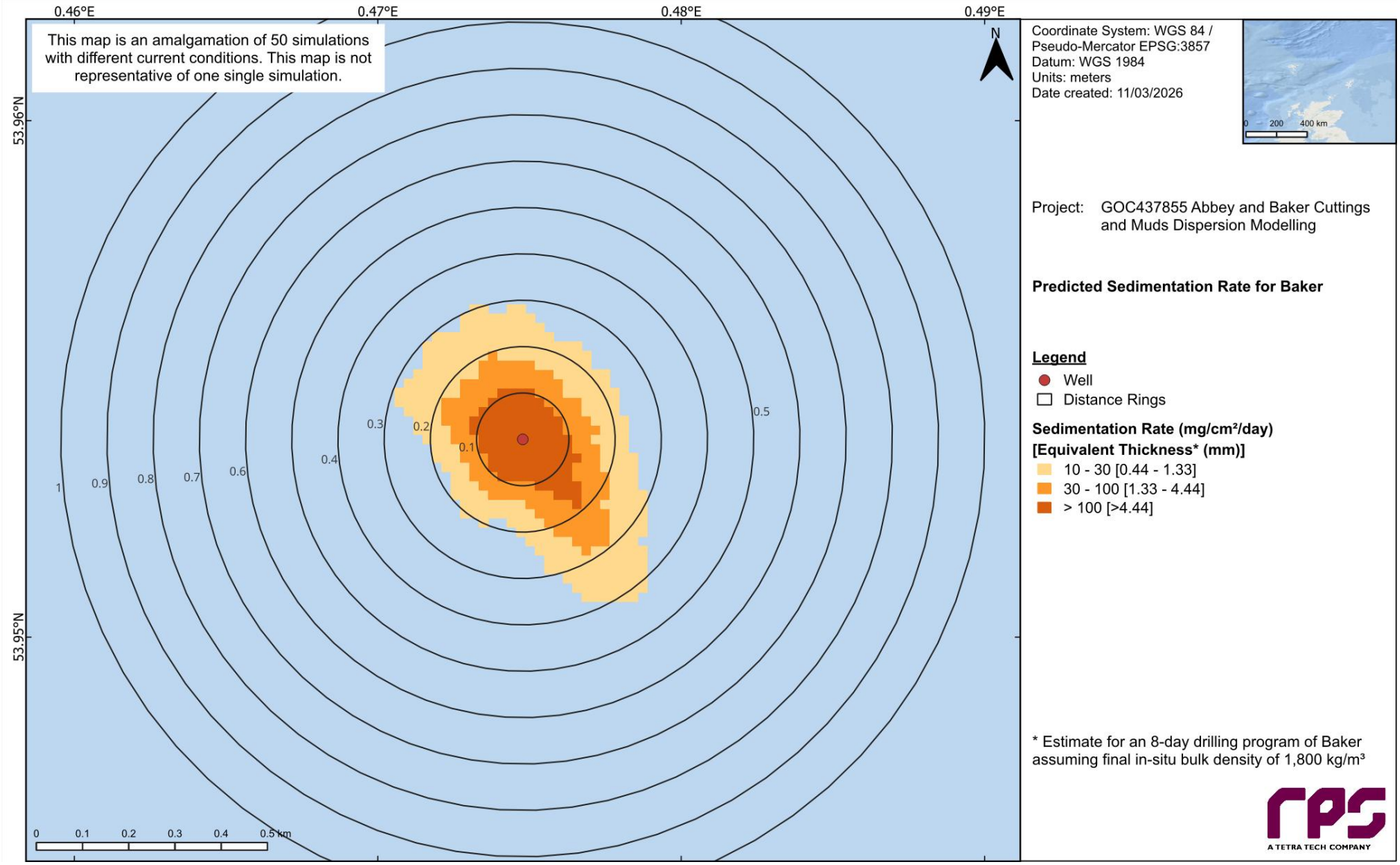

Figure 6.20 Predicted maximum sedimentation rate and equivalent thickness from the discharge of drill cuttings and muds. Results are based on 50 simulations for the Baker well and represent annual conditions.

6.4.2 Total Suspended Solids

Figure 6.21 and Figure 6.22 illustrate the maximum moving average concentrations computed over 1-hr and 24-hr in each grid cell for the Baker well modelled drilling and discharge programs, representing acute and chronic exposures respectively, to define the potential exposure from the discharge of cuttings and muds.

Table 6.4 summarises the total area of coverage and maximum distances from the release location for each TSS concentration threshold based on acute and chronic exposures.

Based on the assessment of 50 simulations for the Baker well, the maximum distance from the release location to the edge of the low exposure TSS concentration threshold (10 mg/L) for acute exposure (1-hr averaged concentration) was 0.43 km. Additionally, the maximum distance from the release location to the edge of the moderate exposure TSS concentration threshold (50 mg/L) for acute exposure (1-hr averaged concentration) was 0.04 km. High exposure (100 mg/L) TSS concentrations did not exceed 0.02 km from the release location. The total area of coverage for the low exposure threshold, or greater, was 0.35 km^2 (Table 6.4).

The maximum distance from the release location to the edge of the low exposure TSS concentration threshold (5 mg/L) for chronic exposure (24-hr averaged concentration) was 0.36 km. Additionally, the maximum distance from the release location to the edge of the chronic moderate exposure TSS concentration threshold (15 mg/L) was 0.12 km. Chronic high exposure (50 mg/L) TSS did not exceed 0.03 km from the release location. The total area of coverage for the low exposure threshold was 0.26 km^2 (Table 6.4).

The discharge of cuttings and muds will lead to relatively short-lived increased TSS concentrations, which dilute and reduce with distance from the release location to concentrations below the reporting thresholds. Based on the temporary elevated concentrations of TSS concentrations at the low exposure threshold, and the limited occurrence of the very localised high exposure, the impact likelihood is thus considered low.

Table 6.4 Predicted total areas of coverage and maximum distances to acute and chronic exposure from the release location to each reporting threshold based on the results of all 50 simulations for the Baker well.

	Annual	
Reporting threshold (mg/L)	**Total area of coverage (km^2)**	**Maximum distance (km) from the release location**
	Acute Exposure (1-hr averaged concentration)	
10	0.35	0.43
50	0.01	0.04
100	<0.01	0.02
	Chronic Exposure (24-hr averaged concentration)	
5	0.26	0.36
15	0.03	0.12
50	<0.01	0.03

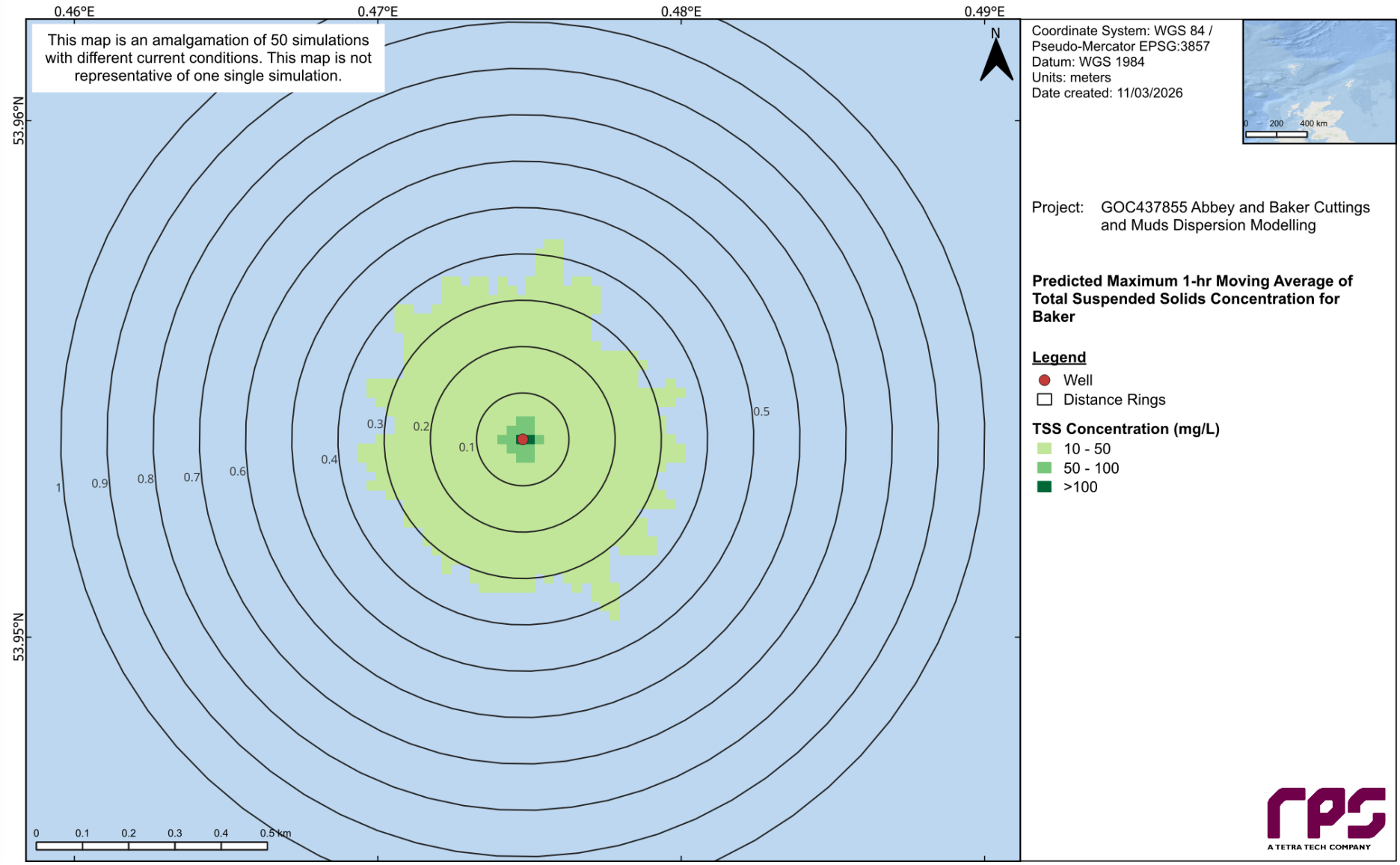

Figure 6.21 Predicted maximum 1-hr moving average of TSS concentrations, representing acute exposure, from the discharge of drill cuttings and muds. Results are based on 50 simulations and represent annual conditions for the Baker well.

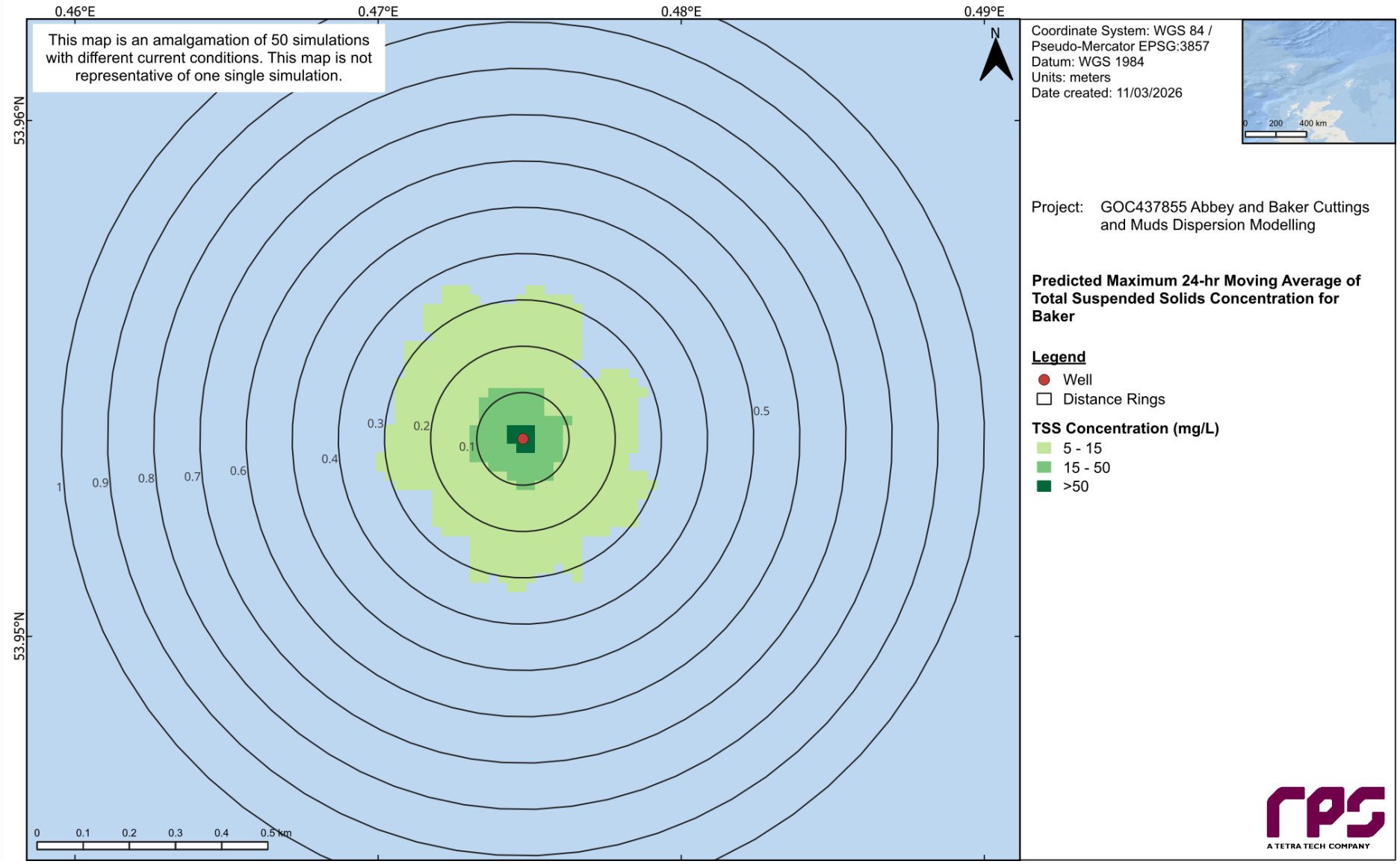

Figure 6.22 Predicted maximum 24-hr moving average of TSS concentrations, representing chronic exposure, from the discharge of drill cuttings and muds. Results are based on 100 simulations and represent annual conditions for the Baker well.

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Appendix D: Quantification of GHG Emissions

D.1 Introduction

This appendix sets out the methodology used to calculate the quantity of GHG emissions estimated to be generated from the proposed Abbey & Baker Development over the life of the field and supports the assessment documented in Section 9 (GHG Emissions) of the ES.

D.2 Direct GHG Emissions

D.2.1 Scope 1 Emissions

Scope 1 emissions are those from sources that are owned or controlled by Petrogas. For Abbey & Baker this includes:

- **Emissions pre-production:** on completion of the proposed drilling operations, GHG emissions will be generated from the well testing (flaring) and clean-up of Abbey & Baker hydrocarbons.
- **Emission associated with the export of Abbey & Baker hydrocarbons:** GHG emissions will be generated offshore at the York platform from 2 x 60kVA diesel generators (one on duty and one on standby operation), which are powering a dedicated switchboard. As the sole purpose of the York platform is to accommodate the surface elements of the SCS used to monitor and control the Abbey & Baker wells and production manifold, all GHG emissions generated at the York platform are attributed to Abbey & Baker.

Calculation Methodology

The following equation has been used to calculate the GHG emissions generated from well testing activities for both gas and oil (condensate) flaring:

1. $GHG\ Emissions_{WELL\ TEST} = Fuel\ Consumption_{(TONNES)} \times GHG\ Conversion\ Factor$

The following equation has been used to calculate the GHG emissions generated at the York platform as a result of Abbey & Baker coming online:

1. $GHG\ Emissions_{YORK} = Fuel\ to\ power\ Generator_{(TONNES)} \times GHG\ Conversion\ Factor$

Table D.1 lists the GHG conversion factors which have been used to calculate GHG emissions generated from well testing (flaring) of Abbey & Baker hydrocarbons and from fuel (diesel) used for power generation at York.

Table D.1: GHG Conversion Factors for Fuel Use and Well Testing (flaring) (EEMS, 2008)

Emission Factor Source	Activity	GHG Conversion Factors (tonnes)			
		CO_2	N_2O	CH_4	CO_2e
'Well Testing – Gas' (EEMS, 2008)	Flaring	2.8	0.000081	0.045	Note [1]
'Well Testing – Oil' (EEMS, 2008) [2]	Flaring	3.2	0.000081	0.025	Note [1]
'Disel Generator' (EEMS, 2008)	York Power Generation	3.2	0.00022	0.0000328	Note [1]

[1] The GWPs used in the calculation of CO_2e are based on the IPCC Fifth Assessment Report (AR5) - GWP values for 100-year time horizon: CO_2 GWP-100 = 1; N_2O GWP-100 = 265; CH_4 GWP-100 = 28. CO_2e is the sum of the individual GHG units post GWP calculation (e.g. $(CO_2*1_{GWP\text{-}100}) + (N_2O*265_{GWP\text{-}100}) + (CH_4*28_{GWP\text{-}100})$).

[2] Oil has been used as a proxy for condensate, as condensate flaring does not exist within the EEMS (2008) emission factors database.

Quantification of Scope 1 Emissions

Table D.2 details the Scope 1 GHG emissions generated during the life of the Abbey & Baker field.

Table D.2: Abbey & Baker Total Scope 1 Emissions

Source	Fuel Use (kt)	Total Emissions (kt) [1]			
		CO_2	N_2O	CH_4	CO_2e
Well Testing (Gas) [2]	9.68	27.10	<0.01	0.44	39.51
Well Testing (Oil) [2]	0.27	0.86	<0.01	0.01	1.06
York Platform (Lifetime) [3]	0.95	3.05	<0.01	<0.01	3.11
Total Scope 1:		**31.02**	**0.00**	**0.44**	**43.68**

[1] Refer to GHG conversion factors in Table D.1.
[2] Well test to be carried out on all 4 wells. The clean-up of the Baker well is expected to take 2 days, the clean-up of the Abbey A2 well is expected to take 5 days, and the clean-up of the Abbey A1 and A3 wells is expected to take 7 days per well (14 days total), giving a total planned flaring duration of 21 days. During this time up to 9,950 tonnes of equivalent hydrocarbon (comprised of 9,680 tonnes of Gas and 270 tonnes of Condensate) may be flared. Well testing (flaring) and clean-up emissions are pre-production (before 2029).
[3] The power demand for Abbey & Baker is ca. 0.163 tonnes of fuel per day or ca. 59.6 tonnes per year. Abbey & Baker has a producing field life of up to 16 years (2029 – 2044).

D.3 Indirect GHG Emissions

D.3.1 Upstream Scope 3 Emissions (Offshore Operations)

Upstream Scope 3 emissions are the indirect emissions which will be generated by Petrogas' contractors offshore when extracting, producing and exporting Abbey & Baker hydrocarbons to the Dimlington Gas Terminal (DGT).

Calculation Methodology

The following equation has been used to calculate the total quantity of upstream Scope 3 emissions generated from the Abbey & Baker development offshore operations:

1. $GHG\ Emissions = Activity\ (Fuel\ Consumption_{(TONNES)}) \times GHG\ Conversion\ Factor$

Table D.3 lists the GHG conversion factors which have been used to calculate GHG emissions generated from offshore transport related activity (i.e. vessel and helicopter movements).

Table D.3: GHG Conversion Factors for Fuel used in Transport Activities (DESNZ, 2025)

Fuel	Abbey & Baker Activity	GHG Conversion Factors (kg CO_2e of GHG per unit)[1]			
		CO_2	N_2O	CH_4	CO_2e [2]
'Marine Gas Oil'	Vessels	3205.99000	38.40721	0.90720	3245.30441
'Aviation Turbine Fuel'	Helicopters	3149.67000	26.50000	2.19520	3178.3652

[1] GHG Conversion Factor converted to tonnes before calculation.
[2] The GWPs used in the calculation of CO_2e are based on the IPCC Fifth Assessment Report (AR5).

Quantification of Total Upstream Scope 3 Emissions

Table D.4: Abbey & Baker Development Total Upstream Scope 3 Emissions (Offshore Operations)

Abbey & Baker Activity	Total Fuel Use (kt) [1]	GHG Emissions (kt) [2]			
		CO_2	N_2O	CH_4	CO_2e
Drilling Operations	7.30	23.40	0.29	0.01	23.69
Installation Operations	4.10	13.13	0.16	<0.01	13.30
Inspection and Maintenance Operations	6.62	21.20	0.28	0.01	21.49
York Topside Modifications	2.01	6.45	0.08	<0.01	6.53
Grand Total	**20.03**	**64.18**	**0.81**	**0.02**	**65.00**

[1] Total fuel use based on vessel and helicopter requirements for drilling operations (Table 3.3), installation operations (Table 3.13), inspection and maintenance operations (Table 3.17), as detailed in Section 3.
[2] Refer to GHG conversion factors in Table D.3.

D.3.2 Downstream Scope 3 Emissions (Well-to-Tank and End Use of Sold Products)

Downstream Scope 3 emissions are the indirect emissions which will be generated once the Abbey & Baker hydrocarbons have been processed to export specification and sold, including from processing, transportation and distribution and from the end use of the sold product (namely, the presumption that all end use Abbey & Baker hydrocarbons are eventually combusted).

D.3.2.1 Well-to-Tank Emissions

Calculation Methodology

Well-to-Tank (WTT) emissions represent the GHG emissions generated during the extraction, refinement, transport and distribution of fuels prior to their end-use. In a downstream context, this includes all emissions associated with the handling and logistical operations required to deliver refined hydrocarbons to market, but excludes combustion or end-use emissions, which are quantified separately below.

The following equations have been used to calculate the total quantity of GHG emissions generated from the further refinement, transportation and distribution of Abbey & Baker hydrocarbons:

For Gas:

$$WTT\ GHG\ Emissions = Production_{GAS(TONNES)} \times GHG\ Conversion\ Factor$$

For Condensate:

$$WTT\ GHG\ Emissions = Production_{CONDENSATE(TONNES)} \times GHG\ Conversion\ Factor$$

The sum of the above two equations (Gas WTT + Condensate WTT) is the total WTT Emissions.

Table D.5 details the GHG conversion factors used to calculate the WTT emissions. 'Natural gas (100% mineral blend)' has been assumed as the downstream proxy fuel for Abbey & Baker gas, and 'Petrol (100% mineral petrol)' has been assumed as the downstream proxy fuel for Abbey & Baker condensate.

Table D.5: Well-to-Tank GHG Conversion Factors (DESNZ, 2025)

Abbey & Baker Hydrocarbon	Downstream Proxy Fuel	GHG Conversion Factor (kg CO_2e of GHG per unit)[1]
Gas	'Natural gas (100% mineral blend)' WTT Fuels	423.16368
Condensate	'Petrol (100% mineral petrol)' WTT Fuels [1]	815.93523

[1] GHG Conversion Factor converted to tonnes before calculation.
[2] There is no WTT conversion factor for condensate in DESNZ (2025), therefore Petrol (100% mineral petrol) has been used as a proxy as it is considered to be a worst-case match for condensate for the purposes of this assessment.

Given the nature of the Abbey & Baker hydrocarbons and the known stages of refinement prior to transport and distribution to market, particularly as gas exported from the DGT feeds directly into the NTS, the quantity of CO_2e emissions calculated for the WTT phase is likely to be a conservative worst-case estimate.

Quantification of GHG Emissions

Table D.6: Abbey & Baker Development WTT Scope 3 Emissions

Year	Abbey & Baker Production (kt)		WTT Emissions ($ktCO_2e$) [2]		
	Gas [1]	Condensate	Gas	Condensate	Total
2029	500.86	27.45	211.95	22.40	**234.34**
2030	666.42	36.24	282.00	29.57	**311.57**
2031	652.78	35.16	276.23	28.69	**304.92**
2032	568.86	30.39	240.72	24.80	**265.52**
2033	454.58	24.40	192.36	19.91	**212.27**
2034	375.58	20.15	158.93	16.44	**175.37**
2035	317.29	17.00	134.27	13.87	**148.14**
2036	272.88	14.55	115.47	11.88	**127.35**
2037	236.43	12.62	100.05	10.30	**110.34**
2038	206.57	11.00	87.41	8.97	**96.38**
2039	179.84	9.54	76.10	7.79	**83.89**
2040	159.64	8.42	67.55	6.87	**74.42**
2041	141.22	7.45	59.76	6.08	**65.84**
2042	125.28	6.59	53.02	5.38	**58.39**
2043	111.72	5.86	47.28	4.78	**52.06**
2044	92.85	4.79	39.29	3.91	**43.20**
Total	**5,062.79**	**271.61**	**2,142.39**	**221.61**	**2,364.00**

[1] Refer to Section 3.6.1 for Abbey & Baker production profile. Gas converted from m^3 to tonnes using a density of 0.617 kg/m^3.
[2] Refer to GHG conversion factors in Table D.5.

D.3.2.2 End Use of Sold Products

Calculation Methodology

The following equation has been used to calculate the total quantity of Scope 3 emissions generated from the end use of sold products (namely, the worst case presumption that all end use Abbey & Baker hydrocarbons are eventually combusted).

For gas:

$$End\ Use\ GHG\ Emissions = Production_{GAS(TONNES)} \times GHG\ Conversion\ Factor$$

For condensate:

$$End\ Use\ GHG\ Emissions = Production_{CONDENSATE(TONNES)} \times GHG\ Conversion\ Factor$$

Table D.7 lists the GHG conversion factors which have been used to calculate End Use GHG emissions.

Table D.7: End Use GHG Conversion Factors (DESNZ, 2025)

Abbey & Baker Hydrocarbon	Proxy Fuel	GHG Conversion Factors (kg CO_2e of GHG per unit)[1]			
		CO_2	N_2O	CH_4	CO_2e [2]
Gas	'Natural Gas (100% mineral blend)' (DESNZ, 2025)	2,598.26	3.8528	1.19161	2,603.30441
Condensate	'Petrol (100% mineral petrol)' (DESNZ, 2025)	3135	11.04320	8.03893	3154.08213

[1] GHG Conversion Factor converted to tonnes before calculation.
[2] The GWPs used in the calculation of CO_2e are based on the IPCC Fifth Assessment Report (AR5).

Production values presented in Section 3.6.1 have been rounded for simplification in the ES. All calculations in Appendix D were undertaken using the original unrounded data. Reproduction of calculations using the rounded figures in from Section 3.6.1 may therefore result in minor discrepancies.

Quantification of GHG Emissions

Table D.8: GHG Emissions from Combustion of Abbey & Baker Gas and Condensate (High Case)

Year	Volume of Gas Produced [1]		Emissions (kt) [2]			
	Mm^3/yr	kt/yr	CO_2	N_2O	CH_4	CO_2e
2029	811.77	500.86	1,301.37	1.93	0.60	1,303.89
2030	1,080.10	666.42	1,731.53	2.57	0.79	1,734.89
2031	1,057.99	652.78	1,696.09	2.52	0.78	1,699.38
2032	921.97	568.86	1,478.04	2.19	0.68	1,480.91
2033	736.76	454.58	1,181.13	1.75	0.54	1,183.42
2034	608.71	375.58	975.84	1.45	0.45	977.74
2035	514.25	317.29	824.40	1.22	0.38	826.00
2036	442.27	272.88	709.02	1.05	0.33	710.40
2037	383.19	236.43	614.30	0.91	0.28	615.49
2038	334.79	206.57	536.71	0.80	0.25	537.75
2039	291.48	179.84	467.28	0.69	0.21	468.19
2040	258.73	159.64	414.77	0.62	0.19	415.58
2041	228.89	141.22	366.94	0.54	0.17	367.65
2042	203.05	125.28	325.52	0.48	0.15	326.15
2043	181.07	111.72	290.28	0.43	0.13	290.85
2044	150.48	92.85	241.24	0.36	0.11	241.70
Totals:	**8,205.50**	**5,062.79**	**13,154.45**	**19.51**	**6.03**	**13,179.99**

Year	Volume of Condensate Produced (kt/yr) [3]	GHG Emissions (kt) [2]			
		CO_2	N_2O	CH_4	CO_2e
2029	27.45	86.05	0.30	0.22	86.57
2030	36.24	113.60	0.40	0.29	114.30
2031	35.16	110.22	0.39	0.28	110.89
2032	30.39	95.28	0.34	0.24	95.86
2033	24.40	76.49	0.27	0.20	76.96
2034	20.15	63.16	0.22	0.16	63.55
2035	17.00	53.29	0.19	0.14	53.62
2036	14.55	45.63	0.16	0.12	45.91
2037	12.62	39.56	0.14	0.10	39.80
2038	11.00	34.48	0.12	0.09	34.69
2039	9.54	29.92	0.11	0.08	30.10
2040	8.42	26.41	0.09	0.07	26.57
2041	7.45	23.36	0.08	0.06	23.51
2042	6.59	20.66	0.07	0.05	20.79
2043	5.86	18.36	0.06	0.05	18.47
2044	4.79	15.01	0.05	0.04	15.10
Totals:	**271.61**	**851.49**	**3.00**	**2.18**	**856.67**
	High (P10) Case Totals:	**14,005.94**	**22.51**	**8.22**	**14,036.66**

[1] Gas volumes based on Abbey & Baker high case production profile (refer to Section 3.6.1), with production commencing in April 2029 and cessation of production in December 2044; volumes in the start and end years are pro-rated to reflect partial-year. Gas converted from m^3 to tonnes using a density of 0.617 kg/m^3.

[2] Refer to GHG Conversion Factors in Table D.7

[3] Condensate volumes based on Abbey & Baker high case production profile (refer to Section 3.6.1), with production commencing in April 2029 and cessation of production in December 2044; volumes in the start and end years are pro-rated to reflect partial-year production.

D.3.2.3 Total Downstream Scope 3 Emissions

Table D.9 details the total downstream Scope 3 emissions which will be generated from the proposed Abbey & Baker Development.

Table D.9: Abbey & Baker Development Total Downstream Scope 3 Emissions (High Case)

Downstream Activities	Total GHG Emissions (kt CO_2e)
Well-to-Tank Emissions	2,364.00
End Use of Sold Products	14,036.66
Total (High Case):	**16,400.67**

D.4 Summary of Total GHG Emissions

Table D.10 details the worst-case total GHG emissions estimated to be generated as a result of the proposed Abbey & Baker Development.

Table D.10: Abbey & Baker Development Total GHG Emissions (High Case)

Emissions Category	Total GHG Emissions (kt CO_2e)
Total Direct GHG Emissions (Scope 1) [1]	43.68
Total Indirect Upstream GHG Emissions (Scope 3) [2]	65.00
Total Indirect Downstream GHG Emissions (Scope 3) [3]	16,400.67
Grand Total	**16,509.35**

[1] Refer to Section D.2.1
[2] Refer to Section D.3.1
[3] The total indirect downstream GHG emissions generated depend on the Abbey & Baker production profiles as the methodology applies GHG conversion factors to production volumes (refer to Section D.3.2).

In summary, the worst-case total gross GHG emissions generated over the life of the Abbey & Baker Development are estimated to be ca. 16,509.35 kilotonnes of CO_2e, based on the High (P10) production case (assuming a four well development), which represents a 'worst case' emissions profile.

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Appendix E: Oil Spill Modelling Study

This appendix presents the results of the oil spill modelling study undertaken to support the Abbey & Baker Development ES in order to gain an understanding of the behaviour of a potential worst case oil spill scenario in the marine environment originating from a subsea well blowout. The modelling has been completed in line with the OPRED Guidance Notes for Preparing Oil Pollution Emergency Plans for Offshore Oil & Gas Installations and Relevant Oil Handling Facilities (Revision 7: June 2022).

E.1 OILMAP Spill Modelling Package

This oil spill modelling study has been carried out in RPS ASA's OILMAP (Version 7.7.218.1528) modelling system, which predicts the surface trajectory of spilled oil and includes algorithms for oil spreading, evaporation, emulsification, entrainment, and oil shoreline interaction. The distribution and mass balance of oil with respect to time are predicted for the specific oil spilled. Additional modules are utilised in OILMAP to execute more in-depth modelling processes such as simulating subsurface oil releases and computing probability.

The following modules have been utilised in OILMAP for the Abbey & Baker Development oil spill modelling study:

- **Trajectory and Fates Model:** The trajectory and fates module is a far-field model, for surface and subsurface releases, that predicts the 3D trajectory and fate of oil for instantaneous or continuous release spills.
- **Stochastic Model (RunStoch):** The stochastic module is used for risk assessment and contingency planning. It helps determine the most likely spill paths and the minimum time for oil to reach specific points on monthly, seasonal, or annual basis.

E.1.1 Trajectory and Fates Model

The Trajectory and Fates model simulates the droplet rise phase and surfaced oil. The model predicts the transport and weathering of oil from instantaneous or continuous spills. Predictions show the location and concentration of the surface and subsurface oil versus time. The model estimates the temporal variation of the oil's areal coverage, oil thickness, and oil viscosity.

The model also predicts the oil mass balance or the amount of oil on the free surface, in the water column, evaporated, on the shore, and outside the study domain versus time. The fate processes in the model include spreading, evaporation, entrainment or natural dispersion, emulsification and an oil-shoreline interaction:

- **Spreading** is represented using the thick slick portion of Mackay *et al*. (1980, 1982) thick-thin approach.
- **Evaporation** is based on Mackay's analytic formulation parameterized in terms of evaporative exposure (Mackay *et al*., 1980, 1982).
- **Entrainment or Natural Dispersion** is modelled using Delvigne and Sweeney's (1988) formulation which explicitly represents oil injection rates into the water column by droplet size. The entrainment coefficient, as a function of oil viscosity, is based on Delvigne and Hulsen (1994).
- **Emulsification** of the oil, as function of evaporative losses and changes in water content, is based on Mackay et al. (1980, 1982).
- **Oil-Shoreline Interaction** is modelled based on a simplified version of Reed *et al*. (1989) which formulates the problem in terms of a shore type dependent holding capacity and exponential removal rate.

E.1.2 Stochastic Model (RunStoch)

The stochastic model is useful as a contingency planning tool. It is used to determine the range of distances and directions oil spills from a particular site are likely to travel, given the historical wind speed and direction data for the area. The stochastic model performs a large number of single

simulations (typically 100 individual trajectory runs) for a given spill site, varying the wind and tidal conditions for each scenario. These trajectories are used to predict probabilities and minimum time that water surface and shoreline areas will be oiled by a release from the given site.

Figure E.1 shows how a simple probability map is created. The example uses four trajectory runs to create a final probability map. Following the same example, Figure E.2 demonstrates how to interpret probability and features of interest (e.g. marine protected areas).

Figure E.1: Diagram to show how stochastic probability maps are made

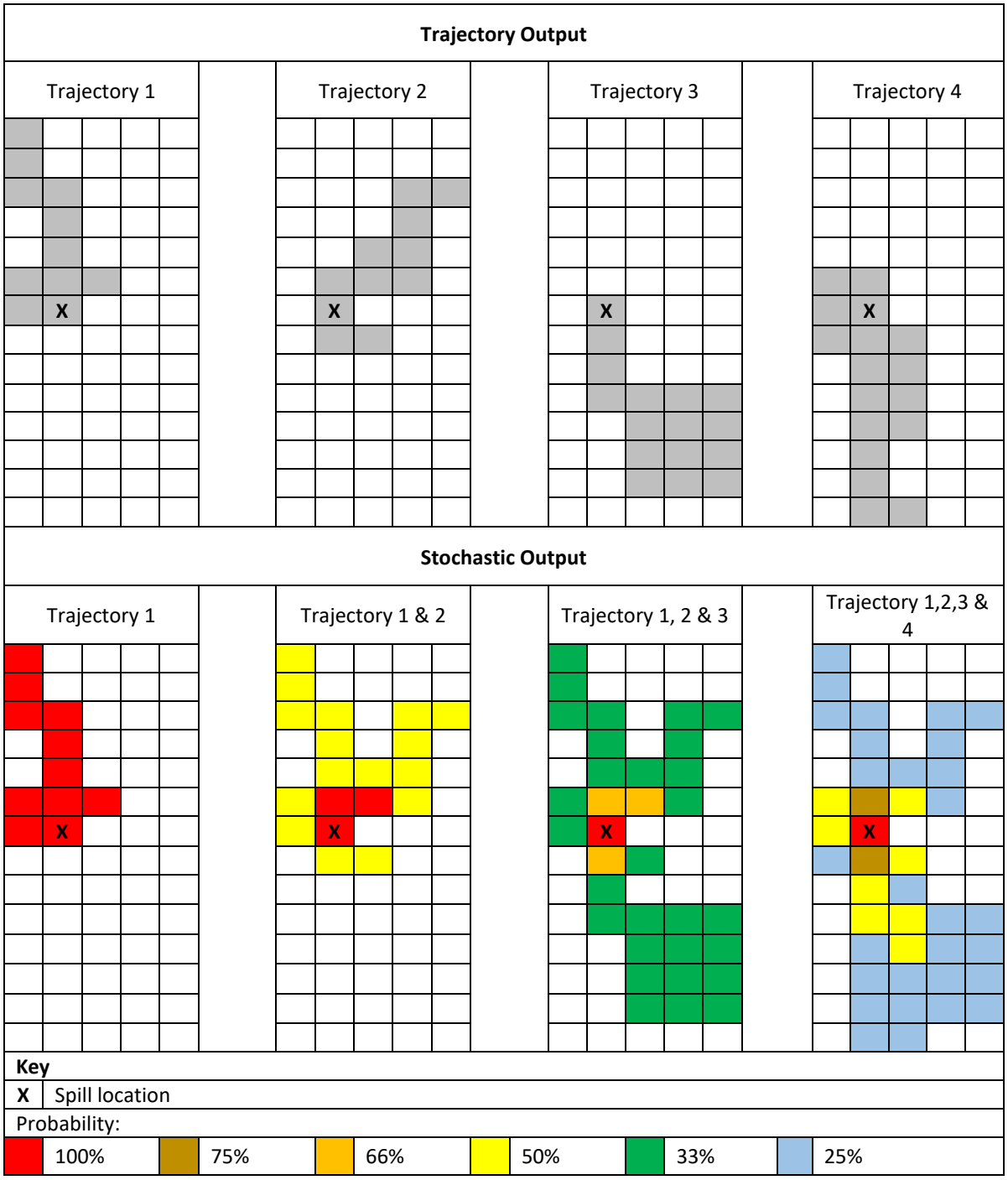
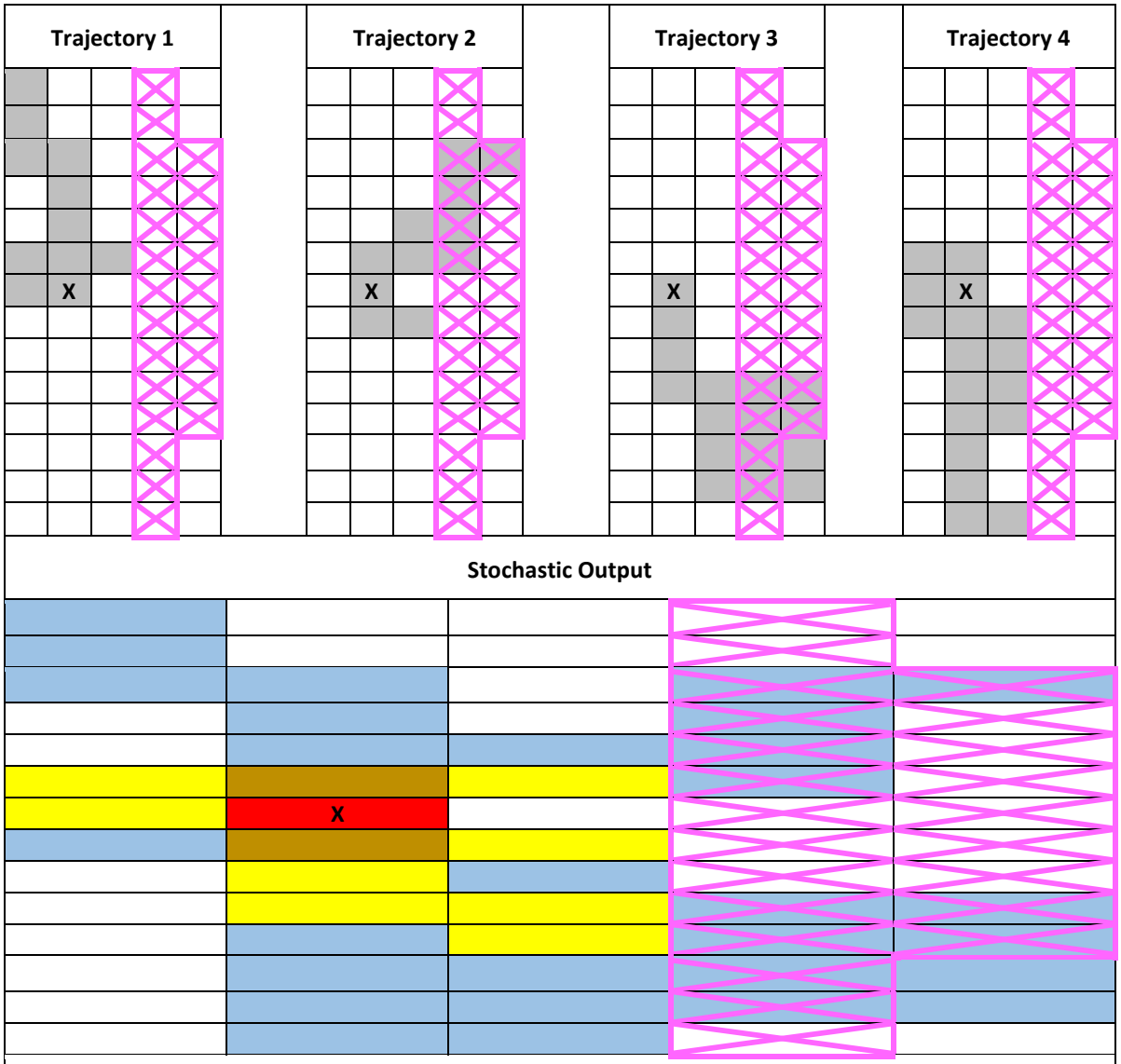


Figure E.2: Interpretation of Probability Mapping (Probability Grid vs Context Driven)



Key	
X	Spill location
	Marine Protected Area
Gridded Probability Output:	
100%	75% 66% 50% 33% 25%

Interpretation of Probability

A grid is over laid onto the trajectory runs to produce the gridded probability output. The grid 'cell size' is important in determining the resolution of the results.

A typical grid cell size for a blowout scenario is 1 x 1 km.

Overlaying features (e.g. Marine Protected Areas) onto a probability map can be misleading when interpreting results. In the example above, the gridded probability suggests that there is a 25 % probability of the Marine Protected Area being hit by oil. Whereas, a context driven approach that counts the number of trajectory runs that enter the Marine Protected Area produces a probability of 50 % (i.e. two trajectory simulations out of four enter the Marine Protected Area).

Therefore, to avoid underestimating probability a context driven approach is used when reporting results.

E.2 Modelled Scenario

E.2.1 Worst Case Spill Scenario

The following worst case spill scenario has been modelled for the Abbey & Baker Development:

- Subsurface blowout release from the Baker Development well with a cumulative release of 175,223.07 barrels (bbl) (27,860.47 cubic metres (m^3)) of 57.5°API condensate, released over a period of 79 days.

E.2.2 Summary of Model Input Parameters

The model input parameters for the Abbey & Baker Development subsea blowout scenario are detailed in Table E.1.

Table E.1: Model Input Parameters for a Subsurface Blowout in the Abbey & Baker Development

Scenario 1: Well Loss Parameters			
Loss from Well / FPSO / Rig (please specify)	Abbey & Baker Development Subsea Well Blowout (at Baker)	**Instantaneous Loss?**	No
Worst case volume	175,223.07 bbl (27,860.47 m^3)	**Will the well self-kill? If yes, when**	No, it is assumed a relief well would be required.
Flow rate	Declining flow rate - starting at 3,212.2 bbl (510.74 m^3) / day on day 1, declining to 1,757.1 bbl (279.38 m^3) / day on day 79 (refer to Section E.6.3)		
Justification for predicted worst case volume	This represents the anticipated worst case blowout scenario for the Abbey & Baker Development in terms of both the volume of condensate which would be released and the duration of the spill (i.e. it assumes the flow can only be stemmed by drilling a relief well which would take a total of 79 days to drill).		
Location (WGS84)			
Spill Source point Latitude (N/S)	53° 56′ 40.8268″ N	**Spill source point Longitude (E/W)**	0° 29′ 5.2376″ E
Installation / Facility Name	Proposed Baker Development Well	**Quad / Block**	47/3
Hydrocarbon Properties			
Hydrocarbon name	Condensate		
Assay available	No	**Was an analogue used for spill modelling?**	Yes

	Name	**ITOPF Category**	**Density**	**API**	**Viscosity at temp**	**Pour Point (°C)**	**Wax Content (%)**	**Asphaltene Content (%)**
Analogue	Condensate Sleipner	Group 1	0.75	57.5°	0.766cP @ 25°C	-30	0	1

Metocean Parameters				
Sea surface temperature	Winter (Dec – Feb)	6°C	Summer (June – Aug)	14°C
	Spring (Mar – May)	9°C	Autumn (Sep – Nov)	10°C
Wind data	Data period	2019 – 2023		
	Data reference	European Centre for Medium-Range Weather Forecasts (ECMWF) - Reanalysis v5 (ERA5)		
Current data	Data period	2019 – 2023		
	Data reference	HYCOM (HYbrid Coordinate Ocean Model) general ocean circulation model and HYDROMAP hydrodynamic model		

Modelled Release Parameters			
Surface or Subsurface	Subsurface	**Depth**	46 m
Release duration	79 Days	**Instantaneous?**	No
Persistence duration	10 Days	**Release rate**	Declining flow rate - starting at 3,212.2 bbl (510.74 m^3) / day on day 1, declining to 1,757.1 bbl (279.38 m^3) / day on day 79 (refer to Section E.6.3)
Total simulation time	89 Days	**Total cumulative release**	175,223.07 bbl (27,860.47 m^3)

Subsea Release Parameters	**Gas to Oil Ratio (GOR)**	18,940 m^3/m^3
	Salinity and Temperature Profile	Refer to Section E.6.1.
	Gas Viscosity	0.0190 Centipoise (cP)
	Gas Diffusivity	0.0000000011 m^2/s
	Diameter of Release Hole	0.5 m
	Particle Size / Velocity Distribution Method	Model calculated with 6 droplet size bins. Each bin represents 16.6667% of spill volume released.

Season	**Average Oil Droplet Size (micrometre (µm))**					
	Bin 1	**Bin 2**	**Bin 3**	**Bin 4**	**Bin 5**	**Bin 6**
Winter (Dec – Feb)	20.6	47.6	60.5	75.0	95.8	130.5
Spring (Mar – May)	20.5	47.2	60.0	74.4	95.0	129.4
Summer (Jun – Aug)	20.1	46.4	58.9	73.0	93.3	127.1
Autumn (Sep – Nov)	20.3	46.8	59.4	73.7	94.2	128.2

No. of Runs	100 simulation runs per season

Stochastic Parameters		
Probability grid (Grid Cell Size)	Fixed Cell Size: Cell Size (X and Y axis) = 1,000 metres (m) Cell Size (Z axis) = 200 m	
Distribution of Mass On Grid Cells	Fixed Mass (mass of spillet is placed only in the grid cell that intersects with the centre of the spillet, without any spreading). Mass is not distributed to any other grid cells.	
Minimum Thresholds	Surface Thickness:	0.0003 millimetres (mm)

	Shoreline Thickness:	0.001 mm
	Water Column Concentration:	1.0 parts per billion (ppb)

Oil Spill Modelling Software			
Name of software	OILMAP	**Version**	7.7.218.1528

E.2.3 Reporting Thresholds

Probability and Minimum Time

Table E.2 outlines the minimum oiling thresholds used for this study to determine the probability and minimum time for oiling.

Table E.2: Minimum Oiling Thresholds used for Probability and Minimum Time Reporting

Category	Threshold	Justification
Surface	Minimum Thickness of 0.3 micrometres (µm)	The OPRED Guidance Notes for Preparing OPEPs for Offshore Oil & Gas Installations and Relevant Oil Handling Facilities (Revision 7: June 2022) states that model results must be displayed to an oil thickness of 0.3 µm.
Water Column	Minimum Concentration of 1.0 ppb (total oil)	Screening threshold for potential effects on sensitive organisms & socio-economic activity (e.g. seafood production) (Trudel, 1989; French-McCay, 2002; French-McCay, 2004; French-McCay, *et al*. 2012).
Shoreline	Minimum Thickness of 1.0 µm	This threshold has been selected for potential effects on socio-economic resource uses, as this amount of oil may conservatively trigger the need for shoreline clean-up on amenity beaches. And impact shoreline recreation and tourism (French-McCay, *et al*. 2011 and French-McCay, *et al*. 2012). Shoreline oiling at this threshold may appear as a coat, patches or scattered tar.

Surface Oiling Severity

The surface oil thickness key in Table E.3 is derived from the Bonn Oil Appearance Code (BOAC). Mapping surface oil thickness by the BOAC will help determine surface oiling severity in the spatial context.

Table E.3: The Bonn Agreement Oil Appearance Code

Code	Description - Appearance	Layer Thickness Interval (µm)	Litres per km^2	Colour
1	Sheen (silvery/grey)	0.04 to 0.30 Note 1	40 – 300	
2	Rainbow	0.30 to 5.0	300 – 5000	
3	Metallic	5.0 to 50	5000 – 50,000	
4	Discontinuous True Oil Colour	50 to 200	50,000 – 200,000	
5	Continuous True Oil Colour	More than 200	More than 200,000	

Note 1: The OILMAP outputs are modelled to a minimum of 0.30 µm as per the OPRED Guidance Notes for Preparing OPEPs for Offshore Oil & Gas Installations and Relevant Oil Handling Facilities (Revision 7: June 2022).

Water Column Oiling Severity

Table E.4 details four different thresholds for water column oiling concentrations and the effect on marine fauna. The different thresholds are derived from various research papers and will help determine sub surface oiling severity in the spatial context.

Table E.4: Water Column Oil Concentration Thresholds

Minimum Threshold for Water Column Oil Concentration (ppb)	Justification	Colour
1	Screening threshold for potential effects on sensitive organisms & socio-economic activity (e.g. seafood production) (Trudel, 1989; French-McCay, 2002; French-McCay, 2004; French-McCay, et al. 2012).	
70.5	Smit *et al*. (2009) calculated an EC_5 for growth, reproduction and survival of marine organisms of 70.5 ppb THC based on laboratory experiments performed at IRIS (Norway). The dataset included organisms representing five different phyla (fish, crustaceans, polychaetes, echinoderms and molluscs). The 70.5 ppb figure is the OSPAR recommended predicted no-effect concentration (OSPAR, 2014).	

Shoreline Oiling Severity

Table E.5 details three different thresholds for shoreline oiling concentrations that represent light oiling, moderate oiling and heavy oiling. The shoreline oiling classifications are derived from the International Tanker Owners Pollution Federation Limited (ITOPF) Technical Information Paper No.6 'Recognition of oil on shorelines (ITOPF, 2014b). The shoreline oiling classifications will help determine shoreline oiling severity in the spatial context.

Table E.5: Shoreline Oil Thickness Thresholds

Shoreline Oiling Classification (ITOPF, 2014b)	Thickness Threshold (mm)	Concentration	Colour
Light Oiling	0.001 - <1	0.001 – 1 litres / m^2	
Moderate Oiling	1 – 10	1 – 10 litres / m^2	
Heavy Oiling	>10	>10 litres / m^2	

E.3 Stochastic Modelling Results

E.3.1 Summary of Results

Table E.6 summarises the stochastic results for a worst case subsea well blowout associated with the Baker Development well across all seasons. The results in Table E.6 report the minimum arrival time and probability of condensate to reach land and the territorial waters of nearby countries.

Table E.6: Summary of Stochastic Modelling Results

Scenario 1: Abbey & Baker Development Subsea Well Blowout (at the Baker Development Well)					
Spill Scenario / Descriptor: 175,223.07 bbl (27,860.47 m^3) of Condensate (57.5 °API) released over 79 days					
Season		Winter (December – February)	Spring (March – May)	Summer (June – August)	Autumn (September – November)
Median Crossing [Note 1]					
Identified Median Line	**Surface Oil: Probability and Shortest Time to Reach (Minimum Thickness of 0.3 µm)**				
Netherlands	*Maximum Probability*	14 %	N/A	3 %	17 %
	Shortest Arrival Time	222 hrs	N/A	882 hrs	410 hrs
Germany	*Maximum Probability*	5 %	N/A	N/A	2 %
	Shortest Arrival Time	457 hrs	N/A	N/A	1,196 hrs
Belgium	*Maximum Probability*	N/A	N/A	N/A	2 %
	Shortest Arrival Time	N/A	N/A	N/A	1,367 hrs
France	*Maximum Probability*	N/A	N/A	N/A	1 %
	Shortest Arrival Time	N/A	N/A	N/A	1,382 hrs
Denmark	*Maximum Probability*	2 %	N/A	N/A	1 %
	Shortest Arrival Time	785 hrs	N/A	N/A	2,099 hrs
Identified Median Line	**Subsurface Oil: Probability and Shortest Time to Reach (Minimum Water Column Concentration 1.0 ppb)**				
Netherlands	*Maximum Probability*	67 %	3 %	32 %	80 %

	Shortest Arrival Time	199 hrs	1,412 hrs	721 hrs	403 hrs
Germany	*Maximum Probability*	44 %	N/A	3 %	20 %
	Shortest Arrival Time	478 hrs	N/A	1,659 hrs	1,067 hrs
Belgium	*Maximum Probability*	10 %	1 %	11 %	25 %
	Shortest Arrival Time	897 hrs	1,418 hrs	1,078 hrs	757 hrs
France	*Maximum Probability*	5 %	1 %	12 %	20 %
	Shortest Arrival Time	933 hrs	1,352 hrs	986 hrs	743 hrs
Denmark	*Maximum Probability*	14 %	N/A	N/A	3 %
	Shortest Arrival Time	788 hrs	N/A	N/A	1,190 hrs
Norway	*Maximum Probability*	3 %	N/A	N/A	N/A
	Shortest Arrival Time	1,712 hrs	N/A	N/A	N/A
Sweden	*Maximum Probability*	4 %	N/A	N/A	N/A
	Shortest Arrival Time	1,396 hrs	N/A	N/A	N/A
Landfall [Note 1]					
Predicted Locations	**Shoreline Oil: Probability and Shortest Time to Reach (Minimum Thickness of 1.0 µm)**				
Netherlands	*Maximum Probability*	1 %	N/A	N/A	1 %
	Shortest Arrival Time	1,120 hrs	N/A	N/A	2,018 hrs
Germany	*Maximum Probability*	2 %	N/A	N/A	N/A
	Shortest Arrival Time	1,242 hrs	N/A	N/A	N/A
Denmark	*Maximum Probability*	1 %	N/A	N/A	1 %
	Shortest Arrival Time	1,227 hrs	N/A	N/A	2,094 hrs

France	*Maximum Probability*	N/A	N/A	N/A	1 %
	Shortest Arrival Time	N/A	N/A	N/A	1,748 hrs
UK Counties					
East Riding of Yorkshire	*Maximum Probability*	40 %	58 %	34 %	13 %
	Shortest Arrival Time	157 hrs	119 hrs	101 hrs	115 hrs
North Yorkshire	*Maximum Probability*	33 %	26 %	22 %	7 %
	Shortest Arrival Time	149 hrs	191 hrs	118 hrs	335 hrs
Lincolnshire	*Maximum Probability*	9 %	11 %	4 %	2 %
	Shortest Arrival Time	350 hrs	272 hrs	320 hrs	525 hrs
Norfolk	*Maximum Probability*	7 %	3 %	N/A	2 %
	Shortest Arrival Time	628 hrs	394 hrs	N/A	447 hrs
Northumberland	*Maximum Probability*	N/A	1 %	N/A	N/A
	Shortest Arrival Time	N/A	932 hrs	N/A	N/A
Durham	*Maximum Probability*	10 %	1 %	N/A	1 %
	Shortest Arrival Time	573 hrs	570 hrs	N/A	2,023 hrs
Tyne and Wear	*Maximum Probability*	6 %	1 %	N/A	1 %
	Shortest Arrival Time	673 hrs	532 hrs	N/A	2,054 hrs
Suffolk	*Maximum Probability*	1 %	N/A	N/A	1 %
	Shortest Arrival Time	872 hrs	N/A	N/A	1,348 hrs
Essex	*Maximum Probability*	1 %	N/A	N/A	N/A
	Shortest Arrival Time	1,595 hrs	N/A	N/A	N/A

Kent	*Maximum Probability*	1 %	N/A	N/A	N/A
	Shortest Arrival Time	1,489 hrs	N/A	N/A	N/A
Worst Case Trajectory Simulations Identified from Stochastic Results					
Greatest Volume of Condensate Beached (in any one location)	*Trajectory Run No. (out of 100)*	64	24	38	84
	m^3	42.09	29.73	15.93	6.03
	bbl	264.72	186.98	100.19	37.92
	Tonnes	31.57	22.30	11.95	4.52
	Sim Start Date	02/02/2021	15/03/2021	06/06/2021	17/11/2020
	Sim Start Time	16:00	23:00	13:00	10:00

Note 1: Shortest arrival time and maximum probability values are not necessarily linked to the same run. The results represent a worst-case scenario for each feature based on the analysis of all model runs.

E.3.2 Stochastic Maps

The stochastic results for the Abbey & Baker Field Development worst case subsea well blowout scenario were calculated from a total of 400 trajectory runs (100 simulations per season). The well blowout scenario involves the release of 175,223.07 bbl (27,860.47 m^3) of Condensate (57.5 °API) over a 79-day period. The model is simulated for an additional 10 days following cessation of the blowout.

The stochastic model analysis used a 1 kilometres (km) x 1 km grid cell size. Therefore, the mapped stochastic output is shown at a 1 square kilometre (km^2) resolution. The following maps are presented using the WGS84 coordinate system:

Sea Surface

- **Figure E.3** - Probability of oil reaching surface cells.
- **Figure E.4** - Minimum arrival time of oil to surface cells.
- **Figure E.5** - Maximum surface oil thickness.

Water Column

- **Figure E.6** - Probability that a water column cell could be impacted.
- **Figure E.7** - Minimum arrival time of oil to water column cells.
- **Figure E.8** - Maximum total water column oil concentration.

Shoreline

- **Figure E.9** - Probability that a shoreline cell could be impacted.
- **Figure E.10** - Minimum arrival time of oil to shoreline cells.
- **Figure E.11** - Maximum shoreline oil thickness.

In accordance with the OPRED Guidance Notes for Preparing OPEPs for Offshore Oil & Gas Installations and Relevant Oil Handling Facilities (Revision 7: June 2022), the stochastic map outputs have not displayed surface and subsurface oiling probabilities <10 %.

Figure E.3: Probability of Oil Reaching Surface Cells

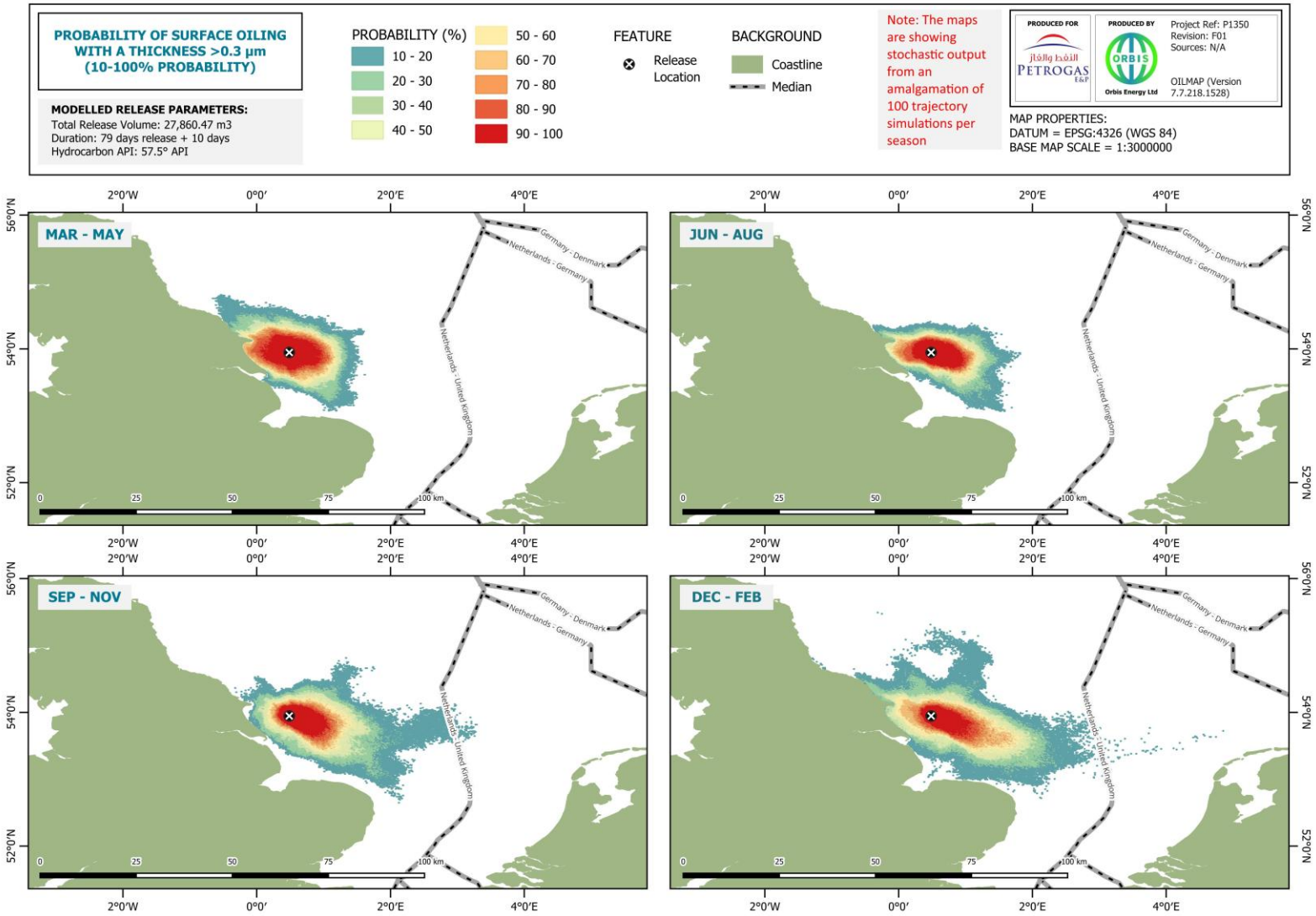


Figure E.4: Minimum Arrival Time of Oil to Surface Cells

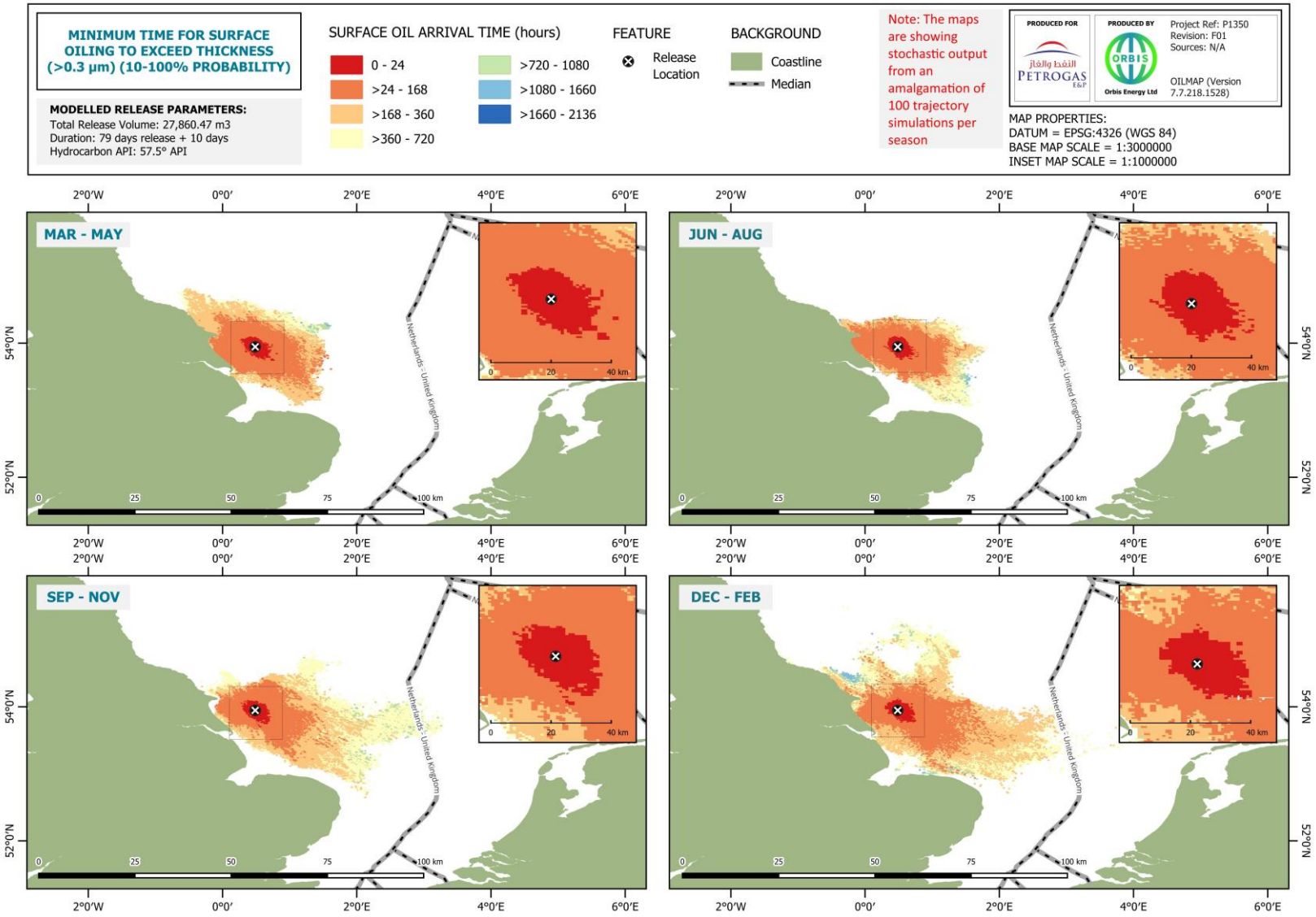


Figure E.5: Maximum Surface Oil Thickness (Bonn Code)

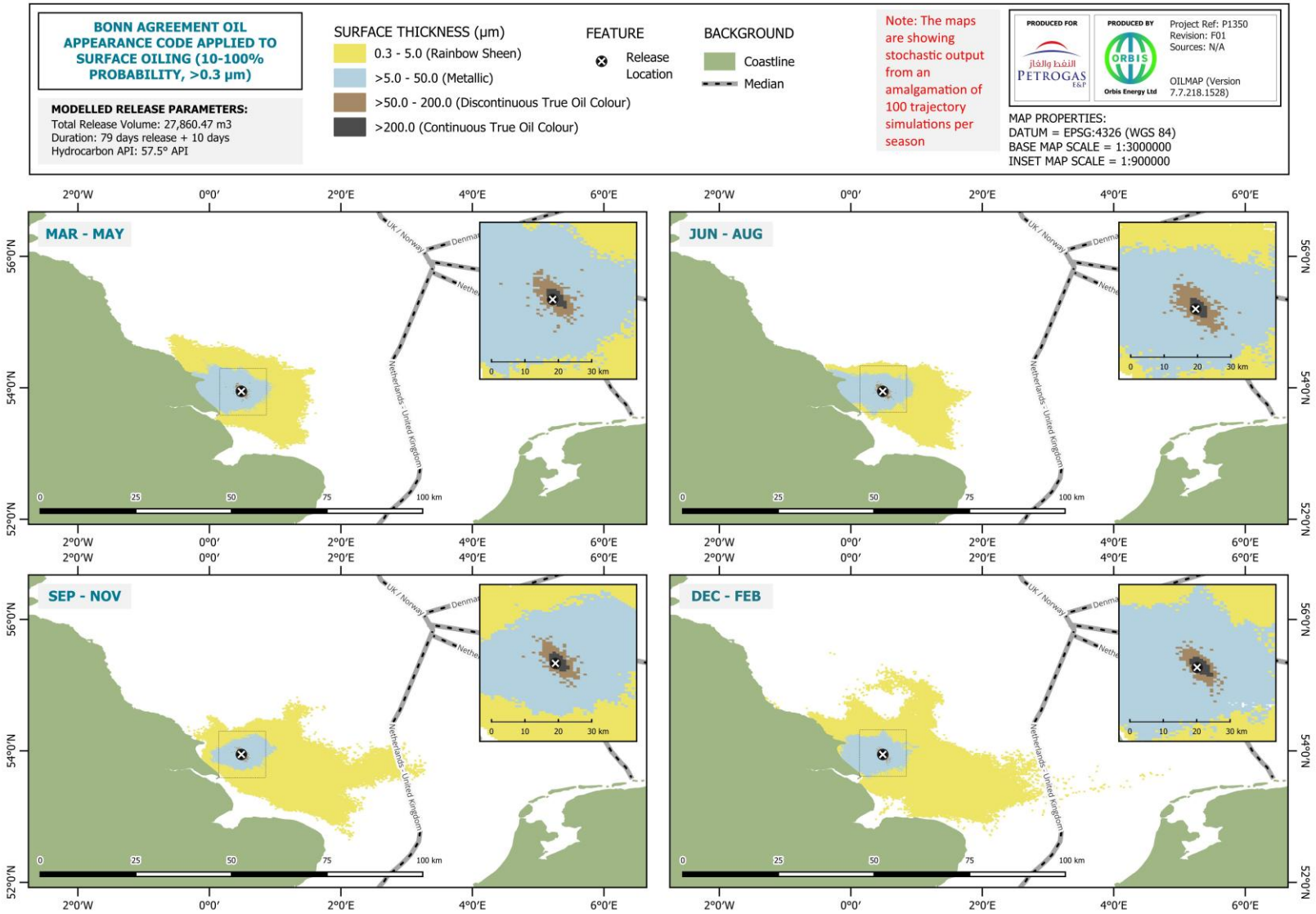


Figure E.6: Probability of Water Column Cells Impacted

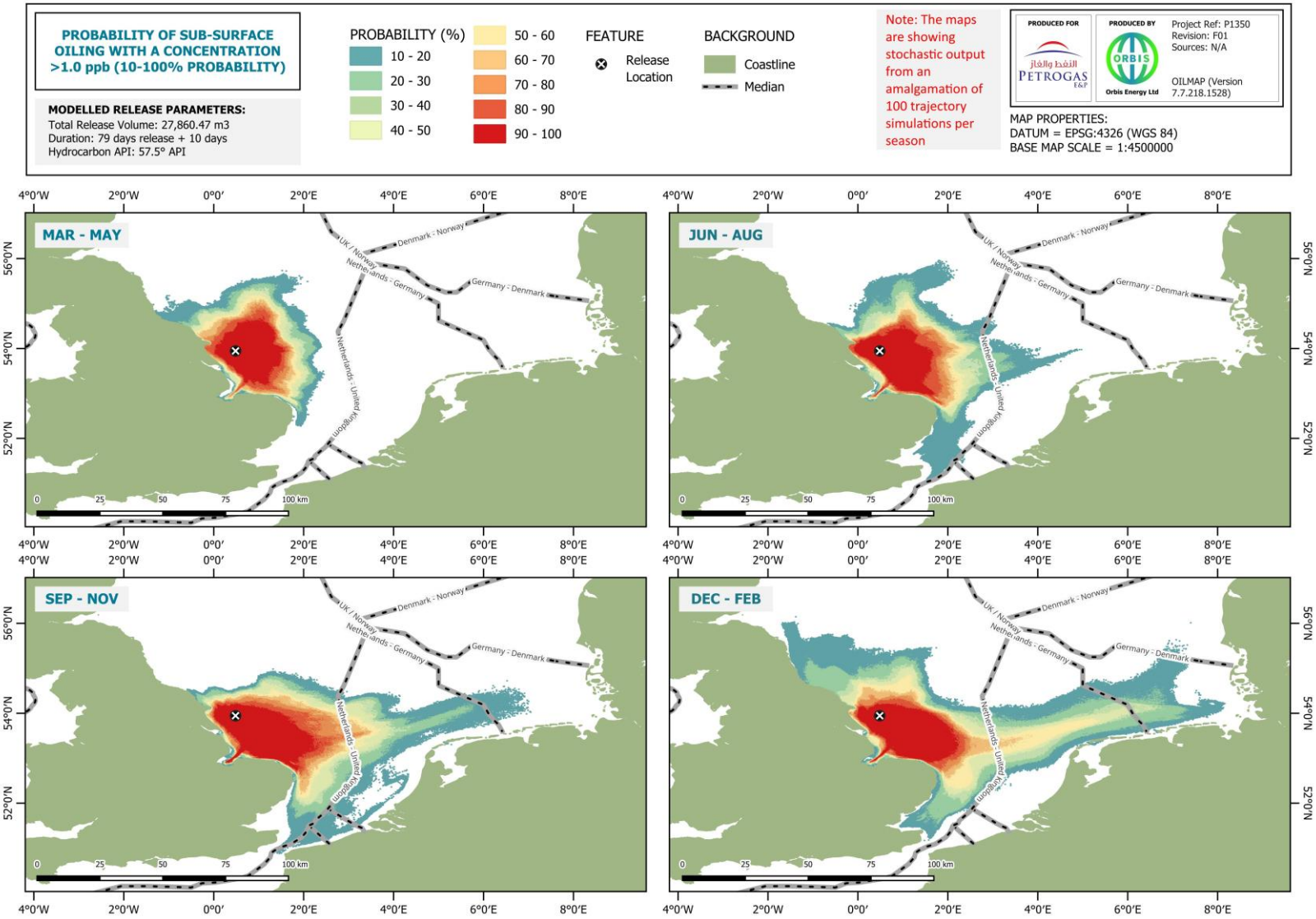


Figure E.7: Minimum Arrival Time of Oil to Water Column Cells

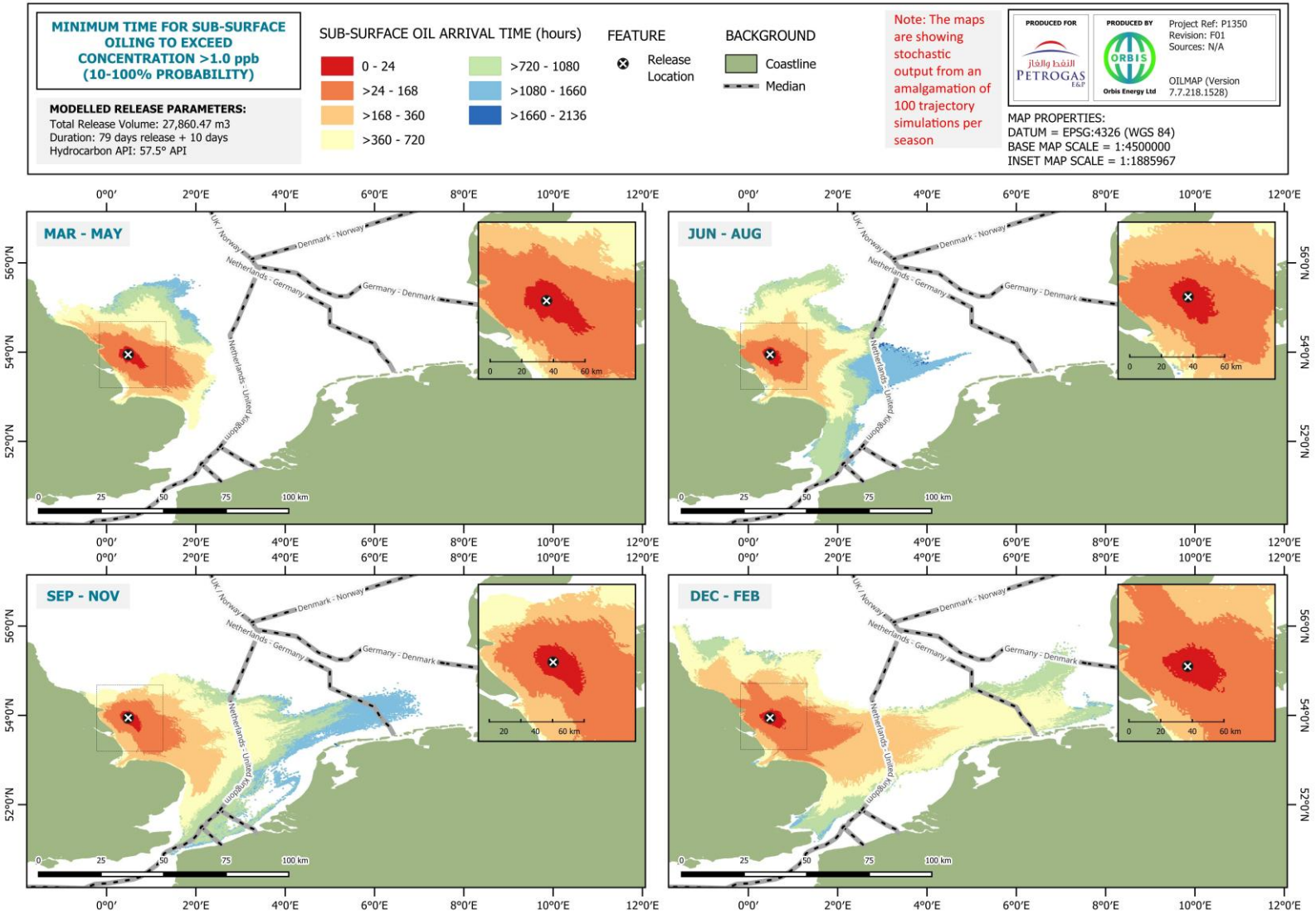


Figure E.8: Maximum Total Water Column Oil Concentrations

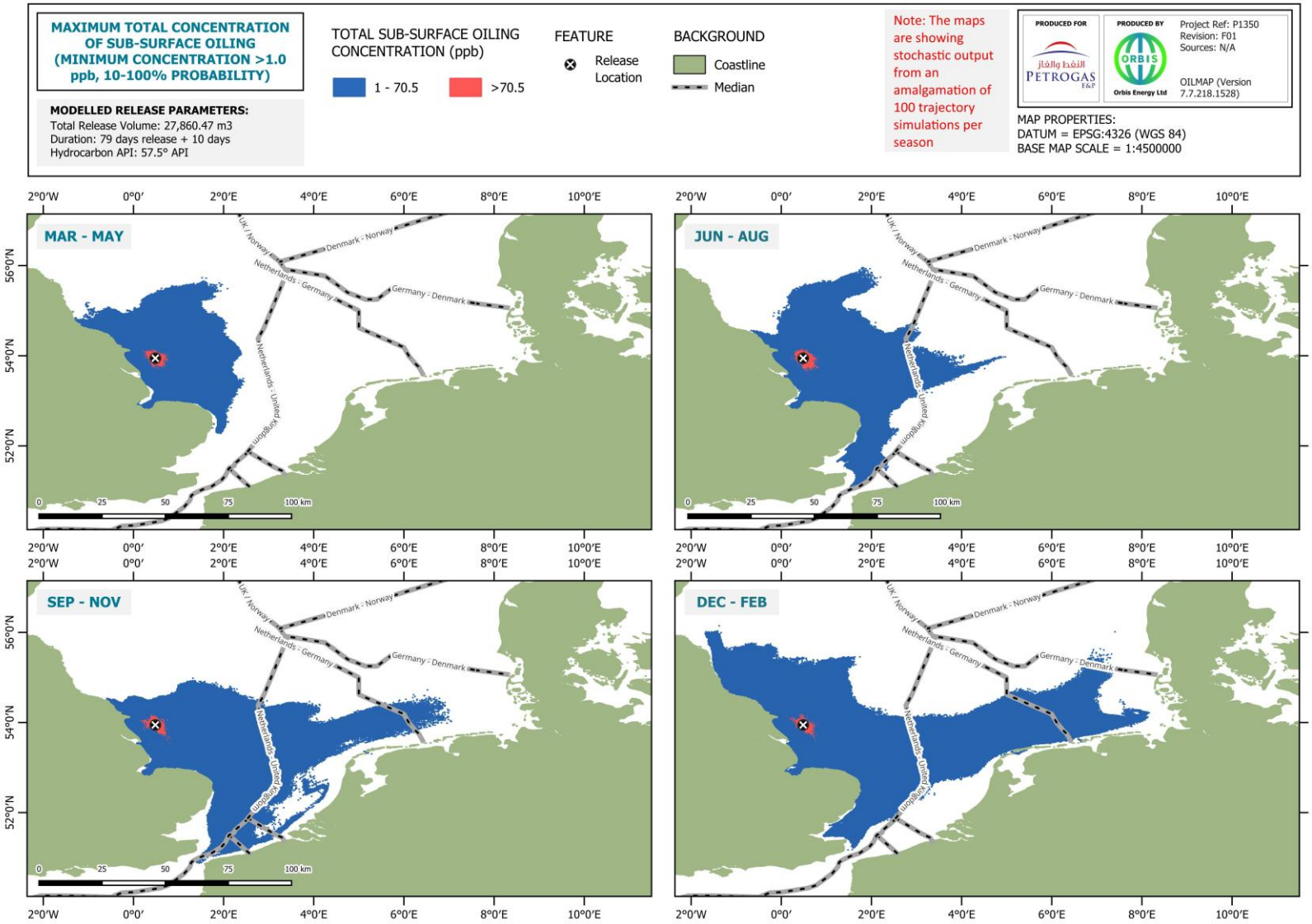


Figure E.9: Probability of Shoreline Oiling

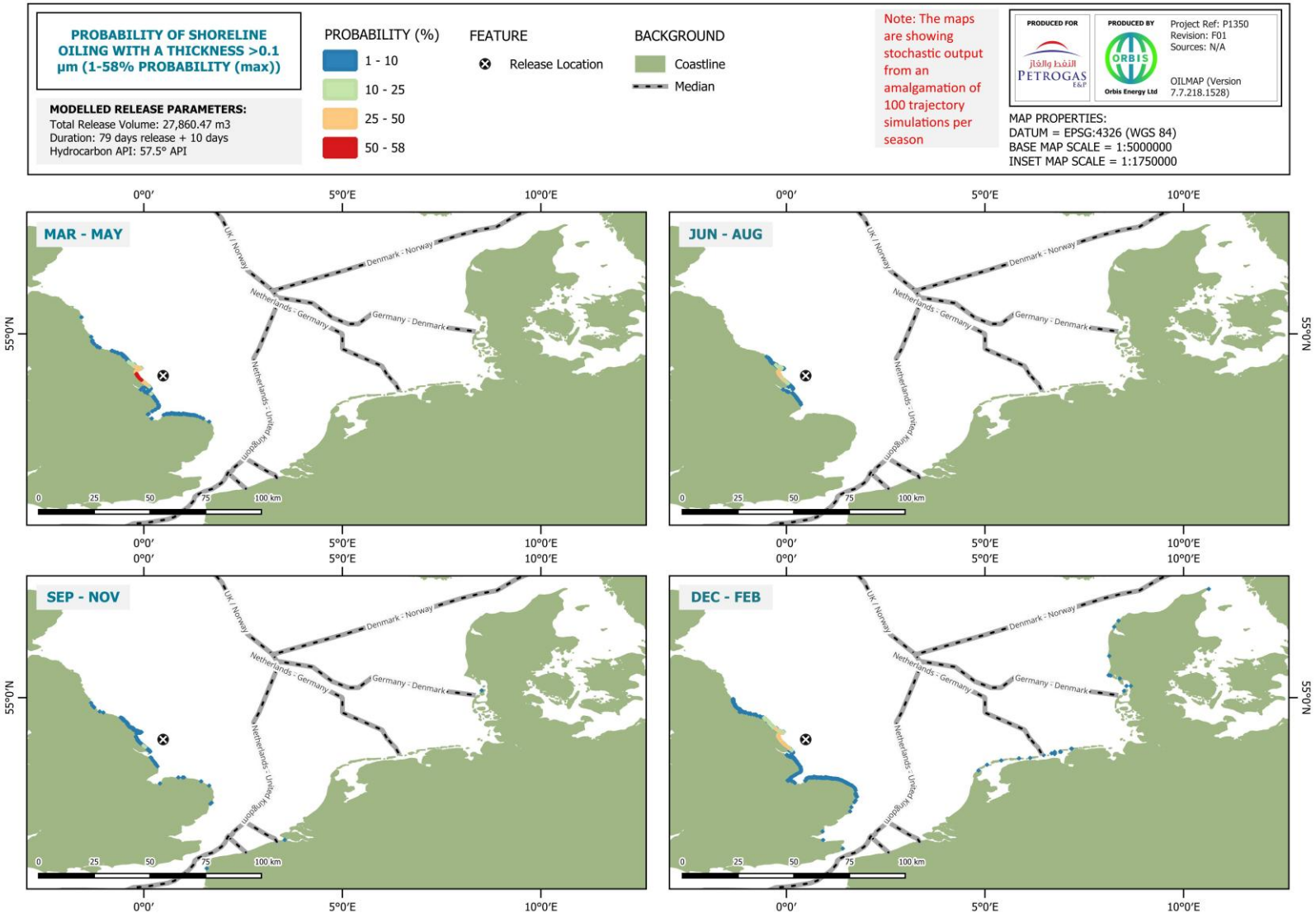


Figure E.10: Minimum Arrival Time of Oil to Shoreline Cells

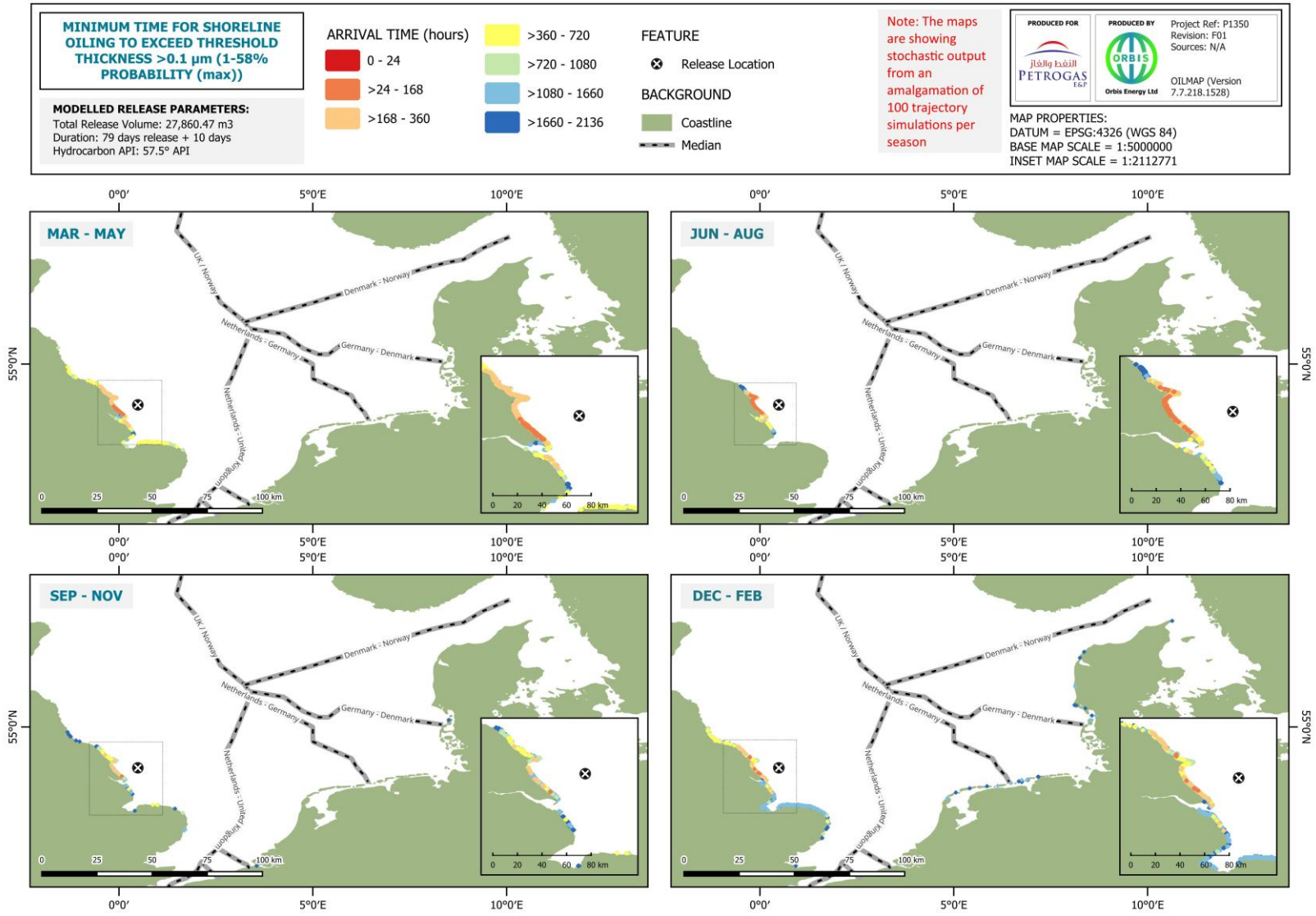
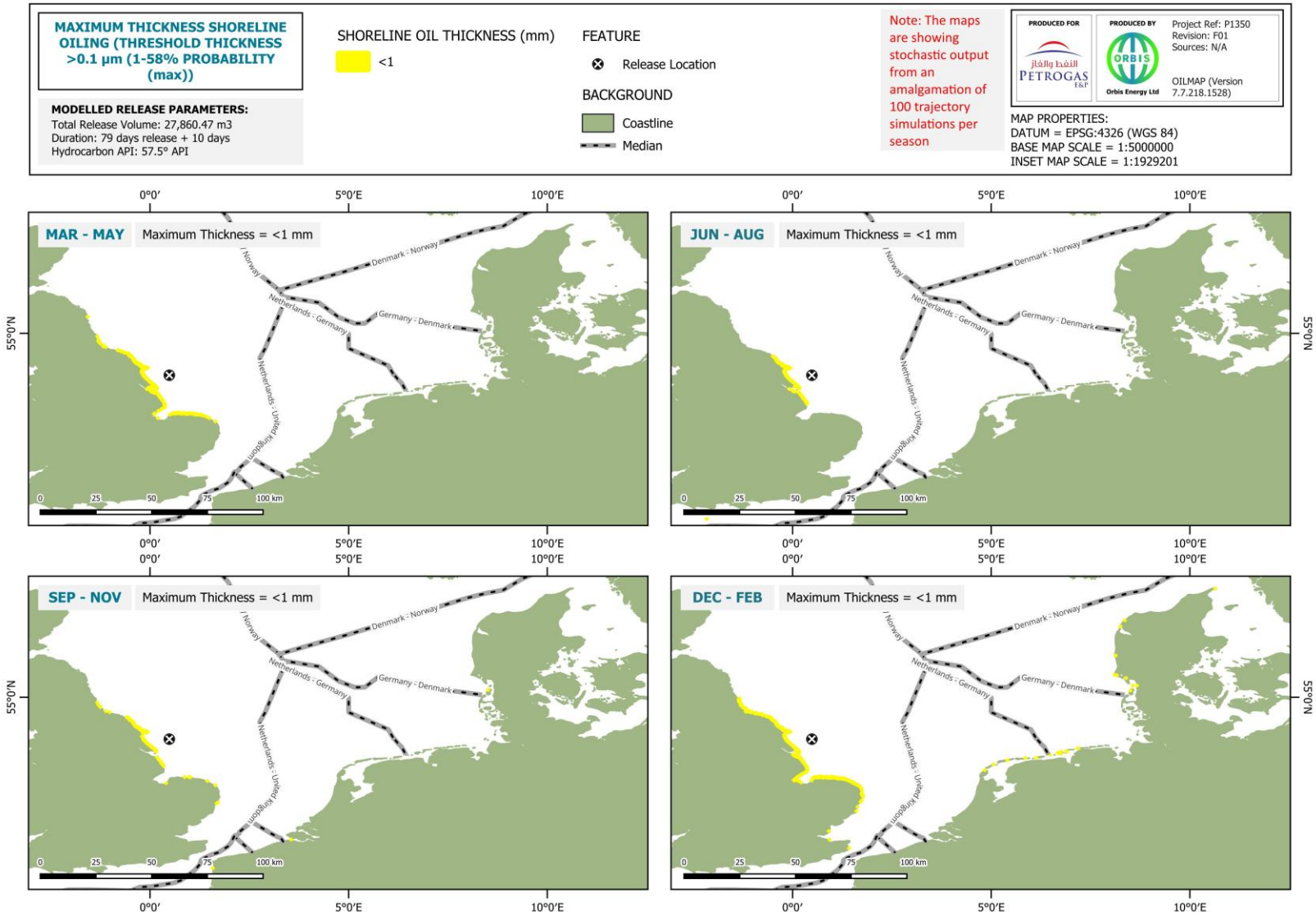


Figure E.11: Maximum Shoreline Oiling Thickness



E.3.3 Protected Areas at Risk

Stochastic Analysis for Protected Areas at Risk

Table E.7 lists the protected areas at risk from oiling. The worst-case probability, minimum time and severity of oiling is reported for surface, shoreline and subsurface oil across all seasons.

Table E.7: Protected Areas at Risk from Surface, Shoreline and Subsurface Oiling [Note 1]

Protected Area	Surface Oil (Minimum Thickness of 0.3 µm)			Shoreline Oil (Minimum Thickness of 1.0 µm)			Subsurface Oil (Minimum Water Column Concentration 1.0 ppb)		
	Maximum Probability	Shortest Arrival Time	Maximum Severity of Surface Oiling (refer to Table E.3)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Shoreline Oiling (refer to Table E.5)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Water Column Oiling (refer to Table E.4)
Special Protected Areas (SPA) with Marine Components									
Dungeness, Romney Marsh and Rye Bay SPA	1 %	1427 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	7 %	938 hrs	Below OSPAR PNEC (<70.5 ppb)
Flamborough and Filey Coast SPA	75 %	63 hrs	Bonn Code: 3 Metallic	33 %	118 hrs	Light Oiling (0.001 – 1 litres / m^2)	91 %	65 hrs	Below OSPAR PNEC (<70.5 ppb)
Greater Wash SPA	93 %	54 hrs	Bonn Code: 4 Discontinuous True Oil Colour	51 %	108 hrs	Light Oiling (0.001 – 1 litres / m^2)	100 %	58 hrs	Below OSPAR PNEC (<70.5 ppb)
Humber Estuary SPA	19 %	142 hrs	Bonn Code: 2 Rainbow	11 %	178 hrs	Light Oiling (0.001 – 1 litres / m^2)	50 %	251 hrs	Below OSPAR PNEC (<70.5 ppb)
Northumberland Marine SPA	1 %	795 hrs	Bonn Code: 2 Rainbow	1 %	932 hrs	Light Oiling (0.001 – 1 litres / m^2)	15 %	492 hrs	Below OSPAR PNEC (<70.5 ppb)

Protected Area	Surface Oil (Minimum Thickness of 0.3 µm)			Shoreline Oil (Minimum Thickness of 1.0 µm)			Subsurface Oil (Minimum Water Column Concentration 1.0 ppb)		
	Maximum Probability	Shortest Arrival Time	Maximum Severity of Surface Oiling (refer to Table E.3)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Shoreline Oiling (refer to Table E.5)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Water Column Oiling (refer to Table E.4)
Outer Firth of Forth and St Andrews Bay Complex SPA	N/A	N/A	N/A	N/A	N/A	N/A	1 %	1231 hrs	Below OSPAR PNEC (<70.5 ppb)
Outer Thames Estuary SPA	9 %	280 hrs	Bonn Code: 2 Rainbow	1 %	1465 hrs	Light Oiling (0.001 – 1 litres / m^2)	72 %	233 hrs	Below OSPAR PNEC (<70.5 ppb)
Teesmouth and Cleveland Coast SPA	12 %	529 hrs	Bonn Code: 2 Rainbow	10 %	573 hrs	Light Oiling (0.001 – 1 litres / m^2)	22 %	316 hrs	Below OSPAR PNEC (<70.5 ppb)
The Wash SPA	11 %	407 hrs	Bonn Code: 2 Rainbow	2 %	514 hrs	Light Oiling (0.001 – 1 litres / m^2)	100 %	196 hrs	Below OSPAR PNEC (<70.5 ppb)
Special Area of Conservation (SAC) with Marine Components									
Bassurelle Sandbank SAC	N/A	N/A	N/A	N/A	N/A	N/A	3 %	1127 hrs	Below OSPAR PNEC (<70.5 ppb)
Berwickshire and North Northumberland Coast SAC	1 %	795 hrs	Bonn Code: 2 Rainbow	1 %	932 hrs	Light Oiling (0.001 – 1 litres / m^2)	15 %	566 hrs	Below OSPAR PNEC (<70.5 ppb)
Dogger Bank SAC	N/A	N/A	N/A	N/A	N/A	N/A	90 %	246 hrs	Below OSPAR PNEC (<70.5 ppb)

Protected Area	Surface Oil (Minimum Thickness of 0.3 µm)			Shoreline Oil (Minimum Thickness of 1.0 µm)			Subsurface Oil (Minimum Water Column Concentration 1.0 ppb)		
	Maximum Probability	Shortest Arrival Time	Maximum Severity of Surface Oiling (refer to Table E.3)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Shoreline Oiling (refer to Table E.5)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Water Column Oiling (refer to Table E.4)
Flamborough Head SAC	N/A	N/A	N/A	27 %	124 hrs	Light Oiling (0.001 – 1 litres / m^2)	93 %	65 hrs	Below OSPAR PNEC (<70.5 ppb)
Haisborough, Hammond and Winterton SAC	N/A	N/A	N/A	N/A	N/A	N/A	100 %	165 hrs	Below OSPAR PNEC (<70.5 ppb)
Humber Estuary SAC	19 %	142 hrs	Bonn Code: 2 Rainbow	11 %	272 hrs	Light Oiling (0.001 – 1 litres / m^2)	41 %	251 hrs	Below OSPAR PNEC (<70.5 ppb)
Inner Dowsing Race Bank and North Ridge SAC	N/A	N/A	N/A	N/A	N/A	N/A	100 %	55 hrs	Below OSPAR PNEC (<70.5 ppb)
Margate and Long Sands SAC	N/A	N/A	N/A	N/A	N/A	N/A	24 %	622 hrs	Below OSPAR PNEC (<70.5 ppb)
North Norfolk Sandbanks and Saturn Reef SAC	N/A	N/A	N/A	N/A	N/A	N/A	100 %	72 hrs	Below OSPAR PNEC (<70.5 ppb)
Southern North Sea SAC	100 %	3 hrs	Bonn Code: 5 Continuous True Oil Colour	N/A	N/A	N/A	100 %	1 hr	Above OSPAR PNEC (>70.5 ppb)
The Wash and North Norfolk Coast SAC	18 %	193 hrs	Bonn Code: 2 Rainbow	7 %	394 hrs	Light Oiling (0.001 – 1 litres / m^2)	100 %	104 hrs	Below OSPAR PNEC (<70.5 ppb)
RAMSAR									

Protected Area	Surface Oil (Minimum Thickness of 0.3 µm)			Shoreline Oil (Minimum Thickness of 1.0 µm)			Subsurface Oil (Minimum Water Column Concentration 1.0 ppb)		
	Maximum Probability	Shortest Arrival Time	Maximum Severity of Surface Oiling (refer to Table E.3)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Shoreline Oiling (refer to Table E.5)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Water Column Oiling (refer to Table E.4)
Dungeness, Romney Marsh and Rye Bay RASMAR	N/A	N/A	N/A	N/A	N/A	N/A	7 %	953 hrs	Below OSPAR PNEC (<70.5 ppb)
Humber Estuary RAMSAR	19 %	142 hrs	Bonn Code: 2 Rainbow	11 %	178 hrs	Light Oiling (0.001 – 1 litres / m^2)	52 %	237 hrs	Below OSPAR PNEC (<70.5 ppb)
The Wash RAMSAR	11%	407 hrs	Bonn Code: 2 Rainbow	2 %	514 hrs	Light Oiling (0.001 – 1 litres / m^2)	100 %	196 hrs	Below OSPAR PNEC (<70.5 ppb)
Nature Conservation Marine Protected Areas (NC MPA)									
East of Gannet and Montrose Fields NC MPA	N/A	N/A	N/A	N/A	N/A	N/A	1 %	1958 hrs	Below OSPAR PNEC (<70.5 ppb)
Firth of Forth Banks Complex NC MPA	1 %	995 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	13 %	685 hrs	Below OSPAR PNEC (<70.5 ppb)
Marine Conservation Zones (MCZ)									
Beachy Head East MCZ	N/A	N/A	N/A	N/A	N/A	N/A	7 %	1030 hrs	Below OSPAR PNEC (<70.5 ppb)
Beachy Head West MCZ	N/A	N/A	N/A	N/A	N/A	N/A	2 %	1686 hrs	Below OSPAR PNEC (<70.5 ppb)

Protected Area	Surface Oil (Minimum Thickness of 0.3 µm)			Shoreline Oil (Minimum Thickness of 1.0 µm)			Subsurface Oil (Minimum Water Column Concentration 1.0 ppb)		
	Maximum Probability	Shortest Arrival Time	Maximum Severity of Surface Oiling (refer to Table E.3)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Shoreline Oiling (refer to Table E.5)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Water Column Oiling (refer to Table E.4)
Berwick to St Mary's MCZ	2 %	432 hrs	Bonn Code: 2 Rainbow	1 %	932 hrs	Light Oiling (0.001 – 1 litres / m^2)	15 %	438 hrs	Below OSPAR PNEC (<70.5 ppb)
Blackwater, Crouch, Roach and Colne MCZ	1 %	1545 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	16 %	1029 hrs	Below OSPAR PNEC (<70.5 ppb)
Cromer Shoal Chalk Beds MCZ	17 %	131 hrs	Bonn Code: 2 Rainbow	3 %	498 hrs	Light Oiling (0.001 – 1 litres / m^2)	100 %	94 hrs	Below OSPAR PNEC (<70.5 ppb)
Dover to Deal MCZ	N/A	N/A	N/A	1 %	1489 hrs	Light Oiling (0.001 – 1 litres / m^2)	6 %	1414 hrs	Below OSPAR PNEC (<70.5 ppb)
Dover to Folkestone MCZ	N/A	N/A	N/A	N/A	N/A	N/A	7 %	961 hrs	Below OSPAR PNEC (<70.5 ppb)
Farnes East MCZ	1 %	817 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	15 %	626 hrs	Below OSPAR PNEC (<70.5 ppb)
Folkestone Pomerania MCZ	N/A	N/A	N/A	N/A	N/A	N/A	8 %	954 hrs	Below OSPAR PNEC (<70.5 ppb)
Foreland MCZ	N/A	N/A	N/A	N/A	N/A	N/A	18 %	800 hrs	Below OSPAR PNEC (<70.5 ppb)

Protected Area	Surface Oil (Minimum Thickness of 0.3 µm)			Shoreline Oil (Minimum Thickness of 1.0 µm)			Subsurface Oil (Minimum Water Column Concentration 1.0 ppb)		
	Maximum Probability	Shortest Arrival Time	Maximum Severity of Surface Oiling (refer to Table E.3)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Shoreline Oiling (refer to Table E.5)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Water Column Oiling (refer to Table E.4)
Fulmar MCZ	N/A	N/A	N/A	N/A	N/A	N/A	8 %	1016 hrs	Below OSPAR PNEC (<70.5 ppb)
Goodwin Sands MCZ	2 %	958 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	20 %	813 hrs	Below OSPAR PNEC (<70.5 ppb)
Holderness Inshore MCZ	84 %	77 hrs	Bonn Code: 4 Discontinuous True Oil Colour	51 %	498 hrs	Light Oiling (0.001 – 1 litres / m^2)	93 %	86 hrs	Below OSPAR PNEC (<70.5 ppb)
Holderness Offshore MCZ	100 %	3 hrs	Bonn Code: 5 Continuous True Oil Colour	N/A	N/A	N/A	100 %	2 hrs	Above OSPAR PNEC (>70.5 ppb)
Inner Bank MCZ	N/A	N/A	N/A	N/A	N/A	N/A	7 %	1035 hrs	Below OSPAR PNEC (<70.5 ppb)
Kentish Knock East MCZ	2 %	944 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	23 %	618 hrs	Below OSPAR PNEC (<70.5 ppb)
Kingmere MCZ	1 %	1606 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	1 %	1581 hrs	Below OSPAR PNEC (<70.5 ppb)
Markham's Triangle MCZ	20 %	215 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	76 %	194 hrs	Below OSPAR PNEC (<70.5 ppb)

Protected Area	Surface Oil (Minimum Thickness of 0.3 µm)			Shoreline Oil (Minimum Thickness of 1.0 µm)			Subsurface Oil (Minimum Water Column Concentration 1.0 ppb)		
	Maximum Probability	Shortest Arrival Time	Maximum Severity of Surface Oiling (refer to Table E.3)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Shoreline Oiling (refer to Table E.5)	Maximum Probability	Shortest Arrival Time	Maximum Severity of Water Column Oiling (refer to Table E.4)
Medway Estuary MCZ	N/A	N/A	N/A	N/A	N/A	N/A	7 %	1424 hrs	Below OSPAR PNEC (<70.5 ppb)
North East of Farnes Deep MCZ	4 %	687 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	14 %	851 hrs	Below OSPAR PNEC (<70.5 ppb)
Offshore Overfalls MCZ	1 %	1700 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	1 %	1257 hrs	Below OSPAR PNEC (<70.5 ppb)
Orford Inshore MCZ	4 %	778 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	55 %	395 hrs	Below OSPAR PNEC (<70.5 ppb)
Runswick Bay MCZ	12 %	219 hrs	Bonn Code: 2 Rainbow	2 %	399 hrs	Light Oiling (0.001 – 1 litres / m^2)	25 %	231 hrs	Below OSPAR PNEC (<70.5 ppb)
Swallow Sands MCZ	3 %	1011 hrs	Bonn Code: 2 Rainbow	N/A	N/A	N/A	27 %	671 hrs	Below OSPAR PNEC (<70.5 ppb)
Thanet Coast MCZ	N/A	N/A	N/A	N/A	N/A	N/A	18 %	1013 hrs	Below OSPAR PNEC (<70.5 ppb)
The Swale Estuary MCZ	N/A	N/A	N/A	N/A	N/A	N/A	6 %	1640 hrs	Below OSPAR PNEC (<70.5 ppb)

Note 1: Shortest arrival time and maximum probability values are not necessarily linked to the same run. The results represent a worst case scenario for each feature based on the analysis of all model runs.

E.4 Trajectory Modelling Results

The stochastic modelling results detailed above in Section E.3 were composed of 100 individual trajectory simulations per season. The worst-case trajectory simulation for each season has been extracted to produce a fates analysis for the duration of the spill plus 10 days (total 89 days model duration).

The worst-case trajectory simulations have been identified by the 'greatest mass of beached condensate at any one location'. The following trajectory simulations have been extracted and analysed:

- **Winter (Dec-Feb):** Run No. 64 (Start Date: 02/02/2021; Start Time: 16:00), 31.57 tonnes (264.72 bbl or 42.09 m^3) of condensate beached.
- **Spring (Mar-May):** Run No. 24 (Start Date: 15/03/2021; Start Time: 23:00), 22.30 tonnes (186.98 bbl or 29.73 m^3) of condensate beached.
- **Summer (Jun-Aug):** Run No. 38 (Start Date: 06/06/2021; Start Time: 22:00), 11.95 tonnes (100.19 bbl or 15.93 m^3) of condensate beached.
- **Autumn (Sep-Nov):** Run No. 84 (Start Date: 17/11/2020; Start Time: 10:00), 4.52 tonnes (37.92 bbl or 6.03 m^3) of condensate beached.

Figure E.12 displays the trajectory simulations spatially, with total swept area of surface and shoreline oiling at 12-hour time steps after 89 days.

Table E.8 provides summary statistics for the trajectory simulations. The fate of the released condensate is consistent between seasons with the majority evaporated and degraded after 89 days. The winter and spring simulations produce the greatest impact on the shoreline.

Table E.8: Fate Analysis Summary for Trajectory Simulations

Season	Trajectory Run No.	Minimum Time for Surface Oiling	Maximum Surface Slick Area	Minimum Time for Shoreline Oiling	Impacted Length of Coastline after 89 days	Fate of Released condensate after 89 days (% of total release) Note 1					
						Ashore	Surface	Water Column	Evaporated	Degraded	Sediment
Winter	64	2 hrs	357.94 km^2	149 hrs	103.19 km	0.13	0.002	3.60	56.65	39.61	0.00
Spring	24	2 hrs	285.17 km^2	699 hrs	68.67 km	0.08	0.001	3.76	58.30	37.86	0.00
Summer	38	2 hrs	88 km^2	807 hrs	35.57 km	0.05	0.001	3.88	58.44	37.62	0.00
Autumn	84	2 hrs	96.27 km^2	1,203 hrs	30.32 km	0.02	0.000	3.73	56.75	39.50	0.00

Note 1: Refer to fates analysis graphs (**Winter**: Figure E.13; **Spring**: Figure E.14; **Summer**: Figure E.15; **Autumn**: Figure E.16) showing spill progression over the total simulation time of 89 days (2,136 hours).

Figure E.12: Worst Case Trajectory Simulations Showing Swept Area for Surface and Shoreline Oiling at 12-hour intervals

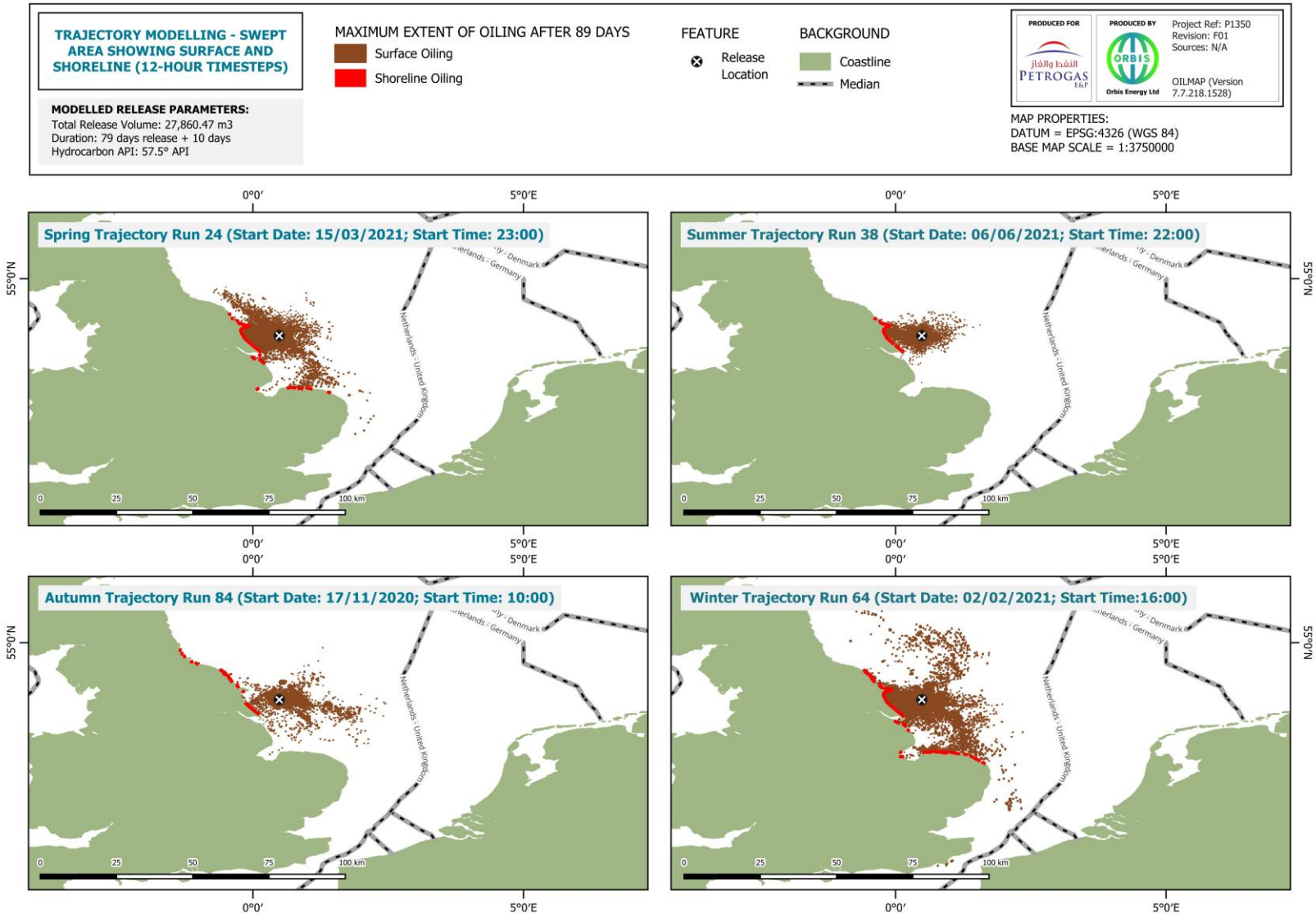


Figure E.13: Fate of the condensate released from Winter Run No. 64 (showing model duration 89 days)

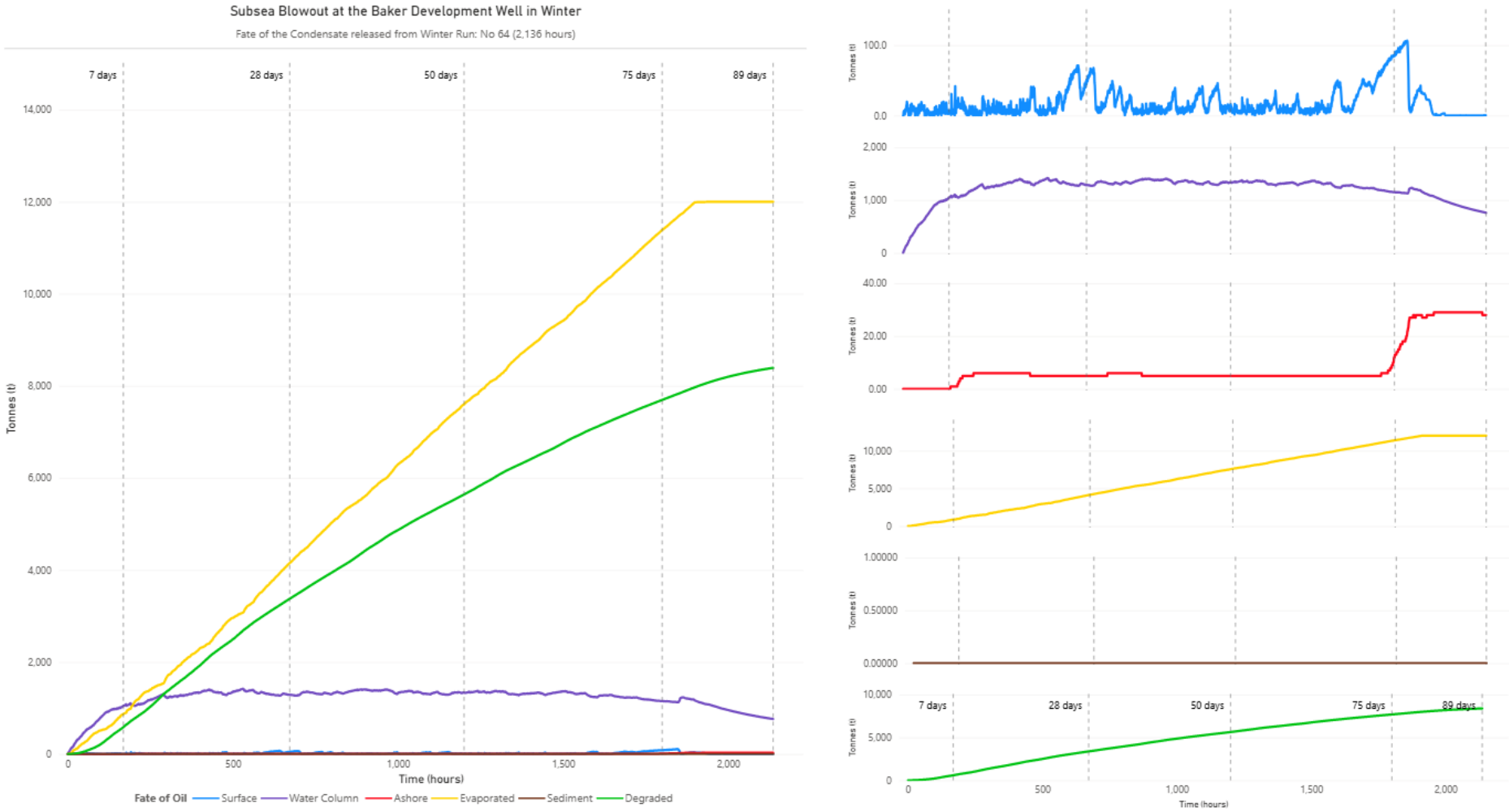


Figure E.14: Fate of the condensate released from Spring Run No. 24 (showing model duration 89 days)

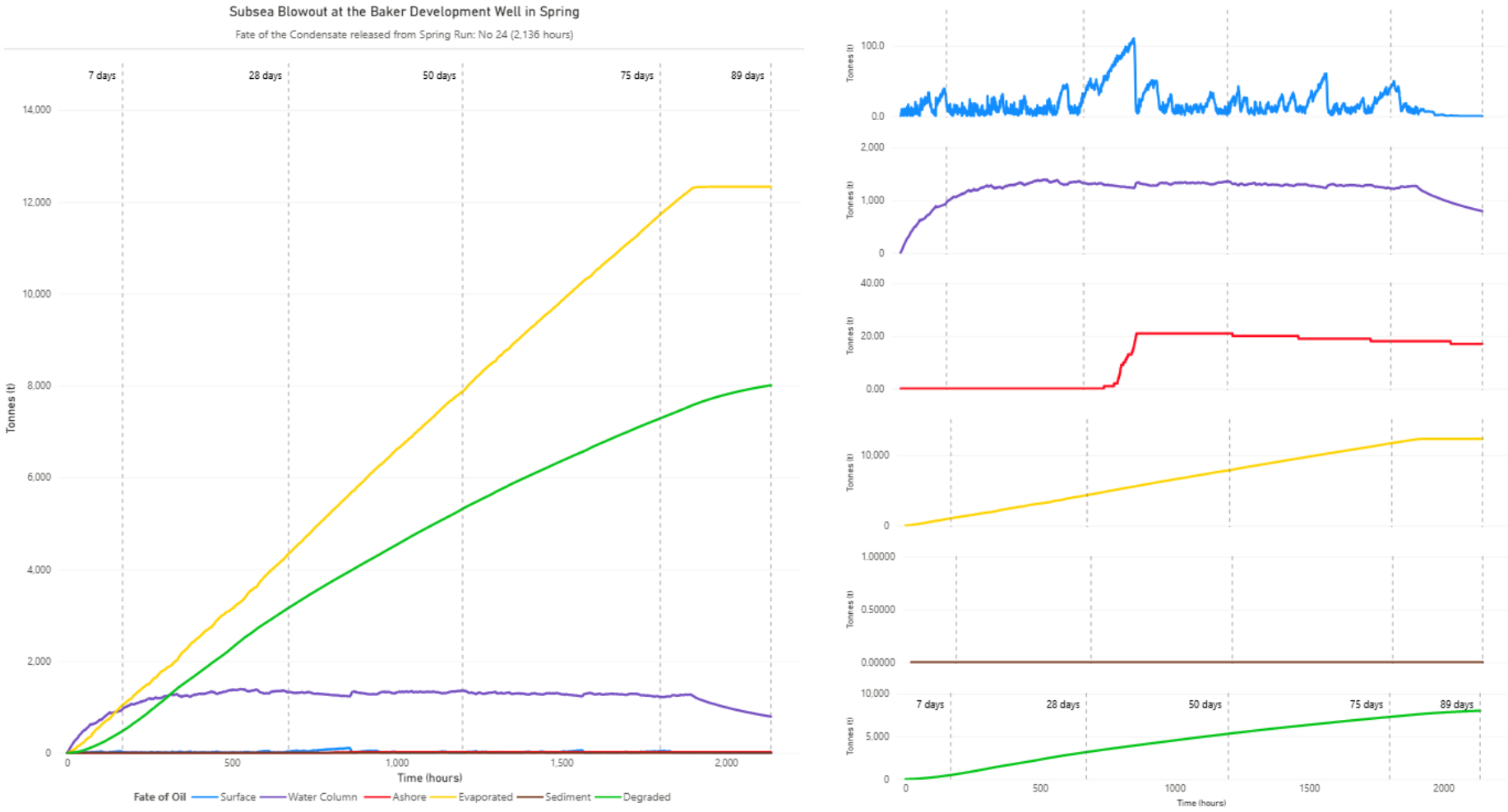


Figure E.15: Fate of the condensate released from Summer Run No. 38 (showing model duration 89 days)

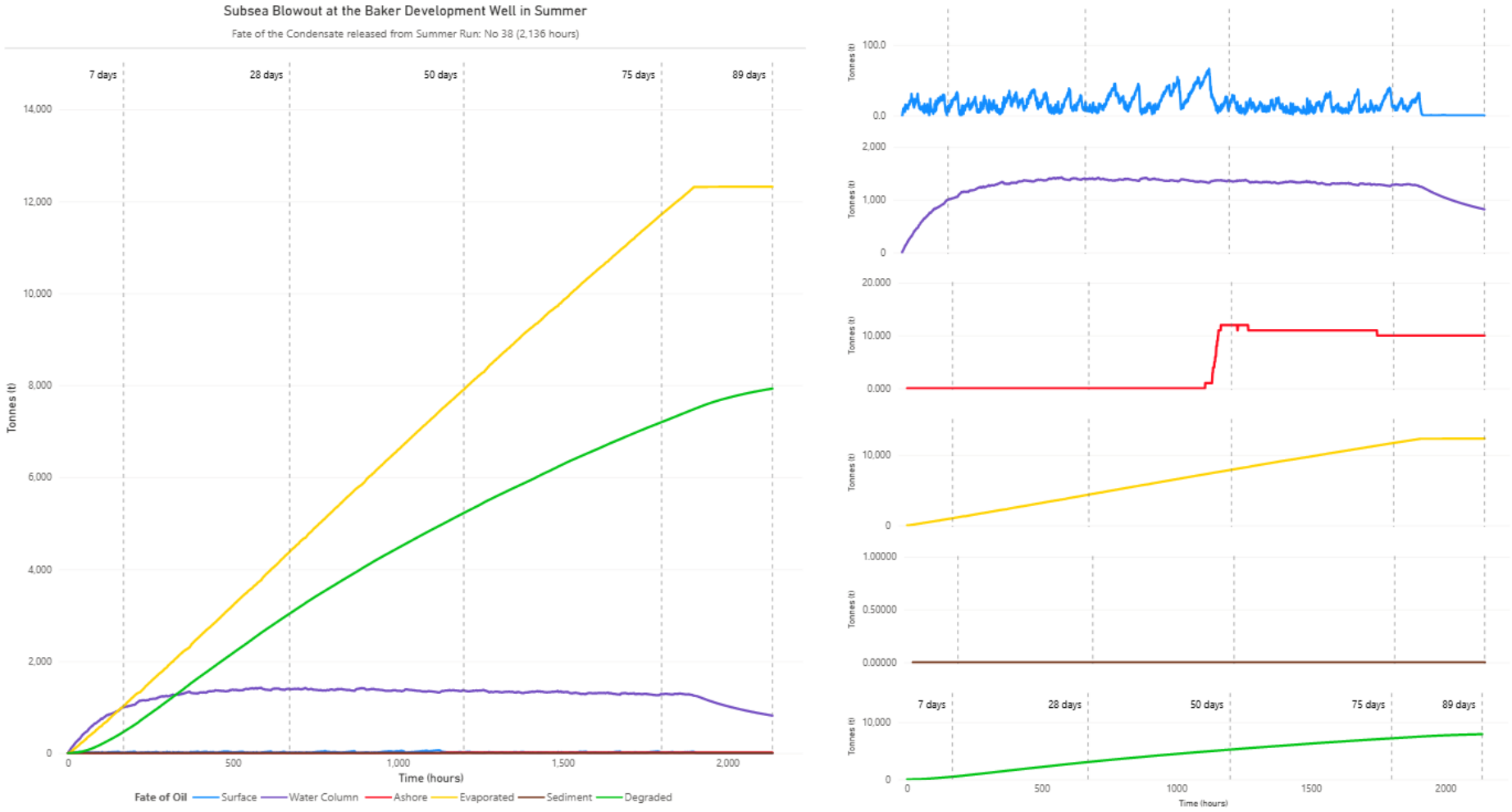
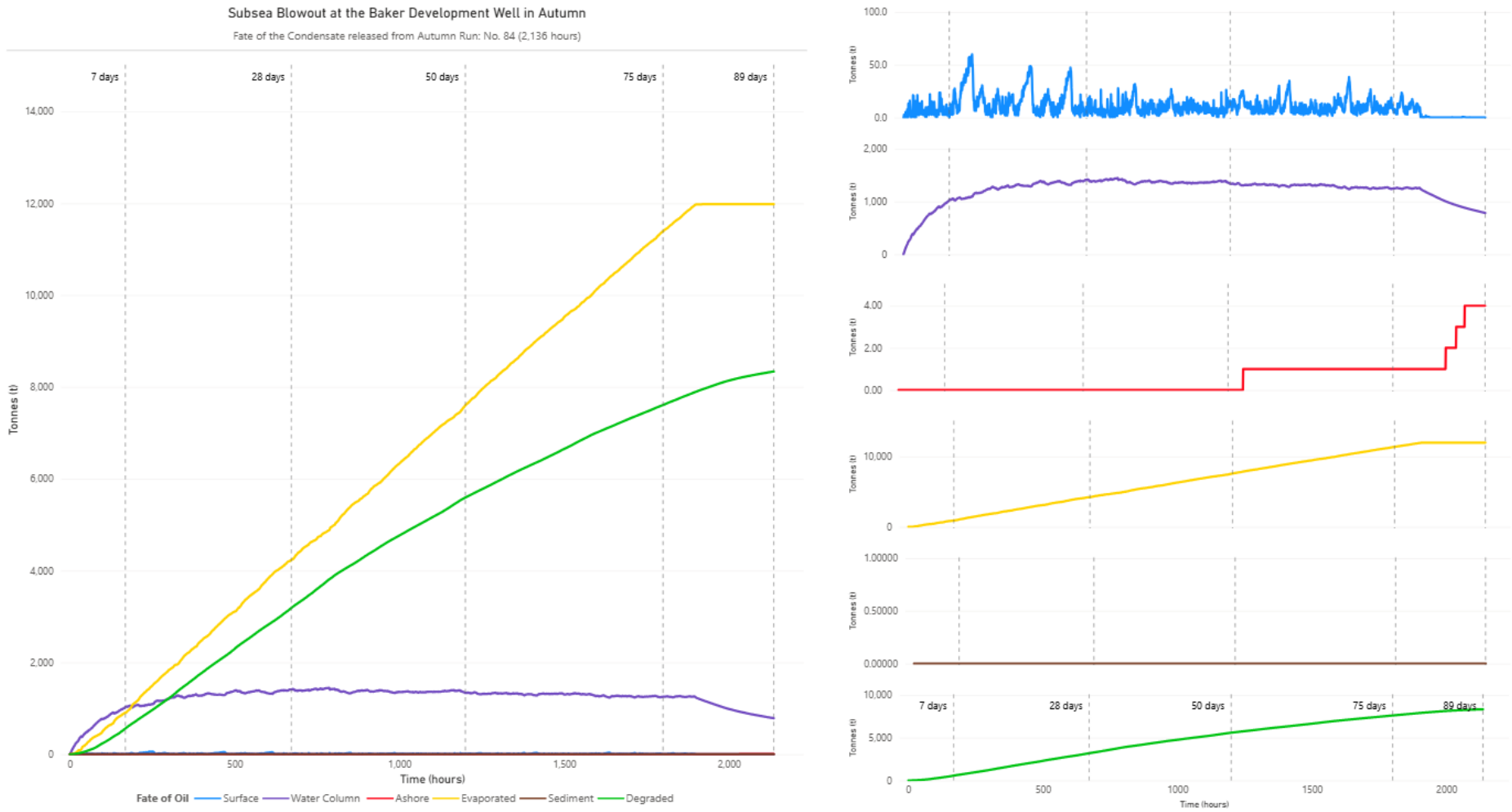


Figure E.16: Fate of the condensate released from Autumn Run No. 84 (showing model duration 89 days)



E.6 Model Input Data

E.6.1 Metocean Data

Current and Tidal Data

To capture the complex nature of the regional and coastal circulation for the areas near to the UK, two different current datasets are provided which can be combined to simulate an oil spill (refer to Table E.9):

- A regional dataset (HYDROMAP) that captures the general mesoscale circulation (HYCOM);
- A higher resolution dataset developed by RPS to capture the tidal circulation important in the coastal areas.

Table E.9: Current dataset details used for the modelling

Parameter	Global	Regional tidal
Name of Dataset	HYCOM (GLBy0.08/expt_93.0)	HYDROMAP
Owner/Provider	Naval Research Laboratory (USA)	RPS
Bathymetry	GEBCO	GEBCO
Wind Forcing	NAVGEM (USA)	No
Tides	No	Yes
Horizontal Grid Size	0.08° x 0.04°	~300m to 9km
Hindcast Period	2019 - 2023	Periodic tidal constituents' phase and amplitude
Output Frequency	Daily	30-minute processing

Global Current dataset – HYCOM analysis

Current data was obtained from the HYCOM + Navy Coupled Ocean Data Assimilation (NCODA) Global 1/12° analysis (Table E.9) which captures the oceanic large-scale tidal residual circulation. Details of the data assimilation procedure are described in Cummings and Smedstad (2013) and Cummings (2005). Forcing data for the model comes from the NAVy Global Environmental Model (NAVGEM). The analysis is composed of 3-D temperature, salinity, sea surface height, zonal velocity and meridional velocity fields. Ocean dynamics including geostrophic, and wind driven currents are reproduced by the model. The most recent version of the model is 'GLBu0.08/expt_93.0' which includes data from January 2019 to December 2023. However, as this version of HYCOM does not include tidal information, a separate model (HYDROMAP Tidal Model) was used to supplement HYCOM and generate tidal currents.

Tidal Currents – HYDROMAP Tidal Model

HYDROMAP, a hydrodynamic model (Table E.9) developed by RPS, was used to reproduce the local circulation due to tides around UK. It is a globally re-locatable hydrodynamic model (Isaji, et al., 2001a, 2001b) capable of simulating complex circulation patterns due to tidal forcing, wind stress, and freshwater flows. The framework used by HYDROMAP, employs a novel step-wise-continuous-variable-rectangular gridding strategy with up to six levels of resolution. The term "step-wise continuous" implies that the boundaries between successively smaller and larger grids are managed in a consistent integer step. This model has been applied in numerous sediment dispersion and transport studies in the U.S. and worldwide.

HYDROMAP can be used to make constant cyclical current fields for each component of the circulation separately. These cyclical current fields in the form of tidal ellipses are saved in CIR file. Once generated,

the CIR file can be combined with the HYCOM circulation to present a complete hydrodynamic dataset for the oil spill simulation.

Wind Data

Wind model output was obtained from the ECMWF Reanalysis Product for a 5-year period (2019 to 2023), as described in Table E.10. The ECMWF provides the ERA5 reanalysis product that includes wind hindcast data on a global scale. The data are generated using an atmospheric model with data assimilation and distributed on a grid with 0.25° horizontal resolution. ERA5 covers the period of January 1st, 1979, to present time. Gridded data products include a large variety of surface parameters, describing atmospheric as well as ocean-wave and land-surface conditions (Dee et al., 2011).

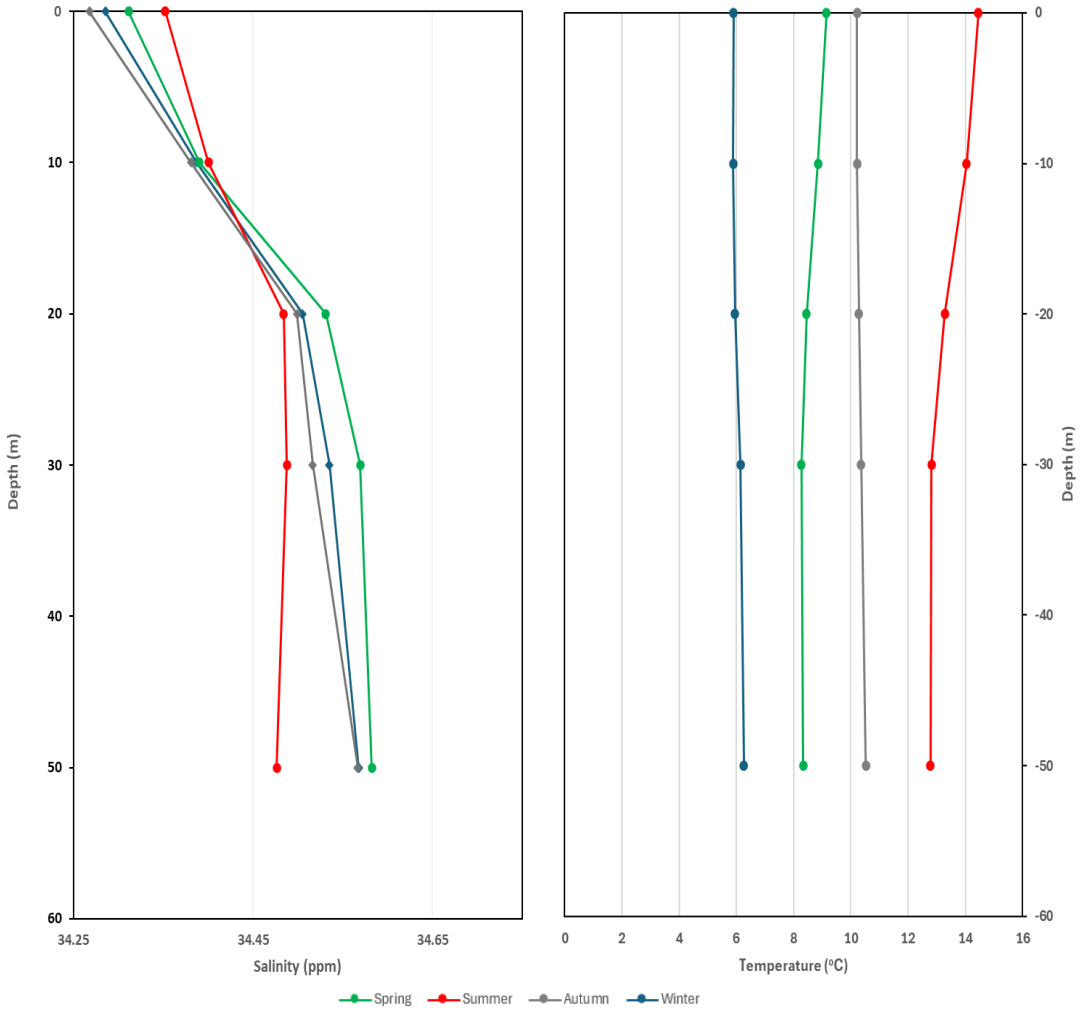
Table E.10: Wind dataset details used for the modelling

Name of Dataset	ERA5
Coverage	-20°E to 30°E and 40°N to 72°N
Owner/Provider	ECMWF
Horizontal Grid Size	0.25°x0.25°
Hindcast Period	2019 - 2023
Time Step	6-hour

Temperature and Salinity Data

Figure E.17 presents a salinity and temperature plot against depth for the modelled location per season.

Figure E.17: Salinity and Temperature plot against depth for each modelled season at the Baker Development release location



E.6.2 Model Domain Setup

Bathymetry

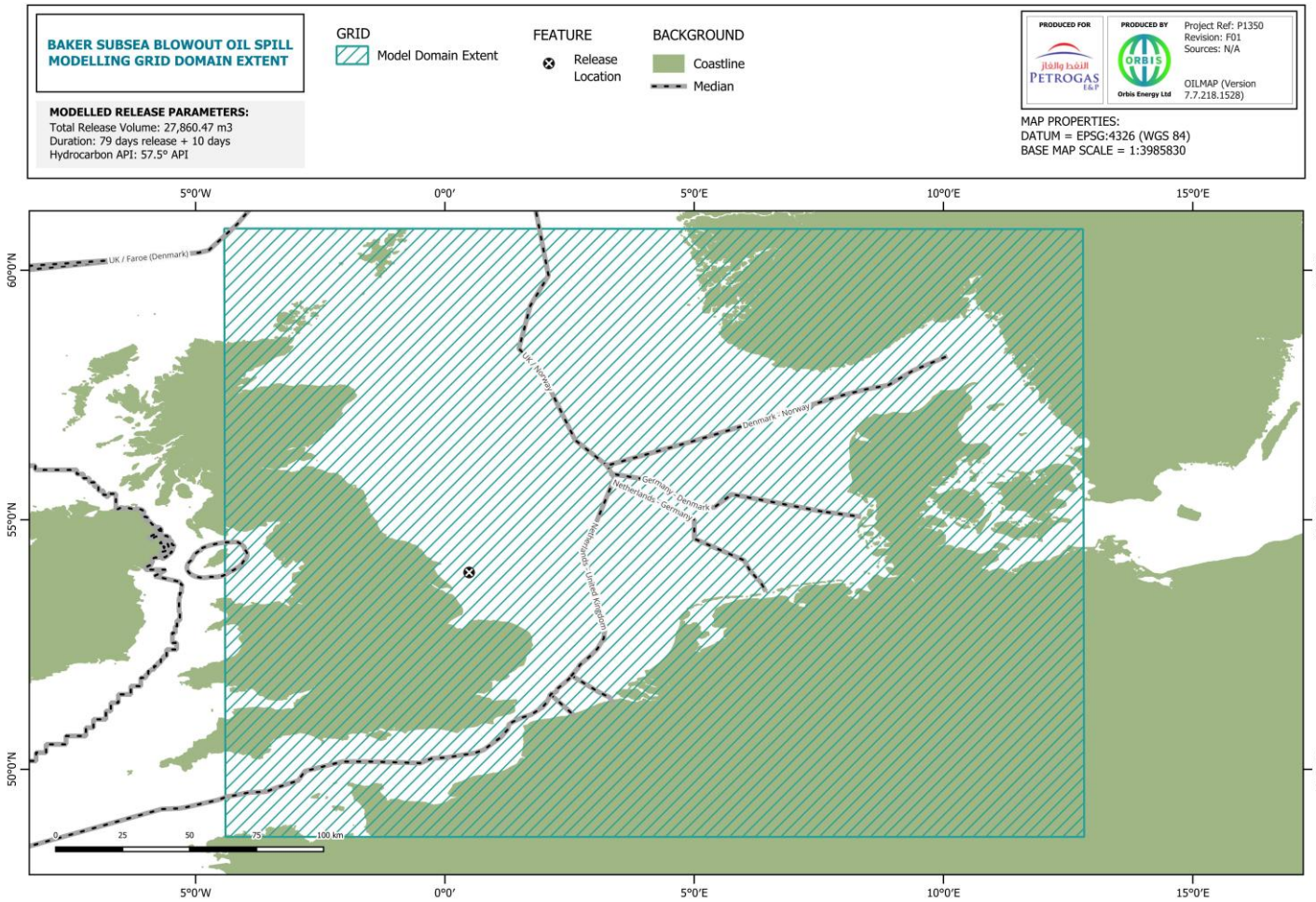
General Bathymetric Chart of the Oceans (GEBCO) ESRI ASCII files (GEBCO 2025 Grid) were retrieved from https://download.gebco.net and inputted into the OILMAP Land-Water domain grid.

The GEBCO 2025 Grid was released in August 2025. It provides global coverage of elevation data, in meters, on a 15 arc-second interval geographic grid and consists of 43200 rows x 86400 columns, giving 3,732,480,000 data points. The data values are pixel-centre registered i.e. they refer to elevations, in meters, at the centre of grid cells. The grid uses as a 'base' Version 2.7 of the SRTM15+ data set (Harper & Sandwell, 2024; Tozer et al., 2019) largely between latitudes of 50° South and 60° North. This data set is a fusion of land topography with measured and estimated seafloor topography. The SRTM15+ base grid has been augmented with the gridded bathymetric data sets developed by the four Seabed 2030 Regional Centres to produce the GEBCO 2025 Grid. The Regional Centres have compiled gridded bathymetric data sets, largely based on multibeam data, for their areas of responsibility. These regional grids were then provided to the Global Centre.

Model Domain Extent

The model domain extent area (including bathymetry, current and tidal, and wind data coverage) is shown in Figure E.18.

Figure E.18: Model Domain Extent



E.6.3 Declining Flow Rate

Figure E.19 shows the high case open hole flow rate from the Baker development well for 79 days. The worst-case condensate flow rate starts at 3,212.2 bbl (510.74 m^3) / day on day 1, declining to 1,757.1 bbl (279.38 m^3) / day on day 79. The total cumulative release of oil after 79 days is 27,860.47 m^3 (175,223.07 bbl).

Figure E.19: Declining flow rate for the Baker Development Well (Reservoir Case = High) (79 days)

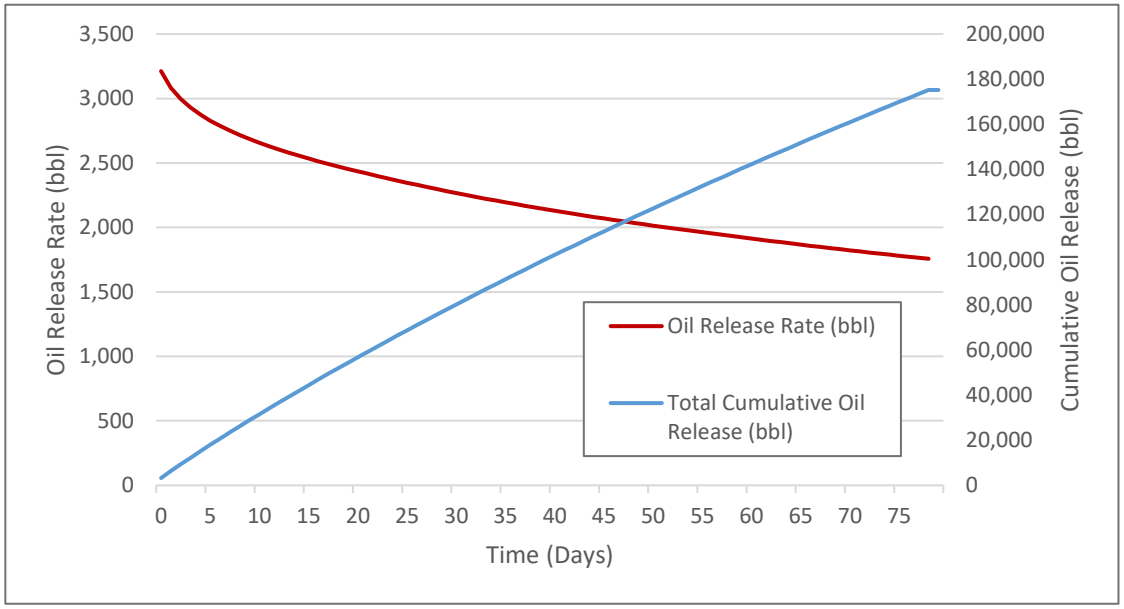


Table E.11 displays the declining flow rate data at 24-hour intervals which was input into the OILMAP modelling software.

Table E.11: Variable Flow Rate (VFL file) Model Input Data

Time (Hours)	Declining flow rate for the Baker development well (Reservoir Case = High) (79 days) (bbl)
24.00	3212.2
48.00	3084.03
72.00	2997.12
96.00	2930.31
120.00	2875.36
144.00	2828.22
168.00	2786.92
192.00	2749.88
216.00	2716.29
240.00	2685.41
264.00	2656.67
288.00	2629.75
312.00	2604.31
336.00	2580.13
360.00	2557.05
384.00	2534.89
408.00	2513.54

Time (Hours)	Declining flow rate for the Baker development well (Reservoir Case = High) (79 days) (bbl)
432.00	2492.97
456.00	2473.15
480.00	2453.95
504.00	2435.31
528.00	2416.89
552.00	2398.92
576.00	2381.26
600.00	2363.83
624.00	2346.78
648.00	2330.06
672.00	2313.68
696.00	2297.68
720.00	2282.04
744.00	2266.73
768.00	2251.74
792.00	2237.09
816.00	2222.73
840.00	2208.65
864.00	2194.83
888.00	2181.27
912.00	2167.96
936.00	2154.9
960.00	2142.07
984.00	2129.47
1008.00	2117.09
1032.00	2104.91
1056.00	2092.94
1080.00	2081.15
1104.00	2069.56
1128.00	2058.14
1152.00	2046.92
1176.00	2035.87
1200.00	2024.97
1224.00	2014.24
1248.00	2003.65
1272.00	1993.18
1296.00	1982.85
1320.00	1972.64
1344.00	1962.56
1368.00	1952.6

Time (Hours)	Declining flow rate for the Baker development well (Reservoir Case = High) (79 days) (bbl)
1392.00	1942.75
1416.00	1933.01
1440.00	1923.37
1464.00	1913.8
1488.00	1904.35
1512.00	1894.93
1536.00	1885.56
1560.00	1876.32
1584.00	1867.19
1608.00	1858.02
1632.00	1848.97
1656.00	1840.06
1680.00	1831.27
1704.00	1822.6
1728.00	1814.03
1752.00	1805.58
1776.00	1797.25
1800.00	1789.01
1824.00	1780.88
1848.00	1772.84
1872.00	1764.9
1896.00	1757.1
Cumulative Condensate Release	**175,223.1**

E.7 Abbreviations

µm	Micrometres
°C	Degrees Celsius
bbl	Barrels
API	American Petroleum Institute
BOAC	Bonn Oil Appearance Code
cP	Centipoise
ECMWF	European Centre for Medium-Range Weather Forecasts
GEBCO	General Bathymetric Chart of the Oceans
GOR	Gas to Oil Ratio
HYCOM	Hybrid Coordinate Ocean Model
IFT	Interfacial Tension
ITOPF	International Tanker Owners Pollution Federation Limited
km	Kilometres
km^2	Square kilometres
m	Metres
m^2	Square metres
m^3	Cubic metres
MCZ	Marine Conservation Zones
mm	Millimetres
NAVGEM	Navy Global Environmental Model
NCODA	Navy Coupled Ocean Data Assimilation
NC MPA	Nature Conservation Marine Protected Areas
ppb	Parts per billion
SAC	Special Area of Conservation
SPA	Special Protected Area
THC	Total Hydrocarbon Concentration

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