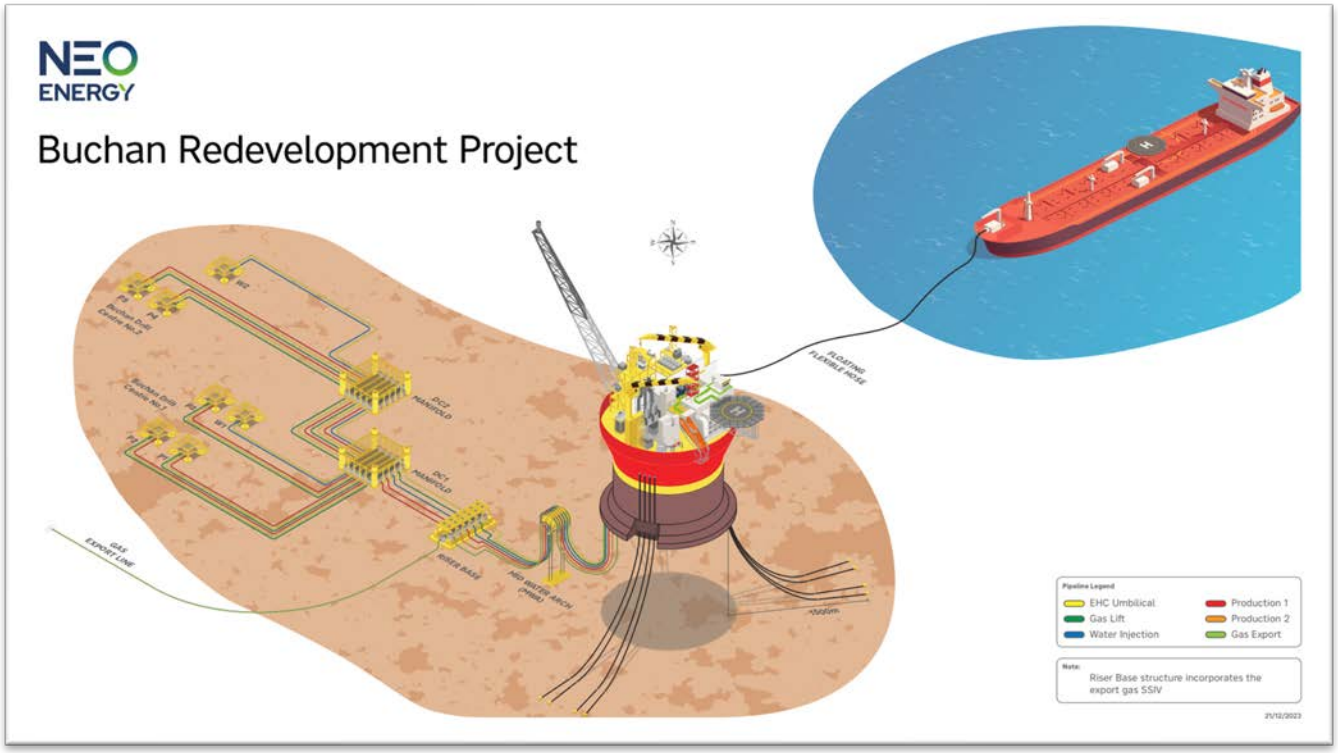
Buchan Redevelopment Project Environmental Statement

DESNZ Reference: ES/2023/007



Revision	Issue Description	Issue Date	Prepared by	Checked by	Approved by
2	Issued for use	16/01/2024	[redacted]	[redacted]	[redacted]
			Genesis Environmental Specialists	Genesis Environmental Specialists	NEO Project HSEQ Manager

ENVIRONMENTAL STATEMENT DETAILS

Section A: Administrative Information

A1 – Project Reference Number

Please confirm the unique ES identification number for the project.

Number: ES/2023/007

A2 - Developer Contact Details

Company name: NEO Energy (ZEX) Limited (NEO Energy)

Contact name: [redacted]

Contact title: Project HSEQ Manager

A3 - ES Contact Details (if different from above)

Company name: As above

Contact name: As above

Contact title: As above

A4 - ES Preparation

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

N[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

A5 - Licence Details

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

Licence number(s): P2498

b) **Please confirm licensees and current equity**

Licence Number: P2498	
Licensee	**Percentage Equity**
NEO Energy (ZEX)	50%
Jersey Petroleum Ltd.	50%
Note: In December 2023, Serica Energy entered into an agreement with Jersey Oil & Gas plc to acquire a 30% non-operated interest in the Buchan Horst Field; subject to certain conditions precedent and regulatory approval, with the transaction expected to be completed in January 2024.	

Section B: Project Information

B1 - Nature of Project

a) **Please specify the name of the project.**

Name: Buchan Redevelopment Project

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

Name: Buchan Redevelopment Project

c) **Please provide a brief description of the project.**

NEO Energy on behalf of themselves and their partners, propose to redevelop the Buchan Horst Field (formerly known as the Buchan Field). The field is located in UK Blocks 20/5 and 21/1 in the Central North Sea, c. 115 km northeast of the Aberdeenshire coastline and c. 103.5 km west of the UK/Norway median line. The proposed Project involves installation of new subsea production gathering infrastructure tied back to a redeployed Floating Storage Offloading (FPSO) vessel; the Western Isles FPSO. Oil will be offloaded from the Western Isles FPSO via shuttle tanker and excess gas will be exported via a new gas export pipeline. The new gas export pipeline will be tied back to either the SAGE (Scottish Area Gas Evacuation) pipeline system or to the Frigg UK Association (FUKA) pipeline system. Five production wells and two water injection wells will be drilled. Artificial gas lift and water injection (including produced water) will be required. The proposed Project can be summarised as follows:

- The drilling of up to five production wells and two water injection wells at the Buchan Horst Field;
- Installation of the repurposed Western Isles FPSO;
- Installation of subsea infrastructure to support tie-back of the wells to the FPSO;
- Installation of a gas export pipeline;
- Production over the repurposed Western Isles FPSO, export of gas via the gas export pipeline and export of oil via shuttle tanker; and

Modifications to the Western Isles FPSO to be 'electrification ready' to receive power from an 3rd party supplier.

B2 - Project Location

a) Please indicate the offshore location(s) of the main project elements (for pipeline projects please provide information for both the start and end locations).

Quadrant number(s): 21

Block number(s): 1

FPSO location:	**Latitude:**	57° 53' 04.73" N	**Longitude:**	00° 03" 19.19" E
Drill Centre 1 location:	**Latitude:**	57° 53' 51.78" N	**Longitude:**	00° 01" 18.54" E
Drill Centre 2 location:	**Latitude:**	57° 53' 58.86" N	**Longitude:**	00° 01" 10.75" E

Distance to nearest UK coastline (km): 115 km
Which coast? Scotland

Distance to nearest international median line (km): 103.5km
Which line? UK / Norway

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

Name of project: N/A

Date of submission of ES: N/A

Identification number of ES: N/A

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Non-Technical Summary

Background

The Buchan Horst Field is located in UK Continental Shelf (UKCS) Blocks 20/05a and 21/01a in the Central North Sea (CNS), *c*. 115 km northeast of the Aberdeenshire coastline and c. 103.5 km west of the UK/Norway median line (Figure 1). Repsol Resources UK Limited previously produced from the field (formerly referred to as the Buchan Field) with production ceasing in May 2017, due to the certification limitations of the Buchan Alpha floating production vessel. NEO Energy (ZEX) Limited (hereafter referred to as NEO Energy), on behalf of themselves and their partners, propose to redevelop the Buchan Horst Field. As per licensing requirements, NEO Energy changed the name of the Buchan Field to the Buchan Horst Field. The proposed Project referred to as the Buchan Redevelopment Project can therefore be considered to be concerned with the development of the Buchan Horst Field.

Jersey Petroleum Ltd (a subsidiary of Jersey Oil and Gas plc) was awarded Blocks 20/05a and 21/01a (Licence P2498) in the 31st Supplementary Offshore Licencing Round. The blocks contain the Buchan Horst Oil Field and the J2 oil discovery. In addition, the Verbier oil discovery and additional prospects are in adjacent Blocks 20/5b and 21/1d (Licence P2170), awarded to Jersey Petroleum Ltd in the 28th Offshore Licensing Round. Collectively, these licences/blocks are referred to as the Greater Buchan Area. The Buchan Horst Field will be operated by NEO Energy which has a 50% interest equity whilst Jersey Oil and Gas plc holds a 50% non-operated working interest in the field. In December 2023, Serica Energy entered into an agreement with Jersey Oil & Gas to acquire a 30% non-operated interest in the Buchan Horst Field; subject to certain conditions precedent and regulatory approval, with the transaction expected to be completed in January 2024.

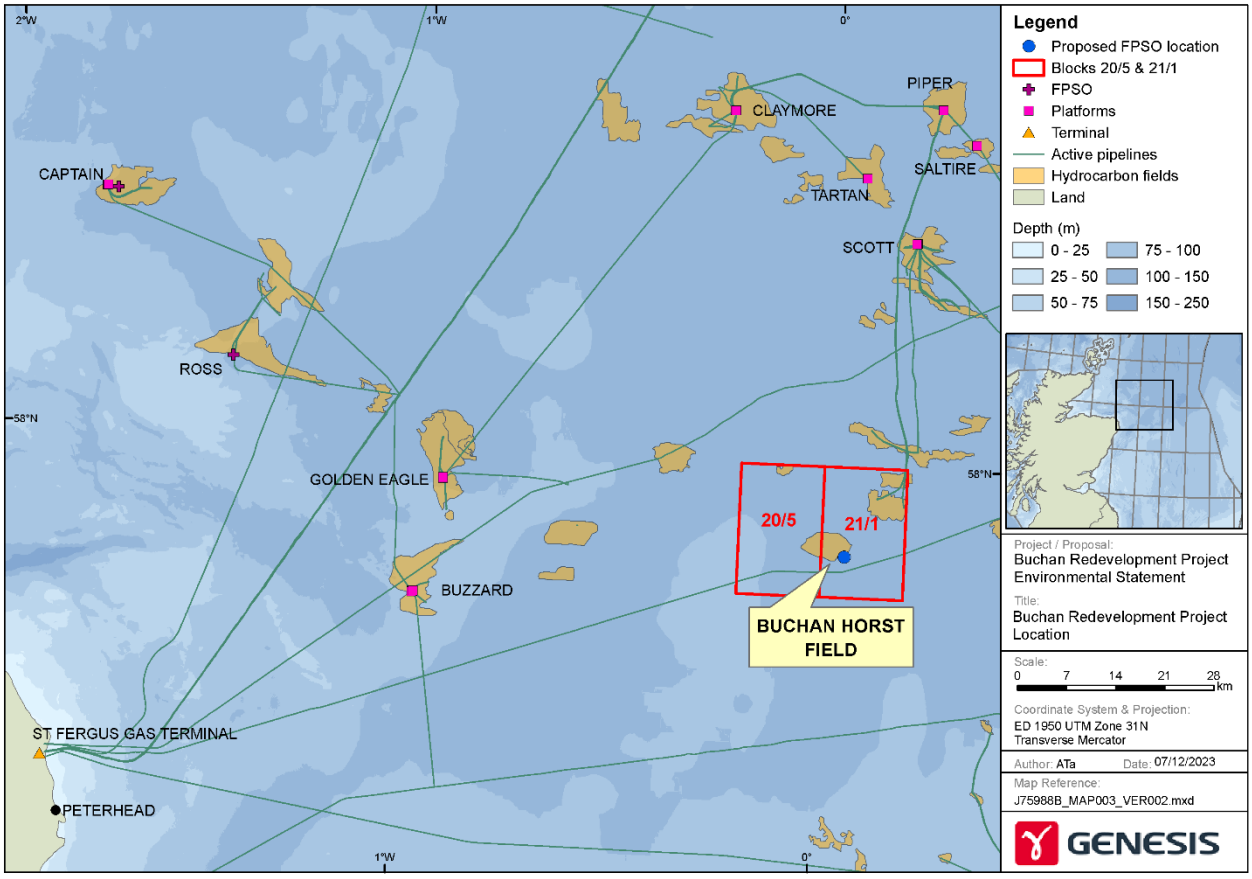


Figure 1: Buchan Redevelopment Project location.

Environmental Statement Scope

The scope of the Environmental Impact Assessment (EIA) and resultant Environmental Statement (ES) includes the following activities:

- The drilling and completion of up to five production wells and two water injection wells at the Buchan Horst Field;
- Installation of the repurposed Western Isles Floating Production Storage and Offloading vessel (FPSO) [1].;
- Installation of subsea infrastructure to support tie-back of the wells to the repurposed Western Isles FPSO;
- Installation of a gas export pipeline tied back to either the SAGE (Scottish Area Gas Evacuation) pipeline system or to the Frigg UK Association (FUKA) pipeline system;
- Production over the repurposed Western Isles FPSO, export of gas via the gas export pipeline and export of oil via shuttle tanker.

In line with the 2020 Offshore EIA Regulations, the EIA sets out to describe and evaluate the impacts of any emissions to air, discharges to sea, seabed disturbance, underwater noise, waste production and resource use resulting from the proposed development on a range of receptors including flora, fauna, water, air, climate, and material assets. In addition, the potential interactions with other users of the sea are considered. These aspects are considered for planned activities and unplanned (i.e. accidental) events.

Consideration of Alternatives

Development Concept

The proposed Buchan Redevelopment Project considered a number of alternative development concepts for the Buchan Horst Field to ensure the chosen development plan was optimal. Three development concepts were initially screened with the intent of identifying viable development concepts to carry forward to more detailed technical and economic assessment. The three concepts screened were:

- A new build fixed or floating production facility;
- A re-deployed floating facility; and
- A tie-back to an existing host facility.

Based on the outcome of the initial concept screening exercise, the following development concepts were selected for further evaluation:

- Installation of a new fixed platform;
- Redeployment of the Western Isles FPSO;
- Tie-back to the Forties Alpha platform. This option would necessitate the installation of a new Normally Unattended Installation (NUI) at the Buchan Horst Field;
- Tie-back to Piper platform via Tweedsmuir subsea infrastructure. This option would also require the installation of a new NUI to be installed at the Buchan Horst Field; and
- Tie-back to the Avalon FPSO.

Further evaluation ranked these development concepts based on the following criteria:

- Maximising Economic Recovery (MER) from the Buchan Horst Field;

[1] The Western Isles FPSO is currently supporting production at the Dana operated Barra and Harris Fields. These fields are expected to cease production in Q1 2024 and a Sale and Purchase Agreement has been completed, under which NEO Energy will acquire Dana's full equity in the Western Isles FPSO.

- MER from the wider Greater Buchan Area,
- Minimising carbon emissions (aligning to the UK's Net Zero target),
- Subsurface uncertainty;
- Field operability;
- Deliverability of the development on time and on budget;
- Minimising operability risks;
- Utilisation of existing infrastructure; and
- Economic returns on investment.

In addition to ranking scores, each selection criterion was weighted according to the significance afforded in the selection process. The ability to maximise economic recovery and align to the UK's Net Zero target were weighted highest.

For all criteria the option to redeploy the Western Isles FPSO ranked higher (or equal) to the other options.

With respect to Greenhouse Gas Emissions (GHG) the development concepts were assessed to quantify the GHG emissions for activities prior to start-up and for the production phase. The pre start-up activities considered were: production of materials; engineering, construction and major equipment manufacture; drilling and installation. With respect to the option to redeploy the Western Isles FPSO, the lower emissions associated with production of material and the installation activities meant that this option resulted in the lowest pre start-up emissions.

The development concepts were also assessed to quantify the GHG emissions during operations. The emissions considered were: combustion emissions from the use of gas turbine generators and emissions flaring and venting during start-up and production operations. The UK Government's Net Zero ambition was a key driver during consideration of alternatives for the Development concept. The Western Isles FPSO, fixed platform and tie-back to Avalon development concepts all allowed for the electrification via a 3rd Party reducing emissions associated with routine power generation to very low levels, with remaining emissions associated with outages of the 3rd party power supply. Note the preferred source of electrical power is from one of the planned Innovation and Targeted Oil and Gas (INTOG) windfarms (which are key to the transition to Net Zero for the UKCS offshore oil and gas industry), however consideration of the provision of power from shore is also necessary as contingency. For the other two tie-back development concepts (Forties Alpha and Tweedsmuir), whilst the NUI would be able to obtain its power from a 3rd party, it is assumed that the host facilities will not be electrified. With respect to flaring strategy the fixed platform, Western Isles FPSO and tie-back to Avalon development concepts would be designed with the goal of no routine flaring and venting. For the other two tie-back development concepts, flare strategy would be dependent upon current provisions at the host platforms, and hence flaring emissions may be larger.

Taking account of all the criteria considered during Concept Evaluation, the redeployment of the Western Isles FPSO was found to be the optimum development concept for the Buchan Horst Field.

Oil Export

Four options were initially considered for the export of oil from the Western Isles FPSO. These included three tie-back options (one via Forties Pipeline System and export via shuttle tanker:

- Option 1: Oil exported via the Forties Pipeline System using an existing decommissioned pipeline;
- Option 2: Oil exported via shuttle tanker;
- Option 3: Oil exported via a new pipeline tied into the Flotta Catchment Area;
- Option 4: Oil exported via a new pipeline tied into the Forties Pipeline System.

Screening of the four oil export options followed the same process used for the selection of the development concept. Oil export via a shuttle tanker was found to be the optimal option.

Pipeline Installation

Several installation options were considered for installation and protection of the infield lines and the gas export pipeline, including trenching and mechanical backfill, trenching and natural backfill (gas export pipeline only), surface laid and rock covered, bundled flowline and Electro-Hydraulic-Control (EHC) umbilical (infield lines

only). Each option was assessed against three criteria: environment, safety and practicality. For both the infield lines and the gas export pipeline it was concluded from the assessment that trenching and mechanical burying of the lines is the optimal approach.

Jet trenching was not considered as part of the initial assessment that was carried out; however it has since been determined that it may be suitable for installation of the lines. Further engineering/assessment will be carried out to determine if the lines could be jet trenched and if suitable depth of burial can be achieved to mitigate upheaval buckling.

Buchan Redevelopment Project

The proposed Buchan Redevelopment Project involves installation of new subsea production gathering infrastructure tied back to the Western Isles FPSO. Oil will be offloaded from the Western Isles FPSO via shuttle tanker and excess gas will be exported via a new gas export pipeline. The new gas export pipeline will be tied back to either the SAGE pipeline system or to the FUKA pipeline system. A total of seven wells will be drilled: five production wells and two water injection wells. Reservoir pressure will be maintained with a combination of water injection (including produced water) and gas lift.

Final well location has yet to be determined, however the base case is for all seven wells to be drilled across two drill centres located within a single 500 m safety zone. The drill centres will be located *c*. 1.5 km from the Western Isles FPSO location. At the time of writing it had yet to be determined if a semi-submersible drilling rig or a heavy-duty jack-up (HDJU) drilling rig will be used to drill the proposed Buchan Horst wells. The water depth, weather conditions and seabed conditions in the area are such that either type of drilling rig could be used. The ES therefore takes into consideration both options, and for each environmental aspect considered, the drilling rig resulting in the worst-case environmental impact will be assessed.

Figure 2 provides an indicative layout of the proposed Buchan Redevelopment Project.

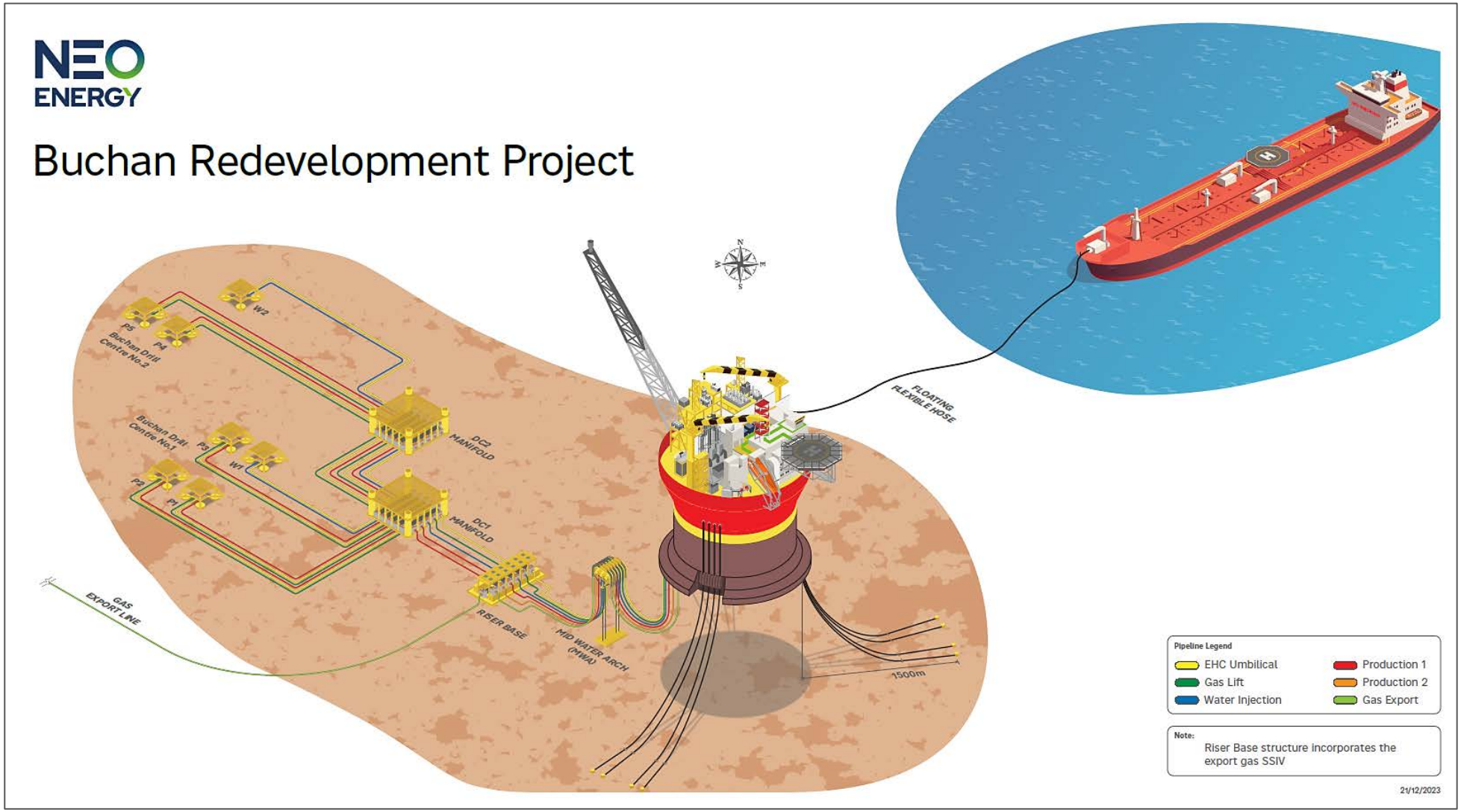


Figure 2: Indicative schematic of the proposed Buchan Redevelopment Project.

Infrastructure to be installed as part of the proposed Buchan Redevelopment Project includes:

- Anchors and anchor lines associated with the Western Isles FPSO mooring system and the riser base and mid-water arch to be located within the FPSO 500 m exclusion zone;
- Infield flowlines for transporting oil and gas, injection water and gas for artificial lift; an Electro Hydraulic Control umbilical for well control (the main length of all flowlines and the umbilical will be trenched and buried), drill centre manifolds and Xmas trees and well head protection structures for direction and monitoring flow;
- A 6 inch gas export pipeline made of carbon steel that will either tie-in to the SAGE pipeline system at the Ettrick manifold (c. 41.77 km pipeline) or tie-in to the FUKA pipeline system at the Tweedsmuir manifold (c.19.31 km pipeline). Regardless of tie-in location the main length of the gas export flowline will be trenched and buried. If selected the tie-in to the SAGE pipeline system would require installation of a piled and fishing friendly Pipeline End Manifold (PLEM), a new PLEM would not be required for tie-in to the FUKA pipeline system.

The infield flowlines and the gas export pipeline will be trenched and buried, it is assumed that all trenches will be cut using a towed plough and mechanically backfilled using a separate towed backfill plough. The Project is also considering the potential to jet trench the lines, however the ES assesses the impacts associated with trenching and mechanical backfill due to the expected larger area of impact. Stabilisation and protection materials such as grout bags and mattresses will be required where flowlines and the gas export pipeline transition out of the seabed trenches. A contingency volume of rock cover has been presented in the ES as a worst case in the event that there are areas along the gas export pipeline route where the target depth of burial (> 0.6 m) is not achieved. In addition, the ES also assumes that depth of burial required to mitigate upheaval buckling is not reached on the infield flowlines such that the full length of the flowlines are rock covered. Prior to production, the integrity of the flowlines and gas export pipeline will be confirmed via testing such as leak detection.

The redeployed Western Isles FPSO will receive and process the reservoir fluids. Excess gas will be exported, produced water will be reinjected and oil will be stored for subsequent offload to oil tankers. The Western Isles FPSO mooring system will comprise twelve (3 groups of 4) mooring lines measuring *c* 1.52 km radiating from the FPSO and anchored using either driven pile anchors or suction anchors. The operations onboard the FPSO will be powered by gas turbine generators initially until a 3rd party source of electricity e.g. an INTOG windfarm is available. Gas will also be required for gas lift of the wells. During the first few years of production there will be a surplus of associated gas which will be exported. As production declines the amount of gas available for export declines, and after around six years of production the Western Isles FPSO will start to become gas deficient. The transition to electrification will assist in addressing the power generation needs of the FPSO. However, there may be a requirement for fuel gas import via the gas export pipeline if the electrification initiatives are not on schedule; notwithstanding gas import will be required through field life to provide make-up to the gas lift system.

It is expected that from 2030 onwards the Western Isles FPSO will be electrified. Prior to deployment of the Western Isles FPSO to the Buchan Horst Field, upgrade work will be undertaken to enable to FPSO to be electrification ready with the aim of minimising any offshore workscope. This will help to ensure an efficient switch to a 3rd party energy source e.g. an INTOG windfarm with minimal offshore work scope and minimal downtime to field operations. During operation, the Western Isles FPSO flare and vent gas recovery systems will achieve ‘no routine flaring and venting’.

Taking account of the anticipated High Case production profiles, daily oil and gas production rates are anticipated at the start of field life (in 2027) at an approximate rate of 5,976 te/day (tonnes per day) and 352 km^3/day (thousand cubic meters per day) respectively. Production rates for both oil and gas subsequently decrease every year to end of field life. The reservoir will require water injection to maintain the pressure required during production, produced water profiles increase over field life with maximum produced water rates associated with the final years of production.

At the end of field life the infrastructure installed as part of the proposed Buchan Redevelopment Project will be decommissioned in line with legislation in force at that time. In line with current guidelines and legislation the activities are expected to include the flushing and cleaning of the pipelines/flowlines and infrastructure. A comparative assessment will be carried out to determine the optimal approach to decommission the buried lines whilst all surface infrastructure, mattresses and grout bags will be removed from the seabed and returned to shore for management via the waste hierarchy. It is expected the wells will be plug and abandoned using cement to plug and seal the wells. The Western Isles FPSO will be taken off station and the mooring system

recovered. Following recovery activities a safe seabed survey will be conducted to ensure no snagging risks remain.

Schedule of Activities

An indicative schedule of the offshore activities associated with the proposed Buchan Redevelopment Project is shown in Figure 3. As can be seen offshore activities are expected to commence in Q2 2025 whilst first oil is expected in Q4 2026. Note the schedule is indicative only, and highlights the earliest start and end dates, and as such should not be through to represent the full duration of the activities.

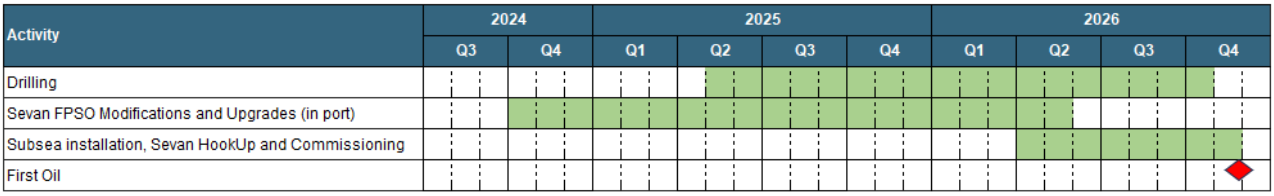


Figure 3: Indicative schedule for the proposed Buchan Redevelopment Project.

Baseline Environment

A high level summary of the environment at the Buchan Horst Field location is provided in Table 1.

Table 1: Summary Description of the Baseline Environment.

Bathymetry and Metocean characteristics
Water depths range from c. 107 – 111 m at the proposed Western Isles FPSO location, between 84.4 – 121.4 m along the potential gas export pipeline route to the Ettrick PLEM and between 108.8 – 136.7 m along the potential gas export pipeline route to the Tweedsmuir manifold. Wind direction and speed is changeable throughout the year. The area experiences rough seas, particularly from October to March. Currents in the area originate from the vertically well-mixed coastal water and the inflow of Atlantic water from the Fair Isle and Dooley current.
Sediment and Seabed Features
The project area is characterised by muddy sediments with some areas of sandy sediments along the gas export pipeline route to the Ettrick PLEM. A number of seabed depressions have been observed in the wider project area and along the potential gas export pipeline route to the Tweedsmuir manifold
Plankton
Plankton form the basis of the food chain in the marine ecosystem and are a crucial source of food for multiple species. The composition and abundance of plankton communities varies throughout the year; influenced by several factors including depth, tidal mixing, temperature stratification, nutrient availability, and the location of oceanographic fronts. The zooplankton community is dominated by copepods, although other groups such as *Paracalanus* and *Pseudocalanus* are also abundant. There is also a high biomass of Calanus larval stages present in the region.
Seabed Habitat and communities
Cohesive mud and sandy mud, offshore mixed sediment and fine sand were the three main habitats identified across the Buchan Horst field using the JNCC marine habitat classification. Other habitats in the project area are sea pen and burrowing megafauna communities and submarine structures made by leaking gases. These habitats support sea pen species, sand smelts, starfish and species of the family *Gobiidae*.
Fish and Shellfish
A variety of fish species inhabit the shelf seas in the project area some identified as priority marine features and others of commercial importance. Cod, herring, lemon sole, N*ephrops*, Norway pout, sandeel, spotted ray, sprat and whiting all may use the area for spawning and nursing. Several species may use the area as nursery grounds including anglerfish, blue whiting, European hake, haddock, ling, mackerel and plaice. Nursery grounds are also present for some shark, skate and ray species including common skate, spotted ray, spurdog and tope shark.
Seabirds
A number of seabird species are likely to occur in the area over the summer breeding season and winter months. Many species, e.g., terns, overwinter out with the area, whilst other seabirds e.g., little auks, move

to the area from more northerly breeding grounds to overwinter. For all species combined, a maximum of 125 seabirds are predicted to occur per km^2 during the breeding season (April to September), this number reduced to 37 seabirds per km^2 during summer months (July to August) and 27 seabirds per km^2 during the winter months (November to March).The large variety of seabirds using the area include guillemot, European storm petrel, Manx Shearwater, northern fulmar and Sandwich Tern. The nearby coastlines of North East Scotland support a number of seabird colonies for various species.
Marine Mammals
Both harbour and grey seals are unlikely to occur in the area, however there have been sightings from a number of North Sea platforms. Several whales and dolphin species have been sighted in the area including, harbour porpoise, bottlenose dolphin, white-beaked dolphin. Atlantic white-sided dolphin and minke whale. Distribution and abundance of these dolphin and whale species varies throughout the year, with an increase in abundance of species over the summer months for all species.
Conservation
There are no protected areas within 40 km of the proposed Buchan Redevelopment Project area. The closest protected areas to the proposed Project are the Turbot Bank Nature Conservation Marine Protected Area (NCMPA) and the Scanner Pockmark Special Area of Conservation (SAC). The Loch of Strathbeg Special Protection Areas (SPA) and the Buchan Ness to Collieston Coast SPA are the closest coastal sites to the Project area. A number of species identified in the area are afforded protection under European, UK and Scottish conservation regulations.
Other Sea Users
The area is fished by local and international vessels, with fishing effort tending to be higher in spring and summer. Otter trawls targeting demersal and shellfish species have been used the most intensely in the area while seine nets have been used rarely. Commercial shipping activity at the Buchan Horst field is considered very low but this increases to low and moderate along the potential gas export route to the Ettrick PLEM. There are a number of Scotwind lease areas and successful Innovation and Targeted Oil & Gas application sites within 40 km of the proposed Project. The proposed Project lies within a well-developed oil and gas production area with a number of installations, pipelines and umbilicals present.

Environmental Impact Assessment

In order to determine the impact that the proposed Buchan Redevelopment Project may have on the environment an ENVironmental and socio-economic impact IDentification (ENVID) was undertaken following a structured methodology. The purpose of the ENVID was to identify the significance of the environmental and socio-economic risks associated with the planned activities and any possible unplanned events and to identify appropriate mitigation measures, controls and safeguards to minimise this risk.

For each of the planned activities an environmental and/or socio-economic impact significance is assigned for the relevant aspects (e.g. emissions to air, discharges to sea, underwater noise etc.) by taking into account the sensitivity of the receptors and the magnitude of the effect.

For unplanned events the environmental and/or socio-economic significance of risk ranking also takes into account the likelihood of the event occurring. A summary of the key findings of the impact assessment is presented in Table 2.

Table 2: Environmental Impact Assessment key findings.

Physical Presence
The physical presence of project vessels, the drilling rig, Western Isles FPSO and subsea infrastructure associated with the proposed development has the potential to be a navigational hazard, restrict fishing operations in the area and to cause disturbance to marine fauna. Mitigation measures include early consultation with the Scottish Fishermen's Federation (SFF) for all operations, notification to other users of the sea regarding the project's activities, safety exclusion zones in place around the Western Isles FPSO and drill centres, use of a guard vessel to warm of anchor location prior to semi-submersible rig coming on location. The physical presence of the project related aspects listed above is considered a low socio-economic impact significance. In addition, the environmental impact significance in relation to marine mammals, birds and fish is considered low. The environmental and socio-economic impacts are therefore considered acceptable when managed within the additional controls and mitigation measures outlined in Table 3.

Emissions to Air

Activities associated with the proposed Buchan Redevelopment Project, including drilling, subsea installation, FPSO installation, production start-up, FPSO operations and decommissioning will all result in emissions to air which can contribute to global atmospheric concentrations of GHGs and regional acid loads. NEO Energy has assessed the impact associated with atmospheric emissions from the proposed Project. In the drive to towards supporting the UK's Net Zero target and meeting the company's GHG commitments, the identification, assessment, and minimisation of emissions have been embedded in all stages of the project management process. A number of integrated measures across drilling, installation, commissioning and production will be adopted to ensure emissions are minimised to 'as low as reasonably practicable'. A number of measures to reduce emissions have been focused on during the assessment including plant design with the goal of no routine flaring and venting through the provision of existing flare and vent gas recovery systems and minimalised diesel use will be ensured through the installation of a new gas export pipeline and reduced NO_x emissions will be achieved through Dry Low Emission technology on the Gas Turbine Generators (GTGs). The impact of installation, completions and start-up activities on air quality will be localised, short term and will mainly occur *c*. 115 km from the nearest shoreline. The significance of impact to the local ecological receptors is therefore considered to be Low. The introduction of production at the Buchan Horst Field as proposed will result in an increase in emissions of pollutants such NO_x and CO. However, the rapid dispersion anticipated at the proposed location and distance relative to sensitive receptors combined with the fact that the GTGs onboard are equipped with Dry Low Emission (DLE) technology, and that diesel use will be minimised as far as is practicable, it is anticipated that the impact significance of the proposed development on air quality during the production phase will be Low.

In addition, the development of the Buchan Horst Field as proposed would contribute to lower than average GHG intensity compared to oil imports and would support the goals for emissions reduction in the UKCS established by the NSTD, even more so with full electrification of the FPSO from a 3rd party power source e.g. an INTOG windfarm. The proposed development is in alignment overall with the UK Government strategy for transitioning to Net Zero GHG emissions by 2050.

Discharges to Sea

Activities that result in planned discharges to sea will occur from the drilling, installation, commissioning and production phases of the proposed Buchan Redevelopment Project. Discharges from drilling will include drilling fluids and cuttings, cement and well bore clean-up fluids. Installation discharges will include water containing a mix of chemicals used for testing integrity of pipelines. Impacts associated with these drilling and installation related discharges may arise from the suspension of particulate matter in the water column and the presence of chemicals within the discharge. Modeling of drill cuttings discharges was carried out to support the impact assessment. Discharges to sea from the Western Isles FPSO during production will include drainage water discharges and treated produced water discharges in the event that the produced water reinjection system is down. The ES allows for a 10% downtime of the produced water reinjection system. Impacts from production related discharges may arise from a decrease in water quality, which in turn could affect plankton which drift in the water column and therefore cannot avoid discharges in the same way that fish and marine mammal can. Assessment of planned discharges on the water column and its associated receptors concluded that the overall significance of the environmental impacts of all planned discharges is Low and therefore considered acceptable when managed within the additional controls and mitigation measures identified in Table 3.

Seabed Disturbance

There will be disturbance of the seabed during the drilling and installation phases of the project.

It is not known if a semi-submersible drilling rig or a HDJU drilling rig will be used to drill the proposed wells, the assessment considers the worst-case seabed impact associated with anchoring of a semi-submersible drilling rig as this would result in a greater impact than the positioning of the HDJU drilling rig. However the potential for spud can depressions remaining is also considered should a HDJU drilling rig be selected. Having been towed to the site, the semi-submersible drilling rig will be held on location using eight drag anchors connected to the drilling rig via anchor lines measuring c. 1,400 m in length. The ES assumes that the semisubmersible drilling rig and associated anchor system would need to be positioned two times to reach all well surface locations.

Drill cuttings and associated drilling fluids are expected to be discharged at the seabed during drilling of the tophole sections of each well. The lower well sections will be drilled using low toxicity oil based muds (LTOBM). It is not known if the LTOBM contaminated cuttings from the lower sections will be skipped and shipped to shore or if they will be thermally treated offshore and discharged from the drilling rig. The ES

assumes a worst case whereby these cuttings are treated offshore and discharged. Modelling of the discharge of the drill cuttings has been carried out to support the assessment of cuttings. Drill cuttings discharge simulations using the Dose-related Risk and Effects Assessment Model (DREAM) estimated a maximum thickness of cuttings of 4.65 m around the wells, with significant thicknesses (over 6.5 mm) predicted to occur up to c. 950 m from the discharge locations. The area where thickness is greater than 6.5 mm is predicted to be c. 0.1847 km^2 at the end of drilling but reduces over time. To put this into context, a typical exclusion zone around a platform of 500 m radius is equivalent to an area of 0.785 km^2.

The maximum area where there is a combined risk (takes account of depth of burial, change in grain size, oxygen depletion and toxicity due to chemicals) to more than 5% of the most sensitive species in the sediment following drilling is predicted to be approximately 0.478 km^2 after drilling ends. The area reduces to 0.204 km^2 after two years due to re-colonisation by opportunistic species. Seabed recovery then slows down, and after 5 years and 10 years respectively the potentially impacted area is estimated to be 0.153 km^2 and 0.108 km^2 respectively.

Seabed disturbance resulting from trenching and mechanical backfill of the infield flowlines and EHC umbilical and the gas export pipeline is considered temporary as backfill with natural sediment will allow reinstatement of the natural habitat available for recolonisation. There will be an area of permanent disturbance associated with surface laid infrastructure, mattresses, grout bags, and contingency rock cover.

There will also be an area of seabed that is impacted by the repetitive drag of the mooring lines and risers associated with the Western Isles FPSO. This abrasion could change and/or influence the nature of the seabed and the species present.

Impacts resulting from the proposed activities have the potential to impact on areas of potential OSPAR habitat ‘sea pens and burrowing megafauna communities’ however given the widespread distribution of the habitat across the surveyed areas in the vicinity of the project, the impact is not considered significant.

Decommissioning activities will result in temporary disturbance to the seabed. It is anticipated that the area disturbed by the decommissioning activities will be less than that disturbed by the drilling and installation activities and will mostly be within the same footprint disturbed by the installation activities.

Overall, the worst case analysis of the proposed Buchan Redevelopment Project activities that require interaction with the seabed shows that most of disturbance will be temporary whilst the drilling rig is on station and during installation of the infield flowlines and EHC umbilical, the gas export pipeline and other subsea structures. Approximately 3.16 km^2 may be subject to temporary disturbance by drilling and installation activities, and 0.58 km^2 will have a permanent or long-term footprint from the Western Isles FPSO mooring system, subsea structures, stabilisation and protection materials, and residual drill cuttings accumulation.

Though recovery is expected to begin immediately after some of the activities are completed, taking account of the total area that could be impacted either permanently or temporarily, the overall impact significance associated with disturbing the seabed is considered moderate, such that some of the environmental impacts will be discernible after the activities are completed or through to the time of decommissioning. The Project will continue to work towards minimising the potential impact e.g. potential for laying two or more of the infield lines in the same trench will be considered, whilst route surveys carried out to minimise the potential for contingency rock cover.

Underwater Noise

The main sources of underwater noise associated with the proposed Buchan Redevelopment Project will result from drilling operations, contingency rock dumping activities, vessel use and the piling of a number of structures.

Many marine organisms use sound for navigation, communication and prey detection. Therefore, the introduction of man-made sources of underwater noise has the potential to impact marine animals if it interferes with their ability to receive and use sound. Types of impact include temporary avoidance or behavioral changes, the masking of biological sounds as well as auditory and other injuries.

Underwater noise modeling was carried out to assess the impacts of piling noise. Although the sound from the proposed project does have the potential to cause disturbance to marine animals it is not expected to have a significant impact on any cetacean or fish species. Taking this into account and considering the mitigation measures outlined in Table 3, the significance of the environmental impact of the underwater noise associated with the proposed activities is considered Low. The impacts are therefore considered acceptable when managed within the controls and mitigation measures identified.

Waste
NEO Energy is committed to reducing waste production and to managing all produced waste, by applying approved and practical methods and by adhering to the waste hierarchy. Waste will only be disposed of if it cannot be prevented, reclaimed or recovered. All wastes will be managed in accordance with NEO Energy's Waste Management Plan. The procedure establishes the controls required to manage the hazards associated with the transportation and disposal of waste from offshore sites and the processes, and verification activities necessary to ensure legal obligations are satisfied. The overall impact significance of waste generation is therefore considered to be low and is therefore acceptable when managed within the mitigation measures described. With the application of the control and mitigation measures identified the impact significance of waste generation is considered Low such that any environmental impacts associated with waste production are thought to be negligible.
Accidental Events
The ES presents a detailed evaluation of two potential hydrocarbon spill scenarios: (1) a low probability well blowout; (2) a crude inventory loss from the Western Isles FPSO. Small scale accidental events, ranked minor or moderate, have also been reviewed in this ES. The two potential hydrocarbon spill scenarios were modelled using the Oil Spill Contingency and Response (OSCAR) model. The oil spill simulations undertaken established that the well blowout would be the most severe scenario based on surface coverage, water column contamination and onshore deposition of crude. However, the inventory loss would result in higher concentrations at the surface, in the water column and onshore, albeit covering smaller volumes/areas. The likelihood of either of the two hydrocarbon releases modelled occurring is considered remote owing to the procedural and operational controls that will be applied during the Buchan Redevelopment Project. Given the likelihood of such releases, and following the application of control and mitigation measures, the overall environmental risk of impacts from a large hydrocarbon release resulting from a well blowout or a total loss of crude inventory from the Western Isles FPSO are considered to range from Low to Medium depending on the environmental receptor. The well blowout and crude inventory loss scenarios are considered Major Accidental Hazards (MAHs). MAH's must be assessed to determine if they may result in significant adverse effects on the environment and constitute a Major Environmental Incident (MEI). Based on the criteria outlined in the Safety Case Regulations (SCR, 2015) and the oil spill simulation results it was established that both scenarios could lead to impacts in relation to seabirds, and coastal protected areas that would qualify as an MEI as defined in the SCR (2015).

Overall Conclusion

This ES, based on an assessment of significant adverse effects, finds that the proposed Buchan Redevelopment Project would not cause any significant long-term adverse impact to the environment. Risks and impacts can be readily mitigated and controlled through robust design, effective operating practices and systems implemented by a highly trained workforce. NEO Energy has a track record in the delivery and operation of offshore project developments in the North Sea and is committed to protecting the environment by carefully considering the potential impact new developments may have during the planning of projects and throughout the lifetime of operations.

Table 3: Buchan Redevelopment Project commitments.

Aspect	Commitments
Physical Presence	• Operations Notification 6 (Reporting of Offshore Installation Movements) will be submitted prior to rig mobilisation; • A Collision Risk Management Plan will be produced if determined to be required; • All vessels will adhere to the International Regulations for the Prevention of Collisions at Sea and will be equipped with navigational aids, including radar, lighting and AIS (Automatic Identification System) etc.; • The drilling rig will be equipped with navigational aids and aviation obstruction lights system, as per the Standard Marking Schedule for Offshore Installations; • Vessel use will be optimised by minimising the number of vessels required and length of time vessels are on site; • The flowlines and EHC umbilical laid out with the 500 m areas will be trenched and buried; • Following flowline and EHC umbilical installation, surveys will be carried out to ensure a safe seabed; • Any contingency rock cover required will be laid in an over trawlable profile; • 500 m safety zones in place around the Western Isles FPSO and drill centres; • Use of a guard vessel to warn of anchor location prior to the semi-submersible drilling rig coming on location; • Presence of Emergency Rescue and Recovery Vessels (ERRV) which will warn other sea users of the presence of the drilling rig and the Western Isles FPSO.
Emissions to Air	**Proposed Concept Select Mitigation Measures** • Inclusion of optimised energy efficiency and GHG emissions reduction in the rig selection and tendering process. • Investment will be made to ensure the FPSO is electrification ready in advance of the availability of 3rd party power e.g. an INTOG windfarm. **Proposed Logistics and Start-up Mitigation Measures** • Batch drilling and completion opportunities will be evaluated. These would reduce emissions through reduced logistical requirements and fluid handling efficiencies. • The Project team will aim to design wells to minimise use of diesel-powered intervention equipment. • The information gained from each well test will be assessed with a view to reducing the volumes of hydrocarbons to be flared during well testing for each subsequent production well. • Minimise emissions during well clean-up operations with the use of optimised flare burner technology (i.e., 'green burner') and with continuous monitoring weather conditions. • Regarding flaring operations, to ensure all performance related conditions are monitored, and that adjustments can be made accordingly, a dedicated person will be assigned for full-time fire watch duty. • The drilling rig and other project vessels will be subject to audits ensuring compliance with UK legislation. • Vessel use will be optimised where possible by minimising the number of vessels required, and their length of time on site. • Vessels will be operated where possible in modes that allow for economical fuel use. **Proposed Production Mitigation Measures** In accordance with the revised North Sea Transition Authority strategy, and associated Stewardship Expectation 11, as well as with the industry commitments within the North Sea Transition Deal, NEO Energy will incorporate the following controls: • The plant is designed with the goal of no routine flaring and venting through the provision of existing flare and vent gas recovery systems.

Aspect	Commitments
	• 'Zero routine flaring' and minimised diesel use will be ensured through the installation of a new gas export pipeline. • Visiting shuttle tankers will be equipped with a Vapour Emission Control System (VECS) to eliminate emissions while loading. • Diesel use by the GTGs will be limited to turnarounds (and shutdowns) (TARs) and for instances when fuel gas is unavailable e.g. plant re-start. • An N+1 configuration with 2 off GTGs supplying power for production and utility consumers during normal operation with one GTG as standby minimises spinning reserve of standby power generation. • Reduced NOx emissions will be achieved through DLE technology on the GTGs. The use of DLE technology is considered Best Available Technique for offshore GTGs (EU IPPC, 2017). • All three GTGs are equipped with Waste Heat Recovery Units (WHRUs) which will be used to recover heat for the heating medium system, increasing the overall energy efficiency of power generating equipment, which ultimately reduces asset emissions. • NEO Energy will continually monitor and review emissions and carbon intensity of the asset in line with the company's Environmental Social Governance strategy and commitments and in an effort to support the UK's Net Zero target. • An asset GHG Emission Reduction Action Plan will be prepared for first oil. These measures will help to ensure that opportunities for efficiency and reduction of atmospheric emissions, where not in conflict with safe operations, are identified, actioned as appropriate and reviewed.
Discharges to Sea	• Minimise use of vessels, through efficient journey planning; • NEO Energy will review vessel Common Marine Inspection Documents as part of vessel assurance and all vessels will be compliant with the Company's MAS; • All vessels used will be International Convention for the Prevention of Pollution from Ships compliant; • All contracted vessels will originate from countries adhering to the International Maritime Organisation (IMO) Convention; • As part of the Company's auditing process, only vessels adhering to the IMO 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Species will be used. • The drilling rig is to be audited under NEO Energy's marine assurance standards and subject to rig recertification audits; • Where technically feasible NEO Energy will prioritise the selection of chemicals which pose little or no risk, or have the lowest Risk Quotient (RQ); and • The discharges of any water based hydraulic fluids, sand or chemicals are regulated by the Oil Pollution Prevention and Control Regulations and/or Offshore Chemicals Regulations and reported through the Environmental and Emissions Monitoring System. As such, NEO Energy will ensure that sampling, analysis and reporting are undertaken in line with the regulations and permit conditions.
Seabed Disturbance	• Pre-deployment surveys will be undertaken to identify suitable locations for the Western Isles FPSO anchors and drilling rig anchors in the event a semi-submersible drilling rig is utilised; • Pipeline and umbilical route surveys will be undertaken; • NEO will continue to explore the option to lay multiple flowlines in the same trench going between the drill centres and the Western Isles FPSO; • The proposed gas export route will take the most direct/shortest route to the Ettrick PLEM or Tweedsmuir manifold subject to seabed conditions encountered; • The use of mattresses, rock cover and grout bags will be minimised through optimal project design; • Anchors of the drill rig are to be maintained under tension to minimise chain contact on seabed;

Aspect	Commitments
	• Cement volumes required will be planned and optimised; • Use of Remotely Operated Vehicle for visual monitoring and pH monitoring during cementing jobs that allows stopping when cemented is either observed or detected at seabed (minimises excess cement); • Sea dye will be used to indicate when cement is approaching the surface; • The use of dynamically positioned vessels will minimise anchor use; • Use of low toxicity chemicals in Water Based Mud; • Use of specialist contractors to minimise dropped objects; and • Lifting plans in place.
Underwater Noise	• A qualified, trained and equipped marine mammal observer (MMO) will be present. The MMO will carry out a pre-piling survey of a 500 m mitigation zone and, if an animal is detected, the piling will be delayed until all marine mammals vacate the 500 m mitigation zone; • A soft-start/ramp-up of hammer energy will be employed where the hammer will commence at a low energy at the start of piling. The soft start will be such that maximum hammer energy will not be reached until after a period of 20 minutes; • Passive Acoustic Monitoring (PAM) will be employed during periods of low visibility to detect marine mammal presence; and • Avoiding commencing piling at night or in poor visibility when marine mammals cannot reliably be detected. If this cannot be avoided, then PAM will be used.
Waste	• NEO Energy will apply the principles of the Waste Management Hierarchy during all activities i.e. Reduce, Reuse, Recycle; • Asset and vessel Waste Management Plans will be followed; • Only permitted disposal yards / landfill sites will be used.
Accidental Events	• Activities will be carried out by trained and competent offshore crews and supervisory teams; • An approved Oil Pollution Emergency Plan (OPEP) will be in place prior to any activities being undertaken; • Records will be kept of oil spill training and exercises as required by the OPEP; • Process Safety Assurance Processes will be identified and adhered to; • The Western Isles FPSO will be of a double-hull design, meaning oil cargo tanks are not on the outside, thus limiting risk of spill; • The Western Isles FPSO will have a robust maintenance and inspection programme linked into the critical elements and associated verification scheme; • Shipboard Oil Pollution Emergency Plans (SOPEPs) will be in place for project vessels; • A co-ordinated industry oil spill response capability will be available; and • Enhanced sharing of industry best practices via the Oil Spill Response Forum (OSRF) will continue. Wells specific control measures • A robust Blowout Preventer (BOP) pressure and functional testing regime will be in place and the BOP will have fully redundant control systems; • Appropriate mud weights will be used to allow well control to be maintained; • The drilling rig will be appropriately certified; • The drilling rig shall have an approved safety case with all Safety and Environmental Critical Elements (SECEs) verified by an independent verification body and managed through a recognised maintenance management system; • Well construction and operation activities to be conducted with multiple barriers in place; and • Well Control Contingency Plan in place detailing relief well plans and arrangements with internal

Aspect	Commitments
	and external well control specialists. Operations-specific control measures • Tanker offloading procedures will be in place; • Shutte tankers will be required to be Dynamic Positioned 2-classed as a minimum; • Metocean conditions may limit offloading; where production storage limits are reached, production could be curtailed until export can resume. • Import and export facilities will be secured by topside Emergency Shutdown Valves; • A mandatory 500 m safety zone will be in place for the Western Isles FPSO and drilling rig; • There will be agreed approach procedures to the Western Isles FPSO by supply and safety vessels, informed by appropriate collision risk assessments; • Operational restrictions will be in place for visiting vessels in bad weather; • Simultaneous operations (SIMOPS) procedures will be in place; • Pipelines will have pressure monitoring and low pressure alarms; and • Oil spill control measures will be followed as outlined in the OPEP.

Acronyms

>	More Than
<	Less Than
%	Percentage
°	Degrees
°C	Degrees Celsius
°F	Degrees Fahrenheit
µg/g	Micrograms per Gram
µg/l	Micrograms per Litre
µm	Micrometres
µPa	Micro Pascal
µPa2s	Micro Pascal squared second
‰	Per thousand
boe	Barrel of oil equivalent
c.	Circa / Approximately
cm	centimetre
dB	Decibel
gCO2e/MJ	gram carbon dioxide equivalent per megajoule
(H)	Height
Hz	Hertz
kgCO2e/bbl	Kilogram Carbon Dioxide equivalents per Barrel
kHz	Kilohertz
kJ	Kilojoule
km	Kilometre
km^2	Square kilometre
km^3	Cubic kilometer
kteCO2e/mmboe	Kilotonnes of Carbon Dioxide equivalent per million of barrels of oil equivalent
(L)	Length
m	metre
m/s	Metres per second
m^3	Cubic Metre
mbbl	One Million Barrels
mg/l	Milligrams per litre
MJ	Megajoule
MMscf/d	Million standard cubic feet per day
MMTeCO2e	Million Metric Tonne Equivalent Carbon Dioxide equivalent
MMTeOE	million tonnes of oil equivalent
MTe	Metric Tonne equivalent
MTeCO2e	Metric Tonne Equivalent Carbon Dioxide equivalent
MW	Mega Watt
MW(th)	Megawatt thermal

PPM	Parts per million
psig	Pound-Force Per Square Inch Gauge
SCF	Standard Cubic Feet
Scf/bbl	Standard Cubic Foot per Barrel
AC	Alternating Current
ADMS	Air Dispersion Modelling System
AHV	Anchor Handling Vessel
AIS	Automatic Identification System
API	American Petroleum Institute
BAP	Biodiversity Action Plan
BAT	Best Available Technique
BEIS	Department for Business, Energy, and Industrial Strategy
BOP	Blowout Preventer
BREF	Best Available Techniques Reference Document
CAPEX	Capital Expenditure
CCC	Climate Change Committee
CCS	Carbon Capture and Storage
CERC	Cambridge Environmental Research Consultant
CH_4	Methane
CHARMable	Chemical Hazard Assessment and Risk Management
CMID	Common Marine Inspection Documents
CNOOC	China National Offshore Oil Corporation
CNS	Central North Sea
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
COLREGS	International Regulations for the Prevention of Collisions at Sea
CoP	Cessation of Production
CSIP	Cetacean Stranding Investigation Programme
CtL	Consent to Locate
DC1	Drill Centre 1
DC2	Drill Centre 2
DESNZ	Department for Energy Security and Net Zero
DHSV	Downhole Safety Valve
DLE	Dry Low Emission
DP	Dynamic Positioning
DREAM	Dose Related Risk and Effect Assessment Model
DSV	Drilling Support Vessel
EC	European Commission
ED50	Effective Dose 50%
EEC	European Economic Community
EEMS	The Environmental and Emissions Monitoring System

EF	Emission Factor
EHC	Electro Hydraulic Control
EIA	Environmental Impact Assessment
ELV	Emission Limit Values
EMODnet	European Marine Observation and Data Network
EMS	Environmental Management System
EMT	Environmental Management Team
ENVID	Environmental and socio-economic Impact Identification
EPS	European Protected Species
ERAP	Emissions Reduction Action Plan
ERRV	Emergency Response and Rescue Vessel
ES	Environmental Statement (added in section 1.4 see there)
ESAS	European Seabirds at Sea
ESDVs	Emergency Shutdown Valves
ESG	Environmental Social Governance
ESIA	Environmental / socio-economic impact significance
ESRA	Environmental and Socio-Economic Risk Assessment
ETS	Emissions Trading Scheme
EU	European Union
EU ETS	EU Energy Trading Scheme
EUNIS	European Nature Information System
FCA	Flotta Catchment Area
FDP	Field Development Plan
FEAST	Feature Activity Sensitivity Tool
FEPA	Food and Environmental Protection Act
FPS	Forties Pipeline System
FPSO	Floating Production Storage and Offloading
FTHP	Flow Tubing Head Pressure
FUKA	Frigg UK Association (Pipeline System)
GBA	Greater Buchan Area
GBP	Pound Sterling
GHG	Greenhouse Gas
GIS	Geographic Information System
GOR	Gas Oil Ratio
GPIII	Global Producer III
GRI	Global Reporting Index
GTGs	Gas Turbine Generators
GWP	Global Warming Potential
H_2S	Hydrogen Sulphide
HDJU	Heavy Duty Jack Up
HF	High Frequency
HM	Heating Medium

HP	High Pressure
HQ	Hazard Quotient
HSE	The Health and Safety Executive
HSSE	Health, Safety, Security and Environment policy
HV	High Voltage
HVAC	Heating, Ventilation, and Air Conditioning
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organisation
INTOG	Innovation and Targeted Oil and Gas
IOGP	The International Association of Oil & Gas Producers
IPCC	Intergovernmental Panel on Climate Change
IPIECA	International Petroleum Industry Environmental Conservation Association
ISO	International Organisation for Standardisation
ITOPF	International Tanker Owners Pollution Federation Limited
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
KP	Kilometre Point
KPI	Key Performance Indicators
LAT	Lowest Astronomical Tide
LCM	Loss Circulation Material
LCP	Large Combustion Plant
LCTP	Low Carbon Transition Plan
LF	Low frequency
LNG	Liquified Natural Gas
LOLER	Lifting Operations and Lifting Equipment Regulations
LSA	Low Specific Activity
LTOBM	Low Toxicity Oil Based Mud
MAHs	Major Accident Hazards
MarLIN	Marine Life Information Network
MARPOL	International Convention for the Prevention of Pollution from Ships
MAS	Marine Assurance Standards
MAT	Master Application Template
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
MDAC	Methane derived authigenic carbonate structure
MEG	Mono Ethylene Glycol
MEI	Major Environmental Incident
MER	Maximising Economic Recovery
MMO	Marine Management Organisation
MMO	Marine Mammal Observers
MoD	Ministry of Defence
MPA	Marine Protected Area

MSFD	Marine Strategy Framework Directive
MSL	Mean Sea Level
MWA	Mid-water Arch
N/A	Not Applicable
NAEI	UK National Atmospheric Emissions Inventory Report
NCMPA	Nature Conservation Marine Protected Area
NCP	National Contingency Plan
nm	Nautical mile
NMFS	National Marine Fisheries Service
NMP	National Marine Plan
NMPi	National Marine Plan Interactive
NMS	NEO´s Management System
nmVOC	non-methane Volatile Organic Compounds
NOAA	National Oceanic and Atmospheric Administration
NORM	Naturally Occurring Radioactive Material
NO_2	Nitrous Dioxide
NOEC	No-Observed Effect Concentration
NOx	Nitrogen Oxides
NSTA	North Sea Transition Authority
NSTD	The North Sea Transition Deal
NUI	Normally Unmanned Installation
OBM	Oil Based Mud
OCR	Offshore Chemicals Regulations
OESEA3	Offshore Energy Strategic Environmental Assessment
OEUK	Offshore Energies UK
OGA	Oil and Gas Authority
OGUK	Oil and Gas UK
OIW	Oil in Water
ON6	(Operations Notification 6 (Reporting of Offshore Installation Movements)
OPEP	Oil Pollution Emergency Plan
OPEX	Operating Expenditure
OPPC	Oil Pollution Prevention and Control Regulations
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSCAR	Oil Spill Contingency and Response
OSPAR	Oslo and Paris Conventions
OSRF	Oil Spill Response Forum
PAH	Polycyclic Aromatic Hydrocarbons
PAM	Passive Acoustic Monitoring
PLC	Public Limited Company
PLEM	Pipeline End Manifold
PLONOR	Pose little or no risk
PMF	Priority Marine Feature

PNEC	Predicted No Effect Concentration
PPC	Pollution Prevention and Control
PPD	Pour Point Depressants
PPUKL	Ping Petroleum UK Limited's
PTS	Permanent Threshold Shift
PVA	Potentially Vulnerable Areas
PW	Produced Water
PWA	Pipeline Work Authorisation
PWRI	Produced Water Reinjection
Q1, Q2, Q3, & Q4	Quarter 1,2,3,4
RBA	Risk-Based Approach
ROV	Remotely Operated Vehicle
RQ	Risk Quotient
SAC	Special Areas of Conservation
SACFOR	Superabundant, Abundant, Common, Frequent, Occasional and Rare
SAGE	Scottish Area Gas Evacuation (Pipeline)
SCANS	Small Cetacean Abundance in the North Sea
SCOS	Special Committee on Seals
SCR	Safety Case Regulations
SD	Standard Deviation
SDGs	Sustainable Development Goals
SE	Stewardship Expectations
SE 11	Stewardship Expectation 11
SECE	Safety and Environmental Critical Element
SEEMP	Shipboard Energy Efficiency Management Plan
SEL	Sound exposure level
SF_6	Sulphur Hexafluoride
SFF	Scottish Fishermen's Federation
SGT	Siemens Gas Turbine
SIMOPS	Simultaneous Operations
SMRU	Sea Mammal Research Unit
SNH	Scottish Natural Heritage
SO_2	Sulphur Dioxide
SOPEP	Shipboard Oil Pollution Emergency Plan
SOSI	Seabird Oil Sensitivity Index
SO_x	Sulphur Oxides
SPA	Special Protection Areas
SPL	Sound pressure level
SSIV	Subsea Safety Isolation Valves
TARs	Turnarounds (and shutdown)
TCFD	Task Force on Climate-Related Financial Disclosures
THC	Total Hydrocarbon Content

TR	Temporary Refuge
UK	United Kingdom
UK BAP	UK Biodiversity Action Plan
UK ETS	UK Energy Trading Scheme
UKCS	UK Continental Shelf
UKOOA	The UK Offshore Operators Association
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States (of America)
UTM-N	Universal Transverse Mercator-North
VECS	Vapour Emission Control System
VHF	Very high frequency
VMS	Vessel Monitoring Systems
VOC	Volatile Organic Carbon
(W)	Width
WBM	Water Based Mud
WHRU	Waste Heat Recovery Unit
WMP	Waste Management Plan

1 Introduction

1.1 Background

NEO Energy (ZEX) Limited (hereafter referred to as NEO Energy), on behalf of themselves and their partners, propose to redevelop the Buchan Horst Field (previously known as the Buchan Field). The field is located in UK Continental Shelf (UKCS) Blocks 20/5 and 21/1 in the Central North Sea (CNS), *c*. 115 km northeast of the Aberdeenshire coastline and c. 103.5 km west of the UK/Norway median line (Figure 1-1). Repsol Resources UK Limited previously produced from the Buchan Field with production ceasing in May 2017, due to the certification limitations of the Buchan Alpha floating production vessel.

As per licensing requirements, in 2023 NEO Energy have changed the name of the Buchan Field to the Buchan Horst Field. The proposed Project referred to as the Buchan Redevelopment Project can therefore be considered to be concerned with the redevelopment of the Buchan Horst Field.

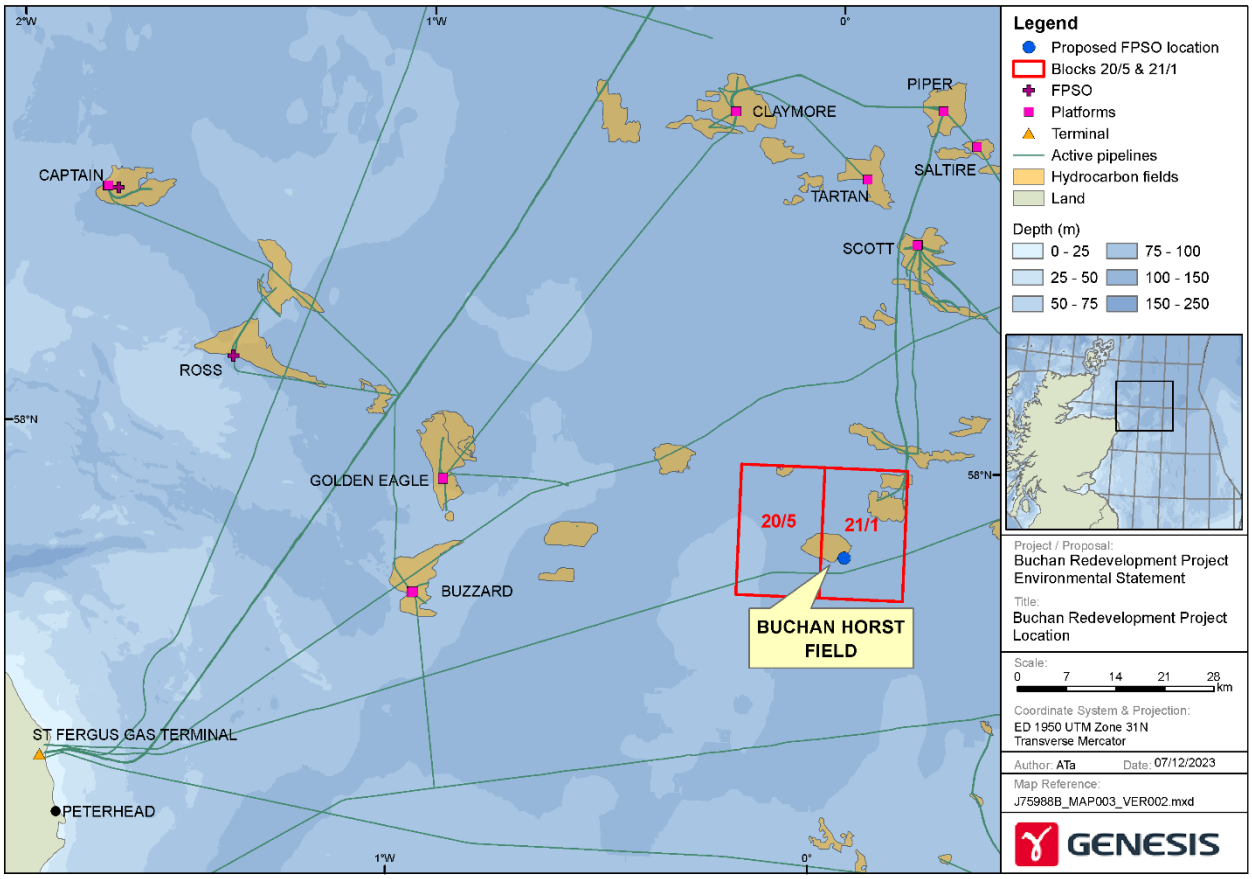


Figure 1-1: Buchan Redevelopment Project location.

NEO Energy propose to redevelop the Buchan Horst Field via five subsea production wells and two water injection wells. The wells will be tied back to a redeployed Sevan Floating Production Storage and Offloading (FPSO) vessel: namely the Western Isles FPSO[1]. Oil from the redeployed Western Isles FPSO will be exported via shuttle tanker. Two different gas export routes are being considered: one via a tie-in to the SAGE (Scottish

[1] The Western Isles FPSO is currently supporting production at the Dana operated Barra and Harris Fields. These fields are expected to cease production in Q1 2024 and a Sale and Purchase Agreement has been completed, under which NEO Energy will acquire Dana's full equity in the Western Isles FPSO.

Area Gas Evacuation) pipeline system and one via a tie-in to the Frigg UK Association (FUKA) pipeline system. Further details are provided in Chapter 3.

1.2 Field Ownership

Jersey Petroleum Ltd (a subsidiary of Jersey Oil and Gas plc) was awarded Blocks 20/05a and 21/01a (Licence P2498) in the 31st Supplementary Offshore Licencing Round. The blocks contain the Buchan Horst Oil Field and the J2 oil discovery. In addition, the Verbier oil discovery and additional prospects are in adjacent Blocks 20/5b and 21/1d (Licence P2170), awarded to Jersey Petroleum Ltd in the 28th Offshore Licensing Round. Collectively, these licences/blocks are referred to as the Greater Buchan Area (GBA). NEO Energy (ZEX) Limited acquired a 50% working interest and became the Licence operator of (i) Licence P2170 on June 21st 2023 and (ii) Licence P2498 on July 31st 2023. In December 2023, Serica Energy entered into an agreement with Jersey Oil & Gas plc to acquire a 30% non-operated interest in the Buchan Horst Field; subject to certain conditions precedent and regulatory approval, the transaction expected to be completed in January 2024. Table 1-1 summarises the ownership of the Buchan Horst Field.

Table 1-1: Percentage ownership of the Buchan Horst Field.

Blocks	Licence	Co-venturers	% equity
20/05a & 21/01a	P2498	NEO Energy (ZEX) (operator)	50 %
		Jersey Petroleum Ltd.	50 %

1.3 The Greater Buchan Area

The Buchan Horst Field is part of the GBA which comprises several discoveries. Others include J2 and Verbier. The Buchan Horst Field (Figure 1-2) contains >100 million barrels of oil equivalent (MMboe). Also, within the remaining GBA prospects, there is *c*. 40 million barrels of oil equivalent (MMboe) of mid-case discovered resources contained within the J2 and Verbier discoveries. Analysis of the J2 and Verbier discoveries has shown that a standalone development of these resources is uneconomic, and that the only economic development solution for both these resources would be through a combined development with Buchan Horst, i.e., via a subsea tie-back to a production hub located at the Buchan Horst Field.

Accordingly, it is expected that in time, the redeveloped Buchan Horst Field will serve as a hub for other discoveries in the area.

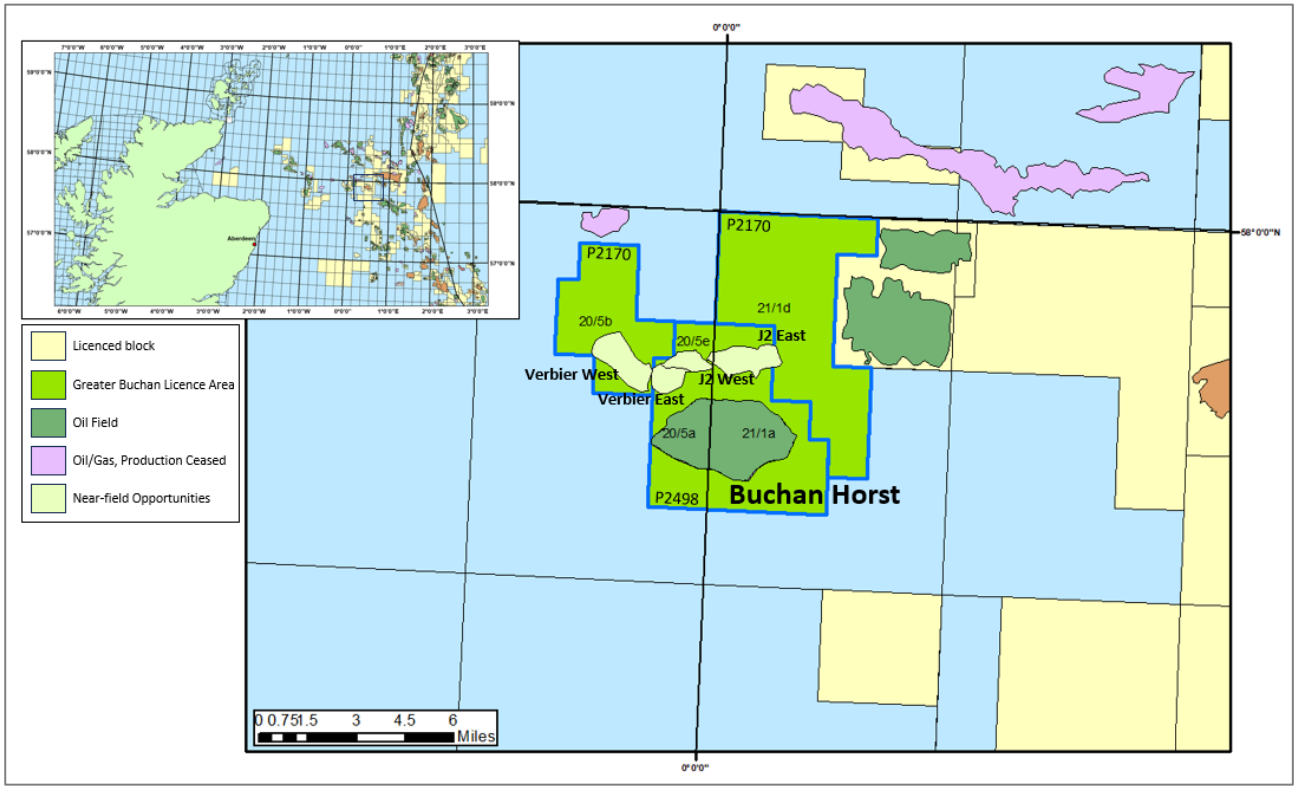


Figure 1-2: Greater Buchan Area discoveries.

1.4 Purpose of Environmental Statement

Under the 2020 Offshore EIA Regulations, the proposed Buchan Redevelopment Project requires an Environmental Impact Assessment (EIA) and ES to be submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) for approval. This requirement is due to the anticipated increased volumes of hydrocarbons to be produced such that consent is being sought for the '*Extraction of oil and natural gas for commercial purposes where the amount extracted exceeds 500 tonnes per day in the case of oil and 500,000 cubic metres per day in the case of natural gas'*.

The purpose of this ES is to report on the EIA process undertaken to meet both statutory and NEO Energy internal project requirements. The ES provides a public consultation document which supports consultees in the decision-making process and is therefore required to be a comprehensive report. The ES provides an opportunity to reassure the Regulator and consultees that NEO Energy is informed and understands:

- the likely consequences of the activities, emissions, discharges, and physical presence of the project;
- the local environment; and
- the nature of the environmental and commercial issues arising for other users of the sea.

The ES has been prepared in accordance with the 2020 Offshore EIA Regulations and guidance from OPRED.

1.5 Scope of the Environmental Statement

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

- The drilling and completion of up to five production wells and two water injection wells at the Buchan Horst Field;
- Installation of the repurposed Western Isles FPSO;
- Installation of subsea infrastructure to support tie-back of the wells to the repurposed Western Isles FPSO;
- Installation of a gas export pipeline tied back to either the SAGE pipeline system or to the FUKA pipeline system.

- Production over the repurposed Western Isles FPSO, export of gas via the gas export pipeline and export of oil via shuttle tanker.

In line with the 2020 Offshore EIA Regulations, the EIA sets out to describe and evaluate the impacts of any emissions to air, discharges to sea, seabed disturbance, underwater noise, waste production and resource use resulting from the proposed development on a range of receptors including flora, fauna, water, air, climate, and material assets. In addition, the potential interactions with other users of the sea are considered. These aspects are considered for planned activities and unplanned (i.e. accidental) events.

1.6 Document Layout

To determine the environmental and socio-economic impacts of the proposed Buchan Redevelopment Project, an understanding of the regulatory context, stakeholder concerns, the proposed activities and the environmental and socio-economic baseline is required. Table 1-2 details the structure of the ES .

Table 1-2: Structure of the Environmental Statement.

Section No.	Title	Contents
0	Non-Technical Summary	A summary of the ES.
1	Introduction	Introduction to the project and scope of the ES. This section also includes a summary of applicable legislation, NEO Energy's Environment Management System, areas of uncertainty and the consultation process to date.
2	Pathway to Net Zero	NEO Energy's approach to reducing greenhouse gas emissions across their portfolio.
3	Project Description	A description of the drilling and subsea installation operations, an overview of the topside modifications and the anticipated production profiles.
4	Baseline Environment	A description of the environmental and socio-economic receptors in the area.
5	Environmental Impact Assessment Methodology	Description of the methodology used to determine the significance of the environmental and social risk of the proposed activities.
6 to 11	Assessment of Aspects	Detailed assessment of Physical Presence (Section 6); Emissions to Air (Section 7); Discharges to Sea (Section 8); Seabed Disturbance (Section 9); Underwater Noise (Section 9); and Waste (Section 11) aspects of the development.
12	Accidental Events	Details of accidental events identified during the ENVironmental and socio-economic impact IDentification (ENVID).
13	Conclusions	Key findings including a register of commitments.
14	References	Lists sources of information drawn upon throughout the ES.
Appendix A	Scottish National Marine Plan	Assessment of the project against Scotland's National Marine Plan.
Appendix B	Aspects Register	Results from the ENVID workshop
Appendix C	Drill Cuttings Modelling	The Drill Cuttings Modelling Report
Appendix D	Underwater Noise Modelling	The Underwater Nose Modelling Report
Appendix E	Oil Spill Modelling	The Oil Spill Modelling Report

1.7 Legislative Overview

This section provides a summary of the current environmental legislation applicable to the project.

Note Energy Transition and Net Zero are discussed in detail Chapter 2 and therefore not described in this subsection.

1.7.1 Environmental Impact Assessment

Offshore environmental control has developed significantly over the past thirty years and is continuing to evolve in response to increasing awareness of potential environmental impacts. Strands of both primary and secondary legislation, voluntary agreement, and conditions in consents granted under the petroleum licensing regime and international conventions have all contributed to the current legislative framework.

The main controls for new oil and gas projects are EIAs, which became a legal requirement of offshore developments in 1998. Current requirements are set out in the 2020 Offshore EIA Regulations and accompanying Guidance Notes for Industry (DESNZ, 2021a).

Schedule 1 of the 2020 Offshore EIA Regulations identifies those projects that require an ES to be prepared. As described previously, the Buchan Redevelopment Project requires an ES due to the anticipated production profiles.

1.7.2 Protected Sites and Species

The EIA needs to consider the impact on the surrounding environment including any protected areas. Many protected areas have been designated in the UK under the European Union (EU) Nature Directives, in particular the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC). Since January 2021 these are now maintained and designated under the Habitats Regulations for England and Wales, Scotland, and Northern Ireland. Amendments to the Habitats Regulations mean that the requirements of the EU Nature Directives continue to apply to how European sites (Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)) are designated and protected. The Habitats Regulations also provide a legal framework for species requiring strict protection, e.g. European Protected Species (EPS). All offshore projects or developments must demonstrate that they are not “likely to have a significant impact on the integrity of the conservation objectives for the protected site” or “significantly disturb European Protected Species (EPS)” either alone or in combination with other plans and projects.

1.7.3 Discharges to Sea

Oil Discharges

In accordance with the Oslo/Paris Convention (OSPAR) Recommendation (2001/1), the UK through OPRED has introduced regulatory requirements which reduce the permitted average monthly oil concentration in produced water discharged overboard from oil and gas installations to a maximum of 30 mg/l. OSPAR Recommendation 2001/1 also required contracting parties to reduce the total discharge of oil in Produced Water (PW) by 15% by 2006 measured against a 2000 baseline. The permits replaced the granting of exemptions under the Prevention of Oil Pollution Act 1971 and are issued under the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended). Under normal operating conditions, all produced water will be injected into the Buchan Horst reservoir. Treated seawater is used as voidage replacement and is comingled with the produced water prior to injection.

Chemical Discharges

In June 2000, the OSPAR Convention for the Protection of the Marine Environment in the North East Atlantic made a decision requiring a mandatory system for the control of chemicals (OSPAR Decision 2000/2 on a Harmonised Mandatory Control System for the Use and Reduction of the Discharge of Offshore Chemicals). This decision operates in conjunction with two OSPAR Recommendations:

- OSPAR Recommendation 2000/4: The application of a Harmonised Pre-Screening Scheme for Offshore Chemicals to allow authorities to identify chemicals being used offshore; and
- OSPAR Recommendation 2000/5: The application of a Harmonised Offshore Chemical Notification Format for providing data and information about chemicals to be used and discharged offshore.

OPRED implemented OSPAR Decision 2000/2 on the control of chemical use offshore, through the Offshore Chemicals Regulations (OCR) 2002 (as amended). The regulations require offshore Operators to apply for permits for the use and / or discharge of chemicals during all relevant offshore energy activities, including well operations, production operations, pipeline operations, and decommissioning operations. The 2011 Amendment Regulations extended the provisions to take enforcement action in the event of any unintentional offshore chemical release.

Risk Based Approach

OSPAR Recommendation 2012/5 for a Risk-Based Approach (RBA) to the Management of Produced Water Discharges from Offshore Installations aims to produce a method for prioritising mitigation actions for those discharges and substances that pose the greatest risk to the environment. As the base case is for produced water to be reinjected, this is not applicable to the proposed project.

1.7.4 Atmospheric Emissions

Combustion installations on oil and gas platforms with a rated thermal input, including flaring of 20 MW(th) or more require permitting under the UK's Emissions Trading Scheme (UK ETS). The UK ETS replaced the UK's participation in the European Union ETS system on 1 January 2021. The EU ETS is based on Directive 2003/87EC establishing a scheme for Greenhouse Gas (GHG) emission allowance trading within the Community (the EU ETS Directive) and the UK ETS broadly aligns with the Directive. The UK ETS is implemented by the GHG Emissions Trading Scheme Order 2020 (as amended). The relevant provisions of the Order include the requirement to monitor and report carbon dioxide (CO_2) emissions, surrender allowances and to notify of any changes affecting the allocation of allowances.

Combustion installations on oil and gas platforms with a rated thermal input of 50 MW(th) or more require permitting under the Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended). This includes conditions limiting releases notably for carbon monoxide (CO), oxides of nitrogen (NO_x), oxides of sulphur (SO_x), methane (CH_4) and volatile organic compounds (VOCs) and the demonstration of the use of Best Available Technique (BAT). Combustion installations with a rated thermal input of 1 MW(th) to 50 MW(th) also require permitting under Pollution Prevention and Control (PPC) regulations to comply with the Emission Limit Values (ELV's) as stipulated in the Medium Combustion Plant directive EU 2015/2193 of 25th November 2015 for sulphur dioxide (SO_2), NO_x and dust.

The revised North Sea Transition Authority (NSTA) Strategy (February 2021) retains a binding obligation to secure that the maximum value of economically recoverable petroleum is recovered from the strata beneath relevant UK waters. The Strategy also states that in doing so, appropriate steps must be taken to reducing GHG emissions and assist in meeting the UK net zero target. The Strategy is supported by Stewardship Expectations (SE). The NSTA 'Stewardship Expectation 11 – Net Zero' (March 2021) (SE 11) sets out the NSTAs expectations of the steps that should be taken across the exploration and production lifecycle, to reduce emissions and promote Carbon Capture and Storage (CCS) and hydrogen.

1.7.5 Marine and Coastal Access Act

The Marine and Coastal Access Act (MCAA) came into force in November 2009. The Act covers all UK waters except Scottish internal and territorial waters which are covered by the Marine (Scotland) Act (2010), which mirrors the MCAA powers. The MCAA provides the legal mechanism to help ensure clean, healthy, safe, productive, and biologically diverse oceans and sea by putting in place a new system for improved management and protection of the marine and coastal environment. It replaces and merges the requirements of the Food and Environmental Protection Act 1985 (FEPA) Part II (environment) and the Coastal Protection Act 1949 (navigation). The MCAA has enabled:

- Establishment of the Marine Management Organisation (MMO) to operate as the competent marine planning authority in English territorial waters and UK offshore waters (for matters that are not devolved) such as marine licensing and enforcement of marine legislation;
- A strategic marine planning system to agree marine objectives and priorities and establish a series of marine plans to implement marine policy;
- A new marine licensing system for marine activities; and
- Powers enabling the designation of Marine Conservation Zones (MCZ) in the territorial waters adjacent to England and Wales and UK offshore waters.

However, the following are exempt from the MCAA as they are regulated under different legislation:

- Activities associated with exploration or production / storage operations that are authorised under the Petroleum Act 1998; and
- Additional activities authorised solely under the OPRED environmental regime, e.g. chemical and oil discharges.

Some oil and gas activities, which are not regulated by the Petroleum Act 1998 or under the OPRED environmental regime, require an MCAA licence.

1.7.6 National Marine Plan

The Scottish National Marine Plan (NMP) comprises plans for Scotland's inshore (out to 12 nm) and offshore waters (12 to 200 miles) as set out under the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009. The NMP represents a framework of Scottish Government policies for the sustainable development of marine resources. The NMP is underpinned by the following strategic objectives:

- Achieving a sustainable marine economy;
- Ensuring a strong, healthy, and just society;
- Living within environmental limits;
- Promoting good governance; and
- Using sound science responsibly.

These objectives are to be achieved through the application of 21 'General Planning Principles'. Development projects should take these principles into account in order to support the overall NMP objectives for sustainable development of Scotland's marine environment.

The NMP sets out specific key issues for the oil and gas sector in supporting the objectives of the plan:

- Maximise extraction;
- Re-use infrastructure;
- Transfer of skills to renewables and CCS;
- Co-operation with the fishing industry;
- Noise impacts to sensitive species;
- Chemical and oil contamination of water, sediments, and fauna;
- Habitat changes.

The NMP also sets out general policies and objectives as part of the UK's shared framework for sustainable development. The proposed operations as described in this ES have been assessed against all NMP objectives (Appendix A) and policies. The objectives and policies are described in Appendix A.

1.8 NEO Environmental Management System

NEO Energy are committed to conducting activities in compliance with all applicable legislation and in a manner that minimises impacts on the environment. The proposed Buchan Redevelopment Project will be delivered in compliance with NEO Energy's Environmental Management System (EMS) which has been developed in line with the principles of the International Standard for Environmental Management Systems (ISO14001:2015).

Health, Safety, Security and Environment Policy Statement

Our Vision

Our vision is to be a next generation UKCS energy platform by breathing new life into the North Sea. We will conduct our business activities with a full commitment to the health, safety and security of our people and to the protection of the environment.

Our Commitments

To meet our commitments, NEO (New European Offshore) Energy shall ensure that:

- Effective leadership is in place and all employees and contractors promote a positive HSSE (Health, Safety, Security and Environment) culture.
- Robust systems and processes are implemented to ensure that all applicable health, safety, security and environmental legislation, standards and other requirements are met.
- All personnel hold responsibility for their own health, safety and security, observe company values and are trained and competent for their roles.
- All personnel are aware of their responsibility to choose safety over operational results.
- All personnel are aware of the expectation that they will use their "Stop Work Authority" if they see or suspect an unsafe condition or behaviour.
- Safe, secure, and healthy workplaces are provided to protect workers from injury and ill health with robust barriers in place aimed at preventing work-related incidents.
- All operated assets adopt the IOGP life-saving rules to build an incident and injury free culture.
- We minimise our environmental impact and prevent pollution.
- All risks are identified, assessed, and managed to levels that are as low as reasonably practicable.
- Integrity of our assets is maintained over their lifecycle from design and construction to decommissioning.
- All changes are identified and managed to ensure they are implemented correctly as per our company procedures.
- Effective engagement is maintained with all stakeholders.
- HSSE performance is prominent in the selection of our contractors and suppliers.
- Incidents and near misses are reported in a timely manner and are fully investigated.
- Appropriate plans for emergency situations and incidents are in place and regularly tested.
- HSSE management and performance is regularly assessed, reviewed, and audited to achieve continuous improvements.
- By integrating human and organisational factors into all our business activities, our personnel are equipped with the underlying Human Factors principles that enable them to ensure the interaction between people, the environment, equipment, and procedures are considered in all aspects of our activities.

22 May 2023

Paul Harris
Chief Executive Officer

Figure 1-3: NEO Energy's HSSE Policy.

1.9 Areas of Uncertainty

This ES was prepared during the Concept Select and Front End Engineering phases of the Project. As a result, some assumptions have been made in order to undertake the EIA. Where assumptions have been made, the environmental worst-case option was assessed. Assumptions and uncertainties are outlined below.

1.9.1 Drilling Rig

The type of drilling rig to be used is not known at this time, either a semi-submersible or a heavy-duty jack-up (HDJU) will be decided upon at a later phase. The ES will carry both options and present whichever option is deemed to be the worst case environmentally. For example, anchoring of a semisubmersible will have a larger footprint of impact on the seabed relative to the HDJU footprint, however the HDJU would likely result in deeper impressions on the seabed.

1.9.2 Well Locations

Indicative well locations are provided in the ES. It is possible that at the time of drilling the final well location may differ slightly, however they would still be expected to be within a few hundred meters of the locations provided and all will be located within a single 500 m safety zone. Locations provided in the ES allow for inclusion of maximum length of lines (including the flowlines, spools, umbilical and umbilical jumpers) and the maximum anticipated quantities of stabilisation materials. The ES allows for two drill centre manifolds, though the project will continue to consider the option of using a single manifold. Note the requirement for two manifolds is driven by the potential weight of a single structure.

1.9.3 Rock Cover, Mattresses, and Grout Bags

Maximum anticipated quantities of rock cover, mattresses and grout bags are presented in the ES to assess the worst-case scenario in terms of impacts on the seabed. The requirements for stabilisation/protection material will be further assessed and confirmed in later Pipeline Work Authorisation (PWA) and associated environmental permit applications.

1.9.4 Western Isles FPSO Anchoring System

At the time of writing it had yet to be determined if piled or suction can anchors will be used for the Western Isles FPSO mooring system. Both options are therefore considered in the ES.

1.9.5 Gas Export

Gas will be exported via a tie-in to either the SAGE pipeline system or the FUKA pipeline system. As the gas pipeline route is yet to be decided the ES will discuss both options, with area of impact focusing on the longest pipeline route i.e. tie-in to the SAGE pipeline system.

1.9.6 Production Profiles

Production profiles based on models have a certain degree of uncertainty associated with them. The production profiles presented in this ES are based on the mid case and high case scenarios and are an annualised average of the projected production from the Buchan Horst Field.

1.9.7 Electrification

In line with NEO Energy's commitment to Net Zero, it is proposed to make the Western Isles FPSO "electrification-ready" in anticipation of the availability of power from a 3rd party source. The exact source of electrical power has yet to be finalised though the preferred source is one of the nearby Innovation and Targeted Oil & Gas (INTOG) developments. The exact timing of electrification is also not finalised though if available NEO Energy plan for the FPSO to be electrified in time to receive power from a 3rd party supply from early 2030.

1.10 Consultation Process

Consulting with stakeholders is an important part of the impact assessment process as it allows any concerns which stakeholders may have, to be communicated and addressed. In June 2023, as part of the informal stakeholder engagement process, Jersey Petroleum Ltd issued a scoping report to stakeholders. The Scoping

Report provided an overview of the proposed Project and the impacts to be assessed in the ES. Stakeholders were invited to comment on the Scoping Report with respect to any concerns they may have.

In addition to issuing the Scoping Report NEO Energy held a Stakeholder Engagement Meeting in August 2023, again with the aim of allowing stakeholders to raise any concerns they may have regarding the proposed Project and the proposed approach to the ES.

Comments received on the Scoping Report and comments/issues/concerns raised during the workshop are summarised in Table 1-3 and Table 1-4 respectively.

As required by the 2020 Offshore EIA Regulations, a copy of the ES and the public notice has been made publicly available on the Company's website at the time of submission. In addition, NEO Energy will continue the process of consultation throughout the Project.

Table 1-3: Comments received on the Scoping Report.

Comments on the Scoping Report	Response
Scoping Report was issued to the following in June 2023: • Scottish Fishermen's Federation (SFF) – written response received. • Following organisations responded to say they had no comment on the Scoping Report: Maritime and Coastguard Agency, Crown Estate Scotland; Royal Society for the Protection of Birds; Marine Scotland; The United Kingdom Hydrographic Office; and The Ministry of Defence (MoD). • Joint Natural Conservation Committee (JNCC) – no written response but did attend stakeholder engagement session. • OPRED Environmental Management Team (EMT) - no written response received but did attend stakeholder engagement session. • No response received from the Northern Lighthouse Board, NatureScot or the North & East Coast Regional Inshore Fisheries Group.	
i. SFF advised that trenched and mechanical backfill is their preferred method of pipeline installation and advise that given past experiences they would expect some form of remedial work (possibly chain matting) to be necessary in the area.	i. Project propose to trench and bury the lines and to ensure a safe seabed following installation (see Chapter 6).
ii. SFF noted the proposed project is in a predominantly prawn fishing grounds and have concerns that if the flowlines were to be rock dumped it could cover and destroy prawn burrows, possibly harming the stock. SFF requested that quantities of stabilisation materials (rock, and mattresses) are therefore minimised.	ii. The ES captures contingency rock cover; however the base case is to trench and mechanically backfill the lines. Rock cover will only be used to meet targeted depth of burial to mitigate upheaval buckling / snagging hazards (see Section 3.6).
iii. SFF requested that any mattresses laid out with the 500 m safety zones are rock covered to prevent snagging of fishing gear.	iii. The Project does not plan to lay any mattresses out with the 500 m safety zones.
iv. SFF recommend that any type of construction/development work is carried out, out with the spawning and nursery periods for those fish species that occur in the area to prevent any potential damage to the juvenile fish.	iv. NEO Energy note the request to avoid offshore activities during the spawning and nursery periods for fish in the area. This will be taken account of during planning; however the Project recognises that it will likely be difficult to avoid activities during these periods, give the duration of the drilling and installation campaigns.
v. SFF advised caution when using the annual fishing effort, annual fish landings and the species targeted data provided by the Scottish Government and Vessel Monitoring Systems (VMS) (Kafas *et al*., 2012). They note that as fishing has been excluded at the Buchan Field since the early 1980s, due to the anchor spread and other oil and gas infrastructure, the SFF feels that the VMS data will be misleading. They note that ideally, the fisheries base data for an oil & gas field area, should be obtained prior to any oil & gas field being developed.	v. SFF's concerns regarding the VMS data is noted and considered in the ES when describing commercial fishing activity in the area (see Section 4.5.1).
vi. In addition, SFF believes that VMS data is not fully comprehensive and does not include accurate track of fishing vessels movements. Therefore, we would also propose that the mentioned data is cross checked with the fishing industry for accuracy.	vi. As for response to v.

Table 1-4: Comments from Stakeholder Engagement Workshop.

Stakeholder Engagement Workshop (24th August 2023)	Response
Attendees included: JNCC OPRED EMT SFF	
JNCC commented that they'd like to see the geophysical and geotechnical survey data collected in Q4 2023 interpreted to determine the habitat type in the Western Isles FPSO anchor locations and presented in the ES.	Environmental survey data is presented in Chapter 4 and used to support the impact assessment of Seabed Disturbance presented in Section 9, including those areas possibly impacted by the anchor lines. The specific survey referenced by JNCC had not been completed at time of writing.
OPRED requested that the alternative concepts considered by the project are clearly presented in the ES, including presenting a comparison of atmospheric emissions from oil export via a pipeline vs export via shuttle tankers and presenting carbon intensity of gas import vs electrification.	Assessment of alternatives is presented in Section 3.2 which includes consideration of emissions associated with the different options. Chapter 7 also presents the difference in GHG intensities between electrification and no electrification.
OPRED requested that NEO Energy's strategy for achieving Net Zero is considered throughout the ES.	NEO Energy's Company and Project strategy to achieving Net Zero is presented in Chapter 2 and where relevant is tied in across the ES (in particular Chapter 7).

2 Pathway to Net Zero

As public concern increases in relation to the impact of climate change, so has the acknowledgement that timely action is required to address the global rise in temperature. The Paris Agreement (adopted in 2015; in force 2016) under the United Nations Framework Convention on Climate Change (UNFCCC) relating to GHG emissions mitigation, adaptation and finance provides for all signatories to keep the increase in global average temperature to well below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5°C (UNFCCC, 2016).

In 2019, following the ratification of the Paris Agreement by the UK, the government introduced a legally binding commitment (through the Climate Change Act 2008 (2050 Target Amendment) Order 2019) setting the UK on a firm pathway to Net Zero GHG emissions; in other words, targeting at least 100% GHG emissions reduction by 2050 compared to 1990 levels (UK Government, 2019). In Scotland, the target year was set as 2045 via the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019. The Net Zero targets are supported by a system of legally binding five-year Carbon Budgets and an independent body, the Climate Change Committee (CCC), to monitor progress. The UK Carbon Budgets restrict the amount of GHG emissions the UK can legally emit in a defined five-year period. In 2020, the 6th Carbon Budget was published by the CCC for consideration by the Government and was legislated in June 2021 to be the first set under the UK's new Net Zero target.

The Energy White Paper Powering our Net Zero Future (HM Government, 2020a) and the UK 10 Point Plan for a Green Industrial Revolution (HM Government, 2020b) embeds the UK Net Zero emissions strategy by describing how the transition to clean energy can be achieved by 2050. To support the Energy White Paper and the Industrial Decarbonisation Strategy requirement, the North Sea Transition Authority (NSTA) revised the oil and gas sector specific Maximising Economic Recovery Strategy to include the following central obligation with underpinning requirements:

"Relevant persons must, in the exercise of their relevant activities, take the steps necessary to:

- *Secure that the maximum value of economically recoverable petroleum is recovered from the strata beneath relevant UK waters; 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 greenhouse gas emissions from sources such as flaring and venting and power generation, and supporting carbon capture and storage projects."*

The NSTA Revised Strategy, which came into force on 11th February 2021, reflects the ongoing energy transition and features a range of net zero obligations for the oil and gas industry, including increasing efforts to reduce production emissions, support CCS projects and unlock clean hydrogen production (NSTA, 2021b). The revised guidance on the development of fields demonstrates where the Net Zero requirements are embedded in the NSTA assessment and approvals process (NSTA, 2021c). In addition, the NSTA expects the following requirements in relation to emissions from flare and vent sources (NSTA Flaring and Venting Guidance, 2021):

- "Flaring and venting and associated emissions should be at the lowest possible levels in the circumstances.
- Zero routine flaring and venting for all by 2030; and
- All new developments should be planned and developed based on zero routine flaring and venting."

The North Sea Transition Deal (NSTD) (BEIS, 2021) introduced a sector deal between the UK government and the offshore oil and gas industry. The NSTD includes early reductions in offshore production emissions of 10% by 2025; 25% by 2027; and 50% by 2030, against a 2018 baseline (NSTA, 2023), It recognises the key role the UKCS offshore oil and gas sector plays in meeting the UK government's Net Zero commitments and supports the sector's transition to clean, green energy and a secure future for high-skilled oil and gas workers and the supply chain.

This Chapter summarises how NEO Energy as a UK operating Company supports the UK Government Net Zero target and how the proposed Buchan Redevelopment Project aligns with the NSTD policies and commitments and NEO Energy Net Zero ambitions.

2.1 NEO Energy's Corporate Strategy

NEO Energy is an independent North Sea operator in the UKCS backed by HitecVision, a leading provider of institutional capital to the North Sea region's energy industry. NEO Energy is focused on combining value creation from the prospective North Sea basin with integrated Environmental, Social and Governance (ESG) standards. It operates a multiple asset base with a significant scope to grow production organically, by extending the life of its assets and through acquisitions.

2.2 Climate Change Governance

2.2.1 Low Carbon Transition Plan

The Company published their Low Carbon Transition Plan (LCTP) in 2021 (NEO Energy, 2021a), setting out an ambitious strategy to reduce its carbon emissions. As part of the LCTP, the Company is determined to reduce GHG emissions across its portfolio and have set a 50% carbon intensity reduction target for direct emissions by 2030 from a 2020 base year and be net zero by 2050. Emission intensity is a key performance indicator for the Company (NEO Energy Group Limited, 2023). In addition to achieving the targets the Company set itself in the LCTP, it is also committed to playing its part in meeting the industry targets as agreed in the NSTD.

To ensure their sustainability efforts are focused, NEO Energy has developed an ESG strategy and a Five-year ESG plan which outline the pathway taken by the Company to produce energy in a safe, responsible way (Section 2.2.2).

2.2.2 ESG Strategy and Climate-Change Risk

NEO Energy recognises that responsible behaviour that creates value while protecting the environment and contributing to society is central to their licence to operate. NEO Energy's ESG strategy seeks to ensure the business aligns with the international reporting frameworks of the UN Sustainable Development Goals (UN SDGs) and Global Reporting Index (GRI), and the Task Force on Climate-Related Financial Disclosures (TCFD) (NEO Energy, 2023a). The Company has developed a Five-Year Plan to deliver its ESG Strategy and the targets set out in its LCTP and the NSTD. This plan facilitates participation from all areas of the business which includes the mapping of a robust and transparent route to delivering emissions reduction (NEO Energy Group Limited, 2023). The Five-Year Plan is a continuous process and is reviewed and updated when required to ensure it remains fit for purpose.

NEO Energy is aligned with the UK's Net Zero by 2050 target and is proactively working with partners, regulators, and industry bodies to play its part in achieving this goal.

Furthermore, to ensure their sustainability efforts are focused with their overall business strategy, NEO Energy have established a Sustainability Policy (see Figure 2-1). This policy sets out the framework for setting sustainability objectives, and complements the Company's Health, Safety, Environment & Social Responsibility Policy (see Section 2.2.3).

Acknowledging that climate change is one of the world's greatest challenges and that it demands thoughtful and urgent action, it has been established as one of the key ESG objectives outlined in NEO Energy's strategy (see Figure 2-2).

Environmental, Social and Governance (ESG) Policy Statement

Our Vision

Our vision is to be a next generation UKCS energy platform by breathing new life into the North Sea. We recognise that our licence to operate is earned through responsible behaviour that creates value while protecting the environment and contributing to society.

This policy reflects a commitment to increased beneficial, sustainable, and measurable socio-economic impacts from NEO (New European Offshore) Energy's business activities.

Our Commitments

To meet our commitments, NEO Energy shall ensure that:

- We support the UN Sustainable Development Goals and the Paris Agreement with specific carbon intensity reduction targets, net zero targets and a climate action plan.
- We publish an annual Sustainability Report for internal stakeholders and adhere to required and recommended ESG (Environmental, Social and Governance) reporting frameworks, regulations, and disclosures.
- We identify, manage, and mitigate the transitional and physical climate-related risks associated with our activities.
- We provide clear reporting on our performance relating to the environment, health and safety, our employees, and ethics.
- We continually improve efforts towards more sustainable actions and behaviours promoting awareness of consumption, recycling, reuse and circular design throughout our operations and supply chain.
- We act responsibly and respectfully towards our employees and society and safeguard the health, safety and well-being of our employees and the communities and environments where we do business.
- We promote an inclusive culture and ensure the values of diversity, equity and inclusion are reflected in the way NEO Energy operates.
- We safeguard human and labour rights and freedoms.
- We evaluate our suppliers and stakeholders to mitigate sustainability-related risks in our value chain and to identify opportunities for improvement
- We, and those conducting business on behalf of NEO Energy, operate in accordance with the principles set out in this policy and our Code of Conduct acting honestly and respecting the law and human rights.

This Policy is underpinned by more detailed Policies and Standards on Health, Safety, Security & Environment, Code of Conduct, Anti-Bribery & Corruption, Data Privacy and the Modern Slavery Act.

22 May 2023

Paul Harris
Chief Executive Officer

Figure 2-1: Environmental, Social and Governance Policy Statement.

UN SDG	Global Importance	NEO Energy Objective
UNSDG 13 Climate Action	Prioritising the climate.	Protection of the environment is part of our license to operate which is reflected in our LCTP. As part of this, we are determined to reduce GHG emissions across our portfolio and have set a 50% carbon intensity reduction target for scope 1 emissions by 2030 from a 2020 baseline and be net zero by 2050.
UNSDG 14 Life Below Water	Protecting biodiversity around our operations.	NEO seeks to minimise the impact on flora and fauna and conserve the biodiversity in ecosystems where we operate, carrying out environmental impact assessments and monitoring campaigns.
UNSDG 5 Gender Equality	Working against discrimination to create an inclusive culture, with equal pay and opportunities for all.	A strategic priority is to build a high performing organisation with world-class operating capabilities. An integral part of this is to ensure non-discrimination, equality and development. This will help unlock new ideas, greater productivity and employee wellbeing.
UNSDG 8 Decent work and Economic Growth	A focus on providing a safe place to work and creating local value.	We support local value throughout our supply chain and community investment.
UNSDG 3 Good Health and Well Being	Sustainable development cannot be achieved unless everyone's primary health needs are met.	NEO's employees are at the heart of its business so the health and safety of employees and contractors is the number one priority. We work to ensure that all our operations and activities are performed safely.
UNSDG 16 Peace, Justice and Strong Institutions	Responsible business practices contribute to social and economic stability.	NEO strives to ensure adherence to its Code of Conduct throughout the business, maintaining the highest standards in ethics, integrity, and transparency at all levels.

Figure 2-2: NEO Energy ESG Strategy and Goals (NEO Energy, 2023a).

2.2.3 Environmental Stewardship and NEO Energy's Management System

The Company's management system was optimised in 2022, ensuring policies, procedures and way of working remain fit for purpose as the business grows and evolves. NEO Energy operates under an integrated Health, Safety, Environmental and Quality Management System (the NMS), which is designed to meet the requirements of international standards, including ISO 14001 (NEO Energy EMS Public Statement, 2021). The NMS provides assurance that all NEO Energy activities are managed in a safe and environmentally responsible way and conducted in accordance with the Company's Health, Safety and Environment and Social Responsibility Policy Statement (see Figure 2-3).

To demonstrate that environmental management is undertaken in accordance with the requirements of a recognised environmental management system standard, the NMS is periodically independently verified in accordance with OSPAR Recommendation 2003/5 (NEO Energy EMS Public Statement, 2021).

Health, Safety, Security and Environment Policy Statement

Our Vision

Our vision is to be a next generation UKCS energy platform by breathing new life into the North Sea. We will conduct our business activities with a full commitment to the health, safety and security of our people and to the protection of the environment.

Our Commitments

To meet our commitments, NEO (New European Offshore) Energy shall ensure that:

- Effective leadership is in place and all employees and contractors promote a positive HSSE (Health, Safety, Security and Environment) culture.
- Robust systems and processes are implemented to ensure that all applicable health, safety, security and environmental legislation, standards and other requirements are met.
- All personnel hold responsibility for their own health, safety and security, observe company values and are trained and competent for their roles.
- All personnel are aware of their responsibility to choose safety over operational results.
- All personnel are aware of the expectation that they will use their "Stop Work Authority" if they see or suspect an unsafe condition or behaviour.
- Safe, secure, and healthy workplaces are provided to protect workers from injury and ill health with robust barriers in place aimed at preventing work-related incidents.
- All operated assets adopt the IOGP life-saving rules to build an incident and injury free culture.
- We minimise our environmental impact and prevent pollution.
- All risks are identified, assessed, and managed to levels that are as low as reasonably practicable.
- Integrity of our assets is maintained over their lifecycle from design and construction to decommissioning.
- All changes are identified and managed to ensure they are implemented correctly as per our company procedures.
- Effective engagement is maintained with all stakeholders.
- HSSE performance is prominent in the selection of our contractors and suppliers.
- Incidents and near misses are reported in a timely manner and are fully investigated.
- Appropriate plans for emergency situations and incidents are in place and regularly tested.
- HSSE management and performance is regularly assessed, reviewed, and audited to achieve continuous improvements.
- By integrating human and organisational factors into all our business activities, our personnel are equipped with the underlying Human Factors principles that enable them to ensure the interaction between people, the environment, equipment, and procedures are considered in all aspects of our activities.

22 May 2023

Paul Harris
Chief Executive Officer

Figure 2-3: Health, Safety, Environment and Social Responsibility Policy Statement.

2.2.4 Transparent Disclosure

In 2021, NEO Energy introduced reporting in line with the TCFD. The purpose of this action was to increase and improve reporting of climate-related financial issues, whilst providing stakeholders with a view on how NEO Energy identifies and plans for climate-related risks and opportunities. Having the ability to do so will allow stakeholders to assess the Company's performance and track our progress.

2.3 Decarbonisation of NEO Energy's Operations

2.3.1 Low Carbon Energy Production

2.3.1.1 Improving Operational Efficiencies

In 2022, based on a full year of emissions NEO-Energy's net equity emissions decreased thanks to improved operational efficiency and several carbon abatement actions. A focus area of the Five-Year Plan defines a clear pathway to delivering the target of reducing direct emissions through initiatives such as: improving operational efficiencies; minimising flaring and venting; tackling methane emissions; and smart decommissioning.

Carbon Intensity

As an ongoing process, NEO Energy continually reviews carbon intensity, one of the Company's key strategic Key Performance Indicators (KPIs). It is monitored by the UK regulators and the banks that help finance NEO Energy's growth plans. In 2022, the carbon intensity of the Company's portfolio decreased to 21 $kgCO_2e$/boe from 25 $kgCO_2e$/boe in 2021 (NEO Energy Group Limited, 2023). This is a result of continued improvements in emission reduction, such as investing in zero flaring systems and upgrading turbines, production optimisation and an acquisition strategy which considers the impact on the portfolio's carbon intensity.

Abatement Action Plans

Central to the 'license to operate' obligations set out in the NSTA Revised Strategy is the requirement for UK operators to undertake their upstream operations in line with the NSTA Stewardship Expectations (SE) including Stewardship Expectation 11 – Net Zero (SE11) (NSTA, 2021a). SE11 imposes that for each UK offshore operated asset or hub a GHG Emissions Reduction Action Plan (ERAP) is developed, implemented, and maintained. NEO Energy's operated assets, GPIII and Babbage, have established ERAPs to target emission reductions and improve operational efficiency through a variety of projects, including power generation, flaring, and venting.

In the Company's non-operated asset portfolio, NEO Energy work with the operating partner to identify and champion opportunities to improve the operational efficiency and emission reduction actions at these assets. In 2022, the Company undertook an extensive exercise to collate all ERAPs from across the Operated by Others portfolio and map a pathway to Net Zero. Expertise from across the business was leveraged to ensure a high level of capability and knowledge across the reporting method and allocation of carbon emissions, including technical expertise of operations (NEO Energy, 2023a).

Flaring

The World Bank aims for zero routine flaring by 2030 through their Zero Routine Flaring 2030 initiative. At NEO Energy, flaring strategies are continuously reviewed with an aim of continuous improvement to target zero routine flaring by 2030 (NEO Energy, 2023d).

Methane

In an offshore setting, methane emissions are predominantly attributed to venting, gas turbine and flare system combustion inefficiencies and fugitive emissions from the processing plant. Improving the Company's understanding of methane emissions is an ongoing process and developing a framework for a Methane Action Plan will seek to monitor and reduce methane emissions on NEO Energy's operated assets (NEO Energy EMS Public Statement 2022, 2023).

Digital Solutions

Carbon intensities and emissions at an asset level are now available via digital dashboards. This supports transparency across the Company and encourages a proactive approach to deliver continuous improvement in absolution reduction and reduction in emission intensity.

2.3.1.2 Electrification

NEO Energy is committed to exploring all avenues for decarbonisation to ensure the current portfolio and concepts perform in line with the NSTD and the Company's LCTP. The electrification of offshore platforms can help reduce emissions, as gas turbines used to generate heat and power are replaced with an electricity supply. The Company has invested considerable resources to advance understanding of the options for electrification of several online assets and planned endeavours. NEO Energy currently play an active role alongside our partners in driving dialogue with peers, regulators, industry bodies and external stakeholders in the supply chain to explore routes to electrification; either through collaboration with other Joint Venture Partners within a larger industry-led project or as stand-alone projects. For the Buchan Horst Field, the preferred source of power for the electrified FPSO is an offshore windfarm which is part of with Crown Estate Scotland's INTOG leasing round for offshore wind projects. NEO recognise that the INTOG initiative is a key part of the transition to Net Zero for the UKCS offshore oil and gas industry. Notwithstanding, Power From Shore (PFS) is also considered as a contingency.

2.3.1.3 Indirect Emissions Reporting

NEO Energy has begun expanding the Company's capability to map indirect emissions through the supply chain. The Company's transparency on indirect emissions reporting has increased through improved travel tracking; reporting Category 11 sale of product; and engaging the supply chain. NEO Energy have begun to map supply chain emissions and plan to include a supplier ESG framework. The Company is also further engaging the supply chain to encourage emissions reductions through means such as vessel sharing (NEO Energy Group Limited, 2023).

2.3.2 Buchan Redevelopment Concept Design

2.3.2.1 Alternatives

The Buchan Redevelopment Project considered numerous development concepts for the Buchan Horst Field through concept screening with three principal development concepts identified (see Section 3.2.1). During this process, the concepts were screened based on project pre-defined criteria as outlined in Section 3.2.1 including the selection of a concept which can minimise carbon emissions during the life cycle of the field development, aligning to the UK's Net Zero target. These criteria are aligned with the NSTA requirements as set out in their revised guidance on the development of fields (NSTA, 2021c). The redeployment of the Western Isles FPSO was found to be the optimum development concept for the Buchan Redevelopment Project in terms of maximising economic recovery and Net Zero as well as investment returns, full life cycle emissions, and execution and operating risks. Central to the decision for selecting the optimum concept for the proposed Buchan Redevelopment Project was the consideration of emissions' contribution from the new development and the committed efforts to significantly reduce production emissions through the project life to ensure to full alignment with NEO Energy's LCTP and the wider industry targets as set out in the NSTD whilst maximising domestic economically recoverable reserves critical to the UK energy security.

Export options from the FPSO were also assessed for their GHG emission potential. Shuttle tanker export was compared against pipeline export to a host facility for onward processing. Shuttle tanker emissions were found to result in less emissions principally due to the relatively high power requirements of the FPSO crude oil pipeline export pumps compared to pumps used for cargo offloading to an FPSO.

2.3.2.2 Drilling and Well Design

Aspects of emissions to air during the drilling phase will be managed within the framework of NEO Energy´s Management System (NMS) and will include the following Net Zero considerations to reduce emissions:

- Batch drilling and completion opportunities will be evaluated. These would reduce emissions through reduced logistical requirements and fluid handling efficiencies.
- The rig selection criteria will include the technical capacity for logistical and operational efficiencies which have the potential to reduce emissions through improved performance, reduced operational time and reduced logistical requirements.
- During well completion it is common to use slickline and electric line intervention equipment which is powered using diesel power packs. The Project aims to design the well such that use of these units is limited thereby reducing emissions. If required, the Project are committed to trying to source use slickline and electric line intervention equipment that are electrically driven (currently limited in their availability).

- The Project is investigating the use of autonomous devices within the completion of the production wells to facilitate shut-off of water during the production phase (i.e., to reduce the volume of water being recovered from the reservoir). The use of these devices could mitigate the need to carry out some well intervention activities from a vessel or drilling rig.

2.3.2.3 Carbon Intensity Strategy

The acquisition of new interests in the UKCS will involve an associated increase in production, thus an increase in absolute direct emissions. However, overall, the carbon intensity across the Company's portfolio has fallen and is expected to continue to fall due to an increase in production and continuous efforts in reducing emissions. The impact of any potential new acquisition, including the Buchan Redevelopment Project, on the portfolios carbon intensity is a key factor in NEO Energy's business development strategy. When it comes on line the proposed Buchan Redevelopment Project is not anticipated to negatively impact the Company's carbon intensity targets (see Sections 2.1 and 2.2).

Reduction initiatives and learnings from current assets are being carried across into the design of the Buchan Redevelopment Project to ensure the Project stays aligned with the Company's LCTP and wider NSTA goals such as the provision of existing flare and vent gas recovery systems to satisfy the commitment of no routine flaring and delivery of 'electrification ready' facilities to facilitate future connection to imported power. In addition, due diligence activities carried out by NEO have identified aspects of the FPSO which will be assessed further as part of the Project activities to identify opportunities for emission reduction and to implement emission reduction measures where practicable. This will go forward for inclusion into the installation ERAP which will be developed over the course of the Project, and which will form part of the installation operating documentation. An ERAP will be implemented in the production phase of the development which will set out the emissions management strategy for the vessel through field life and define certain activities which will implement this strategy in support of UK's net zero target.

Additional potential for limiting the emission intensity for the FPSO also arises from the potential for the FPSO to act as a hub for future neighbouring prospects as ullage becomes available.

2.3.2.4 Electrification Strategy

As part of the concept select process, various concepts were evaluated against criteria such as the ability to generate electrical power from an alternative source other than conventional dual fuel turbines. The Western Isles FPSO design, with no turret or swivel technology, lends itself ideally to future electrification. In addition, the Buchan Horst Field's close proximity to the INTOG licencing areas (see Section 4.5.4) creates the opportunity for more cost-effective electrification, with a higher uptime from renewable power. Following removal from its current location, the Western Isles FPSO will be modified so that it is able to accept 3rd party power. Some of these modifications will be carried out inshore, while some will be completed after deployment to the Buchan Horst location. The Western Isles FPSO will initially be powered by onboard dual fuel turbines with the facility converted to import power from a 3rd party source e.g. an INTOG wind farm when available.

2.3.2.5 Flaring and Venting Strategy

The Western Isles FPSO concept is also seen as a preferred concept because it is designed with a closed flare system, and hence offers a zero routine flaring solution in keeping with the NSTA and NEO Energy's commitments (see Section 2.3.1.1).

Additionally, the majority of the FPSO facilities will be commissioned onshore prior to redeployment to the Buchan Horst Field. Those systems that cannot be commissioned onshore will be commissioned offshore during the hook-up and commissioning phase. Commissioning work will aim to achieve the safe start-up of the field while minimising flaring and emissions.

2.3.3 Climate Change Impact Assessment

An assessment of the magnitude of the climate change impacts through GHG emissions associated with operating the proposed Development is presented in Section 7 of this ES. The purpose of this assessment is to determine the potential effects on the climate from GHG emissions arising from the proposed Project, including how it would affect the ability of the UK Government to deliver its carbon reduction targets. As stated in Section 2.3.1.2, the concept selected for the Buchan Redevelopment Project will be 'electrification ready' to facilitate future connection to a renewable power source. However, for the purpose of this Report, the climate change impact associated with GHG emissions in Section 7 is evaluated considering a 'no electrification scenario' as a worst case in line with the EIA Guidance (OPRED, 2020).

3 Project Description

3.1 Development Overview

The proposed Buchan Redevelopment Project can be summarised as follows:

- The drilling and completion of up to five production wells and two water injection wells at the Buchan Horst Field;
- Installation of the repurposed Western Isles FPSO;
- Installation of subsea infrastructure to support tie-back of the wells to the repurposed Western Isles FPSO;
- Installation of a gas export pipeline tied back to either the SAGE pipeline system or to the FUKA pipeline system. Tie-in to the SAGE pipeline system would occur at the existing Ettrick Pipeline End Manifold (PLEM) whilst tie-in to the FUKA pipeline system would occur at the existing Tweedsmuir subsea manifold;
- Production over the repurposed Western Isles FPSO, export of gas via the gas export pipeline and export of oil via shuttle tanker.

Figure 3-1 and Figure 3-2 provide indicative layouts of the proposed Buchan Redevelopment Project.

This chapter presents:

- A description of the concepts considered for the Buchan Redevelopment Project;
- A description of the oil export options considered for the proposed Project;
- Description of the options considered for pipeline installation;
- Indicative schedule for offshore activities;
- Overview of the field and reservoir;
- Description of the activities associated with each phase of the Project: drilling installation, commissioning and production.

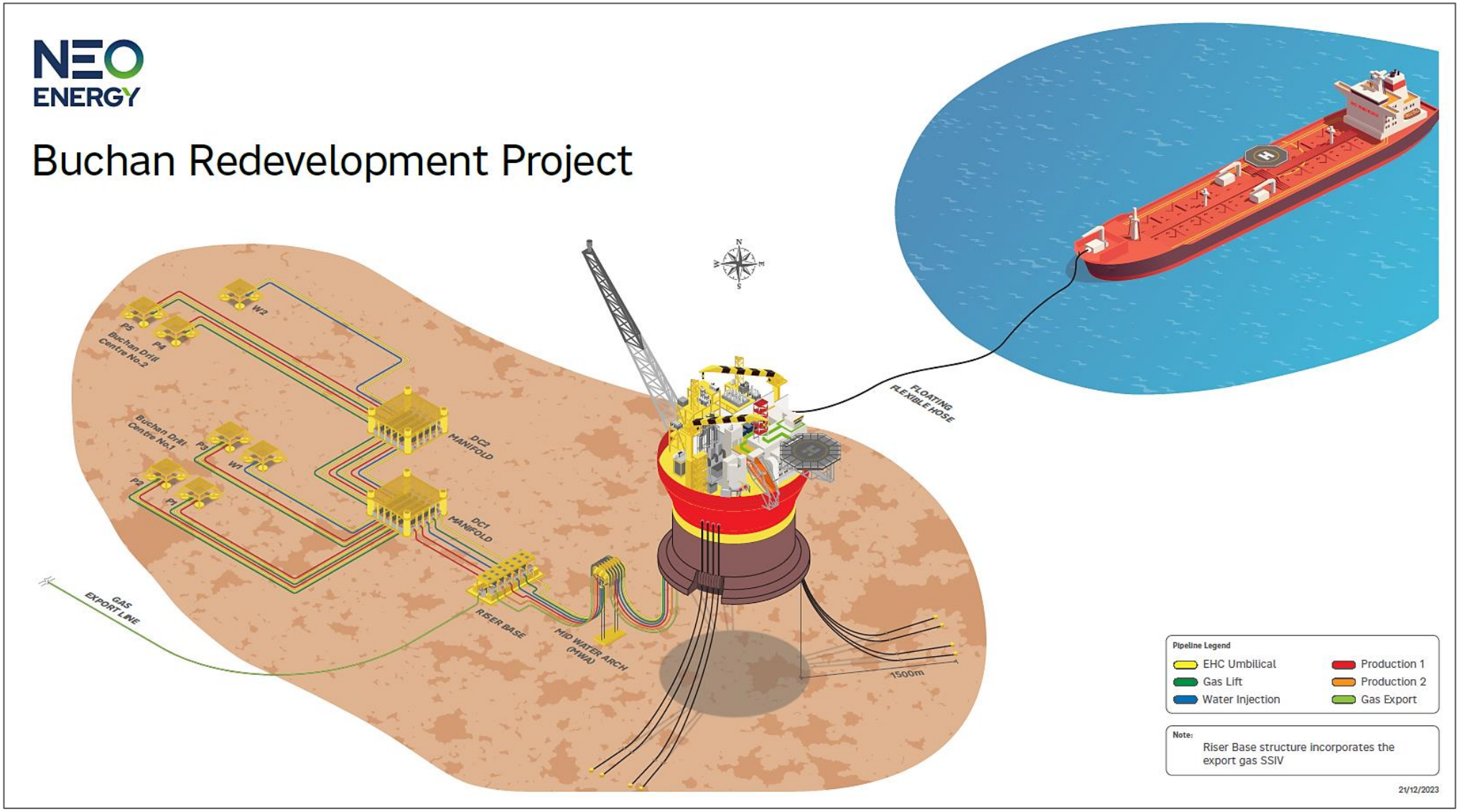
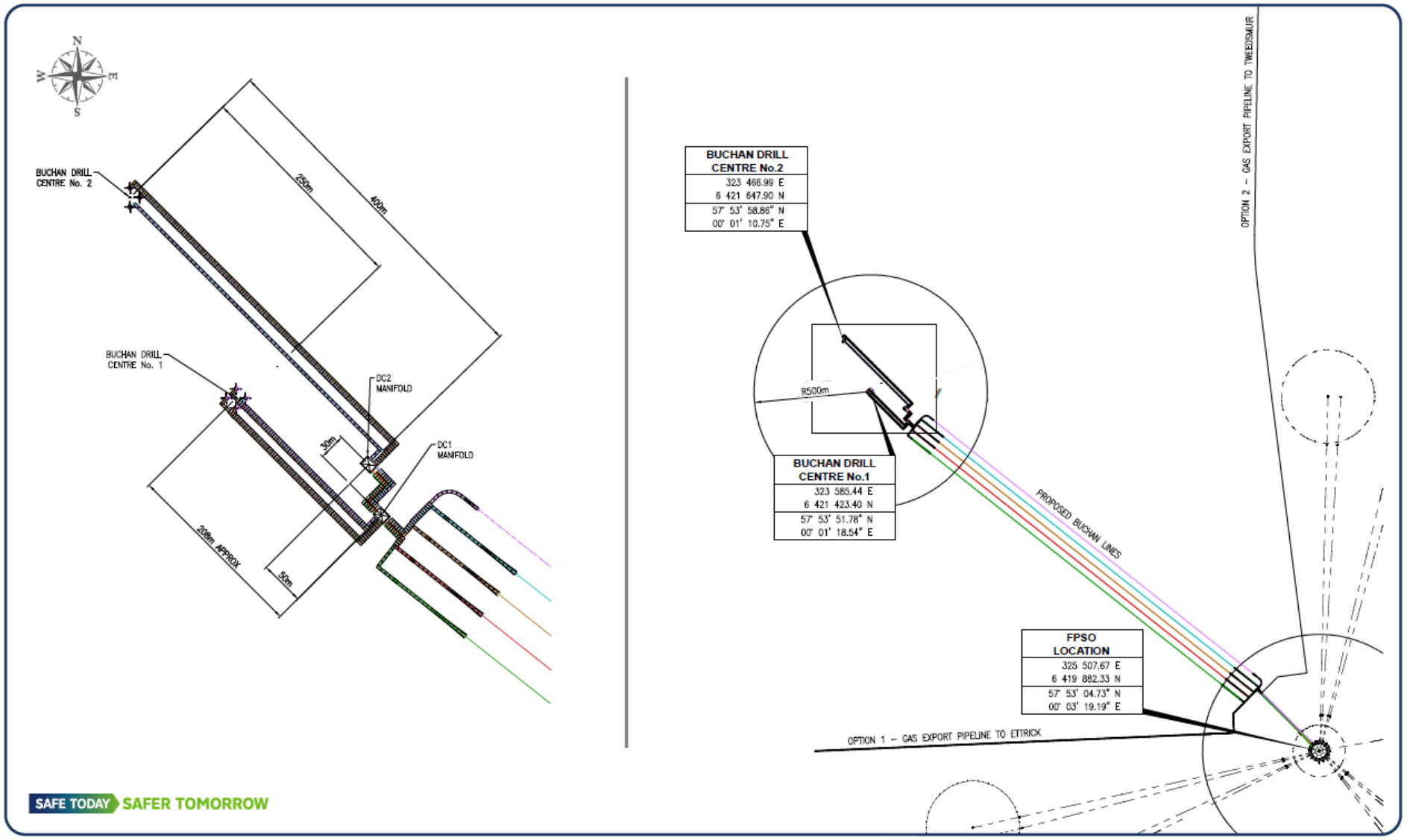


Figure 3-1: Indicative schematic of the proposed Buchan Redevelopment Project.



Created 27/11/2023

Figure 3-2: Indicative drawing of field layout (showing the two different gas export options being considered).

3.2 Analysis of Alternatives

3.2.1 Development Concepts

The proposed Buchan Redevelopment Project considered a number of development concepts for the Buchan Horst Field. This section presents a summary of the development concepts considered by the project and the screening process that was undertaken to identify the preferred development concept.

3.2.1.1 Concept Screening

Initial concept screening identified three principal development concepts for the Buchan Redevelopment Project;

- A new build fixed or floating production facility;
- A re-deployed floating facility; and
- A tie-back to an existing host facility.

An exercise was undertaken to identify and evaluate options within each of these categories utilising in-house industry knowledge/experience, public domain information via the Industry Code of Practice Infrastructure Access, and via direct engagement with infrastructure owners. The intent of this screening exercise was to identify viable development concepts to carry forward to more detailed technical and economic assessment. The results of this screening exercise are summarised below.

New-Build Fixed or Floating Production Facility

The “New-Build” concepts considered were:

- A fixed platform with oil and gas exported via pipeline.
- A ship-shaped FPSO with oil export via tanker and gas export via pipeline.
- A Sevan FPSO with oil export via tanker and gas export via pipeline.

All three concepts offered a viable technical solution for the proposed Buchan Redevelopment Project and have been previously utilised in the Central North Sea. The selection of a new build ship-shaped or Sevan FPSO over a fixed platform is normally driven by one, or a combination of, the following factors:

- Extreme water depth precluding the use of a fixed platform with a steel substructure.
- Remoteness from a viable oil export pipeline means oil storage capacity is required to facilitate tanker offloading.
- Short field life (*c*. 8 years or less) means a leased FPSO offers the only economic solution.

In the case of the proposed Buchan Redevelopment Project, none of these factors apply. The water depth means a steel substructure is viable (as evidenced by neighbouring infrastructure). Two main oil export routes are in relatively close proximity (Forties Pipeline System (FPS) and Flotta Catchment Area (FCA)). Field life is estimated to be more than 20 years and so the leased FPSO option is not likely to offer a favourable economic solution.

There was therefore no compelling technical reason to select a new build floating solution, the only remaining driver was cost with in-house benchmarking data showing that the cost for each of the new build concepts is similar. However, new build floating concepts present a significantly higher level of technical and deliverability risk compared to a fixed platform, primarily due to the complexity that arises from the interfaces between mooring, vessel, and topsides facilities. A study conducted by the North Sea Transition Authority (NSTA) of new development projects undertaken in the UKCS between 2011 and 2016 (OGA (now NSTA), 2017) shows that floating concepts consistently deliver over-budget and over schedule.

For these reasons with respect to new builds only the fixed platform concept was selected for more detailed evaluation.

Re-deployed Floating Facility

The project conducted a market screening exercise of available floating production facilities suitable for re-deployment at the Buchan Horst Field, including direct engagement with the current vessel owners.

The Western Isles FPSO is currently operated by Dana Petroleum Limited (Dana) (a wholly owned subsidiary of the Korea National Oil Corporation) and has been deployed at the Harris and Barra fields in the Northern North Sea since 2017. Dana have advised that production at Harris and Barra is forecast to cease in 2024. Screening of the Western Isles FPSO's capabilities indicated its potential suitability for Buchan fluids and hence the option was carried forward for further detailed evaluation.

Tie-Back to an Existing Host Facility

Whilst the Buchan field is in an area with a number of existing oil and gas production facilities, it is relatively remote when considering conventional tie-back distances. The closest surface production facilities are;

- Britannia operated by Harbour Energy PLC, *c*. 65 km to the east of Buchan.
- Forties operated by Apache Corporation (Apache), *c*. 60 km to the east of Buchan.
- Piper operated by Repsol Resources UK Limited, *c*. 63 km to the north of Buchan.
- Scott operated by CNOOC International Limited (CNOOC), *c*. 44 km to the north of Buchan
- Golden Eagle operated by CNOOC, *c*. 56 km to the west of Buchan.
- Buzzard operated by CNOOC, *c*. 60 km to the west of Buchan.

Britannia is a gas/condensate production facility, and hence is not suitable for processing Buchan fluids. Britannia was therefore discounted as a viable option. The project engaged with each of the operators of the remaining facilities to confirm production capabilities, current and forecast production data, and expected remaining life of field. It was concluded that tie-backs to Forties and Piper were viable therefore these options were carried forward further evaluation. A further potential tie-back opportunity exists within the area, namely tie-back to the proposed floating production facility at Ping Petroleum UK Limited's (PPUKL) Avalon field. Whilst subject to some uncertainty at the time of screening because Field Development Plan (FDP) approval had not yet been achieved by PPUKL, the option was selected for further evaluation.

3.2.1.2 Concept Evaluation and Selection

Based on the outcome of the concept screening exercise, the following development concepts were selected for further evaluation:

- Installation of a new fixed platform.
- Redeployment of the Western Isles FPSO.
- Tie-back to the Forties Alpha platform. This option would necessitate the installation of a new Normally Unattended Installation (NUI) at the Buchan Horst Field.
- Tie-back to Piper platform via Tweedsmuir subsea infrastructure. This option would also require the installation of a new NUI to be installed at the Buchan Horst Field.
- Tie-back to the Avalon FPSO.

Assessment criteria for ranking these five development concepts were based on the following concept selection criteria:

- Concept meets objectives of maximising economic recovery from the Buchan Horst Field.
- Concept meets objectives of maximising economic recovery from the wider Greater Buchan Area.
- Concept minimises carbon emissions during the life cycle of the field development, aligning to the UK's Net Zero target.
- Concept is robust to subsurface uncertainty.
- Concept operability is understood to ensure the above objectives are achieved.
- Concept deliverability provides confidence of delivering the development on time and on budget.
- Concept utilises as far as practicable existing infrastructure.
- Concept offers acceptable economic returns on investment.

For each of the development concepts the criteria were scored for ranking purposes as follows:

1	Concept offers significant disadvantages compared to the other concepts.
2	Concept satisfactorily meets the selection criterion.
3	Concept meets the selection criterion and offers significant additional advantages compared to the other concepts.

A summary of the scoring for each development concept is presented in Table 3-1. In addition to ranking scores, each selection criterion was weighted according to the significance afforded in the selection process. Weightings for each criterion are shown in Table 3-2. The ability to meet Maximum Economic Recovery and Net Zero were weighted highest. Further information on the alignment to the UK's Net Zero target for each development concept is provided in Section 3.2.1.3.

Table 3-1: Summary of ranking rationale for each Development Concept.

Selection Criterion	Fixed Platform	Western Isles FPSO	Tie-Back to Piper	Tie-Back to Forties	Tie-Back to Avalon
Maximising Economic Recovery (MER) from the Buchan Horst Field	Ranks lower than Western Isles FPSO due to higher operating costs.	Ranks highest as economic recoverable resources are highest over field life for this concept compared to other concepts, due predominantly to lower operating costs.	Tie-back considered to present greater risk of earlier Cessation of Production (CoP) than FPSO concept due to the potential for increased costs of late life extension works and/or reduced productivity from the hosts reservoir.		Ranks lowest due to production constraints and the limited field life of the FPSO significantly reducing potential recoverable resources.
MER from the wider Buchan area: the J2 and Verbier fields which are part of the Greater Buchan Area.	Both concepts rank highest as they have sufficient ullage to allow timely development of the J2 and Verbier discoveries.		Tie-back to Piper constrains production such that reduced volumes from these discoveries would be produced within the realistic remaining lifetime of the facility.	Concept has sufficient ullage to allow timely development of the J2 and Verbier discoveries, however the age of the host facilities reduces the potential to add reserves by carrying out further exploration of neighbouring prospects.	Ranks lowest due to the limited size of the oil processing capabilities which would prevent development of J2 and Verbier discoveries.
Aligning to the UK's Net Zero Target (further detail provided in Section 3.2.1.3).	Ranks highest as allows future electrification via an offshore windfarm which allows all future power requirements to be provided from renewables. Even in the absence of electrification, the emissions associated with these options and the Avalon tie-back option are lower that the two tie-back options.		Ranks lower as both concepts retain a higher level of carbon emissions unless the host facility elects to also electrify (outside the control of the Buchan Horst owners). In the absence of electrification these two tie-back options would result in a higher GHG intensity than the other three options.		Ranks highest as allows electrification via an offshore windfarm which allows all future power requirements to be provided from renewables. Even in the absence of electrification, the emissions associated with

Selection Criterion	Fixed Platform	Western Isles FPSO	Tie-Back to Piper	Tie-Back to Forties	Tie-Back to Avalon
					this option and the new platform/ repurposed FPSO are lower that the two tie-back options.
Subsurface uncertainty.	Ranks highest as both concepts, being under the direct control of the Buchan Horst owners, offer the opportunity for future mitigations to be implemented in an efficient and timely manner.		Ranks lower as these concepts would require modifications to third party infrastructure, the implementation of which would be under the control of third parties, presenting a risk of slower and/or more costly implementation.		
Field operability.	Ranks highest as both concepts would be operated by the Buchan Horst owners with full autonomy over all operational decisions.		These options rank lower as concepts reliant on third-party operators and the Buchan Horst Field would be just one component of an overall facility and production management picture, hence Buchan Horst production could be negatively impacted by issues associated with the host facility that are outside the direct control of the Buchan Horst owners. Concepts present operability risks such as pipeline slugging as well as temperature management during start-up and shutdown.		
Confidence of delivering on time and in budget- consider number of work phases: drilling; subsea infrastructure; installation and brownfield (host) modifications.	Ranked higher as concept involves three of four work elements (no host modifications).	Ranked higher as concept involves three of four work elements (no new build greenfield facilities) and new modifications to the FPSO can be made in-shore prior to redeployment.	Ranked lowest, as concepts involve all four elements of work (drilling, new build greenfield facilities (the NUIs), host modifications (Piper or Forties) and subsea infrastructure. Execution of brownfield host modifications required to be undertaken on an offshore operating facility. In addition, these concepts have the largest subsea scopes of work.		Ranked higher as concept involves three of four work elements (no new build greenfield facilities) and new modifications to the FPSO can be made in-shore prior to redeployment.
Use of existing infrastructure.	Ranked lowest as although the concept would utilise existing oil and gas export pipelines, all production facilities are by default brand new.	Ranked highest as utilises existing production facilities and offers the opportunity of retaining a proportion of the workforce associated with the FPSO's current operations.	Concepts rank lower than Western Isles FPSO concept due to new subsea tie-back infrastructure that would be required (e.g. long-distance pipelines). In addition, in the case of the tie back to Piper and Forties, a new NUI would be required.		
Economic returns on investment	This concept and tie-back to Forties and Avalon rank the lowest as they offer the lowest returns.	Ranks highest as offers attractive returns in terms of net present value and rate of return.	Offers lower returns than Western Isles FPSO but higher returns than other development concepts.	Offers lowest returns like the fixed platform concept.	

The individual criteria scores were combined with the individual weightings to produce a weighted score for each development concept. For example, a development concept may score 2 for economic recovery, where this criterion has a weighting of 20%. The weighted score for this criterion is therefore 2 × 20% i.e. 0.4. The weighted scores for all the criteria were then summed to provide a total score. Given that each development concept may have a score of either 1, 2 or 3 the highest weighted score achievable is 3 × 100% i.e. 3. The

results of the ranking are presented in Table 3-2. From Table 3-2 it can be seen when all selection criteria were considered, the option to redeploy the Western Isles FPSO was found to be the optimal approach.

Table 3-2: Summary of scoring of the Development Concepts.

Selection Criterion	Weighting %	Fixed Platform	Western Isles FPSO	Tie-Back to Piper	Tie-Back to Forties	Tie-Back to Avalon
MER from Buchan	20	2	3	2	2	1
MER from wider Buchan Area	10	3	3	2	2	1
Aligning to the UK's Net Zero Target	20	3	3	2	2	3
Subsurface Uncertainty	5	3	3	2	2	2
Field Operability	5	3	3	2	2	2
Deliverability	5	2	2	1	1	2
Use of existing infrastructure	15	1	3	2	2	2
Investment returns	20	1	3	2	1	1
Total Score	**100**	**2.05**	**2.95**	**1.95**	**1.75**	**1.70**

3.2.1.3 Consideration of the Options in Relation the UK's Net Zero Targets

For each development concept, GHG emissions were analysed and assessed for those activities leading up to installation facilities start-up, and those activities during operations.

Activities Prior to Start-Up

The scope of work to deliver each development concept will encompass the following principal activities up to installation facilities start-up:

- Engineering.
- Procurement of goods and services.
- Construction.
- Installation.
- Drilling.

For the purposes of the GHG evaluation the key differentiators were in procurement i.e. in the amount of goods and services, construction, installation, and drilling. It was considered that emissions during engineering were broadly similar across the development concepts. The following data were used as input to the emission comparison:

- Equipment weights.
- Published data relating to carbon intensities for materials manufacture and construction activities.
- Published data e.g. in Environmental Statements relating to installation activities.

The results of the assessment are shown in Figure 3-3.

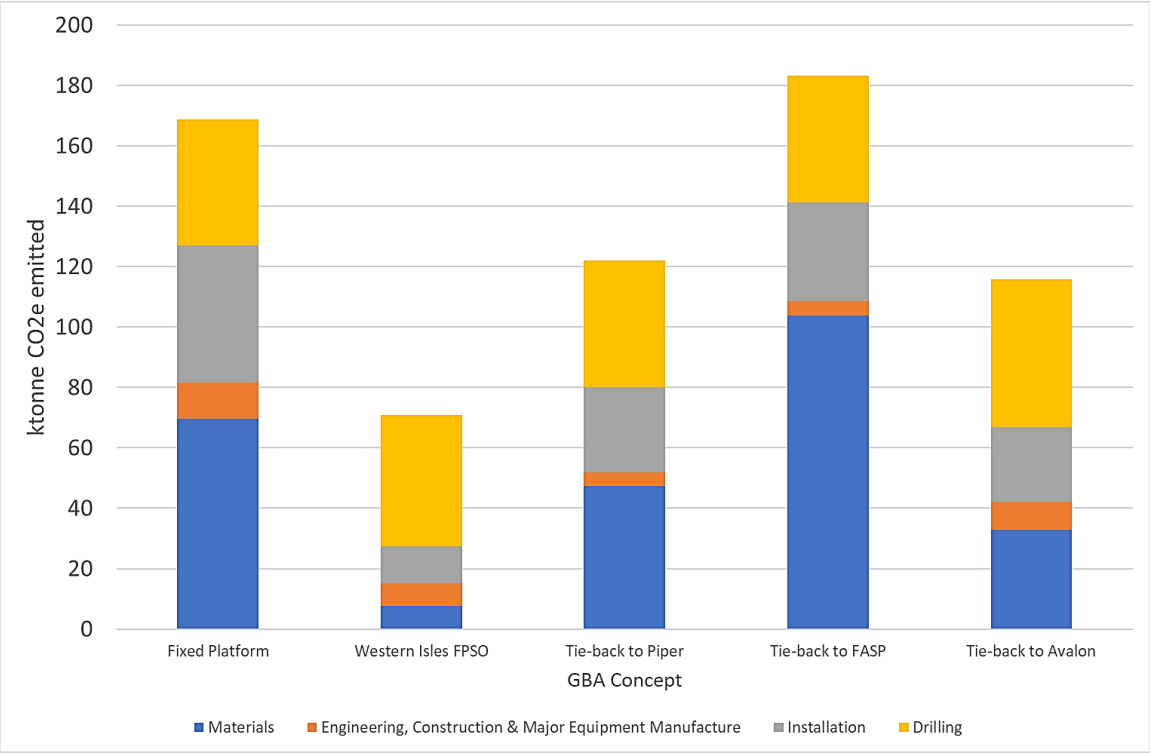


Figure 3-3: GHG emissions for the different development concepts prior to start-up.

For all development concepts, the drilling programme results in a substantial proportion of pre-operations GHG emissions. The GHG emissions are broadly similar for construction and installation activities for the various development concepts. However, there are significant differences in emissions resulting from materials manufacture e.g. steel plate and steel pipework; with the re-deployed FPSO development concept producing the least emissions. The emissions for the Western Isles FPSO development concept are lower than for the tie-back to Avalon development concept because there are fewer number of flowlines (of shorter length).

GHG Emissions During Operations

The development concepts were assessed to quantify the GHG emissions during the operational phase. The emissions considered were:

- Combustion emissions arising from the use of gas turbine power generation during operations. These emissions are made up of two components:
    - Emissions associated with the power required for facilities located at Buchan Horst i.e. a fixed platform, FPSO or NUI (required for the tie-back options).
    - Emissions associated with new equipment on the tie-back host and incremental emissions associated with the shared facilities on the host.
- Flaring and venting during start-up and production operations e.g. during periodic maintenance activities.

For the Western Isles FPSO, fixed platform and tie-back to Avalon development concepts, the facilities will be electrified via supply from a 3rd Party e.g. an Innovation and Targeted Oil and Gas (INTOG) windfarm. There is a degree of uncertainty on the schedule for the provision of the external power source. Whilst the Buchan Horst licensees have the ambition to target first electrons as soon as possible it is our current understanding that the INTOG providers are forecasting a window of 2028 to 2029 for first power. Given the relatively immature nature of the INTOG concepts it has been assumed that Western Isles could be fully electrified from 2030. Once electrified, emissions associated with routine power generation would be reduced to very low levels associated with outages of the 3rd party power supply. The remaining emissions from these facilities will be associated with the use of the emergency diesel generator and flaring due to process upsets and also periodic maintenance. The tie-back to Avalon development concept forecasts slightly lower emissions due to the smaller processing capabilities of the Avalon FPSO resulting in a reduced power demand.

For the tie-back to Piper and Forties development concepts, whilst the NUI would be able to obtain its power from a 3rd Party e.g. an INTOG windfarm from *c*. 2030, it is assumed that the host facilities are not electrified and hence the proposed Buchan Redevelopment Project would be responsible for a portion of these emissions. Emissions allocation to Buchan from the host facility power usage is calculated proportionally on a throughput basis relative to the host installations forecast throughput (provided by the operator of the respective facility). The Forties power total demand (40MW) is greater than the Piper power demand (32MW) and hence produces a larger amount of emissions.

With respect to flaring strategy the fixed platform, Western Isles FPSO and tie-back to Avalon development concepts would be designed with the goal of no routine flaring and venting through the provision of, or in the case of the Western Isles FPSO existing flare and vent gas recovery systems. These systems will return all such potential emissions to the appropriate export stream. For the tie-back to Piper and Forties development concepts, flare strategy is dependent upon current provisions, and hence flaring emissions may be larger.

Forecast direct GHG emissions produced during normal operation over field life for each development concept are shown in Figure 3-4 and Figure 3-5. The data presented relates to direct emissions through power generation. Flaring is not included due to the level of uncertainty associated with host platform flaring from the NUI tie-back options and the likelihood of process upset across all concept options. Figure 3-4 assumes no electrification for any of the options.

For the NUI tie-back option to Forties, the estimated emissions include those associated with powering the new NUI (estimated power demand of 15 MW) and an estimate of the power demand at the host platform that would be associated with the Buchan Horst fluids: estimated to be 83% at start of field life and dropping to *c*. 72 % from 2037 onwards.

For the NUI tie-back option to Piper, the estimated emissions also include those associated with powering the NUI (estimated power demand of 14 MW) and an estimate of the power demand at the host platform that would be associated with the Buchan Horst fluids: estimated to decrease from 78 % at start of field life, dropping to *c*. 63 % from 2033 and increasing to 100 % in 2046.

Figure 3-5 assumes electrification of the new NUI at the Buchan Horst Field for the Piper and Forties tie-back options with no electrification of the host platforms. For the remaining three options (fixed platform, Western Isles FPSO and Avalon tie-back), Figure 3-5 assumes electrification of the installations from 2030. An uptime of electrification for 98% of the time has been allowed for.

Even in the unlikely event that the Buchan Horst Installation (whether it was a fixed platform or a repurposed FPSO) or the Avalon FPSO would not be electrified, it can be seen from Figure 3-4 that the emissions for these three options would be lower than those from the Piper or Forties tie-back options.

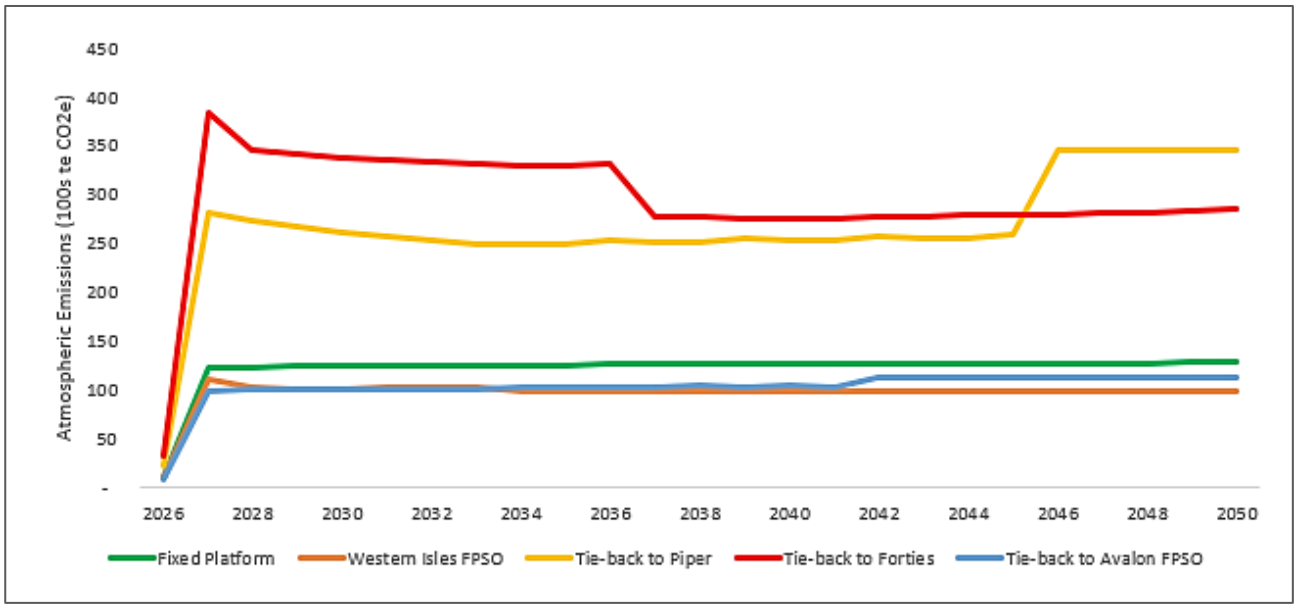


Figure 3-4: Annual CO_2e emissions produced for each development concept without electrification.

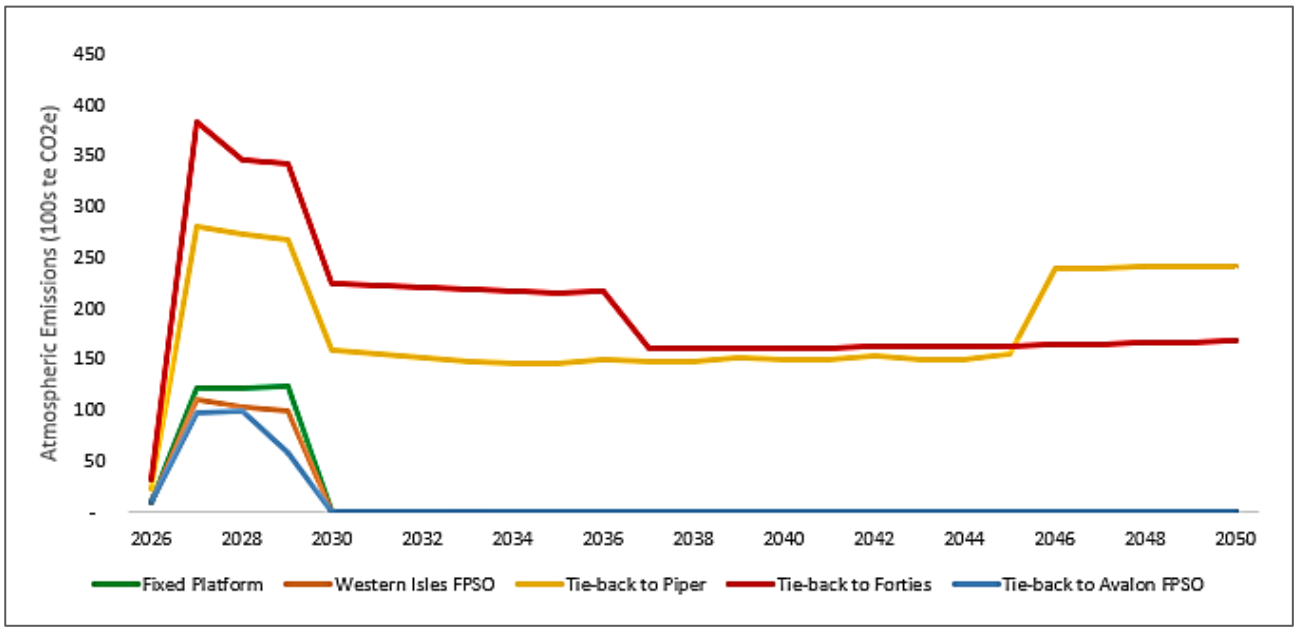


Figure 3-5: Annual CO_2e emissions produced for each development concept with electrification.

3.2.1.4 Preferred Development Concept

The concept select process identified a number of technically viable and economic development concepts that deliver upon the central obligations of the NSTA Strategy. The redeployment of the Western Isles FPSO was found to be the optimum development concept for Buchan Horst in terms of MER and Net Zero as well as in terms of investment returns, full life cycle emissions, and execution and operating risks.

3.2.2 Oil Export Options

Four options were initially considered for the export of oil from the Western Isles FPSO. These were:

- Option 1: Oil exported via the decommissioned Buchan-Forties Charlie pipeline and onwards to the FPS.
- Option 2: Oil exported via shuttle tanker.
- Option 3: Oil exported to the FCA via the Tweedsmuir and Piper Bravo Infrastructure (operated by Repsol Resources UK Ltd). This option would require a new export flowline of *c*. 17 km.
- Option 4: Oil exported into the FPS via a hot-tap downstream of the Unity platform or a new riser tie-in at Unity. This option would require installation of a new export line of *c*. 27 km or *c*. 48 km depending on what tie-in location would be selected.

3.2.2.1 Option 1: Oil exported via the decommissioned Buchan-Forties Charlie pipeline & onwards to the FPS.

The potential re-use of the decommissioned Buchan – Forties Pipeline was subject to technical evaluation, in accordance with a milestone detailed in the P2498 licence award, which required the Buchan Horst Operator to "*confirm the decision on re-use of the Buchan to Forties Pipeline for the Buchan re-development".* A technical assessment was carried out by a third party (Petrofac) and an independent technical peer review of their findings was also carried out (completed by Crondall Energy).

The decommissioned pipeline is in two parts; the first is a 1.5 km long surface laid pipeline (PL126) at Buchan and the second is a 54 km long trenched pipeline (PL401) from Buchan to the Forties Charlie platform. The larger section was commissioned in 1986 and a shorter section at Buchan in 1981. Following cessation of production of the original Buchan Alpha Floating Production Vessel (FPV), the pipeline was flushed and the connecting flexible riser from the FPV to the pipeline was removed. The pipeline was left open ended, such that over time incursion of seawater could occur.

The review of historic pipeline operating data identified significant uncertainties relating to the pipeline's internal corroded condition due to conflicting survey reports, and difficulties in predicting the corrosion since cessation of use (due to the pipeline's open end). The study concluded that PL126 should not be re-used owing to its condition at cessation of use and the likely corrosion caused by seawater replenishment under the currently open-ended condition. The remaining operating life of PL401, considering conservative corrosion conditions, was estimated to be less than the forecast design life for the proposed Project and it was therefore concluded that PL401 would require implementation of remedial measures to ensure the integrity of the pipeline would be sufficient for re-use for the revised extended design life. An inspection of the pipeline would be required to establish what remedial measures would be required.

The inspection operation itself would require extensive pre-works including provision of a bespoke subsea pig launcher, owing to the lack of an available subsea connection for a pig launcher at the Buchan Horst end of the pipeline. The pipeline end condition would need to be surveyed and engineering/fabrication activities undertaken to develop a subsea pig launcher that could be safely and effectively attached to the pipeline end. The cost of the inspection, including the pre-works and the costs of the subsequent remedial measures necessary to extend the life of PL401 are uncertain, but were estimated to be in excess of £100 million. It was recognised that there would be a risk of significant cost growth if the condition of the pipeline was discovered to be worse than predicted. Further, there was a risk that an inspection would provide inconclusive results; necessitating development of a new pipeline, meaning the money and time spent conducting the inspection would be forfeited.

Given the costs and uncertainties detailed above the option to reuse the decommissioned Buchan-Forties Charlie pipeline was scoped out for further assessment.

3.2.2.2 Screening of Options 2 to 4

Screening of the different oil export options followed the same process used for the selection of the development concept (describe in Section 3.2.1.2). A summary of the scoring for Options 2 to 4 is presented in Table 3-3.

Table 3-3: Summary of ranking rationale for each oil export option.

Selection Criterion	Export via Shuttle Tanker	Export via the Flotta Catchment Area	Export via the Forties Pipeline System
MER from the Buchan Horst Field	Economic evaluation shows that the economic recoverable resources with the oil exported via tanker are higher over field life compared to oil export via pipeline, due to lower CAPEX and lower operating costs.	Exporting via pipeline into the FCA or FPS presents a greater risk of earlier CoP than oil exported via shuttle tanker due to the likely switch from processing tariff to cost share for the pipeline system infrastructure. FCA is ranked lower than FPS due to the dependency on continued production from the single Piper Bravo Field, where reduced production rates or cessation of production would result in the majority of Piper Bravo operating costs becoming attributable to Buchan Horst.	Exporting via pipeline into the FCA or FPS present a greater risk of earlier CoP than oil exported via shuttle tanker due to the likely switch from processing tariff to cost share for the pipeline system infrastructure. FPS is ranked higher that FCA due to the latter's dependency on continued production from the single Piper Bravo Field.
MER from the wider Buchan area: the J2 and Verbier fields which are part of the Greater Buchan Area	Considered a lower risk relative to the two oil export pipeline options.	For the export pipeline options the age of the existing infrastructure could potentially curtail production from the GBA earlier than shuttle tankers export.	For the export pipeline options the age of the existing infrastructure could potentially curtail production from the GBA earlier than shuttle tankers export. FPS is ranked higher than FCA due to the latter's dependency on continued production from the single Piper Bravo Field
Aligning to the UK's Net Zero Target	This option is considered to present the lowest emissions during construction since the Western Isles FPSO is fitted with existing offloading facilities and does not require further modification. The tanker export option is also considered to result in the lowest emissions during the operational phase because emissions from the FPSO for the pipeline options result in a higher power usage associated with the need to transport the exported oil via pipeline over greater distances.	Construction and production emissions are considered higher for the pipeline options relative to the shuttle tanker emissions. Indirect emissions will also be lowest for the shuttle tanker export option. All options ultimately result in oil transport via tanker; however, the pipeline options would result in increased emissions at Piper Bravo and Unity and the associated onshore infrastructure, essentially "double handling" the fluids compared to direct export to tanker.	
Subsurface uncertainty	The entry specifications for each export option are broadly similar and can all be achieved by the FPSO without modification, and hence the choice of export	The potential for future souring risk of reservoir fluids due to the planned seawater injection is forecast to present a low-intermediate risk later in	The potential for future souring risk of reservoir fluids due to the planned seawater injection is forecast to present a low-intermediate risk later in

Selection Criterion	Export via Shuttle Tanker	Export via the Flotta Catchment Area	Export via the Forties Pipeline System
	option does not specifically influence the subsurface development plan for Buchan. The lower capital and operating costs associated with tanker export do however contribute to mitigating the risk of Buchan Horst reservoir under performance and hence reduces the risk of premature cessation of production. For these reasons the pipeline export options are ranked lower than the shuttle tanker offloading case.	field life. The use of scavengers to ensure export specification, is achieved is considered robust for the shuttle tanker offloading and FCA cases. However use of scavengers may not be acceptable to FPS, and the FPS presents a greater residual risk of early curtailment of production if souring were to occur relative to the other options. For this reason the FCA option is ranked higher than the other options.	field life. The use of scavengers to ensure export specification, is achieved is considered robust for the shuttle tanker offloading and FCA cases. However use of scavengers may not be acceptable to FPS, and the FPS presents a greater residual risk of early curtailment of production if souring were to occur relative to the other options. For this reason the FPS option is ranked lower than the other options.
Field operability	It is recognised there could be risk of downtime due to adverse weather, however the adverse weather risk is considered low given the Buchan Horst location and is also considered manageable due to the relatively low average offloading frequency (i.e. production rates compared to storage capacity).	Export via pipeline has additional operability risks such as pipeline slugging and waxing. Whilst considered manageable, the pipeline slugging introduces a risk of production trips that are not present in the shuttle tanker offloading case. Similarly, management of wax formation in the subsea pipelines would likely require regular pipeline pigging (with a possible impact of production throughput) and the risk of production shutdowns if, for example, the required export temperatures could not be achieved on the FPSO.	Assessment of the uptime for the two oil pipeline export options indicates that the FCA option including routing fluids via the Piper Bravo platform offers lower uptime compared to the FPS option.
Confidence of delivering on time and in budget	As this option requires no modifications to the FPSO or installation of pipelines, it presents the least deliverability risk.	Whilst all scopes are achievable and have been delivered successfully in other North Sea developments, the pipeline options require the manufacture and installation of the necessary infrastructure whilst the tanker export option requires no modification scope. These activities mean the pipeline options have a greater deliverability risk and therefore are ranked lower than the tanker export option.	
Use of existing infrastructure	This option utilises existing facilities and requires no new infrastructure	Though the pipeline export options do utilise existing infrastructure, both options require new pipelines to be manufactured and installed hence they are ranked less favourable than the shuttle tanker option which requires no new infrastructure to be constructed.	
Economic returns on investment	Analysis shows this option offers the best return on investment from both Buchan Horst and from other GBA discoveries.	Export via FCA or FPS offers lower returns and therefore were ranked lower than the export via shuttle tanker option.	

As for the screening of the development concepts, the individual criteria scores were combined with the individual weightings to produce a weighted score for each oil export option. The weighted scores for all the criteria were then summed to provide a total score (method described in Section 3.2.1.2). The results of the ranking are presented in Table 3-4. From Table 3-4 table it can be seen when all selection criteria were considered, the option to export oil via a shuttle tanker is the optimal option.

Table 3-4: Summary of scoring of the oil export options.

Selection Criterion	Weighting %	Export via Shuttle Tanker	Export via the Flotta Catchment Area	Export via the Forties Pipeline System
MER from Buchan	20	3	1	2
MER from wider Buchan Area	10	3	1	2
Aligning to the UK's Net Zero Target	20	3	2	2
Subsurface Uncertainty	5	3	2	1
Field Operability	5	3	1	2
Deliverability	5	3	2	2
Use of existing infrastructure	15	3	2	2
Investment returns	20	3	1	1
Total Score	**100**	**3**	**1.45**	**1.75**

3.2.3 Pipeline Installation Options

For each of the lines (infield flowlines) laid between the Western Isles FPSO and the drill centre (i.e. two production, one gas lift, and one water injection flowline and one EHC umbilical) the following options were considered for the protection of the lines:

- Trench and mechanical backfill;
- Surface laid and rock covered; and
- Bundled flowline and EHC umbilical.

Options considered for the gas export pipeline included:

- Trench and mechanical backfill;
- Trench and natural backfill; and
- Surface laid and rock covered.

For each option considered for the infield lines and the gas export line, three criteria were assessed: environment, safety and practicality. A summary of the qualitative assessment of each option against these criteria is presented in Table 3-5. For both the infield lines and the gas export pipeline it was concluded from the assessment that trenching and mechanical burying of the lines is the optimal approach.

Jet trenching was not considered as part of the initial assessment that was carried out; however it has since been determined that it may be suitable for installation of the lines. Further engineering/assessment will be carried out to determine if the lines could be jet trenched and if suitable depth of burial can be achieved to mitigate upheaval buckling. Given the larger area of disturbance associated with the 'trench and mechanical backfill' approach, this is the option being assessed in the ES.

Table 3-5: Screening of options considered for protection of the infield lines and the gas export pipeline.

Options considered	Environment	Safety	Practicality
Flowlines and EHC umbilical between the Western Isles FPSO and the drill centre manifolds			
Trench and mechanical backfill	The trenched and mechanical backfill option reduces the permanent change to existing seabed habitats. Following the trenching and backfilling operation the seabed ecosystem around the trench is expected to recover.	Mechanical backfilling of the trench removes any lasting seabed feature which could present a risk to fishing gear. Spot rock berms (if required) shall be profiled to minimise fishing gear snag risk.	The offshore campaign will include mobilisation of pipelay, trench and bury, and rock cover vessels. Simultaneous operations are therefore likely to occur.
Surface laid and rock covered	The rock cover option results in a permanent seabed feature over a large area of seabed. Rock cover vessel time is expected to be similar to that of the vessel for the trench and burial option, thus atmospheric emissions are not likely to be significantly different between these options. Concerns have previously been raised by SFF regarding the destruction of prawn burrows resulting from the use of rock berms.	Rock berms have been widely used for protection of subsea pipeline in the UKCS. Berm profiles shall be made such that there is minimal risk to fishing gear snagging.	The use of rock cover allows for the flowlines to be more readily inspected, relative to the trenched and buried base case.
Bundled flowline and EHC umbilical	The flowline bundle option results in an introduced seabed feature which shall remain in-place for the duration of the field life. As it is surface laid there is likely to be a localised impact on the seabed ecosystem. Atmospheric emissions from vessels during bundle loadout and installation is expected to be equivalent to the other options presented. Rock cover and trenching vessels are not required for this option however at least two vessels shall be required for the tow-out of the bundle.	The bundle carrier pipe results in a seabed feature which is deemed to be over trawlable.	During the decommissioning of the field it is likely that the bundle shall be required to be removed and the seabed reinstated.

Options considered	Environment	Safety	Practicality
Gas Export Pipeline			
Trench and mechanical backfill	The trenched and mechanical backfill option reduces the permanent change to existing seabed habitats. Following the trenching and backfilling operation the seabed ecosystem around the trench is expected to recover.	Mechanical backfilling of the trench removes any lasting seabed feature which could present a risk to fishing gear. Spot rock berms shall be profiled to minimise fishing gear snag risk.	The offshore campaign will include mobilisation of pipelay, trench and bury, and rockdump vessels. Simultaneous operations are therefore likely to occur.
Trench and natural backfill	The trenched and natural backfill option reduces the permanent change existing seabed habitats. Following the trenching and backfilling operation the seabed ecosystem around the trench is expected to recover over time as the trench backfills. The omission of mechanical backfill reduces the short-term disruption to seabed habitat.	With the natural backfill option the spoil mounds along the trench may take an extended length of time to disperse. Clay berms may remain a permanent feature on the seabed which would need further remedial work to remove.	The offshore campaign will include mobilisation of pipelay, trench and bury, and rock cover vessels. Simultaneous operations are therefore likely to occur.
Surface laid and rock covered	The rock cover option results in a permanent seabed feature over a large area of seabed. Rockdump vessel time is expected to be similar to that of the vessel for the trench and burial option, thus atmospheric emissions are not likely to be significantly different between these options. Concerns have been raised by SFF regarding the destruction of prawn burrows resulting from the use of rock berms.	Rock berms have been widely used for protection of subsea pipeline in the UKCS. Berm profiles shall be made such that there is minimal risk to fishing gear snagging.	The vessel time estimated to provide rock cover for the gas export pipeline is expected to be approximately the same as the vessel time required for a vessel to trench and bury the pipeline.

3.3 Schedule

An indicative schedule of the offshore activities associated with the proposed Buchan Redevelopment Project is shown in Figure 3-6. As can be seen offshore activities are expected to commence in Q2 2025 whilst first oil is expected in Q4 2026. Note the schedule is indicative only and highlights the earliest start dates and end dates, and as such should not be through to represent the full duration of the activities.

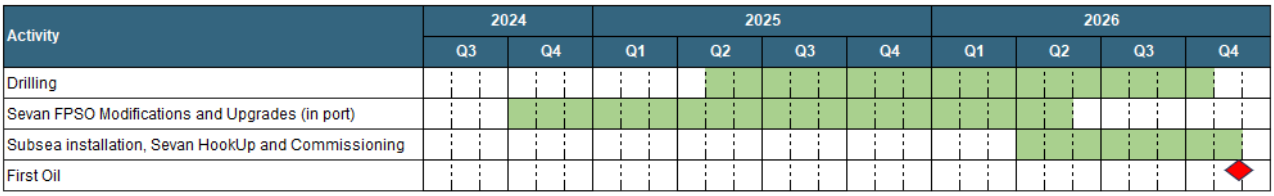


Figure 3-6: Indicative schedule for the proposed Buchan Redevelopment Project.

3.4 Field and Reservoir Characteristics

The Buchan Horst oil field is located in UKCS Blocks 20/5a and 21/1a and was discovered in 1974. The well drilled at this time (well 21/01-1) encountered a *c*. 600 m (1,900ft) oil column in the over-pressured, sandstones of the Upper Devonian to Lower Carboniferous Buchan Formation. The field comprises a horst-like, tilted and eroded fault block with four-way dip closure. Fractures in the competent sandstones help in enhancing the permeability of the matrix, which aid in production. Buchan Horst reservoir fluid properties are presented in Table 3-6.

Table 3-6: Buchan Horst reservoir fluid properties.

Property	Value
Reservoir temperature at Datum (^{O}F)	222
Reservoir Pressure at Datum (psig)	7,506 (initial) ca 2,500
Saturation pressure (Psat) at 192-201°F (psig)	1271
Oil density at saturation pressure (g/cm^3)	0.7759
Initial Gas Oil Ratio (GOR) (SCF/bbl)	285
Oil gravity (°API)	33.5

As mentioned previously Repsol Resources UK Ltd. ceased production from the Buchan Horst Field in May 2017. This decision to cease production was primarily driven by the certification limitations on the Buchan Alpha Floating Production Vessel. Having been awarded the licence in August 2019, Jersey Oil and Gas Ltd. undertook a full subsurface evaluation of the Greater Buchan Area (i.e. the Buchan Horst, J2 and Verbier fields) which included; seismic interpretation and structural modelling, geological and petrophysical interpretation of all well data, detailed reservoir correlation and 3D static modelling. Results of the subsurface evaluation indicate that there is significant exploration potential of *c*. >160 Mmboe (million barrels of oil equivalent) of neighbouring prospective resources in the Greater Buchan Area. For the Buchan Horst Field (boundaries of this ES) the High Case and Mid Case recoverable volumes are estimated at 124 MMboe and 79 MMboe respectively.

3.5 Drilling Phase

As described previously, seven wells (five production and two water injection) will be drilled as part of the proposed Buchan Redevelopment Project. This section describes the proposed drilling activities.

3.5.1 Drilling Location

Final well location has yet to be determined, however the base case is for all seven wells to be drilled across two drill centres located within a single 500 m safety zone. The drill centres will be located *c*. 1.5 km from the Western Isles FPSO location. Indicative well locations are provided in Table 3-7.

Table 3-7: Indicative well locations.

	Easting	Northing
Production Well 1	0° 1’ 24.411”	57° 53’ 53.761”
Production Well 2	0° 1’ 23.74”	57° 53’ 54.088”
Production Well 3	0° 1’ 24.354”	57° 53’ 54.445”
Production Well 4	0° 1’ 29.13”	57° 53’ 56.502”
Production Well 5	0° 1’ 28.453”	57° 53’ 56.829”
Water Injection Well 1	0° 1’ 25.025”	57° 53’ 54.118”
Water Injection Well 2	0° 1’ 29.745”	57° 53’ 56.859”
Datum is ED50 Transverse Mercator: UTM-N Zone 31		

3.5.2 Drilling Rig

At the time of writing it had yet to be determined if a semi-submersible drilling rig or a heavy-duty jack-up (HDJU) drilling rig will be used to drill the Buchan Horst wells. The water depth, weather conditions and seabed conditions in the area are such that either type of drilling rig could be used. The ES therefore takes into consideration both options, and for each environmental aspect being considered, the drilling rig resulting in the worst-case environmental impact will be assessed. For example, anchoring of a semi-submersible drilling rig would result in a greater seabed impact than the positioning of the HDJU drilling rig, however the HDJU drilling rig would likely result in deeper impressions on the seabed.

If used, the HDJU drilling rig would be towed to site using up to three tow vessels (tugs). The HDJU drilling rig will have three vertical legs fitted through openings on the outer hull that are raised and lowered by a jacking mechanism on the deck. Once on location, the HDJU drilling rig legs will be jacked down onto the seabed with the hull raised above the water providing a stable platform. Excessive penetration by the legs into the seabed will be prevented by spud cans at the bottom of the legs, each with a diameter of *c*. 22 m. The HDJU spudcan penetration into the seabed will be between 10 and15 m deep.

It is expected that all seven wells could be drilled with a maximum of three placements of the HDJU drilling rig.

If used, the semi-submersible drilling rig will self-propel to the drill centre and will be held in position using eight anchors (maximum dimensions 7.1 m (L) x 6.4 m (W) each). Anchor lines of *c*. 1.5 km will connect each anchor to the semi-submersible drilling rig and up to 1.280 km of each anchor line will be in contact with the seabed.

Prior to the semi-submersible coming on location, the anchors will be deployed using up to three Anchor Handling Vessels (AHVs). The precise anchor mooring spread for the drilling rig will be defined by a mooring analysis at the drill centre prior to anchor set down. The mooring analysis will take into account the water depth, currents, tides, prevailing wind conditions and any seabed features at the drilling locations. Details of the placement of the anchors will be provided in the Consent to Locate (CtL) permit applications which will be submitted before the drilling rig is mobilised to the drill centre.

It is expected that if a semi-submersible drilling rig is used, all seven wells could be drilled from a maximum of two positionings of the semi-submersible drilling rig and associated anchor system.

Whilst on site, the drilling rig (HDJU or semi-submersible) will have an established 500 m exclusion zone such that unauthorised vessels, including fishing vessels, are not permitted to enter this 500 m zone.

The drilling rig will be equipped with navigation lights, radar and radio communications. An emergency response and rescue vessel (ERRV) will patrol the 500 m exclusion zone whilst the drilling rig is on location.

For the semi-submersible drilling rig, the anchors will be located out with the 500 m exclusion zone, therefore prior to the drilling rig coming on location, a guard vessel will be present to warn other sea users of the anchor locations.

Once on location, the drilling rig will be serviced by supply vessels which will transport drilling equipment, supplies, water, fuel and food and will backload wastes and surplus equipment to shore. Helicopters will also be used to transport personnel to and from the drilling rig.

3.5.3 Blowout Preventer

A blowout preventer (BOP) stack (fully rated for pressures beyond the maximum anticipated well pressure) will be used and will be located either on the drilling rig or on the seabed depending on the rig to be used. The function of the BOP is to prevent uncontrolled flow from the well by positively closing the well in, as and when required. BOPs comprise a series of hydraulically operated rams that can be closed in an emergency from a safe location.

The integrity of the BOP will be tested prior to usage and rated over the range of pressures predicted to occur within the wells. Pressure testing of the BOP will be undertaken in line with the drilling contractor, NEO Energy procedures, and UK legislation and industry standards.

3.5.4 Well Design

Each well will be of a similar design and will be drilled to *c*. 3,143 m depth. Each well is expected to comprise six hole sections as summarised in Table 3-8. Steel casings will be installed and cemented in place in the wellbores to provide structural strength, isolate drilling hazards, and enable pressure containment. An indicative schematic of the well design is shown in Figure 3-7.

Table 3-8: Indicative well design.

Section Diameter (inches)	Casing (inches)	Section length (m)
42	30	105
26	20	631
17.5	13.375	1,036
12.25	9.625	700
8.5	7	214
6	4.5	457
Total vertical depth (m)		3,143

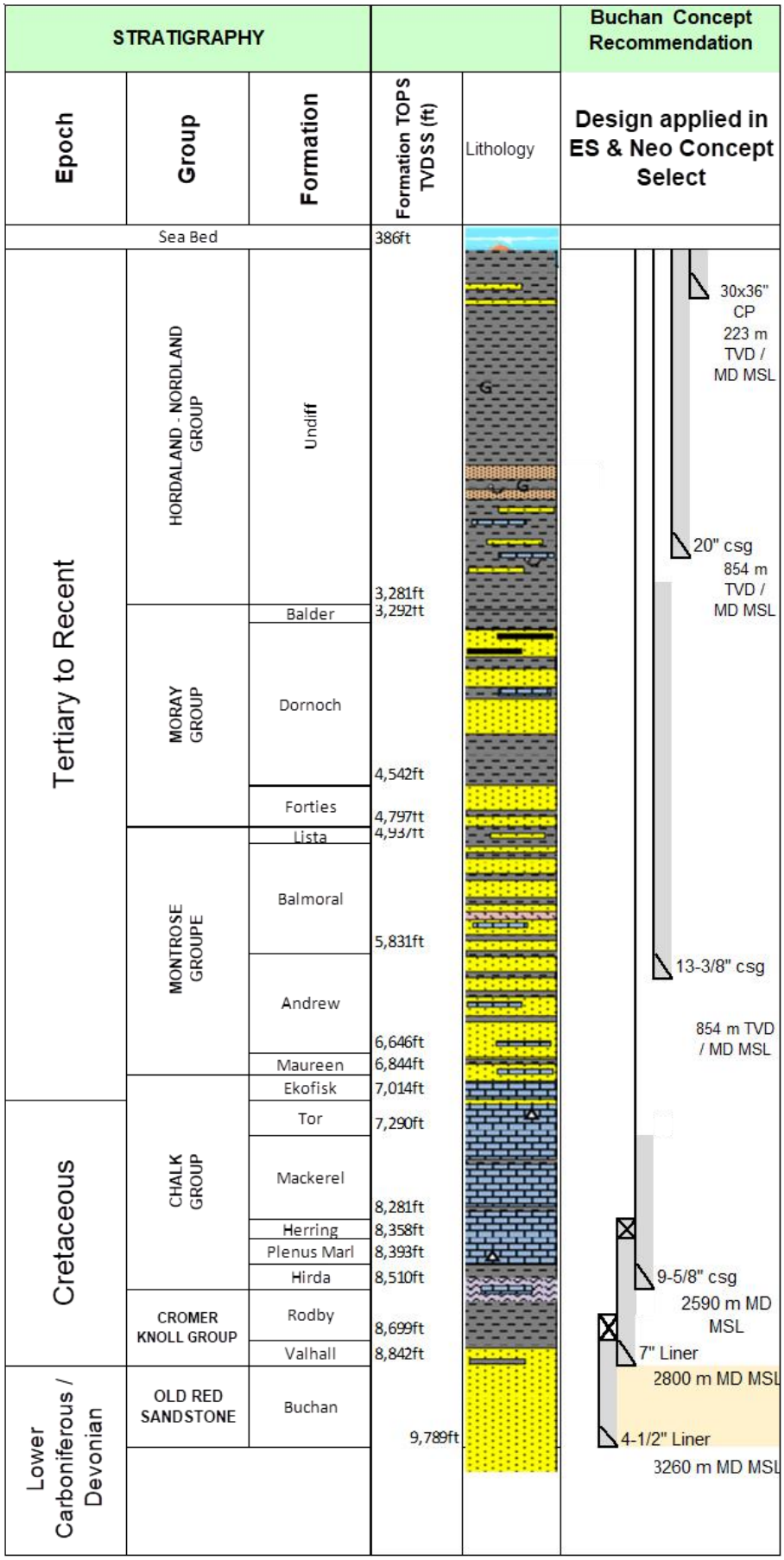


Figure 3-7: Generic Buchan Horst well design.

3.5.5 Drilling Fluids and Cuttings

Drilling fluid (also known as drilling mud) is added to the wellbore to facilitate the drilling process. It is required for several reasons including:

- Managing hydrostatic pressure and primary well control;
- Transportation of the cuttings to the surface;
- Preservation of the wellbore to facilitate casing/completion installation; and
- Cooling and lubrication of the drill bit.

Drilling fluid is continuously pumped down the drill string to the drill bit and returns to the surface through the annular space between the drill string and the sides of the well. Different fluid formulations are required at different stages in the drilling operation because of variations in pressure, temperature and the physical characteristics of the rock being drilled.

The two top hole sections (42" and 26") will be drilled using seawater and high viscous sweeps whilst the lower sections will be drilled using Low Toxicity Oil Based Mud (LTOBM) contaminated cuttings.

At the time of writing, it is expected that the cuttings from the two top hole sections will be discharged to the seabed. It is not known if the LTOBM contaminated cuttings from the lower sections will be skipped and shipped to shore or if they would be thermally treated offshore and discharged from the drilling rig. Modelling of the discharge of the drill cuttings has been carried out to support the impact assessment and it assumes treatment and discharge of the LTOBM contaminated cuttings. A summary description of the thermal treatment of LTOBM contaminated cuttings is provided in the shaded area below.

The anticipated drilling fluid type, the cuttings mass and the fate of cuttings for each well section is summarised in Table 3-9.

Table 3-9: Anticipated cuttings mass associated with each well.

Section Diameter	Drilling Fluid	Cuttings Mass (te)			Discharge Location
		For 1 well	For 7 wells	With additional contingency re-spuds and side tracks ***	
42"	Seawater with high viscous sweeps	270.29 *	1,892.06	3,784.12	Discharged at seabed
26"		622.48 *	4,357.36	8,714.72	
17.5"	LTOBM	424.42 **	2,970.95	5.941.9	May be skipped and shipped to shore for treatment or treated and discharged offshore ****
12.25"		140.52 **	983.62	983.62	
8.5"		20.68 **	144.78	144.78	
6"		22.01 **	154.06	154.06	

* includes a 20% contingency.
**includes a 10% contingency.
***drill cuttings modelling and assessment of atmospheric emissions within the ES assumes a worst case whereby a re-spud of the 42" and 26" sections and a contingency side track of the 17.5 section is required across all seven wells.
****assessment of offshore impacts assumes LTOBM contaminated cuttings will be thermally treated offshore and discharged to the water column.

Thermal Treatment of Cuttings – Summary Description of the TCC RotoMill® Technology

The TCC RotoMill® technology uses, as a basis, a cylindrical mill that grinds a bed of solids within the mill chamber and subjects the ground particles to a high temperature in order to flash evaporate liquid oil and water from the solids. The liberated gases are discharged from the mill and passed through a cyclone where fine entrained particles are removed. From the cyclone the gases pass to oil and steam condensers from where the liquids are recovered as base oil and water (Figure 3-8). The resulting rock powder is collected from the mill and cyclone and is disposed of directly overboard as slurry. The final constituent materials from the TCC RotoMill® process and their destination is as follows:

- Recovered solids – recovered solids are separated at the TCC RotoMill® stage for discharge to sea. In line with regulatory requirements, they will have a hydrocarbon content < 1% and typically <0.1%;
- Recovered water – recovered water is separated within the steam condenser of the RotoMill® and will be discharged following testing and confirmation that it meets any prescribed discharge requirements (the recovered water has a hydrocarbon content of less than 30ppm and regularly less than 20ppm); and
- Recovered base oil – due to pre-determined temperatures within the mill chamber, the recovered base oil can retain the physical properties found in the drilling fluid's base oil. The base oil is separated out in the oil condenser and will be recycled back into the drilling fluid system.

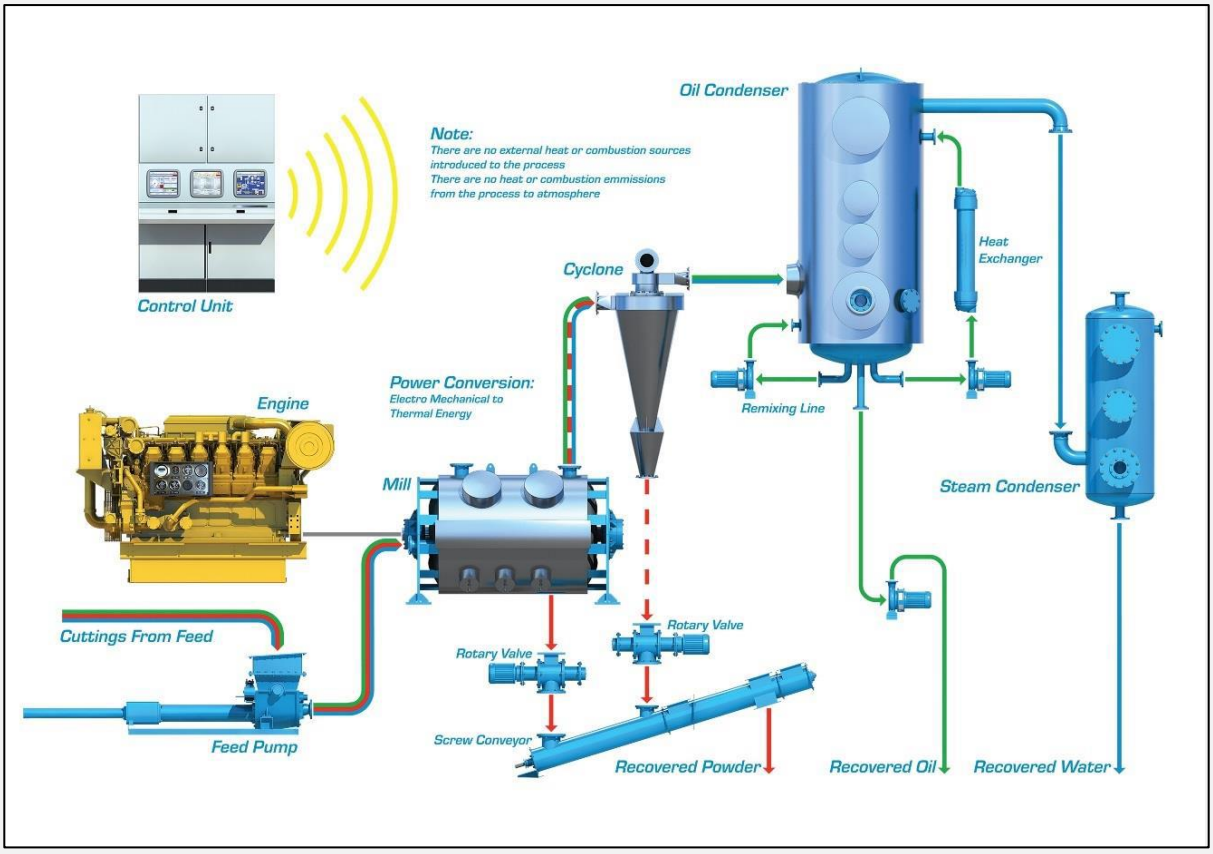


Figure 3-8: Offshore thermal processing unit process flow diagram (Pond *et al.*, 2017).

3.5.6 Cementing Chemicals

Cement is used to secure the steel conductor and casings in the well bore, whilst cementing chemicals are used to modify the technical properties of the cement slurry. During cementing operations, the majority of these chemicals are left downhole, but a small quantity of cement may be discharged onto the seabed around the top of the 30" conductor while filling the annulus between conductor and the host rock formation with cement. This excess over the annulus volume is required to give confidence that the cement has completely filled the conductor annulus and displaced all the mud present to provide a strong bond, on which the entire well is secured. It is estimated that *c*. 20 te of cement could be discharged on the seabed immediately adjacent to

each well location. The ES assumes that at each well location the resultant cement patio will have a radius of 7.5 m Subsequent use of cement is contained downhole as further casings do not require the cement to be pumped into the annulus all the way up to the surface.

Discharges of other cementing chemicals such as cement mix water and spacers may occur when cleaning out the cement mixing and pumping equipment. Cement mix water is the term used to describe the fluids used to mix the cement, whilst spacers are the fluids used to aid the removal of drilling fluids before cementing.

At the time of writing the detailed cement design has yet to be finalised, however, estimates of spacer and cement volumes are provided in Table 3-10.

Table 3-10: Estimated volumes of spacer and cement for each well section.

Section	Spacer	Class G cement	Will excess cement be disposed on seabed?
36" x 42"	60 m^3	230 m^3	Yes
26"	50 m^3	221 m^3	
$17^1/_2$"	50 m^3	97 m^3	No
12 $^1/_4$"	32 m^3	35 m^3	
8 $^1/_2$"	32 m^3	11 m^3	

All cementing chemicals to be used will be selected based on their technical specifications and environmental performance. Class G cements have no additions other than calcium sulphate and/or water and are intended for use as a basic well cement. Chemicals with substitution warnings (i.e., chemicals that are considered to be harmful to the environment) will be avoided where technically possible. The cementing chemicals to be used have not yet been determined but will be detailed in subsequent drilling permit applications.

Like the drilling and cementing chemicals, the chemicals associated with the completion's operations will be captured in the subsequent drilling permit applications.

3.5.7 Well Clean-Up and Well Testing

It is expected that the five production wells will require clean-up flow periods due to the use of Loss Circulation Material (LCM) during the drilling phase[1]. The clean-up will be followed by a flowing period to allow data acquisition for the assessment of productivity (well test). At this time it is not known what quantity of hydrocarbons will be flared for the clean-up and testing of the five production wells, however it will not exceed 2,000 te of hydrocarbons. It should be noted that the information gained from each well test will be assessed with a view to reducing the volumes of hydrocarbons to be flared during well testing for each subsequent production well.

LCM will also be used during the drilling of the water injection wells such that a clean-up will be required which may include flaring of some hydrocarbons. The exact quantities to be flared are not known at this time, however they are not expected to exceed 2,000 te per water injection well.

Table 3-11 summarises the maximum quantities of hydrocarbon fluids to be flared during well clean-up and well testing.

[1] LCMs is the collective term for substances added to drilling fluids when drilling fluids are being lost to the formations downhole. Commonly used LCMs include fibrous (cedar bark, shredded cane stalks and hair), flaky (mica flakes and pieces of plastic or cellophane sheeting) or granular (ground and sized limestone or marble, wood, nut hulls, formica, corncobs and cotton hulls) materials.

Table 3-11: Maximum quantity of fluids to be flared during well clean-up and well testing.

Activity	Maximum volume flared per well (te)	Maximum volumes flared for all wells: five production wells and two water injection (te)
Clean-up and well testing of production wells	2,000	10,000
Clean-up of water injection wells	2,000	4,000

3.5.8 Drill Rig Support Activity

Various support vessels will be associated with the drilling operations such as AHVs, supply vessels etc. Table 3-12 summarises the estimated duration each vessel will be on site and their estimated fuel use. Estimates provided are based on an indicative maximum drilling duration of 639 days. If a semi-submersible drilling rig is used, it is expected that all seven wells will be drilled from a maximum of two positions of the drilling rig. In the event that a HDJU drilling rig is used, it is expected that all wells will be drilled from a maximum of three positionings of the rig.

Table 3-12: Anticipated vessel and associated fuel use for the Buchan Horst drilling campaign should (a) a semi-submersible or (b) a HDJU be used.

Vessel Type	Active Days	Fuel Use per Day (te)	Total Fuel Use (Te)
(a) Semi-Submersible Drilling Rig			
Semi-submersible : mobilisation/demobilisation/in transit	48	24	1,152
Semi-submersible – on location	706	24	16,944
AHVs – assumes three AHVs and assumes two positionings of the drilling rig. Total of 48 days per AHV.	144	17	2,448
Guard vessel following set down of anchors and before rig comes on site – assumes two weeks between anchor set down and rig on site during initial mobilisation	14	1.5	21
ERRV in transit (assumes one vessel change per 21 days for duration of drilling campaign and round trip of 1 day)	35.9	10	359
ERRV working on site	754	1.5	1,131
Two supply vessels	1,508	7	10,556
Helicopter flights: 4.5 flights per week and 3 hour round trip. Therefore 484.7 flights x 3 hrs per flight.	1,454 hours	0.5 te per hour	727
Total fuel use associated with drilling using a semi-submersible drilling rig			**33,338**
(b) HDJU Drilling Rig			
HDJU: mobilisation/demobilisation/in transit	54	12	648
HDJU- on location	706	12	8,472
Three tugs to bring rig location. Assumes three positionings of the HDJU across whole campaign. Allows for 12 days per vessel for initial mobilisation and then four days per vessel to reposition at field (two repositions allowed for)	108	17	1,836
ERRV in transit (assumes one vessel change per 21 days for duration of drilling campaign and round trip of 1 day)	36.2	10	362
ERRV working on site	760	1.5	1,140
Two supply vessels	1,520	7	10,640
Helicopter flights: 4.5 flights per week and 3 hour round trip. Therefore 488.6 flights x 3 hrs per flight.	1,466 hours	0.5 te per hour	733
Total fuel use associated with drilling using a HDJU drilling rig			**23,831**
Note: Length of drilling campaign assumes worst case requirements for a re-spud of the top two sections across all seven wells and a contingency side track of the $17^{1}/_{2}$" section for all seven wells.			

3.6 Subsea Installation Phase

3.6.1 Overview

Table 3-13 summarises the infrastructure to be installed as part of the proposed Buchan Redevelopment Project (illustrated in Figure 3-1).

Table 3-13: Subsea infrastructure to be installed.

Item	Description
Western Isles FPSO Mooring System	
Anchors	12 anchors will be installed for the FPSO. It has yet to be determine if piled anchors or suction anchors will be used. Dimensions of piled anchors: 35 m (L) x 2 m (diameter) Dimensions of suction anchors: 16 m (L) x 6 m (diameter)
Anchor lines	12 x 1.52 km anchor lines to be installed. ES assumes that up to 500 m of each anchor line will be in contact with the seabed and the remaining length will be in the water column.
Structures to be installed within FPSO 500 m zone	
Riser Base	Dimensions: 12 m (L) x 8 m (W) x 3.5 m (H). Weight in air 100 te. The riser base contains the SSIVs and an arrangement of pipework, flanges, and valves. Riser base will be a piled structure: Four piles 20 m (L) x 1.25 m (diameter).
Mid-Water Arch (MWA)	MWA Buoyancy tank structure The buoyancy tank structure will comprise three buoyancy tanks and will be designed to support six risers. Dimensions: 14.5 m (L) x 11.5 m (W) x 7.0 m (H) and will weight *c*. 160 te in air. MWA Foundation Base The 2-piece foundation base will be either a gravity based or piled structure: four piles measuring 30 m (L) x 1.25 m (diameter). Dimensions of the 2-piece foundation base: 16 m (L) x 10 m (W) x 1.5 m (H) and will weight c. 260 te in air. Tether Wires Four tether wires will connect the buoyancy tank to the 2-piece foundation base.
Lines laid between the Western Isles FPSO and the drill centre manifolds	
Two 8" production flowlines	Each production flowline will be a maximum of 2.66 km in length. The 2.66 km comprises a 500 m riser; 2,040 m of flowline on the seabed; 60 m of spools at riser base and 60 m of spools at the first drill centre manifold (i.e. DC1 manifold). The main length of each production flowline will be trenched and buried.
One 6" gas lift flowline	The gas lift flowline will be a maximum of 2.66 km in length. The 2.66 km comprises a 500 m riser; 2,040 m of flowline on the seabed; 60 m of spools at riser base and 60 m of spools at the DC1 manifold. The main length of the gas lift flowline will be trenched and buried.
One 8" water injection flowline	The water injection flowline will be a maximum of 2.66 km in length. The 2.66 km comprises a 500 m riser; 2,040 m of flowline on the seabed; 60 m of spools at riser base and 60 m of spools at the DC1 manifold. The main length of the water injection flowline will be trenched and buried.
One EHC umbilical	The EHC umbilical will be a maximum of 2.66 km in length. The 2.66 km comprises: a 500 m dynamic umbilical; 2.040 m of static umbilical on the seabed; and 60 m of umbilical jumper at the riser base and at the DC1 manifold. The main length of the static umbilical will be trenched and buried.

Item	Description
Lines and structures laid at the drill centres	
Two drill centre manifolds referred to as the DC1 and DC2 manifolds	Dimensions of each manifold: 12 m (L) x 10 m (W) x 4 m (H). Piled, fishing friendly structure: four piles measuring 25 m (L) x 1.25 m (diameter).
7 x Xmas trees	Each well will have a horizontal Xmas tree and well head protection structure associated with it. Approximate dimensions of each Xmas tree/protection structure are 7.9 m (L) x 7.9 m (W) x 5.3 m (H).
Lines between wells at Drill Centre 1 and the DC1 manifold.	Three production wells and one water injection well will be drilled at Drill Centre 1. Three lines will be laid between each production well and the DC1 manifold including: a 6" production spool; a 2" gas lift spool; and an EHC umbilical jumper. Two lines will be laid between the water injection well and the DC1 manifold including a 6" water injection spool; and an EHC umbilical jumper. As a worst case, the ES assumes a maximum length of 281 m for each of these lines. All lines will be surface laid and protected with mattresses and grout bags.
Lines between wells at Drill Centre 2 and the DC2 manifold.	Two production wells and one water injection well will be drilled at Drill Centre 2. Three lines will be laid between each production well and the DC2 manifold including: a 6" production spool; a 2" gas lift spool; and an EHC umbilical jumper. Two lines will be laid between the water injection well and the DC2 manifold including: a 6" water injection spool; and an EHC umbilical jumper. As a worst case, the ES assumes a maximum length of 572 m for each of these lines. All lines will be surface laid and protected with mattresses and grout bags.
Lines between the DC1 and DC2 manifolds	Five lines will be laid between the two manifolds including: 2 x 8" production spools; 1 x 6" gas lift spool; 1 x 8" water injection spool and an EHC umbilical jumper. As a worst case the ES assumes a maximum length of 44 m for each of the lines laid between the two manifolds. All lines will be surface laid and protected with mattresses and grout bags.
Gas export line and associated structure	
6" gas export flowline	Tie-in to SAGE pipeline system at the Ettrick manifold (*c*. 41.77 km pipeline) or tie-in to the FUKA pipeline system at the Tweedsmuir manifold (*c*.19.31 km pipeline). If selected the 41.77 km line will comprise: a 500 m riser; 40,900 m of flowline on the seabed; 275 m of spools at the riser base; and 100 m of spools at the new PLEM (see next row item). If selected the 19.31 km line will comprise: a 500 m riser; 18,500 m of flowline on the seabed; 250 m of spools at the riser base; and 60 m of spools at the Tweedsmuir manifold. The main length of the gas export flowline will be trenched and buried.
Pipeline End Manifold (PLEM)	Dimensions: 10 m (L) x 8 m (W) x 3.5 m (H). Weight in air *c.* 60 te. Piled, fishing friendly structure: four piles measuring 25 m (L) x 1.25 m (diameter). Note: the PLEM is only required if the option to tie-in to SAGE pipeline system via the Ettrick manifold is selected. A new PLEM is not required for tie-in to the FUKA pipeline system.

3.6.2 Installation of the Mooring System & Connection to the Western Isles FPSO

The FPSO mooring system will comprise twelve (3 groups of 4) mooring lines measuring *c* 1.52 km radiating from the FPSO and anchored using either driven pile anchors or suction anchors (expected dimensions are provided in Table 3-13). The precise anchor mooring spread for the FPSO will be defined by a mooring analysis at location. The mooring analysis will be undertaken prior to pre-laying the anchors, and will consider the water depth, currents, tides, prevailing wind conditions and any seabed features at the location. Details of the placement of the anchors will be provided in the CtL permit applications which will be submitted before the FPSO is mobilised to location.

Piled anchor systems work on the principle whereby there is resistance against moving upward due to the force subjected on the pile from the soil. Resistance is increased by increasing the length of the pile. It is anticipated that piles of 35 m length and 2 m diameter will be used and that each pile will be hammered to a depth of 35 m.

Suction piles (also called suction anchors) typically comprise a steel cylindrical shell with a top plate and various fittings that allow water to be pumped into or out of the shell. It has an open bottom that allows soil to enter the internal volume of the cylinder.

It is planned to pre-lay the anchors prior to the FPSO arriving on site and it is expected that a single AHV will be deployed to carry out the pre-lay. Pre-laying of anchors is an efficient method for anchor handling in regions with narrow weather windows. Prior to the FPSO and supporting ERRV coming on site, a guard vessel will be on location to advise other sea users of the presence of the anchors. Three AHVs will be used to tow the Western Isles FPSO to the Buchan Horst Field. Once on site the AHVs will be used to tie in the anchor lines to the FPSO.

3.6.3 Installation of Subsea Structures

As summarised in Table 3-13 the following structures will be installed as part of the proposed Buchan Redevelopment Project.

1. Xmas trees with associated protective wellhead structures.
2. Two drill centre manifolds.
3. Riser base structure.
4. PLEM on the gas export pipeline if tie-in is to the SAGE pipeline system. Tie-in to the FUKA pipeline system does not require a PLEM.
5. MWA including 2-piece foundation base, tethers and buoyancy tank.

Each of these structures are expected to be lowered through the water column using a vessel crane and winch.

Xmas Trees

A horizontal Xmas tree with protective structure will be installed on each well. The Xmas trees will have an arrangement of hydraulically operated valves, with manual back-up valves, to provide integrity barriers from the reservoir. The production and water injection wells will also feature a Downhole Safety Valve (DHSV) which is a hydraulically operated isolation device. There will be gas lift flow meters mounted on each of the production wells.

Drill Centre Manifolds

The two drill centre manifolds will be lowered to the seabed using a crane and winch from a construction vessel (or similar). Once in position four driven piles will be used to maintain position of each manifold. Manifold dimensions, pile lengths and pile diameters are provided in Table 3-13. The drill centre manifolds will both be located within the single 500 m safety zone that will be in place around the two drill centres.

Riser Base Structure

The riser base structure will be lowered to the seabed using a crane and winch from a construction vessel (or similar). Once in position four driven piles will be used to maintain its position. Riser base structure dimensions, pile lengths and pile diameters are provided in Table 3-13. The riser base structure will be located within the 500 m exclusion zone that will be associated with the Western Isles FPSO. The FPSO will be protected from the gas export pipeline inventory by a Subsea Isolation Valve (SSIV) located within the riser base structure. The dynamic umbilical will have functionality for operation of the SSIV via the FPSO control system.

PLEM on Gas Export Line (for tie-in to the SAGE pipeline system)

Should the gas export pipeline be tied into the SAGE pipeline system (at the Ettrick manifold), it will be necessary to install a new PLEM. As with the drill centre manifolds and the riser base structure, the PLEM will be lowered to the seabed using a crane and winch. Once in position four driven piles will be used to maintain its position. PLEM dimensions, pile lengths and pile diameters are provided in Table 3-13. A new 60 m spool will connect the new gas export pipeline to the new PLEM, and a new 40 m spool will connect the PLEM to the existing Ettrick manifold. Both spools will be surface laid and protected with mattresses. The PLEM, spools and mattresses will be located within an existing 500 m safety zone.

Should the gas export pipeline be tied into the Tweedsmuir manifold, a new PLEM structure will not be required. A 100 m surface laid spool will connect the new gas export pipeline to the existing Tweedsmuir manifold. The spool will be protected with mattresses. The spool and mattresses will all be laid within an existing 500 m safety zone.

Mid-Water Arch

The installed MWA arrangement will comprise a buoyancy tank tethered to 2-piece piled or gravity base foundation structure (see Table 3-13) and will be located *c*. 80 m from the Western Isles FPSO. The primary base of the MWA foundation will be lowered through the water column and located on the seabed using a crane and held in position using self-weight or four piles. Before lowering it from the installation vessel, the MWA buoyancy tank will be connected by the tethers to a secondary base and the combined arrangement lowered through water column using a crane. Temporary chain ballast or a winch will be used as necessary to help position the MWA at the required depth (c. 58m). The secondary base is then bolted to the primary base and any temporary chain ballast recovered to vessel. The MWA buoyancy tank remains anchored to the primary and secondary foundation base via the four tethers. Only the primary base of the MWA foundation structure will contact the seabed during installation.

3.6.4 Installation of the Flowlines, EHC Umbilical, Spools and Umbilical Jumpers

Lines Between the Western Isles FPSO and Drill Centre Manifolds

The base case is that the lines (2 x production flowlines, 1 x gas lift flowline, 1 x water injection flowline and one EHC umbilical) to be installed between the FPSO and the drill centre manifolds will be trenched and buried for the most part. The ES assumes a worst case whereby each line is laid in a separate trench; however the project will continue to investigate the potential to lay multiple (2 +) lines in each trench, thereby minimising the impact on the seabed. If the option to trench and bury the lines is carried forward, it is assumed that all trenches will be cut using a towed plough and mechanically backfilled using a separate towed backfill plough. Note as described in Section 3.2.3 the Project is also considering the potential to jet trench the lines, however the ES assesses the impacts associated with trenching and mechanical backfill due to the expected larger area of impact.

At either end where the trenched lines exit the seabed within the two 500 m safety zones, the surface laid transition end will be covered with mattresses and grout bags. It is expected that the target depth of burial ≥ 0.6 m to top of pipe, will be reached. However, as a worst case the ES assumes that the full length of the flowlines between the FPSO and the drill centre will be rock covered (within the trench) to mitigate upheaval buckling should the target depth of burial not be achieved (see Section 3.6.5).

Gas Export Flowline

The ES assumes that the gas export flowline will also be trenched and buried though as for the infield lines, the option to jet trench is also being considered by the Project. As a worst case it is assumed that spot rock cover could be required for up to 25% of the line length ((see Section 3.6.5). As for the lines being laid between the FPSO and the drill centre manifolds, the ends of the gas export flowline on approach to the riser base structure and the PLEM will be surface laid and protected with mattresses and grout bags.

As for the infield lines, the ES assumes that the trench for the gas export pipeline will be cut using a towed plough and mechanically backfilled using a separate towed backfill plough.

Spools and Umbilical Jumpers

All the production, gas lift and water injection spools and all the umbilical jumpers will be surface laid and protected using mattresses and grout bags. Lines laid between each well and the drilling manifolds will be laid in as close a proximity as possible to minimise mattress use.

Risers

At the time of writing it has not been finalised on whether the risers will be installed before or after the Western Isles FPSO has been brought on location. It is expected that pre-installing the risers prior to the FPSO coming on location would result in a greater seabed impact such that the ES assesses that approach. It is expected that following installation of the riser base and the MWA, the risers will be tied into the riser base and laid out over the MWA. The ends of the risers are then left on the seabed until the FPSO comes on station. Once on station and following hook-up to the pre-laid mooring system, a winch will be lowered from the FPSO and used to raise the riser ends through the water column for tie-in to the FPSO.

3.6.5 Stabilisation and Protection Material

Table 3-14 outlines the anticipated maximum stabilisation and protection requirements for the Buchan Redevelopment Project. The quantities of grout bags and mattresses include 10% and 20% contingency volumes respectively. The base case is to not use rock cover, however as a worst case the ES allows for rock cover over 25% of the gas export pipeline in the event that there are areas where the target depth of burial (> 0.6 m) is not achieved. Final volumes will be optimised using the results from shallow geotechnical route surveys, and trenching performance by the appointed contractor. Given the soils in the area, the volume of rock allowed for in the ES is not expected to be exceeded.

In addition, the ES assumes that depth of burial required to mitigate upheaval buckling is not reached on the lines between the drilling manifolds and the Western Isles FPSO such that the full length of the flowlines are rock covered.

Table 3-14: Anticipated stabilisation and protection requirements.

Item	Mass of Rock (te)	No. of Mattresses 6 m (L) x 3 m (W) x 0.5 m (H)	No. of 25 kg Grout Bags
Five lines between the FPSO and the drill centre manifolds – length out with the 500 m zones	32,364	-	-
Within the FPSO 500 m zone	-	288 In proximity to riser base	528
Within the drill centre 500 m zone	-	1,020	836
Along the gas export route- assumes tie-in to the SAGE line at the Ettrick manifold	47,167	35 at tie-in to Ettrick manifold	44
Total	**79,531**	**1,343**	**1,408**

Note: Rock volumes outlined in this table are considered contingency rock. Also as the option to export gas via the SAGE pipeline system would require the longest pipeline and therefore the largest volume of stabilisation material, the quantities presented are based on that option (as opposed to the option to tie into the FUKA pipeline system at the Tweedsmuir manifold).

As a worst case the ES assumes:

-that the target depth burial cannot be reached for *c*. 25% of the gas export pipeline.

-target depth cannot be reached for the flowlines between the Western Isles FPSO and the drill centre such that the full length of the lines require to be rock covered (within the trench) to avoid upheaval buckling.

The mattress quantities include a 20% contingency whilst the grout bag quantities include a 10% contingency.

3.6.6 Pipeline Commissioning

Following installation of the flowlines, EHC umbilical, spools and umbilical jumpers various commissioning activities will be required. It is expected that the flowlines will be installed empty while the spools are likely to contain inhibited seawater (e.g. containing biocides). It is expected that some of the cores within the EHC umbilical and umbilical jumpers will be filled with water based hydraulic fluids and others with (Mono Ethylene Glycol) MEG.

Following leak testing, the pipeline systems shall be dewatered. The oil flowlines are expected to be dewatered with MEG propelled by nitrogen. The chemicals to be used are yet to be finalised, however the doses and quantities will be in accordance with the manufacturers specifications and will be captured in the relevant permit applications prior to use.

Introduction of first hydrocarbons will occur only upon full completion of the leak testing and commissioning activities and all the systems are deemed fit for operation.

3.6.7 Subsea Installation Support Vessels

Various support vessels will be required to support the installation of subsea infrastructure. Table 3-15 summarises the estimated duration that each vessel will be on site for.

Table 3-15: Anticipated vessel use for the subsea installation campaign.

Vessel Type	Duration (days)	Fuel Use per Day (te)	Total Fuel Use (te)
Pipeline route survey vessel - mob/demob	7	1	7
Pipeline route survey vessel- transit	4	10	40
Pipeline route survey vessel - working	27*	1.5	40.5
Pipelay barge - mob/demob	4	4	16
Pipelay barge - transit	2	7	14
Pipelay barge - working	16*	22	352
Construction vessel - mob/demob	3	4	12
Construction vessel - transit	4	20	80
Construction vessel - working	15*	17	255
Pipelay support vessel - mob/demob	4	4	16
Pipelay support vessel - transit	2	20	40
Pipelay support vessel - working	16*	17	272
Trenching vessel - mob/demob	4	2	8
Trenching vessel - transit	4	10	40
Trenching vessel - working	18*	15	270
Backfill vessel - mob/demob	4	2	8
Backfill vessel - transit	4	10	40
Backfill vessel - working	18*	15	270
Rock dumping - mob/demob	4	2	8
Rock dumping - transit	4	10	40
Rock dumping - working	12*	15	180
DSV - mob/demob	36	3	108
DSV - transit	36	18	648
DSV - working	110*	15	1,650
Guard vessel- mob/demob	4	0.8	3.2
Guard vessel - transit	4	3.5	14
Guard vessel - working	144*	0.8	115.2
One AHV to prelay anchors - mob/demob	3	3	9
One AHV to prelay anchors - transit	2	22	44
One AHV to prelay anchors - working	15*	18	270
AHV to tow FPSO to site - three vessels will be required. One day mob and one day demob per vessel.	6	3	18
AHV for FPSO tow– transit - two days to field and one day return, therefore three days per vessel	9	22	198
AHV for FPSO hookup. Three vessels in the field.	29*	8	522
Total Fuel Use			**5,608**
*All working times include a waiting on weather allowance of between 10 and 33 %. Note the AHVs associated with installing the mooring system and the Western Isles FPSO are included here rather than in Table 3-20, due to Table 3-1 focusing on those vessels on site during the production phase.			

3.7 Description of the Western Isles FPSO

3.7.1 Overview

As described previously, the proposed Buchan Redevelopment Project will comprise a central production facility: the redeployed Western Isles FPSO. The Western Isles installation is a Sevan 400 2nd generation FPSO first commissioned in November 2017 with a design life of 20 years. The FPSO is currently operating on the Harris and Barra Fields in the North Sea and forecast to decommission by the end of Q1 2024. Subsequently, the FPSO will be docked, inspected and upgraded before deployment to the Buchan Horst Field in 2026.

The FPSO is a design principally comprising a moored cylindrical hull containing marine systems, cargo handling and storage; topped with a deck system onto which the process, utilities and accommodation (including helideck) are installed. Being cylindrical, Sevan FPSOs are designed as geo-stationary FPSOs which do not weather vane, and therefore have no internal turret and swivel arrangement. The hulls contain tanks for cargo oil storage, ballast water, slops, and marine diesel oil.

Sevan FPSOs are a proprietary design which are typically sized from 60 m to 90 m in diameter, depending on storage capacity. The Western Isles FPSO (Figure 3-9) has a diameter of 70 m.



Figure 3-9: Photograph of the Western Isles FPSO.

3.7.2 Anchoring of the Westen Isles FPSO and Vessel Support During Production

The installation of the mooring system and the Western Isles FPSO is described in Section 3.6.2. Whilst on location, a statutory 500 m safety exclusion zone will be automatically established around the FPSO. Unauthorised vessels, including fishing vessels, are not permitted to enter this 500 m zone.

Once on location, the FPSO will be serviced by supply vessels which will transport equipment, supplies, water, fuel and food and will backload waste and surplus equipment to shore. An ERRV will also be on site. Staff changes on the Western Isles FPSO will be by helicopter.

Assuming a shuttle tanker volume of 400,000 bbl and considering the High Case production profiles it is expected that over life of field there will be *c*. 296 shuttle tanker offloads. The annual number of offloads will vary from c. 40 offloads during the year of maximum production (2027) to *c*. 5 per annum for years of least production (2048 to 2050)[2].

Section 3.8.5 provides the number of anticipated vessel days and associated fuel use.

3.7.3 Topsides

The Western Isles FPSO topsides layout is shown in Figure 3-10. The topsides principally comprise process facilities which receive well fluids which are separated into oil, gas and produced water. The oil is stored prior to export via shuttle tanker. Gas is compressed and returned to the wells for artificial lift: excess gas is exported via pipeline. Produced water is re-injected into the reservoir. The hull contains tanks for cargo oil storage, ballast water, slops and marine diesel oil. The tops of the cargo tanks make up the main deck. Above the main deck is the process deck (diameter 82.5m) which carries process and utilities equipment. The process deck is bisected (port-starboard) by a cross deck structural fire/blast wall with the forward (bow) of the vessel being designated the living quarters side[3]. The process equipment is in the aft of the vessel, utilities are in the forward section. The living quarters module is at the forward end of the installation. When on site at the Buchan Horst Field, the FPSO is expected to be orientated such that 'FPSO north' is 135^{o} from true north, such that the process area is downwind of the Temporary Refuge (TR)[4] in the prevailing wind direction. The offloading reel faces due east permitting shuttle tankers to approach into the prevailing wind and the flare tower points in a northerly direction down wind of the TR.

[2] For the Mid Case production profiles the total number of offloads reduces from 296 (for High Case) to 188.

[3] The Western Isles FPSO has 70 beds in single cabins, 93 beds for hook-up and shutdowns (23 flip beds).

[4] The TR contains a protected muster area and command and control facilities in the event of a major accident hazard occurring on the vessel.

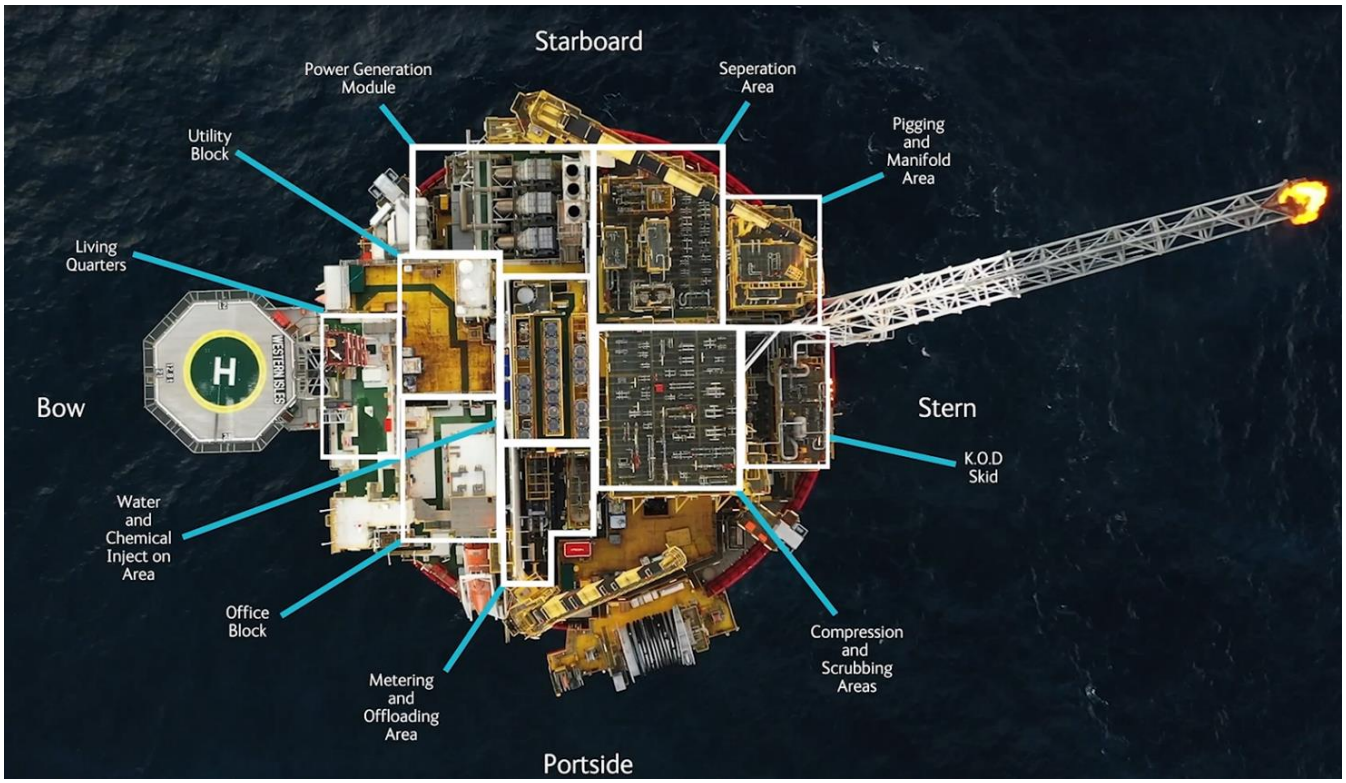


Figure 3-10: Western Isles FPSO topsides layout.

3.7.3.1 Process and Utility Systems

The topsides process and utility facilities comprise the following systems:

- Pigging Facilities
- Inlet Heating
- 3-phase separation of oil, gas and water
- Allocation / Export Metering
- Gas Treatment (Hydrocarbon & Water Dewpointing)
- Mercury Removal Unit
- Gas Compression
- Gas Lift
- Gas Export / Import
- Produced Water Treatment
- Water Injection
- Chemical Injection Facilities
- Fuel Gas
- Flare
- Drains
- Gas Turbines / Waste Heat Recovery
- Heating Medium
- Cooling Medium
- Seawater Treatment
- Methanol Injection

3.7.3.2 Marine Systems

The marine utilities on the Western Isles FPSO comprise the following systems:

- Cargo and Slop tank
- Utilities Cooling Medium
- Process Sea Water
- Ballast Water System
- Fresh Water System
- Utilities Sea Water
- Diesel System
- Compressor Air System
- Fire Water System
- Inert Gas System
- Open Drains System
- Electrochlorination System

3.7.3.3 Open Drains System

The open drains system on the Western Isles FPSO is divided into four separate systems/areas:

- Hazardous open drains;
- Non-hazardous open drains;
- Chemicals; and
- Clean drains.

The hazardous and non-hazardous open drains have dedicated collection systems kept apart from each other, preventing backflow from hazardous to non-hazardous drains system. Both systems are routed to dedicated drains tanks in the hull for further treatment. Chemical drainage is collected in a dedicated tank. Clean drains are routed directly overboard.

Hazardous Open Drains

Hazardous open drains are defined as drains collected in/from a hazardous area. This includes both drains from drip trays underneath equipment and deck drains for the entire hazardous area. Drip trays are installed under hydrocarbon process equipment to collect spillage of hydrocarbons in order to avoid spreading and possible escalation during a fire. All equipment containing flammable liquids has drip trays covering the tank perimeter with adequate drainage.

The hazardous open drains system is designed to handle rain water, fire water, oil spills and accidental releases and wash down water in the hazardous area and is routed to a dedicated hazardous open drains tank in the hull structure. The collected drains are treated for discharge of “clean” water (oil content < 15ppm) to sea, and the overboard discharges will be recorded and reported to be compliant with UK legislation. The metering for overboard discharges includes a manual sampling point downstream of the meter for sampling the oil in water concentrations in-line with OPPC permit requirements.

Non-Hazardous Open Drains

Non-hazardous open drains are defined as drains from drip trays underneath equipment and areas in the non-hazardous areas where there is a risk of dirty liquid. For some areas the non-hazardous open drains are designed to handle water from the firefighting system (e.g. in the diesel generator room and inert gas generator room) - depending on the type of firefighting selected in each case (water spray/mist-, foam- or gaseous system). The non-hazardous open drains are routed to a dedicated non-hazardous open drains tank in the hull structure. Drains from different fire areas/modules are isolated from each other by liquid seals, however liquid seals are not dedicated for each drains box. The collected drains are treated for discharge of “clean” water (oil content < 15ppm) to sea, and the overboard discharges are recorded and reported to be compliant with UK legislation. The metering for overboard discharges from the non-hazardous drains includes a manual sampling point downstream of the meter for sampling the oil in water concentrations in-line with OPPC permit requirements.

Chemical Drains

On the Western Isles FPSO there is a dedicated chemicals drains tank for gravity draining of chemical spills as well as chemical storage tank draining. Spills of hazardous chemicals that cannot be recycled are transported to shore as hazardous waste.

The chemical injection tote tanks area is bunded and the bund is sized to hold the largest chemical tote tank in case of spill. The chemical injection tanks/pump skid are also bunded and again the bund is sized to hold the largest chemical storage tank in case of spill. The bunds have two valves, one to the chemicals drains tanks and one to hazardous open drain. The valves to the hazardous open drains system will be normally open to drain rainwater but are closed in case of a leak or prior to maintenance.

It is also possible to hard pipe drains from any of the chemicals storage tanks to the chemicals drains tank. From the drains tank, the chemicals may either be pumped back to the chemical’s storage tank or to a tote tank for transport to shore.

Non-compatible chemicals can form slurries or solids and create problems if they are drained into the same system. In case of non-compatible chemicals, the bunds are divided to prevent non-compatible chemicals from mixing.

Clean Drains

Clean drains are drains from deck houses and other areas where the risk of dirty liquid is insignificant.

The following areas are served by the clean drains:

- Helideck (the helideck drainage is routed separately to other clean drains).
- Roof of accommodation and deck houses (without walkways). Drains from areas for temporary storage of hazardous materials are routed to the non-hazardous open drains system.
- Rooms or spaces containing large sized water piping/equipment, e.g. the firefighting room drains to sea. The capacity of the drains is sufficient to avoid flooding of the room in case of failure of one pressurised water pipe.
- Main deck can be exposed to green sea. The main deck is protected with a bulwark consisting of overlapping plates, giving a protection for sea spray and this will break the energy of green sea into the deck. Behind the bulwark there will be a coaming reducing the probability for seawater entering the area where equipment is located on main deck. Green sea entering the area between the bulwark and the coaming is considered as clean water and overflows back to sea.

3.7.3.4 Closed Drains System

The closed drains system on the Western Isles FPSO collects hydrocarbon liquid drain from equipment and piping for safe disposal and degassing of the liquid. The closed drains are routed to the closed drains tank, located on the main deck. From the closed drains tank, the collected liquid can be returned to the process or routed to the cargo slop tank. Generally, all closed drains connections (not including those from level bridles) from the process are equipped with a double block and bleed arrangement with a normally closed spectacle blind, in order to avoid accidentally opening of live process equipment to drain. Equipment to be drained will be shut-in and depressurised prior to draining. Equipment and piping located at main deck, which cannot be drained by gravity to the closed drains header, are connected to the slop tank.

3.7.3.5 Gas Utilisation/Export/Import

Gas will be required for gas lift and for fuelling the Gas Turbine Generators (GTGs).

During the first few years of production there will be a surplus of up to around 9 MMscf/d (*c*. 0.255 MMm^3) of associated gas which will be exported. As production declines the amount of gas available for export declines, and after around six years of production the Western Isles FPSO will start to become gas deficient. At times of gas deficiency, gas will be imported via the gas export pipeline.

As the facility becomes gas deficient, the transition to electrification will assist in addressing the power generation needs of the FPSO. However, there may be a requirement for fuel gas import if the electrification initiatives are not on schedule; notwithstanding, gas import will be required through the remainder of field life to provide makeup to the gas lift system.

3.7.3.6 Hydrocarbon Metering

Gas that is exported or imported via the gas pipeline will be fiscally metered. Crude offloaded to shuttle tankers will be metered to fiscal standards. All fuel gas and flare streams will be metered in accordance with UK ETS requirements.

3.7.3.7 Chemical Injection

Chemicals will be used to optimise performance, and prolong the life of the facilities. The Western Isles FPSO chemical injection facilities will be designed to receive, store and deliver all the chemicals required for production and injection. The following chemicals are expected to be utilised.

Subsea Chemicals

The subsea systems will be treated with the following chemicals:

- Methanol will be required for hydrate management during well restart conditions and flushing requirements.
- Scale squeeze will be required for batch squeeze dosing.
- Scale inhibitor chemical injection downhole.
- Asphaltene inhibitor will potentially be required downhole.
- Production scale inhibitor is injected continuously to prevent excessive scaling in production headers and flowlines.
- Wax inhibitor/Pour Point Depressants (PPD) will be injected continuously downstream of the subsea chokes or manifolds to prevent or minimize the rate of wax deposit deposition.

Topsides Chemicals

The topsides systems will be treated with the following chemicals:

- Demulsifier will be injected continuously to assist in the oil water separation by breaking up emulsions.
- Corrosion inhibitor injection pending material selection.
- Reverse demulsifier/de-oiler will be injected as a contingency for water treatment to specification.
- Defoamer is injected as a contingency due to uncertain foaming risk.
- H_2S scavenger potentially injected to control the level of H_2S.
- After additional fields are subsequently tied back asphaltene inhibitor may be required prior to blending the fluids from different fields to avoid precipitation.

Water Injection Chemicals

The water injection system will be treated with the following chemicals:

- Biocide will be periodically injected (shock dose) to eliminate sulphate reducing bacteria whose activity results in formation of H_2S.
- Oxygen scavenger will be injected continuously to aid in removing oxygen in seawater.

Hull Chemicals

The hull systems will be treated with the following chemicals:

- Biocide will be periodically injected into the bottom of cargo oil and slops tanks to prevent the growth of bacteria.
- Sodium hypochlorite will be used as a backup for Cu/Cl system and will be injected at the inlet of the seawater lift pumps (process, utility, fire water & ballast) to control marine and biological growth in the seawater system.

3.7.3.8 Power Generation

The FPSO was originally powered by three SGT-400 Siemens Dry Low Emission (DLE) dual fuel gas turbine generators (GTGs) complete with waste heat recovery units (WHRUs), each rated at 12.3 MW electrical output. Currently, one of the 12.3MW has been replaced with a 15 MW unit. The power requirements at the Buchan Horst location will be reviewed prior to redeployment and the remaining units upgraded as required to enable all installation power consumers to be served by two GTGs working and the third on standby.

There are two diesel generators, each rated at 2,098 kW electrical output. One diesel generator is designated as the standby generator and the second is designated the emergency generator. Both of the diesel units can power accommodation, lighting and utility areas.

After deployment to the Buchan Horst Field, the Western Isles FPSO will initially be powered by the existing GTGs and in future powered by an external source of supply (the preferred supply is an INTOG windfarm). The earliest that 3rd power will be available is early 2030.Electrification of a Sevan type FPSO is relatively simple without the turret and electric swivel constraints and has been proven in Norway on the Goliat field. Prior to deployment of the Western Isles FPSO to the Buchan Horst Field, the facilities will undergo modification to ensure an efficient switch to a renewable energy source with minimal downtime to field operations. Note, though it is expected that the FPSO will be electrified from 2030, the ES assesses the worst case assuming the FPSO is powered by the GTGs for whole field life.

3.7.3.9 Future Capacity

Flexibility will be built into the facilities design to accommodate the tie-in of future prospects such that the Western Isles FPSO is expected to serve as hub for other fields in the area.

3.7.4 FPSO Modifications before Deployment

Prior to redeployment, the Western Isles FPSO will be modified to extend the vessel life so that it will continue to meet all relevant requirements for producing at the Buchan Horst location for the duration of the field life. As well as vessel modifications, additional modifications to the FPSO will include:

- Electrical power and process heating modifications to permit 100% electrification of the FPSO from renewable power sources, to meet the project's Net Zero objectives (see Section 3.7.3.8);
- Produced water system modifications to permit produced water injection (primary disposal route) as well as overboard dumping (secondary disposal route in upset conditions);
- Water injection modifications to deliver the pressures required to meet the Buchan Horst water injection well Flow Tubing Head Pressure (FTHP).

3.7.4.1 Modifications to Support Electrification

Ensuring that the redeployed Western Isles FPSO is electrification ready when it leaves the pitstop yard has been a key consideration during the Select phase of the project. The Define Phase will further develop the upgrade requirements to achieve the switchover from GTG power supply to a fully electrified renewable electrical supply.

In addition to establishing how full electrification of the vessel will be achieved, there has also been significant time spent by the team engaging with potential power providers on a technical and commercial level to establish Heads of Terms and an outline timeline for delivery.

The primary option being considered is the potential for supply from INTOG wind farm (e.g. Green Volt or Cerulean initiatives). Other options such as power cable from shore, supply from a dedicated windfarm associated with the Buchan Horst redevelopment have also been considered as has combined supply with other Operators via a shared cable from shore.

To reduce the carbon intensity of the FPSO, it is proposed to transition from GTG power to renewable power from an INTOG wind farm when sufficient reliable power is available.

An electrification study has been performed during Select to evaluate the Western Isles power demand for Buchan Horst, INTOG power supply and how process heating could be supplied *in lieu* of GTG WHRU heat supply. The study shows that for Buchan Horst production, sufficient GTG capacity exists from first oil. When alternative power is available, a submarine cable from the wind farm to the FPSO could supply all electrical power.

To facilitate reception of electrical power from an external source, significant modifications are required to the existing system and extensive new equipment is required. This forms most of the upgrade scope for the FPSO.

Once the FPSO is electrified, the GTG WHRUs will no longer be available for process heating. Process heating will be supplied by new electric Heating Medium (HM) heaters to replace the WHRU's, which leaves the existing HM system largely unaffected, and will include a changeover from WHRU heating to electric heating without major disruption to production.

The modifications will comprise equipment capable of receiving a power source of at least 66 kV AC and transforming this down to the 11kV board on the FPSO.

The current assumed load is 23 MW comprising 14 MW power and 9 MW process heating to make up from the loss of waste heat recovery from the GTG exhaust gases.

The anticipated component breakdown for electrification is as follows:

- Main Transformer – Power supply likely to be at 66kV minimum whereas Western Isles main board operates at 11kV
- Frequency Converter – windfarm may supply power at 60Hz whereas Western Isles operates at 50 Hz
- Switchgear – Gas Insulated Switchgear is required for voltage levels 66kV and greater.
- Heating Medium Heaters – to replace the GTG WHRUs.
- Thyristor Control panels for the new heaters.
- A pressurised E-House to accommodate the electrical equipment and ensure it is in a safe area. The thyristor panels are safe area only and must be installed within the pressurised E-House.

The method and extent of pre-installation of this equipment prior to sail away from the quay side to the field is to be assessed; the execution strategy will ensure that the FPSO is ready to accept electricity from the renewable power source when this is available.

3.7.4.2 Modifications to the Produced Water Reinjection System

A new PWRI system will be required. The proposed modifications to the produced water system will include:

- New produced water filtration equipment;
  - PWRI coarse filter / desanding hydrocyclone - designed to remove particles above 50 microns.
  - PWRI fine filter - designed to remove particles above 5 microns prior to re-injection.
- New produced water booster pumps - provides the suction head for the main injection pump;
- New produced water and seawater injection pumps;
- Water injection discharge pipework replacement.

3.7.4.3 Modifications to the Water Injection System

Currently, the Western Isles FPSO production system is supported by a seawater treatment and injection system which facilitates the injection of treated seawater for reservoir pressure support. Modifications to the existing seawater injection system are required to incorporate the capability of re-injecting the produced water combined with seawater at a higher pressure than the current design.

To meet the required pressures, the proposed seawater and produced water injection system modifications will include the replacement of the main injection pumps and the associated discharge pipework system.

3.7.4.4 Vessel Use for Offshore Electrification Related Modifications

It is planned that as much of the modifications to the Western Isles FPSO as practicable will be carried out onshore i.e. prior to the vessel being deployed to the Buchan Horst Field. However, major equipment lead times may require that some electrical installation work need to be completed offshore. Table 3-16 captures the anticipated vessel use associated with these possible modifications. However it should be noted that the

vessels associated with these modifications to make the FPSO electrification ready are included as a worst case as the base case is they will be completed onshore prior to FPSO deployment.

Table 3-16: Vessel use associated with electrification activities to be completed offshore.

Vessel Type	Duration (days)	Fuel Use per Day (te)**	Total Fuel Use (te)
Heavy lift vessel - mob/demob	3	5	15
Heavy lift vessel - transit	4	30	120
Heavy lift vessel - working	4*	50	200
Total Fuel Use			**335**
* Working times include a waiting on weather allowance of 33 %. ** Fuel use – estimated fuel use for a crane vessel was used as an analogue (taken from IoP (2000) publication). At the time of writing it is expected these activities if required will take place in 2029. However, base case is these modifications will be carried out in port prior to deployment of the FPSO.			

3.7.5 Start-Up and Commissioning Philosophy

Commissioning and pre-commissioning will be maximised whilst the Western Isles FPSO is in the shipyard. Initial introduction of hydrocarbons will only be done after a comprehensive pre-start up review to ensure safe start-up.

A detailed plan for the initial field start-up will be developed; this will address the safe start-up of the field while minimising flaring and emissions. The activities will include flowline dewatering, initial well start-up, oil plant live commissioning and gas plant live commissioning. This commissioning work will aim to achieve:

- 100% mechanical completion and activation of the key FPSO topsides facilities.
- Completion and testing of the integrated controls and shutdown system so that it is fully operational.
- Nitrogen/helium leak testing of hydrocarbon systems to eliminate hydrocarbon releases during start-up operations.
- Load testing of power generation and functional testing of the supporting ancillary systems.
- System testing of rotating equipment and package items.

The majority of the FPSO facilities will be commissioned onshore before the FPSO is mobilised. Those systems that cannot be commissioned onshore will be commissioned offshore during the hook-up and commissioning phase. The sequence and method for offshore commissioning will be developed during detailed design phase. The strategy for start-up, commissioning planning and quality assurance/quality control, and gas management through the initial production phase will be addressed within the Buchan Redevelopment Project gas management plan.

3.8 Production Phase

3.8.1 Artificial Lift and Water Injection

Production from the Buchan Horst Field will require both artificial lift (gas lift) and water injection.

Artificial lift involves pumping gas below the surface of the liquid in the well. The gas forces the fluid through the well tubing and to the surface. In effect, gas lift uses gas pressure to make the fluid weigh less. This reduces the pressure required to push the fluids out of the well system to the point that bottomhole pressure is enough. Gas lift can be used to coax a natural flow or increase an already existing flow. As long as the bottomhole pressure combined with the gas lift is enough to push fluid to the surface, production will continue. It's a commonly used method, particularly in wells that have lower production volumes.

Water injection is the most prevalent oil recovery technique. Water is injected into the reservoir and helps maintain pressure through voidage replacement, and forces oil towards the wells, thereby increasing production. Injection water will be made up of produced water and treated seawater.

3.8.2 Flaring and Venting

Flaring is anticipated during the following activities:

- Start-up flaring at the commencement of production;
- Subsequent start-ups i.e. following planned shutdowns; and
- Process flaring and blowdown following an upset.

During operation, the Western Isles FPSO flare and vent gas recovery systems will achieve 'no routine flaring and venting'.

3.8.3 Produced Water Re-Injection

During the production phase, the produced water will be treated and reinjected with the injection water. It will be treated to reduce oil in water to target of 15 mg/l (and a maximum of 30 mg/l). The Western Isles FPSO's produced water treatment system is designed to reduce the oil content in the produced water to a target concentration of around 25mg/l (monthly average). As part of the modifications described in Section 3.7.4.2, the produced water treatment facilities will be reviewed with a view to improve on this target concentration i.e. to achieve less than the 25mg/l oil in water.

The PWRI system on board the Western isles FPSO has a design specification of 90% uptime.

3.8.4 Production Profiles

The following subsections present the High Case and Mid Case production profiles for oil, gas and the associated produced water from the proposed Buchan Redevelopment Project. All profiles presented are based on the base case of five production wells and two water injection wells.

3.8.4.1 Oil Production Profiles

Figure 3-11 shows the anticipated High Case oil production profiles whilst Table 3-17 provides the anticipated High Case and Mid Case oil production profiles from the Buchan Horst reservoir. Maximum daily oil production rates are anticipated at the start of field life (in 2027) at an approximate rate of 5,979 te/day for the High Case and 4,959 te/day for the Mid Case. Production rates subsequently decrease every year to 2050.

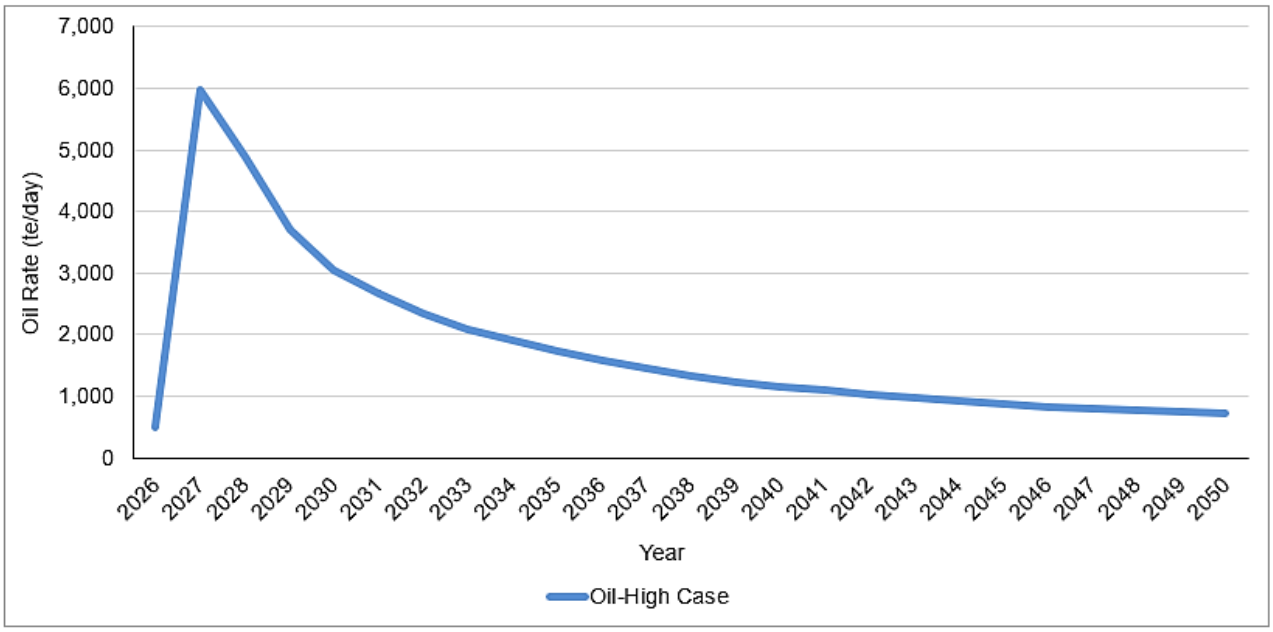


Figure 3-11: Forecasted oil profiles associated with the proposed Buchan Redevelopment Project.

Table 3-17: Forecasted oil profiles associated with the proposed Buchan Redevelopment Project.

Year	Oil Rate (te/day)	
	High Case	Mid Case
2026 (*)	502	502
2027	5,979	4,959
2028	4,880	3,596
2029	3,697	2,760
2030	3,054	2,172
2031	2,667	1,705
2032	2,348	1,431
2033	2,083	1,253
2034	1,899	1,103
2035	1,724	984
2036	1,578	891
2037	1,454	787
2038	1,340	708
2039	1,242	633
2040	1,167	575
2041	1,095	533
2042	1,034	503
2043	982	476
2044	924	454
2045	873	418
2046	835	394
2047	800	373
2048	769	352
2049	743	336
2050	715	327
*Initial production in December 2026. The rate provided is an average production rate over full year.		

3.8.4.2 Gas Production Profiles

Figure 3-12 shows the anticipated High Case gas production profiles whilst Table 3-18 provides the anticipated High Case and Mid Case gas production profiles from the Buchan Horst reservoir. Maximum daily gas production rates are anticipated at the start of field life (in 2027) at an approximate rate of 352 km^3/day (thousand cubic meters) for the High Case and 292 km^3/day for the Mid Case. Production rates subsequently decrease every year to 2050.

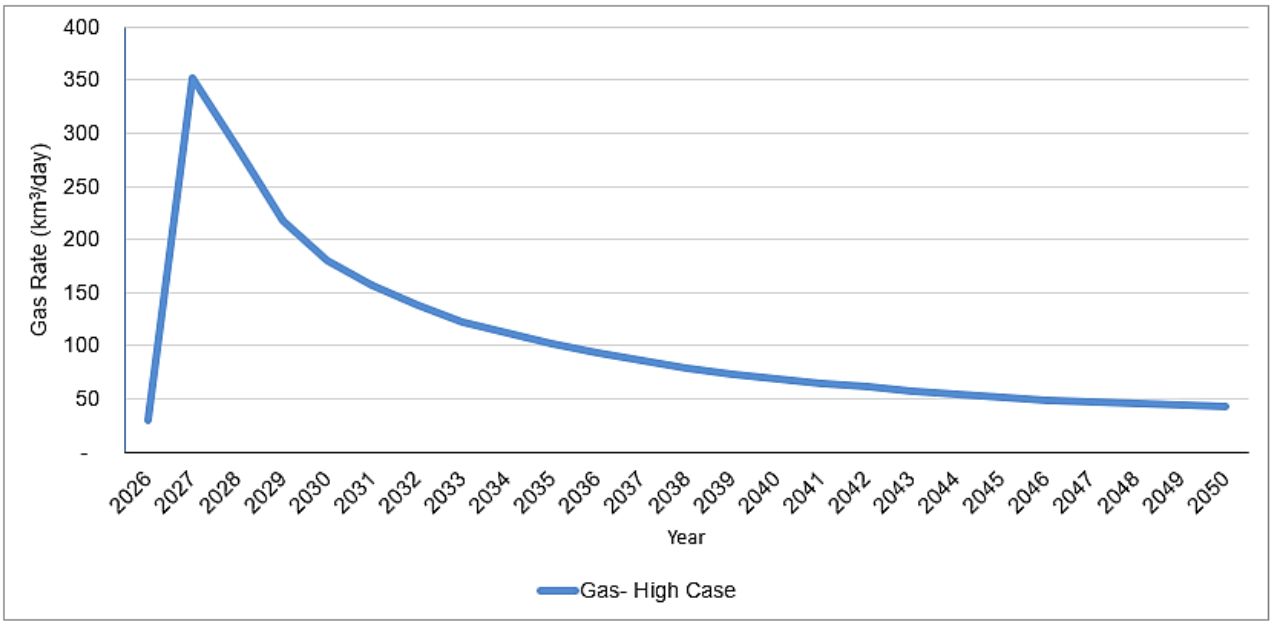


Figure 3-12: Forecasted gas profiles associated with the proposed Buchan Redevelopment Project.

Table 3-18: Forecasted gas profiles associated with the proposed Buchan Redevelopment Project.

Year	Gas Rate (km^3/d) **	
	High Case	Mid Case
2026*	30	30
2027	352	292
2028	287	212
2029	218	163
2030	180	128
2031	157	100
2032	138	84
2033	123	74
2034	112	65
2035	101	58
2036	93	52
2037	86	46
2038	79	42
2039	73	37
2040	69	34
2041	64	31
2042	61	30
2043	58	28
2044	54	27
2045	51	25
2046	49	23
2047	47	22
2048	45	21
2049	44	20
2050	42	19

* Initial production in December 2026. The rate provided is an average production rate over full year.
** thousand cubic meters per day.

3.8.4.3 Water Production Profiles

Figure 3-13 and Table 3-19 show the anticipated produced water rates from the Buchan Horst reservoir. Daily produced water rates associated with the High Case production profiles are lower than those associated with the Mid Case profiles. Produced water profiles increase over field life with maximum produced water rates associated with the final years of production.

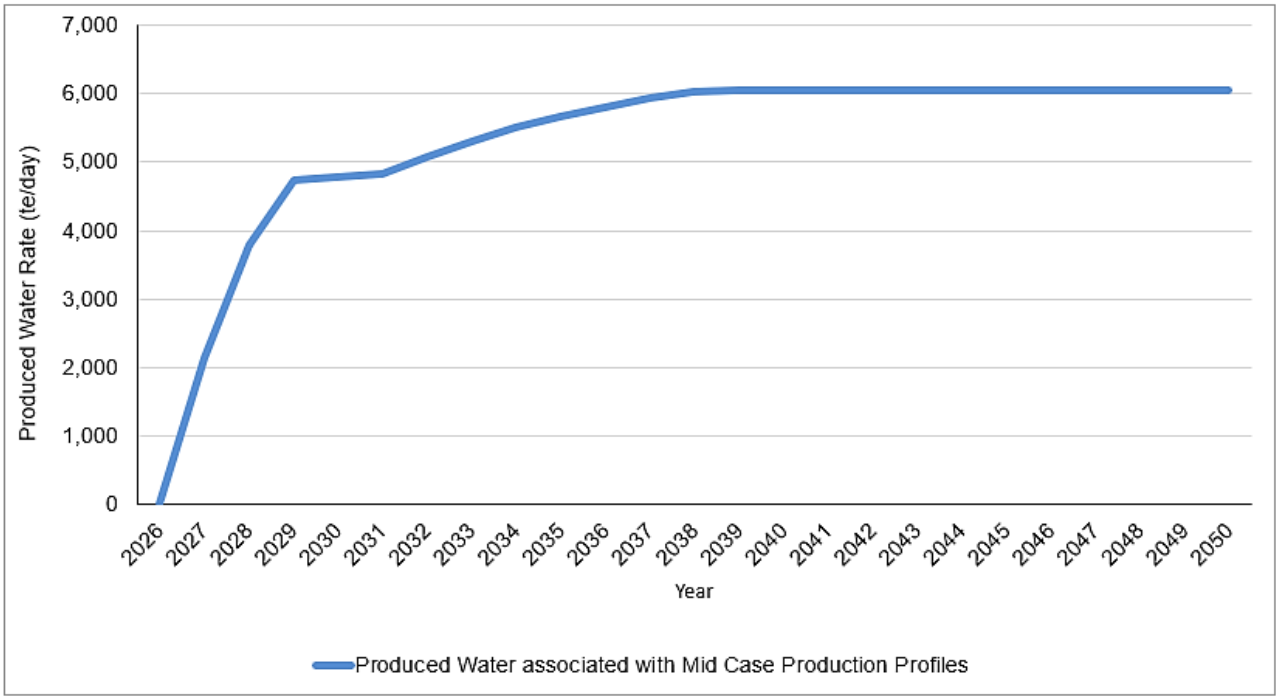


Figure 3-13: Forecasted produced water profiles associated with the proposed Buchan Redevelopment Project.

Table 3-19: Forecasted produced water profiles associated with the proposed Buchan Redevelopment Project.

Year	Produced Water (te/day)	
	PW associated with the High Case production profiles**	PW associated with the Mid Case production profiles**
2026 (*)	13	1
2027	658	2,146
2028	1,691	3,777
2029	2,246	4,746
2030	2,651	4,778
2031	2,969	4,817
2032	3,293	5,072
2033	3,612	5,309
2034	3,874	5,510
2035	4,115	5,673
2036	4,332	5,803
2037	4,525	5,930
2038	4,702	6,030
2039	4,857	6,042
2040	4,983	6,042
2041	5,096	6,042
2042	5,193	6,042
2043	5,279	6,042
2044	5,360	6,042
2045	5,434	6,042
2046	5,494	6,042
2047	5,548	6,042
2048	5,594	6,042
2049	5,634	6,042
2050	5,672	6,042

* Initial production in December 2026. The rate provided is an average production rate over full year.
PW = Produced water

3.8.5 Vessel Use During Production

Table 3-20 summarises the vessels required per annum during the production phase. An ERRV will be on location for the duration of the production phase whilst it is expected the Western Isles FPSO will be served by a supply vessel every two weeks.

In line with the production profiles the number of shuttle tanker offloads will vary annually over life of field. Across the life of field it is expected there will be 296 offloads, with maximum number of offloads occurring in 2027 (*c*. 40 offloads). This number of offloads will drop to *c*. 10 offloads in 2037 and *c*. 5.5 offloads in 2047. It is unknown at this time where the oil will be transported to. The ES assumes a transit of 805 km which is based on an average of the distances from the Buchan Horst Field to Rotterdam (Netherlands), Le Harve (France) and Finnart (Helensburgh, Scotland) based on NEO Energy's export operations experience.

It should be noted that in line with current NEO Energy practices, the shuttle tankers used will be equipped with a Vapor Emissions Control System to prevent any vented VOC emissions at the shuttle tankers during offloads from the Western Isles FPSO.

Table 3-20: Annual vessel use during the production phase (based on High Case profiles for 2027).

Vessel Type	Duration (days)	Fuel Use per Day (te)	Total Fuel Use (te)
ERRV - mob/demob/transit. Allows for one change of ERRV per 21 days with journey taking 1 day	17.5	10	175
ERRV - working	365	1.5	547.5
Supply vessel – mob/demob/transit (in transit every two weeks with each trip taking two days)	52	7	364
Supply vessel - working	26	1.5	39
Shuttle tanker – in port. Number of offloads allowed for is based on year of maximum production (2027) 40 offloads. 3.8 hours manoeuvring in port on engines for each offload transit.	6.5	32	208
Shuttle tanker – transit. Number of offloads allowed for is based on year of maximum production (2027) 40 offloads. 1.45 transit days allowed for per offload.	58	32	1,856
Shuttle tanker - time at field. Number of offloads allowed for is based on year of maximum production (2027) 40 offloads. Assumed shuttle tanker is on site for 24 hours per offload.	40	32	1,280
CSV/Inspection vessel - mob/demob Required for inspection of flowlines, EHC umbilical, Xmas trees, mooring lines etc.	2	4	8
CSV/Inspection vessel - transit	2	20	40
CSV/Inspection vessel - working	10	17	170
Helicopter flights – assumes 73 flights per year and 3 hours per round trip	219 hours	0.5 te per hour	109.5
Total fuel use in 2027*			**4,797**
*Total fuel use will be less in other years as the number of shuttle tanker offloads decreases e.g. in 2037 (*c*. 10 offloads) and 2047 (*c*. 5.5 offloads) the total combined fuel use for vessels and helicopters decreases to 2,214 te and 1,692 te per annum respectively given the reduced number of offloads. **Inspections expected to take place once every two years, with inspections expected to last a maximum of 10 days.			

3.9 Decommissioning

At Cessation of Production (CoP) the infrastructure installed as part of the proposed Buchan Redevelopment Project will be decommissioned in line with legislation in force at that time. In 2023 this would constitute the following:

- The Petroleum Act 1998 (as amended);
- OPRED Decommissioning Guidance (November 2018);
- The UK Guidelines for Suspension and Abandonment of Wells (2015);
- The Pipeline Safety Regulations 1996 requiring the safe decommissioning of pipelines;
- Any additional applicable legislation in place at the time of decommissioning; and
- Any other agreements with OPRED and relevant regulatory bodies.

Nearer the time of CoP, a full decommissioning plan will be developed in consultation with the relevant statutory authorities. The plan will be designed to ensure that potential effects on the environment resulting from the decommissioning of the facilities are considered and minimised.

3.9.1 Pipeline and Subsea Infrastructure

In line with current guidelines and legislation the decommissioning of the subsea flowlines and EHC umbilical would be subject to a Comparative Assessment and Decommissioning Programme. The FPSO will be taken off station and managed under the waste hierarchy: reuse / recycle / disposal. It is expected that the mooring lines, subsea structures, spools, jumpers, risers, mattresses and grout bags will be removed from the seabed and returned to shore for reuse / recycling / disposal and a safe seabed survey conducted, however, this will be subject to future legislative requirements and guidance.

3.9.2 Wells

All well programmes will be subject to a Well Notification assessed by the Health and Safety Executive (HSE) under the Offshore Installations (Offshore Safety Directive) (Safety Case etc). Wells will be plugged and permanently abandoned in accordance with Offshore Energy UK (OEUK) well decommissioning guidelines (OGUK, June 2018) (or applicable guidance at that time). All well programmes will have been reviewed by the HSE Offshore Safety Department as required under the Design and Construction Regulations.

On completion of the well abandonment programme each conductor and internal tubing will thereafter be cut below the seabed. The subsea wellheads will then be recovered at location which could be conducted using either a DSV or semi-submersible drilling rig.

4 Environmental Baseline

An understanding of the environmental and socio-economic baseline is required to identify the potential impacts of the proposed Project. This Chapter outlines the main environmental and socio-economic sensitivities within the area of the proposed Buchan Redevelopment Project that could be impacted by the proposed activities.

4.1 Environmental Baseline Surveys

A number of environmental baseline surveys have been carried out in the Project area and where relevant these have been used to inform this chapter. Survey reports used to support this chapter are listed in Table 4-1 whilst associated survey sampling locations are provided in Figure 4-1. A summary of the findings of each survey is provided on Table 4-2.

Table 4-1: Environmental surveys in the area of the Greater Buchan Field.

Map Ref	Surveys and Reports	Report Reference
Site Surveys		
Ref 1	Rig site survey UKCS 20/2a & 20/3a Ettrick Drill Sites Report No. 68-8713.2. Volume II: Environmental Baseline Survey	Fugro (2006)
Ref 2	Geophysical and Environmental Site Survey UKCS Blocks 20/2, 20/3, 20/7 and 20/8 Proposed Blackbird PB2 Location. FSLTD Report No. 130612.6	Fugro (2013)
Ref 3	Rig Site Survey UKCS Block 20/02 Proposed location 20/02 Blackbird. Volume 1 of 2. FSLTD Project No 00644.5	Fugro (2012)
Ref 4	Site Survey 20/05b-13 Verbier (ST16323). UKCS Blocks 20/05b & 21/01. Survey Period: 24 October to 20 November 2016. Fugro Report No.: 131807V00. Volume 1 of 2: Interpretation Report	Fugro (2016)
Ref 6	Buchan and Hannay Decommissioning Survey. Surveyed in September/October/November 2018.	Benthic Solutions Ltd. Habitat Assessment Report: (2019a) Sampling Assessment Report (2019b) Drill Cuttings Analysis (2019c)
Route Surveys		
Ref 5	Pipeline Route Survey Brodgar UKCS Block 21/03a. Surveyed in February/March 2018.	Fugro (2018)
Ref 7	Greater Buchan Area Development Oil Route 01a_Buchan to Forties Pipeline System. Surveyed in June/July 2021. *	Benthic Solutions Ltd Habitat Assessment Report: (2021a) Environmental Baseline Survey Report (2021b)
Ref 8	Greater Buchan Area Development Gas Route 06a_Buchan - Direct to Ettrick PLEM. Surveyed in June/July 2021.*	Benthic Solutions Ltd Habitat Assessment Report: (2021c) Environmental Baseline Survey Report (2021d)
Ref 9	Greater Buchan Area Development Gas Route 09_Buchan to Tweedsmuir Manifold PLEM. Surveyed in June/July 2021.*	Benthic Solutions Ltd Habitat Assessment Report: (2021e) Environmental Baseline Survey Report (2021f)
*At the time of these surveys the option to export oil to the FCA or the FPS via the Forties, Ettrick or Tweedsmuir pipeline routes had not been ruled out in favour of oil export via shuttle tanker.		

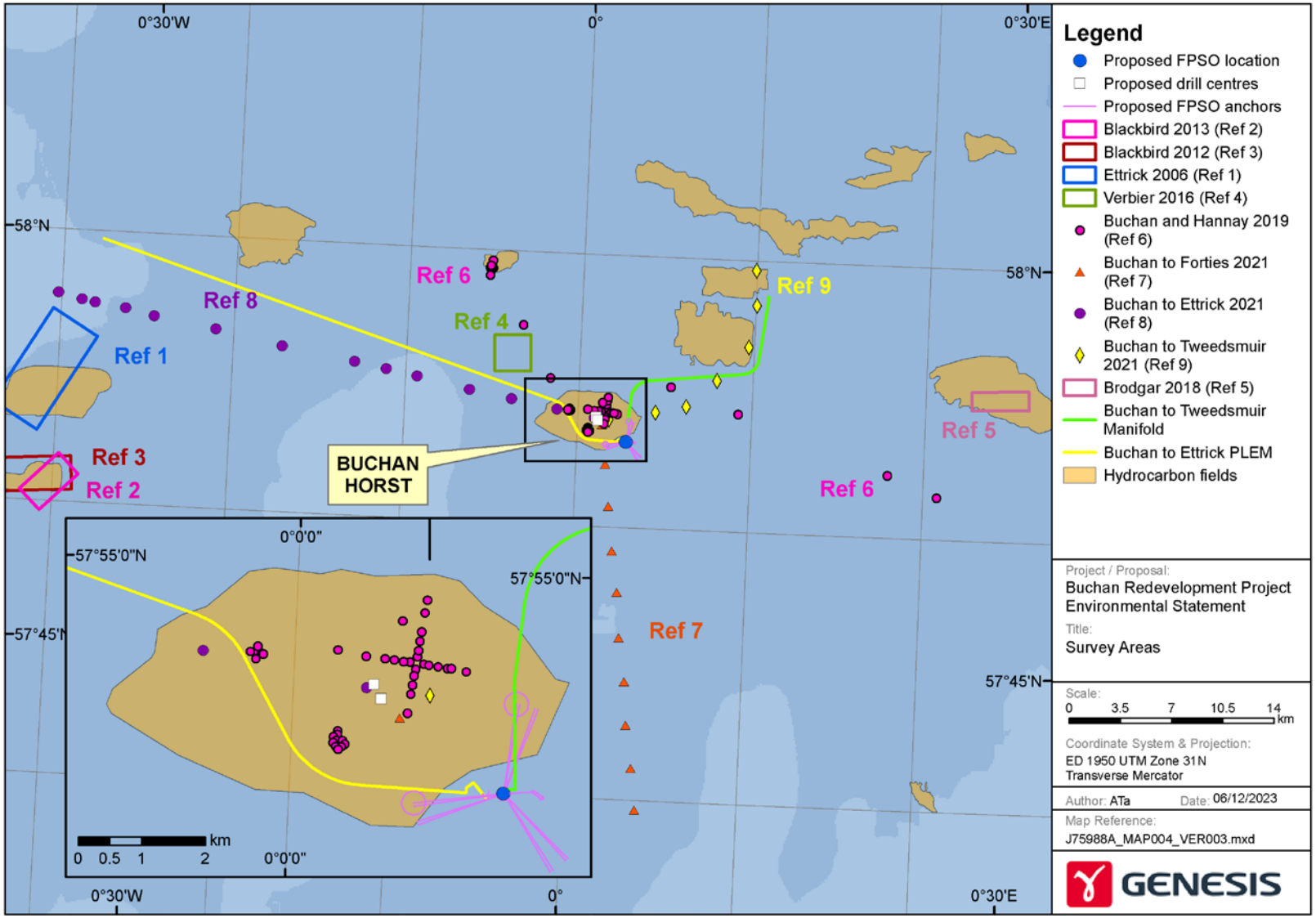


Figure 4-1: Map showing surveys carried out in the vicinity of the Buchan Horst Field.

Table 4-2: Summary description of the different environmental surveys identified in Figure 4-1.

Location/Field	Description
Buchan to Forties, Buchan to Ettrick PLEM and Buchan to Tweedsmuir manifold Benthic Solutions Ltd (2021)[1] (Map Ref. 7, 8 & 9)	Environmental sampling along the proposed Forties, Ettrick PLEM and Tweedsmuir export pipeline routes involved acquisition of physio-chemical and macrofauna samples using a dual Van Veen grab, and underwater video footage and still at a total of ten, 14 and seven locations respectively. Stations were positioned at *c*. 3 km intervals along the routes. A further three camera transects were surveyed over features of interest along the Forties route and a further four along the Ettrick PLEM route. The water depth fluctuated along all of the survey routes, ranging between 102.7 m to 118.4 m along the Buchan to Forties route, 89.9 m to 121 m along the Buchan to Ettrick PLEM route, and 108.9 m to 136.7 m along the Buchan to Tweedsmuir route. The seabed along the survey routes was characterised by muds with variable sand, gravel and shell content. Metal concentrations showed no particular spatial pattern but were elevated above background levels for most metals at every station along both the Forties and Ettrick PLEM routes. While some heavy metal concentrations were elevated across the proposed Tweedsmuir route, most fell well below concentrations that would be expected to cause negative environmental impacts. The main habitat observed along all routes was the EUNIS habitat type: MD621 'Offshore circalittoral mud' (SS.SMu.OMu). The Ettrick PLEM and Tweedsmuir routes also comprise patches of MD421 'Offshore Circalittoral Mixed Sediments'. The frequency of *N. norvegicus* burrows, sea pens and the infauna community were consistent with the level five EUNIS habitat of MC6216 'Seapens and burrowing megafauna in circalittoral fine mud' (SS.SMu.CFiMu.SpnMeg) at all burrows. However, only the Forties route fully met the requirements for this habitat classification. No adult *A. islandica* (Species Feature of Conservation Interest, Scottish PMF OSPAR threatened and/or declining species) were recorded in the survey areas, in either the grab samples or on the seabed video footage, nor was there any evidence of their distinct siphons. However, juveniles were recorded in the macrofaunal analysis of each survey route. Several seabed depressions were noted in the geophysical data, but there was no evidence of methane-derived authigenic carbonates (MDAC) (EC Habitats Directive Annex I Habitat 'submarine structures made by leaking gases') on camera data and the presence of boulders in the majority of depressions suggests formation by scour and not from the release of shallow gas. Hydrocarbon analyses revealed that the THC concentrations at all stations along the Forties route fell within expected values for the CNS. THC concentrations at all stations, bar one, exceeded the UKOOA 50th percentile for the CNS but were below the 95th percentile level along the Ettrick PLEM route. Similarly, THC concentrations along the Tweedsmuir route exceeded UKOOA 50th percentile for the CNS but were below the 95th percentile level at all stations.
Buchan and Hannay Benthic Solutions Ltd (2019a) (Map Ref. 6)	This pre-decommissioning environmental baseline survey was conducted around the Buchan and Hannay assets (on behalf of Repsol Resources UK Ltd.). A total of 63 stations (2 stations were camera only) were investigated as part of the survey. Acoustic data were acquired at all stations to identify habitat types and environmental ground-truthing employed a combination of seabed video footage and seabed sampling. The seabed was considered generally flat throughout with little variation in the water depth (115 m to 135 m) and only a minor slope gradient. Three main habitats were determined across the survey area: sublittoral cohesive mud and sandy mud communities, offshore circalittoral mixed sediments, and circalittoral fine sands. Three variations to the offshore circalittoral mixed sediment habitat were also identified and described: sandy silt and fine shell debris, sandy silt with relic *Mytilus edulis* debris, sandy gravelly silt with occasional glacial dropstones. The environmentally sensitive habitat of burrowing megafauna communities were present throughout the Hannay field survey area and less evident within the Buchan field survey

[1] At the time of the 2021 surveys the Buchan Field had not been renamed to the Buchan Horst Field and therefore reference to the Buchan Field is retained in this chapter when presenting the survey results.

Location/Field	Description
	area, most stations were considered as UK Habitat Feature of Conservation Importance of 'mud habitats in deep water' (also a UK Biodiversity Action Plan (BAP) habitat). A potential Annex I habitat was identified in the form of pockmarks or depressions along the Buchan to Forties Charlie pipeline route from the interpretation of geophysical data. MDAC, which can constitute to the Annex I habitat "Submarine structures made by leaking gases" were however not identified in the depressions ground-truthed. Total hydrocarbon content was recorded at moderate levels across the survey area, with the exception of stations within 100-200m north and south of the Buchan drilling template where levels exceeded the UKOOA 95th percentile background concentration for the central North Sea. In the Buchan survey area concentrations of heavy metals exceeded the Effect Range Low at several stations. The macrofauna community was dominated in richness by annelids, crustaceans and molluscs, of which the polychaete *Paramphinome jeffreysii* accounted for 16% of the community.
Verbier Fugro (2016) (Map Ref. 4)	This site survey was carried out in order to identify potential shallow gas and other shallow drilling rig installation hazards on or beneath the seabed at the proposed well location. The water depth within the survey area generally increased from a minimum 105.6 m (LAT) in the west of the survey area to 127.6 m (LAT) in the east of the survey area. Irregularly shaped depressions, interpreted to be pockmarks, were present throughout the survey area. The pockmarks ranged from less than 5 m wide to 200 m wide and were up to 5.5 m deep. Seabed sediments within the survey area were characterised by generally low reflectivity on side scan sonar data and were interpreted to comprise silty clay.
Ettrick Fugro (2006) (Map Ref. 1)	Samples were taken from 13 stations during this rig site survey. A full sampling program (four grabs and camera) was carried out at eleven of the stations, with solely camera footage acquired at the remaining two stations. In addition, six depressions were identified from the side scan sonar data and further investigated using the video / stills footage. The seabed in the area showed variable depths and a gently sloping profile with a maximum depth of 113 m and a minimum depth (at the proposed drill centre) of 109 m. The sediments in the area comprised moderately to poorly sorted very fine to fine sands with concentrations of the majority of the heavy metals being within published UK Offshore Operators Association (UKOOA; now OGUK) mean concentrations for the CNS. The macrofauna found in the area were characteristic of the fine sand substrates of the CNS and generally reflected the sediment type of the individual stations with most showing relatively high abundances and a high diversity. The dominant species overall was the polychaete worm *Paramphinome jeffreysii* which dominated every sample. The gastropod mollusc *Retusa obtusa* and the polychaetes *Diplocirrus glaucus*, *Galathowenia oculata* and *Ampharete* sp. also number amongst the top 10 species at many stations. This polychaete dominated structure is typical of benthic communities in the CNS. Overall the community showed a high diversity with good abundances and high levels of similarity between samples. The habitat investigation showed no evidence of bacterial mats, gas seepages or MDAC in the depressions surveyed demonstrating they were unlikely to represent examples of Annex I habitats.
Blackbird Fugro (2013) (Map Ref. 2)	This survey targeted the area around two proposed well locations at the Blackbird field. Seabed video / stills were collected from four locations using drop down equipment and two transects were examined using a towed camera system (some grab samples were taken but never analysed). Water depth in the area of the survey was between 105 m and 114 m with a number of depressions observed in the area. These were up to 165 m in diameter and up to 2.2 m in depth. Some objects were detected inside these depressions but there was no evidence for the existence of MDAC or signs of escaping gas. Two biotope complexes were recorded in the survey area; 'circalittoral fine mud (A5.36)'; and 'circalittoral mixed sediment (A5.44)'. The 'circalittoral fine mud' biotope complex was recorded at the majority of stations, while a patch of 'circalittoral mixed sediments' was encountered at a single location. No Annex I habitats were identified. The 'circalittoral fine mud' biotope was considered to comprise elements of the OSPAR habitat 'sea pens and burrowing megafauna communities'. This habitat is transposed as a Priority Marine

Location/Field	Description
	Feature (PMF), for which Marine Protected Areas (MPAs) may be designated in Scottish offshore waters. However, the density of the sea pens observed was not considered sufficient to explicitly classify the area as 'sea pen and burrowing megafauna communities', and therefore the potential for this area to be selected to be representative of this habitat PMF is low.
Blackbird Fugro (2012) (Map Ref. 3)	The environmental component of this work targeted four well locations, with the main objective of collecting acoustic data over the sites with ground truthing stills and grab samples. The sediments across the survey area were interpreted to predominantly comprise silty sand with occasional patches of medium-high reflectivity suggesting coarser sediments in the area. Approximately 230 depressions / pockmarks of varying size were identified within the survey area. In addition, a single large depression (180 m x 380 m), characterised by the presence of several small depressions and by a large object (12.0 m x 11.0 m x 1.4 m) in its centre, was identified. The benthic communities were generally dominated by polychaetes (mainly *Paramphinome jeffreysii*). The communities exhibited high diversity across all samples. The area was classified under a single EUNIS classification as 'Circalittoral Muddy Sand' although the epifaunal community was described as relatively depauperate, consisting mainly of sea pens (*Pennatula phosphorea*) and sparsely distributed megafaunal burrows. Although an increase in faunal diversity and abundance was observed within the pockmarks these areas were not considered as separate habitats due to their small areal coverage. No Annex I habitats were considered to be present.
Brodgar pipeline route Fugro (2018) (Map Ref 5)	Geophysical, geotechnical and habitat assessment surveys were conducted over a length of *c*. 4 km, with a corridor width of 500 m. Water depths along the route ranged from 134 m and 136 m. Sediments in the area were described as mud with varying proportions of shell fragments. There is a potential for the presence of the OSPAR listed threatened and/or declining habitat 'Sea pens and burrowing megafauna communities' to occur within the survey area, due to the presence of sea pens and megafaunal burrows.

4.2 Physical Environment

The type and distribution of marine life is influenced by the physical conditions of the surrounding environment, biological interactions, and anthropogenic activities. These physical factors, which include currents, tides, waves, temperature, salinity, and wind also influence the fate and behaviour of emissions and offshore discharges (planned and unplanned) from vessels and installations, and the risks associated with them.

4.2.1 Bathymetry

Bathymetry around the proposed Buchan Redevelopment Project area is shown in Figures 4-2, 4-3 and 4-4. Water depths range from *c.* 107 – 111 m at the proposed Western Isles FPSO location, between 84.4 – 121.4 m along the potential gas pipeline route to the Ettrick PLEM (Benthic Solutions Ltd, 2021c) and between 108.8 – 136.7 m along the potential gas pipeline route to the Tweedsmuir manifold (Benthic Solutions Ltd, 2021e).

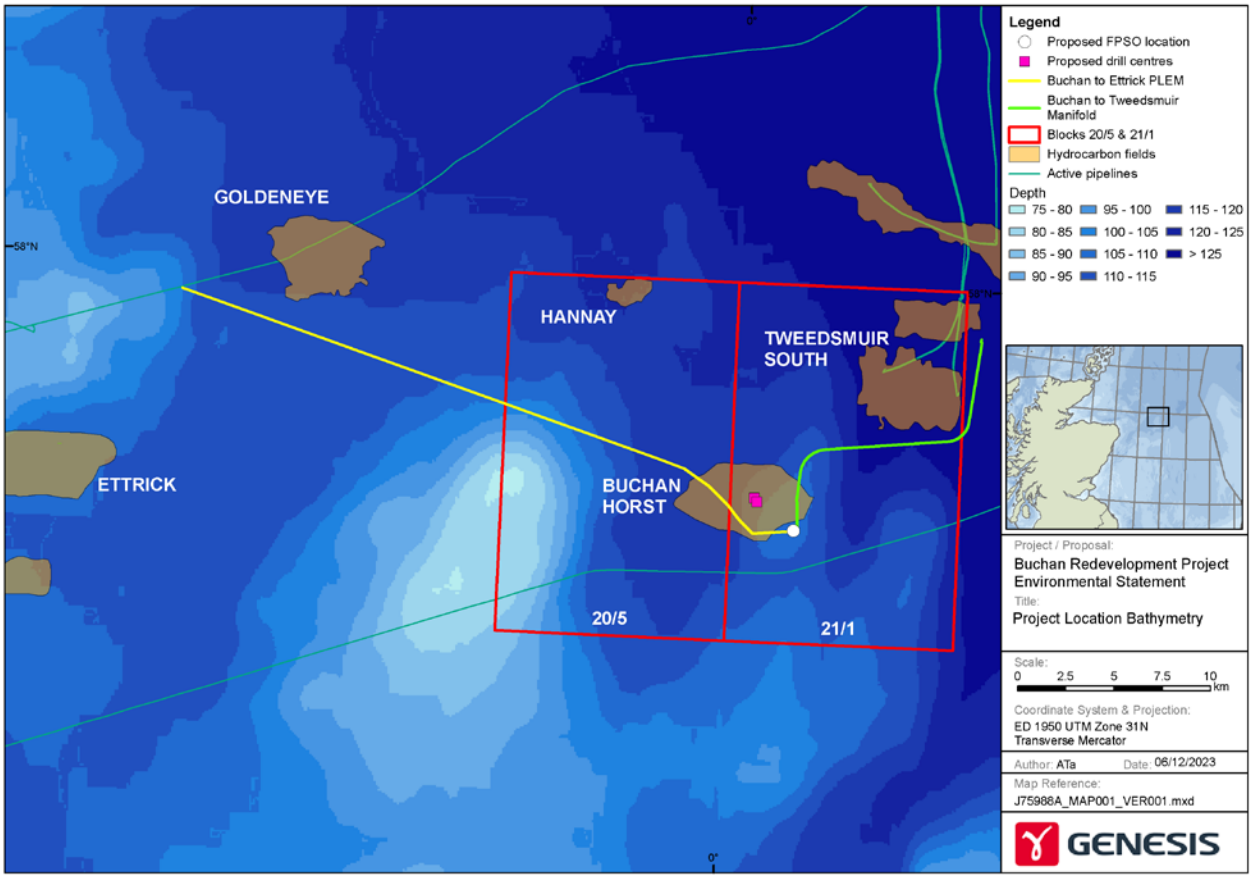


Figure 4-2: Bathymetry in the vicinity of the proposed Buchan Redevelopment Project.

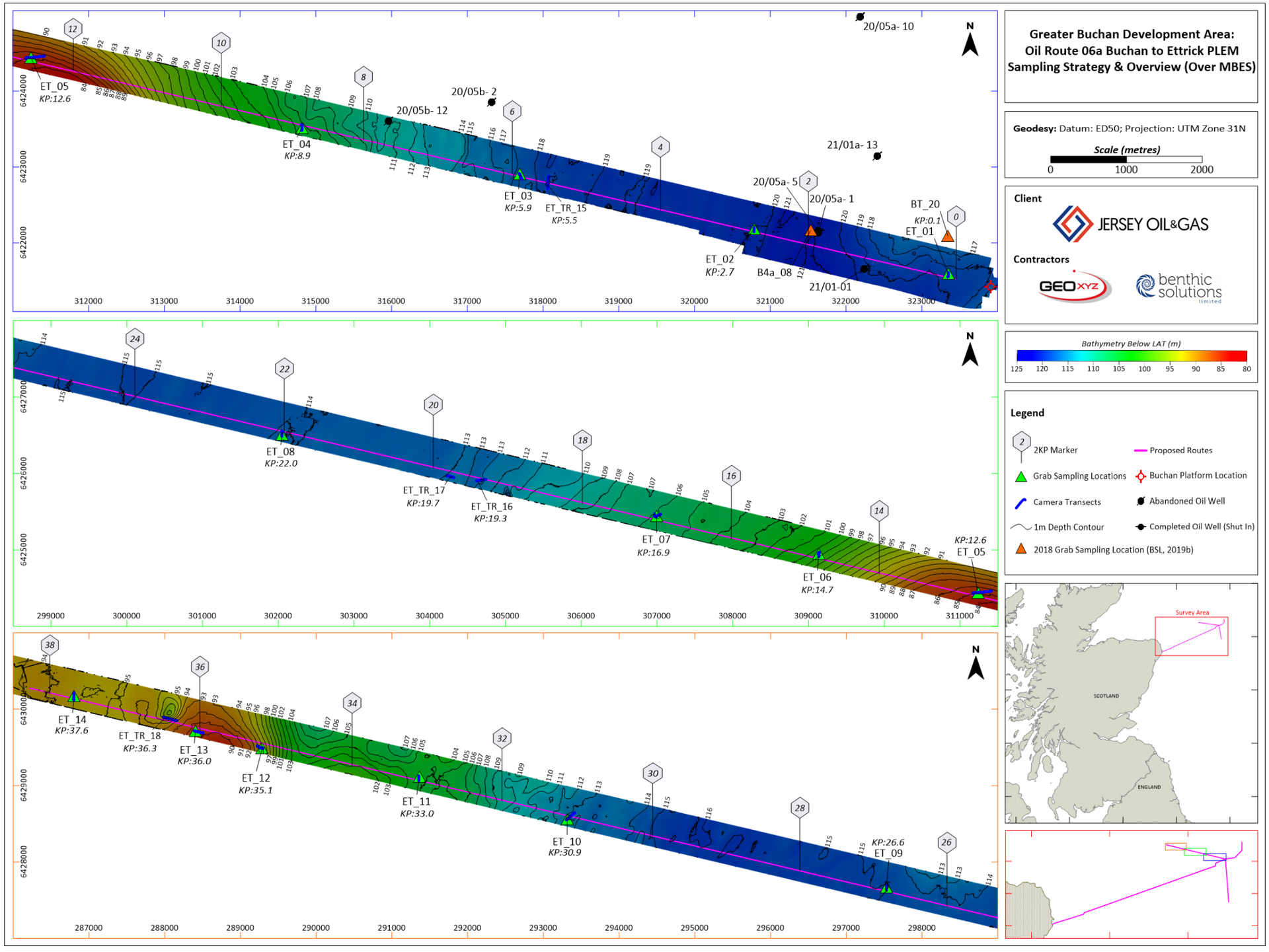


Figure 4-3: Bathymetry along the Buchan to Ettrick PLEM route (Benthic Solutions Ltd, 2021b).

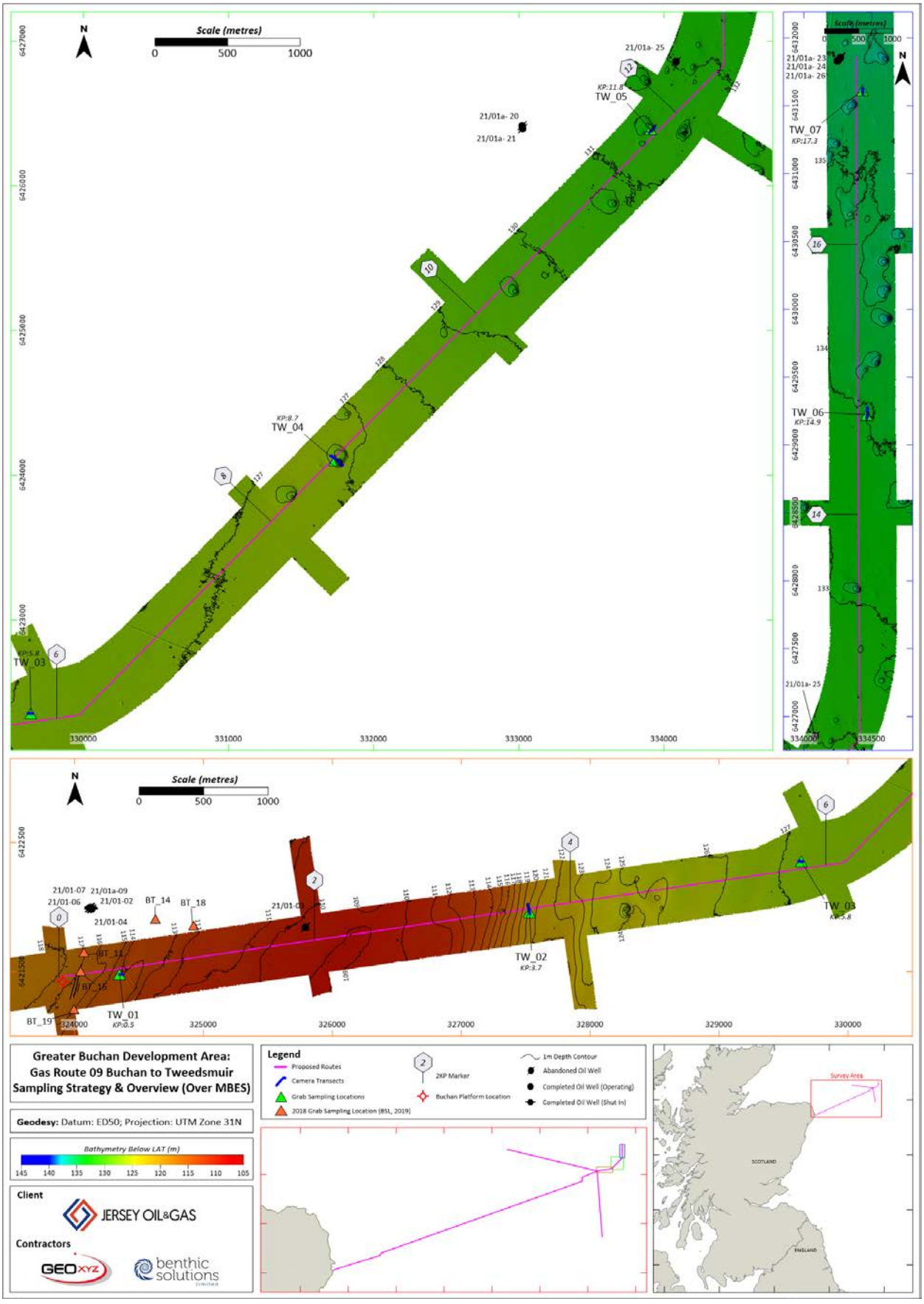


Figure 4-4: Bathymetry along the Buchan to Tweedsmuir route (Benthic Solutions Ltd, 2021e).

4.2.2 Water Masses, Currents and Tides

Water masses, local current speeds and direction all influence the transport, dispersion and ultimate fate of marine discharges, nutrients, plankton, and larvae (OSPAR, 2010).

The major water masses in the North Sea can be classified as Atlantic water, Scottish coastal water, Northern North Sea water, Norwegian water, CNS water, Southern North Sea water, Jutland water and Channel water (Turrell, 1999).

The proposed Project area is located in the area influenced by the Northern North Sea water mass (Figure 4-5). The predominant regional current in the CNS originates from the vertically well-mixed coastal water and Atlantic water inflow of the Fair Isle/Dooley current, which flows around the north of the Orkney Islands and into the North Sea.

Typical current speeds in the CNS are 0.1 m/s and the maximum current speed during mean spring tide is between 0.4 and 0.5 m/s. The mean spring tidal range is between 0.1 - 1.0 m (DESNZ, 2022).

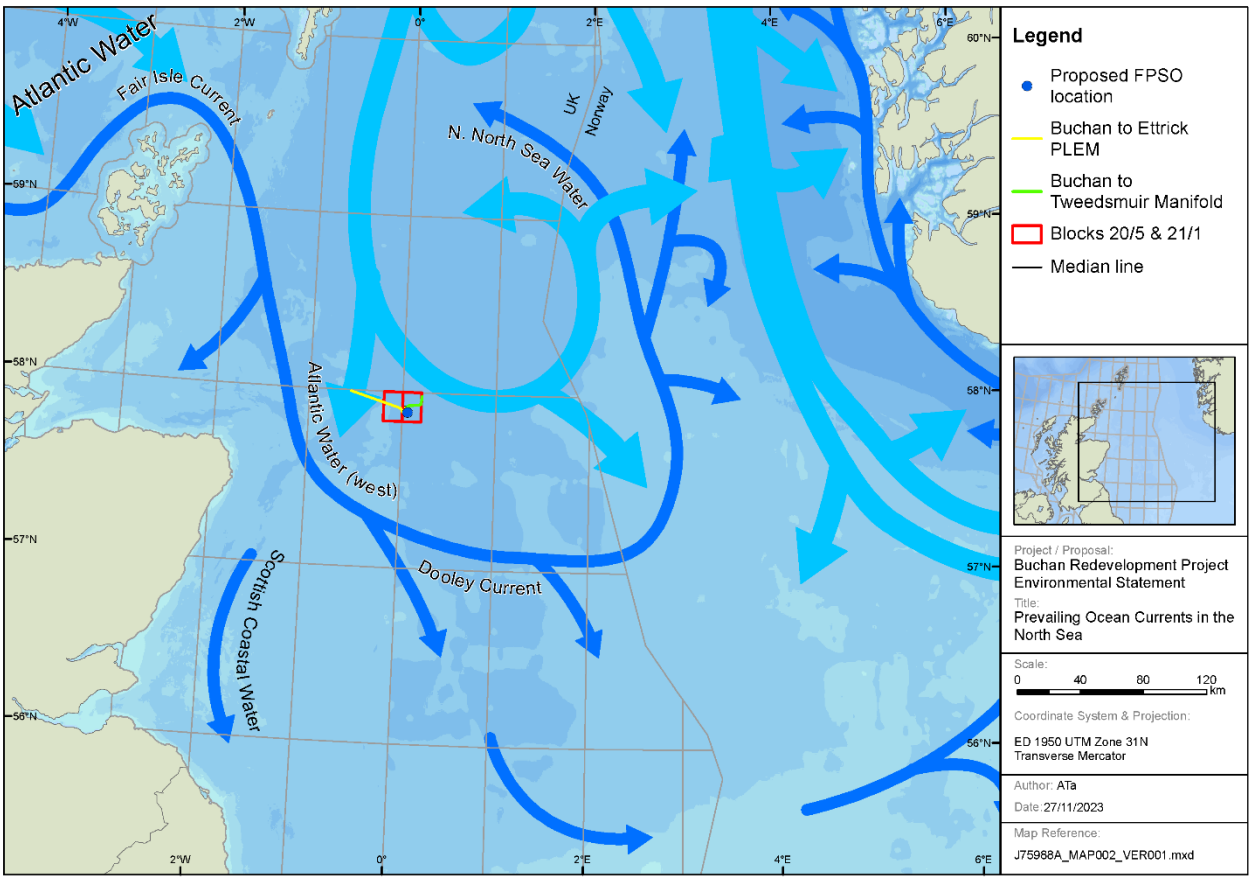


Figure 4-5: General circulation in the North Sea (Turrell *et al*., 1999).

4.2.3 Wind and Waves

Wind direction and speed directly influence the transport and dispersion of atmospheric emissions from a development. These factors are also important for the dispersion of marine discharges, including oil spills, influencing the movement, direction and break up of substances on the sea surface. The UK is subject to strong maritime influences with coastal areas and island locations (Shetland and Orkney) being strongly impacted. The annual mean wind speed is 8.8 m/s at proposed project area (Scottish Government NMPi).

Waves are the result of wind action on the sea surface and wave size is dependent on the distance or fetch over which the wind blows. Rough seas are common in the North Sea, particularly from October to March. The annual mean wave power at the proposed project area 25.26 kW/m. The highest proportion of waves (65-70%) originate from a north, northwest, or south direction and the annual mean significant wave height at the project location is 2.1 m and (Figure 4-6; Saha *et al*., 2010; ABPmer, 2013).

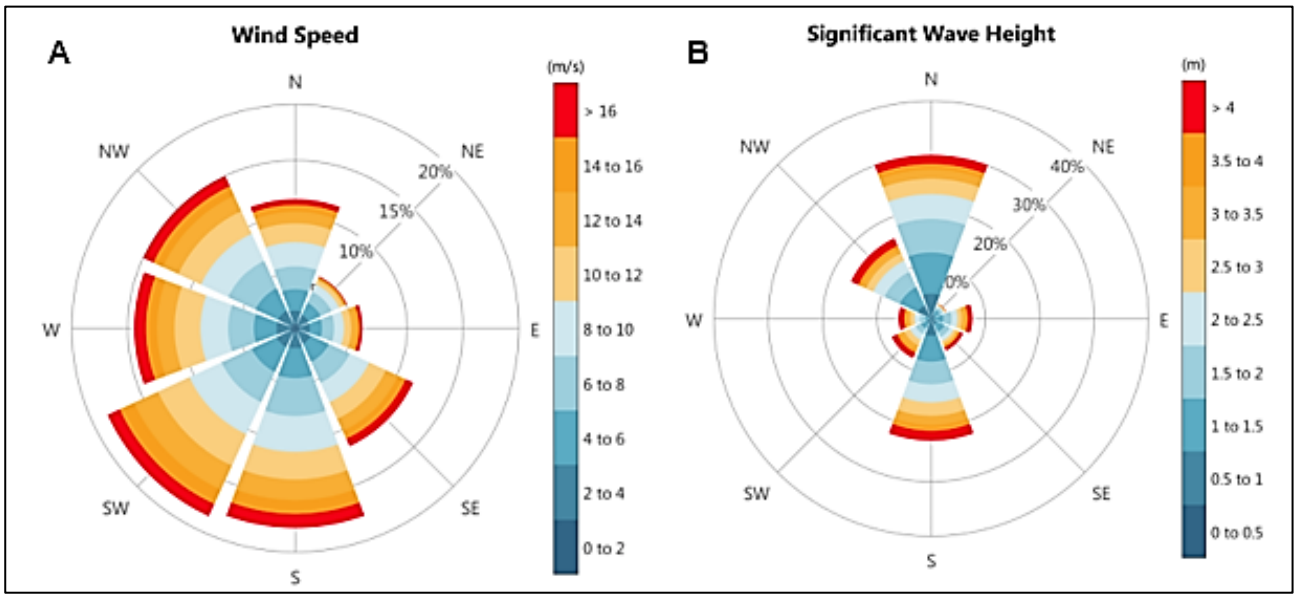


Figure 4-6: Wind rose (A), and Wave rose (B) for the Project area (ABPmer, 2013).

4.2.4 Sea Temperature and Salinity

The temperature of the sea affects both the properties of the seawater and the fates of discharges and spills to the environment. Seawater temperatures vary with season, depth, and proximity to land. Sea surface temperature and salinity within the proposed Project area are governed by the flow of oceanic Atlantic waters into the North Sea through the Fair Isle Channel (Turrell *et al.*,1999).

According to data collected between 1971 and 2000, the annual mean near-bed water temperature at the proposed project area is *c.* 8 °C and the annual mean seawater surface temperature at the is *c.* 10 °C (Berx & Hughes, 2009).

Fluctuations in salinity are largely caused by the addition or removal of freshwater to or from seawater through natural processes such as rainfall and evaporation. Salinity increases with water depth and distance from shore. The salinity of seawater around an installation has a direct influence on the initial dilution of aqueous effluents such that the solubility of effluents increases as the salinity decreases.

The water column in the CNS is vertically stratified during the summer months with a thermocline in August/ September, typically in the region of 50 m water depth. The strong stratification of the water mass in the CNS effectively isolates the bottom water and seabed fauna from the large-scale temperature changes that occur in the upper water column. Water temperatures remain reasonably constant throughout the winter months, with only a marginal seasonal variation in salinity that is typical of the open and western waters of the North Sea (Berx & Hughes, 2009).

Salinity in the proposed Buchan Redevelopment Project area shows little seasonal variation through the water column. Average salinity at the proposed Project area is *c.* 35.1 ‰ near-bed and *c.* 35.02 ‰ at the sea surface (Berx & Hughes, 2009).

4.2.5 Seabed Sediments

The seabed sediments around the proposed Buchan Project Redevelopment area are shown in Figure 4-7 (EMODnet, 2021). The sediments around the proposed Buchan Project Redevelopment area at the Buchan drill centres and Buchan to Tweedsmuir manifold pipeline route are predominantly comprised of offshore circalittoral mud. However, the middle and end section of the Buchan to Ettrick PLEM export pipeline comprises some areas of offshore circalittoral sand.

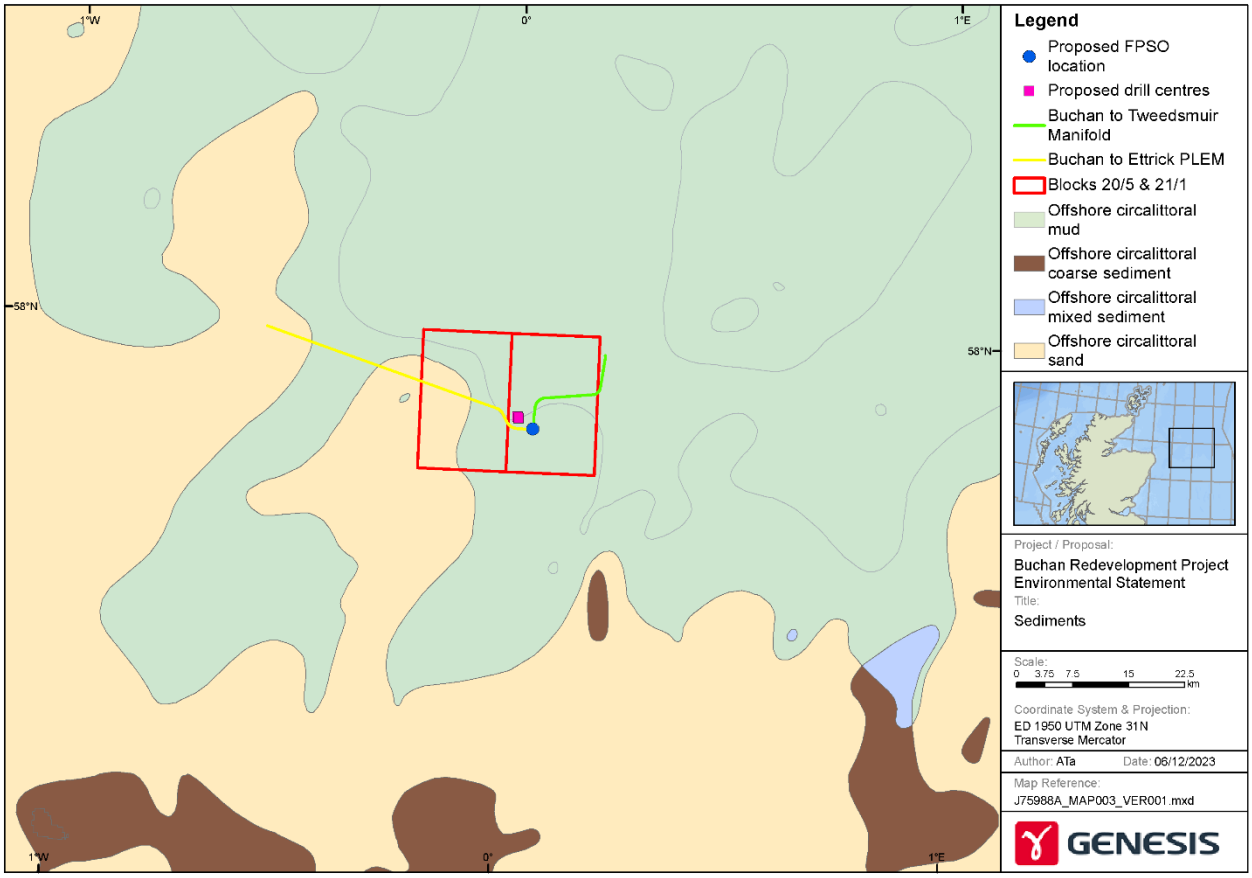


Figure 4-7: Modelled distribution of seabed sediments in the vicinity of the proposed Buchan Redevelopment Project (EMODnet, 2021).

4.2.5.1 Particle Size Distribution

The mean sediment particle size recorded in the 2018 survey across the Buchan and nearby Hannay Fields ranged from 0.01 mm to 0.13 mm demonstrating variability in the proportions of silts, clays, sands and gravels recorded around a generally sandy profile (Benthic Solutions Ltd, 2019b). The average sediment composition across the samples was:

- Fines: mean 53.33 % ±11.99 SD (standard deviation)
- Sand: mean 49.02 % ± 11.99 SD
- Gravel: mean 0.66 % ± 1.76 SD.

Fine sediments (< 63 µm) were present at all stations and exhibited a low overall coefficient of variation (24.73 %) as expected in the CNS region. In some areas coarser sediment with a higher proportion of shell debris (*Mytilus edilus*) was observed. This was expected to be induced by the presence of the infrastructure associated with the previous Buchan Development changing the near-seabed current flows and increasing the ecosystem diversity and from the dispersal of mollusc shells growing on the structures themselves. The Wentworth Classification[2] scale identified five different sediment classifications ranging from very fine silt to fine sand with 81 % of stations described as coarse silt. A comparison of the particle size distribution dataset by Wentworth Classification indicated that the majority of samples showed a bi-modal distribution spiking in the silt (i.e. silts and clays, 63 µm) and sand fractions (> 63 µm and < 200 µm). A small number of samples

2 The Wentworth Classification assigns a single sediment classification based upon the average size class for the distribution.

showed had percentage sands ranging from *c*. 68 % to 76 % which were though to be associated with the discharged cuttings from the upper sections of the historic wells.

4.2.5.2 Sediment Hydrocarbons

As the proposed Project is a development of an existing field, the seabed in the area has been impacted by previous drilling, installation and production activities.

Total Hydrocarbon Concentrations (THCs)

Across the 2018 samples, similar THC concentrations (ranging from 5.06 $mg.kg^{-1}$ to 21.0 $mg.kg^{-1}$) were noted between the samples taken (Benthic Solutions Ltd, 2019b). Results from analysis of these samples suggested there was no spatial distribution with respect to the proximity of the samples collected at these locations from the existing well infrastructure. In addition, THC concentrations at all these locations were well below the UKOOA 95th percentile (40.1 $mg.kg^{-1}$) and none of the levels were significantly higher than the mean of the reference locations (12.5 $mg.kg^{-1}$).

Higher THC concentrations (ranging from 5.59 mg.kg-1 to 407 $mg.kg^{-1}$) were recorded in a few samples taken however it should be noted that the THC concentrations exceeded the UKOOA 95th percentile in only two samples.

Similar concentrations of THC above the UKOOA 50th percentile have been recorded during the nearby 2021 environmental surveys conducted along the gas export pipeline routes, suggesting the concentrations are within the range of natural background variation for the CNS. THC concentrations were below the UKOOA 95th percentile for all samples taken during the 2021 gas export pipeline route surveys (Benthic Solutions Ltd, 2021b, Benthic Solutions Ltd, 2021d and Benthic Solutions Ltd, 2021f).

Polycyclic Aromatic Hydrocarbons (PAHs)

Total Polycyclic Aromatic Hydrocarbons (PAHs) concentrations within the samples taken in 2018 showed a similar pattern to the THC concentrations for those samples taken at least 50 m from the well locations in that the highest concentrations of PAHs were found in those samples taken around the Buchan template (ranged from 83.7 $ng.g^{-1}$ to 694 $ng.g^{-1}$). Note cuttings from five wells had previously been discharged at the Buchan template (to be recovered by Repsol Resources UK Ltd as part of the approved decommissioning programme). PAH concentrations in samples taken at the remote Buchan wells and along the pipeline route ranged from 70.1 $ng.g^{-1}$ to 388 $ng.g^{-1}$ and showed a direct negative correlation between concentration and distance from the wells. It should be noted that the PAHs in all these samples fell below the US Environmental Protection Agency toxicity reference value of 870 $ng.g^{-1}$ and the NOAA effect range low of 552 $ng.g^{-1}$ with the exception of one sample at the Buchan template: which had a PAH concentration of 694 $ng.g^{-1}$. However it should be noted that all of the PAH concentrations in the 2018 samples fell within the range of PAH values (20 to 74,700 $ng.g^{-1}$) recorded by Cefas for sediments surrounding North Sea oil and gas installations. Total PAHs concentrations from the samples taken in 2021 aligned with the 2018 sample results in that they showed a negative correlation with distance from the closest well suggesting low levels of historic drilling contamination may be evident across the survey area. The majority of PAH concentrations in the 2021 samples fell within the range of PAH values (20 to 74,700 $ng.g^{-1}$) recorded by Cefas for sediments surrounding North Sea oil and gas installations with the exception of seven sample stations across parts of the proposed Ettrick gas export pipeline survey corridor route, most notably between KP0 to KP6 and at stations ET_07 and ET_09 (Benthic Solutions Ltd, 2021d).

4.2.5.3 Existing Cuttings Piles

Figure 4-8 shows the location of the cuttings piles identified as part of the 2018 survey carried out to support Repsol Resources UK Ltd's decommissioning programme. The cuttings pile referenced as the 'five well cuttings pile' was drill at the Buchan template whilst the other cuttings piles are associated with individual wells.

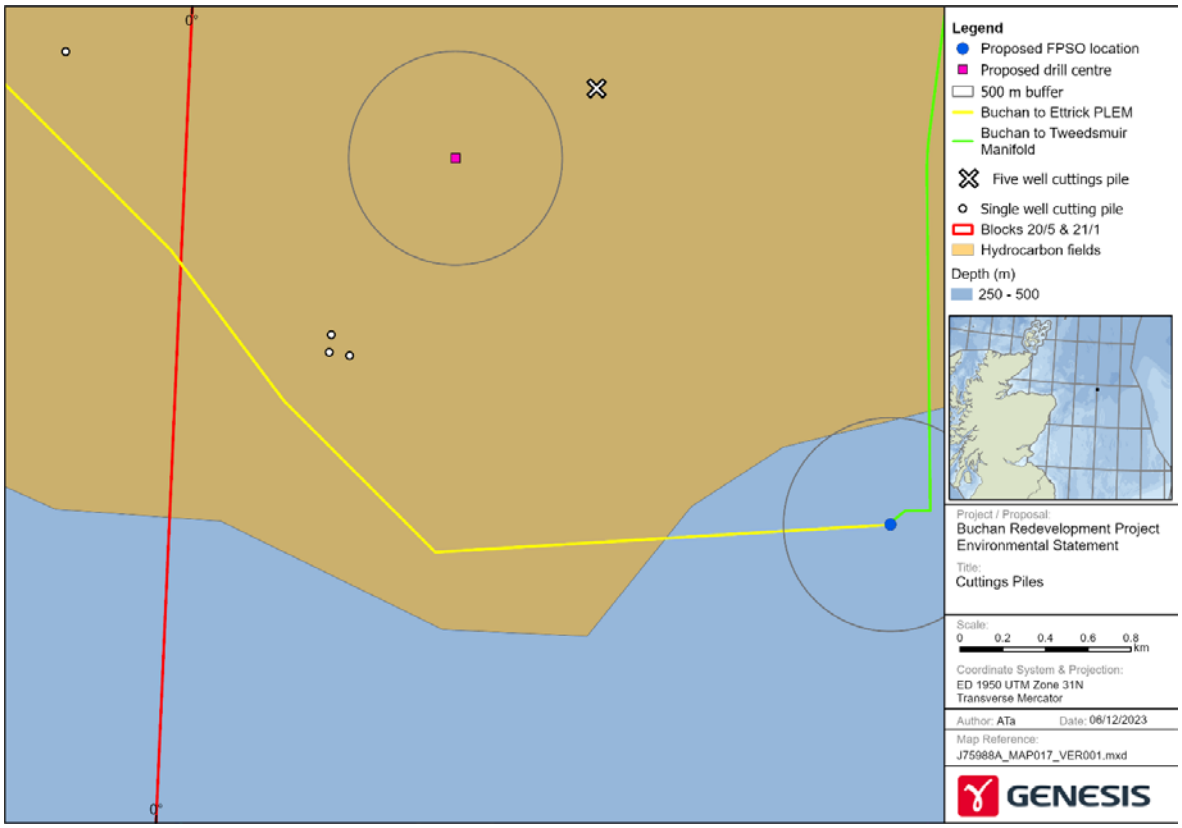


Figure 4-8: Location of historic cuttings piles relative to location of proposed Project infrastructure.

In summary the largest volume of cuttings was observed at the Buchan template, covering an area of 3,731 m^2 (Benthic Solutions, 2019c). These cuttings comprise discharges from five wells and are considered to comprise a cuttings pile. The pile measured 550 m long, 200 m wide, aligning with the prevailing current direction. The highest point of the pile was estimated to be approximately 1.3 m above the natural seabed. The pile height decreased rapidly to less than 50 cm above natural seabed at 15 m south of the template, while to the north of the template the pile height did not exceed 20 cm above the seabed. Oil content within the five well pile was estimated to be less than 1 te. Much smaller volumes of cuttings were observed at the remaining four locations (see Table 4-3).

Table 4-3: Characteristics of the existing cuttings piles in the vicinity of the proposed Project.

Well location	Cuttings area (footprint) (m^2)	Cuttings volume (m^3)	Highest point above natural seabed (m)	Number of wells	Area exceeding OSPAR 50 ppm (m^2)
Five well cuttings pile	3,731	828	1.3	5	68,000
Single well pile 1	68	60	-*	1	1,096
Single well pile 2	40	24	between 0.30 and 0.40	1	0
Single well pile 3	110	82		1	1,149
Single well pile 4	55	36		1	0
* Not reported, and expected the highest point at this well are expected to be less the other single well piles.					

4.3 Biological Environment

4.3.1 Plankton

Plankton are drifting organisms that inhabit the pelagic zone of a body of water and include single-celled organisms such as bacteria as well as plants (phytoplankton) and animals (zooplankton). Phytoplankton are the primary producers of organic matter in the marine environment and form the basis of marine ecosystem food chains. They are grazed on by zooplankton and larger species such as fish, birds, and cetaceans. Therefore, the distribution of plankton directly influences the movement and distribution of other marine species. Meroplankton includes the eggs, larvae, and spores of non-planktonic species (fish, benthic invertebrates, and algae). This meroplankton population may have a very different seasonal cycle depending on the life cycle strategy of the fish species and benthic organisms which inhabit the area.

The composition and abundance of plankton communities varies throughout the year; influenced by several factors including depth, tidal mixing, temperature stratification, nutrient availability, and the location of oceanographic fronts. Species distribution is directly influenced by temperature, salinity, water inflow and the presence of local benthic communities (Robinson, 1970; Colebrook, 1982). Seasonal stratification of the water column into layers of different temperatures can have an important impact on phytoplankton abundance. Phytoplankton numbers usually peak in the spring and there may be an additional, but smaller, peak in phytoplankton numbers during the autumn (Nielsen and Richardson, 1989). The seasonal timing of phytoplankton and zooplankton production has altered in recent decades with some species present up to four to six weeks earlier than twenty years ago, which affects predators such as fish. During this period there has been a significant increase in the presence of some warm water species, such as *Calanus helgolandicus* with a corresponding decline in some cool water species, e.g., *Calanus finmarchius* (OSPAR, 2010).

Zooplankton species richness is higher in the northern North Sea than in the southern North Sea and the community displays greater seasonal variability (Lindley & Batten 2002). The zooplankton community is dominated by calanoid copepods, although other groups such as *Paracalanus* and *Pseudocalanus* are also abundant. There is also a high biomass of Calanus larval stages present in the region. Euphausiids, *Acartia*, and decapod larvae are all important components of the zooplankton assemblage. Jellyfish are typically less abundant in northern and eastern coasts of the UK, although species commonly sighted include *Aurelia aurita*, *Cyanea capillata* and *Cyanea lamarckii* (Pikesley *et al*. 2014).

4.3.2 Habitat Type and Benthic Communities

Activities that result in disturbance to the seabed such as those involved in the proposed development can affect habitats and the associated benthic fauna (Clark, 1996).

4.3.2.1 Habitat Type

Applying the JNCC marine habitat classification, three main habitats were identified across the area surveyed in 2018 (Benthic Solutions, 2019a). This survey included the Buchan field and the nearby Hannay field. These habitat types are identified in Table 4-4 which also provides the corresponding European Nature Information System (EUNIS) classification. Similar habitats were identified along the two potential gas pipeline routes (Benthic Solutions 2021c; and 2021e). Figure 4-9 and Figure 4-10 provides photographs of some of the habitats observed during the 2018 and 2021 surveys (Benthic Solutions 2019a; 2021c; and 2021e).

Table 4-4: Habitat classifications.

Habitat	JNCC Marine Habitat Classification	JNCC Description	EUNIS Classification	EUNIS Description
Sandy silt with bioturbation and lebensspuren*	SS.SMu	Sublittoral cohesive mud and sandy mud communities	A5.3	Sublittoral mud
Sandy gravelly silt and fine shell debris	SS.SMx.OMx	Offshore circalittoral mixed sediment	A5.45	Deep circalittoral mixed sediment
Sandy silt with relic *Mytilus edulis* debris				
Sandy gravelly silt with occasional drop-stones				
Fine sand with relic shell material	SS.SSa.CFiSa	Circalittoral fine sand	A5.25	Circalittoral fine sand
*Lebensspuren are biologically formed sedimentary structures found in sediments including tracks, trails, burrows, borings, faecal casts and coprolite (fossilised faecal pellets).				

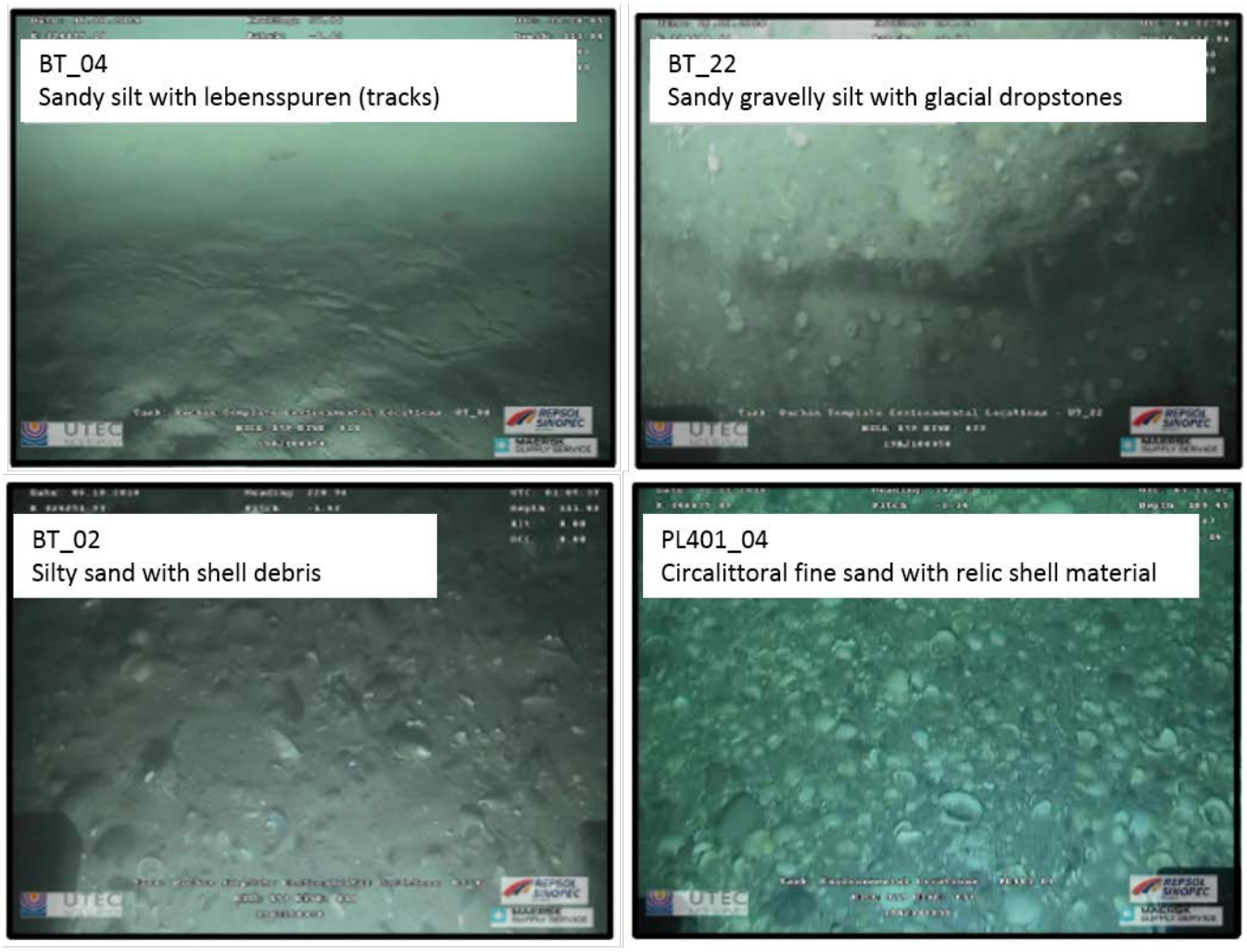


Figure 4-9: Photographs of different habitat types observed in the project area (Benthic Solutions Ltd, 2019b).

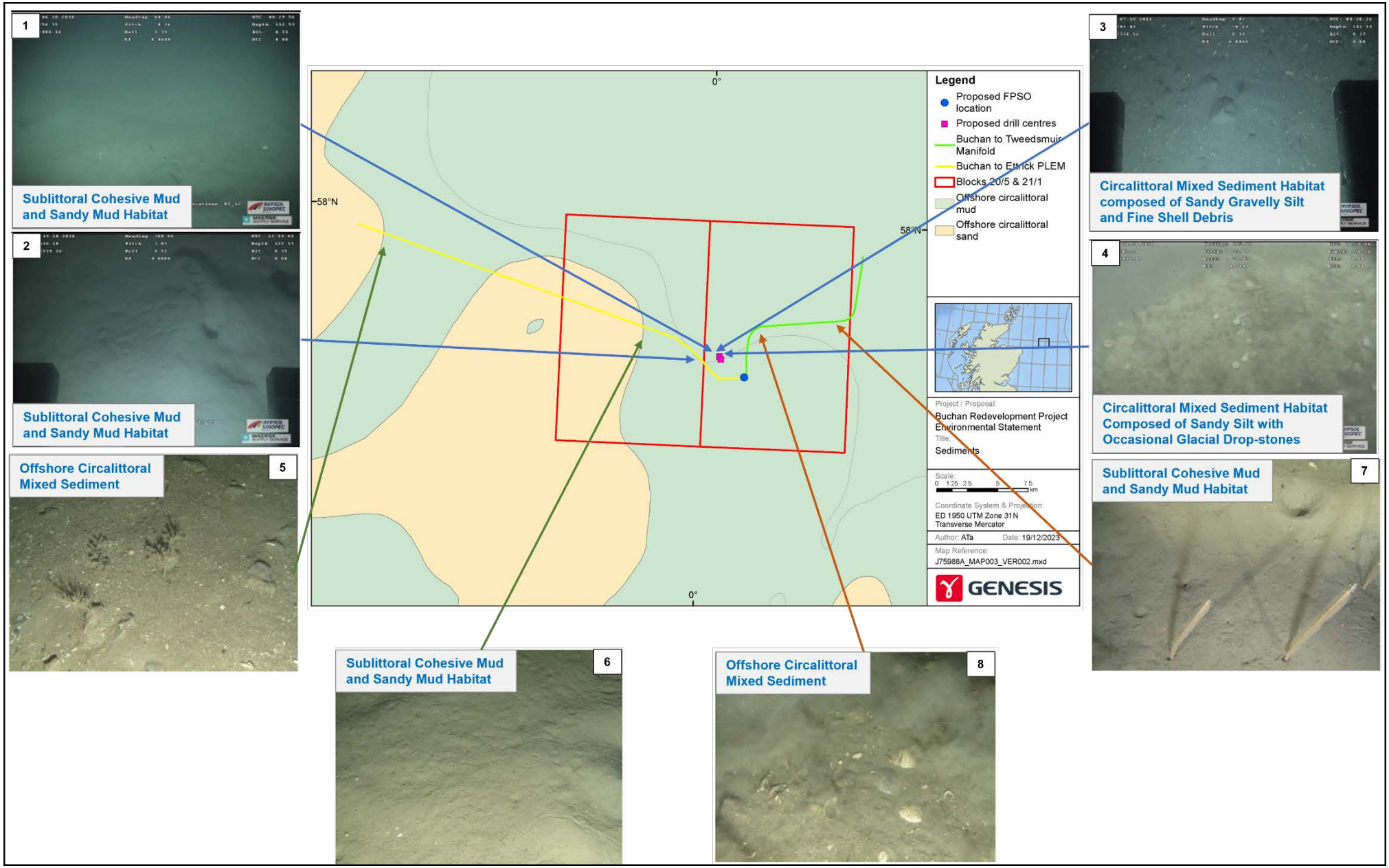


Figure 4-10: Seabed photographs taken in vicinity of the proposed project. Source: Photos 1-4 (Benthic Solutions Ltd., 2019b); Photos 5 & 6 (Benthic Solutions Ltd., 2021c); Photos 7 & 8 (Benthic Solutions Ltd., 2021e).

Sea Pen and Burrowing Megafauna Communities

The habitat 'Sea pen and burrowing megafauna communities' is considered an OSPAR threatened and / or declining habitat in the North Sea and within Scottish waters is also considered a Priority Marine Feature (PMF).

JNCC provides guidance (JNCC, 2014) on classification of OSPAR 'Sea pens and burrowing megafauna communities habitats'. These criteria take into account water depths, particle size analysis and presence of mud sediments (fine mud or sandy mud sediments, such as EUNIS A5.36 Circalittoral fine mud or A5.35 Circalittoral sandy mud biotope complexes), presence of multiple burrows or mounds from associated megafauna: burrows or mounds should be classified at least as "frequent" or higher on SACFOR (super abundant, abundant, common, frequent, occasional, rare and present) scale, where frequent represent (1-9 species for 10 m^2), and presence of certain faunal borrowing species. Sea pens may or may not be present.

The environmentally sensitive habitat of burrowing megafauna communities is present in some areas of the Buchan field with most stations classified as either having 'common' or 'frequent' burrows on the SACFOR scale and could therefore be considered as UK Habitat Feature of Conservation Importance of 'mud habitats in deep water' (Benthic Solutions, 2019a). The densities for large burrows were 3 per m^2 and 13 per m^2 for smaller burrows (< 3 cm). However, the survey report concluded that it was likely that the burrowing densities were over estimated due to inclusion of non-megafaunal species (polychaetes) and by counting multiple burrow openings made by the same individuals.

In areas along the gas pipeline route to the Ettrick PLEM, burrow frequency was also considered to be 'frequent' (Benthic Solutions, 2021c) whilst along the route to the Tweedsmuir manifold the densities were considered 'common' or 'frequent' (Benthic Solutions, 2021e). The reports associated with the two export routes concluded that both routes can be considered to represent 'sea pen and burrowing megafaunal communities'.

Though the report associated with the 2018 survey across the Buchan and Hanny fields (Benthic Solutions, 2019) suggested the number of burrows may be over estimated, in order to align with assessing the 'worst case' impact of the proposed activities, the ES assumes that the seabed in the area of the Buchan field also represents the habitat sea pen and burrowing megafaunal communities'.



Figure 4-11: Example of high density burrows along route to Ettrick manifold (Benthic Solutions, 2021c).

Pockmarks

The habitat 'Submarine structures made by leaking gases' is listed as an Annex I habitat under the EC Habitat Directive (92/43/EEC). These structures comprise methane-derived authigenic carbonates (MDAC) structures which take the form of rocks, pavements or pillars of carbonate cement (JNCC, 2014). MDAC is formed by the microbial anaerobic oxidation of methane coupled with sulphate reduction within the sulphate-methane transition zone which typically lies beneath the seabed surface immediately above the boundary between well-oxygenated aerobic sediments and underlying anaerobic sediments. As a by-product of this process, carbonate precipitates out into the pore spaces and binds together the surrounding sediments into a hard, rock-like substance (Judd *et al*., 2019). While MDAC may form in isolation in sandy substrate, it is often found in association with seabed depressions, known as pockmarks, which can form in muddy seabed when shallow gas is unable to escape freely from the sediment into the water column. As a result, the surficial sediments become gas-charged and, once sufficient pressure builds, the surface sediments become fluidised by the escape of the shallow gas and a pockmark is formed.

As part of the 2018 survey, pockmarks or depressions were observed at one of the stations located c. 15 km from the Buchan field (on PL401) however there was no evidence of MDAC such that the pockmarks were not considered to represent the habitat 'Submarine structures made by leaking gases' (Benthic Solutions, 2019a).

A possible pockmark depression was also observed at one location on the gas pipeline route to Ettrick (Figure 4-12; Benthic Solutions, 2021c). Ground truthing of the area revealed similar mud-dominated sediments to those observed elsewhere along the route but with high densities of relic shells and shell fragments, explaining the higher reflectivity observed. The relic shells were dominated by the chemotrophic indicator species, *Lucinoma borealis,* a bivalve commonly associated with pockmark communities (Dando *et al*., 2010). The area displayed no evidence of MDAC and therefore was not classified as the EC Habitats Directive habitat 'submarine structures made by leaking gases', but the presence of significant quantities of chemotrophic *Lucinoma borealis* shells suggests that the depression is an inactive pockmark.

A number of depressions were observed on the Buchan to Tweedsmuir route, however there was an absence of MDAC such that there was no evidence of the habitat 'Submarine structures caused by leaking gases' (Benthic Solutions, 2021e).

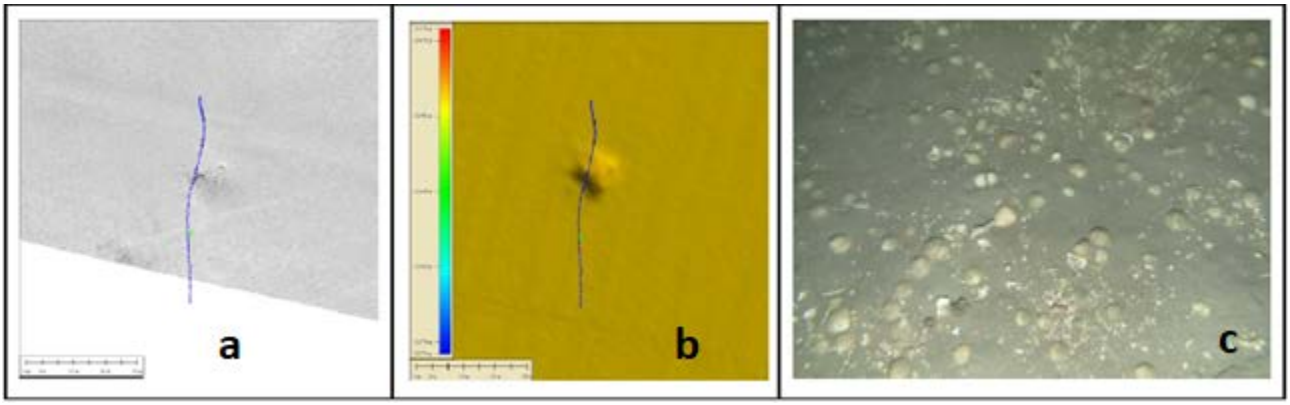


Figure 4-12: Example images of seabed depression observed on Buchan to Ettrick route (a) side scan sonar (b) bathymetry and (c) video (Benthic Solutions, 2021c).

4.3.2.2 Benthic Communities

Bacteria, plants, and animals living on or within the seabed sediments are collectively referred to as benthos. Species living on top of the sea floor may be sessile (e.g., seaweeds) or freely moving (e.g., starfish) and collectively are referred to as epibenthic or epifaunal organisms. Animals living within the sediment (e.g., clams, tubeworms, and burrowing crabs) are termed infaunal species. Semi-infaunal animals, including sea pens and some bivalves, lie partially buried in the seabed. The majority of marine benthic invertebrates exhibit a life cycle that includes a planktonic larval phase from which the bottom dwelling juvenile and adult phases recruit.

The dominant epifauna taxa found distributed across the mud habitat included sea pen species such as *Virgularia mirabilis* and *Pennatula phosphorea*. sand smelts (*Atherina presbyter*), starfish (*Asterias rubens*), and species of the family *Gobiidae* such as *lesueurigobius friesii* were all commonly observed throughout the site (Benthic Solutions Ltd., 2019b). Buchan and Hannay infrastructure was seen to be colonised by sessile fauna species such as anemones (particularly *Metridium senile* and *Urticina felina*) and the octocoral dead men's finger (*Alcyonium digitatum*).

Within the mixed sediment areas the drop-stones were colonised by a wide range of epifauna with observed species including the Devonshire cup coral (*Caryophyllia smithii*), hydroids (*Hydrozoa sp.*) and anemones (*Urticina felina*). The sediment was characterised by hermit crabs (*Paguridae sp.*) and urchins (*Gracilechinus acutus* and *Spatangus raschi*). No live specimens of *Arctica islandica* were observed either through the video or grab sampling campaign, however evidence off *A. islandica (*juvenile shells) were returned in the grab samples indicating they occur in the area.



Figure 4-13: Photographs of different fauna associated with the area (Benthic Solutions, 2019b).

No adult *Arctica islandica* (Species Feature of Conservation Interest, Scottish PMF, OSPAR threatened and/or declining species) were recorded in the survey areas, in either the grab samples or on the seabed video footage, nor was there any evidence of their distinct siphons. However, juveniles were recorded in the macrofaunal analysis of samples from the 2018 (Benthic Solutions, 2019b), and 2021 surveys (Benthic Solutions 2021b; Benthic Solutions 2021d; Benthic Solutions 2021f).

4.3.3 Fish and Shellfish

More than 330 fish species are thought to inhabit the shelf seas of the UKCS (Pinnegar *et al*., 2010). Pelagic species (e.g., herring, mackerel, blue whiting, and sprat (*Sprattus sprattus*) are found in mid-water and typically make extensive seasonal movements or migrations. Demersal species (e.g., cod, haddock (Melanogrammus aeglefinus), Sandeels (*Ammodytes tobianus*), sole (*Solea solea*) and whiting live on or near the seabed and similar to pelagic species, many are known to passively move (e.g., drifting eggs and larvae) and / or actively migrate (e.g., juveniles and adults) between areas during their lifecycle.

Fish occupying areas in close proximity to offshore oil and gas installations will be exposed to aqueous discharges and may accumulate hydrocarbons and other contaminating chemicals in their body tissues. The most vulnerable stages of the fish life cycle, to general disturbances such as disruption to sediments and oil pollution, are the egg and larval stages. Hence, recognition of spawning and nursery times and areas within a development area is important when considering potential disturbance caused by installation activities and when responding to accidental releases during operations.

Table 4-5 shows the approximate spawning and nursery times of some of the fish species known to occur in the vicinity of the proposed Buchan Redevelopment Project area, while Figure 4-14 and Figure 4-15 show the location of these areas (Coull *et al*., 1998; Ellis *et al*., 2012; Aires *et al*., 2014). The proposed redevelopment area is situated within International Council for the Exploration of the Sea (ICES) rectangles 44E9 and 44F0.

It should be noted that spawning and nursery areas tend to be transient and therefore cannot be defined with absolute accuracy (Coull *et al*., 1998; Ellis *et al*., 2012).

Of the fish species identified in the proposed Buchan Redevelopment Project area; anglerfish, herring, mackerel, ling, blue whiting, cod, horse mackerel, ling, saithe, Sandeels, whiting and spurdog have been assessed by NatureScot and Joint Nature Conservation Committee (JNCC) as Priority Marine Features (PMFs) in Scotland (SNH, 2016).

Table 4-5: Summary of spawning and nursery activity for species known to occur in the vicinity of the proposed Project area (Coull *et al*.,1998; Ellis *et al*., 2012; Aires *et al*., 2014).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anglerfish	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Blue whiting	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Cod	SNJ	S*NJ	S*NJ	SNJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
European hake	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Haddock	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Herring	N	N	N	N	N	N	N	SN	SN	SN	N	N
Lemon sole	N	N	N	SN	SN	SN	SN	SN	SN	N	N	N
Ling	N	N	N	N	N	N	N	N	N	N	N	N
Mackerel	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Nephrops	SN	SN	SN	S*N	S*N	S*N	SN	SN	SN	SN	SN	SN
Norway Pout	SNJ	S*NJ	S*NJ	SNJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ	NJ
Plaice	N	N	N	N	N	N	N	N	N	N	N	N
Sandeel	SN	SN	N	N	N	N	N	N	N	N	SN	SN
Spotted ray	N	N	N	N	S*N	S*N	S*N	N	N	N	N	N
Sprat	NJ	NJ	NJ	NJ	S*NJ	S*NJ	SNJ	SNJ	NJ	NJ	NJ	NJ
Spurdog	N	N	N	N	N	N	N	N	N	N	N	N
Whiting	NJ	SNJ	SNJ	SNJ	SNJ	SNJ	NJ	NJ	NJ	NJ	NJ	NJ

Key: S = Spawning; S* = Peak Spawning; N = Nursery; J = Juveniles (i.e., 0 group fish)
Blue highlight indicates higher egg concentrations.
Orange highlight indicates high intensity spawning grounds.
Source : Coull *et al.* (1998); Ellis *et al*. (2012); Aires *et al.* (2014).

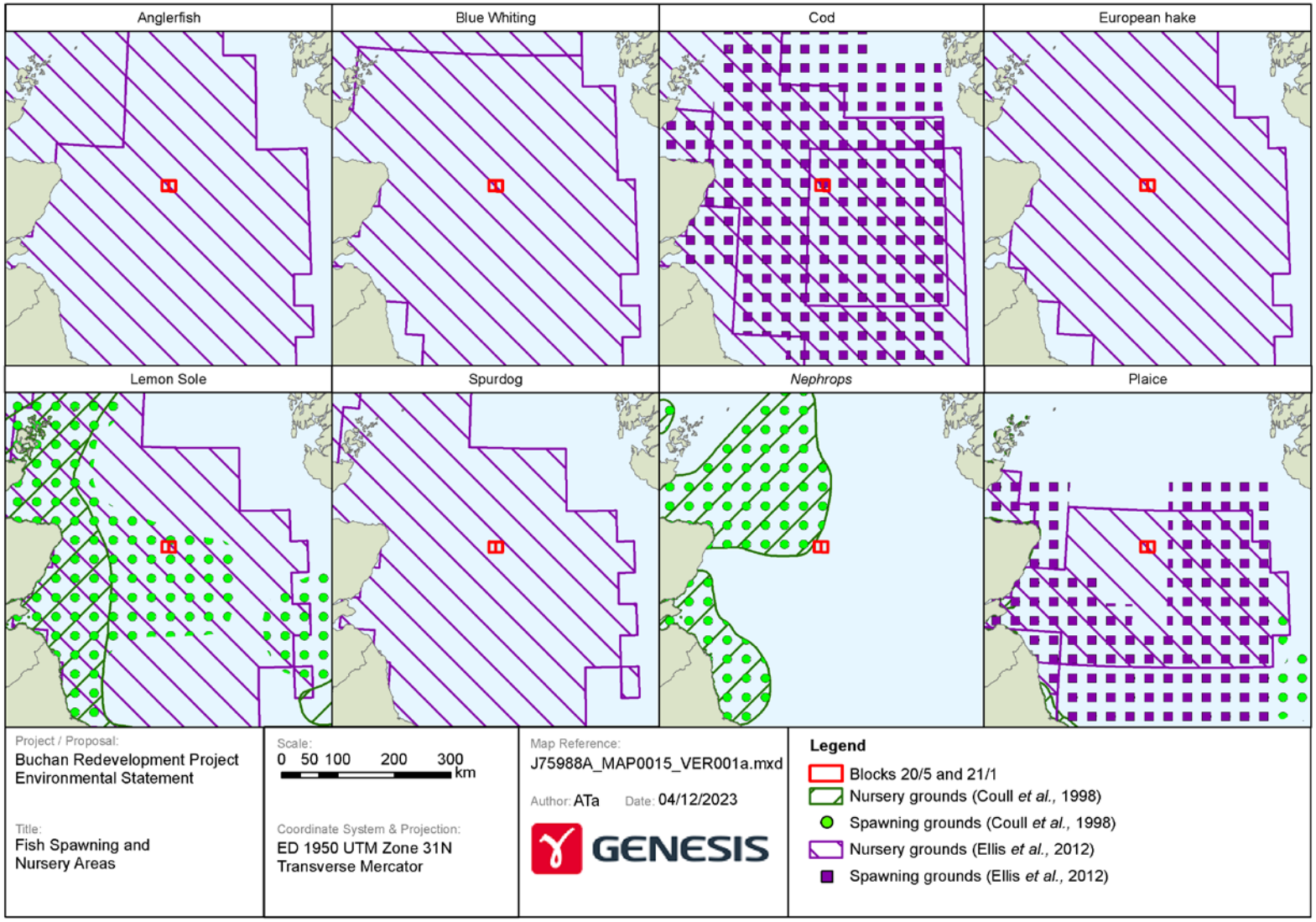


Figure 4-14: Nursery and spawning grounds of fish species in the vicinity of Blocks 22/17 and 22/18 (Coull *et al*., 1998; Ellis *et al*., 2012).

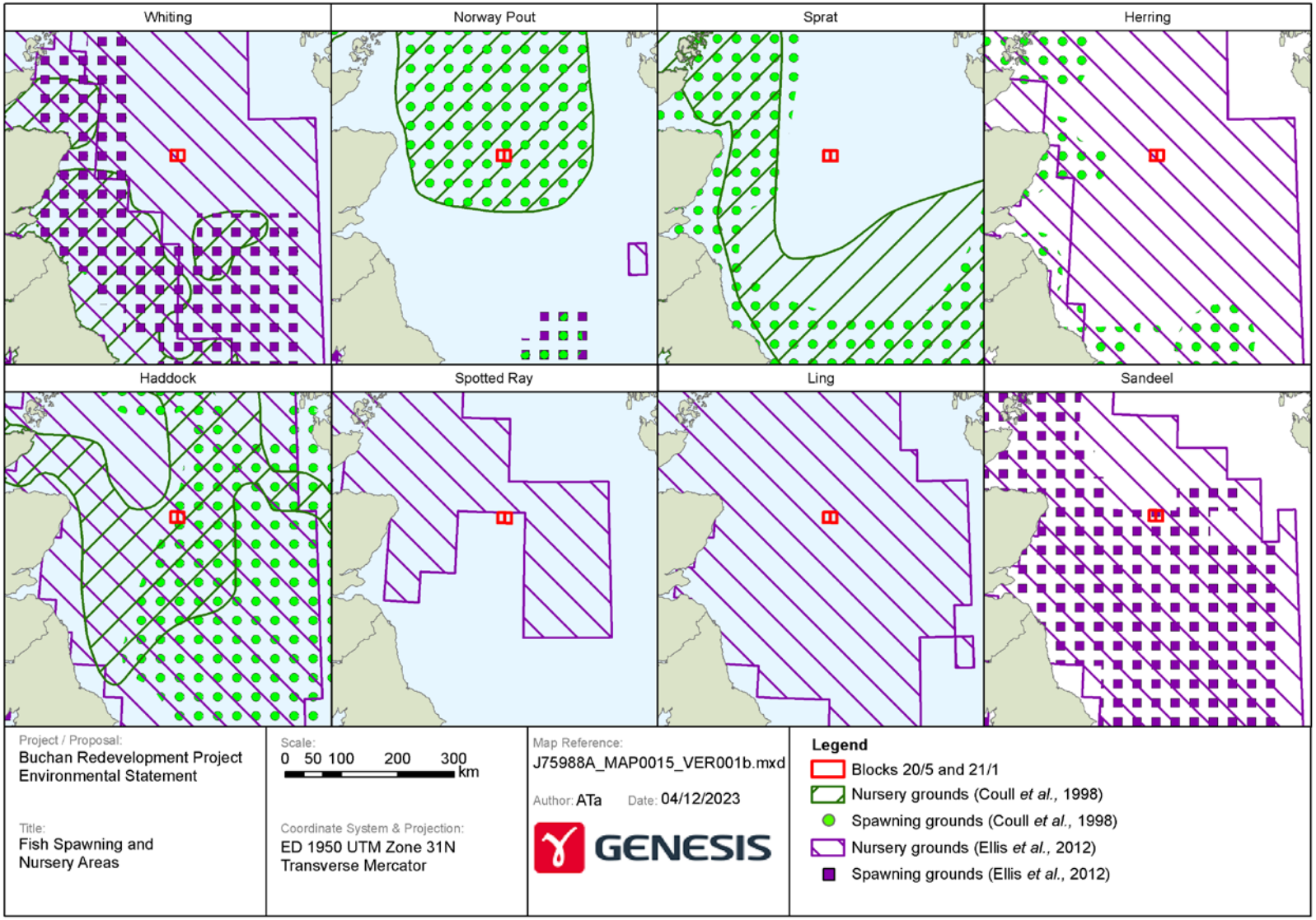


Figure 4-15: Nursery and spawning grounds of fish species in the vicinity of Blocks 22/17 and 22/18 (Coull *et al*., 1998; Ellis *et al*., 2012).

Cod are a species known to aggregate over specific grounds to spawn and form a group on a spawning arena where males hold small territories in a lek-like mating system. This aggregative behaviour together with seasonal site fidelity makes cod especially vulnerable to anthropogenic impacts. The proposed Buchan Redevelopment Project area is described as a relatively discreet 'recurrent' cod spawning area (González-Irusta *et al.,* 2016).

Species which may use the seabed of the proposed Buchan Redevelopment Project area include: lemon sole which, although most commonly found on stony seabed sediments, may occur and spawn on any substrate; plaice which are more common in shallower waters, but which may occur in deeper waters on mixed substrates; and sandeels which lay sticky clumps of eggs on sandy substrates with up to 10% silt/clay component (DESNZ, 2022).

The species which are most likely to spawn on the seabed in the proposed Buchan Redevelopment Project area include: *Nephrops* which live and spawn in shallow burrows in soft, muddy sediments (MarLIN, 2023); and Norway pout which occur on muddy substrates.

No periods of concern have been identified for Block 21/5 (NSTA, 2019).

4.3.4 Sharks, Skates and Rays

Due to their slow growth rates and hence delayed maturity and relatively low reproductive rates, sharks, skates, and rays (all members of the class Chondrichthyes) tend to be vulnerable to anthropogenic activities. Historically, Chondrichthyan species have been targeted by commercial fisheries (specifically common skate (*Dipturus batis*), long-nose skate (*Dipturus oxyrinchus*) and angel shark (*Squatina squatina*) and overfishing has significantly depleted their numbers in the North Sea. More recently these species tend to be taken as bycatch to such an extent that the stocks are still being depleted in UK waters. In order to implement future management and conservation measures, the UK has a shark, skate, and ray conservation plan and supported a binding OSPAR Recommendation (2010/6) targeted at furthering the protection of the common skate complex (*D. batis*), white skate (*Rostroraja alba*), angel shark (*S. squatina*) and basking shark (*Cetorhinus maximus*), in the OSPAR maritime area (UK Government, 2013).

Within the proposed Buchan Redevelopment Project area, there are nursery grounds present for common skate (*D. batis*), spotted ray (*Raja montagui*), spurdog (*Squalus acanthias*), and tope shark (*Galeorhinus galeus*) (Ellis *et al*., 2012).

Of the species identified in the area, spurdog is critically endangered and has been assessed by NatureScot and JNCC as PMFs in Scotland (SNH, 2016). Common skate are afforded the highest level of protection under the shark, skate, and ray conservation plan (UK Government, 2013).

4.3.5 Seabirds

The UK and its surrounding seas are very important for seabirds. The extensive network of cliffs, sheltered bays, coastal wetlands, and estuarine areas provide breeding and wintering grounds for nationally and internationally important bird species and assemblages. Approximately 26 species of seabird regularly breed in the UK and Ireland, as do a number of other water bird and wader species (DESNZ, 2022).

Predicted maximum monthly abundance of seabirds in the proposed Buchan Redevelopment Project area has been based on an analysis of the European Seabirds at Sea (ESAS) data collected over 30 years (Kober *et al*., 2010). Kober *et al* (2010) generated continuous seabird density surface maps using the spatial interpolation technique ‘Poisson kriging’ and fifty-seven seabird density surface maps were created to show particular species distribution in specific areas. Data from the relevant maps have been summarised for the proposed Buchan Redevelopment Project area in Table 4-6.

The data indicate that a number of seabird species are likely to occur in the area over the summer breeding season and winter months. Many species, e.g., Terns (*Sterna* spp.), overwinter out with the area, whilst other seabirds e.g., little auks (*Alle alle*), move to the area from more northerly breeding grounds to overwinter. For all species combined, a maximum of 125 seabirds are predicted to occur per km^2 during the breeding season (April to September), maximum of 37 seabirds predicted to occur per km^2 during summer months (July to August), whilst during the winter months (November to March) a maximum of 27 seabirds are predicted to occur per km^2 (Table 4-6).

Of the species expected to occur in the area; guillemot (*Uria aalge*), European storm petrel (*Hydrobates pelagicus*), Manx Shearwater (*Puffinus puffinus*), and Sandwich Tern (*Sterna sandvicensis*) are afforded protection by the European Commission (EC) Birds Directive (Annex I).

Recent seabird distribution maps produced by Waggit *et al* (2019) indicate the presence of Northern Fulmar at a moderate density of *c.* 1.55 animals/km^2, Black-legged Kittiwake, Common Guillemot, and Northern Gannet at low-moderate densities (*c.* 0.95 – 1.24 animals/km^2), and Atlantic Puffin, European Storm Petrel, Great Skua, Herring Gull, and Razorbill all at low densities (*c.* 0.31 – 0.95 animals/km^2) around the proposed Buchan Redevelopment Project area (Waggit *et al*., 2019).

Table 4-6: Predicted monthly seabird surface density at the proposed Project area (maximum number of individuals/km^2) (Kober *et al*., 2010).

Species	Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern Fulmar	Breeding												
	Winter												
Sooty Shearwater	Summer												
Manx Shearwater	Breeding												
European Storm-petrel	Breeding												
Northern Gannet	Winter												
Arctic Skua	Breeding												
	Additional												
Long-tailed Skua	Additional												
	Additional												
Great Skua	Breeding												
	Winter												
Black-legged Kittiwake	Breeding												
	Winter												
Black-headed Gull	Breeding												
Great Black-beaked Gull	Breeding												
	Winter												
Common Gull	Breeding												
	Winter												
Lesser Black-backed Gull	Breeding												
	Winter												
Herring Gull	Winter												
Arctic Tern	Breeding												
Common Guillemot	Breeding												
	Additional												
	Winter												
Razorbill	Breeding												
	Additional												
	Winter												
Little Auk	Winter												
Atlantic Puffin	Breeding												
	Winter												
ALL species combined	Breeding												
	Summer												
	Winter												
Key Not recorded		≤1.0	1.0 – 5.0		5.0 – 10.0			10.0 - 20.0			20.0 - >30.0		

Seabirds are generally not at risk from routine offshore oil and gas production operations. However, they may be vulnerable to pollution from less regular offshore activities such as accidental hydrocarbon discharges. Oily surface pollution can cause direct toxicity to birds through ingestion and / or hypothermia as a result of the birds' inability to waterproof their feathers.

Seabirds will generally be most vulnerable to the impacts of an oil spill during the post-breeding season (July to September) when breeding birds disperse away from their breeding colonies into the North Sea. Some species, (e.g., guillemots and razorbills), rapidly moult their wing feathers and become flightless for approximately six weeks and consequently spend large amounts of time on the water surface. This significantly increases their vulnerability to the impacts of oil between July and September.

Fulmars (*Fulmarus*. *glacialis*) and auks (*Alcidae* spp.) may be particularly vulnerable to surface pollutants as they spend the majority of their time on the surface of the water. Gulls and terns are less vulnerable as they spend a larger proportion of their time flying and therefore less time on the sea surface (Stone *et al*., 1994).

Using survey data from 1995 – 2015, a Seabird Oil Sensitivity Index (SOSI) has been published (JNCC, 2017). The purpose of the index is to identify areas where seabirds are likely to be most sensitive to oil pollution by considering factors that make a species more or less sensitive to oil-related impacts. Data were collected from a wide survey area extending beyond the UK Continental Shelf using boat-based, visual aerial, and digital video aerial survey techniques.

This seabird data were combined with individual seabird species sensitivity index values. These index values are based on a number of factors which are considered to contribute towards the sensitivity of seabirds to oil pollution. Factors such as:

- Habitat flexibility (a species ability to locate to alternative feeding sites);
- Adult survival rate;
- Potential annual productivity; and
- The proportion of the biogeographical population in the UK (classified following the methods developed by Certain *et al* (2015).

The combined seabird data and species sensitivity index values are subsequently summed at each location to create a single measure of seabird sensitivity to oil pollution. This is presented as a series of fine scale density maps for each month that show the median, minimum, and maximum seabird sensitivity to oil pollution, and an indication of data confidence. The index is independent of where oil pollution is most likely to occur; rather, it indicates where the highest seabird sensitivities might lie if there were to be a pollution incident.

The mean sensitivity SOSI data for the proposed Buchan Redevelopment Project area is shown in Table 4-7. For blocks with 'no data', an indirect assessment has been made based upon guidance from JNCC (JNCC, 2017) where possible. In November (Block 21/1) it was not possible to fill the data gap in some Blocks.

As can be seen from the data available and the indirect assessment, the sensitivity of seabirds to surface pollution within the proposed Buchan Redevelopment Project area varies throughout the year. For the majority of Blocks, sensitivity is low to medium throughout the year. Sensitivity is extremely high in January for Blocks 20/5 and 21/1 but is also very high in some Block 21/1 in March.

Table 4-7: SOSI Indirect Assessment for the proposed Buchan Redevelopment Project area Blocks (JNCC, 2017).

Block	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20/2	4*	5	5	5*	5*	5	4	5	5	5*	4*	4
20/3	5*	5*	5	5*	5*	5	4	5	5	5*	5*	5
20/4	4*	5*	5	5*	5*	5	4	5	5	5*	4*	4
20/5	1	1*	3	4*	5*	5	5	5	5	5*	4*	4
21/1	1	1*	2	2*	5*	5	5	5	4	4*	N	1*
Key	1 Extremely High		2 Very High		3 High		4 Medium		5 - Low	N No Data		

Yellow shading – Indirect Assessment

** data gap filled using data from the same block in adjacent months.*

4.3.6 Marine Mammals

Marine mammals include mustelids (otters), pinnipeds (seals) and cetaceans (whales, dolphins, and porpoises). Marine mammals are vulnerable to the direct effects of oil and gas activities such as noise, contaminants, and oil spills. They may also be affected indirectly by activities that affect prey availability.

4.3.6.1 Pinnipeds

Two species of seal are resident in British waters: the grey seal (*Halichoerus grypus*) and the harbour seal (*Phoca vitulina*). Although both species are Annex II species, they are not listed on Annex IV of the EU Habitats Directive, and as such are not classified as EPS. Seals are protected in the UK under the Conservation of Seals Act 1970, and both species are considered Scottish PMFs.

Both grey seals and harbour (also called common) seals tend to frequent inshore waters but have been seen offshore from a number of platforms in the North Sea (Cosgrove, 1996).

During a study by Carter *et al* (2022) grey (n = 114: 45 male, 69 female) and harbour seals (n = 239: 107 male, 132 female) were tagged at 26 sites in the UK and Ireland between (2005 – 2019). Haulout counts were scaled to total population size for UK and Ireland using the mean estimated proportion of the population hauled-out during the survey window (and thus available to count). Total population size was then scaled to at-sea population size using the mean estimated proportion of time seals spend at-sea based off the telemetry data gathered during the study period.

Telemetry data were analysed at a 5 km^2 cell resolution, enabling the percentage of the at-sea population for the UK and Ireland (i.e. excluding hauled-out animals) present in each cell at any one time to be estimated. The resulting distribution maps indicate that both harbour seals and grey seals are unlikely to occur in the areas of operation (Carter *et al*., 2022; Figure 4-16).

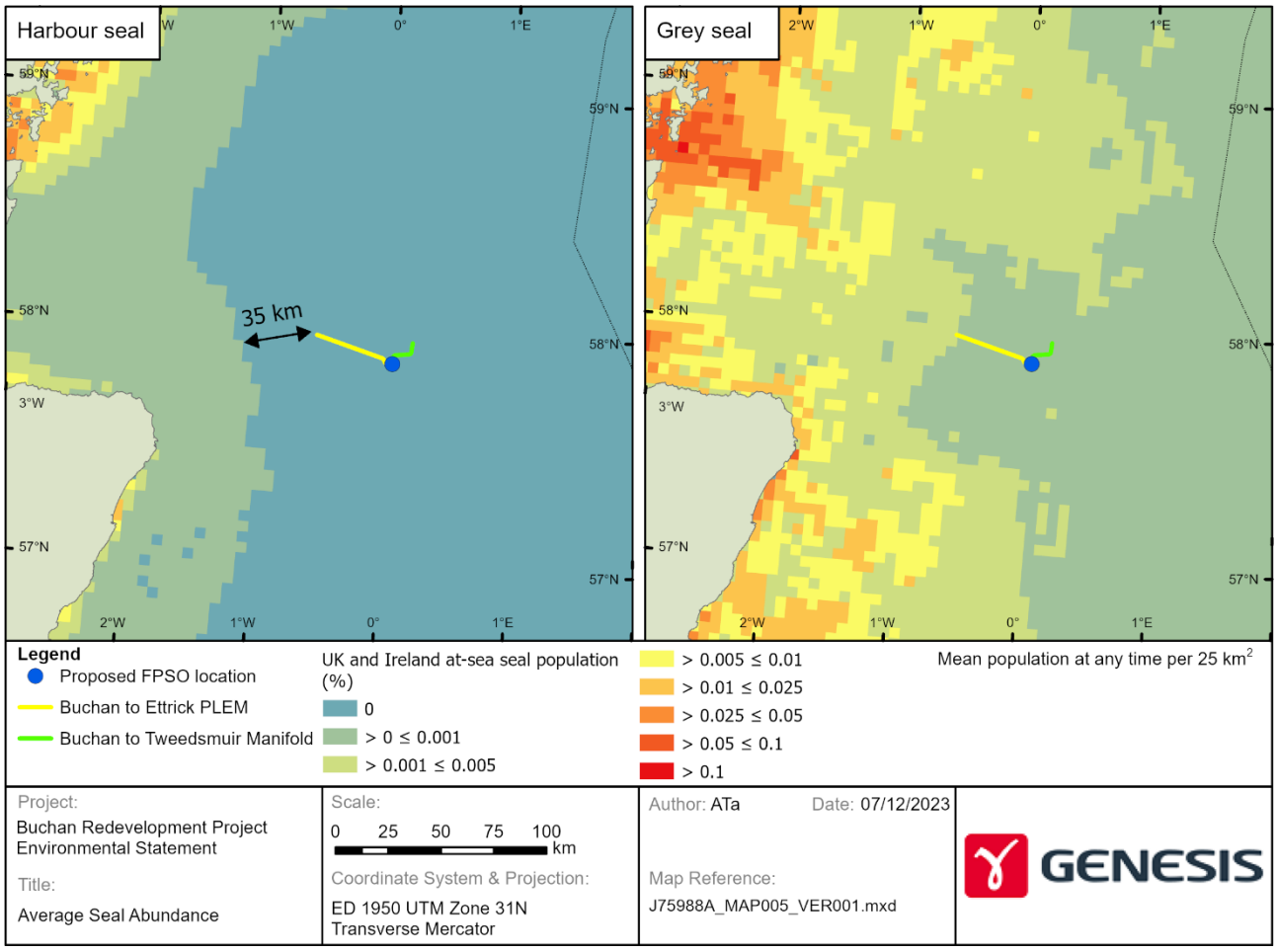


Figure 4-16: Mean UK and Ireland at-sea seal population distribution in the vicinity of the proposed Buchan Redevelopment Project (Carter *et al*., 2022).

4.3.6.2 Cetaceans

Many activities associated with the offshore oil and gas industry have the potential to impact on cetaceans by causing physical injury, disturbance, or changes in behaviour (JNCC, 2008).

A series of Small Cetacean Abundance in the North Sea (SCANS) surveys have been conducted to obtain an estimate of cetacean abundance in the North Sea and adjacent waters, the most recent of which is SCANS-III (Hammond *et al*., 2021). Aerial and shipboard surveys were carried out during the summer of 2016 to collect abundance data for the most commonly occurring cetacean species in the North Sea.

The proposed Buchan Redevelopment Project area lies within SCANS-III Blocks R and T. Aerial survey estimates of animal abundance and densities within this area are provided in Table 4-8. The data show that harbour porpoise, white-beaked dolphin, white-sided dolphin, and minke whale were all observed in both SCANS Blocks R and T during the SCANS-III survey. In addition, bottlenose dolphins were observed in SCANS Block R.

Table 4-8: Cetacean Abundance in SCANS-III Survey Blocks R and T (Hammond *et al*., 2021).

Species	Block R		Block T	
	Animal Abundance	Density (animals/km^2)	Animal Abundance	Density (animals/km^2)
Harbour porpoise	38,646	0.599	26,309	0.402
Bottlenose dolphin	1,924	0.030	N/A	N/A
White-beaked dolphin	15,694	0.243	2,417	0.037
Atlantic white-sided dolphin	644	0.010	1,366	0.021
Minke whale	2,498	0.039	2,068	0.032

The Joint Nature Conservation Committee (JNCC) has compiled an Atlas of Cetacean Distribution in Northwest European Waters (Reid *et al*., 2003) which gives an indication of the seasonal distribution and abundance of cetacean species in the North Sea. In agreeance with the SCANS-III survey data, the Reid *et al*. (2003) data show that harbour porpoise, bottlenose dolphin, white-beaked dolphin, white-sided dolphin, and minke whale have been observed in the area of the proposed Buchan Redevelopment Project (Table 4-9). All cetaceans are European Protected Species (EPS) and are listed under Annex IV of the European Union (EU) Habitats Directive. Harbour porpoise are granted further protection under Annex II of the EU Habitats Directive.

Table 4-9: Seasonal cetacean sightings within the proposed Buchan Redevelopment Project area.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Harbour porpoise	1	1	1	1	1	2	3	2	2	1	1	1
Bottlenose dolphin	1				1	1	1	1	1			
White-beaked dolphin		1	1			2	3	3	3	3		2
Atlantic white-sided dolphin							1	1				
Minke whale						1	3	1	1			
Key: 1 = Low; 2 = Moderate; 3 = High.												

Recent cetacean distribution maps produced by Waggit *et al*. (2019) indicate the presence of White-beaked dolphin in moderate densities (*c.* 0.565 animals/ km^2), Harbour porpoise in low-moderate densities (*c.* 0.339 animals/km^2), and Killer whale, Minke whale, Pilot whale, Risso's dolphin, and White-sided dolphin all in low densities (*c.* 0.113 – 0.339 animals/km^2) around the proposed Buchan Redevelopment Project area. Killer whale, Pilot whale, and Risso's dolphin were not identified by SCANS-III or Reid *et al*., (2003), however, the other species present were identified by all of three of the studies.

4.4 Protected Areas

A network of Marine Protected Areas (MPAs) is in place to aid the protection of vulnerable and endangered species and habitats through structured legislation and policies. These sites include SAC and SPA, which were designated in the UK under the EU Nature Directives (prior to January 2021) and are now maintained and designated under the Habitats Regulations for England and Wales, Scotland, and Northern Ireland.

Amendments to the Habitats Regulations mean that the requirements of the EU Nature Directives continue to apply to how European sites (SACs and SPAs) are designated and protected. The Habitats Regulations also provide a legal framework for species requiring strict protection, e.g., EPS.

There are no protected areas within 40 km of the proposed Buchan Redevelopment Project area. The closest protected area to the proposed Buchan FPSO location is the Turbot Bank NCMPA located *c.* 65 km to the southwest. The Turbot Bank NCMPA is also the closest protected area to any section of the proposed Buchan to Ettrick PLEM export pipeline route, located *c.* 64 km to the southwest. Conversely, Scanner Pockmark SAC is the closest protected area to the Buchan to Tweedsmuir manifold export pipeline route *c.* 54 km northeast of the route. The closest SPAs to the Buchan Redevelopment Project area are the Loch of Strathbeg SPA and the Buchan Ness to Colliestone Coast SPA. The protected areas in closest proximity to the proposed Buchan Redevelopment Project area are shown in Figure 4-17.

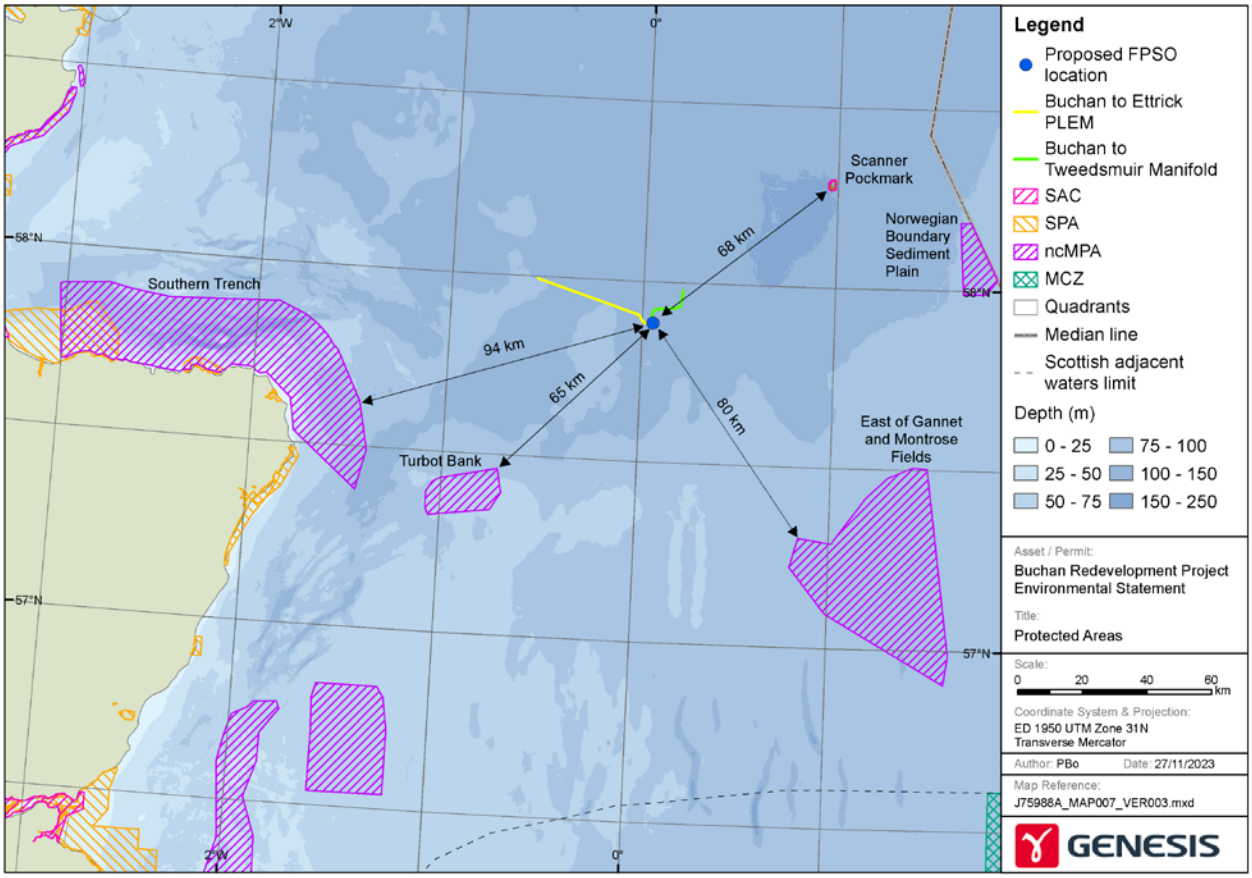


Figure 4-17: Protected areas in the vicinity of proposed Buchan Redevelopment Project.

4.5 Socio-Economic Environment

This section describes the socio-economic activities in the vicinity of the proposed Buchan Redevelopment Project, which primarily includes fishing, shipping and oil and gas operations.

4.5.1 Commercial Fisheries

ICES collates fisheries information for area units termed ICES rectangles measuring 30 nm by 30 nm. The importance of an area to the fishing industry is assessed by measuring the fishing effort (within each ICES rectangle) which is defined as the number of days (time) multiplied by the fleet capacity (tonnage and engine power). Due to the requirement by UK fishermen to report catch information such as total landings (includes

species type and tonnage of each), and location of hauls and catch method (type of gear / duration of fishing), it is possible to get an indication of the value of an area (ICES rectangle) to the UK fishing industry. It should be noted, however, that fishing activity may not be uniformly distributed over the whole area of the ICES rectangle.

The proposed Buchan Redevelopment Project location potentially spans two ICES rectangles: 44E9 and 44F0 (Figure 4-18). The proposed drill centres, the Western Isles FPSO location and the gas pipeline option to the Tweedsmuir manifold all occur within ICES rectangle 44F0 whilst the gas pipeline route to the Ettrick PLEM passes through ICES rectangle 44E9.

From Figure 4-18, it can be seen that a number of 500 m safety zones occur within ICES rectangle 44F0 and 44E9. On completion of the decommissioning activities at the Buchan and Hannay fields, Repsol Resources UK Limited will surrender the 500 m zones associated with those fields. The proposed Buchan Redevelopment Project will have two 500 m safety zones associated with it: one at the Western Isles FPSO and one encompassing the two drill centre locations.

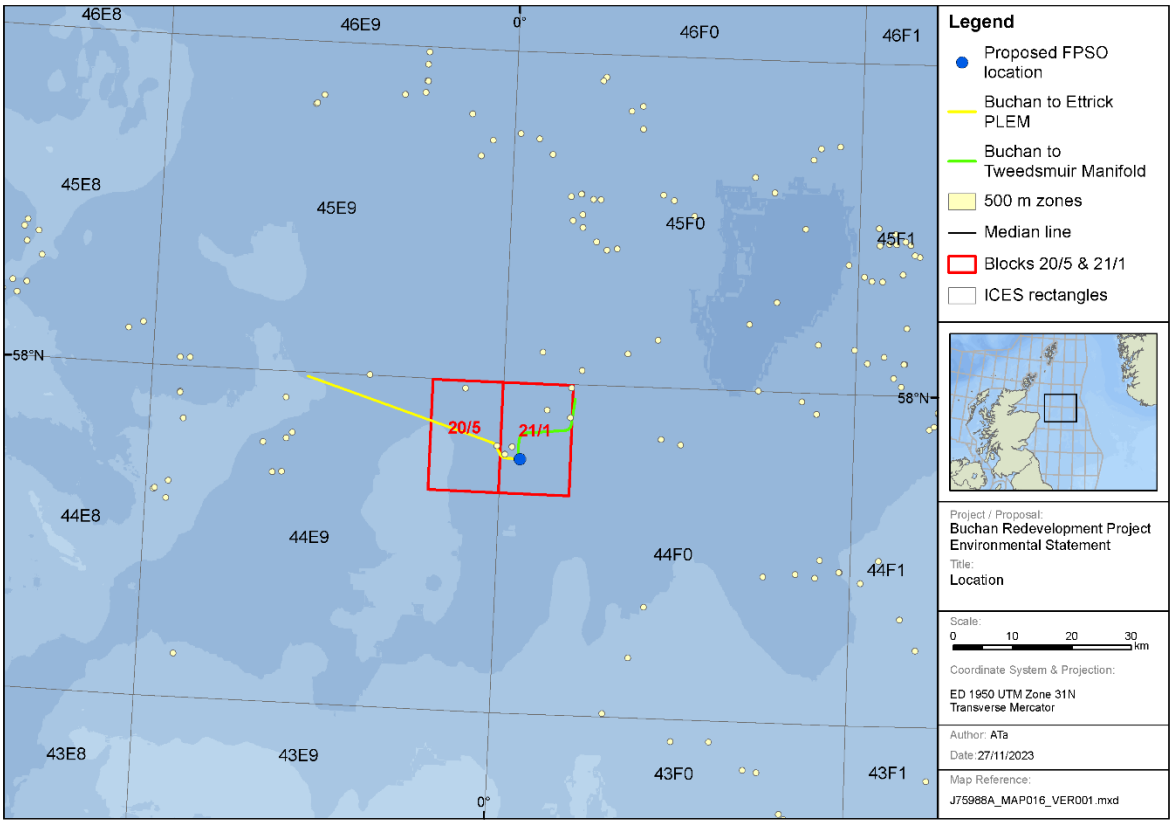


Figure 4-18: Location of the proposed Project in relation to ICES rectangles.

Fishing Effort

Fishing effort statistical data, of UK vessels over 10 m in length, between 2018 and 2022 for ICES rectangle 44E9 and 44F0 are provided in Table 4-10. When compared against effort across all ICES rectangles in the UKCS fishing effort within 44E9 and 44F0 is 1% and 0.9% respectively for the period between 2018 and 2022. Fishing effort within these rectangles is therefore considered Moderate.

Table 4-10: Monthly fishing effort for ICES rectangle 44E9 and 44F0 from 2018-2022.

Year	Monthly Fishing Effort[1]												Total	UK total	% of UK
	J	F	M	A	M	J	J	A	S	O	N	D			
ICES Rectangle 44E9															
2018	61	26	D	8	11	536	199	62	102	71	16	24	1,116	124,843	0.9
2019	318	50	13	23	10	409	251	100	82	21	102	28	1,407	126,245	1.1
2020	57	32	39	59	44	166	67	65	62	74	36	18	719	103,808	0.7
2021	28	15	123	153	220	212	198	54	55	26	61	17	1,162	105,642	1.1
2022	23	23	159	118	306	49	207	81	71	43	18	65	1,163	94,467	1.2
Mean	487	29	84	72	118	274	184	72	74	47	47	30	1,113	111,001	1.0
ICES Rectangle 44F0															
2018	100	14	D	D	11	155	229	142	53	58	12	19	793	124,843	0.6
2019	163	209	94	84	D	184	229	139	350	45	118	7	1,622	126,245	1.3
2020	68	82	139	63	D	32	46	58	111	168	18	26	811	103,808	0.8
2021	42	22	191	286	6	26	157	44	29	33	138	13	987	105,642	0.9
2022	16	D	87	150	87	245	217	31	117	91	D	18	1,059	94,467	1.1
Mean	78	82	128	146	35	128	176	83	132	79	72	17	1,054	111,001	0.9

[1] Monthly effort data are shown for ICES rectangles where five or more UK vessels over 10 m undertook fishing activity on a given year. Rectangles in which fewer than five over 10 m vessels undertook fishing activity are identified but as the data are disclosive they are not shown.

Source: Scottish Government (2023).

Fishing Landings

The annual weight (te) and value (£) of landings from UK vessels into the UK and abroad, and foreign vessels into the UK for demersal, pelagic and shellfish species across 2018-2022 from ICES rectangles 44E9 and 44F0 are shown in Table 4-11 and Table 4-12.

The data show that shellfish contributed the highest landings in terms of value in both 44E9 and 44F0 between 2018 and 2022, however both ICES rectangles were found to have a slightly higher value for demersal catches in 2020. Demersal catches contributed the highest landings in terms of weight for both 44E9 and 44F0 within this time period, though shellfish were marginally higher in 2021 for 44F0.

The difference between landing value and weight between shellfish and demersal catches in these ICES rectangles is likely due to the difference in the price per kg of each catch species.

Table 4-11: Annual landings in weight and value for ICES Rectangle 44E9 from 2018-2022 (Scottish Government, 2023).

Year	Species	Variable	44E9 total	UK total	% of UK total
2018	Demersal	Value (GBP)	£1,824,230	£261,734,637	0.7%
		Weight (te)	1,412	151,528	0.9%
	Pelagic	Value (GBP)	£272,446	£254,102,656	0.1%
		Weight (te)	744	320,828	0.2%
	Shellfish	Value (GBP)	£2,487,380	£249,174,523	1.0%
		Weight (te)	829	83,097	1.0%
2019	Demersal	Value (GBP)	£2,668,844	£253,888,453	1.1%
		Weight (te)	1,943	137,055	1.4%
	Pelagic	Value (GBP)	£364,949	£240,514,355	0.2%
		Weight (te)	456	264,994	0.2%
	Shellfish	Value (GBP)	£4,167,203	£271,468,637	1.5%
		Weight (te)	1,353	90,923	1.5%
2020	Demersal	Value (GBP)	£1,572,126	£177,910,157	0.9%
		Weight (te)	1,167	115,973	1.0%
	Pelagic	Value (GBP)	£16,153	£287,407,418	0.0%
		Weight (te)	17	337,087	0.0%
	Shellfish	Value (GBP)	£1,089,991	£177,097,220	0.6%
		Weight (te)	518	72,602	0.7%
2021	Demersal	Value (GBP)	£1,473,755	£174,154,252	0.8%
		Weight (te)	1,037	99,320	1.0%
	Pelagic	Value (GBP)	£213,188	£299,458,659	0.1%
		Weight (te)	266	364,764	0.1%
	Shellfish	Value (GBP)	£2,379,564	£212,797,458	1.1%
		Weight (te)	968	74,385	1.3%
2022	Demersal	Value (GBP)	1,643,295	163,744,471	1%
		Weight (te)	1,587	95,037	1.7%
	Pelagic	Value (GBP)	21,835	293,572,304	0.0%
		Weight (te)	22	318,442	0.0%
	Shellfish	Value (GBP)	3,127,066	227,181,181	1.4%
		Weight (te)	785	67,919	1.2%

Table 4-12: Annual landings in weight and value for ICES Rectangle 44F0 from 2017-2021 (Marine Scotland, 2022).

Year	Species	Variable	44F0 total	UK total	% of UK total
2018	Demersal	Value (GBP)	£1,309,691	£261,734,637	0.5%
		Weight (te)	904	151,528	0.6%
	Pelagic	Value (GBP)	£3,536	£254,102,656	0.0%
		Weight (te)	4	320,828	0.0%
	Shellfish	Value (GBP)	£1,766,341	£249,174,523	0.7%
		Weight (te)	576	83,097	0.7%
2019	Demersal	Value (GBP)	£2,634,629	£253,888,453	1.0%
		Weight (te)	1,812	137,055	1.3%
	Pelagic	Value (GBP)	£9,966	£240,514,355	0.0%
		Weight (te)	8	264,994	0.0%
	Shellfish	Value (GBP)	£5,118,127	£271,468,637	1.9%
		Weight (te)	1,677	90,923	1.8%
2020	Demersal	Value (GBP)	£1,464,502	£177,910,157	0.8%
		Weight (te)	998	115,973	0.9%
	Pelagic	Value (GBP)	£825,818	£287,407,418	0.3%
		Weight (te)	841	337,087	0.2%
	Shellfish	Value (GBP)	£1,427,977	£177,097,220	0.8%
		Weight (te)	608	72,602	0.8%
2021	Demersal	Value (GBP)	£1,265,730	£174,154,252	0.7%
		Weight (te)	851	99,320	0.9%
	Pelagic	Value (GBP)	£1,359	£299,458,659	0.0%
		Weight (te)	1	364,764	0.0%
	Shellfish	Value (GBP)	£2,618,244	£212,797,458	1.2%
		Weight (te)	888	74,385	1.2%
2022	Demersal	Value (GBP)	1,215,256	£174,154,252	0.7%
		Weight (te)	865	99,320	0.9%
	Pelagic	Value (GBP)	50,043	£299,458,659	0.0%
		Weight (te)	107	364,764	0.0%
	Shellfish	Value (GBP)	3,381,954	£212,797,458	1.6%
		Weight (te)	779	74,385	1.0%

Figure 4-19 shows the main gear types used within Blocks 20/5 and 21/1 between 2010 and 2020. Otter trawls have been used most intensely in the area (ranging between 4-2,845 fishing hours per year in the relevant blocks) while seine nets have been used rarely (around 4 fishing hours per year). Beam trawls were not used in the area at all during this time and this is largely true for dredges too (EMODnet, 2021). Scottish Government (2023) data similarly found that between 2018-2022 trawls were the most dominant gear type used in ICES rectangles 44E9 and 44F0 amounting to a collective total of 10,727 days of fishing effort compared to just 44 days for seine nets.

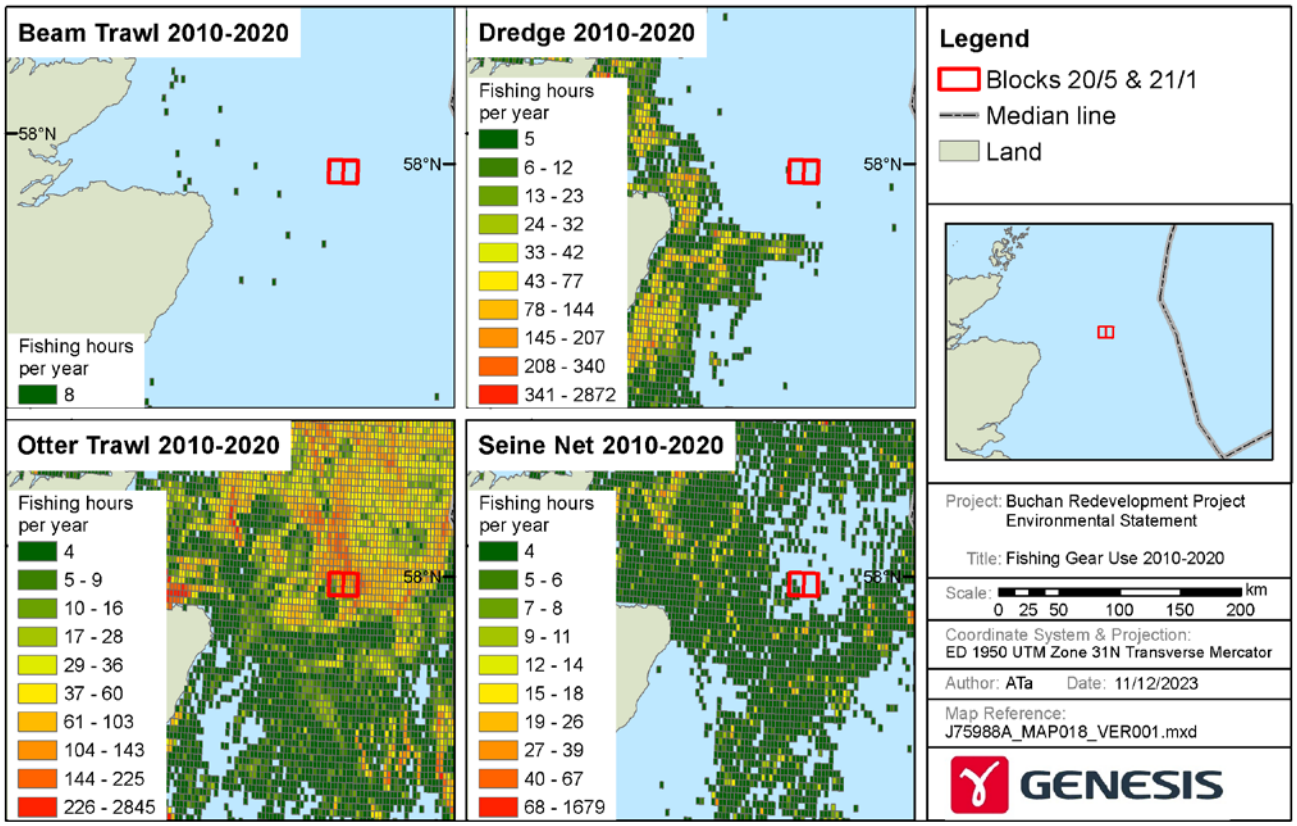


Figure 4-19: Fishing gear use between 2010-2020 around Blocks 20/5 and 21/1 (EMODnet, 2021).

4.5.2 Shipping

The North Sea contains some of the busiest shipping routes in the world, with significant traffic generated by vessels trading between ports at either side of the North Sea and the Baltic. Shipping densities in the North Sea are categorised by the NSTA to be either: negligible; very low; low; moderate; high; or very high.

As can be seen in Figure 4-20, the shipping activity around the proposed Buchan Redevelopment Project area is considered very low within ICES rectangle 21/1, but increases to Low and Moderate along the potential gas pipeline route to the Ettrick PLEM.

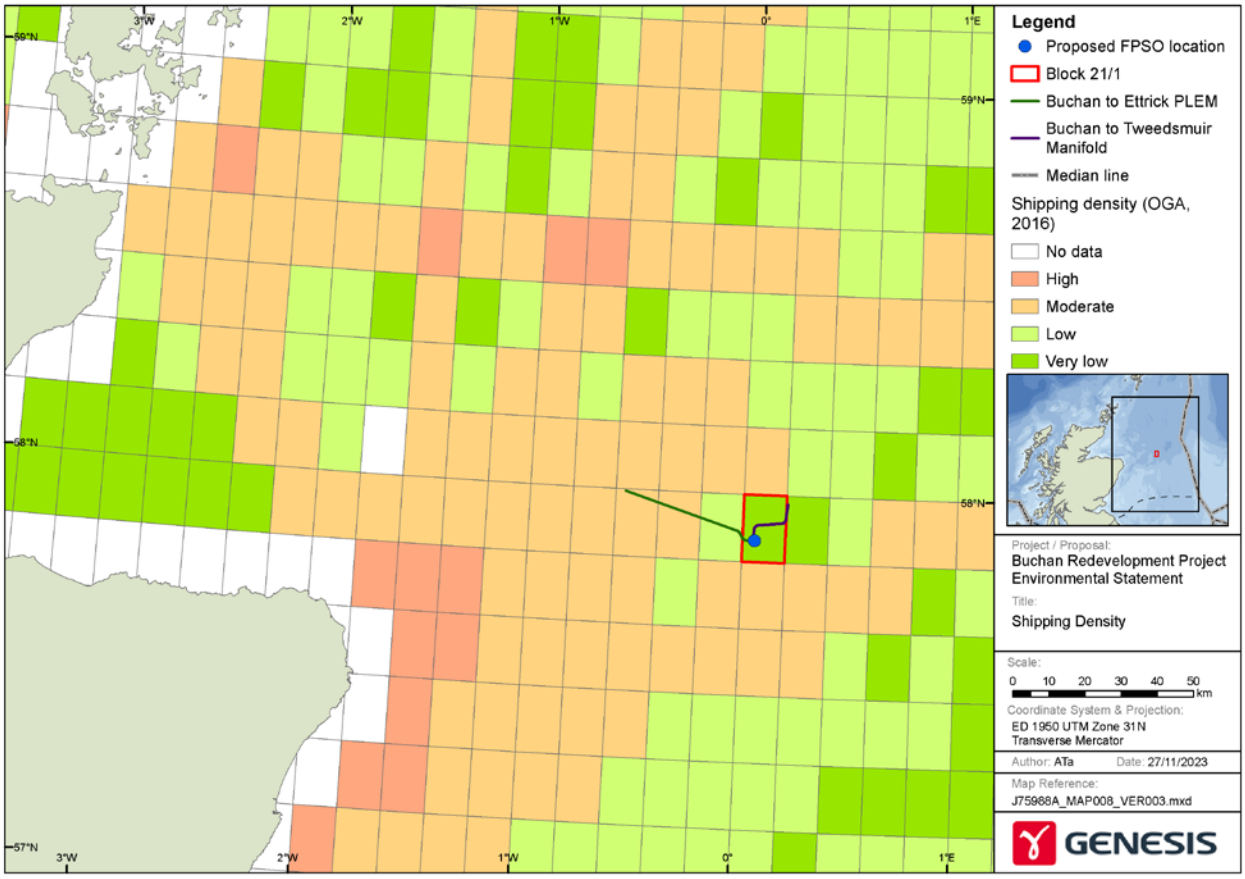


Figure 4-20: Shipping density in the vicinity of the proposed Buchan Redevelopment Project (NSTA, 2016).

4.5.3 Foul Ground and Wrecks

A large number of ship and aircraft wrecks are known in UK waters, including more than 5,200 records in Scottish waters (DESNZ, 2022). Figure 4-21 presents data downloaded from Admiralty Marine Data Solutions (2023). The shapefile shows 'areas of foul ground' and known wrecks (classified as: dangerous wrecks; non dangerous wrecks, distributed remains of wrecks, wrecks showing any portion of hull or superstructure and wrecks showing mast/masts). Foul ground is defined as an area over which it is area to navigate but which should be avoided for anchoring, taking the ground or ground fishing. These could include sites of cleared platforms or ground tackle (Hydrographic Office, 2018).

From Figure 4-21 it can be seen that there are no wrecks in close proximity to the proposed drill centre or Western Isles FPSO location. The closest area of foul ground to the proposed FPSO location is *c*. 1.4 km. Drilling rig, anchor pre-lay and pipeline route pre-lay surveys will be carried out in advance of rig mobilisation/pipeline installation activities to ensure no safety concerns associated with the foul grounds and to avoid interaction with any wrecks along the proposed gas pipeline routes.

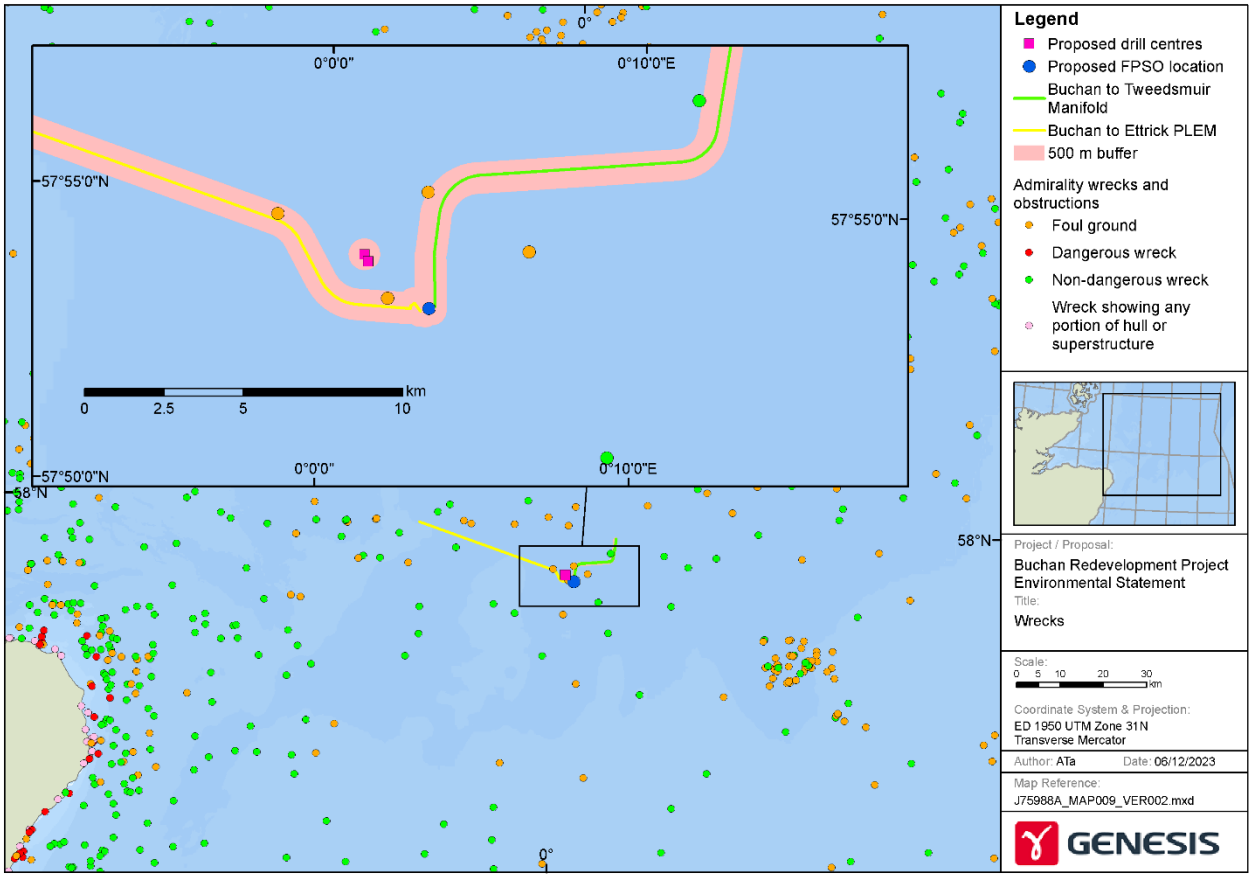


Figure 4-21: Foul ground/wrecks in the vicinity of the proposed Project (Admiralty Marine Data Solutions, 2023).

4.5.4 Offshore Renewable Energy

Figure 4-22 shows the location of the proposed Buchan Redevelopment Project in relation to the closest Scotwind lease area and the closest awarded Innovation and Targeted Oil & Gas (INTOG) Projects. INTOG windfarms are candidates to provide the Western Isles FPSO with 3rd party power as part of the proposed electrification strategy.

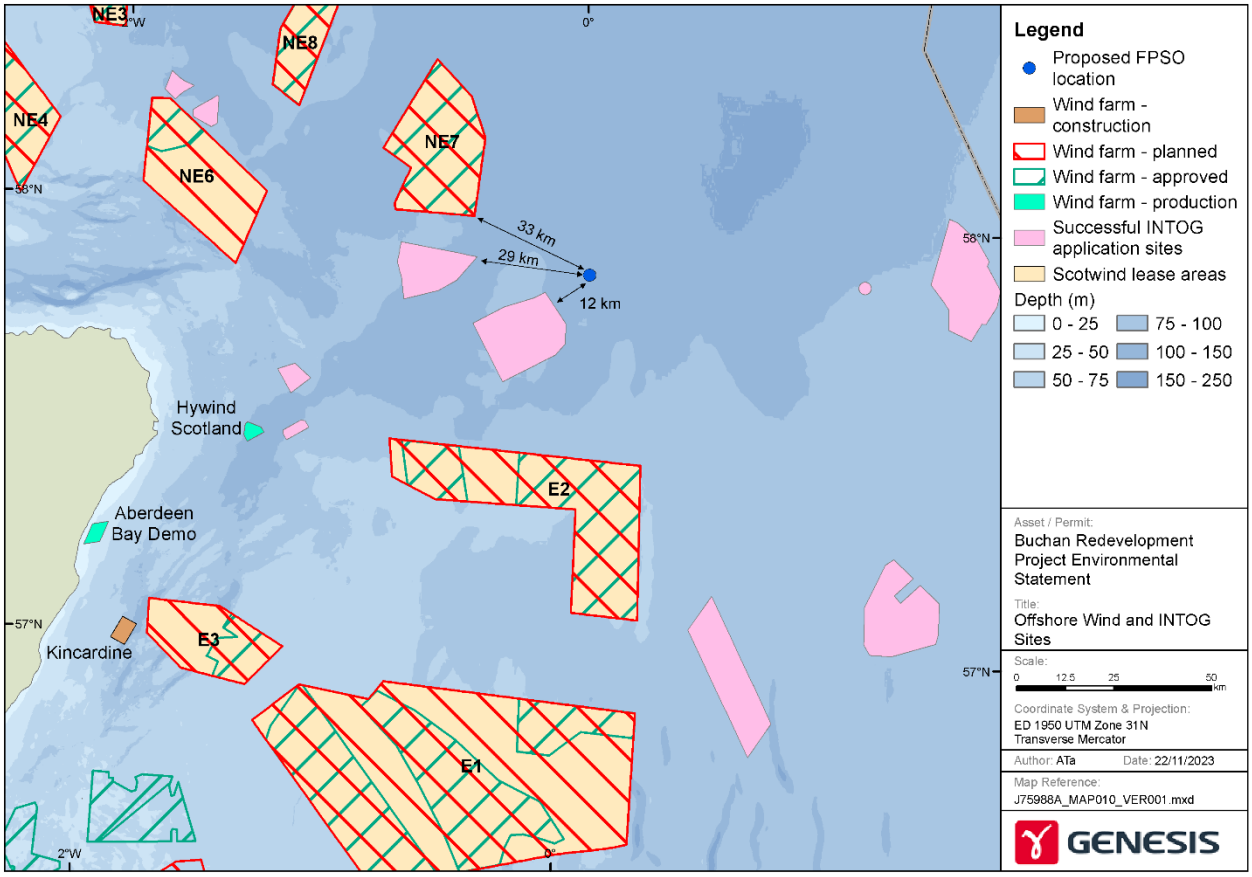


Figure 4-22: INTOG and offshore wind energy sites in the vicinity of the proposed Project.

4.5.5 Oil and Gas Activities

The proposed Buchan Redevelopment Project area lies within a well-developed oil and gas production area with a number of installations, pipelines and umbilicals present.

Table 4-13 and Figure 4-23 shows the surrounding infrastructure in closest proximity to the proposed Buchan Redevelopment Project area.

Table 4-13: Approximate distance between proposed Western Isles FPSO location and nearby installations.

Installation	Approximate distance from proposed Western Isles FPSO location.
Scott	45 km
Forties	46 km
Kitiwake	54 km
Golden Eagle	58 km
Alba FPSO	60 km
Buzzard	62 km

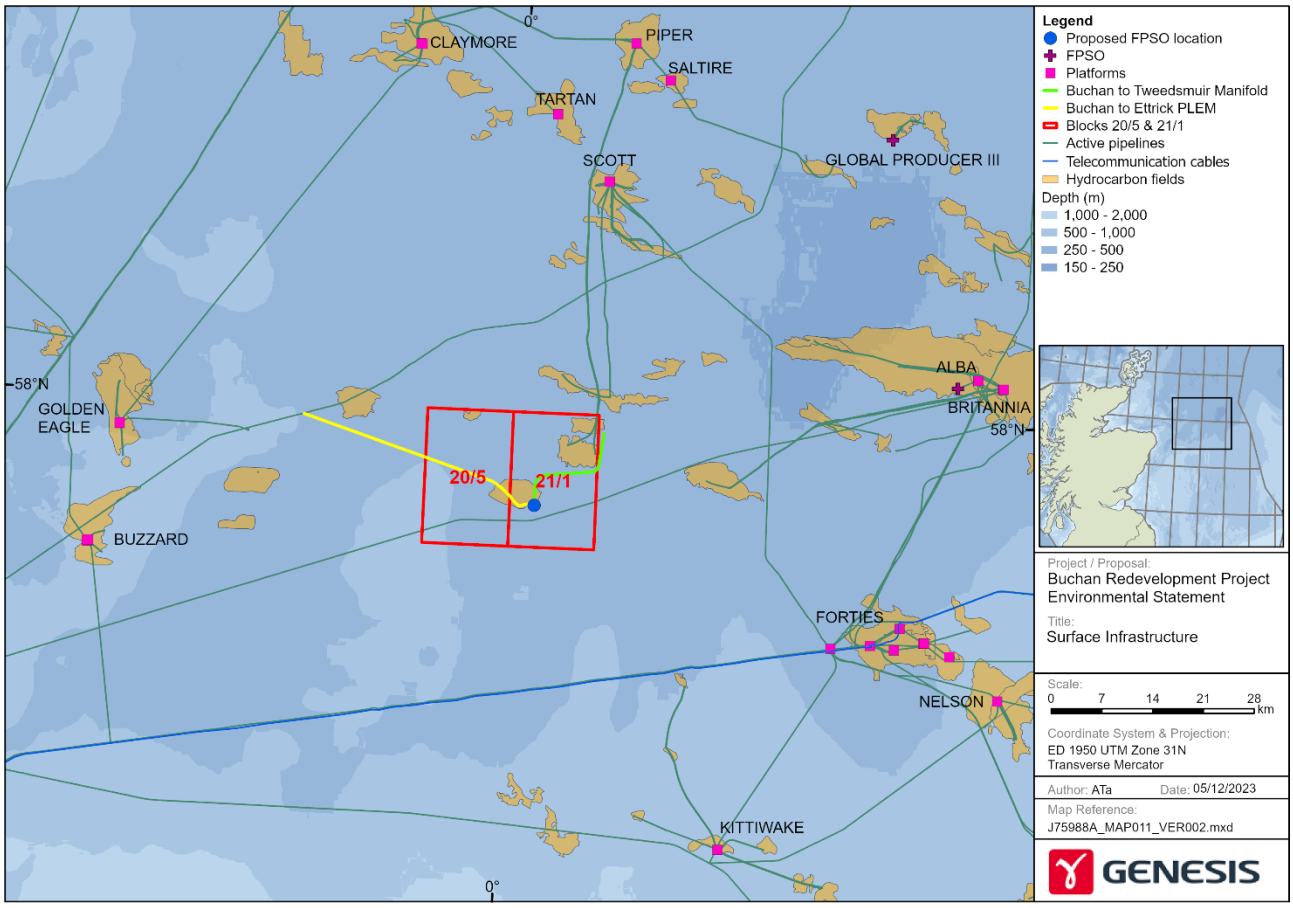


Figure 4-23: Surrounding infrastructure in the vicinity of the proposed Project.

4.5.6 Other Activities

There are no military exercise areas or offshore windfarm developments within the vicinity of the proposed Buchan Redevelopment Project area (Scottish Government NMPi).

The closest telecommunications cable is the CNS fibre optic cable which passes through Blocks 21/8 and 21/9 via the Forties field. It is not crossed by any of the proposed Buchan Redevelopment Project infrastructure (Figure 4-23).

5 Environmental Impact Assessment Methodology

5.1 Introduction

In order to determine the impacts that the proposed Buchan Redevelopment Project may have on the environment an ENVironmental and socio-economic impact IDentification (ENVID) Workshop was undertaken following a structured methodology. The purpose of the ENVID was to identify the significance of the environmental and social impacts associated with the planned activities and the significance of the environmental and social risks associated with unplanned events. Appropriate mitigation measures, controls and safeguards to minimise these impacts/risks were also identified during the workshop.

This Chapter presents the Environmental and Socio-Economic Impact Assessment (ESIA) and the Environmental and Socio-Economic Risk Assessment (ESRA) matrices used to determine the impact of the planned and potential unplanned activities (respectively) associated with the proposed Buchan Redevelopment Project.

During the workshop a number of aspects were considered for each activity:

- Physical presence;
- Emissions to air;
- Discharges to sea;
- Seabed disturbance;
- Noise and visual impact;
- Waste;
- Use of resources; and
- Unplanned events.

The aspects associated with each activity were assessed in terms of their impact on the receptors in the area. For example, the use of vessels will result in emissions to air, discharges to sea, underwater noise, physical use of space and, if anchored, disturbance to the seabed. Receptors potentially impacted by these aspects include air quality, marine mammals, seabirds, other users of the sea, seabed sediments and benthic communities (if anchored).

5.2 ESIA for Planned Activities

The significance of the environmental/socio-economic impact of planned activities on each of the susceptible receptors is derived by considering the ‘Receptor Sensitivity’ in relation to the ‘Magnitude of Effect’ of the aspect.

5.2.1 Receptor Sensitivity

Four categories of Receptor Sensitivity are applied, ranging from ‘Low’ to ‘Very High’, as shown in Table 5-1.

Table 5-1: Receptor Sensitivity.

Category	Environmental Definition
(a) Low	Flora/Fauna/Habitats - within the impacted area • Population sizes are considered to be of little to no geographical importance. • Species do not have designated conservation status and are of International Union for Conservation of Nature (IUCN) ‘Least Concern’. • No designated habitat/sites. • Impacted species are widespread in the Northeast Atlantic region. Air quality: Emissions may impact on other nearby installations.

Category	Environmental Definition
	Water quality: Open offshore water body. Cultural heritage sites: Site integrity is already compromised. Resource availability: (e.g. landfill sites, diesel use) Renewable and/or abundant. Third party users: have capacity to absorb change without impact.
(b) Medium	Flora/Fauna/Habitats – within the impacted area • Significant numbers of at least one receptor of national importance (e.g. PMFs). • Significant numbers of a species which is listed as IUCN 'Near Threatened'. • Nationally designated habitat/sites (e.g. PMFs). • Species may be of regional value. Air quality: Populated areas nearby. Water quality: Semi-enclosed water body with good flushing. Cultural heritage sites: Site is of local heritage importance. Resource availability: (e.g. landfill sites, diesel use) Renewable and/or available. Third party users: have capacity to absorb change without significant impact.
(c) High	Flora/Fauna/Habitats – within the impacted area • Significant numbers of at least one receptor of regional (European) importance (e.g. Annex II / IV species and OSPAR designations). • Significant numbers of a species which are listed as IUCN 'Vulnerable'. • Regionally designated habitats/sites (e.g. OSPAR[1] designations and Annex I habitats: Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)). • Locally distinct sub-populations of some species may occur. Air quality: Densely populated areas nearby. Water quality: Semi-enclosed water body with limited flushing. Cultural heritage sites: Site is of regional heritage importance. Resource availability: (e.g. landfill sites, diesel use) Not renewable and/or limited availability. Third party users: have low capacity to absorb change and significant impact is likely to occur.
(d) Very High	Flora/Fauna/Habitat – within the impacted area • Significant numbers of at least one receptor of international importance. • Significant numbers of a species which are listed as IUCN 'Endangered' or 'Critically Endangered'. • Internationally designated habitats/sites (e.g. Ramsar sites). • At least one receptor is endemic (unique) to the area. Air quality: Very densely populated area with sensitive receptors such as schools and hospitals. Water quality: Enclosed water body with no flushing. Cultural heritage sites: Site is of international heritage importance. Resource availability: (e.g. landfill sites, diesel use) Not renewable and/or scarce availability. Third party users: have no capacity to absorb change e.g. unemployment due to long term closure of fisheries.

[1] OSPAR is the Convention for the Protection of the Marine Environment of the North-East Atlantic.

5.2.2 Climate Change

With respect to the emission of greenhouse gases, climate is considered a global receptor rather than a local receptor. The categories identified in Table 5-1 do not capture definitions for climate change. This is because the sensitivity status of climate is considered to be 'Very High' in line with the 2021 Climate Change Report produced by the Intergovernmental Panel on Climate Change (IPCC, 2021).

5.2.3 Magnitude of Effect

Definitions for the Magnitude of Effect on the receptors are presented in Table 5-2. Prior to determining the Magnitude of Effect, industry recognised 'base case' mitigation measures are assumed to be applied. For example, only MARPOL compliant vessels will be used. These industry recognised mitigations are considered prior to identifying the residual impact.

Table 5-2: Magnitude of Effect.

Magnitude Level		Description	
		Environmental Impact	Social Impact
0	**Positive/No effect** *Regulatory compliance or Company goals are not a concern.*	**No environmental concerns** • Positive environmental impact e.g. retaining a 500 m zone resulting in a 'protected area'. • No significantly negative environmental effects.	**No public concerns** • Possible enhancement in the availability of a resource benefitting the persons utilising the area e.g. removal of 500 m zones results in return of access to fishing grounds. • No impacts on sites or features of cultural heritage. • No impact on resource or landfill availability.
1	**Negligible** *Regulatory compliance or Company goals are not breached.*	**Negligible environmental effects** • Any effects are unlikely to be discernible or measurable and will reverse naturally. • No beaching or transboundary impacts.	**Limited local public awareness and no concerns** • An intermittent short-term decrease in the availability of a resource which is unlikely to be noticed e.g. vessels working out-with existing 500 m exclusion zones could temporarily impact on a shipping route or fishing area. • Undiscernible changes to a site or feature of cultural heritage that do not affect key characteristics and are not above background changes. • Undiscernible use of a resource (e.g. diesel, rock cover or landfill).
2	**Minor** *Regulatory compliance is not breached.*	**Minor, localised, short term, reversible effect** • Any change to the receptor is considered low, would be barely detectable and at same scale as existing variability. • Recover naturally with no Company intervention required. • No beaching or transboundary impacts	**Some local public awareness and concern** • A temporary (<1 year) decrease in the availability or quality of a resource e.g. access to fishing grounds may temporarily be inhibited due to presence of vessels. • Minor changes to a site or feature of cultural heritage that do not affect key characteristics. • Minor use of a resource (e.g. diesel, rock cover or landfill).

Magnitude Level		Description	
		Environmental Impact	Social Impact
3	**Serious** *Possible minor breach of regulatory compliance.*	**Detectable environmental effect within the project area** • Medium localised changes to the receptor are possible. • Localised Company response may be required. • No beaching or transboundary impacts.	**Regional / local concerns at the community or stakeholder level which could lead to complaints** • Medium decrease in the short-term (1-2 years) availability or quality of a resource affecting usage e.g. bring a rig on site for 1-2 years. • Nuisance impacts e.g. marine growth odour coming from yards. • Partial loss of a site or feature of cultural heritage. • Moderate use of a resource (e.g. diesel, rock cover or landfill).
4	**Major effect** *Possible major breach of regulatory compliance.*	**Severe environmental damage extending beyond the project area** • High, widespread mid-term (2-5 years) degradation of the receptor. • Company response (with Corporate support) required to restore the environment. • Possible beaching and / or transboundary impacts.	**National stakeholder concerns leading to campaigns affecting the Company's reputation** • High mid-term (2-5 year) decrease in the availability or quality of a resource affecting usage e.g. closure of fishing grounds. • Substantial loss or damage to a site or feature of cultural heritage. • High use of a resource (e.g. diesel, rock cover or landfill).
5	**Critical effect** *Major breach of regulatory compliance resulting in project delays and prosecution.*	**Persistent severe environmental damage** • Very high, widespread long-term (>5 years) degradation to the receptor that cannot be readily rectified. • Major impact on the conservation objectives of internationally/nationally protected sites. • Full Corporate response required. • Major beaching and/or transboundary impacts.	**International public concern and media interest affecting the Company's reputation** • Very high decrease in availability of a resource and potentially livelihood of users for > 5 years e.g. hydrocarbons on beaches affecting tourism or tainting of fish resulting in the long-term closure of fishing grounds. • Total loss of a site or feature of cultural heritage. • Significant use of a resource (e.g. diesel, rock cover or landfill).

5.2.4 Cumulative Impacts

The EIA sets the activities and potential impacts in the context of all other activities taking place in the wider Project area to determine the additional cumulative effects of the new activities. The potential cumulative effects are discussed in the impact assessment chapters.

5.2.5 Environmental / Socio-Economic Impact Significance

The 'Receptor Sensitivity' (see Table 5-1) and the 'Magnitude of Effect' (see Table 5-2) are then combined using the matrix presented in Table 5-3 to determine the level of impact for planned activities.

Table 5-3: Environmental / socio-economic impact significance (ESIA) matrix for planned activities.

		Receptor Sensitivity			
		(a) Low	(b) Medium	(c) High	(d) Very high
Magnitude of Effect	(0) Positive/No effect				
	(1) Negligible				
	(2) Minor				
	(3) Serious				
	(4) Major				
	(5) Critical				

(i) Positive / No effect significance	• Positive or no environmental or social impact. • No public interest or positive public support.
(ii) Low significance	• No/negligible environmental and social impact. • No concerns from consultees.
(iii) Moderate significance	• Discernible environmental and social impacts. • Requirement to identify project specific mitigation measures. • Concerns by consultees which can be adequately addressed by the Company.
(iv) High significance	• Substantial environmental and social impacts. • Serious concerns by consultees requiring Corporate support. • Alternative approaches should be identified.

5.3 ESRA for Unplanned Events

To determine the environmental and socio-economic risk of an unplanned event (e.g. dropped object or well blowout), the following approach considers firstly the significance of the environmental or socio-economic impacts of an event should it occur and secondly the likelihood of the event occurring.

5.3.1 Environmental and Social Significance of an Unplanned Event

The ESIA approach described above for determining the significance if the environmental and social impacts of planned activities is also used to determine the significance of impacts that may result from unplanned events.

5.3.2 Likelihood of an Unplanned Event

Five categories of 'likelihood', ranging from 'Extremely Remote' to 'Likely', are presented in Table 5-4.

Table 5-4: Likelihood of an unplanned event.

Likelihood	Definition
Extremely Remote	Has never occurred within industry or similar industry but theoretically possible.
Remote	Similar event has occurred elsewhere but unlikely to occur with current practices.
Unlikely	Event has occurred in the industry during similar activities.
Possible	Event could occur during project activities.
Likely	Event is likely to occur more than once during the project.

5.3.3 Environmental Risk of an Unplanned Event

Combining the significance of the environmental/socio-economic impact with the 'likelihood of the unplanned event occurring' allows the level of environmental risk to be determined using the matrix presented Table 5-5. Note the potential for a beneficial impact significance has been removed as it is not expected that an unplanned event would lead to a beneficial environmental or socio-economic impact.

Table 5-5: Environmental / Socio-Economic risk assessment matrix for unplanned activities.

		Environmental significance of unplanned event*		
		(ii) Low	(iii) Moderate	(iv) High
Likelihood of event	Extremely remote	Low	Low	Low
	Remote	Low	Low	Medium
	Unlikely	Low	Medium	Medium
	Possible	Low	Medium	High
	Likely	Low	High	High

*Note the numbers associated with each significance level range from (ii) to (iv) in keeping with the scoring assigned in Table 5-3.

Low risk	• Negligible environmental and social risks. • Mitigation measures are industry standard and no project specific mitigation required. • No consultee concerns.
Medium risk	• Discernible environmental and social risks. • Consultee concerns can be adequately resolved. • Local public interest.
High risk	• Significant environmental and social risks. • Serious consultee concerns. • Media interest and reputational impacts.

5.4 Assessment of Significance of Environmental and Social Risks

Using the information provided in Sections 3 and 4 and the criteria set out above, the Environmental Aspect Register presented in Appendix B identifies all activities associated with the proposed Buchan Redevelopment Project and their potential impact significance (planned) or significance of risk (unplanned events).

The Aspects Register is split into five nodes:

- Node 1: Vessel use during drilling, subsea installation and pipeline commissioning;
- Node 2: Drilling operations;
- Node 3: Subsea installation activities
- Node 4: Western Isles FPSO positioning and mooring; and
- Node 5: Offshore commissioning and production.

Table 5-6 identifies those aspects / activities found to have a moderate or high significance of risk after mitigation measures /safeguards have been applied.

The assessment showed that with the application of industry standard mitigation measures the majority of the planned activities are anticipated to have a low environmental/social impact significance. Eight of the planned activities are considered to have an environmental impact of moderate significance, whilst none are considered to be of high significance.

As with the planned activities the significance of risk associated with most of the unplanned events identified were found to be low following the application of mitigation measures/safeguards which reduced the likelihood of the events occurring. Seven unplanned events were found to be of potential moderate significance, and one was considered to lead to an environmental risk considered to be of high significance (see Table 5-6).

Table 5-6: Activities identified to have moderate or high significance of risk.

Aspect	Source/ Activity	Significance of risk following mitigation
Seabed disturbance	Impacts of semi-submersible drilling rig anchors and associated anchor chains on the seabed.	Moderate
	Installation of pipelines and umbilical.	Moderate
	Installation of riser base structures, MWA, drill centre manifolds, surface laid spools and jumpers, mattresses and grout bags within the drilling and Western Isles FPSO 500 m safety zones.	Moderate
	Installation of contingency rock to pipeline / umbilical routes if targeted depth of burial is not achieved.	Moderate
	Impacts of footprint of Western Isles FPSO anchors and anchor lines.	Moderate
Discharges to sea	Deliberate discharge to sea from drilling operations. Sea water and bentonite sweeps contaminated cuttings, WBM and cuttings, brine, cementing chemicals & clean up chemicals all required in the drilling process.	Moderate
Emissions to air	Emissions from the Western Isles FPSO power generation equipment (three dual fuel gas turbine generators -assume to run on diesel *c*. 5% and essential systems diesel generator).	Moderate
	Emissions from initial start-up flaring, start-up flaring during field life (e.g. following system depressurisation), process flaring and blowdown.	Moderate
Unplanned / accidental events	Snagging or dragging of pipeline resulting in damage and release.	Moderate
	Major hydrocarbon/ chemical spillage (i.e. vessel collision and loss of containment).	Moderate
	Major loss of drilling rig fuel inventory. Hydrocarbon release to sea.	Moderate
	Blowout. Uncontrolled hydrocarbon flow to surface.	High
	In the event that a semi-submersible drilling rig is used the accidental release of the BOP from the wellhead (e.g. due to vessel collision) could result in the release of LTOBM to the seabed and surrounding area.	Moderate
	Dropped objects resulting in damage to subsea infrastructure and small hydrocarbon releases.	Moderate
	Pipeline rupture e.g. due to pipeline corrosion.	Moderate
	Release of Western Isles FPSO inventory due to collision, topsides rupture.	High

Sections 6 – 12 further assess the impacts of the aspects/activities that:

- Are subject to regulatory control;
- Were found to pose a moderate or high risk significance to the environment;
- Were raised during the consultation phase; or
- Were identified as areas of public concern.

Section 12 presents the results of oil spill modelling carried out to determine the impact of a major hydrocarbon loss.

6 Physical Presence

This section discusses the potential impacts associated with the physical presence of:

- the vessels and drilling rig associated with the proposed Buchan Redevelopment Project; and
- the Western Isles FPSO and all subsea infrastructure.

on other sea users and animals (other than the benthic species) using the risk assessment methodology presented in Section 5. The impacts on the seabed and the local benthic communities are discussed in Section 9 'Seabed Disturbance'.

6.1 Presence of Vessels and Drilling Rig

The vessels required for the proposed drilling, and installation activities are listed in Table 3-12 (drilling) and Table 3-15 (installation and pipeline commissioning). Taking account of the contingency drilling allowed for in the ES, it is estimated that as a maximum the drilling rig could be on location for up to 706 days (excluding mobilisation and demobilisation) and an ERRV will patrol the area during this time. The physical presence of the drilling rig, the drilling support vessels and the installation vessels could potentially result in navigational hazards, a restriction of fishing operations, and disturbance to marine mammals and seabirds.

During routine production operations (after drilling, installation and commissioning activities) an ERRV, supply vessels and shuttle tankers will be required to support the production phase (see Table 3-20).

As described in Section 3.7 the main Western Isles FPSO modifications will be carried out prior to deployment to the Buchan Horst Field. However, final modifications associated with electrification and cable tie-in will require a construction vessel to be on site for around four days (see Table 3-16).

6.1.1 Impact of Vessels and Drilling Rig on Other Sea Users

The drill centres and FPSO will both be located within Block 21/1. The information presented in Section 4.5.1 suggests that fishing effort within this area could be considered moderate whilst shipping levels in this block are considered very low (see Section 4.5.2).

As the proposed project is located in close proximity to a well-developed oil and gas area (see Figure 4-12), the increase in vessel traffic required for the drilling and installation activities is not anticipated to result in a significant change to existing levels. In addition, as the proposed Project is a redevelopment of the formerly named Buchan Field, other sea users have previously been acclimatised to having restricted access in the area between 1981 and 2017.

To minimise navigation hazards, all vessels engaged in the project operations will have markings and lightings as per the International Regulations for the Prevention of Collisions at Sea (COLREGS) (IMO, 1972) and vessel use will be optimised where possible.

The selected drilling rig will be equipped with marine navigational aids and an aviation obstruction lights system, as per the Standard Marking Schedule for Offshore Installations (HSE, 2009), to warn ships and aircraft of their position. The systems comprise:

- Marine navigation lights
- Fog-lights
- Aviation obstruction lights
- Helideck beacons (helideck status light system)
- Fog-horns
- Fog detector
- Helideck lighting
- Radar beacons

As required by HSE Operations Notice 6 (HSE, 2014), a rig warning communication will be issued at least 48 hours before any rig movement. The drilling rig routes will be selected with the aim of minimising interference to other vessels and the risk of collision. All drilling activities will occur within 500 m safety zones. In addition, a CtL permit application will be submitted to OPRED and an ERRV will patrol the area during operations.

As detailed in Section 3.5, at the time of writing it had yet to be determined if a semi-submersible or a HDJU rig would be used. If the former, the anchors will be laid out with the 500 m zone. Prior to the rig and supporting ERRV coming on location, a guard vessel will be in place to warn other sea users of the presence of the anchors.

As shipping and fishing activities in the area are considered very low and moderate respectively, receptor (other users) sensitivity is considered Medium (b). In addition, given the use of navigational aids; the presence of a 500 m safety zone around the drilling rig; the submission of a CtL and NEO's commitment to submitting statutory notifications of any drilling rig moves and potential schedule changes; the commitment to only use vessels adhering to the COLREGS; and the use of guard/ERRV vessels, the magnitude of effect of the physical presence of the drilling rig and vessels on other sea users is considered Minor (2). Given the Medium sensitivity and the Minor magnitude of effect, the impact significance is considered Low such that any social impacts are considered negligible.

6.1.2 Impact of Vessels and Drilling Rig on Marine Mammals

Note the impact of underwater noise associated with vessels and drilling activities is discussed in Section 10. This section discusses the physical presence of the vessel and drilling rig. From Section 4.3.7 it can be seen that a number of marine mammals occur in the area which could be disturbed by the increase in vessel traffic. In addition, there could be an increased risk of injury to marine mammals through vessel strikes. Given that all cetaceans are EPS and harbour porpoise, an Annex I species, occur in the area, receptor sensitivity is considered Medium (b).

As the proposed project is within a well-developed oil and gas area, it is likely that marine mammals have been habituated to vessel activity in the area. In addition, the evidence for lethal injury from boat collisions with marine mammals suggests that collisions with vessels are very rare (CSIP, 2011). Out of 478 post-mortem examinations of harbour porpoise in the UK carried out between 2005 and 2010, only four (0.8 %) were attributed to boat collisions.

Marine mammals may be attracted to installations due to increased prey abundance (Todd *et al*.2015); however, no evidence of impacts of installations on marine mammals on the UKCS have been reported. Cetaceans are therefore anticipated to quickly adapt to the presence of the drilling rig and vessels, which will occupy a very small proportion of their overall available habitat such that the magnitude of effect of the presence of the drilling rig and vessels is considered Minor (2). Given the Medium sensitivity and the Minor magnitude of effect, the impact significance is considered Low such that any impacts of the vessels and drilling rig on marine mammals is considered negligible.

6.1.3 Impacts of Vessels and Drilling Rig on Birds

As described in Section 4.3.6 a number of bird species are found in the area of the Buchan Horst Field, however applying the assessment methodology presented in Section 5, the sensitivity of birds likely to be impacted by the physical presence of the vessels and drilling rig is considered Medium (b).

The vessels and drilling rig have the potential to cause displacement of seabirds from foraging habitat and may cause flying birds to detour from their flight routes. For example, auk species (e.g. guillemot, little auk) are believed to avoid vessels by up to 200 to 300 m but gull species (e.g. kittiwake, herring gull and great black-backed gull) are attracted to the presence of them (Furness and Wade, 2012). Seabird densities in the North Sea are reported to be seven times greater within 500 m of a platform. Lights are known to attract seabirds, however, increased food availability at the installation and the availability of roost sites may also be a factor (Weise *et al*. 2001).

Though evidence suggests that the presence of vessels and the drilling rig could cause some bird species to be displaced from their foraging area, the very small proportion of their overall available habitat that will be occupied by the vessels and drilling rig means the impact is not considered to be noticeable. In addition, given the existing oil and gas activity in the area, it is expected that the impact of the vessels and drilling rig on bird migration routes is not expected to be significant. Therefore, the magnitude of impact of the physical presence of the vessels and drilling rig on birds is considered Minor (2). Given the Medium sensitivity and the Minor magnitude of effect, the impact significance is considered Low such that any impacts of the vessels and drilling rig on seabirds is considered negligible.

6.2 Presence of the Western Isles FPSO and the Subsea Infrastructure

The Westen Isles FPSO and all subsea infrastructure including the wellheads, Xmas trees, manifolds, flowlines, spools, umbilical jumpers and flowline protection materials (concrete mattresses, grout and/or sandbags and rockdump) have the potential to impact on other sea users and wildlife as a result of their physical presence.

6.2.1 Impact of Western Isles FPSO and Subsea Infrastructure on Other Sea Users

As described in Section 4.5.1, Block 21/1 occurs within ICES rectangle 44F0. During production, there will be a 500 m safety zone in place around the FPSO and around the drill centres. These two 500 m exclusion zones will both be located with ICES rectangle 44F0. Note the 500 m safety zones associated with the previous Buchan Development were also located with ICES rectangle 44F0. The majority of the fish caught in ICES rectangles 44F0 by UK vessels are demersal and shellfish species. Many of the fishing gears used to catch these species are towed along the seabed such that they may impact on any subsea structures that they come into contact with.

As discussed previously fishing activity in the area is considered Moderate when compared to landings from other ICES rectangles such that receptor sensitivity is considered Medium (b).

Any infrastructure laid out with these two 500 m zones will be trenched and buried and therefore over trawlable. Should it be necessary to add spot rock to reach the required depth of cover of the flowlines or umbilical, rock size and berm profile will be in line with industry standard such that it is over trawlable.

The infrastructure associated with the proposed Project will be located out with any areas identified for offshore wind, or military activities.

Prior to installing the subsea infrastructure, the project will apply for a Pipeline Works Authorisation (PWA), including a Deposit Consent to deposit materials; and the development will comply with any notification requirements associated with the PWA approval. This will include the positions of any flowlines and umbilicals. The project will submit a CtL application to OPRED. The location of all infrastructure to be installed will be submitted for inclusion on the admiralty charts. NEO's adherence to these mitigation measures means the magnitude of impact of the installation of the subsea infrastructure on fishing activity is not considered significant and is therefore considered Minor (2).

Given the Medium sensitivity of fishers and the Minor magnitude of effect, the impact significance on other sea users is considered Low such that the impact significant of the subsea infrastructure on fishing activity is considered negligible.

6.2.2 Impact of Western Isles FPSO and Subsea Infrastructure on Marine Mammals, Fish and Seabirds

With respect to the impact, of the subsea infrastructure and the FPSO on fish and cetaceans receptor sensitivity is considered Medium (b) due to the presence of designated species e.g. PMFs (such as cod, mackerel and sandeel) and EPS (cetaceans). Marine mammals and fish in the area are anticipated to adapt to the presence of the subsea infrastructure and the Western Isles FPSO, which will occupy a very small proportion of their overall available habitat such that the magnitude of effect is considered Minor (2). Given the Medium sensitivity and the Minor magnitude of effect, the impact significance is considered Low such that any impacts on marine mammals and fish is considered negligible.

Some birds from the coastal SPAs (e.g. the Buchan Ness to Collieston Coast SPA) feed in the vicinity of the Buchan Horst Field such that sensitivity of birds as a receptor is considered Medium (b). Though evidence suggests that the presence of the FPSO could cause some bird species to be displaced from their foraging area, only a very small proportion of their overall available habitat will be occupied by the FPSO and the supporting vessels such that any impacts are considered Minor (2). In addition, given the existing oil and gas vessel activity in the area, it is expected that the impact of the FPSO on bird migration routes (e.g. they could be attracted to the FPSO's lights at night) is not significant. Therefore, the magnitude of effect on birds is considered Minor (2) such that the impact significance of the presence of the FPSO on birds is considered Low.

Note, the impact on the benthic communities is discussed separately in Section 9 'Seabed Disturbance'.

6.3 Decommissioning Phase

At end of field life the Buchan Horst Field infrastructure will be decommissioned as part of a Decommissioning Programme. At the commencement of the decommissioning activities, vessel activity in the area will increase relative to the number of vessels typically present in the area of the development during the production phase.

It is expected that at end of field life it will be technically feasible to recover the Xmas trees, manifold, MWA, the riser base structure, PLEM spools, umbilical jumpers, risers, anchor lines mattresses and grout bags. In addition the Western Isles FPSO will be taken off station. In line with current OPRED draft guidance (BEIS, 2018), a comparative assessment will be carried out to determine whether the gas export flowline and the

flowlines and EHC umbilical laid between the FPSO and the drill centres are removed or left *in-situ*. The approach taken to recover the FPSO anchors will depend on the selected anchor type e.g. it is expected that drag anchors and suction anchors would be recovered whilst piled anchors would likely be cut at a pre-agreed depth below seabed (i.e. agreed between operator and OPRED).

Should the comparative assessment determine that the pipelines/umbilical should be decommissioned *in situ*, NEO will agree an ongoing monitoring plan with the relevant authority (currently this is OPRED).

6.4 Cumulative and Transboundary Effects

The proposed activities will occur in proximity to a well-developed oil and gas area and will result in a modest increase in activity because of additional vessel movements. Given that these activities will occur within a well-established area for oil and gas activity, significant cumulative impacts are not expected.

The proposed Buchan Redevelopment Project will be located *c.* 103.5 km from the UK/Norway median line and therefore no transboundary impacts associated with the physical presence of the drilling rig, vessels, Western Isles FPSO, or subsea infrastructure are expected.

6.5 Mitigation Measures

The following industry standard mitigation measures will be undertaken to minimise the impacts associated with the physical presence of the vessels, drilling rig, FPSO, subsea infrastructure and stabilisation material associated with the proposed Buchan Redevelopment Project.

Proposed Mitigation Measures

- ON6 Notification will be submitted prior to rig mobilisation;
- A Collision Risk Management Plan will be produced if determined to be required;
- All vessels will adhere to COLREGS and will be equipped with navigational aids, including radar, lighting and AIS (Automatic Identification System) etc.;
- The drilling rig will be equipped with navigational aids and aviation obstruction lights system, as per the Standard Marking Schedule for Offshore Installations;
- Vessel use will be optimised by minimising the number of vessels required and length of time vessels are on site;
- The flowlines and EHC umbilical laid out with the 500 m areas will be trenched and buried;
- Following flowline and EHC umbilical installation, surveys will be carried out to ensure a safe seabed;
- Any contingency rock cover required will be laid in an over trawlable profile;
- 500 m safety zones in place around the Western Isles FPSO and drill centres;
- Use of a guard vessel to warn of anchor location prior to the semi-submersible drilling rig coming on location;
- Presence of ERRV vessels which will warn other sea users of the presence of the drilling rig and the Western Isles FPSO.

Applying the risk assessment methodology described in Section 5 and taking account of the mitigation measures listed above, the physical presence of the vessels, drilling rig, FPSO and subsea infrastructure associated with the proposed development is considered a low socio-economic impact significance. In addition, the environmental impact significance in relation to marine mammals, birds and fish is considered low (the environmental impact significance in relation to benthic species in considered separately in Section 8). The environmental and socio-economic impacts are therefore considered acceptable when managed within the additional controls and mitigation measures described. The proposed project will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

7 Emissions to Air

This Chapter identifies the various sources of atmospheric emissions associated with the proposed Buchan Redevelopment Project. The quantity of atmospheric emissions is estimated, and their impact assessed using the assessment methodology presented in Section 5.

The assessment considers the impact of the following air pollutants: carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x), nitrous oxide (N_2O), sulphur dioxide (SO_2), methane (CH_4), and non-methane Volatile Organic Compounds (nmVOC).

The development concept will follow a gas handling strategy whereby associated gas will initially be used to provide artificial lift for the production wells and fuel gas for power generation. Excess gas will be exported via pipeline until the installation becomes gas deficient, when gas will be imported to the installation. There will be no routine flaring or venting, and vapour recovery systems will ensure there is no routine venting from the cargo tanks.

Emissions associated with the use of fuel gas to generate power for the full expected field life are assessed. However, recognising the need to reduce emissions during field life, NEO Energy are investigating the potential for receiving power from a 3rd party supplier. To this end the technical feasibility of importing electrical power from one of the planned INTOG windfarms in the vicinity of the Buchan Horst Field (see Figure 4-22) has been assessed and found favourable. The Project therefore intends to modify the Western Isles FPSO topsides facilities prior to redeployment to facilitate an efficient future switch to import power from a 3rd party supplier such as one of the INTOG windfarms. Electrification from INTOG developments will not only result in a reduction in direct emissions from the Western Isles FPSO, but also provide an increase in renewable generation capacity for the UK grid, assisting in the UK Government's Net Zero target. The ES therefore presents the benefits of this emissions reduction plan via future electrification.

Following the adoption of appropriate control and mitigation measures, residual effects and impacts are assessed in the context of the sensitivity of, and the dispersive capacity of the receiving environment.

7.1 Assessment Overview

In order to assess the magnitude of the impacts resulting from atmospheric emissions associated with the proposed Project, emissions of air pollutants are estimated based on the assumptions / exclusions listed below as per the EIA guidance (OPRED, 2020):

- Emissions during production are related to the production profiles of the Buchan Horst Field. A degree of uncertainty will remain over the production profiles until the reservoir behaviour can be monitored following commencement of production. The highest predicted hydrocarbon case represents the greatest potential for environmental impact because the high-case reserves will result in a longer economic field life compared to the mid-case. In alignment with the rest of the ES, the emissions estimates presented herein are based on the high hydrocarbon case production scenario.
- Projected emissions associated with the production phase are estimated to represent a reasonable worst-case assumption of power requirements. Notwithstanding, there is anticipated to be little difference between requirements for the high and mid production cases because the overall fluid handling power requirements i.e. oil and water processing and lift gas compression remain broadly the same in both cases.
- Projected estimates of GHG intensity during production (emissions per barrel or tonne of oil equivalent) for the field are presented for both the high-case and mid-case production profiles. Whereas the GHG emissions profiles during production are similar for both cases (as discussed above), production figures for the mid-case are lower than the high-case, leading to higher GHG intensity estimations. However, as noted above, the high-case represents the worst-case environmental impact due to the longer economic field life.
- As discussed in Chapter 3, the Western Isles FPSO will be modified to be 'electrification ready' to facilitate future connection to a 3rd party power source anticipated to supply power from 2030 onwards. However, to evaluate the overall worst-case predicted impact, it is assumed that power generation on the Western Isles FPSO will be provided by the existing GTGs running on fuel gas with diesel use as a back-up from first oil planned in late 2026 to 2050. Aggregated production emissions and associated GHG intensity over the full field life have also been considered based on an electrification scenario with first power supply occurring in 2030 and will be presented herein for context.

- The FPSO is designed to achieve zero routine flaring and venting, however the emissions calculation includes allowances for estimates of flaring resulting from planned maintenance operations and unplanned process upsets requiring, for example, depressurising of the production flowlines and process equipment following a prolonged shutdown.
- The FPSO is designed to operate with Fuel Gas Blanketing and a Vapour Recovery Unit, so there will be no routine venting of vapour from the Cargo Oil Tanks.
- In line with current NEO operating practice, visiting shuttle tankers will be equipped with a VECS so that there will be no routine venting of vapour during cargo offloading operations.
- In keeping with assessing a worst-case scenario, the impact assessment in this section assumes that drilling will be undertaken from a semi-submersible drilling rig as opposed to a HDJU drilling rig due to the overall higher fuel consumption should a semi-submersible be used (see Table 3-12).
- The environmental impact associated with direct GHG emissions have been included. Indirect GHG emissions associated with drilling, offshore installation and hook-up and production logistical services (helicopters, vessels and shuttle tankers) have also been included. Further information on GHG emissions sources is presented in Table 7-1.
- GHG and other emissions from the proposed Buchan Redevelopment Project are derived based on industry standard emissions factors (EEMS, 2008) as follows:

  'M(is) = A(s) x EF (is)'

  where:

  - M(is) is the emitted mass of a particular emission gas (i) for a given source (s);
  - A(s) is the source (s) activity factor (typically based on engineering estimates);
  - EF (is) is the emission factor for the emission gas (i) relevant to the emission source.
- The values for GHG emissions are derived from aggregated CO_2, CH_4 and N_2O calculations, using Global Warming Potentials (GWP) for 100-year time horizon values from the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (IPCC, 2014).

7.2 Sources

The principal planned activities, including their location and estimated duration, are described in Chapter 3. Of these, the general use of vessels (including the drilling rig), well completion, commissioning and the production of hydrocarbons have been identified as warranting further assessment in terms of the impact of their atmospheric emissions.

Table 7-1 provides the list of predicted emissions generated by project activities from the proposed Buchan Redevelopment Project which are included in the scope of this assessment.

Table 7-1: Emissions to atmosphere activities for the proposed Buchan Redevelopment Project.

Project Phase	Activity	Source of emissions
Drilling	Drilling rig	Onboard power generation
	Well completion and clean-up	Non routine flaring during well clean-up and testing onboard drilling rig for each production and water injector well.
	Drilling rig support activity	Support vessels i.e., AHV, supply and ERRV, and helicopters
Subsea Installation	Installation and commissioning of flowlines, EHC umbilicals, subsea structures, stabilisation material etc.	Pipeline route survey vessel, pipelay barge, pipelay support vessel, construction vessel, rock dumping vessel, DSV, guard boat(s), trenching and backfill vessels.
FPSO Installation	Positioning and anchoring of the FPSO	AHV, DSV and barge.
Production Start-up	Well start-up activity	Gas to flare
FPSO Operations	Power generation	Combustion of fuel gas in dual fuel turbines with diesel used as a back-up
	Process upsets and maintenance	Gas to flare Note 1
	Cargo tank storage	Vent and inert gas system Note 2
	Miscellaneous diesel engines	Combustion of diesel for use by emergency generator, standby generator, inert gas generator and firewater pumps.
	Support logistics during operations	Supply vessels, inspection vessels, helicopters, and shuttle tankers (includes transit only) Note 3

Note 1: the FPSO is designed to operate with a flare gas recovery system, so there will be no routine flaring during normal operations.

Note 2: the FPSO is designed to operate with fuel gas blanketing and a Vapour Recovery Unit, so there will be no routine venting of vapour from the Cargo Oil Tanks.

Note 3: In line with current NEO Energy practices, shuttle tankers will be equipped with VECS to prevent any vented VOC emissions from the shuttle tankers during offloads from the Western Isles FPSO.

7.2.1 Drilling and Support Logistics

Combustion emissions associated with power requirements for the drilling phase and associated logistics are estimated based on the total predicted diesel consumption and planned work programme as presented in Chapter 3. Emissions estimates are presented in Table 7-2.

Table 7-2: Emissions associated with drilling and support logistics.

Source	Fuel use (te)	Emissions From Fuel Use (te)							
		CO_2	NO_x	N_2O	SO_2	CO	CH_4	nmVOC	CO_2e
Total fuel use for drilling operations (see Table 3-12)	33,338	106,682	1,980.28	7.33	66.68	523.41	6.00	66.68	109

Aspects of emissions to air during the drilling phase will be managed within the framework of NEO Energy´s Management System as outlined in Chapter 2 and will include the following proposed measures to reduce emissions:

- Inclusion of optimised energy efficiency and GHG emissions reduction in the rig selection and tendering process such as:
    - Use of low sulphur diesel (<0.1% S content);
    - Implementation of a Shipboard Energy Efficiency Management Plan (SEEMP) describing how fuel consumption is minimised during transit (economical fuel use mode where possible);
    - Demonstrable equipment efficiency and operations e.g., optimised power management system, planned maintenance system etc.
    - Drilling execution plan with optimised mobilisations and / rig move (where applicable) frequency.
- The drilling rig will be subject to a Health, Safety and Environment Management System audit upon contract award (including planned maintenance system implementation).
- Implementation of a SIMOPs plan which allows for simultaneous operations to occur in a safe and optimised manner whilst minimising rig downtime and mobilisation/demobilisation frequency associated with drilling logistics.
- Batch drilling and completion opportunities will be evaluated. These would reduce emissions through reduced logistical requirements and fluid handling efficiencies.
- During well completion it is common to use slickline and electric line intervention equipment which is powered using diesel power packs. The Project aims to design the well such that use of these units is limited thereby reducing emissions. If required, the Project are committed to trying to source use slickline and electric line intervention equipment that are electrically driven (currently limited in their availability).
- The Project is investigating the use of autonomous devices within the completion of the production wells to facilitate shut-off of water during the production phase (i.e., to reduce the volume of water being recovered from the reservoir). The use of these devices could mitigate the need to carry out some well intervention activities from a vessel or drilling rig.

7.2.2 Well Clean-Up and Well Testing

As described in Section 3.5.7, it is expected that hydrocarbon fluids will be flared during well clean-up and well testing activities, and this will require flaring of fluids from the drill rig. Table 3-11 presents the maximum volume of hydrocarbons to be flared, whilst Table 7-3 below presents the associated emissions. Standard emissions factors from the EEMS Atmospheric Emissions Calculations guidance (EEMS, 2008) have been applied.

Table 7-3: Maximum emissions from hydrocarbon flaring from well clean-up and well testing operations.

Source	Mass of hydrocarbons flared (te)	Total emissions from flaring (te)							
		CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	CO_2e
Injection wells: clean-up only	4,000	12,800	14.80	0.32	0.05	72	100	100	15,686
Production wells clean-up and testing	10,000	32,000	37	0.81	0.13	180	250	250	39,215

The following mitigation measures will be applied to reduce the impacts of the flaring associated with the proposed well clean-up and testing activities:

- During the well clean-up and well testing activities, optimised flare burner technology (i.e., ‘green burner’) will be used to ensure a more effective flame pattern and reduce the likelihood of fallout. Various propellants, such as air, steam, demulsifiers and diesel, and the optimisation of the pressure and vortex at the burners will aid enhancement of the combustion process.
- Flaring operations during well clean-up and well testing will only commence in daylight hours and weather conditions will be monitored throughout. A dedicated person will be assigned for full-time fire watch duties to ensure that all performance related conditions are monitored, and adjustments can be made accordingly.
- As described in Section 3.5.7, the information gained from each well test will be assessed with a view to reducing the volumes of hydrocarbons to be flared during well testing for each subsequent production well.

7.2.3 Installation Operations

Various support vessels will be required to support the installation of subsea infrastructure and FPSO positioning and mooring activities. Energy in the form of liquid fuel (e.g., marine diesel, combustion of which will result in atmospheric emissions) is required by vessels to provide propulsion, dynamic positioning and ancillary services (e.g., electrical power).

While contracts securing the services of named vessels have not yet been established, the performance characteristics (including the fuel consumption) of the required generic vessel types are well understood. This has allowed, in conjunction with a consideration of the planned vessels' work programme (as outlined in Chapter 3), estimates of atmospheric emissions to be made and presented in Table 7-4.

Table 7-4: Emissions associated with the proposed installation activities.

Source	Fuel use (te)	Total emissions (te)							
		CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	CO_2e
Installation vessels (see Table 3-15)	5,608	17,945	333.11	1.23	11.22	88.04	1.01	11.22	18,300

As per the drilling phase, vessels associated with the subsea and FPSO installation phase will be owned and operated by a third party and the activities subject to the company's construction contract and tendering process managed within the framework of NEO Energy's Management System (see Chapter 2). In line with the emissions reduction commitments outlined in Chapter 2, the following proposed measures will form part of the tendering selection criteria for the installation vessels:

- Selection of vessels which are compliant with MARPOL requirements.
- Use of low sulphur diesel (<0.1% S content).
- Implementation of a SEEMP for each vessel including information relating to minimising fuel consumptions e.g., economical speeds when operationally appropriate.
- Optimisation of construction activities where appropriate through effective construction and SIMOPs planning to minimise number of vessels required and duration on site; and
- Review of vessels' Common Marine Inspection Documents (CMID) as part of vessel assurance (evidence of maintenance).

7.2.4 Start-up

During start-up some gas will be flared until the flowlines and FPSO topsides reception equipment is brought up to the required temperature and pressure conditions to allow for stabilisation of the oil plant, start-up of the gas conditioning plant including flare gas recovery process start up. This is estimated to result in a total amount of 4,473 te of hydrocarbon gas being flared which corresponds to the initial start-up of the first 2 production wells without availability of the compression plant.

The resultant emissions from well start up are presented in Table 7-5.

Table 7-5: Emissions during well first start-up.

Source	Mass Flared (Te)	Emissions from Flare (Te)							
		CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	CO_2e
Flared gas associated with well start-up	4,473	12,077	5.37	0.36	0.06	29.97	80.51	8.95	14,428

7.2.5 Production of Hydrocarbons

The principal atmospheric emissions that will arise during production are associated with power generation, emergency flaring from the FPSO and support logistics. The basis of the production emissions estimates presented in this ES is described below.

7.2.5.1 Main Power Generation

The FPSO currently has three dual fuel SGT-400 Dry Low Emission (DLE) Siemens Gas Turbine Generators (GTG) two of which are rated at 12.3 MW and one at 15 MW electrical output. Initially, during normal production and during production plus offloading operations, all electrical power consumers will be supplied from the main GTGs in a 2 out of the 3 (N+1) configuration (Section 3.7.3.8).

Assuming no electrification to 2050 as a worst-case scenario (Section 7.1), the anticipated power demand and fuel gas requirements of the Buchan Redevelopment Project are shown in Table 7-6 below; noting that, in this scenario, the FPSO is anticipated to become gas deficient by 2032 and that fuel gas requirements would be met, thereafter, by gas import.

Table 7-6: Western Isles FPSO power and fuel requirements.

Buchan Redevelopment Project – Power and Fuel Demand Profile							
Year	**2026**	**2028**	**2030**	**2032**	**2034**	**2035**	**2050**
Power Requirement (MW)	14,414	14,489	14,703	14,435	13,547	13,626	13,237
Fuel Gas Use (kg/d)	98,086	98,320	98,989	98,153	95,344	95,611	94,374

As indicated in Chapter 3, the Western Isles FPSO will be deployed to the Buchan Horst Field 'electrification ready' to facilitate the switch to a 3rd party power source when available (the earliest date being early 2030). The emissions profiles associated with the worst case no electrification scenario are presented for context relative to the expected electrification scenario where all emissions associated with gas turbine power generation would be eliminated as of 2030. The comparison is made in Section 7.4.

7.2.5.2 Flaring

The production facility is designed for a policy of zero operational flaring in alignment with the World Bank's Zero Routine Flaring by 2030 initiative, the NSTA offshore flaring and venting guidance (NSTA, 2021), and NEO Energy's commitments (Chapter 2). The Flare System is equipped with a Flare Gas Recovery System, which will direct off-gas from the process to the compression system which would otherwise have been flared.

Non routine flaring is only anticipated during maintenance activities requiring depressurising of sections of process. It is also possible that the production flowlines may require depressurising to prevent hydrate formation in the event of a process upset. The ES includes an allowance for blowdown activities based around depressurising of the process train and flowlines in these instances. Note that process trips do not result in flaring of the topsides process flammable inventories, in general trips will result in process shut-in. For example, trips of the compression system which may be expected to result in flaring will result in the lift gas system tripping out also. As the Buchan Horst Field wells require lift to flow, then production immediately ceases and there is no flaring in this instance.

7.2.5.3 Diesel Use

The GTGs will occasionally be run on diesel when fuel gas is not available or recovery from shut down requires re-start on liquid fuel. Main power generation is supplemented on the FPSO by diesel generators; one designated as the Standby generator and the second as the Emergency Generator (see Section 3.7.3.8). Both of these diesel units can power accommodation, lighting and utility areas. The firewater system also comprises four firewater pumps running in diesel. There are no routine users of diesel during normal production operations.

An estimated diesel consumption allowance has been included to account for one GTG running on diesel for re-start periods with an additional 5% allowance assumed for small miscellaneous diesel users.

7.2.5.4 Operational logistics

The production phase will require the assistance of support vessels as well as a helicopter service for crew transport. In addition, the oil export product from the Buchan Horst Field will be exported via shuttle tankers. The basis of the emissions estimates associated with operational logistics is as outlined in Chapter 3.

7.2.5.5 Logistics during offshore electrification related modifications

The main modifications to the Western Isles FPSO will be carried out prior to the vessel being deployed to the Buchan Horst Field. However, equipment lead times may require that some electrical installation work need to be completed offshore. The basis of the emissions estimates associated with the use of offshore vessels for offshore electrification related modifications is as outlined in Chapter 3.

7.2.5.6 Emissions Estimates

Table 7-7 presents the estimated direct emissions generated on the FPSO during the production phase assuming no electrification to 2050. It shows that GHG emissions associated with diesel consumption and safety flaring accounts for 6.6% and 0.2% respectively of the total GHG emissions which is comparatively small compared to GHG emissions associated with fuel gas use which represent 93% of the total GHG emissions to 2050.

Table 7-7: FPSO emissions estimates (excluding electrification) between 2026 and 2050.

	Rates (2026-2050) (te)	Total Emissions (2026-2050) in Te							
		CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	$ktCO_2e$
Fuel Gas	754,486	2,157,830	1,620.92	165.99	9.66	4,526.92	694.13	27.16	2,221
Diesel	48,250	154,400	295.58	10.61	96.50	78.35	1.92	18.15	157
Flaring	1,289	3,409	1.55	0.10	0.02	8.63	23.19	2.58	4

Indirect emissions associated with operational logistics (helicopter support and vessels) during the production phase are shown in Table 7-8 below.

Table 7-8: Emissions associated with operational logistics between 2026 and 2050.

	Total Emissions (2026-2050) in Te							
	CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	$ktCO_2e$
Helicopter Support and Vessels including ERRV, supply vessels	111,985	2,078.73	7.70	69.99	549.43	6.30	69.99	114

Indirect emissions associated with shuttle tanker engines emissions are presented in Table 7-9. As outlined in Chapter 3, the number of shuttle tanker offloads will vary annually to 2050 depending on the Buchan Horst Field oil production throughputs. The high-case production profiles have been used to estimate the number of offloads to 2050. The emissions estimates presented below also account for shuttle tanker transit and offloads to an onshore reception facility. Shuttle tanker emissions have been estimated, based on the likely transit voyage duration and the likely fuel consumption. Voyage duration in turn is based on the location of the cargo offload. It is likely that the offload location for the Buchan cargo will be terminal facilities located on the North Sea coast e.g. Rotterdam. NEO's operational experience of transits was used to provide a representative voyage duration to estimate fuel consumption and the consequent emissions.

Table 7-9: Emissions associated with shuttle tanker engines between 2026 and 2050.

	Total Emissions (2026-2050) in Te							
	CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	$ktCO_2e$
Shuttle Tanker Emissions associated based on high case profiles	79,012	1,466.66	5.43	49.38	387.65	4.44	49.38	81

Additionally indirect emissions associated with the potential use of vessels for offshore electrification related modifications are presented in Table 7-10 as a worst case. Note, any offshore modifications for electrification would be anticipated to take place in 2029.

Table 7-10: Emissions associated with vessels for offshore electrification related modifications.

	Fuel use (te)	Total Emissions in Te							
		CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	$ktCO_2e$
Fuel associated with vessels for offshore electrification related modifications in 2029	335	1,072	19.90	0.07	0.67	5.26	0.06	0.67	1

7.2.5.7 Minimising GHG emissions during the production phase

As outlined in Chapter 2, NEO Energy is committed to continuously improving the operational efficiency of its operated and non-operated assets in an effort to reduce and maintain the carbon intensity of its portfolio as low as reasonably achievable.

The design and operating philosophy of the combustion plant onboard the FPSO is also considered to meet industry best practice in terms of emissions reduction and to adhere to Best Available Technique (BAT) standards as follows:

- The plant is designed with the goal of no routine flaring and venting through the provision of existing flare and vent gas recovery systems.
- With the installation of a new export pipeline, the Development will allow for excess associated gas to be exported and for gas to be imported during periods of gas deficiency, thus offering 'zero routine flaring' and minimising diesel use.
- Diesel use by the GTGs will be limited to TARs (Turnarounds (and shutdown)) and for plant re-start when fuel gas is unavailable.
- Facilities are provided with good operational uptime with GTGs sizing and configuration reducing downtime and the need for load shedding. The FPSO has an N+1 configuration with two off GTGs supplying power for production and utility consumers for normal operation including offloads under all operating cases and one GTG as standby. This is a common power generation design concept which allows for maintenance and overhaul with no loss of generation capacity. The load shedding system is an integral part of the safety automated system and continuously monitors the electrical load requirement to minimise spinning reserve of standby power generation.
- Initial load profile estimates the power demand for the Buchan Redevelopment Project to be similar to that of the Harris and Barra Fields Development, therefore the current GTG configuration looks a good fit for Buchan Redevelopment Project. Potential power generation downtime will be reduced by consultation with the original equipment manufacturer to establishing the root cause of the power generation outages – and rectifying these accordingly to ensure the GTG system uptime is maximised. As outlined above load shedding is included in the FPSO electrical system functionality. As part of the Buchan Redevelopment Project, this system will be reviewed to ensure functionality meets the revised requirements associated with the FPSO redeployment.
- The GTGs onboard the FPSO are provided with DLE technology. DLE gas turbine burners are a system that include the premixing of the air and fuel before entering the combustion zone. By mixing air and fuel before combustion, a homogeneous temperature distribution and a lower flame temperature are achieved, resulting in lower NOx emissions. The Siemens GT units onboard the FPSO have been shown to operate in DLE mode throughout their operating range (Dana, 2017). The use of DLE technology is considered BAT for offshore GTGs (EU IPPC, 2017).
- All three GTGs are equipped with Waste Heat Recovery Units (WHRUs) which will be used to recover heat for the heating medium system. The heating medium system will provide direct heating for process application and utility system on the installation. WHRUs increase the overall energy efficiency of power generating equipment as it enables the cogeneration of electricity and usable heat. The overall energy recovered from input energy expended by combustion of the fuel source is then greater when compared to power generating equipment which do not have waste heat recovery technology installed. It therefore reduces or eliminates the need for additional fuel to be combusted in boilers or heaters to provide heat, which ultimately reduces asset emissions.
- During the operational phase, NEO Energy will continually monitor and review emissions and carbon intensity of the asset in line with the company's ESG strategy and commitments and in an effort to support

the UK's Net Zero target (Chapter 2). As per the obligations set out under the NSTA SE11, an ERAP will be developed to support the redeployment of the Western Isles FPSO at the Buchan Horst Field to document the outcome of these continuous emissions and energy efficiency reviews and to investigate potential opportunities to further reduce emissions against the sector targets outlined in the NSTD.

7.3 Aggregated Emissions

Of interest to the impact assessment are:

- The maximum emission levels for substances that reduce air quality; and
- The aggregated emissions of GHGs for the proposed Development to 2050.

7.3.1 Emission Gases Impacting Air Quality

To consider the impacts from a realistic worst case, emissions for the production phase are presented for the high case profiles along with estimates for emissions during the installation and start-up phases of the Project.

The drilling phase is scheduled to span from Q2 2025 to Q4 2026 whilst the installation and commissioning phases are planned to be executed during 2026 as discussed in the indicative schedule in Chapter 3.

Total emissions attributed to the pre start-up (drilling, subsea and FPSO installation) and start-up phase (well start-up) of the Buchan Redevelopment Project are presented in Table 7-11 for the years in which these activities are expected to occur (Q2 2025 – Q4 2026).

Table 7-11: Total pre-production emissions for the proposed Buchan Redevelopment Project.

Total Annual Emissions	Annual Pre-Production Emissions from the Proposed Development in Te							
	CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	$ktCO_2e$
Emissions in 2025 associated with the start of drilling	47,612	883.79	3.27	29.76	233.60	2.68	29.76	49
Emissions in 2026 associated with drilling, installation, commissioning and start-up	133,893	1,486.77	6.79	48.37	659.83	434.85	407.08	148

Production at the Buchan Horst Field is scheduled to begin in late 2026. The peak year for emissions (based on $kteCO_2e$) attributed to the production phase from the proposed Development is identified as 2027, whereby the emissions are predicted to reach approximately 116 $ktCO_2e$ for this year. These emissions are the aggregated quantities from the topside facilities and operational logistics (including shuttle tanker emissions) as presented below in Table 7-12.

Table 7-12: Total annual production emissions for the proposed Buchan Redevelopment Project during peak year.

Peak Annual Emissions	Post-Production Annual Peak Emissions from the Proposed Development in Te							
	CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	$ktCO_2e$
Peak annual emissions during production reached in 2027 with operational logistics (helicopters, field support vessels, shuttle tankers)	112,975	364.68	8.37	13.97	269.83	31.22	11.57	116

The overall peak year in terms of emissions (based on kte CO_2e) from the proposed Development when considering all the project phases (drilling, construction, commissioning, well start-up and production) will be reached in 2026 as shown in Table 7-13 below.

Table 7-13: Overall peak annual emissions for the proposed Buchan Redevelopment Project.

Peak Annual Emissions	Annual Peak Emissions from the Proposed Development in Te							
	CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	$ktCO_2e$
Peak annual emissions overall reached in 2026	144,726	1,518.49	8.28	49.56	685.31	437.90	408.04	159

7.3.2 GHG Emissions and Intensity of Production

Direct and indirect GHG emissions for the proposed Project between 2026 and 2050 are presented in Table 7-14.

Direct GHG emissions from the FPSO during production are used in conjunction with the high-case production profiles to generate estimates for the GHG intensity of the product as kg of CO_2e per barrel of oil equivalent (boe) as the high production case represents insofar in this ES the worst case environmental footprint. GHG intensities have also been estimated using the mid-case production profiles because these production profiles correspond to the expected production volumes and present more conservative GHG intensity figures for the Development compared to the high-case GHG intensity.

GHG intensities below associated with the worst case no electrification scenario are also presented for context relative to the expected electrification scenario. Note, further comparison in terms of emissions profiles between the no electrification and electrification case is made in Section 7.4.

Whereas the direct GHG emissions profiles during production are similar for both the high and mid production cases as discussed in Section 7.1, predicted production figures for the mid-case are lower than the high-case, leading to higher GHG intensity estimations. Notwithstanding, it should be noted that while Table 7-14 shows predicted GHG intensities up to 2050, production forecasts for the mid-case indicate that expected economic recovery of available reserves will be complete by 2045.

For the worst case no electrification scenario, the average mid-case GHG intensity (to 2045) is 26 $kgCO_2e$/boe. The high-case production forecasts show that the average GHG intensity to 2050 is 19 $kgCO_2e$ /boe. While the mid-case GHG intensities are higher than for the high-case, this does not represent the worst-case environmental footprint in terms of overall emissions. Cumulative GHG emissions for the high-case are approximately 20% higher compared to the mid-case where predicted reserves are recovered earlier (2045) i.e. 2,383 $kteCO_2e$ for the high-case compared to 1,893 $kteCO_2e$ for the mid-case. Thus, while the mid-case GHG intensity of 26 kg CO_2e/boe appears high compared to the high-case GHG intensity of 19 kgCO2e/boe, the mid-case overall GHG emissions indicate that this case represents a more favourable environmental footprint.

Table 7-14: Proposed Project GHG emissions and production carbon intensity.

Year	Without Electrification			With Electrification		
	Emissions	Annual GHG Intensity ($kgCO_2e/boe$)		Emissions	Annual GHG Intensity ($kgCO_2e/boe$)	
	$kteCO_2e$	High Case	Mid Case	$kteCO_2e$	High Case	Mid Case
2026	9.82	6.99	6.99	9.82	6.99	6.99
2027	100.51	6.01	7.25	100.51	6.01	7.25
2028	100.73	7.36	10.00	100.73	7.36	10.00
2029	100.73	9.75	13.05	100.73	9.75	13.05
2030	101.37	11.88	16.70	3.10	0.36	0.51
2031	101.37	13.60	21.27	3.10	0.42	0.65
2032	100.57	15.28	25.07	3.08	0.47	0.77
2033	100.57	17.28	28.71	3.08	0.53	0.88
2034	97.88	18.44	31.76	3.01	0.57	0.98
2035	98.14	20.37	35.67	3.02	0.63	1.10
2036	98.14	22.19	39.31	3.02	0.68	1.21
2037	98.14	24.14	44.62	3.02	0.74	1.37
2038	98.14	26.21	49.56	3.02	0.81	1.53
2039	98.14	28.27	55.46	3.02	0.87	1.71
2040	98.14	30.00	60.88	3.02	0.92	1.87
2041	98.14	32.08	65.85	3.02	0.99	2.03
2042	98.14	33.95	69.77	3.02	1.04	2.15
2043	98.14	35.77	73.79	3.02	1.10	2.27
2044	98.14	37.89	77.13	3.02	1.17	2.37
2045	98.14	40.23	83.94	3.02	1.24	2.58
2046	98.14	42.06	89.04	3.02	1.29	2.74
2047	98.14	43.89	94.01	3.02	1.35	2.89
2048	98.14	45.52	99.51	3.02	1.40	3.06
2049	98.14	47.26	104.42	3.02	1.45	3.21
2050	96.96	48.49	106.22	2.99	1.49	3.28
Drilling, Installation, Commissioning and Start-up	196			196		
Operational Logistics	178			178		
Offshore Modifications for Electrification (2029)	1			1		
Total Development	2,758			750		

7.4 Future Emissions Reductions

The largest contributor to emissions from the Western Isles FPSO derives from the use of fuel gas in the GTGs to power the facility. Electrification via import of power from a renewable power generating source (e.g., an INTOG windfarm) has therefore been identified as a significant reduction opportunity for decarbonisation (see Chapter 3).

The selection of a Sevan FPSO for the Buchan Redevelopment Project delivers a concept technically proven to enable import power and it is intended that the topside facilities will undergo modification to facilitate an efficient future switch to import power. Hence the FPSO will be 'electrification ready' with the facility converted to import power from a 3rd party source e.g. a nearby INTOG wind farm when available (earliest anticipated power supply is 2030). The switch to a 3rd party power source such as a new offshore windfarm delivers a solution that contributes to decarbonisation of both the FPSO and the UK grid supporting the UK Government and NSTA in reaching its Net Zero target.

Table 7-15 presents the estimated emissions generated on the FPSO during the production phase assuming electrification from 2030 onwards, accounting for a 98% uptime from the 3rd party power supplier, with an outage of seven days every three years. As a worst case, it is currently assumed that the remaining 2% will come from back-up power by the GTGs onboard the FPSO.

Table 7-15: Western Isles FPSO emission estimates (including electrification) between 2026 and 2050.

	Rates (2026-2050) (te)	Total Emissions in Te							
		CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	$ktCO_2e$
Fuel Gas	115,930	331,560	249.06	25.50	1.48	695.58	106.66	4.17	341
Diesel	9,225	29,521	160.46	2.03	18.45	42.45	0.64	6.64	30
Flaring	1,289	3,409	1.55	0.10	0.02	8.63	23.19	2.58	4

Table 7-15 shows that electrification would contribute to a significant reduction in GHG emissions of over 80% associated both with the combustion of fuel gas and diesel for power compared to the base case (no electrification) (see Table 7-7) with flaring emissions attributable to non-routine flaring events projected unchanged.

Table 7-16 shows the forecast emissions reduction for the FPSO compared to the base case of utilising the GTGs. The assessment shows a potential 84% reduction in carbon dioxide emissions.

Table 7-16: Western Isles FPSO emissions reduction following electrification.

	Total Emissions (2026-2050) in Te							
	CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC	$ktCO_2e$
Base Case	2,315,639	1,918.05	176.71	106.17	4,613.90	719.24	47.89	2,383
Electrification Case	364,493	411.07	27.64	19.95	746.66	130.49	13.39	375
% Reduction	84%	79%	84%	81%	84%	82%	72%	84%

The benefit of electrification in terms of GHG intensity reduction is presented in Section 7.3.2.

7.5 Emissions Performance Benchmarking

GHG intensity expressed in kg CO_2e per boe is used as a key performance metric at group level by NEO Energy (Chapter 2) as well as the NSTA to compare asset performance and drive improvements integral to the sector's stewardship process (NSTA, 2023a).

Predicted FPSO GHG intensity for the Development during production have been derived both for the base case (Section 7.3.2) and for future electrification. These values are compared to the NSTA benchmark value of 22.9 $kgCO_2e$/boe corresponding to the average UKCS offshore GHG intensity in 2022.

In comparing against sector's performance, it is important to recognise that the benchmark values reported by the NSTA are based on actual GHG emissions (principally based on verified UK ETS data) and reported production data whilst the GHG intensity presented for the Development represents conservative estimates indicative of the degree of uncertainty born by the production profiles and by the GHG estimates based on the assumptions made regarding power requirements, diesel consumption and flaring at this time of the design development (refer to Section 7.1).

The mid-case GHG intensity associated with the FPSO for the proposed Development is estimated to be 26 $kgCO_2e$/boe up to the expected economic recovery of available reserves, which is comparable with the NSTA 2022 benchmark value of 22.9 $kgCO_2e$/boe.

Given that the uncertainty associated with the oil and gas production rates increases in later field life, a higher degree of confidence can be gained in comparing the sector's averages with the predicted GHG intensity for the proposed Development corresponding to the initial 10 years of production. Figure 7-1 thus compares the reported average GHG intensity for an FPSO in the UKCS (NSTA, 2023a) which is less than 10 years old with the estimated mid-case GHG intensity for the Western Isles FPSO after 10 years of production in field and these are shown to be comparable. Note that although the age of the Western Isles FPSO on deployment to the Buchan Horst Field will be 7 years, equivalence is drawn with a "New" FPSO as the intensity profile over time is influenced by the time the FPSO spends in production, rather than the age of the FPSO.

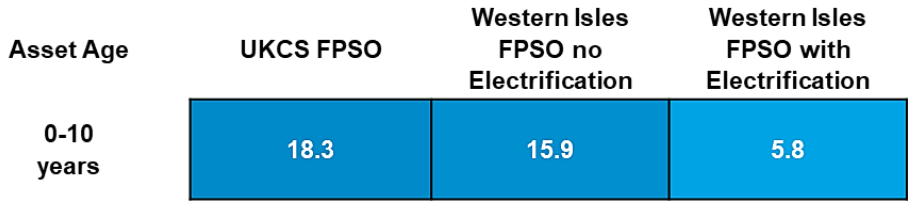


Figure 7-1: Mid-case GHG intensity (in kgCO2e/boe) of the proposed Project relative to UKCS FPSO < 10 years.

NEO are fully committed to developing the Buchan Horst Field in line with the NSTA Stewardship expectations and all conditions relative to their license to operate and to drive GHG intensity performance as low as reasonably practicable in accordance with the company's pathway to Net Zero (Chapter 2). As such, GHG intensity values for the proposed Project are also presented in the context of future improvements that are expected notably with full electrification. A significant reduction of 10.1 kg CO_2e/boe in GHG intensity for the FPSO is predicted with full electrification bringing the overall intensity to 5.8 kg CO_2e/boe.

As noted in Chapter 3, the proposed Project also offers significant potential regarding the development of other prospects in the Greater Buchan Area and in this way, the potential to act as an energy hub for future critical development to the UK contributing to maintaining the GHG intensity of the asset to low values. As discussed in Chapter 2, the impact of any potential new acquisition, including the Buchan Redevelopment Project, on the NEO Energy's portfolio carbon intensity is a key consideration in terms of business development strategy.

7.6 Impacts on Air Quality

Increased concentrations of NOx, SO_2 and VOCs in the atmosphere can result in the formation of photochemical pollution in the presence of sunlight, comprising mainly low-level ozone, but by-products may include nitric acid, sulphuric acid and nitrate-based particulate. The formation of acid and particulates contributes to acid rainfall and the dry deposition of particulates. If such deposition occurs at sea, it is possible that the substances will dissolve in seawater. The ultimate fate of emitted pollutants can often be difficult to predict owing to the dependence on metocean conditions (especially wind), which may be highly variable and lead to wide variations in pollutant fate over short timescales.

7.6.1 Drilling, Installation and Commissioning Phases

Drilling, construction, well clean-up and flaring during start-up emissions summarised in Table 7-2 to Table 7-5 will be of localised extent, of relatively short duration, and take place a substantial distance (more than 115 km) from the nearest coastline. These are expected to disperse rapidly and dilute to background concentrations, resulting in localised and short-term impacts only to air quality.

Given the offshore location of the Buchan Horst Field, applying the assessment methodology presented in Chapter 5 the sensitivity of air quality as a receptor is considered Low (a). Based on the estimated quantity of emissions, the magnitude of effect of the emissions from the proposed drilling, installation and commissioning activities on air quality is considered Minor (2). Combining the Low sensitivity and Minor magnitude of effect, the significance of impact is therefore considered Low such that any impacts on air quality are considered negligible.

7.6.2 Production Phase

The impact of emissions from the Western Isles FPSO on air quality at its current location northeast of Shetland (at the time of writing) was assessed in 2017 as a supporting study for the asset PPC permit currently held by Dana (Dana, 2017). The Cambridge Environmental Research Consultant (CERC) Atmospheric Dispersion Modelling Software (ADMS) was used to compare predicted atmospheric concentrations of NO_2, SO_2, CO and VOC generated by the FPSO to onshore air quality standards under the following worst-case scenarios:

- Scenario 1 – Maximum emissions from normal power generation using fuel gas without flaring. Scenario 1 assumed two (out of three) turbines running at 100% load on fuel gas for normal power generation.
- Scenario 2 – Maximum emissions from start-up / emergency power generation using diesel fuel without flaring. Scenario 2 assumed two (of three) turbines running at 100% load on diesel for start-up / emergency power generation.

- Scenario 3 – Maximum emissions from emergency operating conditions with power generation using diesel fuel and flaring. Scenario 3 assumed two (of three) turbines running at 100% load on diesel fuel for emergency power generation with flaring.

The combustion plant equipment after redeployment of the Western Isles FPSO at the Buchan Horst Field is expected to operate within the limits of the same modelled operating envelope basis.

The report notably demonstrates that pollutant concentrations would not exceed air quality criteria, at all locations within 100 km of the proposed Development, and therefore no significant potential impacts were anticipated from the emission of NO_2 and SO_2. Table 7-17 presents the highest predicted concentrations of NO_2, SO_2, benzene and CO shown at the nearest receptor (Tern Platform – 11.5km) (Dana, 2017).

Table 7-17: Predicted concentrations of NO_2, SO_2, benzene and CO at the nearest receptor for each of the scenarios. (Dana, 2017).

	NO_2 1-hr 99.79%ile ($\mu g/m^3$)	NO_2 Annual average ($\mu g/m^3$)	SO_2 1-hr 99.73%ile ($\mu g/m^3$)	SO_2 24-hr 99.18%ile ($\mu g/m^3$)	SO_2 15-min 99.90%ile ($\mu g/m^3$)	SO_2 Annual average ($\mu g/m^3$)	Benzene Annual average ($\mu g/m^3$)	CO 8-hr running average in 24 hrs ($\mu g/m^3$)
Standard ($\mu g/m^3$)	**200**	**40**	**350**	**125**	**266**	**20**	**5**	**10**
Scenario 1	0.52	0.01	n/a	n/a	n/a	n/a	n/a	0.00
Scenario 2	1.21	0.03	1.32	0.33	2.55	0.04	0.00	0.00
Scenario 3	27.30	0.60	2.23	0.60	4.39	0.06	0.00	0.00

Additionally, the distances relative to sensitive receptors are greater at the proposed FPSO redeployment location compared to the current FPSO location (at the Harris and Barra Fields) (Table 7-18).

Table 7-18: Western Isles FPSO distance relative to sensitive receptors.

	FPSO location at the Harris and Barra Fields	FPSO location at the Buchan Horst Field
UK coastline	93 km	115 km
UK/Norway median line	57 km	103.5 km
Nearest offshore platform	Tern Platform – 11.5 km	Scott platform – 45 km (see Table 4-13)

Meteorological conditions have a significant effect on the dispersion within the ADMS model. A comparison of the windrose displays at the Harris and Barra Fields (current location) and at the Buchan Horst Field (as presented in Section 4) shows similarities in terms of wind direction distribution and intensity. This would suggest that the redeployment location at the Buchan Horst Field would present similar meteorological conditions compared to the FPSO current location and would be representative of dynamic offshore environment and conducive to rapid dispersion of emissions.

In summary, given the demonstration of no significant impact from the previous modelling (Dana, 2017), it is not anticipated that there will be any significant impact as the combustion plant of the FPSO at its redeployment location for the following reasons:

- The combustion plant is anticipated to operate within the same modelled operating envelope,
- The nearest receptor being a greater distance from the combustion plant; and
- The meteorological conditions are comparable.

Additionally, there are no other major emissions sources in the immediate area other than the intermittent in-field and passing traffic, as a result no cumulative effects are considered to occur.

Based on the estimated quantity of emissions presented the magnitude of effect of the emissions from the production phase on air quality is considered Minor (2). Combining the Low sensitivity (as described in

Section 7.6.1) and Minor magnitude of effect, the significance of impact is therefore considered Low such that any impacts on air quality during the production phase is considered negligible.

7.6.3 Decommissioning Phase

A range of specialist and support vessel types will be required at various times, and for various durations, to undertake the decommissioning activities at the end of field life. This will lead to an increase in vessel activity relative to that associated with production.

A drilling rig will be brought to the Buchan Horst Field to plug and permanently abandon the wells. In addition, vessels will be required to remove and recover seabed infrastructure, and to complete pre-decommissioning, execute phase and post-decommissioning legacy surveys.

Vessel emissions associated with decommissioning activities are likely to be similar to those associated with subsea infrastructure installation (see Table 7-4). The extent, magnitude and duration of impact on air quality from offshore decommissioning activities are consequently anticipated to be less than those for the installation and commissioning phase such that the significance of impact is expected to be Low.

This will be confirmed during the preparation of the decommissioning programme and supporting documents.

7.6.4 Transboundary and Cumulative Impacts to Air Quality

The proposed Buchan Redevelopment Project will be located approximately 103.5 km west of the UK/Norway median line. Given this distance and the localised nature and low level of air quality impacts expected, no transboundary impacts are anticipated.

The emissions reported for the UK, and for the UKCS offshore oil and gas industry in 2021 are presented in Table 7-19 in units of thousand tonnes per year.

The contribution that the development of the Buchan Horst Field will make to the cumulative emissions across the UKCS, and to the UK emissions as a whole can be seen from comparison of the overall peak annual emissions for the Buchan Redevelopment Project in 2026.

By way of an example, the NOx emissions from the proposed Project in 2026 (year of the highest emissions as shown in Section 7.3.1) would approximately be 3.81% of the annual emissions from the UKCS industry in 2021 and approximately 0.22% of the annual UK emissions in 2021; noting that in subsequent years during the production phase the proportion of NOx emissions would reduce to approximately 0.9% and 0.05% compared to NOx emissions reported in the UKCS industry and across the UK in 2021 respectively.

Table 7-19: Comparison with emissions from the UK and from the UKCS as reported in 2021.

Year	Emissions						
	CO_2	NO_X	N_2O	SO_2	CO	CH_4	nmVOC
UK Emissions - 2021[1] (kTe/year)	342,600	689	65	127	1,312	2,050	783
Peak Buchan Redevelopment contribution to UK Emissions (2026) (%)	0.04	0.22	0.01	0.04	0.05	0.02	0.05
UKCS Emissions-2021[2] (kTe/year)	10,452	40	1	2	23	26	30
Peak Buchan Redevelopment contribution to UKCS Emissions (2026) (%)	1.38	3.81	0.86	3.28	2.97	1.71	1.36

1. UK Greenhouse Gas Inventory, 1990 to 2021 – Annual Report for Submission under the Framework Convention on Climate Change' - (NAEI, 2023)
2. UKCS EEMS emissions data (EEMS, 2021)

7.7 Impact on Climate Change

In isolation, the GHG emissions from the proposed Buchan Redevelopment Project would not cause a change to the global climate, however it is their contribution to the cumulative impact of total global emissions that is of relevance in assessing the impact of the proposed Project. As such, the resultant GHG emissions are considered in the context of the UK emissions and the UK commitments to emissions reductions, noting that the estimated cumulative increase in GHG emissions as a result of the proposed Project is worst case and does not take into consideration future full electrification with a switch to a 3rd party power source.

7.7.1 Buchan Redevelopment Project GHG Emissions in the Present National and Sector-Wide Context

Total GHG emissions for 2021 across the UK were reported in the UK National Atmospheric Emissions Inventory Report (NAEI) as 430.7 $MTeCO_2e$ (NAEI, 2023). Of this, the UK offshore oil and gas sector accounted for 11.2 $MTeCO_2e$ (NSTA, 2023a), approximately 3% of the UK total.

For context and as shown in Table 7-20, the overall annual peak GHG emissions from the proposed Project when considering all the project phases (drilling, construction, commissioning, well start-up and production) is estimated to reach 0.16 $MTeCO_2e$, which is 0.04 % of the UK total and 1.42 % of the UKCS oil and gas total in 2021.

Table 7-20: Buchan Redevelopment Project incremental GHG emissions in the context of total UK and UKCS.

GHG Source	Emissions (MTe CO_2e)	% UK Total	% UKCS Total
UK Total (2021)[1]	430.70	-	-
UKCS Total (2021)[2]	11.20	-	-
Peak annual emissions (2026)	0.16	0.04	1.42

1. UK Greenhouse Gas Inventory, 1990 to 2021 – Annual Report for Submission under the Framework Convention on Climate Change' - (NAEI, 2023)
2. Carbon Emissions Intensity Analysis - (NSTA, 2023a)

7.7.2 Buchan Redevelopment Project GHG Emissions in the Future National Context

The Climate Change Act 2008, which committed the UK government by law to reducing greenhouse gas emissions by at least 80% of 1990 levels by 2050, was amended in 2019 to commit to achieving 100% reduction (net zero) by 2050. The Climate Change (Scotland) Act (2019) establishes an accelerated target for achieving net zero emissions by 2045 in Scotland.

The Climate Change Act requires the government to set legally-binding 'carbon budgets' to act as stepping stones towards the 2050 target. A carbon budget is a cap on the amount of greenhouse gases emitted in the UK over a five-year period.

Table 7-21 shows the UK Carbon Budgets allocation set under the UK Climate Change Act alongside the projected additional emissions from the proposed Project.

The proposed Buchan Redevelopment Project will span across the 4th, 5th, and 6th UK carbon budgets with drilling, installation, start up, and early production occurring within the 4th budget period and the subsequent two budget periods coinciding with the subsequent 10 years of production. The total future GHG emissions from the proposed Project within each budget period are presented in Table 7-21 as million tonnes of CO_2 equivalent, and as a percentage of the UK budget allocation. These are presented based on a no electrification scenario as worst case.

It is not feasible to calculate the proportion of GHG emissions from the Buchan Redevelopment Project that constitute to the wider UK budget allocation between 2038 and 2050 since carbon budgets beyond 2037 have not yet been established. Regardless of the accounting period, it is evident that the proposed Project will only make up a very minor portion of the UK's available carbon budget and will be even less than the percentage shown when the Western Isles is powered by a 3rd party.

Table 7-21: Buchan Redevelopment Project GHG emissions in the context of UK Carbon Budgets.

Carbon Budget	Budget Period	UK Budget Allocation[1]	Buchan Redevelopment Project	
		($MTeCO_2e$)	($MTeCO_2e$)	% of Budget Allocation
1	2008 - 2012	3,018	-	-
2	2013 - 2017	2,782	-	-
3	2018 - 2022	2,544	-	-
4	2023 - 2027	1,950	0.32	0.02
5	2028 - 2032	1,725	0.56	0.03
6	2033 - 2037	965	0.53	0.06

1. Carbon Budget Delivery Plan – (HM Government, 2023)

7.7.3 Buchan Redevelopment Project GHG Emissions in the Future Oil & Gas Sector Context

In keeping with the Net Zero pathway the UK Government and offshore oil and gas industry established the NSTD in 2021 which, among other actions, agreed targets for staged reductions in GHG emissions from the UKCS against a 2018 baseline year as presented in the first two columns of Table 7-22.

Based on the recorded UKCS GHG emissions for 2018 (baseline year), the third column of the table shows the target emissions for subsequent years stipulated in the NSTD. The final two columns of the table present the proportion of the NSTD budget that GHG emissions from the proposed Project as a whole are projected to account for. In a worst-case no electrification scenario, it is estimated that the proposed development will contribute to a relatively small proportion of UKCS GHG emissions between 2030 and 2050 for the operational phase of the Project in the high production case (representing the greatest potential for environmental impact as outlined in Section 7.1).

Table 7-22: Buchan Redevelopment GHG emissions in the context of the North Sea Transition Deal.

Year	North Sea Transition Deal (1)		Buchan Redevelopment	
	% of 2018	$MTeCO_2e$	$MTeCO_2e$	(%)
2018	100	14.5	-	-
2025	90	13.1	0.05	0.4
2027	75	10.9	0.12	1.1
2030	50	7.3	0.11	1.5
2050	0	0	0.10 (2)	-

1. North Sea Transition Deal – (BEIS, 2021)
2. production forecasts for the mid-case indicate that expected economic recovery of available reserves will l be completed by 2045.

The GHG emissions from the Buchan Redevelopment Project represent a small proportion of the UKCS and UK annual totals, and make up a small proportion of the 4th, 5th and 6th Carbon Budget allocations and of the total UKCS emissions targets established for 2025, 2027 and 2030 under the NSTD.

7.7.4 Buchan Redevelopment Project Carbon Intensity Relative to Production

Whilst the figures presented in Table 7-22 indicate that the GHG emissions from the proposed Buchan Redevelopment Project are anticipated to account for a relatively small proportion of future emissions budgets from the UKCS, these are also discussed below in the context of the UK oil and gas demand.

The demand in the UK for oil and gas is predicted to decline significantly over the next years to 2050, although the UK Government forecasts show that oil and gas will remain an important part of the UK energy mix for the foreseeable future, including under net zero (OGA, 2021). As production from existing fields naturally depletes, meeting the continued demand will require a combination of either the development of new fields within the UKCS or increasing reliance on imported energy products. Current projections show that the UK is forecast to remain a net importer of oil and gas for the foreseeable future, even with the development of new fields within existing licensed blocks (BEIS, 2021b).

In this context, the UK Government's plan for transitioning to Net Zero emissions by 2050 and securing the maximum value of domestic reserves is most aligned with the development of fields in the UKCS that have a relatively low GHG intensity.

The NSTA published an analysis in 2023 demonstrating that North Sea gas is significantly cleaner and supports the drive to net zero GHG emissions far more than imports. The research notably shows that domestically produced gas is on average almost four times cleaner than importing gas in LNG form (NSTA, 2023b).

The corresponding carbon intensity of imported oil, however, is more difficult to ascertain. A study to estimate carbon intensities of global oil production has been published by Masnadi *et al.* (2018) involving a comprehensive analysis of available datasets pertaining to multiple aspects of oil production and their differences between regions, onshore and offshore, around the world. The study concluded a global average GHG intensity of crude oils up to the point of delivery to refinery as being 10.3 gCO_2e/MJ (Masnadi *et al*, 2018). The estimation method derived by the Masnadi *et al*. study is relatively complex and direct comparison for the UKCS should be made with a degree of caution.

From 2004 to 2019, the UK became a net importer of oil, though still an exporter of some oil products. The latest UK energy brief (National Statistic, 2023) shows that in 2022 imports rose by 11%, with rises in imports of coal, primary oil, petroleum products and gas with the key source of oil imports being Norway and the US. Looking forward, in their oil and gas UK Market Insights (OEUK, 2021) OEUK states that oil demand is likely to have already peaked but that oil will continue to play an important part of the mix supplying 29% of cumulative demand through to 2050, and gas providing 21%. OEUK also advises in this same report that out to 2050 UK domestic production can continue to meet around half of demand levels, the deficit met by oil imports.

The Buchan Horst Field is predominantly an oil field, with a relatively small proportion of gas anticipated. Note, to allow for direct comparison with the carbon intensity of global oil production reported by Masnadi *et al.* (2018), the proposed Development GHG intensity have been expressed in gCO_2e/MJ. The proposed Project is estimated to produce 70,506 mbbl (oil) (mid-case up to the expected economic recovery of available reserves) with an average GHG intensity of 4.2 gCO_2e/MJ and 0.8 gCO_2e/MJ with full electrification from 2030, which would be at least 2 times cleaner (mid case) compared to the average global well-to-refinery intensity of crude oils. Based on an outlook to 2050 and in the context of the UK energy demand mix, the Buchan Horst Field could thus play a significant part in supporting the domestic oil demand.

7.7.5 Climate Change Impact Conclusion

Impacts from GHG emissions are difficult to assess in isolation because they are derived from cumulative emissions generated across a range of fossil fuel and industry activities, rather than from any single activity. Nevertheless, GHG emissions from the proposed Project are relatively low in the context of current UK and UKCS emissions and in the context of projected targets for future emissions. Furthermore, the development of the Buchan Horst Field as proposed would contribute to lower than average GHG intensity compared to oil imports and would support the goals for emissions reduction in the UKCS established by the NSTD, even more so with full electrification of the FPSO with a 98% uptime from a 3rd party power source. The electrification plans for Buchan are in support of the INTOG process, which is aimed at increasing the UK's renewable capacity, and is a UK government initiative. The proposed Project is in alignment overall with the UK Government strategy for transitioning to Net Zero GHG emissions by 2050.

Finally, applying the assessment methodology presented in Chapter 5 the sensitivity of climate change as a receptor is considered Very High (d). Based on the estimated quantity of emissions associated with the worst case of no electrification, the magnitude of effect of the proposed project on climate change is considered Minor (2). Combining the Very High sensitivity and Minor magnitude of effect, the significance of impact is therefore considered Moderate such that there is a requirement for the Project to identify specific mitigation measures, in this case electrification of the Western Isles FPSO by a 3rd party. Electrification of the Western Isles FPSO would mean that the magnitude of effect reduces to Negligible (1) and the impact significance would reduce to Low.

7.8 Mitigation Measures

NEO Energy have assessed the impact associated with energy use and atmospheric emissions from the proposed Buchan redevelopment Project. In the drive to towards supporting the UK's Net Zero target and meeting the company's GHG commitments (as outlined in Chapter 2), the identification, assessment, and minimisation of emissions have been embedded in all stages of the project management process. The following integrated measures across drilling, installation, commissioning and production will be adopted to ensure emissions are minimised to 'as low as reasonably practicable'.

Proposed Mitigation Measures

Proposed Concept Select Mitigation Measures

- Inclusion of optimised energy efficiency and GHG emissions reduction in the rig selection and tendering process.
- Investment will be made to ensure the redeployed Western Isles FPSO is electrification ready in advance of the availability of 3rd party source of power e.g. an INTOG windfarm.

Proposed Logistics and Start-up Mitigation Measures

- Batch drilling and completion opportunities will be evaluated. These would reduce emissions through reduced logistical requirements and fluid handling efficiencies.
- The Project team will aim to design wells to minimise use of diesel powered intervention equipment.
- The information gained from each well test will be assessed with a view to reducing the volumes of hydrocarbons to be flared during well testing for each subsequent production well.
- Minimise emissions during well clean-up and well testing operations with the use of optimised flare burner technology (i.e., 'green burner') and with continuous monitoring weather conditions.
- Regarding flaring operations, to ensure all performance related conditions are monitored, and that adjustments can be made accordingly, a dedicated person will be assigned for full-time fire watch duty.
- The drilling rig and other project vessels will be subject to audits ensuring compliance with UK legislation.
- Vessel use will be optimised where possible by minimising the number of vessels required, and their length of time on site.
- Vessels will be operated where possible in modes that allow for economical fuel use.

Proposed Production Mitigation Measures

In accordance with the revised NSTA strategy, and associated Stewardship Expectation 11, as well as with the industry commitments within the NSTD, NEO Energy will incorporate the following controls:

- The plant is designed with the goal of no routine flaring and venting through the provision of existing flare and vent gas recovery systems.
- 'Zero routine flaring' and minimised diesel use will be ensured through the installation of a new gas export pipeline which will also be used to import gas for fuel use when the FPSO becomes gas deficient.
- Visiting shuttle tankers will be equipped with a Vapour Emission Control System (VECS) to eliminate emissions while loading.
- Diesel use by the GTGs will be limited to TARs and for instances when fuel gas is unavailable e.g. plant re-start.
- An N+1 configuration with 2 off GTGs supplying power for production and utility consumers during normal operation with one GTG as standby minimises spinning reserve of standby power generation.
- Reduced NO_x emissions will be achieved through DLE technology on the GTGs. The use of DLE technology is considered BAT for offshore GTGs (EU IPPC, 2017).
- All three GTGs are equipped with Waste Heat Recovery Units (WHRUs) which will be used to recover heat for the heating medium system, increasing the overall energy efficiency of power generating equipment, which ultimately reduces asset emissions.
- NEO Energy will continually monitor and review emissions and carbon intensity of the asset in line with the company's ESG strategy and commitments and in an effort to support the UK's Net Zero target.
- An asset GHG Emission Reduction Action Plan will be prepared for first oil.

These measures will help to ensure that opportunities for efficiency and reduction of atmospheric emissions, where not in conflict with safe operations, are identified, actioned as appropriate and reviewed.

The mitigation measures described above will be managed and delivered within the framework of NEO Energy´s Management System as described in Chapter 2.

Applying the risk assessment methodology described in Section 5 and taking account of the mitigation measures listed above, the following conclusions are made:

- The impact of installation, completions and start-up activities on air quality will be localised, short term and will mainly occur more than 115 km from the nearest shoreline. The significance of impact to the local ecological receptors is therefore considered to be Low.
- The introduction of production from the Buchan Horst Field will result in an increase in emissions of pollutants such NO_x and CO. However, the rapid dispersion anticipated at the proposed location and distance relative to sensitive receptors combined with the fact that the GTGs onboard are equipped with DLE technology, and that diesel use will be minimised as far as is practicable, it is anticipated that the impact significance of the proposed development on air quality during the production phase will be Low.
- In addition, the development of the Buchan Horst Field as proposed would contribute to lower than average GHG intensity compared to oil imports and would support the goals for emissions reduction in the UKCS established by the NSTD, even more so with full electrification of the FPSO from a 3rd party power source. The proposed Project is in alignment overall with the UK Government strategy for transitioning to Net Zero GHG emissions by 2050.

In summary, the overall significance of the impact of atmospheric emissions from the proposed Project on air quality is considered to be Low. With respect to the impact on climate change the impact significance is considered Moderate in the absence of electrification, however as the Project proposes to electrify the Western Isles FPSO as soon as a 3rd party supplier is available the impact significance on climate change is considered Low.

8 Discharges to Sea

Marine discharges can have an impact on water quality and local flora and fauna. This Chapter assesses the impact from the planned marine discharges from each phase (drilling, installation, commissioning and production) of the proposed Buchan Redevelopment Project using the impact significance assessment methodology presented in Section 5.

Planned discharges from vessels and the drilling rig will include waste water discharges from sewage and food waste. These discharges will be managed in line with the International Convention for the Prevention of Pollution from Ships (MARPOL) requirements and their environmental impact significance is considered Low (Appendix B). These are therefore not assessed further in this ES. Similarly, any waste water such as food waste and grey and black water from the Living Quarters on the Western Isles FPSO during production operations will be discharged in line with MARPOL and therefore are not discussed further.

Unplanned discharges leading to accidental releases to the sea are discussed in Chapter 12.

8.1 Sources of Discharges

8.1.1 Drilling Phase

Discharges of solids and fluids to the water column during the drilling phase include:

- drilling fluids and cuttings;
- cement and cementing chemicals; and
- well bore clean-up fluids.

8.1.1.1 Drilling Fluids and Cuttings

The fate and the maximum estimated quantity of drill cuttings and fluids associated with the proposed wells are presented in Section 3.5.5.

Across the seven wells it is expected that around 6,249 te of cuttings will be discharged from the top hole sections (42" and 26") directly to the seabed. However, the ES and supporting drill cuttings discharge modelling assumes a worst case whereby each of the seven wells will require a respud of the two top hole sections such that a maximum discharge of 12,499 te of cuttings has been allowed for. At the time of writing it is not known if the drill cuttings from the lower sections (17.5", 12.25", 8.5" and 6") which are expected to be drilled using LTOBM will be skipped and shipped or thermally treated offshore and discharged. The drill cuttings modelling assumes that these cuttings will be treated and discharged. Total volume of cuttings from the lower sections of the seven wells is estimated at around 4,253 te, however to allow for contingency side tracks the modelling assumes a discharge of 7,224 te of treated cuttings. These treated cuttings will be discharged from a cuttings chute on the drilling rig after re-mixing with the recovered water which allows a slurry to be formed, which will flow and descend in the water column.

The seawater with high viscous sweeps used for the top sections on the wells are typical of drilling fluids used in the UKCS and will contain seawater as the base fluid and barite as the weighing agent. These will be the major components of the drill mud used. Various additives will then be used to improve the technical performance of the mud. Examples include bentonite clay and a biopolymer which will be incorporated to create a homogeneous fluid and for viscosity control. Other chemicals (such as caustic soda) will also be added to achieve shale stability, cooling and lubrication. Most of the additives, except for the caustic soda and biopolymer are considered to Pose Little or No Risk (PLONOR).

The LTOBM drilling fluids used for the drilling of the lower well sections will consist of a low-aromatic mineral oil as the base fluid and barite (weighing agent). Various additives will be added again to improve the performance of the mud such as viscosifiers, emulsifiers, pH and shale control agents and deflocculants (which reduce tendency of the mud to coagulate into mass of particles and become less effective). Chemical additives returned to the drilling rig which pass through the thermal treatment unit on the drilling rig are expected to be broken down by the thermal treatment (Vik *et al*., 2014).

Further details regarding the thermal processing of cuttings are provided in Section 3.5.5. Treated LTOBM cuttings typically contain under 0.1 % hydrocarbon content by weight which is well below the regulatory

requirement of 1 %. The actual level of oil on cuttings will be determined by measurement on the rig prior to discharge.

Modelling was carried out to determine the environmental risk to the water column from drill cutting discharges from the proposed Buchan Redevelopment Project. DREAM modelling was used to assess the risk to the water column associated with drill cuttings toxicity and particle suspension and to assess the recovery of the water column over time. The modelling report is provided in Appendix C and the results are summarised in Section 8.5.1.

8.1.1.2 Cement and Cementing Chemicals

As described in Section 3.5.6, when drilling a well, cement is used to secure the steel conductor and casings in the well bore and cementing chemicals are used to modify the technical properties of the cement slurry. These include:

- discharge of residual mixed cement from the rig following a cementing operation;
- discharge of cement as a result of an aborted cementing job; and
- discharge onto the seabed of excess cement pumped down the well (note that the associated impact is assessed in Chapter 9 and is thus not considered further here).

Typical cementing chemicals include:

- anti-settling agents used to stabilise mixed cement;
- wetting agents used to ensure an improved cement bond;
- cement slurry dispersants used to reduce the viscosity of the slurry and aid displacement;
- fluid loss reducers used to control water loss from cement slurries;
- cement slurry spacer viscosifier used to build weighted fluid spacers to separate cement slurry from drilling muds during slurry displacement;
- cement accelerants used to reduce the time taken for cement to set.

Prior to carrying out the cementing job, dry cement is mixed in a cement unit on board the drilling rig. Once the cement job is completed, the cement unit is washed to remove any residual chemical additives and / or cement slurry from the lines, as any cement slurry left in the lines will set and block the line rendering the cement unit incapable of performing the next job until this blockage is removed. The water and residual cement are discharged overboard.

The need to abort a cement job could arise for a number of reasons including: a total failure of the pumping equipment, a blockage (either on surface or down the wellbore) in the pipes through which the cement is pumped, or due to changing downhole well conditions (for example wellbore collapse, losses, or well control scenarios). In these instances, the consequences of not discharging mixed cement would be severe with the potential for cement to settle in the pumps, pits and lines on the rig, rendering the equipment unusable until the hardened cement is removed from surface equipment. This could in turn result in major workscopes associated with disconnecting, removing and cleaning the lines before reconnecting them in order to return the equipment to operational status.

8.1.1.3 Well Bore Clean-up and Well Test Fluids

Each well will be displaced from LTOBM to inhibited brine during the completion phase. The displaced LTOBM will be retained offshore or returned to shore for re-use. Any LTOBM contaminated water will be returned to the mud pits initially to allow for testing. Fluids which meet the oil-in-water discharge criteria will be discharged overboard. All other fluids will be returned to shore for further treatment.

The well bore clean-up process could result in a volume of approximately 1,000 bbls (*c*. 164 m^3) per well of brine being discharged overboard. The LTOBM chemical additives selected will be subject to the Offshore Chemicals Regulations requirements and the potential traces contained in the cleaned wellbore fluid discharge will be risk assessed as part of the drilling application for chemical use/ discharge. It will occur in discrete volumes at the end of each well allowing time between the discharges for the water to disperse.

During well clean-up to the rig, the well completion fluids comprising inhibited brine will be separated, filtered, sampled and those which meet the oil in water discharge criteria will be discharged to sea. Fluids which do not meet the discharge criteria will be returned to shore for processing.

8.1.2 Subsea Installation and Commissioning Phase

Planned discharges to sea during the installation and commissioning phase will include:

- sediment suspension during subsea installation activities, and trenching and backfilling (discussed further in Chapter 9);
- hydrotesting water during the installation, flooding, cleaning and gauging of the new pipelines;
- low toxicity water-based chemicals during the installation of the new pipelines;
- inhibited water discharges during the pipeline tie-in to the spools and risers; and
- water and MEG discharges during the pipeline dewatering.

The installation of structures on the seabed and the proposed trenching and backfilling of the infield flowlines and EHC umbilical and the gas export pipeline will result in sediments being suspended in the water column and subsequent resettlement on the seabed. Once activities are completed the suspended sediments are expected to settle out of the water column relatively quickly such that the impacts to the water column are temporary. Note impacts of the resettled sediments on the seabed are considered in Chapter 9 (Seabed Disturbance).

Following installation of the subsea infrastructure (summarised in Table 3-13) flooding, gauging (for the export pipeline), strength testing and hydrotesting will be required. During the test, the new gas pipeline, the infield flowlines and the tie-in spools will be flooded with inhibited seawater and an inhibited mixture of water (most likely containing biocide, oxygen scavenger and corrosion inhibitor chemicals) and MEG (listed as PLONOR). The lines will be subsequently pressurised and monitored for a period (typically less than 24 hours) to check for leaks before the water is released in a controlled manner at the seabed.

Following the hydrotest, the gas pipeline and infield system will be de-watered and filled with nitrogen prior to start-up. Approximately 1,160 m^3 of inhibited water and MEG will be discharged during the de-watering phase at the drill centre manifolds and the Ettrick PLEM. Inhibited water and MEG for the water injection flowline will remain downhole.

8.1.3 Sources of Discharges During the Production Phase

Discharges to sea associated with the production phase will include:

- drainage water discharges from the Western Isles FPSO; and
- produced water discharges at the Western Isles FPSO in the event of failure of the produced water reinjection system.

8.1.3.1 Drainage Water Discharges

As described in Section 3.7.3 liquids collected in the open drain system will include rainwater and deck-washing from hazardous areas. Small amounts of chemicals and hydrocarbons can be entrained in the wash-down water collected by the drains. The open drain system will be routed to dedicated drain tanks located in the hull of the FPSO. The drain tanks are fitted with oil skimming facilities and residual hydrocarbon-free water will be routed to sea via the drains caisson. A manual sample point is located downstream of the meter for sampling the oil in water in overboard discharges. The closed drains will be routed to closed drain tank located on the main deck of the FPSO. The closed drain will normally be routed back into the process stream - with the option to route the liquid to the slop tank.

8.1.3.2 Produced Water Discharges

The discharge of produced water to sea is one of the largest discharges associated with offshore oil and gas developments. Produced water may contain residues of reservoir hydrocarbons (oil), dissolved organic and inorganic compounds present in the geological formation and chemicals added during the production process. Examples of the types of chemicals which may be used on the Western Isles FPSO include defoamer, demulsifier, wax inhibitor, biocide, reverse emulsion breaker, scale inhibitor and oxygen scavenger.

The produced water treatment system on the Western Isles FPSO is designed to remove the majority of residual hydrocarbons and substances held in the oil phase. The treatment system is not expected to have any impact on any chemicals or naturally occurring substances which have dissolved in the water phase. The normal disposal route of the treated produced water is re-injection into the Buchan Horst reservoir via the FPSOs PWRI system. The design specification of operational availability of at least 90% has been used to calculate the total annual produced water volume that may be discharged overboard, when the PWRI system is unavailable.

If regulatory oil in water requirements for overboard discharge cannot be met (i.e. if >30 mg/l monthly average or >100 mg/l at any time) during any periods that the PWRI system is unavailable, the procedure will be to use temporary storage in slop tanks and then, if necessary, to restrict or shut-in production until the PWRI system is brought back on line or overboard discharge concentration requirements can be met.

This section assesses the impacts of the dispersed oil, and production chemicals associated with the discharge of the produced water associated with the proposed Project.

Oil Associated with Produced Water

The Western Isles FPSO's produced water treatment system is designed to reduce the oil content in the produced water to a target concentration of around 25 mg/l (monthly average). As part of the modifications described in Section 3.7.4, the produced water treatment facilities will be reviewed with a view to improve on this target concentration i.e. to achieve less than the 25mg/l oil in water.

As detailed in Section 3.8.3, produced water volumes increase over field life and the produced water volumes associated with the Mid Case production profiles are greater than those associated with the High Case production profiles. Table 8-1 shows the volume of oil in water associated with the years of maximum produced water (2039 onwards) based on 10% down time of the PWRI system. For 2039 this would equate to an average discharge of *c*. 604 m^3 of produced water per day (associated with the Mid Case hydrocarbon production profiles). Estimated oil volumes have been calculated based on an oil in water concentration of 25mg/l (in line with the Western Isles system design) and an oil in water concentration of 30 mg/l (maximum regulatory requirement). When compared to total UKCS oil in produced water discharged in 2020, the discharges associated with the proposed Project would represent ~~t~~less than 0.3 % for the years of maximum production (Table 8-1).

Table 8-1: Dispersed oil associated with maximum produced water profiles.

Source	Annual oil discharged in Produced Water (te)	Maximum daily oil discharged in PW (te)
Based on oil in water concentration of 30 mg/l		
Dispersed oil associated with year of maximum produced water production (2039 onwards). Volumes of oil based on 10% discharge of produced water.	6.615	0.018
2020 UKCS dispersed oil in produced water discharged (OGUK, 2021) (te)	2,234	6.12
Estimated worst case oil in water discharged at Buchan Horst as a % of UKCS 2020 total	0.296	
Based on oil in water concentration of 25 mg/l		
Dispersed oil associated with year of maximum produced water production (2039 onwards). Volumes of oil based on 10% discharge of produced water.	5.513	0.015
2020 UKCS dispersed oil in produced water discharged (OGUK, 2021)	2,234	6.12
Estimated worst case oil in water discharged at Buchan Horst as a % of UKCS 2020 total	0.247	
*Produced water associated with the Mid Case production profiles are higher than those associated with the High Case production profiles and therefore Mid Case produced water for 2039 is considered to represent worst case: 6,042 te/day. Estimates of oil in water discharge volumes are based on the PWRI system having a 90% uptime.		

Chemicals Associated with Produced Water

Chemical use and discharge during production is regulated under the Offshore Chemicals Regulations 2002 (as amended). Chemicals discharged into the marine environment have the potential for acute or long-term effects on marine organisms. Whether these effects are realised depends on a number of factors such as the inherent toxicity of the material, the quantities discharged and resulting concentrations in the water column, the length of time biota are exposed to that concentration and the sensitivity of the organisms to the particular chemical. Chemicals discharged from offshore operations are immediately diluted in the sea. The amount of dilution depends on the water depth and water currents but is estimated at approximately 1,000 at a distance

of 500 m from the discharge point. This dilution tends to reduce concentrations to levels which are not acutely toxic to marine organisms (OGUK, 2009).

Details (e.g. type/volume) of all proposed chemicals will be provided in the Developments Production Operation MAT (Master Application Template) application. The chemicals to be used during the processing of the Buchan Horst hydrocarbons have yet to be confirmed. However chemicals which are PLONOR or of lowest toxicity will be prioritised.

8.1.4 Decommissioning Phase

Some discharges to sea are likely to occur during the decommissioning of the Buchan Horst facilities at the end of field life. These will and/or may include planned discharges during abandonment, cleaning, disconnection and removal of infrastructure from the proposed Buchan Redevelopment Project.

Discharges to sea resulting from the decommissioning activities will be described in the environmental impact assessment submitted in support of the Decommissioning Programme.

In addition to chemical discharges, there is potential for some discharge of scale and debris during well abandonment. All discharges that may be contaminated with hydrocarbons will be cleaned to below minimum levels required at the time of decommissioning or shipped to shore for treatment and disposal.

8.2 Discharges to Sea Impact Assessment

8.2.1 Impacts Associated with the Drilling Phase

The impacts associated with the deposition of drill cuttings on the seabed and the return of cement to the seabed are discussed in Section 9 (Seabed Disturbance), whilst this section focuses on the discharges to the water column.

Modelling of the fate of the drill cuttings from the proposed seven wells and worst case contingencies (see Section 8.1.1.1) was carried out using Dose-related Risk and Effect Assessment Model (DREAM) to predict environmental risks to the seabed and the water column as a result of the discharge of drill cuttings (full details of the scenario modelled, assumptions made, results and uncertainties are provided in Appendix C). With respect to the impact on the water column, the results indicated that the volume of the water column where there is a risk to over 5% of sensitive species varies over time and that the volume at risk reduces rapidly after each discharge stops whilst 24 hours after drilling has ceased there are no areas of significant risk within the water column. The primary risk to the water column was due to an increase in suspended solids: barite (42.0%), bentonite (34.09%) and rotomill barite (23.1%).

Any discharges of cement to the water column (e.g. from planned flushing operations of the cement unit or from an aborted cement job) are expected to disperse rapidly in the upper water column. Stark and Mueller (2003) concluded that at North Sea temperatures, cement particles that have been diluted will not increase significantly in particle size due to their hydration reaction and will remain in the range 10-30 microns or smaller which is controlled by their manufacture and specification. Such particles will take many days to settle through the water column and will be in an inert reacted state once on the seabed. The initial discharge may affect plankton in the localised area of the plume, with rapid recovery expected similar to a discharge of drilling solids.

All chemicals used during the drilling phase will be compliant with the Offshore Chemicals Regulations and will be selected to minimise environmental impact. As such, all chemicals selected will have gone through rigorous testing with regards to their biodegradability, toxicity and persistence and PLONOR chemicals will be prioritised where possible. With careful selection of chemicals known to have minimal environmental effect, any potential impact may be limited to acute effects. While there is the possibility for acute effects, it is expected that concentrations of these chemicals upon discharge will be rapidly diluted by currents such that no chronic impact is anticipated.

Suspended sediments in the water column resulting from the discharge of the drill cuttings or cement washes have the potential to impact on the flora and fauna associated with the water column.

Primary production by phytoplankton may be impacted by reduced light penetration and nutrient availability, however given the short duration of the discharges, and their dilution following discharge, any potential impacts on primary production are not considered measurable. Argendt *et al*. (2011) found that some species of copepods (species of zooplankton) were found to feed at lower rates in the presence of high concentrations of suspended sediments. Their findings also suggest that in the presence of ongoing high levels of elevated sediments, egg production rates by some zooplankton could be reduced. As the discharges are short term and

will be diluted immediately, any potential impacts on zooplankton are expected to be at an individual level (e.g. particle may clog filter feeding structures) and not a population level such that any impacts on zooplankton of these discharges are not considered measurable.

Todd *et al*. (2015) carried out a review of the potential impacts of marine dredging activities on marine mammals. The authors concluded that there was no evidence of significant impacts on marine mammals of suspended sediments. Therefore it is expected that any impacts from the discharged drill cuttings and cement fluids will not be measurable.

The sensitivity of fish to suspended sediments varies greatly between species and their life history stages and depends on sediment composition (particle size and angularity), concentration and the duration of exposure (Newcombe and Jensen, 1996). Being the major organ for respiration and osmoregulation, gills are directly exposed to, and affected by, suspended solids in the water. If sediment particles are caught in or on the gills, gas exchange with the water may be reduced leading to oxygen deprivation (Essink 1999; Clarke and Wilber 2000). This effect is greatest for juvenile fish as they have a higher oxygen demand and small gills at higher risk of clogging (FeBEC 2010). However, as the discharges are short term and will be diluted immediately, any potential impacts on fish are expected to be at an individual level (e.g. particles may clog filter feeding structures) and not a population level such that any impacts are not considered measurable.

Given that a number of fish species in the area of the Buchan Horst Field are considered to be PMFs (see Section 4.3.3), and that all cetaceans are considered Annex IV species the sensitivity of receptors in the water column is considered Medium (B). The results of the drill cuttings discharge modelling indicate that any potentially significant impacts on the water column will disappear within 24 hours. In addition, it is expected that over a period of hours, the cement discharges to the water column (e.g. following the washing of the cement unit or as a result of an aborted cement job) will be indistinguishable from background suspended solids concentrations. The magnitude of effect of these discharges on the water column is therefore considered Negligible (1). The overall impact significance is therefore considered Low such that any impacts of the suspended drill cuttings and cement discharges are thought to be negligible. Note the impacts on benthic species is considered in Section 9 (Seabed Disturbance).

8.2.2 Impacts Associate with the Installation and Commissioning Phase

As described in Section 8.1.2, following installation and hook-up of the flowlines, a number of activities will be carried out that may result in discharges to sea.

These discharges could contain chemicals including oxygen scavengers and biocides to mitigate the risks of corrosion or bacterial growth whilst an ultraviolet-fluorescent dye may be added to assist in leak detection.

Neo Energy aims to minimise the effect of the chemicals used/discharged during its operations and as such, wherever possible, chemicals will be chosen which are PLONOR (Pose Little Or No Risk) or are of a Hazard Quotient (HQ) <1. All CHARMable (Chemical Hazard Assessment and Risk Management) chemicals discharged will be further assessed by calculating a Risk Quotient (RQ). Where chemical use and discharge results in a RQ value >1, thus indicating a possible risk of the discharge causing harm to the marine environment, further investigation of the product will be carried out to determine if there is an alternative product that can be used which produces a lower RQ.

There is also the possibility of some hydraulic fluids being released during subsea valve operation and maintenance. However given the use of water based hydraulic fluids, any environmental impacts will be limited.

All chemicals used during pipeline testing and commissioning will be risk assessed within the relevant chemical permit applications. The testing will be carried out over a short timescale and the amount of chemicals discharged to the marine environment will be minimised.

Marine flora and fauna may be affected on a localised level but given NEO Energy's commitment to prioritise the use of chemicals which are PLONOR, or are of a HQ <1, the rapid dilution that will occur on discharge means that the magnitude of effect is considered Negligible (1). Combined with a receptor sensitivity of Medium (b) the impact of significance is considered Low such that any impacts of the chemicals discharged during commissioning are thought to be negligible.

8.2.3 Impacts Associated with the Production Phase

8.2.3.1 Drainage Water

Drainage discharges will predominantly contain rainwater but may also contain minor traces of chemicals, grease or hydrocarbons in the wash-down water collected by the drains. Whilst the risk of a slight contamination of the deck wash-down water is possible following chemical and fuel resupply, and planned and unplanned maintenance, the risk will be minimised by good operating practice and bunds onboard the Western Isles FPSO to prevent spillages. The design will ensure that any discharge meets regulatory requirements. In addition, any discharges are expected to be rapidly diluted by currents such that any possible impact will be localised, short-lived and any effect to water quality and marine organisms unlikely to be detectable above background level.

Marine flora and fauna may be affected on a localised level but given NEO Energy's commitment to good practice, and the rapid dilution that will occur on discharge, the magnitude of effect of any drain discharges is considered Negligible (1). Combined with a receptor sensitivity of Medium (b) the impact of significance is considered Low such that any impacts of drain discharges during the production phase are thought to be negligible.

8.2.3.2 Produced Water

Following its discharge to sea, produced water undergoes several weathering processes, partly influenced by the behaviour of the discharge plume which may be dense and sink towards the seabed or buoyant and rise to the surface. The effluent dilutes rapidly upon discharge to well-mixed seawater. Low molecular weight organic compounds will either volatilise into the air or be degraded by micro-organisms present in seawater. Many constituents will precipitate on discharge (e.g. metals). Higher molecular weight organic particles could adsorb onto suspended solid and sediment. Individually or collectively, these processes tend to reduce concentrations of produced water compounds in the receiving environment and thereby decrease their potential toxicity and bioavailability to marine organisms (IOGP, 2003).

Research into the effects of PW discharges has focused on components that could result in chronic biological effects, in particular PAHs and high molecular weight phenols. PAHs are known to have mutagenic, carcinogenic and teratogenic properties. However, many marine organisms have the ability to metabolise and detoxify PAHs at the concentrations found in the receiving environment. In the laboratory, high molecular weight phenols can be shown to exhibit endocrine disruption. However, for both PAHs and phenols it has not been possible to identify any significant biological effects resulting from exposure to produced water discharges (Oil & Gas UK, 2009).

The produced water system is designed to reduce the oil content in the produced water to a target of 25 mg/l OIW or less (monthly average). Produced water discharges will mix with seawater and be dispersed by local currents. Potential impacts on water quality could affect plankton drifting in the water column that come into contact with the discharge plume. It is unlikely that fish or marine mammal species will be directly impacted by produced water discharges to sea due to their ability to avoid the discharge.

In normal operations, produced water will be treated and reinjected into the reservoir such that the potential impacts described above are unlikely to occur given the high dilution rates that would be expected in the area. Given the open nature of the North Sea, the sensitivity of water quality as a receptor is considered Low. Given that the base case is to treat and reinject all produced water, and NEO Energy's commitment to cease overboard discharge should regulatory targets not be met, the magnitude of effect of the discharges of produced water is considered Negligible (1). The overall impact significance on water quality is therefore considered Low such that any impacts of these discharges are thought to be negligible.

8.2.4 Impacts Associated with Decommissioning

The quantity and nature of the marine discharges associated with the decommissioning activities are anticipated to be such that the potential risks associated with these discharges would not exceed those associated with the drilling, installation and production activities.

8.3 Cumulative and Transboundary Effects

The cumulative impact of drill cuttings and cement on the seabed are discussed in Chapter 9. In relation to all other discharges, given the proposed mitigation measures no significant cumulative impacts are anticipated.

In terms of cumulative impacts resulting from increased concentration, extent and duration of the drilling and installation discharges, there are no other oil and gas drilling and construction activity currently scheduled to

occur in the Project area during the proposed drilling campaign and installation campaigns. However it is possible that decommissioning activities associated with the initial Buchan development may be ongoing, however any cumulative impacts on the water column and faunal receptors in the area are not expected to be measurable. As discussed in Section 8.2, any impacts from drilling and installation discharges will be short-term and fully reversible once the activity ceases.

Any planned marine discharges at the Western Isles FPSO during production will be limited to the minor discharge of drainage water the potential discharge of 10% of the treated produced water. Owing to the geographical location of the Western Isles FPSO and the degree of dispersion at this location, no cumulative effects are anticipated.

The Buchan Redevelopment Project area is located *c.* 103.5 km west of the UK/Norway median line and therefore no transboundary impacts are anticipated from the discharges associated with the proposed Project.

8.4 Mitigation Measures

The following industry standard mitigation measures will be undertaken to minimise the impacts of any discharges to sea associated with the proposed Buchan Redevelopment Project.

Proposed Mitigation Measures

- Minimise use of vessels, through efficient journey planning;
- NEO Energy will review vessel CMID as part of vessel assurance and all vessels will be compliant with the Company's MAS;
- All vessels used will be MARPOL compliant;
- All contracted vessels will originate from countries adhering to the IMO Convention;
- As part of the Company's auditing process, only vessels adhering to the IMO 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Species will be used.
- The drilling rig is to be audited under NEO Energy's marine assurance standards and subject to rig recertification audits;
- Where technically feasible NEO Energy will prioritise the selection of chemicals which are PLONOR, or have the lowest RQ; and
- The discharges of any water based hydraulic fluids, or chemicals are regulated by the OPPC and/or OCR regulations and reported through the EEMS. As such, NEO Energy will ensure that sampling, analysis and reporting are undertaken in line with the regulations and permit conditions.

Applying the risk assessment methodology described in Chapter 5 and taking account of the mitigation measures listed above, the impact significance associated with the discharges to sea (other than those associated with the accumulation of drill cuttings or cement on the seabed, which are discussed in Chapter 9, Seabed Disturbance) is considered low. The impacts are therefore considered acceptable when managed within the additional controls and mitigation measures described. The proposed activities will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

9 Seabed Disturbance

This section assesses the potential impacts of different sources of seabed disturbance associated with the Buchan Redevelopment Project, using the risk assessment methodology presented in Section 5.

Seabed disturbance will occur during the drilling and installation phases of the proposed Project. Short term disturbance (such as placement of drilling rig anchors) is considered to be temporary, whereas the footprint of infrastructure (such as the FPSO mooring system, spot rock cover and mattresses) that will be in place for the life of the field (long term) is considered to be permanent.

9.1 Drilling Phase

9.1.1 Drilling Rig

As described in Section 3.5 at the time of writing, it is not known if a semi-submersible drilling rig or a HDJU drilling rig will be used to drill the proposed wells. This section considers the worst-case seabed impact associated with anchoring of a semi-submersible drilling rig as this would result in a greater impact than the positioning of the HDJU drilling rig. However the potential for spud can depressions remaining is also considered should a HDJU drilling rig be selected.

Having been towed to the site, the semi-submersible drilling rig will be held on location using eight drag anchors connected to the drilling rig via 8 x c. 1,400 m anchor lines. Anchor dimensions of 7.1 m x 6.4 m are assumed. During positioning it is assumed each anchor will impact an area of 10 m x 10 m, whilst a maximum length of 1,000 m of each anchor line is anticipated to come into contact with the seabed. A single positioning of the drilling rig at each of the two drill centres (i.e. two positionings in total) will allow all well top-hole targets to be reached with the drilling rig skidding between wells at each drill centre. The maximum anticipated area of seabed disturbance associated with the installation of the anchor system is provided in Table 9-1 whilst the impacts on the seabed and associated ecosystem are discussed in Section 9.6. If a HDJU drilling rig is used the spudcan penetration into the seabed will be between 10 and 15 m deep and 22 m in diameter. It is expected that all wells could be reached with three positionings of a HDJU rig such that a maximum of nine spudcan depressions could remain.

9.1.2 Drill Cuttings and Drilling Mud Discharges

It is expected that drill cuttings and associated seawater and high viscous sweeps will be discharged at the seabed during drilling of the 42” and 26” sections of each well (see Section 3.5.5).

The lower sections will be drilled with LTOBM. As described in Section 3.5.5, at the time of writing it was not known if the LTOBM contaminated cuttings from the lower sections will be skipped and shipped to shore or if they would be thermally treated offshore and discharged from the drilling rig. Modelling of the discharge of the drill cuttings has been carried out to support the seabed disturbance impact assessment of cuttings and it assumes the LTOBM contaminated cuttings will be thermally treated and discharged. If thermally treated offshore, the resulting cuttings powder will be discharged via a chute *c*. 15 m below the water surface. The processed powder typically contains under 0.1 % hydrocarbon content by weight (Kirkness and Garrick, 2008). This is well below the regulatory requirement of 1 %.

As described in Section 8.2 modelling was carried out to determine the environmental risk of the discharge of drill cuttings (Appendix C). The modeled scenario considered a worst case with the discharge of cuttings from a number of respud and contingency sections also being included (detailed in Section 8.1.1). The modelling calculated the risk to the seabed sediments based on a combination of stressors including: burial thickness, change to grain size, toxicity of chemicals/ base oil, and pore water oxygen depletion. In the absence of any other stressors a risk to more than 5% of the species most sensitive to change in one or more environmental parameter would occur when:

- Burial thickness exceeds 6.5 mm;
- A median grain size change greater than 52.7µm;
- Oxygen content depletion greater than 20 % and

- Toxicity where chemical concentration (in this case of the base oil) exceeds Predicted No Effect Concentration (PNEC).

(Trannum, 2004; Kjeilen-Eilertsen *et al*. 2004; and Neff 2005 as cited in Genesis, 2023).

The model calculates the risk to sensitive species for each of the seabed stressors individually and for all stressors combined. The main contributor to the risk is oxygen depletion (57.5%). Burial thickness and sediment grain size change 24.4% and 18.1% respectively. There is minimal contribution (0.1%) from toxicity, from the reservoir oil. This contribution is very limited as there are no added chemicals and only a small mass of SARALINE 185V is discharged after treatment through the rotomill. Further details are provided in the modelling report (Appendix C).

The modelling predicted a maximum thickness of cuttings of 4.650 m around the wells, with significant thicknesses (over 6.5 mm) predicted to occur up to *c*. 950 m from the discharge locations. The area where thickness is greater than 6.5 mm is predicted to be *c*. 0.1847 km^2 at the end of drilling but reduces over time. To put this into context, a typical exclusion zone around a platform of 500 m radius is equivalent to an area of 0.785 km^2. It is noted that the modelled cuttings pile is primarily made up of cuttings from the top-hole sections (seawater and high viscous sweeps). The finer grained powder discharged from the LTOBM sections tends to disperse over a wider area but results in smaller burial thickness.

The maximum area where there is a combined risk to more than 5% of the most sensitive species in the sediment is predicted to be approximately 0.478 km^2 32 days after drilling discharges end. The area reduces to 0.204 km^2 after two years following the discharge due to re-colonisation by opportunistic species. Seabed recovery then slows down, and after 5 years and 10 years respectively the potentially impacted area is estimated to be 0.153 km^2 and 0.108 km^2 respectively. The predicted combined risk at 32 days post drilling, at two years, five years and 10 years is shown in Figure 9-1.

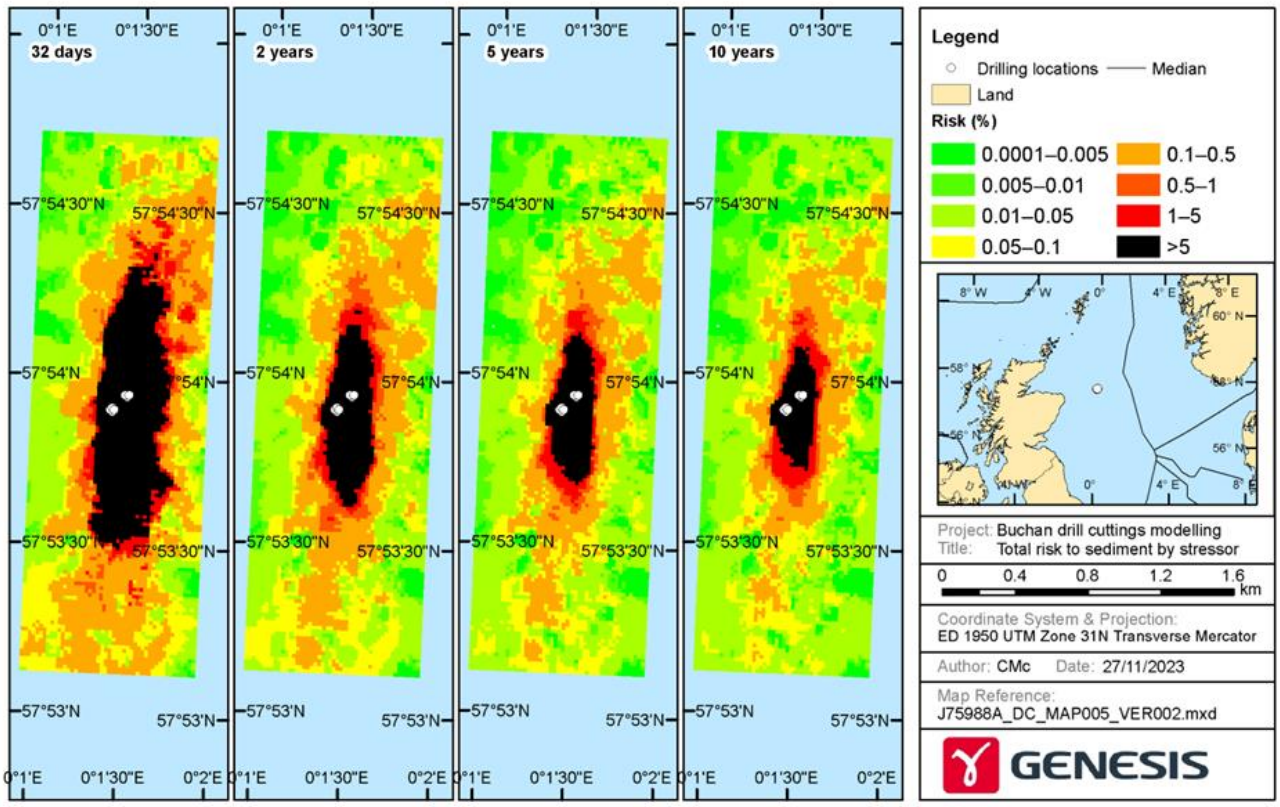


Figure 9-1: Predicted combined potential risk to the sediment over time.

Table 9-1 summarises the anticipated maximum area of seabed to be impacted during the drilling phase and therefore includes areas impacted by the drill cuttings and drilling mud discharges. The impact of the discharged cuttings is discussed in Section 9.6. Potential impacts to the water column from the discharge of drill cuttings are discussed in Section 8 (Discharges to Sea).

9.1.3 Cement Deposits at the Wells

As discussed in Section 3.5.6 it is possible that solid cement deposits could occur on the seabed in the immediate vicinity of the top of each well. If they do occur these deposits are expected to impact on an area of less than 0.0002 km^2: based on approximately 20 te impacting on an area extending 7.5 m around each well radius. The impact of these deposits on the seabed and its associated ecosystem are discussed in Section 9.6.

9.2 Installation Phase

9.2.1 Subsea Infrastructure and Stabilisation Materials

Table 3-13 and Table 3-14 summarise the subsea infrastructure and stabilisation features to be installed as part of the proposed project. Table 9-1 summarises the seabed areas anticipated to be temporarily and permanently impacted by the proposed installation activities. It should be noted, the area of disturbance presented represents a worst case, for example the area impacted by the grout bags will likely also be impacted by the mattresses and infrastructure. In addition the quantities of mattresses and grout bags allowed for, include a 20% and 10% contingency respectively (see Section 3.6.5). Base case is that no rock cover will be required, however contingencies have been included as described in Section 3.6.5. Also as the option to export/import gas via the SAGE pipeline system (with tie in to the Ettrick PLEM) would require the longest pipeline, the area of seabed disturbance presented in Table 9-1 is based on that option (as opposed to the option to tie into the FUKA pipeline system at the Tweedsmuir manifold). For those structures laid on the seabed (including riser base, drill centre manifolds, Xmas trees and stabilisation features), the impacted area beneath each item is considered to be permanently impacted, however the assessment also allows for temporary disturbance of sediments resettling on the seabed in the immediate vicinity of each item.

The Western Isles FPSO will be moored in place using twelve anchors and associated mooring lines (3 groups of 4). At the time of writing it had yet to be determined if the mooring system would comprise piled anchors or suction anchors; however as the diameter of the suction anchors (6 m) would be greater than that of the piled anchors (2 m), the assessment of area impacted presented in Table 9-1 is based on the suction anchors. It is expected that the full length of each anchor line will be temporarily wet stored on the seabed and following tie-in the Western Isles FPSO it is expected that around 500 m of each mooring line will lie on the seabed and that the maximum lateral movement (swathe) of the mooring line caused by subsea currents will be *c*. 60 m at its widest point.

The impacts of the seabed disturbance associated with subsea infrastructure and stabilisation materials is discussed in Section 9.6.

9.2.2 Trenching and Mechanical Backfill

As recovery of the seabed will begin on completion of the trenching and mechanical backfill of the infield flowlines and EHC umbilical and the gas pipeline, the impacts of this disturbance are considered temporary. The assessment assumes a worst case whereby each infield line is laid in a separate trench; however the project will continue to investigate the potential to lay multiple (2 +) lines in each trench, thereby minimising the impact on the seabed. The trenching activities will create an area of deposited spoil at either side of the excavated trench; however this material will subsequently be backfilled into the trench after the flowlines / EHC umbilical have been laid. Geotechnical data available to date indicates that the seabed in the project area should be sand to approximately 0.5 m with low strength clay beneath. Significant soft clay spoil heaps can pose a risk to fishing gear (depending on their size), and if these are created as a result of the trench and bury activities NEO Energy will work with OPRED and SFF to identify suitable mitigation measures e.g. carrying out trawl sweeps using a chain mat in order to break up large clay lumps. However as clay berms are not expected to be left on the seabed as a result of mechanical backfilling, and as any area impacted as part of their mitigation would be expected to be within the footprint of disturbance associated with the trenching and burying activities, an additional area of disturbance associated with potential mitigation activities has not been included.

The impacts of the seabed disturbance associated with trenching and backfilling activities is discussed in Section 9.6.

9.3 Production Phase

There will be an area of seabed that is impacted by the repetitive movement of the mooring lines associated with the Western Isles FPSO. This abrasion is likely to change and/or influence the nature of the seabed and the species present. As described above (Section 9.2.1), the ES assumes a worst case whereby 500 m of the mooring line is in contact with the seabed and a corridor width of 60 m is impacted.

No other additional seabed disturbance is anticipated to occur during routine production operations. The impacts of the seabed disturbance associated with the movement of the mooring lines over life of field is discussed in Section 9.6.

9.4 Decommissioning Phase

The decommissioning activities at the Buchan Redevelopment Project will result in some temporary disturbance to the seabed. Sources of disturbance are expected to include (but not limited to):

- Localised dredging or jetting to allow access for cutting (pipelines and piles);
- Potential *in-situ* remediation of trench and buried flowlines and the EHC umbilical;
- Removal of the Western Isles FPSO mooring system;
- Recovery of subsea infrastructure, mattresses and grout bags;
- Potential temporary wet storage of items following disconnection and prior to recovery;
- Temporary positioning of baskets for recovery of items such as tie-in spools;
- Anchoring of a drilling rig for plug and abandonment activities.

It is anticipated that the area disturbed by the decommissioning activities will be less than that disturbed by the drilling and installation activities and will mostly be within the same footprint disturbed by the installation activities. Note estimating the area of impact associated with decommissioning the proposed Project is not included in the ES but will be captured in the impact assessments required prior to decommissioning activities commence.

9.5 Overall Area of Impact

The anticipated temporary and permanent areas of seabed disturbance associated with the proposed Buchan Redevelopment Project are summarised in Table 9-1.

Table 9-1: Area of seabed impacts.

Infrastructure	Assumptions	Area Impacted (km^2)	
		Permanent	Temporary
Area impacted during installation of the semi-submersible drilling rig			
Eight anchors	Assessment assumes: • the area of disturbance when positioning each anchor is 10 m x 10 m • that the semi-submersible drilling rig and associated anchor system will need to be positioned two times As the anchors will be recovered at the end of the drilling campaign, the impact is considered temporary.	N/A	0.0016
Eight anchor lines	Assessment assumes: • up to 1,280 m of each anchor line will be in contact with the seabed. • To skid between wells assume a worst case of anchor lines impacting a corridor width of 100 m. Therefore at each drill rig location an area of 0.8 km^2 (1,000 m x 100 m x 8) may be temporarily impacted. • Two set downs of the anchoring system has been assumed. Therefore total area of impact is 1.6 km^2 (0.8 km^2 x 2).	N/A	1.6

Infrastructure	Assumptions	Area Impacted (km^2)	
		Permanent	Temporary
Area impacted during drilling			
Cement on the seabed	Discharged cement at the top of each well associated with cementing of the top hole section. Assessment assumes: • Cement patio forms at the top of each of the seven wells. • Radius of each patio is 7.5 m (based on consultant's experience). If any cement reaches the surface, it will be immediately adjacent to the conductors and within the total footprint of the cuttings pile.	0.0012	N/A
Discharged drill cuttings	With respect to the drill cuttings, the area of impact is considered to be the area where the combined risk to the sediment is >5 %. For permanent disturbance this is considered to be the footprint where this risk remains after 10 years (0.108 km^2), whilst for temporary disturbance this is equivalent to the total area at risk immediately after drilling is completed, less the area considered to be permanently impacted (i.e. 0.478 km^2 – 0.108 km^2 = 0.370 km^2) (see Appendix C).	0.108	0.370
X-mas trees and protective structures	Dimensions (including protection structure): 7.9 m (L) x 7.9 m (W) x 5.3 m (H). To assess the temporary area of disturbance, an area of temporary impact extending 2 m on either side of the structure has been allowed for.	0.00044	0.00055
Area impacted during installation of Western Isles FPSO Mooring System			
12 suction anchors	Area of impact assumes use of suction anchors over piled anchors as the diameter is greater for the former. Assessment assumes: • 12 suction anchors • Each suction anchor is a cylinder with diameter of 6 m (diameter). • Area of temporary disturbance allows for disturbance extending 2 m around each suction pile.	0.00034	0.00060
12 anchor mooring lines	12 x 1.52 km anchor lines to be laid. Assessment assumes: • Pre-installation: the full length of each mooring line will be wet stored on the seabed with a corridor width of 1 m being impacted during set down and lift. Temporary area of impact = 1.52 km x 1 m x 12. • Installed: assumed 500 m of each line on seabed impacting maximum corridor width of 60 m along full length. Permanent area on impact = 500 m x 60 m x 12.	0.36	0.01824
Area impacted by subsea structures			
Riser Base	Dimensions: 12 m (L) x 8 m (W) x 3.5 m (H). To assess the temporary area of disturbance, an area of temporary impact extending 2 m on either side of the structure has been allowed for.	0.000096	0.000096
MWA Foundation Base	Dimensions: 16 m (L) x 10 m (W) x 1.5 m (H). To assess the temporary area of disturbance, an area of temporary impact extending 2 m on either side of the structure has been allowed for.	0.00016	0.00012
Two drill centre manifolds: DC1 & DC2 manifolds	Dimensions: 12 m (L) x 10 m (W) x 4 m (H). To assess the temporary area of disturbance, an area of temporary impact extending 2 m on either side of the structure has been allowed for.	0.00024	0.00021
PLEM on gas pipeline t(for tie-in to Ettrick PLEM option)	Dimensions: 10 m (L) x 8 m (W) x 3.5 m (H). To assess the temporary area of disturbance, an area of temporary impact extending 2 m on either side of the structure has been allowed for.	0.00008	0.00009
Area of seabed impacted by risers	It is estimated that *c*. 200 m or each riser/dynamical umbilical will be on the seabed and combined may impact on a corrider width of 45 m as the buoyancy tank associated with the mid water arch is moved by curents in the water column. As this will occur through life of field the	0.0090	N/A

Infrastructure	Assumptions	Area Impacted (km^2)	
		Permanent	Temporary
	impact is considered to be a permanent impact.		
Area impacted by trenching and burying activities			
Infield lines: 2 x production flowlines; 1 x gas lift flowline; 1 x water injection flowline; and 1 x EHC umbilical	For each line assumed 2,040 m is trenched and buried: Assessment assumes: • Corridor width of 20 m along full length of each line temporarily impacted during trench and bury activities. • All lines laid in separate trenches. • No area of permanent impact as ecosystem begins to recover at end of activities (area of contingency rock cover considered below).	N/A	0.2040
Gas pipeline tied-in to the Ettrick PLEM	40.9 km of gas pipeline to be trenched and buried Assessment assumes: • Maximum length of pipeline (i.e. tie-back to Ettrick PLEM as opposed to Tweedsmuir manifold). • Corridor width of 20 m along full length of pipeline temporarily impacted during trench and bury activities. • No area of permanent impact as ecosystem begins to recover at end of activities (area of contingency rock cover considered below).	N/A	0.8180
Area impacted by stabilisation features			
Mattresses	1,343 (includes contingency) mattresses measuring 6 m (L) x 3 m (W) Assessment assumes: • Permanent impact: 1,343 x 6 m x 3 m. • Area of temporary impact extends 2 m to each side of each mattress.	0.02417	0.06984
Grout bags	1,280 (includes contingency) x 25 kg grout bags. Assessment assumes; • 1 te of grout bags permanently impacts on 1 m^2 of seabed. • 1 te of grout bags temporarily impacts on seabed.	0.00004	0.00004
Contingency rock cover should target depth of burial not be achieved.	Total contingency rock volume of 79,531 te Assessment assumes: • 32,364 te of contingency rock on infield lines. • 47,167 te of contingency rock on gas pipeline. • 1 te rock permanently impacts on 1 m^2 seabed. • 1 te rock temporarily impacts on 1m^2 seabed.	0.07953	0.07953
Maximum area of impact		**0.583 km^2**	**3.16 km^2**
Notes: The spools and EHC umbilical jumpers have not been added as separate row items as they will be laid under the mattresses and grout bags and therefore, they will impact on the same area. Footprint provided is worst case e.g. includes contingency stabilisation features, and in most instances assumes no overlap of some areas of disturbance (e.g. footprint of cement patios will overlap with area of footprint of the drill cuttings).			

The maximum total area predicted to be permanently impacted by the proposed project is anticipated to be around 0.583 km^2 whilst the total area of temporary disturbance is estimated to be around 3.16 km^2 (Table 9-1).

Of the area expected to be permanently impacted, the main area of permanent impact is associated with the Western Isles FPSO mooring system (0.36 km^2) whilst the permanent area of impact associated with the discharged drill cuttings is estimated to be *c*. 0.108 km^2. Most of the remaining area of estimated permanent impact is associated with the use of mattresses and contingency rock cover. Each of these sources of permanent impact have significant contingency associated with them such that the overall area of permanent impact is expected to be less than that assessed in this report.

The area of temporary impacts identified is primarily associated with the area of seabed impacted by the semi-submersible and the trenching and burying activities, the settling out of suspended sediments from the water column and the area where there is combined risk to more than 5 % of sensitive species once the drilling activities have been completed. The largest potential area of temporary disturbance (*c*. 1.6 km^2) is associated

with the semi-submersible mooring system whilst the area of impact associated with the trenching and burying activities account for an area of impact of 1.02 km^2. The maximum area of temporary impact associated with the discharge of drill cuttings is 0.37 km^2.

9.6 Seabed Disturbance Impact Assessment

This section details the impacts of the proposed activities on habitats and associated benthic communities in the vicinity of the Buchan Horst Field.

The permanent disturbance resulting from the discharge of drill cuttings and cement on the seabed, and the placement of the Western Isles FPSO anchor system, the subsea infrastructure, and the stabilisation features can cause mortality or displacement of mobile benthic species and direct mortality of sessile seabed organisms. In addition to causing mortality or displacement of benthic animals the structures and stabilisation features may also create habitats for benthic organisms that live on hard substrates e.g. sponges, soft corals and tubeworms, sea slugs, hermit crabs and brittle stars (Coolen *et al.*, 2018).

The temporary disturbance associated with the drilling rig mooring system and the trenching and burying activities, may also cause direct mortality to individual animals whilst indirect impacts may result from sediment being temporarily disturbed and settling out of the water column once the activities are completed.

Trenching physically disturbs the benthic communities and their habitat within the area and may cause some smothering in the wider area due to the re-deposition of excavated material. Trenching also results in the creation of a temporary plume of suspended solids in the water column. While some organisms are expected to be killed by the passage of the trenching machinery, the majority will be displaced, and are likely to survive. Some of the exposed organisms may not be able to re-bury before being predated upon, while others may be relocated by water movements.

Any impacts from compression are expected to be short lived since most of the smaller sedentary species associated with the area (such as polychaete worms) have short lifecycles and recruitment of new individuals from outside the disturbed area will be rapid.

It is possible that disturbed sediment particles may be transported via tidal currents and subsequently resettle over adjacent seabed areas. This may have indirect negative effects on the benthic ecology in the vicinity, including smothering and scour of seabed communities causing a loss of species diversity, abundance and biomass in effected areas. Sessile epifaunal species may be particularly affected by increases in suspended sediment concentrations as a result of potential clogging or abrasion of sensitive feeding and respiratory apparatus (Nicholls *et al.,* 2003). Larger, more mobile animals, such as crabs and fish, are expected to be able to avoid any adverse suspended solid concentrations and areas of deposition. Re-suspended sediments could have a negative impact on suspension feeding organisms such as sea pens and bivalves including *A. islandica* both of which are known to occur in the area (see Section 4.3.2). Within Marine Scotland's Feature Activity Sensitivity Tool (FeAST) *A. islandica* are described as having a high sensitivity to sub-surface abrasion and siltation changes although damage is related to body size with larger specimens being more vulnerable. Although *A. islandica* burrow into the sediment, they use a short inhalant siphon which sits above the sediment surface for feeding and respiration (Taylor, 1976). Surface abrasion and siltation may therefore damage/clog the inhalant siphon, however it should be noted that following smothering/burial (up to 40 cm), they are able to burrow to the surface (Powilleit *et al.,* 2009). *A. Islandica* is considered not sensitive to smothering of up to 30 cm of material added to the seabed in a single event (Tyler-Walters & Sabatini, 2017).

As described in Section 4.3.2, the surveys identified the presence of the environmentally sensitive habitat of burrowing megafauna communities considered to be representative of the UK Habitat Feature of Conservation Importance of 'mud habitats in deep water'. The proposed activities will impact on areas captured under this habitat type, however given the widespread distribution of the habitat across the survey area and the wider CNS area, the impact is not considered significant. MarLIN (The Marine Life Information Network) indicates that *Nephrops* are not at risk to burial depths up to 5 cm and are also tolerant of increases in suspended sediments but are highly intolerant of habitat loss. Therefore it is expected that some individual *Nephrops* may be impacted by the proposed activities, however it will be within a limited area and not necessarily over the wider area impacted by sediments settling out at depths < 5 cm[1].

[1] Note MarLIN takes a benchmark of 5 cm burial depth for all species. It's possible that *Nephrops* are not impacted by burial depths > 5 cm.

Recolonisation of the impacted areas 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 and burrowing species digging back to the surface. Recovery times for soft sediment faunal communities are difficult to predict, although some studies have attempted to quantify timescales. Collie *et al*. (2000) examined impacts on benthic communities from bottom towed fishing gear and concluded that, in general, sandy sediment communities were able to recover rapidly, although this was dependent upon the spatial scale of the impact. It was estimated that recovery from a small-scale impact, such as a fishing trawl, could occur within about 100 days assuming that recolonisation was through immigration into the disturbed area rather than from settlement or reproduction within the area. Recovery through immigration would be expected to take longer for the more extensive trawled areas, and larval recruitment or local reproduction by surviving individuals may be more important determining factors.

The subsea infrastructure and stabilisation features will create habitats for benthic organisms that live on hard substrates leading to an increase in local habitat and community diversity. As described in Section 4.2 there are glacial drop stones in the area such that the addition of subsea structures and stabilisation material to the area will not be introducing a new hard substrate, rather than increasing the footprint of existing hard substrate.

It is acknowledged that whichever drilling rig type is used; a semi- submersible or HDJU, the anchors or spud cans will likely leave depressions on the seabed. These are expected to backfill over time with benthic communities recolonising the areas as soon as the items have been recovered. Note at the time of decommissioning a safe seabed survey will be carried out to ensure any resultant anchor scars / spud can depressions do not pose a risk to fishing gear.

Evidence suggests that the sensitivity of fish to suspended sediments varies greatly between species and their life history stages and depends on sediment composition (particle size and angularity), concentration and the duration of exposure (Newcombe and Jensen, 1996). Being the major organ for respiration and osmoregulation, gills are directly exposed to, and affected by, suspended solids in the water. If sediment particles are caught in or on the gills, gas exchange with the water may be reduced leading to oxygen deprivation (Essink 1999; Clarke and Wilber, 2000). This effect is greatest for juvenile fish as they have small easily clogged gills and higher oxygen demand (FeBEC 2010). As described in Section 4.3.3, a number of fish species recognised as PMFs occur in the area, and it is possible that suspended sediments in the water column resulting from the recovery, and/or trench and bury activities, could impact on individual fish including PMFs.

The ability for organisms including fish species to detect predators may be reduced as a result of low visibility associated with suspended sediments. In instances of persistent and widespread suspended sediments there is the possibility of reduced feeding success among juvenile fish which may influence survival, year-class strength, recruitment and overall condition (Clarke and Wilber, 2000). However, as the proposed activities are relatively short term any impacts from low visibility are expected to be temporary and are not considered significant.

Figure 4-8 shows the presence of cuttings piles from historic wells across the Buchan Horst Field (drilled when the field was previously referred to as the Buchan Field). It can be seen that the anticipated location of the proposed wells and subsea infrastructure are not in the immediate vicinity of these piles. Finalisation of the mooring layout for the semi-submersible drilling rig will take account of the presence of these historic cuttings piles with disturbance being avoided/minimised where possible. In support of the Environmental Appraisal carried out to support the Buchan and Hannay Decommissioning Programme modelling of disturbance of the drilling cuttings was carried out (Repsol Resources UK, 2020). The modelling showed that the key contributor to risk from disturbing the largest of the historic cuttings piles was from the chemicals they contained with the area impacted reducing significantly over time – reduced by > 99 % over 10 years. Note it is recognised that should the historic piles be disturbed as a result of the proposed Project, the volume disturbed would differ to the volume modelled to support the Buchan and Hannay Decommissioning Environmental Appraisal. However, it is expected that if disturbed, the key contributor to risk would also be expected to be the chemicals and again the area at risk would be expected to decrease over time similar to what was observed in the modelling presented in the Buchan and Hannah Decommissioning Environmental Appraisal.

9.6.1 Impacts from Discharge of Drill Cuttings and Associated Drilling Fluids

The discharge of cuttings and associated drill fluids will impact on the sediments and associated benthic communities.

Following drilling, the area where the combined risk to the sediment to over 5 % of the most sensitive species is predicted to be approximately 0.478 km^2, reducing to 0.108 km^2 after 10 years. The main contributor to the

risk is from oxygen depletion, with much smaller contributions resulting from burial thickness, grain size change, and toxicity.

In the model, the risk reduces over time as a result of bioturbation and re-suspension. However, the model does not account for recolonization of the sediment over time. Therefore, the area where there is a risk to over 5 % of the species represents a potential area of risk rather than an absolute area of risk.

As described above, *A. Islandica* is considered not sensitive to smothering of up to 30 cm of material added to the seabed in a single event (Tyler-Walters & Sabatini, 2017). At the end of drilling the area over which the drill cuttings will settle out at a thickness > 30 cm is 0.004 km^2. *Nephrops* are known to be tolerant to burial depths of at least 5 cm. The area over which depth of burial is > 5 cm is 0.0242 km^2. Therefore, the areas where *A. islandica* and *Nephrops* may be significantly impacted is far less than the area over which 5% of species are at risk at the end of drilling.

The recovery of benthic communities from burial and organic enrichment occurs by recruitment of new colonists from planktonic larvae and immigration from adjacent undisturbed sediments. Ecological recovery usually begins shortly after completion of drilling and often is well advanced within a year. Full recovery may be delayed until concentrations of biodegradable organic matter decrease through microbial biodegradation to the point where surface layers of sediment are oxygenated (Neff, 2005). Gates and Jones (2012) found evidence of recovery when comparing results from a pre-drill survey and one carried out three years later. The authors noted that the visible extent of the cuttings pile had decreased over time and that megafauna had returned to the area though at a lower density to that found in the pre-drill surveys.

Studies have shown effects on benthic macrofauna, notably a decrease in diversity and abundance, are most often confined to within a 250 m radius of the cuttings pile, and are seldom detected beyond 500 m, even around the largest piles, (Breuer *et al.*, 1999 and Breuer *et al.*, 2004). Contaminants within cuttings piles generally have a low solubility and are mainly bound to particulate matter (OSPAR, 2016). Therefore, most of the contaminants follow the solids to the seabed where they settle. Benthic megafauna may take longer to recover than the smaller infauna and a study undertaken at a deep-water hydrocarbon drilling site in the Faroe-Shetland Channel suggested recovery times may be more than 10 years for megafauna species (Jones *et al*. 2012).

A study by Bakke *et al.* (1985), describes an experiment which involved trays of natural seabed sediments, devoid of flora and fauna, being covered in a 10 mm layer of WBM slurry. They were placed on the seabed and it was found that re-colonisation started immediately by the appearance of opportunistic species. Other studies into the impacts of WBM discharges have shown that after a few years, more stable communities develop (UKOOA, 1999).

Crustaceans and molluscs may be affected by drill cuttings. Filter feeders such as mussels and scallops preferentially feed during times of higher suspended solids, and tissues are damaged by suspended barite particles which are ‘sharp’ compared to weathered marine sediments (Strachan, 2010). This could be of concern in longer-lived species such as *A. islandica,* although areas of high exposure would be spatially very limited as indicated by modelling studies (Appendix C).

As described in Section 4.3.2, historic surveys have identified the potential presence of the environmentally sensitive habitat of burrowing megafauna communities and the ES assumes that the habitat is representative of the UK Habitat Feature of Conservation Importance of ‘mud habitats in deep water’. The drill cuttings have the potential to impact on areas captured under this habitat type, however given the widespread distribution of the habitat across the surveyed areas in the vicinity, the impact is not considered significant.

Resuspension and resettlement of disturbed cuttings (e.g. during tie-in operations) may also impact demersal species and/or fish eggs. However, it should be noted that monitoring studies have not found levels of trace metals in fish and shellfish collected close to offshore installations to be significantly above natural background concentrations (Bakke *et al.*, 2013). IOGP report 543 (IOGP, 2016) examines evidence relating to the effect of cuttings discharges on early-stage fish life, and concludes that WBM generally have a low toxicity to pelagic invertebrates and early life stages of fish. Studies on early life stages of sea scallops, lobsters and haddock (Cranford *et al.*, 1998) showed a slight reduction in survival of haddock and fed (but not unfed) lobster after 96 hours exposure at 100 mg/l of drilling fluid suspension and no effect on fertilisation, survival or growth of sea scallops.

9.6.2 Conclusion

As designated habitat (Sea pens and burrowing megafaunal communities), and species (e.g. *A. Islandica*) will be impacted by the proposed activities receptor sensitivity is considered High (c). Though recovery is expected

to begin immediately after some of the activities are completed, taking account of the total area that could be impacted either permanently or temporarily, the magnitude of effect of disturbance to the seabed is considered Serious (3). The overall impact significance associated with disturbing the seabed is therefore considered Moderate, such that some of the environmental impacts will be discernible after the activities are completed or through to the time of decommissioning. The Project will continue to work towards minimising the potential impact e.g. potential for laying two or more of the infield lines in the same trench will be considered, whilst route surveys carried out to minimise the potential for contingency rock cover.

9.7 Cumulative and Transboundary Effects

The effects resulting from the seabed disturbance during the proposed Buchan Redevelopment Project have the potential to act cumulatively with both existing and new developments and other activities. The project will be located in a well-developed area of the North Sea.

The seabed disturbance caused by the proposed project is not expected to have any significant cumulative effects, given the relatively small footprint of permanent disturbance.

It is worth noting that an ICES report on the structure and dynamics of the North Sea benthos (Rees *et al.*, 2007) concluded that the ecological effects of anthropogenic influences arising from oil and gas installations and aggregate extraction were not identifiable on a large ICES block scale. They found no evidence of impacts associated with clusters of installations, rather that variations identified were associated predominantly with natural forces.

The subsea equipment will be installed in UK waters and the cuttings piles will not extend outside UK waters, so there will be no transboundary effects.

9.8 Mitigation Measures

The following industry standard mitigation measures will be undertaken to minimise the impacts associated with the sources of seabed disturbance associated with the proposed Buchan Redevelopment Project.

Proposed Mitigation Measures

- Pre-deployment surveys will be undertaken to identify suitable locations for the Western Isles FPSO anchors and drilling rig anchors in the event a semi-submersible drilling rig is utilised;
- Pipeline and umbilical route surveys will be undertaken;
- NEO will continue to explore the option to lay multiple flowlines in the same trench going between the drill centres and the Western Isles FPSO;
- The proposed gas export route will take the most direct/shortest route to the Ettrick PLEM or Tweedsmuir manifold subject to seabed conditions encountered;
- The use of mattresses, rock cover and grout bags will be minimised through optimal project design;
- Anchors of the drill rig are to be maintained under tension to minimise chain contact on seabed;
- Cement volumes required will be planned and optimised;
- Use of ROV for visual monitoring and pH monitoring during cementing jobs that allows stopping when cemented is either observed or detected at seabed (minimises excess cement);
- Sea dye will be used to indicate when cement is approaching the surface;
- The use of dynamically positioned vessels will minimise anchor use;
- Use of low toxicity chemicals in WBM;
- Use of specialist contractors to minimise dropped objects; and
- Lifting plans in place.

Applying the risk assessment methodology described in Section 5 and taking account of the mitigation measures listed above, the environmental significance of impact of the seabed disturbance resulting from the proposed activities is considered moderate. The environmental impacts are therefore considered acceptable when managed within the additional controls and mitigation measures described.

The proposed project will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

10 Underwater Noise

This chapter assesses the impact of underwater noise associated with the proposed Buchan Redevelopment Project, using the risk assessment methodology outlined in Chapter 5.

10.1 Introduction

Marine fauna use sound for navigation, communication and prey detection (Southall *et al.*, 2007; Richardson, *et al.*, 1995). Therefore, the introduction of anthropogenic underwater noise has the potential to impact on marine animals by interfering with the animal's ability to use and receive sound (OSPAR, 2009). Offshore exploration and production activities invariably generate underwater noise; for example, during geophysical exploration, during drilling activities or piling operations and from the vessel operations. The level and frequency range of noise generated varies with the type of activity.

It is generally accepted that exposure to anthropogenic noise can induce a range of adverse effects on marine life (OSPAR, 2009). The type and extent of potential impact associated with noise on an animal depends on many factors including the level and frequency characteristics of the noise, hearing sensitivity and behaviour of the species, propagation characteristics of the operational area and whether or not marine species are using the areal extent of the noise field. Potential impacts can vary from insignificant impacts such as temporary avoidance or small changes in behaviour to significant impacts such as auditory and physical injury (Southall *et al.*, 2007; Southall *et al.*, 2019; National Marine Fisheries Service (NMFS), 2018; Richardson *et al.*, 1995).

The Offshore Marine Regulations 2007 (as amended, 2010) make it an offence to injure or disturb EPS (including all marine mammals), where disturbance has a likelihood of impairing their ability to survive, to breed or reproduce, to rear or nurture their young, or to migrate. It also includes the likelihood of significantly affecting the local distribution or abundance of the species. New projects must assess if their activity, either alone or in combination with other activities, is likely to cause an offence involving an EPS.

10.2 Noise Sources Associated with the Buchan Redevelopment Project

Activities associated with the proposed Buchan Redevelopment Project, resulting in the generation of underwater noise, include:

- Drilling activities;
- Rock dumping activities (contingency);
- Vessel operations, including FPSO operations; and
- Piling for the installation of anchors for the Western Isles FPSO, the two drill centre manifolds, the riser base, the mid-water arch foundation base, and the gas export PLEM.

These underwater noise sources are discussed in more detail in the next section.

Note: as receptors to underwater noise, marine mammals and fish receptor sensitivity is considered Medium due to a number of the species being designated (e.g. as Annex II species, or PMFs; see Sections 4.3.3 and 4.3.6).

10.3 Impacts of Noise Sources

10.3.1 Drilling Activities

Rotating equipment such as generators and pumps all result in underwater noise during drilling operations. In general, noise from drilling operations has been found to be predominantly low frequency (< 1,000 Hz) with relatively low source levels (Greene, 1987; Nedwell and Edwards, 2004; McCauley, 1998). Furthermore, a study by Greene (1987) noted that the noise generated by drilling activities from a drilling rig did not exceed local ambient levels beyond 1 km. Noise associated with the drilling activities is therefore considered to be of a relatively low level. Sensitivity of marine mammals and fish in the area is considered Medium whilst the magnitude of effect of drilling noise is considered Negligible (1). The impact significance of underwater noise from drilling activities is therefore assessed as Low such that the impact of noise from drilling activities is considered negligible.

10.3.2 Rock Dumping Activities

The base case for the project is that the lines (flowlines and EHC umbilical) between the Western Isles FPSO and the drill centres and the gas pipeline will be trenched and buried. However, some contingency rock cover has been allowed for (see Section 3.6.5). Nedwell and Edwards (2004) reported the noise from the *Rollingstone*, a vessel with a specialised underwater chute to position rock on the seabed. The vessel used dynamic positioning and was powered by two main pitch propellers, two bow thrusters and two azimuth thrusters. It was concluded that the noise levels were dominated by the vessel and not the rock dumping activities. Sensitivity of marine mammals and fish in the area is considered Medium (b) whilst the magnitude of effect of noise associated with rock placement is considered Negligible (1). The impact significance of underwater noise from rock placement is therefore assessed as Low such that the impact of noise from drilling activities is considered negligible.

10.3.3 Vessel Operations

Within the UKCS, vessel traffic is a substantial contributor to general anthropogenic underwater noise with the primary sources of noise coming from the propellers, propulsion and other machinery (Ross, 1976; Wales and Heitmeyer, 2002). Tables 3-12 (drilling), 3-15 (subsea installation), 3-16 (offshore electrification modifications) and 3-20 (production) summarise the total vessel requirements for each phase of the project.

Richardson *et al.* (1995) reviewed the effects of noise from vessels on marine mammals. They noted that it is not always possible to distinguish between effects due to the noise, sight or even smell of a vessel to an animal but there is evidence that noise from vessels has an impact on marine mammals. Animals have been reported to display a range of reactions from ignoring to avoiding the noise. The latter can lead to temporary displacement from an area. Vessel noise can mask communication calls between cetaceans, reducing their communication range (Jensen *et al.*, 2009). It is not obvious whether temporary behavioural reactions translate into long-term effects on an individual or population. Exposure to low frequency shipping noise may be associated with chronic stress in whales; Rolland *et al.* (2012) reported a decrease in baseline levels of stress-related faecal hormones concurrent with a 6 dB reduction in underwater noise along the shipping lane in the Bay of Fundy, Canada, when traffic levels decreased.

Anthropogenic noise has the potential to interfere with acoustic communication, predator avoidance, prey detection, reproduction and navigation in fish. The effects of "excessive" noise on fish include avoidance reactions and changes in shoaling behaviour (Slabbekoorn *et al.*, 2010). Prolonged avoidance of an area may interfere with feeding or reproduction or cause stress-induced reduction in growth and reproductive output. Fish exhibit avoidance reactions to vessels and it is likely that radiated underwater noise is the cause; for example, noise from research vessels has the potential to bias fish abundance surveys by causing fish to move away (de Robertis and Handegard, 2013; Mitson and Knudsen, 2003). Reactions include diving, horizontal movement and changes in tilt angle (de Robertis and Handegard, 2013). Popper *et al.* (2014) reviewed the effects of vessel noise on fish. They noted that there is no direct evidence of mortality or potential mortality to fish from vessel noise or other continuous noise sources The authors concluded that the likelihood of noise from vessels causing mortality or injury to fish was remote, even for fish in close proximity to vessels, however, it is possible noise from vessels may cause some behavioural disturbance to fish.

As receptors to underwater noise, marine mammals and fish receptor sensitivity is considered Medium (B). The area around the Buchan Horst Field presents many background noise sources associated with vessel movements to which marine mammals and fish are exposed. The Buchan Redevelopment Project area itself has been the location of a previous oil production facility, and the associated vessel activity for *c*. 40 years. As the marine mammals and fish in the area are accustomed to the presence of vessels, such that any impacts from vessel noise are typically behavioural impacts, the magnitude of effect of the increased vessel noise on these receptors is considered Negligible (1). Given the Medium receptor sensitivity and the Negligible magnitude of effect, the impact significance of the increased vessel noise in the area is considered Low such that any environmental impacts are thought to be of negligible significance.

10.3.4 Piling Activities

Piling requires a hydraulic hammer to forcibly drive tubular steel piles into the seabed, resulting in substantial levels of pulsed underwater noise being generated. The level of this noise depends on numerous factors such as the size and operating energy level of the hammer, the diameter and length of the piles, the sub-surface depth of pile, number of hammer strikes, and the physical factors that will influence noise propagation (such as bathymetry, type of seabed substrate, water temperature and salinity). As described in Section 3.6, a number of subsea structures will be piled. These include the two drill centre manifolds, the riser base, the mid-

water arch foundation base, and the gas export PLEM. It is also possible that piled anchors would be selected for the FPSO.

The selection of 12 piled anchors to install the Western Isles FPSO (if selected) would be the worst-case scenario in terms of underwater noise. Each pile would measure *c*. 35 m in length and 2 m in diameter. It would be expected that it will take 75 minutes to install a single pile with a maximum of five piles to be installed per day. The piling activities would begin with a soft start, with the energy of 120 kJ for 20 minutes. The maximum, worst case energy requirement for a single pile would be 1,200 kJ, which has been considered in the underwater noise modelling undertaken to support the impact assessment (Appendix D).

Piling for the installation of anchors for the Western Isles FPSO are considered to be the loudest source of noise associated with the Buchan Redevelopment Project, and therefore will be the activity which results in the largest extent of potential injury or behavioural disturbance to marine mammals and fish. Underwater noise modelling has been conducted to estimate the potential impacts of these activities (Appendix D).

10.3.4.1 Marine Mammals

Section 4.3.6 describes the abundance, distribution and seasonal occurrence of marine mammals known to occur in the vicinity of the proposed Project. Marine mammals have been grouped by the NMFS according to the hearing range for the species (Table 10-1; NMFS, 2018). In many species sensitivity to underwater noise is related to their use of high frequency noise for echolocation.

Table 10-1: Marine mammal known to occur in the Buchan Redevelopment Project area and hearing group.

Functional hearing group (Southall *et al.*, 2019**)	Generalised hearing range	Species known to occur in the area
Low-frequency (LF) cetacean	7 Hz to 35 kHz	Minke whale
High-frequency (HF) cetacean	150 Hz to 160 kHz	White-beaked dolphin, white-sided dolphin, bottlenose dolphin, Risso's dolphin, striped dolphin, pilot whale, beaked whale, common dolphin, killer whale
Very High-frequency (VHF) cetacean	275 Hz to 160 kHz	Harbour porpoise
Phocid pinnipeds	50 Hz to 86 kHz	Grey seal, harbour seal

* The frequency bands distinguish between very broad categories of sensitivity and noise sources
** The Southall *et al.* (2019) paper provides identical thresholds to those from the NMFS (2018) guidance for marine mammals but describes the marine mammal categories slightly differently.

Offshore piling has been recognised as an activity that could, under certain conditions, cause disturbance and/or injury to marine mammals (JNCC, 2010). The potential impact of underwater noise on the marine mammal receptors has been assessed using the recommended JNCC guidance (JNCC, 2010). To support the assessment of the impact of piling, underwater noise propagation modelling was carried out. Full details of the modelling are available in Appendix D.

The predicted noise levels from piling have been compared with the NMFS (NMFS, 2018) and Southall *et al.* (2019) precautionary thresholds for Permanent Threshold Shift (PTS) to marine mammals. These thresholds are based on a comprehensive review of evidence for impacts of underwater noise on marine mammals and are now widely applied as appropriate precautionary criteria for assessing the impact of underwater noise on marine mammals (JNCC, 2010). Despite the difference in naming of the hearing groups, the hearing groups proposed by NMFS (2018) and Southall *et al.* (2019) are equivalent and include the same marine mammal species. Furthermore, the PTS thresholds proposed by NMFS (2018) and Southall *et al.,* (2019) are identical. In the remainder of this report, the Southall *et al.* (2019) terminology with regards to the naming of marine mammal hearing groups is used.

As discussed in detail in Appendix D predicted noise levels from the proposed piling at the Buchan Redevelopment Project location have been compared to the Southall *et al.* (2019) zero-to-peak noise pressure level/Sound pressure level (SPL) and cumulative noise exposure level/Sound exposure level (SEL) thresholds for PTS onset. The predicted distances to the Southall *et al.* (2019) PTS thresholds are summarised in Table 10-2 and Table 10-3. As the distances shown in Table 10-3 are less than the nominal 500 m mitigation zone radius include in the JNCC Guidelines (JNCC, 2010), implementation of JNCCs standard mitigation measures (see Section 10.5) will further reduce the likelihood of PTS occurring for all marine mammal groups.

The predicted maximum distances where the zero-to-peak SPL thresholds for PTS onset are exceeded during the piling are summarised in Table 10-2. It is predicted that the zero-to-peak SPL generated throughout the piling will not exceed the PTS thresholds for any marine mammal hearing group outside the standard 500 m mitigation zone that will be employed during the piling operations (JNCC, 2010).

The predicted initial distances that marine mammals must be from the piling location at the start of piling in order to not be exposed to cumulative SELs exceeding the PTS thresholds after they swim away are shown in Table 10-3. The modelling predicts that the PTS thresholds for HF cetaceans, VHF cetaceans and phocid pinnipeds will not be exceeded for marine mammals belonging to these hearing groups assuming that they swim away from the piling location at a minimum speed of 1.5 m/s. The modelling predicts that the PTS threshold for LF cetaceans will be exceeded for any marine mammals belonging to this group that are within 70 m of the piling location at the start of piling and swim away at a speed of 1.5 m/s. A swim speed of 1.5 m/s is relatively conservative since marine mammals exposed to high noise levels would likely swim away at faster speeds. For example, the normal swimming speed of minke whales (which are the only LF cetaceans likely to be in the area) is 2.1 m/s (Williams, 2009) and they have been observed swimming at speeds of up to 7.2 m/s (Lockyer, 1981). The modelling predicts that LF cetaceans swimming away from the piling location at 1.5 m/s or faster will not be exposed to noise levels that exceed the PTS threshold when they are outside the 500 m mitigation zone at the start of piling. The 500 m mitigation zone and associated mitigation measures (e.g., Marine Mammal Observers (MMOs) and Passive Acoustic Monitoring (PAM)) is expected to be sufficient to mitigate against PTS occurring to any marine mammals.

Marine mammals have been modelled (see Appendix D) as swimming away from the piling location at the onset of piling, which has been observed during piling activities (Brandt *et al.,* 2011, 2016, 2018; Carstensen *et al.,* 2006; Dahne *et al.,* 2013). The received cumulative SEL has been calculated for marine mammals swimming away from the piling location at different swim speeds. Results are presented showing the furthest distance that marine mammals must be from the piling location at the start of the piling in order to not be exposed to cumulative SEL exceeding the PTS threshold when they swim away.

Table 10-2 Predicted maximum distances from the piling location where the zero-to-peak SPL thresholds for PTS onset to marine mammals was exceeded.

Marine Mammal Hearing Group	Zero-to-peak SPL PTS Threshold (dB re 1 µPa)	Maximum Distance to Threshold Exceedance (m) [1]
LF cetaceans	219	20
HF cetaceans	230	10
VHF cetaceans	202	150
Phocid pinnipeds	218	20

[1] Predicted distances have been rounded up to the nearest 10 m.

Table 10-3 Predicted maximum distances that marine mammals must be from piling location at the start of piling in order to not be exposed to cumulative SEL exceeding the PTS threshold when they swim away at different speeds.

Marine Mammal Hearing Group	Cumulative SEL Threshold for PTS (dB re 1 µPa²s)	Swim Speed (m/s)	Maximum Distance to Threshold Exceedance (m)[1]
LF cetaceans	183	1.5	70
		2.0	10
		2.5	10
HF cetaceans	185	1.5	Threshold not exceeded
		2.0	Threshold not exceeded
		2.5	Threshold not exceeded
VHF cetaceans	155	1.5	Threshold not exceeded
		2.0	Threshold not exceeded
		2.5	Threshold not exceeded
Phocid pinnipeds	185	1.5	Threshold not exceeded
		2.0	Threshold not exceeded
		2.5	Threshold not exceeded
[1] Predicted distances have been rounded up to the nearest 10 m.			

Table 10-4 presents the results of the modelling for predicting the distance associated with any marine mammal behavioural disturbance due to piling at the Buchan Redevelopment Project location. The predicted disturbance is consistent with observations made during piling activities at other developments. The piling activities are expected to be completed within three days of commencement, such that any marine mammals disturbed are expected to return to the area after cessation of activities. Any disturbance experienced is therefore considered to be temporary.

Table 10-4 Predicted distance and areas where the adopted marine mammal behavioural disturbance thresholds are exceeded.

Criteria	SEL Behavioural Disturbance Threshold (dB re 1 µPa2s)	Maximum Distance to Threshold Exceedance (km) [1]	Area of Threshold Exceedance (km²) [2]
NMFS 'Level B Harassment' criteria for behavioural disturbance to all marine mammals	150 [3]	13	506
Tougaard (2016) criteria for behavioural disturbance to all marine mammals	145	27	1,893
[1] Predicted distances have been rounded up to the nearest 1 km. [2] Predicted areas have been rounded up to the nearest 1 km². [3] The NMFS 'Level B Harassment' rms SPL threshold of 160 dB re 1 µPa has been converted to an SEL threshold of 150 dB re 1 µPa2s assuming a conservative integration time of 100 ms.			

With the application of JNCC guidance any impacts of the proposed piling activities on marine mammals are considered to be short term behavioural impacts rather than resulting in injury such that the magnitude of effect is considered Minor (2). Given the Medium receptor sensitivity and the Minor magnitude of effect, the impact significance of piling noise on marine mammals is considered Low such that any environmental impacts are thought to be negligible.

The maximum hammer energy used to install the piles at the other structures (two drill centre manifolds, the riser base, the mid-water arch foundation base, and the gas export PLEM) is expected to be less than the hammer energy used to install the FPSO piles. The impact significance on marine mammals of piling these other structures is therefore also considered Low.

10.3.4.2 Fish

The fish species associated with the project area are identified in Section 4.3.3. Fish species differ in their hearing capabilities depending on the presence of a swim bladder, which acts as a pressure receiver (McCauley, 1994). Most fish can hear within the range of 100 Hz to 1 kHz, with some able to detect lower frequencies. Within this range, the hearing threshold varies from approximately 50 dB re 1 µPa for hearing specialists to 110 dB re 1 µPa for non-specialists. Fish with a connection between the swim bladder and otolith system have more sensitive hearing and may detect frequencies up to 3 kHz (Popper *et al.*, 2003). Many species of fish produce noises for communication that are typically emitted at frequencies below 1 kHz (Montgomery *et al.*, 2006).

Table 10-5 Fish groupings with respect to presence/absence of swim bladder.

Fish group	Species
Fishes with no swim bladder	Mackerel
Fishes with swim bladder involved in hearing	Herring
Fishes with swim bladder not involved in hearing	Anglerfish, blue whiting, cod, Norway pout, sandeel, spurdog and whiting

Potential impacts to fish species were also assessed by comparing the underwater noise modelling results presented in Appendix D to the Popper *et al.* (2014) fish injury thresholds. The results summarised in Table 10-6 predicts that any injury to fish species, and fish eggs and larvae due to the zero-to-peak SPL will be limited to distances up to a maximum of 60 m from the location of piling activities.

In the cumulative SEL modelling it is assumed that mobile fish will swim away from the piling location at 0.5 m/s, whilst fish eggs and larvae are assumed to remain stationary throughout the piling. The predicted minimum initial distances that fish must be from the pile noise source at the start of pile driving operations in order to not be exposed to cumulative SELs above the Popper *et al.* (2014) thresholds for potential injury are summarised in Table 10-7. The modelling predicts that the cumulative SEL injury thresholds will not be exceeded if fish swim away from the piling location at 0.5 m/s.

Table 10-6 Predicted maximum distances from the piling location where the zero-to-peak SPL thresholds for injury to fish, and fish eggs and larvae are exceeded.

Fish Group	Zero-to-peak SPL Injury Threshold (dB re 1 µPa)	Maximum Distance to Threshold Exceedance (m) [1]
Fishes with no swim bladder	213	30
Fishes with swim bladder involved in hearing	207	60
Fishes with swim bladder not involved in hearing	207	60
Eggs and larvae	207	60
[1] Predicted distances have been rounded up to the nearest 10 m.		

Table 10-7 Predicted maximum distances that fish species, and fish eggs and larvae must be from the piling location at the start of piling in order to not be exposed to cumulative SEL exceeding injury thresholds.

Fish Group	Cumulative SEL Injury Threshold (dB re 1 µPa2s)	Swim Speed (m/s)	Maximum Distance to Threshold Exceedance (m) [1]
Fishes with no swim bladder	219	0.5	Threshold not exceeded
Fishes with swim bladder involved in hearing	207	0.5	Threshold not exceeded
Fishes with swim bladder not involved in hearing	210	0.5	Threshold not exceeded
Eggs and larvae	210	Stationary	130
[1] Predicted distances have been rounded up to the nearest 10 m.			

Any disturbance to fish is expected to be of a short duration such that the magnitude of effect of piling noise in fish is considered Negligible (1). Given the Medium (b) receptor sensitivity and the Negligible (1) magnitude of effect, the impact significance of piling noise on fish is considered Low such that any environmental impacts are thought to be negligible.

As the maximum hammer energy used to install the piles at the other structures (two drill centre manifolds, the riser base, the mid-water arch foundation base, and the gas export PLEM) is expected to be less than the hammer energy used to install the FPSO piles, the impact significance on fish of piling these other structures is also considered Low.

10.4 Cumulative and Transboundary Effects

The level of vessel activity associated with the proposed Buchan Redevelopment Project will be similar to the levels present during the first development phase of the area between 1979 and 2017. Vessel activity has continued in the area since 2017 to the current time associated with decommissioning and abandonment of the first phase facilities and wells. Underwater noise in the area as a result of vessel activity will therefore not increase as a result of the proposed Buchan Redevelopment Project and any cumulative impacts of underwater sound have been shown to not be significant. Piling activities associated with the installation of new facilities will cause a moderate increase in underwater noise but will be relatively short term in nature, any cumulative impacts of underwater sound is not expected to be significant.

The modelled piling location for the proposed Buchan Redevelopment Project is located c. 103.5 km from the UK/Norway median line and therefore no transboundary impacts associated with the underwater noise from the piling activities are expected.

10.5 Mitigation Measures

The following industry standard mitigation measures will be undertaken to minimise the impacts of the underwater noise sources associated with the Buchan Redevelopment Project.

Proposed Mitigation Measures

- A qualified, trained and equipped MMO will be present. The MMO will carry out a pre-piling survey of a 500 m mitigation zone and, if an animal is detected, the piling will be delayed until all marine mammals vacate the 500 m mitigation zone;
- A soft-start/ramp-up of hammer energy will be employed where the hammer will commence at a low energy at the start of piling. The soft start will be such that maximum hammer energy will not be reached until after a period of 20 minutes;
- PAM will be employed during periods of low visibility to detect marine mammal presence; and
- Avoiding commencing piling at night or in poor visibility when marine mammals cannot reliably be detected. If this cannot be avoided, then PAM will be used.

Applying the risk assessment methodology described in Chapter 5 and taking account of the mitigation measures listed above, the impact significance of the various underwater noise sources associated with the proposed project is considered Low. The impacts are therefore considered acceptable when managed within the controls and mitigation measures identified. The proposed project will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

11 Waste Management

This section discusses the types of waste likely to be generated as a result of the proposed Buchan Redevelopment Project, and the waste management procedures that will be implemented to minimise and monitor the volumes produced and disposed to landfill. Waste will be generated during all phases of the project.

NEO Energy is committed to reducing waste production and to managing all produced waste, by applying approved and practical methods and by adhering to the waste hierarchy that shown in Figure 11-1. Waste will only be disposed of if it cannot be prevented, reclaimed or recovered. All wastes will be managed in accordance with NEO Energy's Waste Management Plan (NEO-HSE-L3-PR-00042). The procedure establishes the controls required to manage the hazards associated with the transportation and disposal of waste from offshore sites and the processes, and verification activities necessary to ensure legal obligations are satisfied.

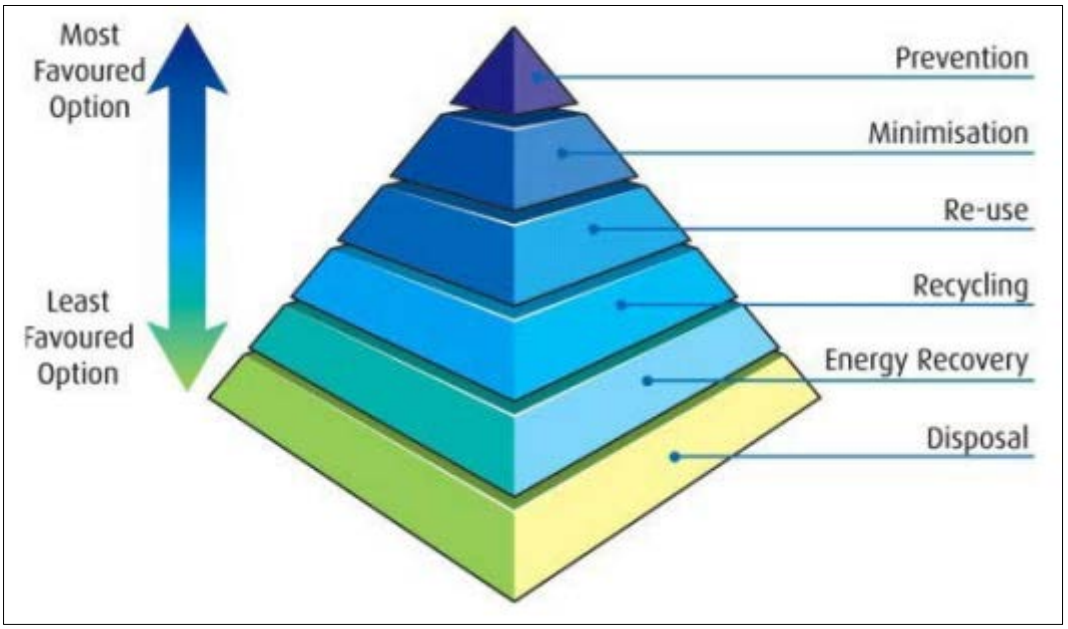


Figure 11-1: NEO Energy Waste Management Hierarchy.

Consent to transfer to the United Kingdom shore is not required but Duty of Care (under the Environment Protection Act 1990) makes it the waste producer's responsibility to ensure that waste is only transferred to an appropriately licensed carrier who should have a Waste Carrier Registration. Transfer of Controlled Waste requires a Transfer Note to be completed (or Consignment Note in the case of Special Waste). The Transfer Note details the type and quantity of waste, from whom and to whom the waste has been transferred, the category of authorised person to whom the waste has been consigned, relevant licence numbers, time, place and date of transfer.

11.1 Vessel Waste

Waste will be generated from a number of vessels associated with the proposed activities including AHVs, supply, DSVs, survey, rock dumping vessels etc. (Table 3-15) identify anticipated vessel requirements). Waste from these vessels will be managed in line with the individual vessel Waste Management Plan (WMP) in accordance with MARPOL requirements, which regulate discharges of waste to sea from ships.

11.2 Drilling Waste

Drilling rigs generate various waste products during routine operations including contaminated cuttings, waste oil, chemical and oil contaminated water and scrap metal. Wastes will be minimised by use of appropriate procurement controls, and all wastes will be properly segregated for recycling / disposal / treatment. The appointed waste management contractor will supply monthly reports of 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.

11.3 Installation and Commissioning

Installation activities will routinely generate a number of wastes including scrap metal, wooden crates etc. All wastes will be properly segregated for recycling/disposal/treatment in accordance with NEO Energy's Waste Management Procedure and Controlled Waste Transfer Notes will be completed.

11.4 Production Phase

The Western Isles FPSO will comply with NEO Energy's waste management procedures. Controlled waste transfer notes will continue to be completed as required and records on monthly waste disposal activities will be maintained.

11.4.1 General Waste

The Western Isles FPSO's general waste streams will be segregated by personnel at the source of generation, and manually handled to the appropriate labelled waste receptacle until transferred onshore for disposal. All waste will be segregated in accordance with waste management procedures and controlled waste transfer notes will be completed. Waste Management Duty of Care audits will also be carried out.

11.4.2 Laboratory waste

Waste laboratory chemicals will be segregated on site and sent to shore for disposal via a licensed contractor. As for general waste streams, a WMP will be put in place to minimise laboratory waste.

11.4.3 Special Waste

The Western Isles FPSO will ship to shore a number of hazardous solid and liquid waste streams which may include Naturally Occurring Radioactive Material (NORM) / Low Specific Activity (LSA) scale.

11.5 Decommissioning Phase

The waste generated as a part of future decommissioning activities will be a combination of both hazardous (special) and non-hazardous wastes. As operator, NEO Energy will have in place a WMP developed to identify, quantify (where possible) and discuss available disposal options for waste resulting from decommissioning activities. Where possible, materials will be recycled or sold and reused taking into account a waste hierarchy similar to that shown in Figure 11-1.

It is intended that recovered infrastructure will be returned to shore and transferred to a decommissioning facility, which will have all necessary approvals and licences in place and possess the capability to reuse or recycle the majority of recovered material. The minimisation of waste is a factor considered at every stage of the project.

11.5.1 Cumulative and Transboundary Effects

Waste will be managed in line with existing procedures and significant cumulative or transboundary impacts are not expected.

11.6 Mitigation Measures

The following mitigation measures are proposed to minimise the waste produced from the proposed Buchan Redevelopment Project.

Proposed Mitigation Measures

- NEO Energy will apply the principles of the Waste Management Hierarchy during all activities i.e. Reduce, Reuse, Recycle;
- Asset and vessel WMPs will be followed;
- Only permitted disposal yards / landfill sites will be used.

As a receptor, landfill sites can be considered abundant, such that applying the assessment methodology presented in Section 5, the sensitivity of landfill sites as a receptor is considered Low (A). With the application of the above control measures the magnitude of effect of waste generated throughout the project is deemed to be Negligible (1). Given the Low sensitivity and the Negligible magnitude of effect, the impact significance is considered Low such that any environmental impacts associated with waste production are thought to be negligible.

The proposed project will be conducted in compliance with all NMP policies; an assessment against the relevant NMP objectives is given in Appendix A.

12 Accidental Events

In addition to environmental impacts from planned activities, it is possible that impacts may arise from unplanned or accidental events. Worst case accidental events are considered to have releases of hazardous liquids and/or gases associated with them. This section identifies the sources of worst-case accidental events and assesses the potential impacts associated with them.

12.1 Sources of Accidental Releases

Sources of accidental releases of hazardous liquids and gases are varied and could include very large spill events such as a well blowout and relatively smaller scale releases such as a loss of small volumes of diesel from the Western Isles FPSO during bunkering.

This chapter focuses on the environmental impact associated with the two worst-case accidental hydrocarbon releases, for which modelling has been undertaken (Appendix E). The potential impacts resulting from either of these hydrocarbon releases have been evaluated taking account of the sensitivity and the assimilative capacity of the receiving environment, as well as the volume and behavior of the release. The likelihood of the scenarios considered here is remote. Any accidental scenarios where the final risk was determined to be 'negligible' or to have 'no effect' (Chapter 5) have not been considered further in this section.

12.1.1 Small Scale Accidental Releases

Small scale unplanned or accidental releases of hazardous liquids considered of 'Medium or 'Low' risk during the ENVID workshop (Appendix B) include:

- Loss of helifuel during helicopter use;
- Accidental release of marine diesel during vessel use;
- Accidental release of LTOBM or diesel during drilling rig operations;
- Loss of diesel containment during installation, commissioning and operations;
- Loss of chemical containment during drilling, installation, commissioning and operations;
- Unplanned hydrocarbon flow to the surface during drilling rig operations;
- Loss of water-based hydraulic fluid during installations;
- Unplanned and accidental leaks or ruptures from FPSO crude offloading; and
- Refrigerant leakage SF6 (potentially used in heating, ventilation and air conditioning (HVAC) and refrigeration systems) during operations.

Releases of hazardous liquids to sea could result in toxic or sub-lethal effects on sensitive organisms and ecosystems. The resultant impacts are dependent on spill size, prevailing wind, sea state, temperature and sensitivity of the environmental receptors affected (for example, benthic species, fish, marine mammals, birds and protected areas).

Management and mitigations measures that NEO Energy will have in place are listed in Section 12.6. For example, approved operational procedures in line with the industry best practice will be adhered to. Preventative maintenance will be carried out on a regular basis to ensure integrity of systems. Containment facilities and drains will be inspected as part of marine assurance standards on vessels or as part of the inspection and maintenance schedule on the Western Isles FPSO. Trained personnel will undertake operations in accordance with approved procedures. Where possible given technical requirements, chemicals which are PLONOR, have a Risk Quotient (RQ) < 1, or do not carry substitution warnings will be prioritised. In light of the management and mitigation measures in place, the significance of the impact associated with these 'smaller scale' accidental events was demonstrated to be as low as reasonably practicable.

12.1.2 Releases from Pipeline, Infield flowlines and Risers

Failure of the gas export pipeline resulting in a subsea gas release is very unlikely to result in a MEI and is therefore not considered further.

Failure of the Western Isles FPSO mooring system could result in a release of oil from the risers, if the Western Isles FPSO was then to lose station a further release of oil could be possible from the infield flowlines. Scenarios of loss of containment associated with the loss of mooring events have been experienced by Banff and Gryphon FPSOs in 2011 in adverse weather conditions. The spill volumes in both cases were under 2

tonnes of crude oil from the risers. The volumes released from this type of event are covered by the worst case loss of inventory from the Western Isles FPSO spill modelling (see Section 12.2) and are therefore not considered further in the impact assessment.

12.2 Spill Modelling

12.2.1 Overview

Modelling has been undertaken using the Oil Spill Contingency and Response (OSCAR) model to evaluate potential spills from the Buchan Redevelopment Project. The primary aims of the modelling are to understand:

- Released hydrocarbon fate and behaviour;
- The probability of hydrocarbons accumulating on the sea surface, in the water column, reaching the shoreline and accumulating in the sediment;
- Where hydrocarbon concentrations could exceed thresholds identified to have a significant environmental impact on the sea surface, in the water column, at the coast and in sediments; and
- The minimum time taken for hydrocarbons to cross median lines and to reach the shore.

OSCAR supports two types of simulations: stochastic (probabilistic) and deterministic. The stochastic approach models a spill scenario multiple times over different weather conditions and aggregates results from all the runs. The stochastic modelling indicates the probability of exceeding the pre-defined assessment thresholds.

Deterministic simulations represent the results of a single spill scenario within a defined timeframe of metocean conditions. A deterministic scenario is selected based on the stochastic modelling and represents the timeframe which gives the worst-case shoreline oiling. The deterministic model results are used to predict oil thickness on the sea surface, oil concentrations in the water column, oil concentrations reaching the shoreline, and concentrations deposited in the sediment in the selected modelled worst-case scenario.

The oil spill modelling is described in detail in Appendix E.

12.2.2 Scenarios

Two hydrocarbon release scenarios were modelled. The scenarios are

- Well blowout
- Catastrophic failure of the Western Isles FPSO cargo containment, resulting in a spill of the full inventory.

As noted previously, the Buchan Horst production wells require artificial lift from the commencement of production, and so failure of well containment during production will not result in a substantial release as there is insufficient pressure in the Buchan Horst reservoir. However, it should be noted that the production wells are to be drilled through the Andrew formation (see Figure 3-7) which contains a small oil discovery termed the Andrew reservoir. The Andrew reservoir is uneconomic to attempt to produce from: notwithstanding the reservoir is at sufficient pressure to present a blowout hazard while drilling through the formation to reach the Buchan Horst reservoir. Table 12-1 summarises the modelled scenarios.

Table 12-1: Key parameters used in hydrocarbon spill scenarios.

Scenario	Location	Release Duration	Simulation Duration (Days)	Spill Volume (m^3)
Well blowout	57° 53' 52.95" N 00° 01' 21.13" E	86 days	116[2]	19.142
Western Isles FPSO crude inventory release	57° 53' 04.73" N 00° 03' 19.19" E	1 hour	30[1]	63,509

[1] Simulation duration includes 1 hour release plus 30 days to allow time for the crude to disperse
[2] The simulation duration of 116 days accounts for time taken to drill a relief well (86 days) and a further 30 days to allow enough time for the crude to disperse.

12.2.3 Hydrocarbon Properties

The fate and effect of a spill is dependent on the chemical and physical properties of the hydrocarbons. OSCAR includes a database that contains various oil types. A suitable analogue was selected from this database to represent the Buchan Horst crude.

Although the blow out (if one occurred) would be from the Andrew reservoir, no oil properties were available as the Andrew reservoir has not been sampled. It was considered appropriate to approximate the Andrew crude by assuming the Buchan Horst crude properties could be used. Buchan Horst crude and analogue properties are shown in Table 12-2.

The Oseberg Ost analogue has similar wax and asphaltene content to that of Buchan Horst reservoir oil and will emulsify if released to the marine environment (typically this happens for oils with >0.5% asphaltene content). Viscosity and pour point are also a good match. The specific gravity of the analogue is slightly greater than that of Buchan Horst crude but will behave in a similar manner at the sea surface and in the water column.

Table 12-2: Oil Properties.

Property	Buchan Horst Crude	OSCAR Analogue (Oseberg Ost 13°C)
API (°)	33.5	-
Specific gravity	0.7759	0.835
Viscosity (cP)	11.6 (at 15°C)	16 (at 13°C)
Pour Point (°C)	<0	3.0
Asphaltene content (% weight)	1.78 to 2.1	1.1
Wax content (% weight)	7.5	7.2

12.2.4 Summary of Modelling Results

A summary of the stochastic and deterministic modelling results for the two modelled scenarios, (inventory release and well blowout), are presented in Table 12-3.

Table 12-3: Spill modelling results summary.

Variable	Environmental Fraction		Well Blowout	Western Isles FPSO Inventory Release
Release volume over whole simulation			19,142 m^3	63,509 m^3
% total oil in environmental fraction; (end of deterministic simulation)	Sea surface		0.9%	8.8%
	Shoreline		9.5%	13.8%
	Water Column		21.5%	15.8%
	Sediment		1.8%	1.2%
	Atmosphere		52.6%	51.6%
	Biodegraded		13.6%	8.7%
Total oil (tonnes) in environmental fraction; (end of deterministic simulation)	Sea surface		161 t	4,794 t
	Shoreline		1,657 t	7,475 t
	Water Column		3,738 t	8,599 t
	Sediment		318 t	679 t
	Atmosphere		9,129 t	28,060 t
	Biodegraded		4,753 t	4,753 t
Extent above thresholds (deterministic simulations)	Fraction	Thresholds		
	Sea surface	0.3 µm	85,400 km^2	31,837 km^2
	Shoreline	0.1 kg/m^2 (100 g/m^2)	650 km	237 km
	Water column	10 µg/l	1,960 km^3	271 km^3
	Sediment	5 g/m^2	0 km^2	0 km^2
Shoreline oiling maximum probability (%, stochastic)	UK		25%	1%
	Norway		42%	4%
	Denmark		20%	0%
	Germany		2%	0%
Maximum probability of crude/oil on the surface crossing median lines (%, stochastic)	UK – Norway		100%	42%
	UK – Denmark		14%	2%
	UK – Netherlands		8%	1%
	UK – Germany		13%	1%
	Norway - Denmark		29%	3%
	Norway – Sweden		16%	-
	Denmark – Sweden		21%	-
	Denmark – Germany		13%	1%
	Germany -Netherlands		8%	1%

12.3 Impact Assessment

This section evaluates the impacts of the crude oil releases by considering the predicted modelling results (Appendix E) in relation to the environmental receptors that could be impacted. The classification of environmental significance and magnitude of effect is in line with the methodology described in Section 5. Environmental significance and magnitude of effect are combined to give an environmental significance of impact. This is then combined with likelihood to give an environmental risk. All matrices explaining terminology are shown in Section 5.

Both scenarios (blow out and inventory release) have been assessed and in both cases, it has been assumed that the likelihood of the event occurring is Remote (see Table 5-4).

12.3.1 Water Quality

Accidentally released crude or oil will be dispersed over a wide area by wind, waves and currents. Low viscosity hydrocarbons disperse naturally through the water column, particularly in the presence of breaking waves, where they are rapidly diluted (ITOPF, 2014). Oils with an asphaltene content of greater than 0.5 % tend to emulsify in moderate to rough seas (ITOPF, 2014), increasing the oil's persistence in the environment. The Buchan Horst crude is likely to form emulsions as the asphaltene content is greater than 0.5%.

Applying the assessment methodology presented in Section 5, the sensitivity of water quality in the area is considered to be Low (a) due to the location in open ocean conditions which by nature rapidly disperse and dilute marine discharges.

Modelling results for both deterministic scenarios suggest that the level of hydrocarbons in the water column may reach or exceed the defined NOEC of 10 µg/l over a considerable area (blowout 1,960 km^3 and inventory release 271 km^3). In the case of the inventory release the oil is present over a smaller volume but in much higher concentrations (over 1,000 µg/l) (Figure 12-2) as it has had less time to disperse. For the well blowout maximum predicted concentrations are 250 µg/l (see Figure 12-1). For comparison, typical background values of THC in the North Sea range from 0.5-0.7 µg/l (pristine), 1-30 µg/l near installations to 2 µg/l in coastal waters (DTI, 2001).

The stochastic modelling shows there is moderate to high probability of oil in the water column resulting in transboundary impacts on water quality (see Figure 12-7 and Figure 12-8). Therefore, the magnitude of effect would be classed as Major (4).

Scenario	Receptor Sensitivity	Magnitude of effect	Environmental significance of impact	Environmental risk
Blow out	Low	Major	Moderate	Low
Inventory release	Low	Major	Moderate	Low

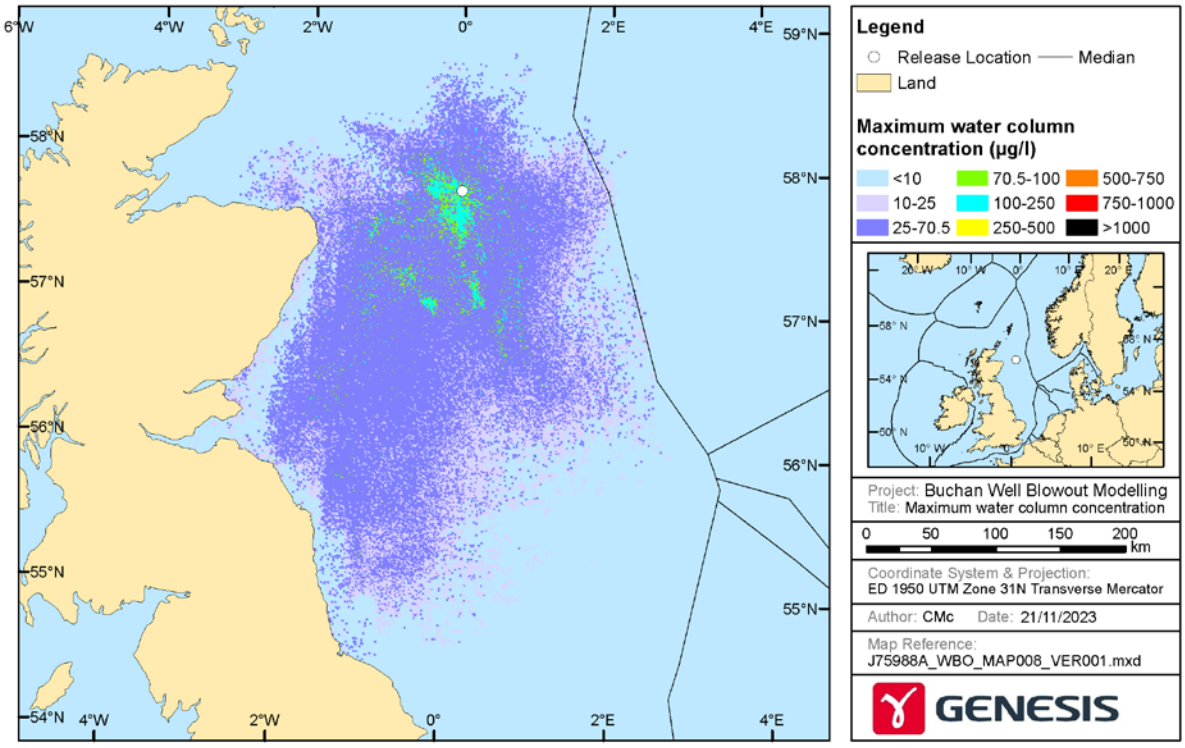


Figure 12-1: Maximum oil concentration in the water column as a result of a well blowout (deterministic)

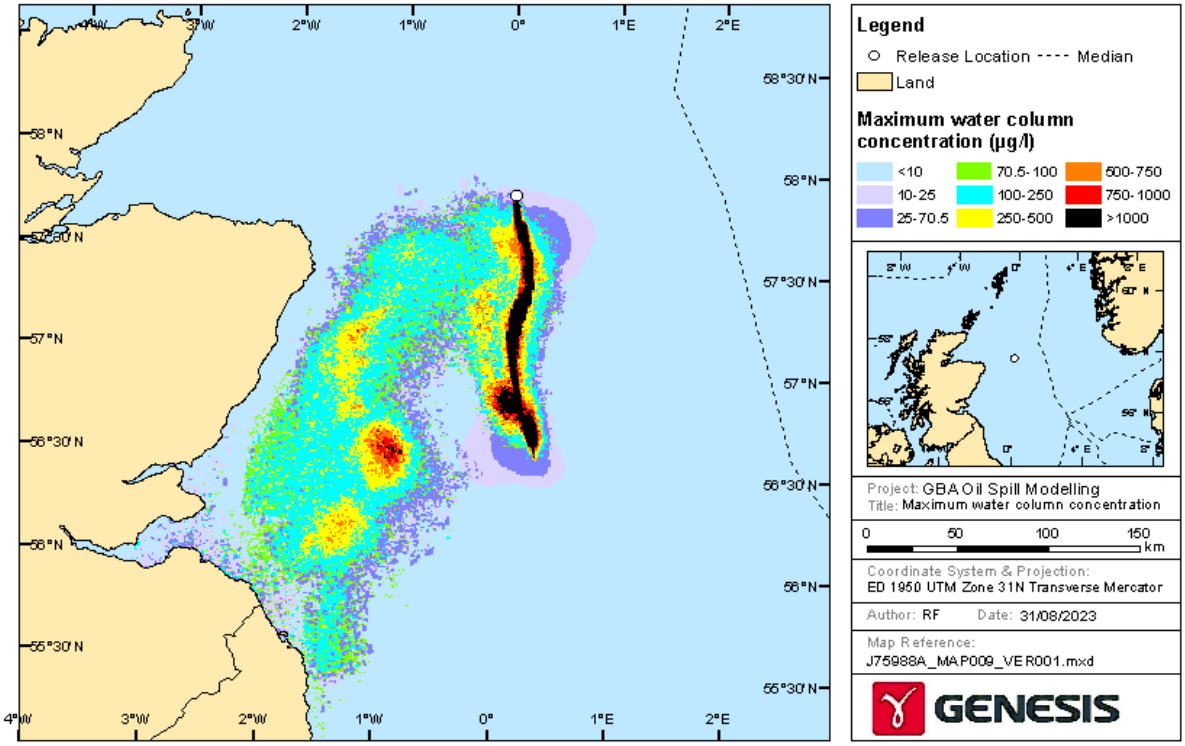


Figure 12-2: Maximum oil concentration as a result of inventory loss (deterministic)

12.3.2 Sediment Quality

Sediments in the Buchan Redevelopment Project area generally comprise poorly to moderately sorted fine sand and mud (Section 4.2.5). The sensitivity of sediments in the area is considered to be High (c) in that some of the species present which rely on the sediment, are recognised to be of conservation significance and some of the habitats are considered Scottish PMF.

Worst-case deterministic modelling predicted that there would be no deposition of oil above the 5 g/m^2 threshold for either the Western Isles FPSO inventory spill and or for the well blowout scenarios. Consequently, the magnitude of impact from these potential releases is considered to be Negligible (1).

Scenario	Receptor Sensitivity	Magnitude of effect	Environmental significance of impact	Risk assessment
Blow out	High	Negligible	Low	Low
Inventory release	High	Negligible	Low	Low

12.3.3 Plankton

Changes in the patterns of distribution and abundance of phytoplankton can have a significant impact on entire ecosystems (Ozhan *et al.*, 2014). Both oil presence and biodegradation can impact phytoplankton in the immediate vicinity of a spill. Hydrocarbon slicks can inhibit air-sea gas exchange and reduce sunlight penetration into the water, both essential to photosynthesis and phytoplankton growth (González *et al.*, 2009). PAHs in the oil also affect phytoplankton growth, with responses ranging from stimulation at low concentrations (1 mg/l) to inhibition at higher concentrations (100 mg/l; Harrison *et al.*, 1986).

Zooplankton at the surface are thought to be particularly sensitive to oil spills due to their proximity to high concentrations of dissolved hydrocarbon and to the additional toxicity of photo-degraded hydrocarbon products at this boundary (Bellas *et al.*, 2013). Following an oil spill, zooplankton may suffer from loss of food resources in addition to the toxic effects from direct exposure, resulting in mortality or impaired feeding, growth, development, and reproduction (Blackburn *et al.*, 2014 and references therein).

The limited swimming ability of the free-floating early life stages (eggs and larvae) of invertebrates such as echinoderms, molluscs and crustaceans renders them unable to escape oil-polluted waters. These early life stages are more sensitive to pollution than adults and their survival is critical to the long-term health of the adult populations (Blackburn *et al.*, 2014 and references therein).

However, impacts on plankton populations from hydrocarbon releases are typically brief and localised. Zooplankton biomass was documented in the month following the *Tsesis* oil spill off the coast of Sweden in 1977 (1,000 te of medium grade fuel oil) with biomass levels being re-established within five days (Johansson *et al.*, 1980). Plankton populations are abundant and widespread, with high rates of reproduction. Typically, recruitment from adjacent areas not affected by the release is sufficient to replace losses (IPIECA-IOGP, 2015). Consequently, the sensitivity of plankton at the Buchan Redevelopment Project location is Low (a).

Based on the stochastic modelling results there is a moderate to high probability of transboundary deterioration in water quality which could impact the plankton. Therefore, the magnitude of effect has been classed as Major (4).

Scenario	Receptor Sensitivity	Magnitude of effect	Environmental significance of impact	Environmental risk
Blow out	Low	Major	Moderate	Low
Inventory release	Low	Major	Moderate	Low

12.3.4 Benthos

Benthic fauna can either move, tolerate hydrocarbons (with associated impacts on the overall health and fitness), or die in response to exposure (Gray *et al.*, 1988; Lee and Page, 1997). The response to hydrocarbon exposure by benthic species differs depending on life history, feeding behaviour and the ability to metabolise toxins, especially PAHs. However, severe oil pollution typically causes initial massive mortality and lowered community diversity, followed by extreme fluctuations in populations of opportunistic mobile and sessile fauna (Suchanek, 1993).

Generally, infaunal polychaetes are affected by oil pollution (Suchanek, 1993). However, their recolonisation of affected areas varies. Some polychaete species decrease in abundance whilst others may be the first

colonisers in the aftermath of an oil spill (Blackburn *et al.*, 2014 and references therein). Some polychaetes contribute to biodegradation of oil in sediments whilst some have different abilities to metabolise contaminants (Bauer *et al.*, 1988; Driscoll and McElroy, 1997).

The different response of polychaetes to oil pollution is likely a consequence of their different feeding strategies and trophic relationships in benthic environments. For example, *Capitella capitata* has been found to be amongst the first colonisers in the aftermath of an oil spill. *C. capitata* thrives in the absence of competition and is a non-selective deposit feeder consuming detritus and algae. It benefits from organic pollution. In contrast, *Heteramalla sarsi* is a predatory polychaete that feeds on benthic amphipods. *H. sarsi* abundance dropped to < 5 % of pre-spill abundance following the *Tsesis* oil spill in the Baltic Sea (1977). This decrease in polychaete abundance was correlated with a decrease in amphipod abundance in the region (Elmgren *et al.*, 1983), indicating that amphipods like *B. elegans* are sensitive to hydrocarbons. Polychaetes of the family Spionidae, which includes *S. bombyx*, have been observed to decrease after an oil spill, then recover quickly. However, they did not recover as quickly as *C. capitata*. *S. bombyx* is therefore considered to have low sensitivity to hydrocarbon contamination (Ager, 2005).

Amphipods (small crustaceans) and burrowing bivalves can be sensitive even to brief exposures of relatively low hydrocarbon concentrations (IPIECA-IOGP, 2015; Suchanek, 1993). Amphipods may be particularly sensitive to the effects of oil pollution because of their low dispersal rate and limited mobility. Juvenile *A. islandica* (considered under OSPAR to be a threatened and/or declining species) were recorded in the in the area (Section 4.3.2). As a burrowing filter feeder, it is expected that any oil in the sediment or water column would impact on the species.

The OSPAR habitat ‘sea pens and burrowing megafauna communities’ has also been recorded from several surveys in the vicinity of the Buchan Horst Field to date as ‘frequent’ density.

Applying the assessment methodology presented in Section 5, the sensitivity of benthic communities in the area is considered to be High (c), as some of the species present (for example *A. islandica*) are recognised to be of conservation significance and/or have OSPAR designations.

For both scenarios, modelling predicted that no areas of sediment would exceed the 5 g/m^2 hydrocarbon threshold. Concentrations ranging from 0.5 g/m^2 to 1 g/m^2 would be present over a wide area. The magnitude is classed as Minor (2) (no breaches of regulatory compliance and no transboundary impacts).

Scenario	Receptor Sensitivity	Magnitude of effect	Environmental significance of impact	Environmental risk
Blow out	High	Minor	Moderate	Low
Inventory release	High	Minor	Moderate	Low

12.3.5 Fish

Exposure of fish to hydrocarbons can occur either through uptake across the gills or skin or direct ingestion of oil or oiled prey. Pelagic species, which spend the majority of their life-cycle in the water column, are likely to receive the highest exposure to oil that remains near the surface, whereas demersal fish species, associated with the seabed, are more likely to be exposed to particle-bound contaminants.

The chemical components of light oils have a high biological availability (bioavailability) and toxicity impacts are more likely than from heavy crude. At exposure concentrations lower than those sufficient to cause mortality, contamination may lead to sub-lethal effects such as impaired feeding and reproduction (ITOPF, 2014).

The likelihood of adult fish mortality due to open water oil spills is small (IPIECA-IOGP, 2015). Significant effects on wild stocks have seldom been detected and fish are thought to actively avoid hydrocarbons (ITOPF, 2014). However, hydrocarbons have been detected in fish bile over one year after the *Deepwater Horizon* oil spill (Murawski *et al.*, 2014), suggesting that adult fish may accumulate hydrocarbons after a large oil pollution event.

An oil spill could have the potential to impact fish spawning success because the eggs and larvae of many species are very sensitive to oil pollution. Joye *et al.* (2016) reported an estimated 2–5 trillion fish larvae were killed as a consequence of the *Deepwater Horizon* oil spill (2010) and while that was deep sea oil blowout it gives a sense of scale on the potential impacts of a blowout to fish populations.

Cod, herring, lemon sole, *nephrops*, Norway pout, sandeel, spotted ray, sprat and whiting have spawning grounds in the Buchan Redevelopment Project area. The eggs and larvae of broadcast spawners, such as

Norway pout, which are widely dispersed, could be exposed to oil in the water column. Modelling shows contamination of the water column is predicted to occur over a large area. Demersal spawner fish, such as sandeels, could be exposed to hydrocarbons deposited on the seabed (Section 4.2.5). In general, sandeels are considered to be fairly tolerant to the exposure to hydrocarbons, for example, studies indicated that exposure to the Braer spill did not significantly impact sandeel survival or settlement (sourced from FEAST). Consequently, the receptor sensitivity for fish is classified as Medium (b), in that some of the species present are recognised to be of conservation significance and recovery is expected to occur within medium-term timescales (< 5 years).

As noted in Section 12.3.1 in the case of the blowout a potentially wider area is impacted by the oil spill but at much lower concentrations than in the case of the inventory release.

Given the water volumes affected in both scenarios and applying the impact assessment methodology presented in Section 5, the magnitude of impacts is classified as Major (4) (possibility of transboundary effects).

Scenario	Receptor Sensitivity	Magnitude of effect	Environmental significance of impact	Environmental risk
Blow out	Medium	Major	Moderate	Low
Inventory release	Medium	Major	Moderate	Low

12.3.6 Seabirds

Seabirds are particularly sensitive to the effects of surface oil pollution, and some oil pollution incidents have resulted in mass mortality of seabirds (for example, Munilla *et al.*, 2011; Votier *et al.*, 2005). Mortality occurs from the ingestion of oil, which results in liver and other organ failure, as well as contamination of plumage, which destroys the insulating properties, leading to hypothermia (Alonso-Alvarez *et al.*, 2007). The impact of oil pollution on seabird populations depends on the numbers of seabirds at sea around the pollution incident and on the seabird species present. Diving seabirds such as seaducks (Anatidae), divers (Gaviidae), cormorants (Phalacracoracidae), grebes (Podicepididae) and auks (Alcidae) are more susceptible than more aerial species such as gulls (Laridae) (Webb *et al.*, 2016).

In the Buchan Redevelopment Project area, lesser black-backed gull and Atlantic puffin have been identified at densities of 1–5 individuals/km^2 and have been recorded throughout the year (Section 4.3.5). They mostly feed on the surface but can also dive and therefore may be exposed to surface and subsurface oiling.

Susceptible species tend to spend a greater proportion of their time at sea and have limited ability to locate alternative feeding sites. At population level, species with small or geographically limited populations, a low potential reproductive rate (productivity) and low adult survival rates are particularly sensitive due to their limited ability to recover (Webb *et al.*, 2016).

There are birds of conservation importance (Section 4.3.3) at national Scottish, OSPAR, European or International Red List Levels within the area of the proposed Buchan Redevelopment Project. Of these species the conservation status of the Black-legged Kittiwake and Northern Fulmar is classified as ‘vulnerable’ and Arctic Skua and Atlantic Puffin on the IUCN Red List for Birds, due to the rapid declines recorded in its European populations. The Black-legged Kittiwake is vulnerable to oil spills from direct mortality and as a result of successive years breeding failure due to ecosystem degradation, leading to reduced numbers of prey species (e.g. herring and sandeels) (Birdlife, 2020). Therefore, the seabird sensitivity is classed as High (c).

There is a high probability of surface oiling over a wide area following a blowout (Figure 12-9) and a low to moderate probability of surface oil following the inventory release (Figure 12-10). However, the predicted thickness of oil at the sea surface is higher for the inventory release (72 mm) compared to the blow out (0.145 mm) (Figure 12-4 and Figure 12-3).

Oil spill modelling for both scenarios also indicates there is a low to moderate probability of oil reaching the coast in areas that are internationally or nationally designated for seabirds (see Figure 12-13 and Figure 12-14). Shoreline oil concentrations would exceed the threshold of 100 g/m^2 (0.1 kg/m^2) above which impacts are considered potentially significant (see Figure 12-6 and Figure 12-5) over 237 km (inventory loss) and 650 km (blow out) length of coastline. It is worth noting that although the potential length of coastline impacted by the spill is smaller for the crude oil inventory release than for the blow out scenario, the overall oil thickness and total quantity of oil at the surface is significantly greater for the inventory release scenario.

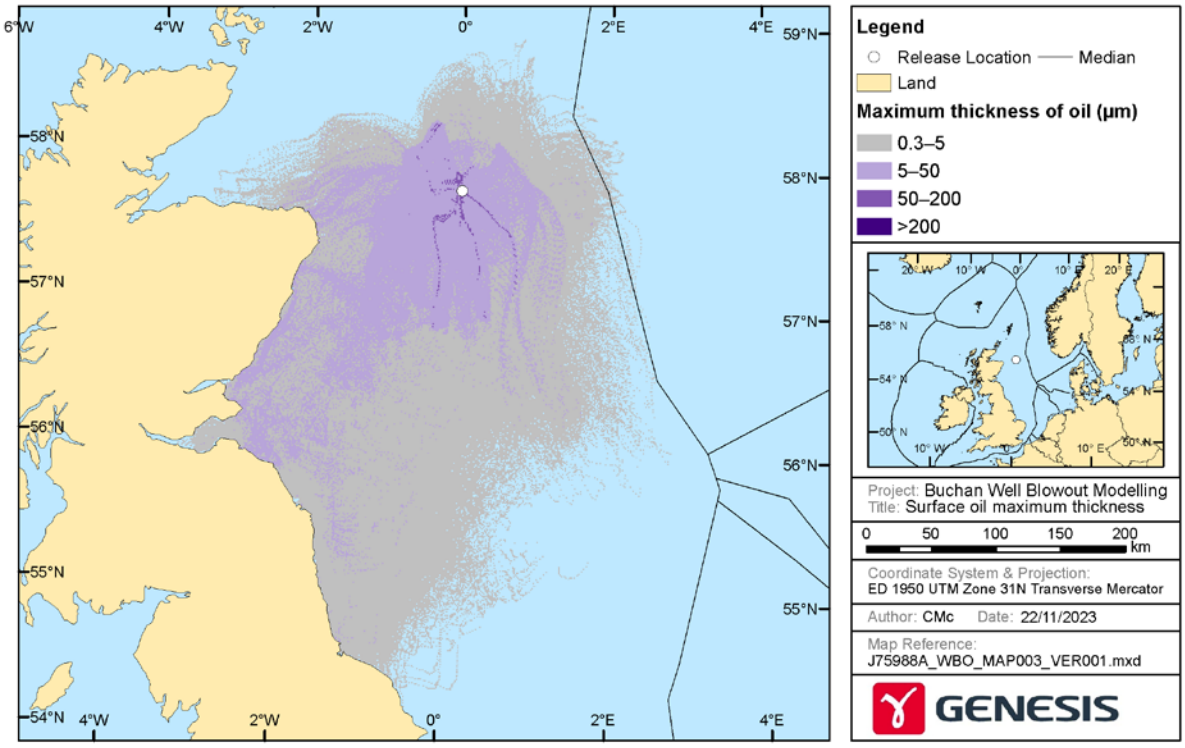


Figure 12-3: Maximum surface sheen thickness well blowout (deterministic).

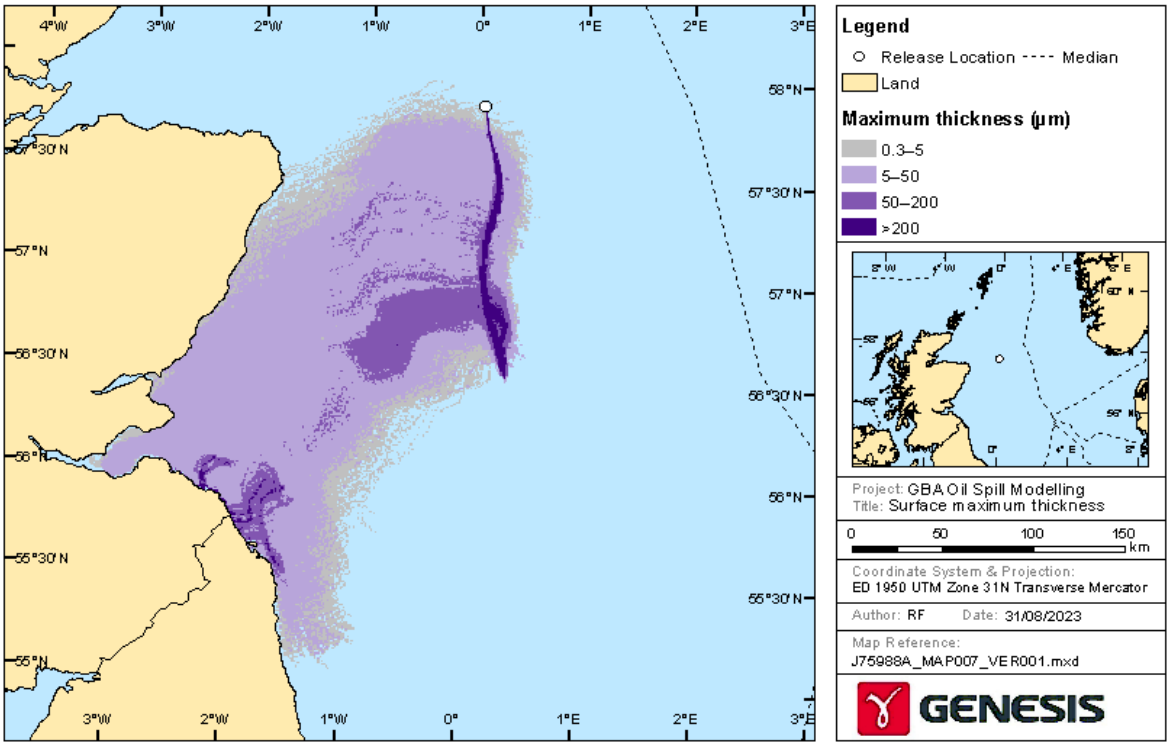


Figure 12-4: Maximum surface sheen thickness as a result of inventory loss (deterministic).

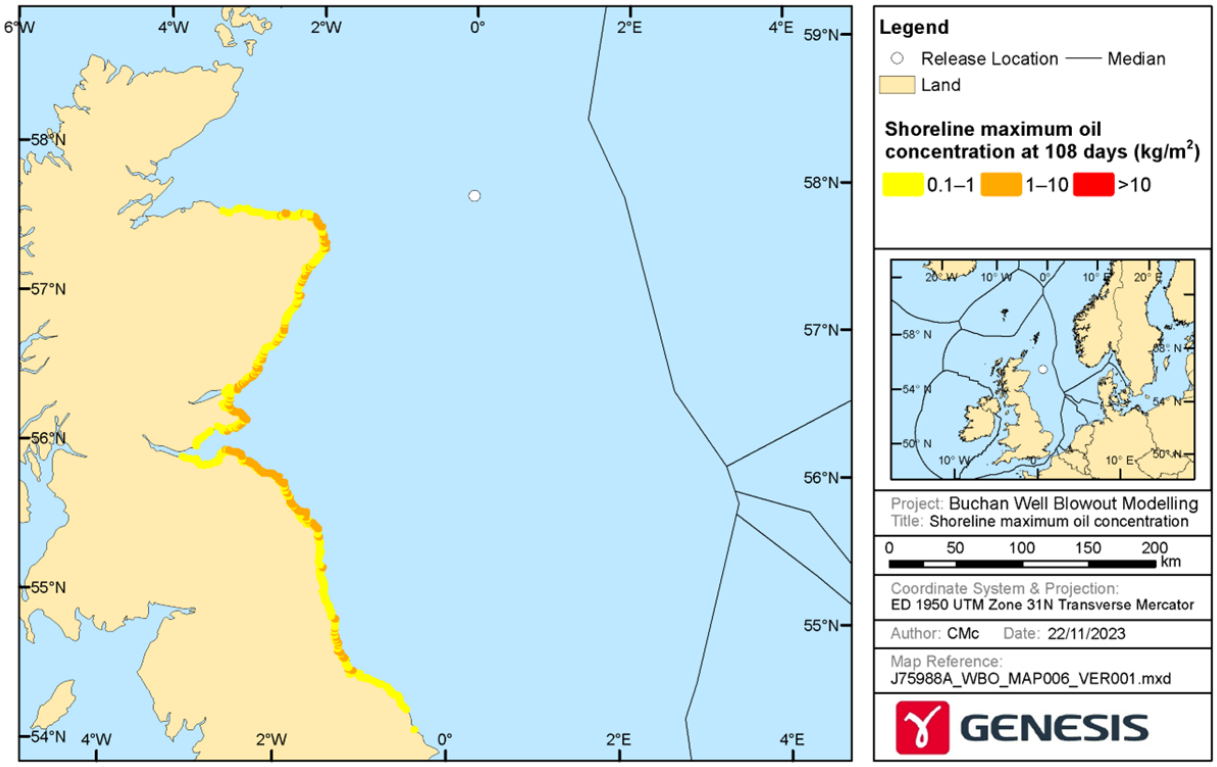


Figure 12-5: Maximum shoreline oil concentrations (well blowout, deterministic)

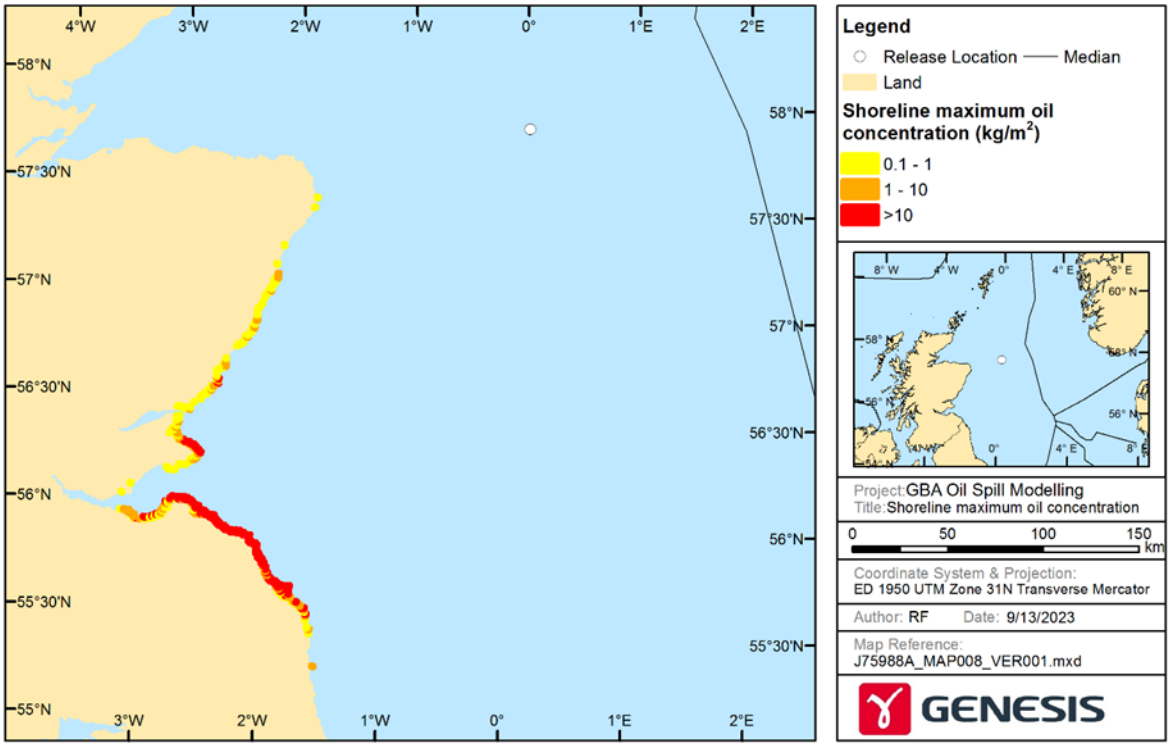


Figure 12-6: Maximum shoreline oil concentrations (inventory loss, deterministic)

The magnitude of effect is classed as Critical (5) as the impacts from a large spill could potentially affect the ability of regional populations to propagate and hence recover within a short time. This could have significant adverse effects on the already declining Black-legged Kittiwake European populations to reach favourable conservation status.

Scenario	Receptor Sensitivity	Magnitude of effect	Environmental significance of impact	Environmental risk
Blow out	High	Critical	High	Medium
Inventory release	High	Critical	High	Medium

12.3.7 Marine Mammals

All cetaceans are EPS and Scottish PMFs. The harbour porpoise and bottlenose dolphin are also Annex II and IV species under the Habitats Directive (JNCC 2019).

Marine mammals may be exposed to hydrocarbons either internally (swallowing contaminated water, consuming prey containing oil-based chemicals, or inhaling of volatile oil related compounds) or externally (oil on skin and body).

The effect of hydrocarbons on marine mammals are dependent upon species but may include:

- Hypothermia due to conductance changes in skin or fur;
- Toxic effects and secondary organ dysfunction due to ingestion of oil, congested lungs;
- Damaged airways;
- Interstitial emphysema due to inhalation of oil droplets and vapour;
- Gastrointestinal ulceration and haemorrhaging due to ingestion of oil during grooming and feeding;
- Eye and skin lesions from continuous exposure to oil;
- Decreased body mass due to restricted diet; and
- Stress due to oil exposure and behavioural changes.

There is little documented evidence of cetacean behaviour being affected by hydrocarbon spills. Evidence suggests they do not necessarily avoid slicks. In the months following the *Exxon Valdez* spill there were observations of harbour porpoises swimming through light to heavy crude oil sheens. Stressed or panicking cetaceans tend to move faster, breathe more rapidly and therefore surface more frequently into oil and increase exposure (Harvey and Dahlheim, 1994).

Cetaceans have smooth skins with limited areas of pelage (hair covered skin) or rough surfaces. Hydrocarbon tends to adhere to rough surfaces, hair or calluses of animals, so contact may cause only minor adherence. However, cetaceans can be susceptible to inhaling hydrocarbon and hydrocarbon vapour when they surface to breathe. This may lead to damaging of the airways, lung ailments, mucous membrane damage or even death.

The likelihood that a feeding cetacean would ingest a sufficient quantity of hydrocarbon to cause sublethal damage to its digestive system, or to present a toxic body burden, is low (IPIECA-IOGP, 2015). Ingestion of subtoxic quantities may have chronic effects and there is potential for PAHs to accumulate in tissues of whales before they are eventually metabolized, and for contaminants to be passed to juveniles through the mother's milk.

The harbour porpoise has been estimated to occur in the project area at densities of around 0.599 individuals per km^2 (Section 4.3.6.2). Other marine mammals regularly occurring in the project area at relatively low densities are bottlenose dolphin, white beaked dolphin, minke whale and Atlantic white-sided dolphin. Therefore, it is likely that cetaceans could encounter hydrocarbons in the event of a large release.

Seals are vulnerable to oil pollution because they spend much of their time near the surface and regularly haul out on beaches. Seals have been seen swimming in hydrocarbon slicks during several documented spills (Geraci and St. Aubins, 1990). Most seals scratch themselves vigorously with their flippers but do not lick or groom themselves, so are less likely to ingest hydrocarbon from skin surfaces. However, a seal mother trying to clean an oiled pup may ingest hydrocarbon, and it is pups that are most vulnerable to hydrocarbon spills when they reach breeding colonies on the shoreline. Furthermore, seals use smell to identify their young in a large colony. If the mother cannot identify its pup because its scent has been masked by hydrocarbons, this can result in abandonment and starvation.

Oil can impact on the mucous membranes that surround the eyes and line the oral cavity, respiratory surfaces, anal and urogenital orifices of seals. This can cause corneal abrasions, conjunctivitis and ulcers. Consumption of oil-contaminated prey will lead to the accumulation of hydrocarbons in tissues and organs. Lesions characteristic of hydrocarbon toxicity were found in the brains of seals exposed to the *Exxon Valdez* spill (Spraker *et al.*, 1994).

Seal abundance in the proposed Project area is low for grey seals and not likely to occur for harbour seals (Section 4.3.6.1) and therefore it is not expected that seals would encounter spilled hydrocarbons.

The sensitivity of marine mammals in the potentially impacted area is considered to be Medium (b) as they are recognised to be of conservation significance given their EPS status.

As noted in Section 12.3.1 the well blowout potentially impacts a larger volume of the water column but at lower concentrations than the inventory release. Given the large water volumes potentially affected in both the scenarios and the potential for transboundary impacts, the magnitude of impacts is classified as Major (4)

Scenario	Receptor Sensitivity	Magnitude of effect	Environmental significance of impact	Environmental risk
Blow out	Medium	Major	Moderate	Low
Inventory release	Medium	Major	Moderate	Low

12.3.8 Offshore Protected Areas

The offshore protected areas which could potentially be affected by hydrocarbons released as a result of the well blowout or inventory rupture scenarios are summarised in Table 12-4 and shown in Figure 12-7 to 12-12. Of the designated areas that fall within areas where there is a greater than 50% probability of either surface or water column oiling Turbot Bank NCMPA and Gytefelt Makrell and Tobisfelt PVAs are designated for receptors potentially present in the water column. The remainder of the sites are designated for benthic/sediment features which would not be impacted by oil in the water column or at surface, and as previously noted there are no predicted concentrations above the 5 g/m^2 threshold in the sediment (see Table 12-3). As these three sites are regional/national importance receptor sensitivity is classed as Medium (b).

Sandeels are an important prey species for many marine predators, such as seabirds, fish and marine mammals. The majority of sandeel stocks in the North Sea have experienced severe decline, thought to have been brought about by a combination of overfishing and the effects of climate change. This decline has coincided with a series of breeding failures amongst sandeel-dependent seabirds such as puffins and kittiwakes (OESEA3). The Turbot Bank and Tobisfelt are considered suitable for sandeel spawning grounds. Sandeels are sensitive to non-synthetic sediment contamination, including hydrocarbons. Oil pollution can result in high levels of sandeel mortality. Sandeels are sensitive to oil, because clean well oxygenated coarse sediment is critical for their preferred habitat. The burial time in sand has been reported to decrease if the sand is contaminated with oil. The sandeels may try to move into clean adjacent areas or into deeper waters. (A.Velando *et al.*, 2005).

Mackerel are broadcast spawners and their eggs and larvae float free in the water column, therefore impacts to the water column could impact mackerel spawning success over one season to a year. Consequently, impacts to the Gytefelt makrell PVA may result in significant adverse effects to the current mackerel population structure within the site.

As noted in Section 12.3.1 the well blowout potentially impacts a larger volume of the water column but at lower concentrations than the inventory release. Similarly the area of oil at the surface is potentially greater from the well blowout but the oil thickness is much smaller than for the inventory release (see Section 12.3.6).

Table 12-4: Potential impact to offshore protected areas from hydrocarbon releases associated with the proposed Project.

Protected Area	Blowout		Inventory release		Protected features
	Probability of surface oiling above impact threshold (> 50%)	Probability of water column oiling above impact threshold (> 50%)	Probability of surface oiling above impact threshold (> 50%)	Probability of water column oiling above impact threshold (> 50%)	
Norwegian Boundary Sediment Plain NCMAP	92	92	<50	59	Ocean quahog and sediment
Central Fladen NCMPA	68	58	<50	< 50	Sea-pens and burrowing megafauna and tall sea-pen components
East Of Gannet and Montrose Fields NCMPA	89	81	<50	< 50	Ocean quahog and sediment
Turbot Bank NCMPA	56	53	<50	< 50	Sandeel habitat and spawning
Scanner Pockmark SAC	99	97	<50	59	Submarine structures made by leaking gases
Braemar Pockmarks SAC	70	69	<50	< 50	Submarine structures made by leaking gases
Gytefelt makrell PVA	87	87	<50	< 50	Mackerel spawning
Tobisfelt PVA	84	70	<50	< 50	Sandeel habitat and spawning

Given the potential for transboundary impacts the magnitude of effect is classed as Major (4). The probability of oil reaching the Norwegian designated sites is lower for the inventory release than for the blowout but there is still a possibility of transboundary impacts and therefore the magnitude has still been classed as Major.

Scenario	Receptor Sensitivity	Magnitude of effect	Environmental significance of impact	Environmental risk
Blow out	Medium	Major	Moderate	Low
Inventory release	Medium	Major	Moderate	Low

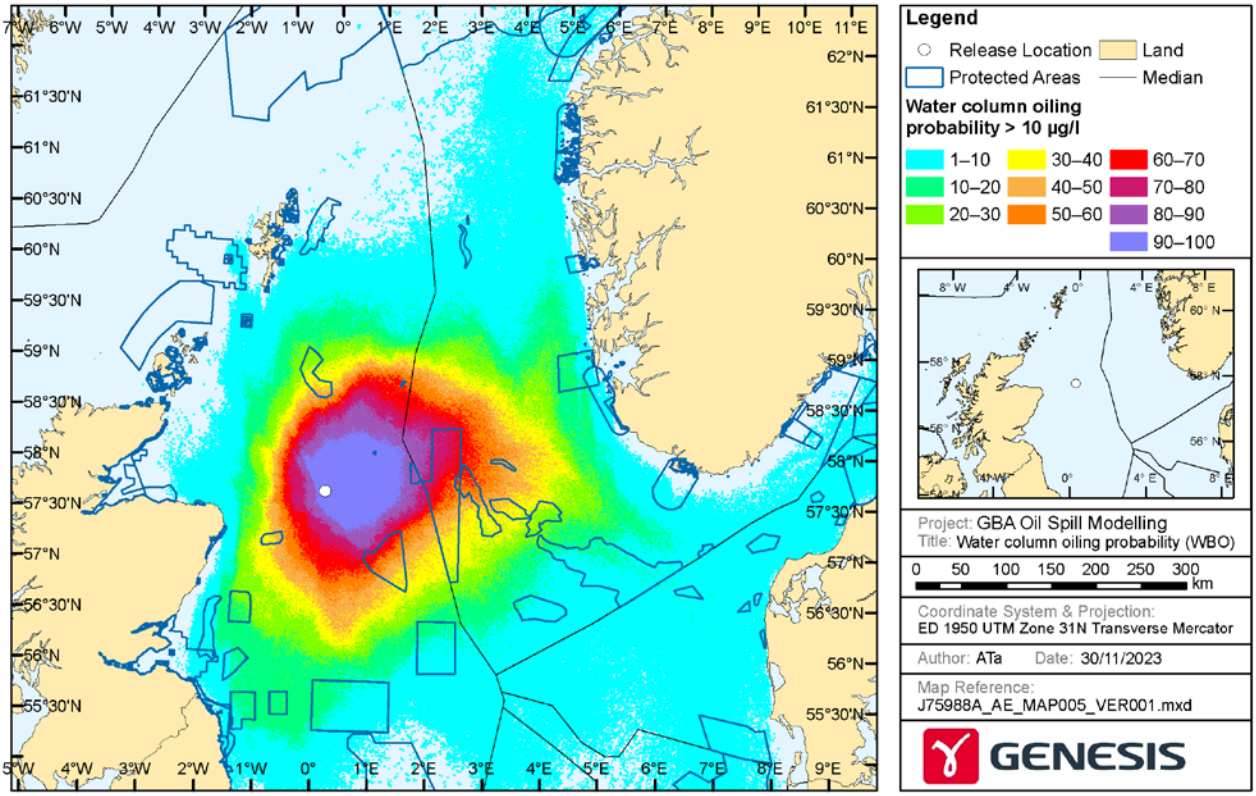


Figure 12-7: Water column oiling and offshore protected areas (blowout).

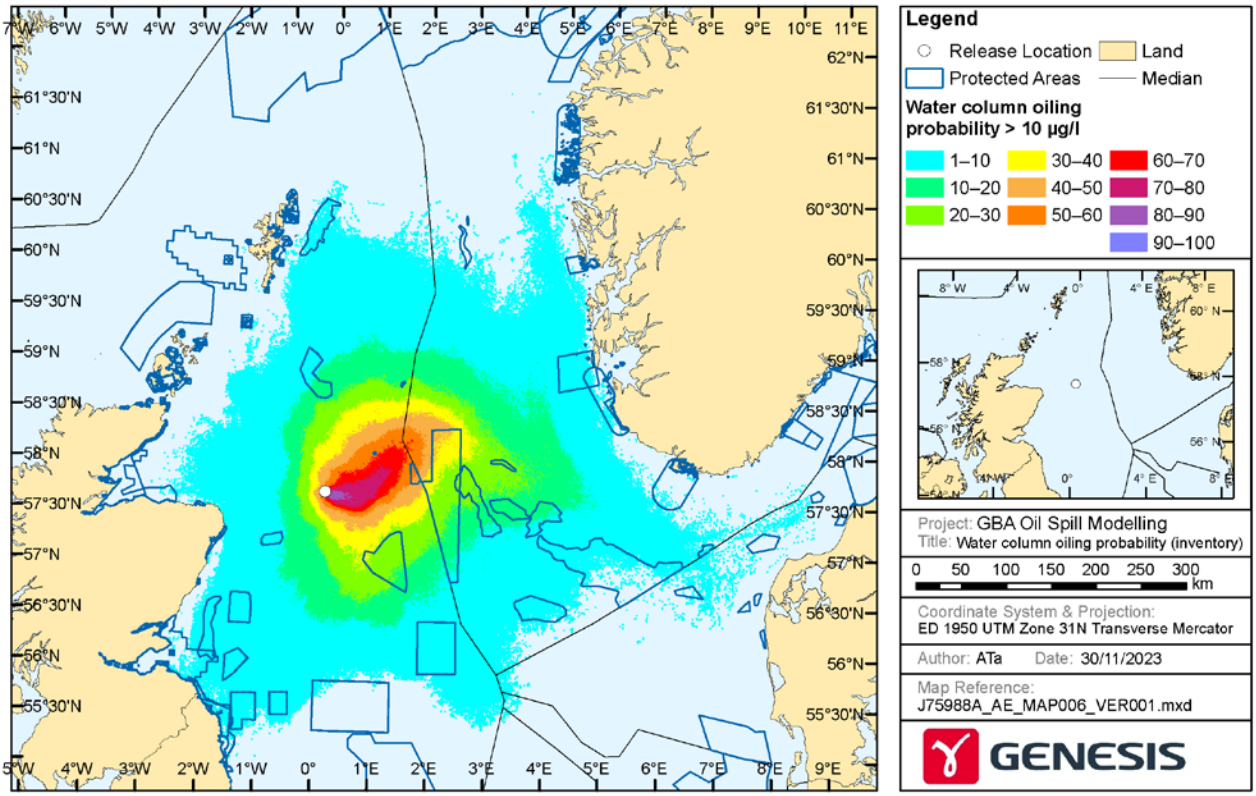


Figure 12-8: Water column oiling and offshore protected areas (inventory loss).

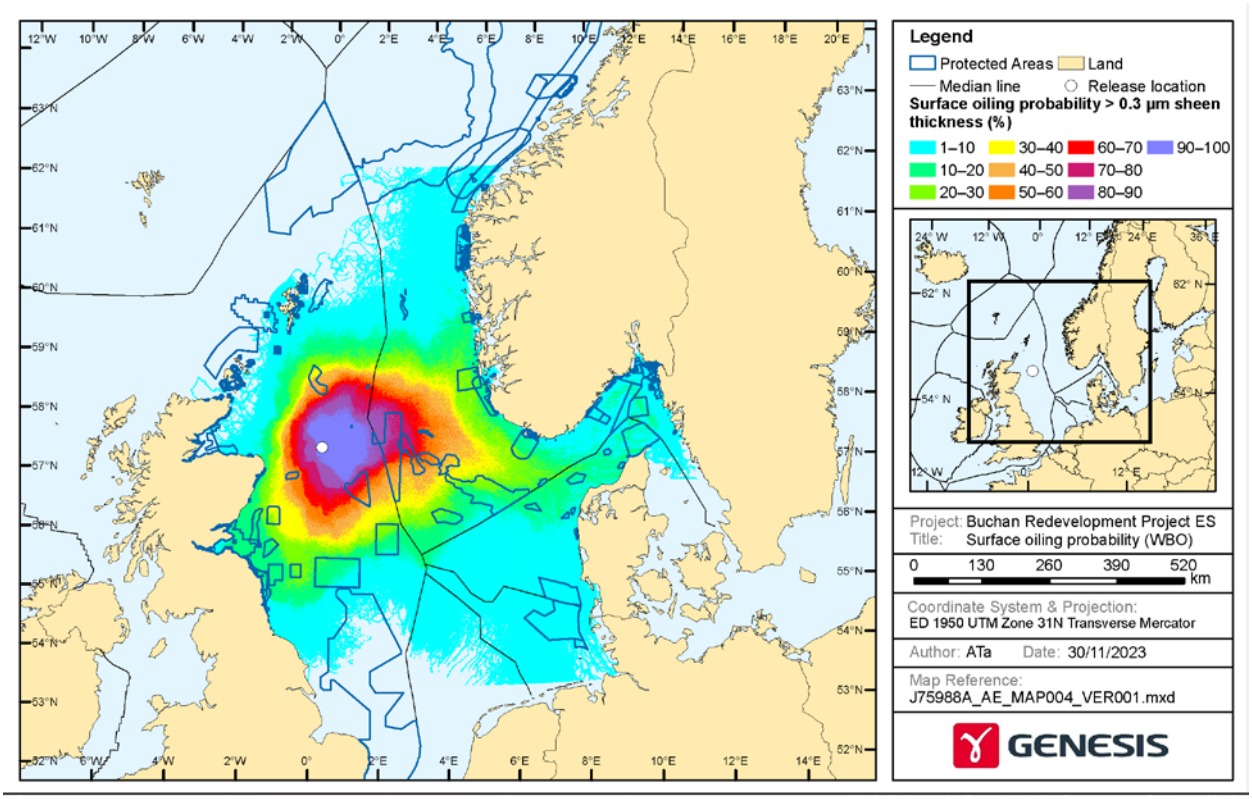


Figure 12-9: Surface oiling and offshore protected areas (blowout).

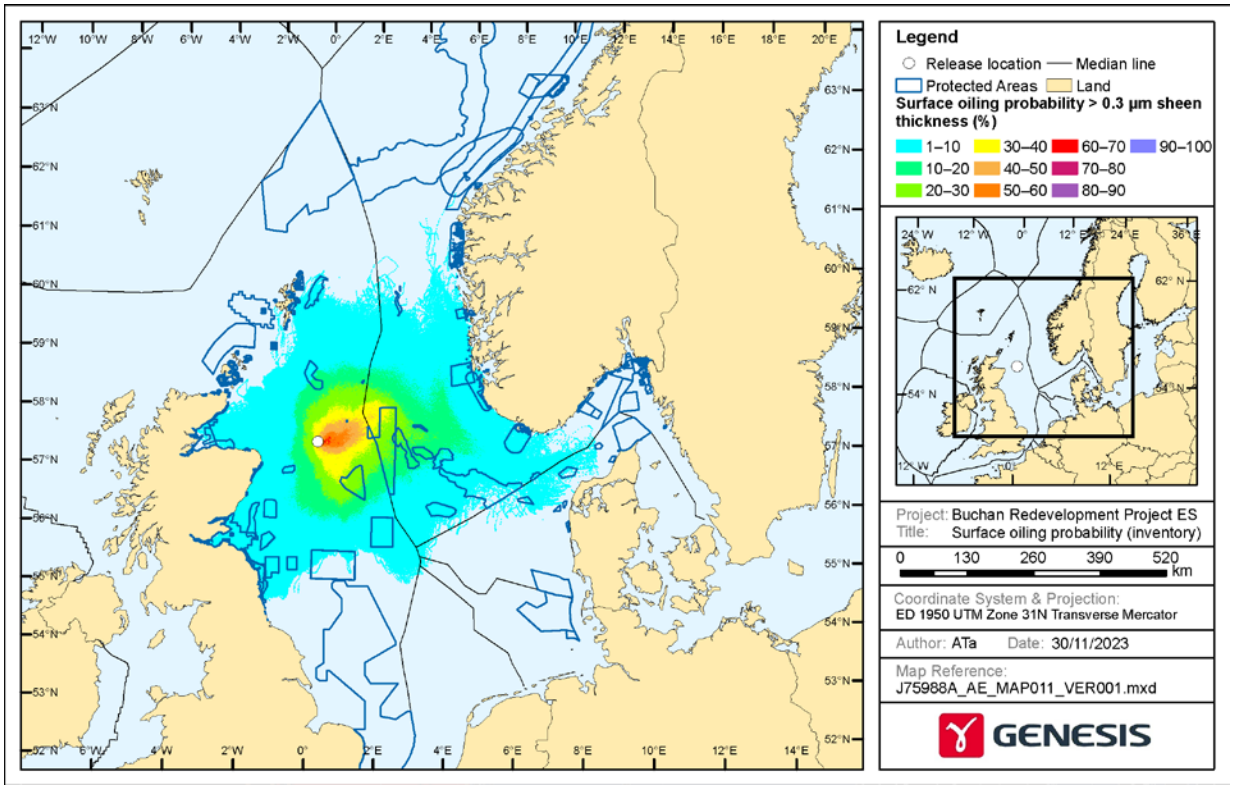


Figure 12-10: Surface oiling and offshore protected areas (inventory loss).

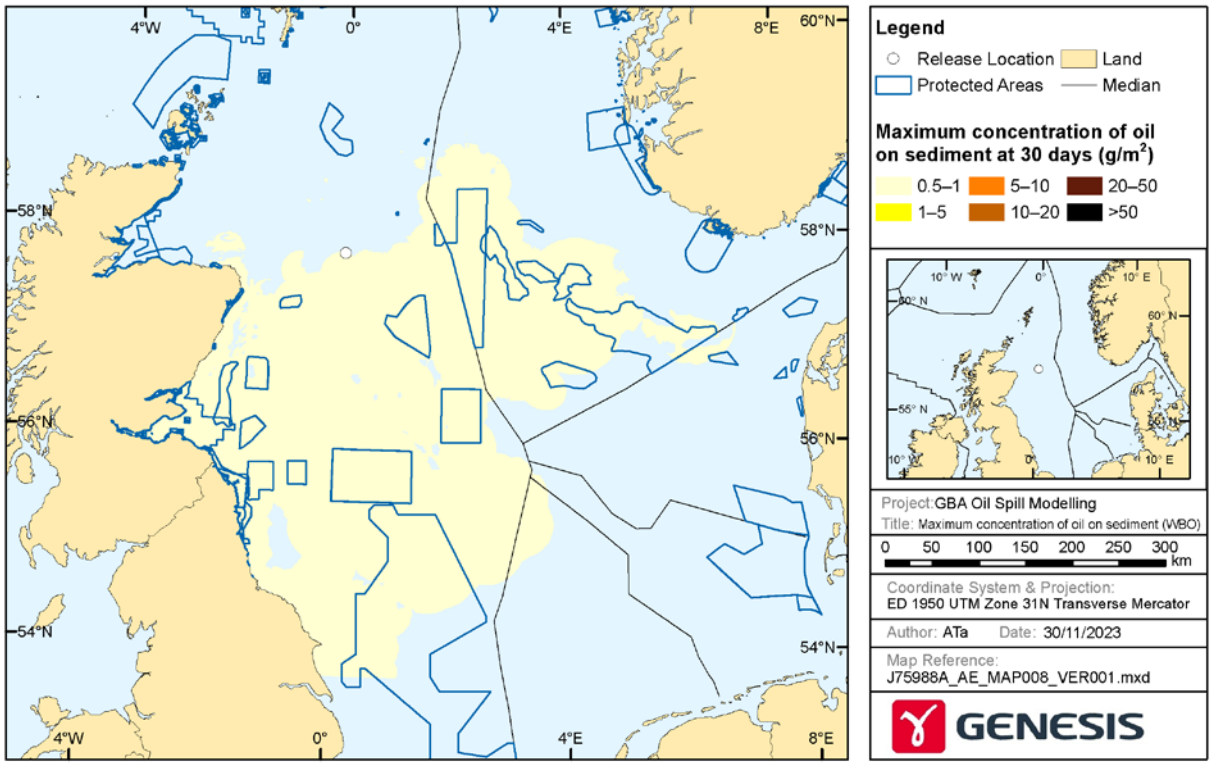


Figure 12-11: Maximum concentration of oil on sediment and offshore protected areas (blowout).

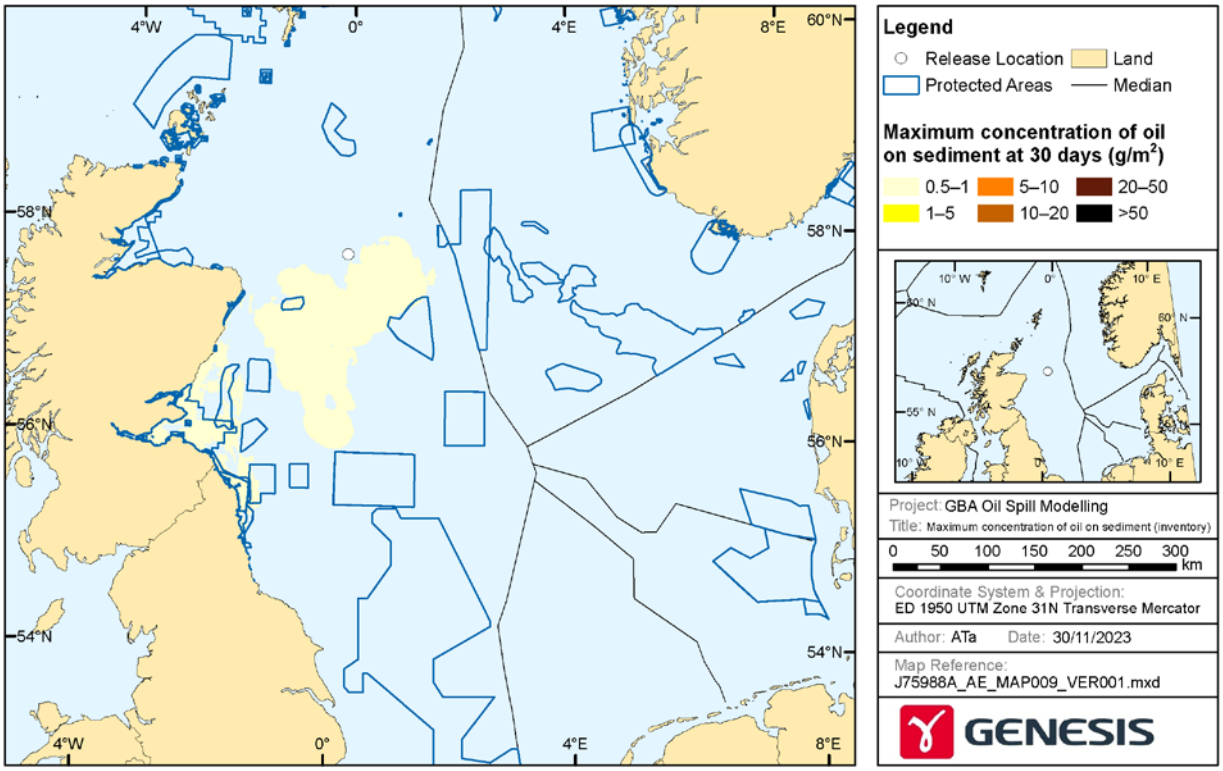


Figure 12-12: Maximum concentration of oil on sediment and offshore protected areas (inventory loss).

12.3.9 Coastal Protected Areas

The probability of shoreline oiling is moderate to low but this could coincide with coastal protected areas (see Figure 12-13 and Figure 12-14). For the worst case shoreline oiling, approximately 650 km in the case of a well blowout and 237 km in the case of the inventory loss (see Figure 12-5 and 12-6) would exceed the threshold of 0.1 kg/m^2. As noted in Section 12.3.6, although the inventory loss would result in a shorter length of coast impacted the quantity of oil deposited is much greater than for the blow out scenario.

The protected area sensitivity is considered to be High (c) because of the presence of protected areas.

The magnitude of impact to coastal protected areas is considered Critical (5) as heavy oiling along the coast could have an impact on the conservation objectives of internationally or nationally designated sites.

Scenario	Receptor Sensitivity	Magnitude of effect	Environmental significance of impact	Environmental risk
Blow out	High	Critical	High	Medium
Inventory release	High	Critical	High	Medium

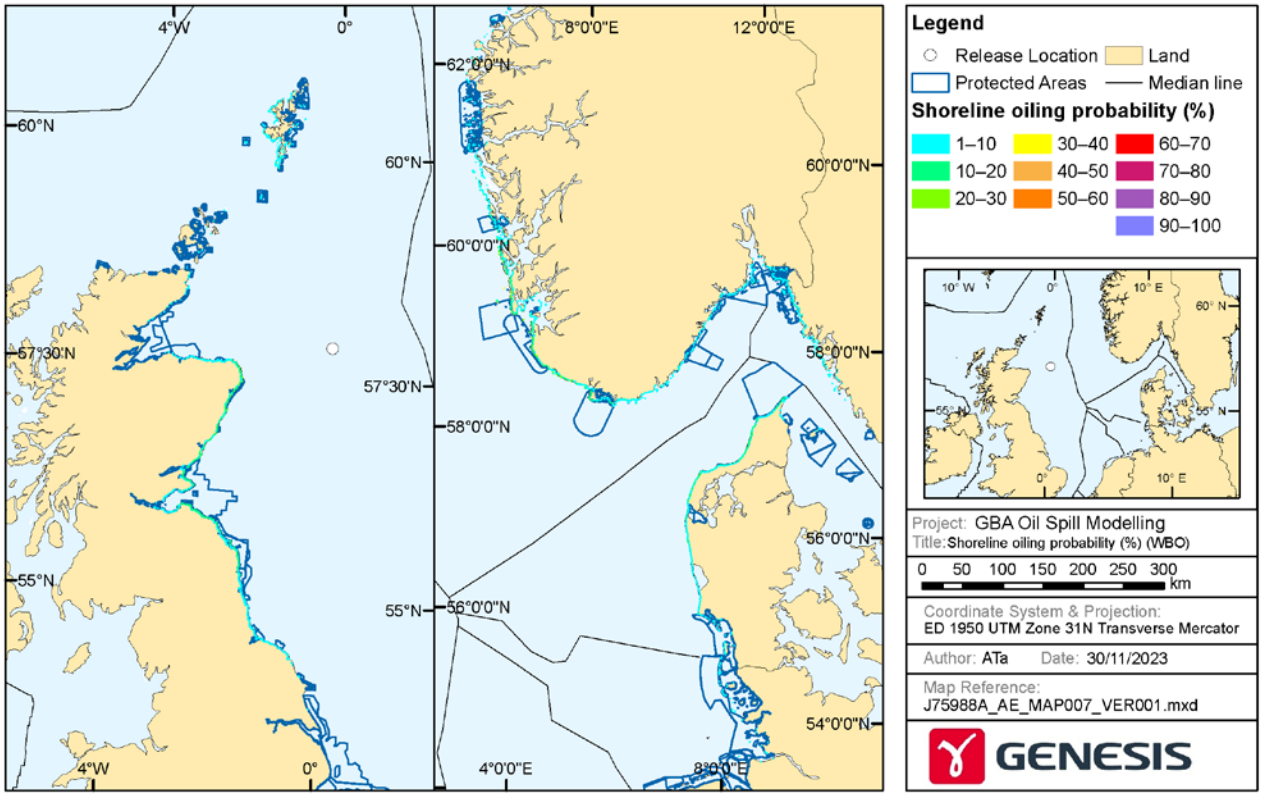


Figure 12-13: Probability of shoreline oiling and coastal protected areas (blowout)

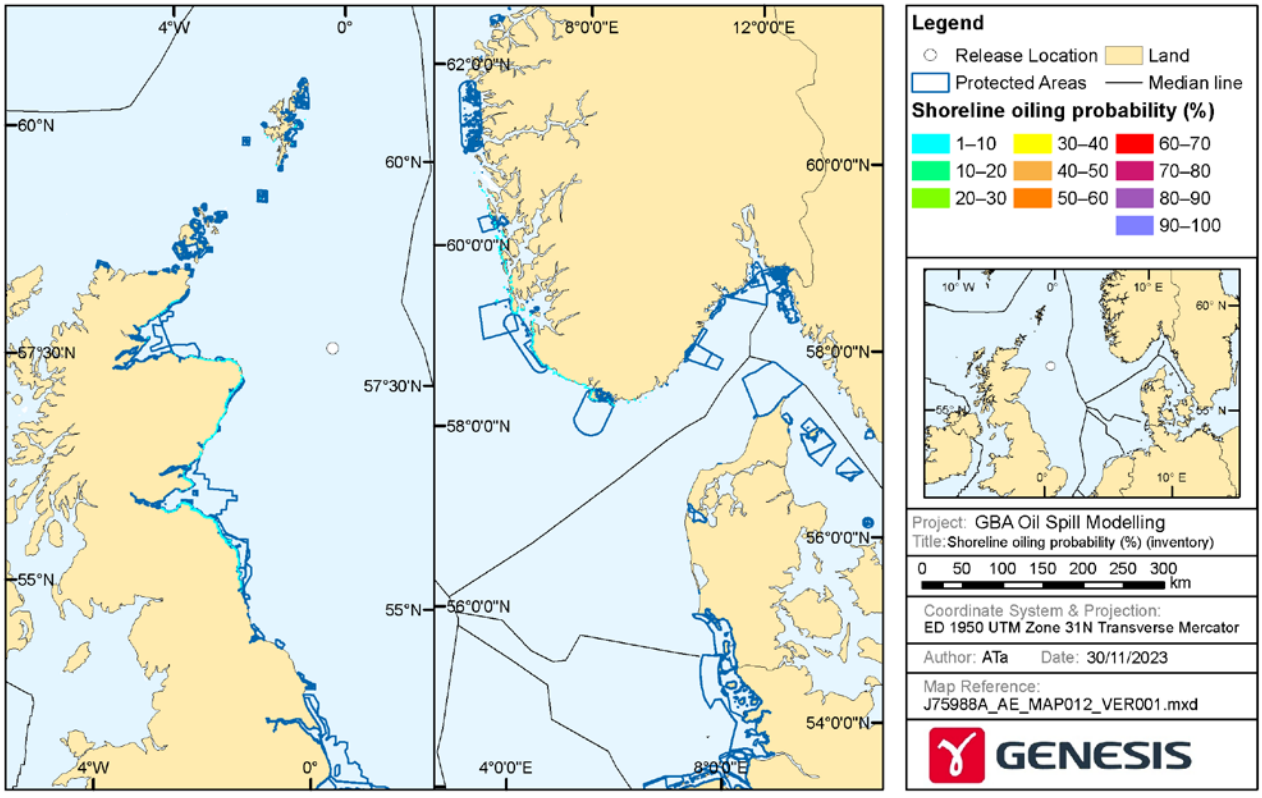


Figure 12-14: Probability of shoreline oiling and coastal protected areas (inventory loss).

12.3.10 Fisheries, Aquaculture and Shellfish Water Protection Areas

Localised mortality of eggs and larvae which may occur following a spill rarely impacts wider fish stocks, and adult fish are relatively resilient to hydrocarbon spills. More significant impacts may be found near shore, where hydrocarbons can accumulate and exposure, particularly of intertidal and shallow subtidal benthos, caged animals and seafood products that are cultivated in fixed locations (ITOPF, 2014).

As discussed in Section 4 Baseline Environment, fishing effort in the Buchan Redevelopment Project area is moderate when compared to other areas of the UKCS. Within the immediate vicinity of the Buchan Redevelopment Project area, fishing is predominately by demersal trawling and the majority of fishing effort takes place in the summer months between June and October.

Deterioration of water quality below the conservative 10 µg/l threshold is unlikely.

Figure 12-15 and Figure 12-16 show the probability of onshore oiling and the location of aquaculture sites. Although the probability of onshore oiling is low it does intersect with a number of aquaculture sites, particularly along the coast of Norway. There is a low probability that traces of hydrocarbons could reach the shoreline in the area of “Firth of Forth Lobster Hatchery” (European lobster). As noted in Section 12.3.6 shoreline oiling concentrations are much higher for the inventory release than for the blowout scenario but cover a shorter section of coastline.

Sensitivity of the receptor is considered High (c) given that fish present in aquaculture site would be unable to swim away from spill and may therefore have a low capacity to absorb change without significant impact.

Given the fact that there are potential transboundary impacts, the magnitude of effect is classed as Major (4).

Scenario	Receptor Sensitivity	Magnitude of effect	Environmental significance of impact	Environmental risk
Blow out	High	Major	High	Medium
Inventory release	High	Major	High	Medium

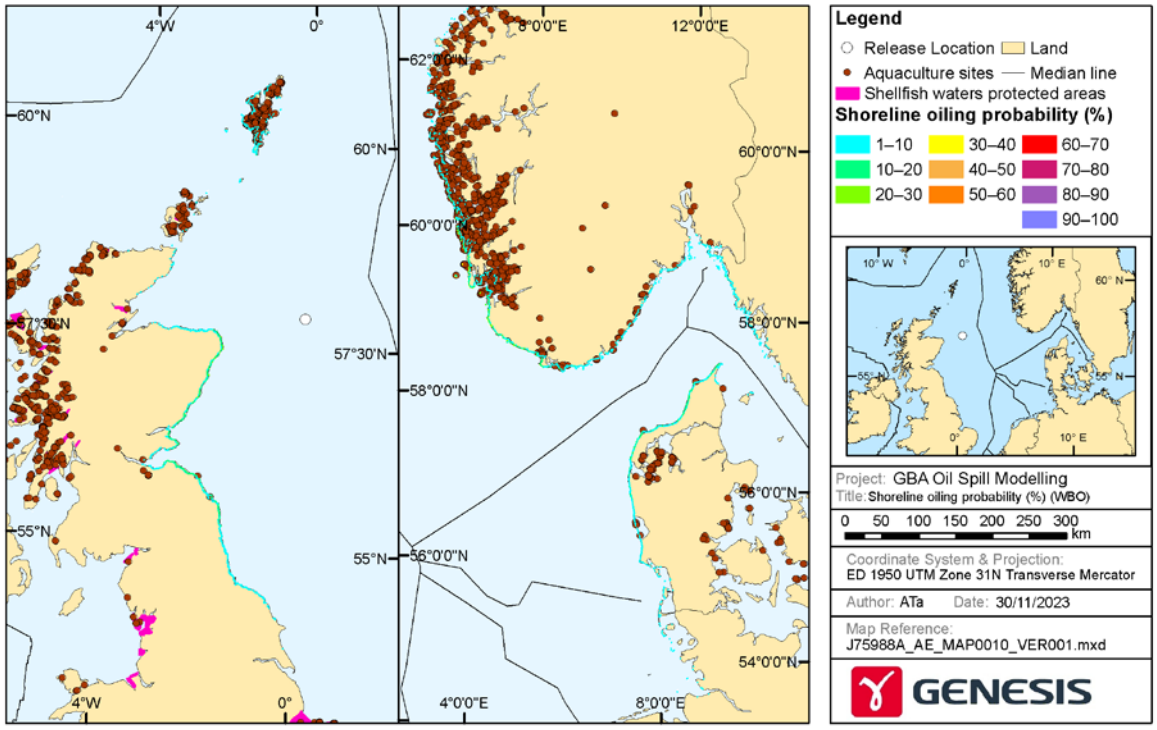


Figure 12-15: Probability of shoreline oiling in relation to aquaculture sites and Shellfish Water Protected Areas (blowout)

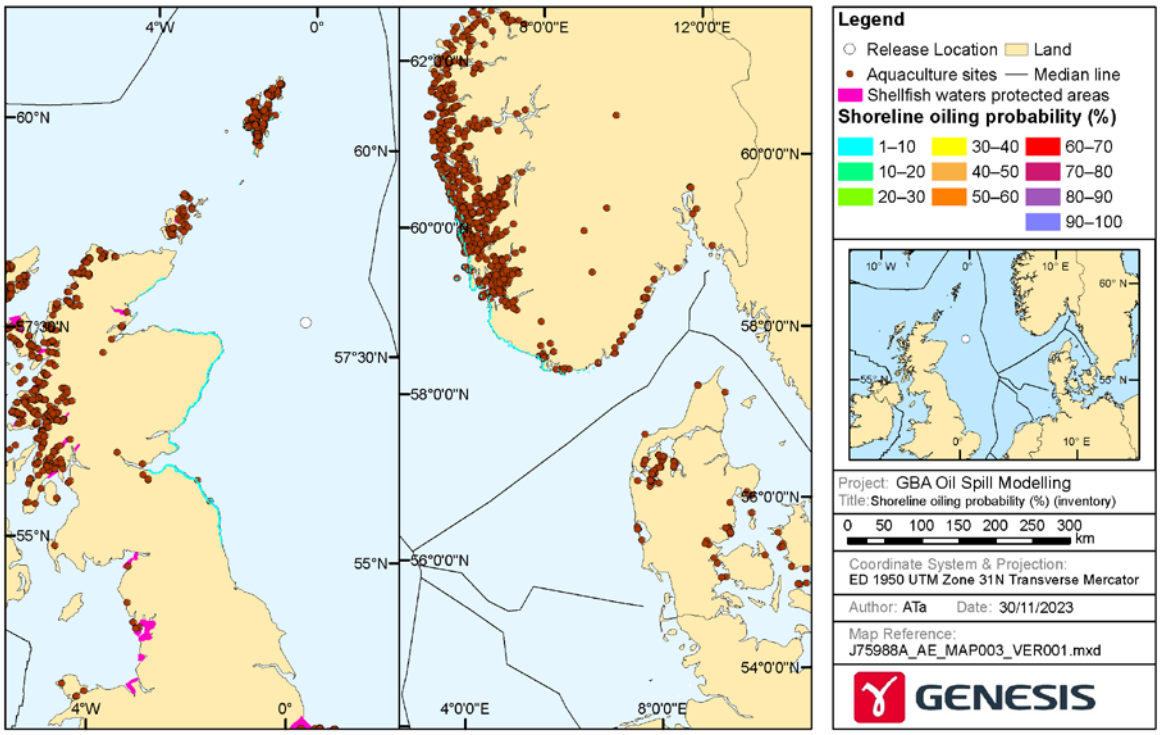


Figure 12-16: Probability of shoreline oiling in relation to aquaculture sites and Shellfish Water Protected Areas (inventory loss)

12.3.11 Transboundary and Cumulative impacts

Probabilities of surface and water column oiling and arrival times across relevant median lines are given in Appendix E and summarised in Table 12-3. Transboundary impacts have been taken into account in the impact assessments undertaken in Sections 12.3.1 to 12.3.10.

In the unlikely event of a well blowout, a large volume of gas containing methane, ethane and CO_2 could potentially be released contributing to localised poor air quality and cumulatively to global climate change (as noted following the Deepwater Horizon event, see for example Middlebrook *et al.*, 2012).

12.4 Major Environmental Incident Assessment

12.4.1 MEI Definition

The Offshore Installations (Safety Case etc.) Regulations 2015 (SCR, 2015) extends the evaluation of major accidents to include their potential consequences on the safety of personnel and the environment (described as a MEI). The well blowout and Western Isles FPSO release scenarios are considered to be Major Accident Hazards (MAHs) and were assessed for an MEI potential.

An MEI is defined in the SCR (2015) as an "*incident which results, or is likely to result, in significant adverse effects on the environment in accordance with the Environmental Liability Directive 2004/35/EC of the European Parliament and of the Council on environmental liability with regard to the prevention and remedying of environmental damage*".

An incident that results, or is likely to result, in significant adverse effects to protected species and natural habitats, affecting their ability to reach or maintain favourable conservation status of such habitats or species is therefore considered an MEI. The significance of such effects should be assessed with reference to the baseline condition, taking account of the criteria set out in Annex I of Directive 2004/35/EC.

The adopted Impact significance assessment methodology (see Section 5) considers the magnitude of impact, including the areal extent or number/density of species that could be affected, and receptor sensitivity, that accounts for a number of criteria, largely aligned with Annex I of the Environmental Liability Directive, such as conservation status, ecosystem services provided by the species or habitats, number of individuals/ area affected, and reproduction cycle of species and their viability, capacity of a habitat for natural regeneration and capacity / duration for recovery.

12.4.2 MEI Conclusion

Significance of impacts to different receptor categories is discussed in Section 12.3. As noted in Section 12.3 although the blowout scenario potentially results in a larger volume/area of the water column, sea surface and shoreline being impacted, the concentrations in the water column, at the sea surface and the shoreline are higher in the case of the inventory release as there is less time for dispersion and dilution in the case of the inventory release.

The environmental impacts resulting from either a well blowout or an inventory loss to seabirds, coastal protected areas and fisheries/aquaculture sites were assessed as resulting in a medium environmental risk, with the potential to disrupt the function and value of the resource/ receptor with broader systemic (e.g. ecosystem or social well-being) consequences. Accordingly, these receptors were assessed as having the potential to result in a MEI under the Safety Case Regulation SCR 2015.

Table 12-5: Summary of environmental risks on receptors.

Receptor	Environmental Risk	
	Well Blowout	Western Isles FPSO Inventory Release
Water quality	Low	Low
Sediment quality	Low	Low
Plankton	Low	Low
Benthos	Low	Low
Fish	Low	Low
Seabirds	Medium	Medium
Marine mammals	Low	Low
Offshore protected areas	Low	Low
Coastal protected areas	Medium	Medium
Fisheries, Aquaculture and Shellfish Water Protection Areas	Medium	Medium

12.5 Susceptibility to Natural Disasters

Some natural disasters could increase the risk of a major pollution event occurring at the Buchan Horst Field. For example, an earthquake could lead to damage to the infrastructure leading to the release of hydrocarbons, however, the likelihood of an earthquake of sufficient magnitude on the UKCS to impact the infrastructure is extremely remote. To mitigate the potential for damage, offshore structures are designed to withstand seismic forces and vibrations with a reasonably low likelihood of exceedance during their lifetime, with little or no damage, and can maintain integrity without major collapse or loss of life.

Climate change effects, such as sea level change and extreme weather events, are not considered to significantly alter the range of effects considered. Extreme weather may make accidents (e.g. collisions/dropped objects) more likely, but the drilling rig and Western Isles FPSO will have procedures in place for making safe and shutting down operations during extreme weather.

12.6 Management and Mitigation Measures

The following measures will be adopted to ensure that the risk and impacts of releases, including large hydrocarbon releases, are minimised to as low as reasonably practicable.

Proposed Mitigation Measures

- Activities will be carried out by trained and competent offshore crews and supervisory teams;
- An approved OPEP will be in place prior to any activities being undertaken;
- Records will be kept of oil spill training and exercises as required by the OPEP;
- Process Safety Assurance Processes will be identified and adhered to;
- The Western Isles FPSO will be of a double-hull design, meaning oil cargo tanks are not on the outside, thus limiting risk of spill;
- The Western Isles FPSO will have a robust maintenance and inspection programme linked into the critical elements and associated verification scheme;
- Shipboard Oil Pollution Emergency Plans (SOPEPs) will be in place for project vessels;
- A co-ordinated industry oil spill response capability will be available; and
- Enhanced sharing of industry best practices via the Oil Spill Response Forum (OSRF) will continue.

Wells specific control measures

- A robust BOP pressure and functional testing regime will be in place and the BOP will have fully redundant control systems;
- Appropriate mud weights will be used to allow well control to be maintained;
- The drilling rig will be appropriately certified;
- The drilling rig shall have an approved safety case with all Safety and Environment Critical Elements (SECEs) verified by an independent verification body and managed through a recognised maintenance management system;
- Well construction and operation activities to be conducted with multiple barriers in place; and
- Well Control Contingency Plan in place detailing relief well plans and arrangements with internal and external well control specialists.

Operations-specific control measures

- Tanker offloading procedures will be in place;
- Shutte tankers will be required to be DP2-classed as a minimum;
- Metocean conditions may limit offloading; where production storage limits are reached, production could be curtailed until export can resume.
- Import and export facilities will be secured by topside ESDVs;
- A mandatory 500 m safety zone will be in place for the Western Isles FPSO and drilling rig;
- There will be agreed approach procedures to the Western Isles FPSO by supply and safety vessels, informed by appropriate collision risk assessments;
- Operational restrictions will be in place for visiting vessels in bad weather;
- Simultaneous operations (SIMOPS) procedures will be in place;
- Pipelines will have pressure monitoring and low pressure alarms; and
- Oil spill control measures will be followed as outlined in the OPEP.

12.8 Conclusions

Two potential hydrocarbon spill scenarios were considered: a release of crude inventory from the Western Isles FPSO and a well blowout. The oil spill simulations undertaken established that the well blowout would be the most severe scenario based on surface coverage, water column contamination and onshore deposition of crude. However, the inventory loss would result in higher concentrations at the surface, in the water column and onshore, albeit covering smaller volumes/areas.

The likelihood of any of the two hydrocarbon releases modelled occurring is considered Remote owing to the procedural and operational controls that will be applied during the Buchan Redevelopment Project. Given the likelihood of such releases, and following the application of control and mitigation measures, the overall environmental risk of impacts from a large hydrocarbon release resulting from a well blowout or a total loss of inventory from the Western Isles FPSO are considered to range from Low to Medium depending on the environmental receptor. Both scenarios have been identified as MEIs in relation to seabirds, coastal protected areas and fisheries/aquaculture.

13 Conclusions

A detailed assessment of the potential environmental impacts associated with the proposed Buchan Redevelopment Project has been carried out. The identification of the potential impacts is based on the nature of the proposed activities and was informed by available literature and guidance documents, industry specific experience and consultation with OPRED and their consultees. The commitments made in this ES will be incorporated into environmental management plans for the drilling, installation, commissioning and operations phases of the proposed project.

13.1 Environmental Effects

The potential impacts to the environment from all phases of the project were assessed. The environmental aspects of each of the key activities for each phase of the project were identified and quantified in terms of their effect on receptors and their magnitude of this effect. The results were assessed on the basis of the impact significance (for planned activities) or the risk posed to the environment (for unplanned), and were summarised as being either low, moderate or high significance.

The environmental impact assessment considered both planned activities and unplanned events. The assessment showed that with the application of the mitigation measures identified, the impacts of the planned activities are of low significance with the exception of disturbance to the seabed impacts which are considered to be of moderate significance.

Two unplanned events (well blowout and a total loss of crude inventory from the Western Isles FPSO) were considered to range from Low to Medium environmental risk depending on the receptor considered. Both unplanned events have been identified as MEIs in relation to seabirds, coastal protected areas and fisheries/aquaculture.

13.2 Minimising Environmental Impact

Following identification of suitable mitigation and control measures, additional assessment was undertaken for the planned activities initially identified as moderate to high significance. This includes quantification of seabed disturbance and oil spill modelling. Following implementation of identified mitigation and control measures, all residual risks to the environment are considered to be as low as reasonably practicable.

The execution of the Buchan Redevelopment Project, incorporating the control measures identified in this ES, is not expected to have a significant impact on the environment.

The Project will continue to work towards minimising the potential impact to the seabed e.g. potential for laying two or more of the infield lines in the same trench will be considered, whilst route surveys carried out to minimise the potential for contingency rock cover. The environmental impacts of seabed disturbance are considered acceptable when managed within the additional controls and mitigation measures described.

Routine atmospheric emissions and discharges to sea would be expected to disperse within a limited distance from the development. It is therefore unlikely that planned emissions and discharges will have a transboundary impact given that the nearest median line (UK/Norway median line) is c. 103.5 km from the proposed development. Hence no significant transboundary impacts were identified as a result of planned activities. There is a risk of transboundary impacts associated with an accidental release of crude oil, as discussed in Chapter 12. Such releases are rare and measures will be in place to minimise the likelihood of such an event occurring. However, should an unplanned release occur there will be measures in place to ensure a coordinated and co-operative response (Chapter 12).

13.3 Commitments

Project specific commitments and mitigation measures to minimise the impact of the proposed project on the environment have been highlighted throughout the ES and are summarised in Table 13-1. These commitments will be integrated into the relevant project design, execution and operational phases.

Table 13-1: Buchan Redevelopment Project commitments

Aspect	Commitments
Physical Presence	• ON6 Notification will be submitted prior to rig mobilisation; • A Collision Risk Management Plan will be produced if determined to be required; • All vessels will adhere to COLREGS and will be equipped with navigational aids, including radar, lighting and AIS (Automatic Identification System) etc.; • The drilling rig will be equipped with navigational aids and aviation obstruction lights system, as per the Standard Marking Schedule for Offshore Installations; • Vessel use will be optimised by minimising the number of vessels required and length of time vessels are on site; • The flowlines and EHC umbilical laid out with the 500 m areas will be trenched and buried; • Following flowline and EHC umbilical installation, surveys will be carried out to ensure a safe seabed; • Any contingency rock cover required will be laid in an over trawlable profile; • 500 m safety zones in place around the Western Isles FPSO and drill centres; • Use of a guard vessel to warn of anchor location prior to the semi-submersible drilling rig coming on location; • Presence of ERRV vessels which will warn other sea users of the presence of the drilling rig and the Western Isles FPSO.
Emissions to Air	**Proposed Concept Select Mitigation Measures** • Inclusion of optimised energy efficiency and GHG emissions reduction in the rig selection and tendering process. • Investment will be made to ensure the FPSO is electrification ready in advance of the availability of 3rd party power e.g. an INTOG windfarm. **Proposed Logistics and Start-up Mitigation Measures** • Batch drilling and completion opportunities will be evaluated. These would reduce emissions through reduced logistical requirements and fluid handling efficiencies. • The Project team will aim to design wells to minimise use of diesel-powered intervention equipment. • The information gained from each well test will be assessed with a view to reducing the volumes of hydrocarbons to be flared during well testing for each subsequent production well. • Minimise emissions during well clean-up operations with the use of optimised flare burner technology (i.e., 'green burner') and with continuous monitoring weather conditions. • Regarding flaring operations, to ensure all performance related conditions are monitored, and that adjustments can be made accordingly, a dedicated person will be assigned for full-time fire watch duty. • The drilling rig and other project vessels will be subject to audits ensuring compliance with UK legislation. • Vessel use will be optimised where possible by minimising the number of vessels required, and their length of time on site. • Vessels will be operated where possible in modes that allow for economical fuel use. **Proposed Production Mitigation Measures** In accordance with the revised NSTA strategy, and associated Stewardship Expectation 11, as well as with the industry commitments within the NSTD, NEO Energy will incorporate the following controls: • The plant is designed with the goal of no routine flaring and venting through the provision of existing flare and vent gas recovery systems. • 'Zero routine flaring' and minimised diesel use will be ensured through the installation of a new gas export pipeline.

Aspect	Commitments
	• Visiting shuttle tankers will be equipped with a Vapour Emission Control System (VECS) to eliminate emissions while loading. • Diesel use by the GTGs will be limited to TARs and for instances when fuel gas is unavailable e.g. plant re-start. • An N+1 configuration with 2 off GTGs supplying power for production and utility consumers during normal operation with one GTG as standby minimises spinning reserve of standby power generation. • Reduced NOx emissions will be achieved through DLE technology on the GTGs. The use of DLE technology is considered BAT for offshore GTGs (EU IPPC, 2017). • All three GTGs are equipped with Waste Heat Recovery Units (WHRUs) which will be used to recover heat for the heating medium system, increasing the overall energy efficiency of power generating equipment, which ultimately reduces asset emissions. • NEO Energy will continually monitor and review emissions and carbon intensity of the asset in line with the company's ESG strategy and commitments and in an effort to support the UK's Net Zero target. • An asset GHG Emission Reduction Action Plan will be prepared for first oil. These measures will help to ensure that opportunities for efficiency and reduction of atmospheric emissions, where not in conflict with safe operations, are identified, actioned as appropriate and reviewed.
Discharges to Sea	• Minimise use of vessels, through efficient journey planning; • NEO Energy will review vessel CMID as part of vessel assurance and all vessels will be compliant with the Company's MAS; • All vessels used will be MARPOL compliant; • All contracted vessels will originate from countries adhering to the IMO Convention; • As part of the Company's auditing process, only vessels adhering to the IMO 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Species will be used. • The drilling rig is to be audited under NEO Energy's marine assurance standards and subject to rig recertification audits; • Where technically feasible NEO Energy will prioritise the selection of chemicals which are PLONOR, or have the lowest RQ; and • The discharges of any water based hydraulic fluids, sand or chemicals are regulated by the OPPC and/or OCR regulations and reported through the EEMS. As such, NEO Energy will ensure that sampling, analysis and reporting are undertaken in line with the regulations and permit conditions.
Seabed Disturbance	• Pre-deployment surveys will be undertaken to identify suitable locations for the Western Isles FPSO anchors and drilling rig anchors in the event a semi-submersible drilling rig is utilised; • Pipeline and umbilical route surveys will be undertaken; • NEO will continue to explore the option to lay multiple flowlines in the same trench going between the drill centres and the Western Isles FPSO; • The proposed gas export route will take the most direct/shortest route to the Ettrick PLEM or Tweedsmuir manifold subject to seabed conditions encountered; • The use of mattresses, rock cover and grout bags will be minimised through optimal project design; • Anchors of the drill rig are to be maintained under tension to minimise chain contact on seabed; • Cement volumes required will be planned and optimised; • Use of ROV for visual monitoring and pH monitoring during cementing jobs that allows stopping when cemented is either observed or detected at seabed (minimises excess cement); • Sea dye will be used to indicate when cement is approaching the surface;

Aspect	Commitments
	• The use of dynamically positioned vessels will minimise anchor use; • Use of low toxicity chemicals in WBM; • Use of specialist contractors to minimise dropped objects; and • Lifting plans in place.
Underwater Noise	• A qualified, trained and equipped marine mammal observer (MMO) will be present. The MMO will carry out a pre-piling survey of a 500 m mitigation zone and, if an animal is detected, the piling will be delayed until all marine mammals vacate the 500 m mitigation zone; • A soft-start/ramp-up of hammer energy will be employed where the hammer will commence at a low energy at the start of piling. The soft start will be such that maximum hammer energy will not be reached until after a period of 20 minutes; • PAM will be employed during periods of low visibility to detect marine mammal presence; and • Avoiding commencing piling at night or in poor visibility when marine mammals cannot reliably be detected. If this cannot be avoided, then PAM will be used.
Waste	• NEO Energy will apply the principles of the Waste Management Hierarchy during all activities i.e. Reduce, Reuse, Recycle; • Asset and vessel WMPs will be followed; • Only permitted disposal yards / landfill sites will be used.
Accidental Events	• Activities will be carried out by trained and competent offshore crews and supervisory teams; • An approved OPEP will be in place prior to any activities being undertaken; • Records will be kept of oil spill training and exercises as required by the OPEP; • Process Safety Assurance Processes will be identified and adhered to; • The Western Isles FPSO will be of a double-hull design, meaning oil cargo tanks are not on the outside, thus limiting risk of spill; • The Western Isles FPSO will have a robust maintenance and inspection programme linked into the critical elements and associated verification scheme; • Shipboard Oil Pollution Emergency Plans (SOPEPs) will be in place for project vessels; • A co-ordinated industry oil spill response capability will be available; and • Enhanced sharing of industry best practices via the Oil Spill Response Forum (OSRF) will continue. **Wells specific control measures** • A robust BOP pressure and functional testing regime will be in place and the BOP will have fully redundant control systems; • Appropriate mud weights will be used to allow well control to be maintained; • The drilling rig will be appropriately certified; • The drilling rig shall have an approved safety case with all SECEs verified by an independent verification body and managed through a recognised maintenance management system; • Well construction and operation activities to be conducted with multiple barriers in place; and • Well Control Contingency Plan in place detailing relief well plans and arrangements with internal and external well control specialists. **Operations-specific control measures** • Tanker offloading procedures will be in place; • Shutte tankers will be required to be DP2-classed as a minimum; • Metocean conditions may limit offloading; where production storage limits are reached, production

Aspect	Commitments
	could be curtailed until export can resume. • Import and export facilities will be secured by topside ESDVs; • A mandatory 500 m safety zone will be in place for the Western Isles FPSO and drilling rig; • There will be agreed approach procedures to the Western Isles FPSO by supply and safety vessels, informed by appropriate collision risk assessments; • Operational restrictions will be in place for visiting vessels in bad weather; • Simultaneous operations (SIMOPS) procedures will be in place; • Pipelines will have pressure monitoring and low pressure alarms; and • Oil spill control measures will be followed as outlined in the OPEP.

13.4 Overall Conclusion

NEO Energy on behalf of itself and its Co-Venturer, Jersey Oil & Gas Ltd., is proposing to redevelop the Buchan Horst Field located in UKCS Blocks 20/5 and 21/1 in the CNS, c. 115 km northeast of the Aberdeenshire coastline and c. 103.5 km west of the UK/Norway median line. Note the field was previously known as the Buchan Field and NEO Energy changed the name to the Buchan Horst Field in December 2023 as part of licensing requirements. The hydrocarbon reservoirs at the Buchan Horst Field are well understood (based on the industry's history of drilling and field development in this area of the North Sea) and will be developed using proven technology incorporating current best practices and latest generation equipment. A robust design, effective operating practices and systems implemented by a highly trained workforce will ensure the proposed development does not result in any significant long-term environmental, cumulative or transboundary effects. Additional measures will also be in place during the operating phase to effectively respond to potential emergency scenarios.

The ES assesses the worst case impact of the project on the environment and is therefore very conservative. Even then, applying the mitigations measures identified it is the conclusion of this ES that the proposed Buchan Redevelopment Project can be completed without causing any significant long term environmental impacts or cumulative or transboundary effects.

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Appendix A - Scotland's National Marine Plan

A.1 Scotland's National Marine Plan

Scotland's NMP (Marine Scotland, 2015) covers the management of both Scottish inshore waters (out to 12 nm) and offshore waters (12 to 200 nm). The aim of the NMP is to help ensure the sustainable development of the marine area through informing and guiding regulation, management, use and protection of the NMP areas. The activities associated with the proposed Buchan Redevelopment Project have been assessed against each of the NMP objectives, details of which can found in Table A-1.

Table A-1: The proposed Buchan Redevelopment Project assessed against Scotland's NMP principles.

Scotland's National Marine Plan Principle Number	Applicable?	Assessment Against Principle
GEN 1 General planning principle		
There is a presumption in favour of sustainable development and use of the marine environment when consistent with the policies and objectives of this Plan.	✓	The proposed project and this EIA has been developed with consideration of the policies and objectives within the Scottish National Marine Plan.
GEN 2 Economic benefit		
Sustainable development and use which provides economic benefit to Scottish communities is encouraged when consistent with the objectives and policies of this Plan.	✓	The proposed project will provide jobs and tax revenues to the economy. In addition the project will provide a hub for facilitating future developments in the area.
GEN 3 Social benefit		
Sustainable development and use which provides social benefits is encouraged when consistent with the objectives and policies of this Plan.	✓	The EIA considers impacts to other sea users in decision making e.g. fisheries and pipelines. Lifecycle of the project is assessed for environmental and economic implications.
GEN 4 Co-existence		
Proposals which enable coexistence with other development sectors and activities within the Scottish marine area are encouraged in planning and decision-making processes, when consistent with policies and objectives of this Plan.	✓	The EIA process involved consultation with other sea users (SFF).
GEN 5 Climate change		
Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change.	✓	Fuel use associated with all phases of the project will be minimised. No planned flaring during production phase. Project plans to electrify the installation from 2030.
GEN 6 Historic environment		
Development and use of the marine environment should protect and, where appropriate, enhance heritage assets in a manner proportionate to their significance.	✓	A number of surveys have been carried out and used to support the EIA. EIA takes cognisance of the wrecks in the area.
GEN 7 Landscape/seascape		
Marine planners and decision makers should ensure that development and use of the marine environment take seascape, landscape and visual impacts into account.	×	The proposed project is located *c.* 115 km from the nearest coastline such that this principle is not relevant.
GEN 8 Coastal process and flooding		

Scotland's National Marine Plan Principle Number	Applicable?	Assessment Against Principle
Developments and activities in the marine environment should be resilient to coastal change and flooding, and not have unacceptable adverse impact on coastal processes or contribute to coastal flooding.	×	The proposed project is located *c.* 115 km from the nearest coastline such that this principle is not relevant.
GEN 9 Natural heritage		
Development and use of the marine environment must: a) Comply with legal requirements for protected areas and protected species. b) Not result in significant impact on the national status of Priority Marine Features. c) Protect and, where appropriate, enhance the health of the marine area.	✓	Environmental surveys undertaken in the area. Design and installation method of the subsea infrastructure informed by these surveys.
GEN 10 Invasive non-native species		
Opportunities to reduce the introduction of invasive non-native species to a minimum or proactively improve the practice of existing activity should be taken when decisions are being made.	✓	All vessels will follow IMO regulations. All vessels will be regulatory compliant, e.g. the International Convention for the Control and Management of Ships' Ballast Water and Sediments, and subject to audit prior to contract award.
GEN 11 Marine litter		
Developers, users and those accessing the marine environment must take measures to address marine litter where appropriate. Reduction of litter must be taken into account by decision makers.	✓	Contractor management plans will be in place. All vessels will follow IMO requirements.
GEN 12 Water quality and resource		
Developments and activities should not result in a deterioration of the quality of waters to which the Water Framework Directive, MSFD or other related Directives apply.	✓	Discharges to sea have been identified and assessed. The proposed project will not result in any measurable deterioration of water quality in the area.
GEN 13 Noise		
Development and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects.	✓	Impacts of the noise generated from the piling of subsea infrastructure have been assessed. Results show that with the implementation of JNCCs standard mitigation measures the likelihood of a permanent threshold shift occurring is low for all the marine mammal hearing groups. The appropriate mitigation measures will be adopted in relation to the piling as well as vessel and drill rig noise.
GEN 14 Air quality		
Development and use of the marine environment should not result in the deterioration of air quality and should not breach any statutory air quality limits.	✓	Emissions to air quantified in the EIA. Assessment concludes that they will present a low environmental risk to air quality the duration of which will be minimised as far as possible.
GEN 15 Planning alignment A		
Marine and terrestrial plans should align to support marine and land-based components required by development and seek to facilitate appropriate access to the shore and sea.	×	The proposed project is located *c.* 115 km from the nearest coastline such that this principle is not relevant.
GEN 16 Planning alignment B		
Marine plans should align and comply where possible with other statutory plans and should consider objectives and	×	Applies to inshore waters only.

Scotland's National Marine Plan Principle Number	Applicable?	Assessment Against Principle
policies of relevant non-statutory plans where appropriate to do so.		
GEN 17 Fairness		
All marine interests will be treated with fairness and in a transparent manner when decisions are being made in the marine environment.	×	Competent Authority responsibility.
GEN 18 Engagement		
Early and effective engagement should be undertaken with the general public and all interested stakeholders to facilitate planning and consenting processes.	✓	The EIA is subject to public consultation. A copy of the ES and the public notice has been made publicly available. An informal Scoping Document was issued and engagement meetings were held with SFF, JNCC and OPRED.
GEN 19 Sound evidence		
Decision making in the marine environment will be based on sound scientific and socio–economic evidence.	✓	Environmental baseline prepared with reference to available literature and site-specific survey data.
GEN 20 Adaptive management		
Adaptive management practices should take account of new data and information in decision making, informing future decisions and future iterations of policy.	✓	NEO Energy's decision making takes into account best understanding of the marine environment through surveys and using latest available scientific data.
GEN 21 Cumulative impacts		
Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation.	✓	Cumulative impacts are considered in the EIA and are considered proportionate to the size of the project.

A.2 Marine Strategy Framework Directive (MSFD)

The aim of the European Union's MSFD is to protect more effectively the marine environment across Europe. The MSFD outlines a transparent, legislative framework for an ecosystem-based approach to the management of human activities which supports the sustainable use of marine goods and services. The overarching goal of the Directive is to achieve 'Good Environmental Status' (GES) by 2020 across Europe's marine environment. Note following Brexit, the UK has made amendments to the Marine Strategy Regulations 2010, which transpose the requirements of the EU's Marine Strategy Framework Directive into domestic law, so that they continue to be effective now that the UK is no longer part of the EU.

The MSFD does not state a specific programme of measures that Member States should adopt to achieve GES, except for the establishment of MPAs. The MSFD does, however, outline 11 high level descriptors of GES in Annex I of the Directive. The activities associated with the proposed GBA Project have been assessed against each of the GES descriptors details of which can be found in Table A-2.

Table A-2: The proposed GBA Project assessed against the MSFD GES descriptors.

Marine Strategy Framework Directive: Good Environmental Status Objectives	Applicable?	Assessment Against Objective
GES 1		
Biological diversity is maintained and recovered where appropriate. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.	✓	Linked to GEN 9. Environmental surveys undertaken in the project area. Design and installation method of the subsea infrastructure informed by these surveys.
GES 2		
Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.	✓	Linked to GEN 10. All vessels will follow IMO regulations. All vessels, including drilling rig, will be regulatory compliant, e.g. the International Convention for the Control and Management of Ships' Ballast Water and Sediments, and subject to audit prior to contract award.
GES 3		
Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.	✓	Linked to GEN 9. Environmental surveys undertaken in the project area. Design and installation method of the subsea infrastructure informed by these surveys.
GES 4		
All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.	✓	Linked to GEN 9. Environmental surveys undertaken in the project area. Design and installation method of the subsea infrastructure informed by these surveys.
GES 5		
Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.	✓	Linked to GEN 9. Environmental surveys undertaken in the project area. Design and installation method of the subsea infrastructure informed by these surveys.
GES 6		
Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.	✓	Linked to GEN 9. Environmental surveys undertaken in the project area. Design and installation method of the subsea infrastructure informed by these surveys.
GES 7		
Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.	✓	Linked to GEN 12. Seabed disturbance and potential impact on marine ecosystems assessed in EIA.
GES 8		
Concentrations of contaminants are at a levels not giving rise to pollution effects.	✓	Linked to GEN 12. The proposed project will not result in the noticeable deterioration of water quality in the project vicinity.
GES 9		
Contaminants in fish and other seafood for human consumption do not exceed levels established by	✓	Linked to GEN 12. The proposed project will not result in the

Marine Strategy Framework Directive: Good Environmental Status Objectives	Applicable?	Assessment Against Objective
Community legislation or other relevant standards.		noticeable deterioration of water quality in the project vicinity.
GES 10		
Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	✓	Linked to GEN 11. Contractor management plans will be in place. All vessels will follow IMO requirements.
GES 11		
Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.	✓	Linked to GEN 13. Piling of the FPSO mooring system was identified as a significant source of marine noise, and therefore this was modelled and the severity was assessed. Results show that with the implementation of JNCCs standard mitigation measures the likelihood of a permanent threshold shift occurring is low for all the marine mammal hearing groups. The appropriate mitigation measures will be adopted.

A.3 Oil and Gas Marine Planning Policies

Objectives and policies for the Oil and Gas sector should be read subject to those set out in the NMP and the MSFD. It is recognised that not all of the objectives can necessarily be achieved directly through the marine planning system, but they are considered important context for planning and decision making. The proposed project activities have been assessed against the oil and gas marine planning policies, details of which can be found in Table A-3.

Table A-3: The proposed GBA Project assessed against the Oil and Gas Marine Planning Policies.

Oil and Gas Marine Planning Policies	Applicable?	Assessment Against Policy
Oil & Gas 1		
The Scottish Government will work with BEIS, the new Oil and Gas Authority and the industry to maximise and prolong oil and gas exploration and production whilst ensuring that the level of environmental risks associated with these activities are regulated. Activity should be carried out using the principles of Best Available Technology (BAT) and Best Environmental Practice. Consideration will be given to key environmental risks including the impacts of noise, oil and chemical contamination and habitat change.	✓	NEO Energy have used and will continue to use BAT as a key tool in the design of the proposed project. Environmental risks addressed/assessed where necessary in the EIA.
Oil & Gas 2		

Oil and Gas Marine Planning Policies	Applicable?	Assessment Against Policy
Where re-use of oil and gas infrastructure is not practicable, either as part of oil and gas activity or by other sectors such as carbon capture and storage, decommissioning must take place in line with standard practice, and as allowed by international obligations. Re-use or removal of decommissioned assets from the seabed will be fully supported where practicable and adhering to relevant regulatory process.	✓	At CoP the infrastructure installed as part of the proposed Project will be decommissioned in line with legislation in force at that time. Nearer the time of CoP, a full decommissioning plan will be developed in consultation with the relevant statutory authorities. The plan will be designed to ensure that potential effects on the environment resulting from the decommissioning of the facilities are considered and minimised.
Oil & Gas 3		
Supporting marine and coastal infrastructure for oil and gas developments, including for storage, should utilise the minimum space needed for activity and should take into account environmental and socio-economic constraints.	×	The proposed project is located *c.* 115 km from the nearest coastline such that this principle is not relevant.
Oil & Gas 4		
All oil and gas platforms will be subject to 9 nautical mile consultation zones in line with Civil Aviation Authority guidance.	✓	NEO Energy will engage as necessary with any developments that fall within 9 NM of the proposed project area to ensure all helicopter flight routes remain free of obstacles.
Oil & Gas 5		
Consenting and licensing authorities should have regard to the potential risks, both now and under future climates, to oil and gas operations in Scottish waters, and be satisfied that installations are appropriately sited and designed to take account of current and future conditions.	✓	The Buchan Horst Field will be developed in a way that that there will not be a significant impact on the physical, biological and socio-economic environment. With respect to future climate, the life of field is estimated up to 2050 (based on high case profiles), whilst design considerations have accounted for 100 year extreme weather events. In this context, the development is appropriately designed for the harsh weather conditions of the North Sea.
Oil & Gas 6		
Consenting and licensing authorities should be satisfied that adequate risk reduction measures are in place, and that operators should have sufficient emergency response and contingency strategies in place that are compatible with the National Contingency Plan and the Offshore Safety Directive.	✓	The proposed project has been subject to this EIA process and potential environmental impacts have been assessed and appropriate mitigation measures developed. The NEO Energy response strategy to a unplanned hydrocarbon release will be developed with due reference to the NCP.

Appendix B – Aspects Register

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (U)	Environmental Risk (U)	Notes on Scoring/Actions/ Comments
Node 1: Vessel Use During Drilling, Installation and Pipeline Commissioning										
1-1	**Physical Presence of vessels**	Emergency Response and Rescue Vessel (ERRV), Pipelay vessel, Multi-service Vessel (MSV), Anchor Handling Vessels (AHV), Drilling Support Vessel (DSV) and standby vessels. . Note: Vessel use for start-up and production are covered in Node 5.	Receptor: Other sea users. Navigation hazard, and restriction of fishing operations.	Optimise vessel use. Consultation with SFF for all operations including surveys. Notice to mariners prior to operations starting. A vessel traffic survey/collision risk assessment will be undertaken (as required).	B	2	Low	N/A	N/A	UK fishing industry and vessels in the area have the capacity to absorb change without a significant impact therefore their Sensitivity is considered to be Medium (B). The Magnitude of Effect on fishermen is considered Minor (2) such that the overall Impact Significance is therefore considered Low.
1-2			Receptors: Birds and marine mammals. Possible behavioural changes in marine mammals e.g. could be attracted to the vessels or may move away from the area. The vessels also have the potential to cause displacement of seabirds from foraging habitat and may cause migrating birds to detour from their flight routes.	Optimise vessel use.	B	2	Low	N/A	N/A	Marine mammals sighted in the Project area include harbour porpoise, bottlenose dolphin, white-beaked dolphin, Atlantic white-sided dolphin and minke whale which are all Priority Marine Features (PMFs). Given the presence of these PMFs and the fact that marine mammals are considered European Protected Species (EPS) their Sensitivity is considered to be Medium (B). The North Sea is a busy shipping area and has well developed fishing, oil and gas industries and offshore wind farms, such that marine mammals in the region are habituated to the presence of vessels. In addition, the evidence for lethal injury from boat collisions with marine mammals suggests that collisions with vessels are very rare (Cetacean Stranding Investigation Programme, 2011). The Magnitude of Effect on marine mammals is therefore considered Minor (2) such that the Impact Significance of vessels on marine mammals is considered Low. Some birds from the coastal SPAs (e.g. the Buchan Ness to Collieston Coast SPA) will feed in the Project area such that Sensitivity of birds as a receptor is considered Medium (B). Though evidence suggests that the presence of the vessels could cause some bird species to be displaced from their foraging area, the very small proportion of their overall available habitat that will be occupied by the vessels means the impact is not considered to be noticeable. In addition, given the existing oil and gas vessel activity in the area, it is expected that the impact of the vessels on bird migration routes (e.g. they could be attracted to the vessel lights at night) is not significant. Therefore, the Magnitude of Effect on birds is considered Minor (2) such that the Impact Significance of vessels on birds is considered Low.
1-3	**Emissions to Air from vessels**	Fuel combustion emissions from vessels (CO_2, CO, SOx, NOx, etc.) and helicopter flights for vessel change overs.	Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	Use of low-sulphur fuel. Minimise use of vessels, through efficient journey planning and potential use of hybrid supply vessels. Review vessel Common Marine Inspection Documents (CMID) as part of vessel assurance (evidence of maintenance). Vessels will be MARPOL compliant. Optimise helicopter transfers. *(For note: the International Maritime Organisation (IMO) 2020 regulation limits sulphur in ships' fuel oil to a maximum 0.50%. The regulation has been in force globally since 1 January 2020, under IMO's MARPOL treaty, with benefits for the environment and human health from a reduction in sulphur oxides in the air. In addition, the North Sea is an Emission Control Area such that the sulphur content should be a maximum of 0.1%).*	D	1	Low	N/A	N/A	The assessment methodology does not easily lend itself to assessing climate change, with the Sensitivity of climate change as a receptor being considered Very High (D) in line with 2014 Climate Change Report produced by the Intergovernmental Panel on Climate Change. NEO, acknowledges that the atmospheric emissions associated with the vessels will contribute to climate change, however the Magnitude of Effect of the incremental increase in emissions to the atmosphere from the vessels was considered Negligible (1) such that the overall Impact Significance is considered Low.
1-4			Receptor: Air quality. Possible reduction in local air quality.		A	1	Low	N/A	N/A	As the installation activities will take place offshore the Sensitivity of air quality as a receptor is considered Low (A). The relatively short duration of the vessel campaigns, means the Magnitude Effect of the vessel emissions on air quality is considered Negligible (1) such that the overall Impact Significance is considered Low.
1-5	**Discharges to Sea**	Vessel sewage/ food waste, ballast water and biofouling.	Receptor: Water quality. Water quality in immediate vicinity of discharge may be reduced (deoxygenation), but effects are usually minimised by rapid dilution in receiving body of water and non-continuous discharge.	Minimise use of vessels, through efficient journey planning. NEO Energy will review vessel CMID as part of vessel assurance and all vessels will be compliant with the Company's MAS. Vessels will be MARPOL compliant. All contracted vessels will originate from countries adhering to the IMO Convention. NEO's audit procedures will ensure that the contracted vessels ballasting procedures are in line with IMO Convention aimed at preventing associated harmful effects. All discharges of ballast water will be monitored, and records maintained. As part of the Company's auditing process, only vessels adhering to the IMO 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Species will be used. All member states of IMO are signed up to these guidelines.	A	1	Low	N/A	N/A	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). As all vessels will be IMO and MARPOL compliant the Magnitude of Impact of any discharges is considered Negligible (1) such that the overall Impact Significance is considered Low.
1-6	**Seabed Disturbance**	Interaction of vessels with the seabed.	Receptors: Benthic flora and fauna	All vessels used will maintain their position using dynamic positioning.	C	1	Low	N/A	N/A	Sensitivity is ranked High (C) due to the presence of the OSPAR threatened and/or declining 'Sea pen and burrowing megafauna communities' habitat (also a Scottish Priority marine Feature (PMF), listed as 'Burrowed Mud'). Given the depth of water the vessels will operate at there is not expected to be any impact from vessel propellers, therefore the Magnitude of Effect is considered Negligible (1) such that the Impact Significance is considered Low.

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (L)	Environmental Risk (L)	Notes on Scoring/Actions/ Comments
1-7	**Underwater Noise**	General vessel noise including dynamic positioning.	Receptors: Marine mammals and fish. Noise from dynamic positioning has the potential to cause disturbance to marine mammals and fish in the form of temporary displacement from the area.	Minimise use of vessels, through efficient journey planning and potential use of hybrid supply vessels.	B	1	Low	N/A	N/A	As described above (Row 1-2), a number of marine mammals are know to occur in the area (considered to be EPS and PMFs) such that their Sensitivity is considered to be Medium (B). Similarly some of the fish species in the Project area are considered to be PMFs (e.g. anglerfish, herring, mackerel, ling, blue whiting, cod, sandeels and spurdog) such that their Sensitivity as a receptor is also considered Medium (B). The North Sea is a busy shipping area and has well developed fishing and oil and gas industries, such that marine mammals and fish in the region are habituated to the presence of vessels. Any impacts from vessel noise on these receptors is expected to be behavioural rather than physical, such that they may cause marine mammals or fish to vacate the area, however they would be expected to return once the vessels have left the location. The Magnitude of Effect of underwater noise, from vessels, on marine mammals and fish is therefore considered to be Negligible (1) such that the Impact Significance is considered Low.
1-8	**Waste**	General operational waste.	Receptor: Landfill take. Waste to landfill.	Compliance with MARPOL requirements. NEO Energy will look to vessel owner to minimise all wastes during the project (monthly reporting of waste sent to shore; Waste Management Plan and Waste Record Book; Waste Management Duty of Care audit). Waste minimisation and supply chain management. Waste will be managed in line with the waste hierarchy.	A	1	Low	N/A	N/A	Sensitivity of landfill as a receptor is considered Low (A) as landfill options are considered abundant. MARPOL Annex V applies to all ships/vessels and generally prohibits the discharge of all garbage into the sea (there are some exceptions which relate for example to food waste and cleaning agents). As vessels will be compliant with MARPOL, there will be no significant impact offshore. NEO Energy recognise landfill sites as a finite resource, however as the vessels will have WMPs in place that will adhere to the waste hierarchy principle of reduce, reuse recycle, the Magnitude of Effect is considered to be Negligible (1) and the Impact Significance is considered Low.
1-9	**Use of Resources**	Fuel for power generation.	Receptor: Resource use Energy use.	MARPOL compliant. NEO Energy will review vessel CMID as part of vessel assurance (evidence of maintenance). Optimise vessel use. NEO Energy have a Marine Specialist in house who is tasked with ensuring vessels meet required standards.	A	1	Low	N/A	N/A	Sensitivity of fuel availability as a receptor is considered Low (A). NEO recognise that hydrocarbon-based fuel is a finite resource, however given the relatively short duration of the proposed vessel activities and the use of MARPOL compliant vessels the Magnitude of Effect of fuel use is considered Negligible (1) such that the Impact Significance is considered Low.
1-10	**Unplanned Events**	Helicopter crash. Loss of helifuel to sea.	Receptor: Water quality, and marine flora and fauna. Water quality deterioration impacting on marine flora and flora.	Auditing of company to ensure helicopter maintenance etc.	B	2	Low	Remote	Low	In the event of a helicopter crash it is expected that any released helifuel would evaporate quickly and would not come into contact with the seabed. Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A), however considering the receptors present including marine mammals (considered to be EPS and PMFs) receptor Sensitivity is considered to be Medium (B). Total quantities of helifuel will be relatively small (*c*. 1,120 litres - Bristow Sikorsky S76D) and given the high evaporation rate and offshore location, it is expected that any impacts would be Minor (2) such that the Impact Significance is Low. With the application of standard industry mitigation the Likelihood of a helicopter crash occurring is considered Remote and therefore the Environmental Risk is considered to be Low.
1-11		Minor chemical / hydrocarbon spill from vessels.	Receptor: Water quality. Water quality deterioration.	Ship Oil Pollution Emergency Plans (SOPEPs) in place. Optimised quantities of chemicals procured & stored on board. COSHH, Task Hazard Assessments are completed and Material Safety Data Sheets (MSDS) are available. Design features including drip pans, bunded areas, process and hazardous drains. Procedures in place for secondary containment should bunding fail. Spill kits located in close proximity to chemical storage areas. Best practise bunkering procedures. NEO Energy auditing vessels to ensure all above are in place.	A	2	Low	Unlikely	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Any impact on water quality from a spill is considered to be localised and have a short term, reversible effect therefore the Magnitude of Effect of a minor spill is considered Minor (2). With the application of standard industry mitigation the likelihood of a spill occurring is considered Unlikely therefore the Environmental Risk is considered Low.
1-12		Major hydrocarbon/ chemical spillage (i.e. vessel collision and loss of containment).	Receptor: Water quality and marine flora and fauna. Water quality deterioration, impact on marine flora and fauna. Immediate oxygen demand on receiving water with consequential impacts on marine fauna.	Emergency response plans in place including vessel SOPEPs. Experienced staff on board (e.g. experienced ship captain therefore reducing likelihood of human error resulting in collisions)	C	3	Moderate	Remote	Low	It is expected that in event of a collision much of the lost inventory would evaporate, however the ENVID conservatively assumes some may come into contact with the seabed. Sensitivity is therefore, ranked High (C) due to the presence of 'Sea pen and burrowing megafauna communities' habitat. The vessel fuel inventories are less than the drilling rig diesel inventory, given the high evaporation rate and offshore location no beaching is likely such that the Magnitude of Effect is considered Serious (3). The Impact Significance is therefore considered Moderate. With the application of standard industry mitigation the Likelihood of a collision occurring that would result in a full loss of vessel inventory is considered Remote therefore the Environmental Risk is considered to be Low.

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (U)	Environmental Risk (U)	Notes on Scoring/Actions/ Comments
Node 2: Drilling Operations										
2-1	**Physical Presence of drilling rig (either HDJU or a semi-submersible)**	Physical presence of drilling rig (semi-submersible or HDJU)	Receptor: Other sea users. Navigation hazard, and restriction of fishing operations.	NEO Energy will submit required notifications to the Hydrographic Office, Kingfisher and Ministry of Defence (MoD) such that all other users of the area will be notified. Drilling rig will have marking and lighting as per the Standard Marking Schedule for Offshore Installations. Notice will be sent to the Northern Lighthouse Board of any drilling rig moves and vessel mobilisation associated with the mobilisation and demobilisation of the rig. Drilling rig will have a 500 m exclusion zone. If anchors for a semi-submersible drilling rig are pre-laid before rig comes on site, a guard vessel will be present.	B	2	Low	N/A	N/A	UK fishing industry and vessels in the area are expected to have the capacity to absorb change without noticeable impact therefore their Sensitivity is considered to be Medium (B). The drilling rig will operate within a 500 m exclusion zone. Any impacts on other sea users are considered Minor (2) and the Impact Significance is considered Low. It is recognised that depending on the weather conditions, if using a HDJU there is the potential that a temporary rig set down location may be used, however this would be for a limited period of time and therefore is not expected to significantly affect fishing in the area. This will be dependant on weather.
2-2			Receptors: Birds and marine mammals. Possible behavioural changes in marine mammals e.g. could be attracted to the drilling rig or may move away from the area. The drilling rig also have the potential to cause displacement of seabirds from foraging habitat and may cause flying birds to detour from their flight routes.	Lighting will be minimised as far as practicable.	B	1	Low	N/A	N/A	As described above (Row 1-2), a number of marine mammals (classified as EPS and PMFs) are know to occur in the area, such that their Sensitivity is considered to be Medium (B). The Magnitude of Effect on marine mammals of the presence of the drilling rig at the offshore location is considered to be Negligible (1) given that marine mammal in the North Sea are habituated to the presence of vessels and offshore oil and gas structures such that the Impact Significance is considered Low. As described above (Row 1-2), birds from the coastal SPAs feed in the project area such that the Sensitivity of birds as a receptor is considered to be Medium (B). The presence of the drilling rig could cause some bird species to be displaced from their foraging area, however this would represent a very small proportion of their overall available habitat such that the Magnitude of Effect on birds is Low (1) and the Impact Significance of the presence of the drilling rig on birds is considered Low.
2-3	**Emissions to Air**	Exhaust emissions from drilling operations (i.e. burning of diesel).	Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	A rig Health, Safety and Environment Management System audit will be carried out as part of awarding contract (including planned maintenance system implementation).	D	1	Low	N/A	N/A	As described above (Row 1-3) the Sensitivity of climate change as a receptor is considered Very High (D). NEO, acknowledges that the atmospheric emissions associated with the use of the drilling rig will contribute to climate change, however the relatively short duration of the drilling campaign, means the Magnitude of Effect of the incremental increase in emissions to the atmosphere as a result of the drilling activities is considered Negligible (1) such that the overall Impact Significance is considered Low.
2-4			Receptor: Air quality. Possible reduction in local air quality.		A	2	Low	N/A	N/A	As described above (Row 1-4) the Sensitivity of air quality as a receptor is considered Low (A). The relatively short duration of the drilling campaigns, means the Magnitude of Effect of the rig emissions on air quality is considered Minor (2) such that the overall Impact Significance is considered Low.
2-5		Flaring resulting in release of CH_4, CO_2, SOx, NOx, VOC, NOx and particulates.	Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	Green burners. No extended well tests. UK Air Quality Standards not exceeded. Flaring during daylight hours only. Only clean-up flaring for the five production wells. Not required for the two injection wells.	D	1	Low	N/A	N/A	As described above (Row 1-3) the Sensitivity of climate change as a receptor is considered Very High (D). NEO, acknowledges that the atmospheric emissions associated with flaring will contribute to climate change, however the relatively short duration of the flaring activities (no extended well tests) means the Magnitude of Effect of the incremental increase in emissions to the atmosphere as a result of the flaring activities is considered Negligible (1) such that the overall Impact Significance on climate change is considered Low.
2-6			Receptor: Air quality. Possible reduction in local air quality.		A	1	Low	N/A	N/A	As described above (Row 1-4) the Sensitivity of air quality at the offshore location is considered Low (A). The relatively short duration of the flaring activities, means the Magnitude of Effect of the flaring emissions on air quality is considered Negligible (1) such that the overall Impact Significance is considered Low.
2-7	**Discharges to Sea**	Deliberate discharge to sea from drilling operations. Sea water and bentonite sweeps/WBM contaminated cuttings, brine, cement, cementing chemicals and clean-up chemicals all required in the drilling process. LTOBM contaminated cuttings to be thermally processed on board and discharged to water column.	Receptor: Seabed habitats	Chemical selection process will aim to select the lowest toxicity chemicals for a given technical requirement. Cement use and discharge will be minimised by good operating practice. Where possible well sections will be batch drilled.	C	2	Moderate	N/A	N/A	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that these and other filter feeders could be impacted by the different discharges. Therefore, receptor Sensitivity is considered High (C). Given the proposed mitigation measures the Magnitude of Effect is considered Minor (2) such that the Impact Significance is considered Moderate.
2-8			Receptor: Water quality		A	1	Low	N/A	N/A	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A), The Magnitude of Effect on water quality of drilling related discharges is considered to be Negligible (1) given that the discharges will be rapidly dispersed by currents. The Impact Significance is therefore considered Low.
2-9			Receptor: Marine fauna. Impact on species occurring in the water column.		B	1	Low	N/A	N/A	As described above (Row 1-2), a number of marine mammals (classified as EPS and PMFs) are know to occur in the area, such that their Sensitivity is considered to be Medium (B). The Magnitude of Effect on marine mammals of drilling related discharges is considered to be Negligible (1) given that the discharges will be rapidly dispersed by currents. Any effects are unlikely to be measurable and will reverse naturally such that the Impact Significance is considered Low.

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (U)	Environmental Risk (U)	Notes on Scoring/Actions/ Comments
2-10	**Discharges to Sea continued**	Discharge of water-based hydraulic fluid from the blowout preventer.	Receptor: Benthic flora and fauna, only of concern in event that a semi-submersible drilling rig is used as the BOP would be on seabed. For the HDJU the BOP is on the rig.	Hydraulic fluids are water-based.	C	1	Low	N/A	N/A	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that these and other filter feeders could be impacted by the discharge of the hydraulic fluids. Receptor Sensitivity is therefore considered High (C), however given the relatively minimal volumes and the fact that the fluids are water based, the Magnitude of Impact is considered Negligible (1) such that the Impact Significance is considered Low.
2-11		Domestic sewage from rig.	Receptor: Water quality. Water quality deterioration.	The drilling rig will be MARPOL compliant.	A	1	Low	N/A	N/A	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). As all vessels will be IMO and MARPOL compliant the Magnitude of Impact of any discharges is considered Negligible (1) such that the overall Impact Significance is considered Low.
2-12		Food waste.			A	1	Low	N/A	N/A	
2-13		Discharge of hydrocarbons/ chemicals to sea e.g. from machinery space drainage.		Adherence to OPPC Regulations.	A	2	Low	N/A	N/A	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Discharges will be in line with permitted limits and regulated and therefore the Magnitude of Effect is considered Minor (2) and the Impact Significance of the discharge of hydrocarbons/ chemicals on water quality is considered Low.
2-14	**Seabed Disturbance**	Impacts associated with the discharged cuttings have been assessed in Discharges to Sea.								
2-15		Impacts of HDJU rig spud cans on the seabed (3 set downs - worst case)	Receptor: Benthic flora and fauna. Seabed disturbance in a small area due to spud cans resulting in potential impact to benthic flora and fauna.	Pre-rig site survey/deep geotechnical surveys aimed to maximise the safe installation of HDJU and minimise potential for repositioning.	C	1	Low	N/A	N/A	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). For a HDJU rig, the Magnitude of Effect on benthic fauna and flora of the spud cans is considered to be Negligible (1) given the relatively small footprint, the fact that this habitat is not unique to this area of the North Sea and the fact that it is expected that recolonisation of the area will occur once the rig departs. The Impact Significance of a HDJU on the seabed is therefore considered Low. It is recognised that the area impacted by the anchors and anchor lines used for a semi-submersible drilling rig would be greater than the area impacted by the spudcans associated with a HDJU, such that the Magnitude if Effect is considered higher. Therefore if a semi-submersible drilling rig is used the impact of the anchors and anchor lines on the sea bed is considered Minor (2) such that the Impact Significance is considered Moderate.
2-16		Impacts of semi submersible anchors and associated anchor chains on the seabed.	Receptor: Benthic flora and fauna. Seabed disturbance due to anchors and anchor lines resulting in potential impact to benthic flora and fauna.	Pre-anchor lay survey to ensure safe deployment of anchors and minimise potential for repositioning.	C	2	Moderate	N/A	N/A	
2-17		Cement plateau on seabed as result of cementing the top holes sections.	Receptor: Marine flora and fauna. Disturbance to seabed impacting on benthic species.	Visual monitoring of cement operations. Use of pH meters carried by ROV to detect when cement discharged at seabed (minimises excess cement).	C	1	Low	N/A	N/A	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). The Magnitude of Effect on benthic fauna and flora of the cement discharged at the seabed is considered to be Negligible (1) given the small footprint and the fact that this habitat is not unique to this area of the North Sea such that the Impact Significance is considered Low.
2-18	**Noise**	Noise and vibration from HDJU/semi-submersible rig engines and machinery.	Receptor: Fish and marine mammals. Generates elevated sound levels which can affect the behaviour of fish and marine mammals in the area.	Minimise rig movements.	B	1	Low	N/A	N/A	As described above (Row 1-2), a number of marine mammals (classified as EPS and PMFs) are know to occur in the area, such that their Sensitivity is considered to be Medium (B). The North Sea is a busy shipping area and has well developed fishing and oil and gas industries, such that marine mammals and fish in the region are habituated to the presence of noise. Any impacts from drilling related noise on these receptors is expected to be behavioural rather than physical, such that they may cause marine mammals or fish to vacate the area, however they would be expected to return once the rig has left the field. The Magnitude of Effect of underwater noise on marine mammals and fish is therefore considered to be Negligible (1) such that the Impact Significance is considered Low.
2-19	**Waste**	General rig waste. Drilling rigs generate a number of wastes during routine operations including waste oil, chemical and oil contaminated water, scrap metal, etc.	Receptor: Use of landfill. Land take from use of landfill.	Wastes will be minimised by use of appropriate procurement controls. All wastes to be properly segregated for recycling / disposal / treatment. Waste will be dealt with in accordance with regulatory requirements. Monthly reporting of waste sent to shore; Waste Management Plan and Waste Record Book; Waste management Duty of Care audit. Targets and KPIs. Adhere to waste hierarchy. NEO Energy auditing contractors to ensure all of the above.	A	1	Low	N/A	N/A	Sensitivity of landfill as a receptor is considered Low (A) as landfill options are considered abundant. NEO Energy recognise landfill sites as a finite resource, however as the rig will have a WMP in place that will adhere to the waste hierarchy principle of reduce, reuse recycle, the Magnitude of Effect is considered to be Negligible (1) and the Impact Significance is considered Low.
2-20	**Use of Resources**	Fuel used for power generation.	Receptor: Resource use. Energy use.	Use of jack-up rig results in decreased diesel use compared with semi-submersible. Rig Health, Safety & Environmental Management System audit.	A	1	Low	N/A	N/A	Sensitivity of fuel availability as a receptor is considered Low (A) as it is abundant. NEO Energy recognise that hydrocarbon-based fuel is a finite resource, however given the relatively short duration of the proposed drilling activities the Magnitude of Effect of fuel use is considered Negligible (1) such that the Impact Significance is considered Low.
2-21		Utilities.	Receptor: Resource use. Use of freshwater - potable supply.	No mitigation measures identified.	A	1	Low	N/A	N/A	Sensitivity of the use of freshwater, materials and chemicals as a receptor is considered Low (A) as all are considered abundant. Given the abundance of these resources the Magnitude of Effect of freshwater, materials and chemicals use is considered Negligible (1) such that the Impact Significance of resource use during drilling is considered Low.
2-22		Materials for well construction.	Receptor: Resource use. Use of materials such as steel.	Well design optimisation.	A	1	Low	N/A	N/A	

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (U)	Environmental Risk (U)	Notes on Scoring/Actions/ Comments
2-23	**Use of Resources continued**	Drilling mud components and chemicals.	Receptor: Resource use. Use of chemicals.	Materials selection. Chemical use minimised where possible. WBM will be recycled and reused during drilling operations.	A	1	Low	N/A	N/A	
2-24		Well clean-up.	Receptor: Resource use. Use of brine and other chemicals/ hydrocarbons.		A	1	Low	N/A	N/A	
2-25	**Unplanned Events**	Flare dropout. During clean-up operations and well testing there is the potential for flare drop-out (unburned hydrocarbons) to fall on to the sea surface and form an oily slick.	Receptor: Water quality deterioration.	Use of high efficiency burners. Continuous monitoring for the detection of any sheen. Start-up of flare during daylight hours only.	B	1	Low	Possible	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). The Magnitude of Effect on water quality of small discharges from flare drop-out is considered to be Negligible (1) such that the Impact Significance is considered Low. The likelihood of a flare dropout water occurring is considered Possible and the Environmental Risk is considered to be Low.
2-26		Deck drains. Discharge of hazardous drainage water.		Spill kit availability. Drilling rig audits Bunding and containment for chemical storage.	B	1	Low	Unlikely	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). The Magnitude of Effect on water quality of small drain discharges is considered to be Negligible (1) such that the Impact Significance is considered Low. The likelihood of discharge of hazardous drainage water occurring is considered Unlikely and the Environmental Risk is considered to be Low.
2-27		Release of LTOBM/WBM, hydrocarbons/ chemicals to sea.	Receptor: Water quality deterioration, potentially impacting on marine flora and flora Fish and marine mammals.	Maintenance and work procedures in place. Approved OPEP. A rig Health, Safety and Environment Management System audit will ensure contractor has procedure in place to deal with a spill. For local response, dispersant available on board standby vessel. Good hose management. Spill kit availability, drill rig audits, bunding. Bunkering procedures developed in line with Best Practice Guidance. Continuous monitoring during bunkering.	A	2	Low	Unlikely	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Note, it is not expected that in this instance any accidentally released volumes would noticeably impact on the flora and fauna in the area given the expected rapid dilution rates. The Magnitude of Effect water quality of an unplanned release during bunkering is considered to be Minor (2) given that the spill would be rapidly diluted, any effects are unlikely to be measurable and will reverse naturally such that the Impact Significance is considered Low. With the application of standard industry mitigation the likelihood of an unplanned release during bunkering is considered Unlikely therefore the Environmental Risk is considered to be Low.
2-28		Major loss of drilling rig fuel inventory. Hydrocarbon release to sea.	Receptor: Water quality	Exclusion zone in place. Standby vessels in site. HDJU/semi-submersible rig will have marking and lighting as per the Standard Marking Schedule for Offshore Installations. Notice will be sent to the Northern Lighthouse Board of any drilling rig moves and vessel mobilisation associated with the mobilisation and demobilisation of the HDJU/semi-submersible.	A	3	Moderate	Remote	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A).Due to high levels of evaporation and the distance from shore a diesel spill is not likely to beach, however a loss in inventory will result in a breach of regulatory compliance and localised changes to water quality are possible therefore the Magnitude of Effect is considered Serious (3). With the application of standard industry mitigation the likelihood of a spill occurring is considered Remote such that the Environmental Risk to the water column is considered Low.
2-29		Major loss of drilling rig fuel inventory. Hydrocarbon release to sea.	Receptor: Flora and fauna e.g. fish, marine mammals and birds.	Exclusion zone in place. Standby vessels in site. HDJU/semi-submersible rig will have marking and lighting as per the Standard Marking Schedule for Offshore Installations. Notice will be sent to the Northern Lighthouse Board of any drilling rig moves and vessel mobilisation associated with the mobilisation and demobilisation of the HDJU/semi-submersible.	B	3	Moderate	Remote	Low	As the quantities of diesel released could result in an offshore sheen, it is possible that birds associated with the east of Scotland coastal SPAs (e.g. the Buchan Ness to Collieston Coast SPA) could be impacted such that receptor Sensitivity is considered Medium (B). Due to high levels of evaporation and the distance from shore a diesel spill is not likely to beach, such that the Magnitude of Effect on birds is not expected to be greater than 3 (Serious). With the application of standard industry mitigation the likelihood of a spill occurring is considered Remote such that the environmental risk is considered Moderate.

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (U)	Environmental Risk (U)	Notes on Scoring/Actions/ Comments
2-30	**Unplanned Events continued**	Blowout. Uncontrolled hydrocarbon flow to surface.	Receptors: Water quality deterioration, Sediment quality deterioration, potentially impacting on plankton, benthic fauna and flora, fish, marine mammals and coastal protected sites and fisheries and aquaculture.	Well design & planning. Drill contractor/ NEO Energy procedures. Well examination schemes. Compliance with Regulations & Best Practice. Regular BOP testing. Rig designed to be in accordance with IP17 Planning relief well. Crew competence. Audit of drilling contractor. Approved OPEP in place. Containment and drainage facilities inspected as part of rig Health, Safety and Environment Management System audit. Member of OSRL and OPOL. Access to capping device (Wild Well Control) Access to dispersant via the Emergency Response and Rescue Vessel (ERRV).	C	5	High	Remote	Medium	Some of the species and bethic habitats present (for example *A. islandica*) are recognised to be of conservation significance and/or have OSPAR designations, such that their sensitivity is considered to be High (C). Modelling results from a well blowout predicted that no areas of sediment would exceed the 5 g/m^2 hydrocarbon threshold. The magnitude is classed as Minor (2) (no breaches of regulatory compliance and no transboundary impacts) such that the Impact Significance of a blowout on bentic species is considered Moderate. Similarly some of the fish species in the Project area are considered to be PMFs (e.g. anglerfish, herring, mackerel, ling, blue whiting, cod, sandeels and spurdog) such that their Sensitivity as a receptor is also considered Medium (B). The impact of a blowout on fish is likely to extend beyond the project area (possibility of transboundary effects) and could cause long term degradation to fish species. Therefore, the Magnitude of Effect on fish is considered Major (4) such that the Impact Significance of a blowout on fish is considered Moderate. Birds of conservation importance from the coastal SPAs (e.g. the Buchan Ness to Collieston Coast SPA) will disperse into the project area following the breeding season and will feed in the Project area such that Sensitivity of birds as a receptor is considered High (C). Oil spill modelling indicates there is a low to moderate probability of oil reaching the coast in areas that are internationally or nationally designated for seabirds. Shoreline oil concentrations would exceed the threshold of 100 g/m^2 (0.1 kg/m^2) above which impacts are considered potentially significant over 650 km length of coastline.This would cause persistent severe environmental damage and is likely to have a major impact on the conservation objectives of the coastal SPAs. Therefore, the Magnitude of Effect on birds is considered Critical (5) such that the Impact Significance of a blowout on birds is considered High. With the application of standard industry mitigation the likelihood of a blowout occurring is considered Remote therefore the environmental risk is considered to be Medium.
2-31		In the event that a semi-submersible drilling rig is used the accidental release of the BOP from the wellhead (e.g. due to vessel collision) could result in the release of LTOBM to the seabed and surrounding area. Release volume equates to the volume of riser.	Receptors: Benthic flora and fauna	Emergency response plans in place including OPEP. 500 m exclusion zone around the drilling rig. Management systems, well control procedures. Interlock equipment to avoid accidental release. Trained and certified personnel.	C	2	Moderate	Remote	Low	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). Magnitude of Impact is considered Minor (2) such that the Impact Significance is considered Moderate. Likelihood of a BOP becoming released from a wellhead is considered Remote, and when considered with the Impact Significance, the Environmental Risk is considered Low.
2-32		Dropped object resulting in interaction with seabed.	Receptor: marine flora and fauna. Disturbance to seabed impacting on benthic species.	Risk assessment prior to equipment transfer. Safe handling zones identified. Double securing of heavy lift items. Adhere to LOLER (Lifting Operations and lifting equipment regulations).	C	1	Low	Possible	Low	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). The Magnitude of Impact of a dropped object is considered Negligible (1) given the relatively small size of any of the objects that could be dropped. The Impact Significance is therefore considered Low. Likelihood of an object being dropped during drilling activities is considered Possible, such that the Impact Significance, the Environmental Risk is considered Low.
Node 3: Subsea Installation Activities										
3-1	**Physical Presence of Subsea Infrastructure**	Presence of installation vessels is covered under Node 1 Vessel Use.								
3-2		Physical presence of subsea infrastructure and the five risers in the water column.	Receptor: Fisheries. Navigation hazard, restriction of fishing operations, snagging risk to fishing nets.	Early consultation with Scottish Fishermen's Federation (SFF). Confirmation of safe seabed for fishing trawlability. Minimisation of footprint through design. Will comply with PWA notification requirements. Pipeline routes added to admiralty charts, Kingfisher database, etc. Consent to Locate will be submitted. Pipelines and umbilical will be trenched and mechanically buried. Burial of pipelines carried out in line with the commitments made in the Risk-Based Inspection (RBI) program. 500 m zone around drill site and a second around FPSO. Risers will be located within the 500 m zone and therefore will not	B	2	Low	N/A	N/A	Landings and fishing effort data suggests that the proposed project occurs in an area that is relatively important to the UK fishing industry, however the UK fishing industry and vessels in the area have the capacity to absorb change without noticeable impact therefore their Sensitivity is considered to be Medium (B). The long-term permanent presence of the new infrastructure outwith the drill centre and FPSO 500 m safety zones may cause a nuisance to commercial fisheries if become unburied, though this is not expected in this area of the North Sea. Access to fishing grounds will be temporarily inhibited from the installation activities but this will be short term, the Magnitude of Effect on fisheries is considered therefore Minor (2) such that the overall Impact Significance is considered Low.

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (U)	Environmental Risk (U)	Notes on Scoring/Actions/ Comments
3-3	**Physical Presence of Subsea Infrastructure continued**		Receptor: Marine flora and fauna. Impacts following installation. Impact associated with installation activities are covered in rows 3-9 and 3-10 below.	come into contact with fishing gear.	C	1	Low	N/A	N/A	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). Following installation, the Magnitude of Effect on benthic species from installation activities is considered to be Negligible (1) given that the habitats are not unique to the North Sea and recolonisation of the area will occur once the pipelines and umbilicals are buried and therefore the Impact Significance is considered Low.
3-5	**Emissions to Air**	Atmospheric emissions associated with the subsea infrastructure installation vessels including helicopters are covered under Node 1 Vessel Use.								
3-6	**Discharges to Sea**	Discharges to sea associated with the subsea infrastructure installation vessels are covered under Node 1 Vessel Use.								
3-7		Leak testing. Potential discharge of chemicals during leak testing of pipelines and umbilical.	Receptor: Water quality. Water quality deterioration.	Chemical selection process will aim to select the lowest toxicity chemicals for a given technical requirement. Discharge of fluids, will follow procedures which will minimise environmental impact. All hydraulic fluids will be water-based.	A	1	Low	N/A	N/A	Pipelines will be filled with water treated with biocide and oxygen scavenger so there is the potential for chemical discharge during leak/ barrier testing. Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Chemicals will be PLONOR where possible and disperse rapidly due to currents, the Magnitude of Impact of any discharges is therefore considered Negligible (1) such that the overall Impact Significance is considered Low.
3-8		Subsea Isolation Valve (within the riser base structure) operation and maintenance. Release of chemicals and hydraulic fluid during valve operation and maintenance.			A	1	Low	N/A	N/A	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Chemicals will be PLONOR where possible and hydraulic fluids will. be water based. Chemicals and hydraulic fluids will disperse rapidly due to currents. The Magnitude of Impact of any discharges is therefore considered Negligible (1) such that the overall Impact Significance is considered Low.
3-9	**Seabed Disturbance**	Installation of pipelines and umbilical. This will include *c.* 2 km lines (2 x production, 1 x gas lift, 1 x water injection and one umbilical) between the two drill centres and the FPSO and potentially a *c* . 41 km gas export pipeline to the Ettrick PLEM.	Receptor: Marine flora and fauna. Seabed disturbance, temporary suspended solids, impact on benthic organisms.	Pipeline and umbilical route surveys. Minimising pipeline route length. All of these lines will be trenched and buried. The Project Team will continue to explore the option to lay multiple lines in the same trench going between the drill centre and the FPSO.	C	3	Moderate	N/A	N/A	Pipeline and umbilical will be trenched and mechanically buried. Trenches will be *c* . 1.2 m deep. Trench will be cut using a towed plough and mechanically backfilled using a separate towed backfill plough. Seabed will recover naturally once activities are finished. As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). The Magnitude of Effect on benthic flora and fauna from the trenching and burying activities is considered to be Serious (3) given the combined length of the lines, such that the Impact Significance is considered Moderate.
3-10		Installation of riser base structures, mid-water arch (MWA), two drill centre manifolds, surface laid spools and jumpers, mattresses and grout bags within the drilling and FPSO 500 m safety zones.	Receptor: Marine flora and fauna. Seabed disturbance, loss of habitat, temporary suspended solids, loss of benthic organisms.	Lifting procedures in place. Optimising quantity of mattresses and group bags.	C	2	Moderate	N/A	N/A	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). Umbilicals, spools, mattresses and grout bags will all be surface laid within the 500 m safety zones as will the structures listed. Area of impact is not considered significant such that Magnitude of Effect is considered Minor (2) and the Impact Significance is Moderate.
3-11		Contingency rock may be added to pipeline / umbilicals routes if targeted depth of burial is not achieved.	Receptor: Marine flora and fauna. Seabed disturbance, loss of habitat, temporary suspended solids, loss of benthic organisms.	Pre lay surveys Preference given to trench and bury over use of rock cover.	C	3	Moderate	N/A	N/A	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). Assessment assumes worst case whereby 25 % of the gas export pipeline will require rock cover and the full length of the infield lines requiring rock cover. Given the relatively sandy habitat, the Magnitude of Effect of the addition of rock cover is considered to be Serious (3) and the Impact Significance is Moderate.
3-12	**Underwater Noise**	Noise associated with topside installation vessels is covered under Node 1 Vessel Use.								
3-13	**Underwater Noise**	Piling Potential for Ettrick PLEM and mid-water arch base to be gravity based while the drilling manifold and riser base structure will be piled. Note potential piling of FPSO anchors is captured in Node 4.	Receptors: Marine mammals and fish. Noise from DP has the potential to cause disturbance to marine mammals and fish in the form of temporary displacement from the area.	Adherence to JNCC guidance. Modelling of underwater noise from piling will be used to confirm that JNCC guidance is adhered to.	B	2	Low	N/A	N/A	As described above (Row 1-2), a number of marine mammals (classified as EPS and PMFs) are know to occur in the area, such that their Sensitivity is considered to be Medium (B). Similarly some of the fish species in the Project area are considered to be PMFs (e.g. anglerfish, herring, mackerel, ling, blue whiting, cod, sandeels and spurdog) such that their Sensitivity as a receptor is also considered Medium (B). Given adherence to JNCC guidance the Magnitude of Effect is considered Minor (2) such that the Impact Significance is Low.
3-14	**Waste**	General vessel waste is covered under Node 1 Vessel Use.								

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (U)	Environmental Risk (U)	Notes on Scoring/Actions/ Comments
3-15	**Waste continued**	General waste from pipelay and installation of infrastructure. Pipelay and installation generate a number of wastes during routine operations including scrap metal, wooden crates etc.	Receptor: Use of landfill. Land take from use of landfill.	All wastes to be properly segregated for recycling / disposal onshore. Waste will be dealt with in accordance with regulatory requirements. Contractors will be audited to ensure above.	A	1	Low	N/A	N/A	Sensitivity of landfill as a receptor is considered Low (A) as landfill options are considered abundant. NEO Energy recognise landfill sites as a finite resource, however the majority of waste will be recycled and the installation vessels will have a WMP in place that will adhere to the waste hierarchy principle of reduce, reuse recycle. The Magnitude of Effect is therefore considered Negligible (1) and the Impact Significance is considered Low.
3-16	**Use of Resources**	Fuel use associated with subsea infrastructure installation vessels is covered under Node 1 Vessel Use.								
3-17		Construction of pipelines and other subsea infrastructure.	Receptor: Resource use. Use of materials such as steel.	Well design optimisation.	A	1	Low	N/A	N/A	Sensitivity of the use of materials (e.g. steel) and chemicals as receptors is considered Low (A) as all are considered abundant. Given the abundance of these resources the Magnitude of Effect of materials and chemical use is considered Negligible (1) such that the Impact Significance of resource use during drilling is considered Low.
3-18		Chemical use including seawater inhibitors during pipeline and umbilical commissioning.	Receptor: Resource use Use of chemicals.	Chemical use minimised where possible.	A	1	Low	N/A	N/A	
3-19	**Unplanned Events**	Unplanned events impacting on the subsea infrastructure after production has commenced are considered under Production.								
3-20		Failure of installation equipment connection. Loss of water-based hydraulic fluid to sea.	Receptor: Water quality. Water quality deterioration.	Contractor selection. Follow standard operating procedures and checks.	A	1	Low	Unlikely	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). The hydraulic fluids will be water-based and will disperse rapidly in the water column to undetectable levels therefore the Magnitude of Effect is considered Negligible (1). With the application of standard industry mitigation the likelihood of a failure of equipment is considered unlikely such that the Environmental Risk is considered Low.
3-21		Damage to umbilical during installation could result in MEG water and/or water-based hydraulic fluids being released.	Receptor: Water quality. Water quality deterioration.	Contractor selection. Follow standard operating procedures and checks. Independent verification of umbilical design.	A	1	Low	Remote	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). The hydraulic fluids will be water-based whilst any chemicals will be PLONOR and will disperse rapidly in the water column to undetectable levels therefore the Magnitude of Effect is considered Negligible (1). With the application of standard industry mitigation the likelihood of damage to the umbilical during installation is considered unlikely such that the Environmental Risk is considered Low.
3-22		Dropped objects directly to seabed or on other infrastructure e.g. xmas trees.	Receptor: marine flora and fauna. Disturbance to seabed impacting on benthic species.	Risk assessment prior to equipment transfer. Safe handling zones identified. Double securing of heavy lift items. Adhere to LOLER (Lifting Operations and lifting equipment regulations).	C	1	Low	Unlikely	Low	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). The Magnitude of Impact of a dropped object is considered Negligible (1) given the relatively small size of any of the objects that could be dropped. The Impact Significance is therefore considered Low. Likelihood of an object being dropped during drilling activities is considered Unlikely, such that the Environmental Risk is considered Low.
Node 4: SEVAN FPSO positioning and mooring										
4-1	**Physical Presence of the SEVAN FPSO**	Presence of the FPSO anchor chains and anchors.	Receptor: Fisheries. Navigation hazard, restriction of fishing operations.	Early consultation with SFF. Consent to Locate applications including vessel traffic surveys will be submitted. Lighting will be minimised as far as practicable and the use of shields such that they illuminate only the area for which it is meant will be considered. Guard vessel as required.	B	2	Low	N/A	N/A	UK fishing industry and vessels in the area have the capacity to absorb change without impact therefore their Sensitivity is considered to be Medium (B). The Magnitude of Effect on fishermen is considered Minor (2) given the relatively small area that the 500 m exclusion zone around the drill centre and the FPSO will occupy compared to the area of the North sea available for fishing.
4-2	**Emissions to Air**	Atmospheric emissions associated with FPSO installation vessels are covered under Node 1 Vessel Use.								
4-3	**Discharges to Sea**	Discharges to sea associated with FPSO tow and anchor installation vessels are covered under Node 1 Vessel Use.								
4-4	**Seabed Disturbance**	Impact of footprint of anchors and anchor lines.	Receptor: Marine flora and fauna Seabed disturbance due to anchors and anchor lines resulting in potential impact to benthic flora and fauna.	Pre-installation surveys will be carried out.	C	3	Moderate	N/A	N/A	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). Given the potential area impacted by the anchors and anchor lines on the seabed, the Magnitude of Effect is considered Serious (3) such that the Impact Significance is considered Moderate.
4-5		Impact of MWA are considered in Node 3.								
4-6	**Noise**	Noise associated with FPSO tow and anchor installation vessels is covered under Node 1 Vessel Use.								

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (U)	Environmental Risk (U)	Notes on Scoring/Actions/ Comments
4-7	**Noise continued**	Piling. Elevated levels of noise due to piling of the anchors.	Receptors: Marine mammals and fish. Noise from DP has the potential to cause disturbance to marine mammals and fish in the form of temporary displacement from the area.	Adherence to JNCC guidance. Modelling of underwater noise from piling will be used to confirm that JNCC guidance is adhered to.	B	2	Low	N/A	N/A	As described above (Row 1-2), a number of marine mammals (classified as EPS and PMFs) are know to occur in the area, such that their Sensitivity is considered to be Medium (B). Similarly some of the fish species in the Project area are considered to be PMFs (e.g. anglerfish, herring, mackerel, ling, blue whiting, cod, sandeels and spurdog) such that their Sensitivity as a receptor is also considered Medium (B). Given adherence to JNCC guidance the Magnitude of Effect is considered Minor (2) such that the Impact Significance is Low.
4-8	**Waste**	General vessel waste is covered under Node 1 Vessel Use.								
4-9		Scrap metal, other construction materials. Installation generates a number of wastes during routine operations including scrap metal, wooden crates etc.	Receptor: Use of landfill. Land take from use of landfill.	Waste minimisation. All wastes to be properly segregated for recycling / disposal onshore. Waste will be dealt with in accordance with regulatory requirements. Adherence to waste hierarchy.	A	1	Low	N/A	N/A	Sensitivity of landfill as a receptor is considered Low (A) as landfill options are considered abundant. NEO Energy recognise landfill sites as a finite resource, however the majority of waste will be recycled and the installation vessels will have a WMP in place that will adhere to the waste hierarchy principle of reduce, reuse recycle. The Magnitude of Effect is therefore considered Negligible (1) and the Impact Significance is considered Low.
4-10	**Use of Resources**	Fuel use associated with FPSO tow and anchor installation vessels and helicopter trips is covered under Node 1 Vessel Use.								
4-11		Materials for anchors, anchor chains and FPSO.	Receptor: Resource use e.g. steel.	Plant optimisation.	A	1	Low	N/A	N/A	Sensitivity of the use of materials (e.g. steel) is considered Low (A) as all are considered abundant. Given the abundance of these resources the Magnitude of Effect of material use is considered Negligible (1) such that the Impact Significance of resource use is considered Low.
4-12	**Unplanned Events**	Loss of vessel fuel due to collision is covered under Node 1 Vessel Use.								
4-13		Dropped objects e.g. MWA, riser base structure	Receptor: marine flora and fauna. Disturbance to seabed impacting on benthic species.	Risk assessment prior to equipment transfer. Safe handling zones identified. Double securing of heavy lift items. Adhere to LOLER (Lifting Operations and lifting equipment regulations).	C	1	Low	Possible	Low	As described above (Row 1-6) the OSPAR threatened and/or declining habitat 'Sea pen and burrowing megafauna communities' occur in the area such that receptor Sensitivity is considered High (C). The Magnitude of Impact of a dropped object is considered Negligible (1) given the relatively small size of any of the objects that could be dropped. The Impact Significance is therefore considered Low. Likelihood of an object being dropped during drilling activities is considered Possible, such that the Impact Significance, the Environmental Risk is considered Low.
Node 5: Offshore Commissioning and Production										
5-1	**Physical Presence**	The physical presence of the FPSO has previously been considered under Node 4.								
5-2		Standby and supply vessels and the shuttle tankers.	Receptor: Fisheries. Navigation hazard, restriction of fishing operations.	Optimise vessel use. Shuttle tanker will be located c. 100 m from FPSO during offloading from FPSO and therefore within existing 500 m zone. ENVID assumed an offload every ten days.	A	1	Low	N/A	N/A	UK fishing industry and vessels in the area have the capacity to absorb change without a significant impact therefore their Sensitivity is considered to be Medium (B). The Magnitude of Effect on fishermen is considered Minor (2) such that the overall Impact Significance is therefore considered Low.
5-3			Receptors: Birds and marine mammals. Possible behavioural changes in marine mammals e.g. could be attracted to the vessels or may move away from the area. The vessels also have the potential to cause displacement of seabirds from foraging habitat and may cause migrating birds to detour from their flight routes.		B	1	Low	N/A	N/A	As described in Row 1-2 the sensitivity of marine mammals and birds in the area is considered Medium (B). The North Sea is a busy shipping area and has well developed fishing, oil and gas industries and offshore wind farms, such that marine mammals in the region are habituated to the presence of vessels. In addition, the evidence for lethal injury from boat collisions with marine mammals suggests that collisions with vessels are very rare (Cetacean Stranding Investigation Programme, 2011). The Magnitude of Effect on marine mammals is therefore considered Minor (2) such that the Impact Significance of vessels on marine mammals is considered Low. Though evidence suggests that the presence of the vessels could cause some bird species to be displaced from their foraging area, the very small proportion of their overall available habitat that will be occupied by the vessels means the impact is not considered to be noticeable. In addition, given the existing oil and gas vessel activity in the area, it is expected that the impact of the vessels on bird migration routes (e.g. they could be attracted to the vessel lights at night) is not significant. Therefore, the Magnitude of Effect on birds is considered Minor (2) such that the Impact Significance of vessels on birds is considered Low.
5-4	**Emissions to Air**	Emissions from standby and supply vessels, the shuttle tankers and helicopter flights and inspection vessels.	Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	Optimise the number of vessels used for supply and for inspection and maintenance and keep the duration of operations to a technical minimum. Optimise the number of helicopter transfers made. UK Air Quality Standards not exceeded.	D	1	Low	N/A	N/A	As described above (Row 1-3) the Sensitivity of climate change as a receptor is considered Very High (D). NEO, acknowledges that the atmospheric emissions associated with the use of support vessels will contribute to climate change, however the Magnitude of Effect of the incremental increase in emissions to the atmosphere as a result of the vessel activities is considered Negligible (1) such that the overall Impact Significance is considered Low.
5-5			Receptor: Air quality. Possible reduction in local air quality.		A	1	Low	N/A	N/A	As described above (Row 1-4) the Sensitivity of air quality as a receptor is considered Low (A). The Magnitude of Effect of the vessel emissions on air quality is considered Negligible (1) such that the overall Impact Significance is considered Low.

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (U)	Environmental Risk (U)	Notes on Scoring/Actions/ Comments
5-6	**Emissions to Air continued**	Power generation from: (i) three dual fuel gas turbine generators (GTGs) -assume to run on diesel *c*. 5%; (ii) standby generator and emergency generator.	Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	Preferentially GTGs are run on gas. Application of BAT. Efficient operating. Preventative maintenance. Operator of an existing FPSO - will look to apply any lessons learned and best practices. Project plans to switch to electrification.	D	2	Moderate	N/A	N/A	As described above (Row 1-3) the Sensitivity of climate change as a receptor is considered Very High (D). The Magnitude of Effect of the increase in emissions to the atmosphere as a result of power generation on the FPSO, is considered Minor (2) such that the overall Impact Significance is considered Low.
5-7			Receptor: Air quality. Possible reduction in local air quality.	The essential systems diesel generator would be used to power the essential systems only i.e. hydrocarbon production would be shut-in when main power is lost.	A	2	Low	N/A	N/A	As described above (Row 1-4) the Sensitivity of air quality as a receptor is considered Low (A). The Magnitude of Effect of the increase in emissions on air quality is considered Minor (2) such that the overall Impact Significance is considered Low.
5-8		Initial start up flaring, start up flaring during field life (e.g. following system depressurisation), process flaring and blowdown	Receptor: Climate change.	Expected that there would be more flaring at initial start up than subsequent start ups. Designing the plant to be as flexible as possible. Pipeline design so as to minimise touch time. Designing system to have as much up time as possible. Flare gas recovery system.	D	2	Moderate	N/A	N/A	As described above (Row 1-3) the Sensitivity of climate change as a receptor is considered Very High (D). NEO Energy Energy, acknowledges that the atmospheric emissions associated with flaring will contribute to climate change, however the Magnitude of Effect of the incremental increase in emissions to the atmosphere is considered Minor (2) such that the overall Impact Significance is considered Moderate.
5-9			Receptor: Air quality. Possible reduction in local air quality.		A	1	Low	N/A	N/A	As described above (Row 1-4) the Sensitivity of air quality as a receptor is considered Low (A). The Magnitude of Effect of flaring emissions on air quality is considered Negligible (1) such that the overall Impact Significance is considered Low.
5-10		Venting from FPSO drain tanks, fuel tanks, etc. VOC emissions will occur from venting of tanks. Vapour Recovery System on the FPSO ensures noemissions from the cargo tank vents.								
5-11	**Discharges to Sea**	Support vessel sewage/ food waste, ballast water and biofouling.	Receptor: Water quality. Water quality in immediate vicinity of discharge may be reduced (deoxygenation), but effects are usually minimised by rapid dilution in receiving body of water and non-continuous discharge.	Minimise use of vessels, through efficient journey planning. NEO Energy will review vessel CMID as part of vessel assurance and all vessels will be compliant with the Company's MAS. Vessels will be MARPOL compliant. All contracted vessels will originate from countries adhering to the IMO Convention. NEO's audit procedures will ensure that the contracted vessels ballasting procedures are in line with IMO Convention aimed at preventing associated harmful effects. All discharges of ballast water will be monitored, and records maintained. As part of the Company's auditing process, only vessels adhering to the IMO 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Species will be used. All member states of IMO are signed up to these guidelines.	A	1	Low	N/A	N/A	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). As all vessels will be IMO and MARPOL compliant the Magnitude of Impact of any discharges is considered Negligible (1) such that the overall Impact Significance is considered Low.
5-12		Produced water discharge (and associated hydrocarbons, production chemicals and naturally occurring heavy metals).	Receptor: Water quality. Water quality deterioration.	Base case is 95% produced water reinjection (PWRI). Discharge only in event of PWRI failure. Produced water will be treated to maintain Oil in Water (OIW) content below 25 mg/l average. Production chemical selection process will aim to select the lowest toxicity chemicals for a given technical requirement (PLONOR).	A	1	Low	N/A	N/A	In normal operations, produced water will be reinjected into the reservoir. Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Given the proposed mitigation measures the Magnitude of Effect of any produce water discharges is considered Negligible (1) such that the overall Impact Significance is considered Low.
5-13		Drainage water. Potential for oily discharge during release of drainage water.		All discharges from drains to sea will be permitted under the Oil Pollution Prevention and Control Regulations (OPPC). Oil to be recovered from closed drains. Chemical selection process will aim for lowest environmental impact. Adherence to Offshore Chemicals Regulations (OCR) and OPPC permit requirements.	A	1	Low	N/A	N/A	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Given the proposed mitigation measures the Magnitude of Effect of any discharge of drainage water is considered Negligible (1) such that the overall Impact Significance is considered Low.
5-14	**Seabed Disturbance**	No planned additional seabed disturbance associated with production.								
5-15	**Noise**	General vessel noise including dynamic positioning plus FPSO noise.	Receptors: Marine mammals and fish. Noise from dynamic positioning has the potential to cause disturbance to marine mammals and fish in the form of temporary displacement from the area.	Minimise use of vessels, through efficient journey planning and potential use of hybrid supply vessels.	B	1	Low	N/A	N/A	As described above (Row 1-2), a number of marine mammals are know to occur in the area (considered to be EPS and PMFs) such that their Sensitivity is considered to be Medium (B). Similarly some of the fish species in the Project area are considered to be PMFs (e.g. anglerfish, herring, mackerel, ling, blue whiting, cod, sandeels and spurdog) such that their Sensitivity as a receptor is also considered Medium (B). The North Sea is a busy shipping area and has well developed fishing and oil and gas industries, such that marine mammals and fish in the region are habituated to the presence of vessels. Any impacts from vessel noise on these receptors is expected to be behavioural rather than physical, such that they may cause marine mammals or fish to vacate the area, however they would be expected to return once the vessels have left the location. The Magnitude of Effect of underwater noise, from vessels, on marine mammals and fish is therefore considered to be Negligible (1) such that the Impact Significance is considered Low.

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (U)	Environmental Risk (U)	Notes on Scoring/Actions/ Comments
5-16	**Waste**	General waste.	Receptor: Use of landfill. Land take from use of landfill.	Waste Management Plan and controlled waste transfer notes; Waste management Duty of Care audit. Asset targets to reduce waste. Adherence to waste hierarchy.	A	2	Low	N/A	N/A	Sensitivity of landfill as a receptor is considered Low (A) as landfill options in the project area are abundant. As the field life is expected to be 25 years, the quantities of waste generated will be more than in previous project phases such that the Magnitude of Effect is considered to be Minor (2) and the Impact Significance is considered Low.
5-17	**Use of Resources**	Fuel use for support vessels, and helicopter transfers.	Receptor: Resource use Resource use e.g. Energy use for power generation.	MARPOL compliant. NEO Energy Energy will review vessel CMID as part of vessel assurance (evidence of maintenance) Optimise vessel and helicopter use.	A	1	Low	N/A	N/A	Sensitivity of fuel availability as a receptor is considered Low (A) NEO Energy Energy recognise that hydrocarbon-based fuel is a finite resource, however given the relatively short duration of the proposed vessel and helicopter activities and the use of MARPOL compliant vessels the Magnitude of Effect of fuel use is considered Negligible (1) such that the Impact Significance is considered Low.
5-18		Materials for maintenance. Routine maintenance operations.	Receptor: Resource use Resource use e.g. paint, oil	Material use minimised where possible. Optimise maintenance activities.	A	1	Low	N/A	N/A	Sensitivity of resource use as a receptor is considered Low (A) as materials for maintenance are abundant. Maintenance activities will be optimised and materials use is thought to be undiscernible so the Magnitude of Effect is considered to be Negligible (1) and the Impact Significance is considered Low.
5-19		Production chemicals.	Receptor: Resource use. Use of chemicals.	Chemical use minimised where possible.	A	2	Low	N/A	N/A	Sensitivity of chemical availability as a receptor is considered Low (A). The use of chemicals will be minimised as far as practicable however due to the development having a field life potentially in excess of 20 years, the Magnitude of Effect is considered Minor (2) and the Impact Significance is considered Low.
5-20	**Unplanned Events**	Minor chemical/ hydrocarbon spills.	Receptor: Water quality. Water quality deterioration.	Installation operator will be a member of OSRL and OPOL. Optimised quantities procured & stored. COSHH, Task Hazard Assessments are completed and MSDS sheets are available. Design features including drip pans, bunded areas, process and hazardous drains. Procedures in place for secondary containment should bunding fail. Spill kits located in close proximity to chemical storage areas. Contaminated chemical spill kits disposed of onshore. Statutory reporting of all spills.	A	2	Low	Unlikely	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Any impact on water quality from a minor chemical or hydrocarbon spill is considered to be localised and have a short term, reversible effect. Therefore the Magnitude of Effect of such a spill is considered Minor (2). With the application of standard industry mitigation the likelihood of a spill occurring is considered Unlikely therefore the environmental risk is considered to be Low.
5-21		Leaks or ruptures from bunkering (diesel).		Observers. Maintenance and operational procedures. Approved OPEP in place. Bunkering procedures will be developed in line with Best Practice Guidance. Continuous monitoring during bunkering.	A	2	Low	Unlikely	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). The Magnitude of Effect of any impact on water quality due to a loss of diesel during bunkering is considered Minor (2). With the application of standard industry mitigation the likelihood of a such a loss is considered Unlikely such that the Environmental Risk is considered Low.
5-22		Leaks or ruptures from offloading (FPSO to shuttle tanker).			A	2	Low	Remote	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). The Magnitude of Effect of any impact on water quality due to a loss of hydrocarbons during offloading is considered Minor (2). With the application of standard industry mitigation the likelihood of a such a loss is considered Remote such that the Environmental Risk is considered Low.
5-23		Pipeline rupture e.g. due to pipeline corrosion.	Receptor: Water quality, seabed sediments and benthic species	Structure protection will be implemented to prolong the life of the equipment. Cathodic protection (corrosion protection). Follow standard operating procedures and checks. Pipeline routes added to admiralty charts, Kingfisher database, etc. Topsides instrumentation will identify drops in pressure, minimising volumes lost. Pipelines will be trenched and buried.	C	2	Moderate	Remote	Low	Sensitivity is ranked High (C) due to the presence of the OSPAR threatened and/or declining 'Sea pen and burrowing megafauna communities' habitat (also a Scottish Priority marine Feature (PMF), listed as 'Burrowed Mud'). Any releases at the seabed could result in long term deterioration of sediment quality in vicinity of the rupture such that the Magnitude of Effect is considered Minor (2)and the Impact Significance is Low. With the application of standard industry mitigation the likelihood of a pipeline rupture is considered Remote such that the Environmental Risk is considered Low.
5-24		Snagging or dragging of pipeline resulting in damage and release.			C	2	Moderate	Unlikely	Low	Sensitivity is ranked High (C) due to the presence of the OSPAR threatened and/or declining 'Sea pen and burrowing megafauna communities' habitat (also a Scottish Priority marine Feature (PMF), listed as 'Burrowed Mud'). Any releases at the seabed could result in long term deterioration of sediment quality in vicinity of a damaged pipeline such that the Magnitude of Effect is considered Minor (2)and the Impact Significance is Low. With the application of standard industry mitigation the likelihood of a pipeline rupture resulting from snagging or dragging is considered Unlikely such that the Environmental Risk is considered Low.
5-25		Helicopter crash. Loss of helifuel to sea.	Receptor: Water quality, and marine flora and fauna. Water quality deterioration impacting on marine flora and flora.	Auditing of company to ensure helicopter maintenance etc.	B	2	Low	Remote	Low	In the event of a helicopter crash it is expected that any released helifuel would evaporate quickly and would not come into contact with the seabed. Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A), however considering the receptors present including marine mammals (considered to be EPS and PMFs) receptor Sensitivity is considered to be Medium (B). Total quantities of helifuel will be relatively small (*c*. 1,120 litres - Bristow Sikorsky S76D) and given the high evaporation rate and offshore location, it is expected that any impacts would be Minor (2) such that the Impact Significance is Low. With the application of standard industry mitigation the Likelihood of a helicopter crash occurring is considered Remote and therefore the Environmental Risk is considered to be Low.

Row	Aspect	Source/ Activity	Receptors and Potential Impacts	Standard Industry Mitigation	Sensitivity	Magnitude of Effect	Significance	Likelihood (L)	Environmental Risk (L)	Notes on Scoring/Actions/ Comments
5-26	**Unplanned Events continued**	Release of FPSO inventory due to collision, topsides rupture.	Receptor: Water quality. Water quality deterioration. Immediate oxygen demand on receiving water.	500m zone and navigational aids. Kingfisher, MoD and other users of the area will be notified of existing infrastructure. Statutory reporting of all spills. Installation operator will be a member of OSRL and OPOL. Emergency Response Plan implemented in the event of a loss of well control/fire, explosion or activation of fire-fighting systems. Regular drills held. Access to dispersant via the ERRV. Installation management personnel have undergone training. Approved OPEP in place.	A	4	Moderate	Remote	Low	Given the open nature of the North Sea, the Sensitivity of water quality as a receptor is considered Low (A). Modelling results for the deterministic scenario suggest that the level of hydrocarbons in the water column may reach or exceed the defined NOEC of 10 µg/l over a considerable area (271 km^3). The stochastic modelling shows there is moderate to high probability of oil in the water column resulting in transboundary impacts on water quality. Therefore, the magnitude of effect would be classed as Major (4) such that the Impact Significance is considered Moderate. With the application of standard industry mitigation the likelihood of such a loss is considered Remote such that the Environmental Risk is considered Low.
5-27			Receptor: Marine flora and fauna. Impact on marine flora and fauna.		C	5	High	Remote	Medium	Some of the species and bethic habitats present (for example *A. islandica*) are recognised to be of conservation significance and/or have OSPAR designations, such that their sensitivity is considered to be High (C). Modelling results from a loss of FPSO inventory predicted that no areas of sediment would exceed the 5 g/m^2 hydrocarbon threshold. The magnitude is classed as Minor (2) (no breaches of regulatory compliance and no transboundary impacts) such that the Impact Significance of a inventory release on benthic species is considered Moderate. Similarly some of the fish species in the Project area are considered to be PMFs (e.g. anglerfish, herring, mackerel, ling, blue whiting, cod, sandeels and spurdog) such that their Sensitivity as a receptor is considered Medium (B). The impact of a loss of FPSO inventory on fish is likely to extend beyond the project area (possibility of transboundary effects) and could cause long term degradation to fish species. Therefore, the Magnitude of Effect on fish is considered Major (4) such that the Impact Significance of a inventory releaseon fish is considered Moderate. Birds of conservation importance from the coastal SPAs (e.g. the Buchan Ness to Collieston Coast SPA) will disperse into the project area following the breeding season and will feed in the Project area such that Sensitivity of birds as a receptor is considered High (C). Oil spill modelling indicates there is a low to moderate probability of oil reaching the coast in areas that are internationally or nationally designated for seabirds. Shoreline oil concentrations would exceed the threshold of 100 g/m^2 (0.1 kg/m^2) above which impacts are considered potentially significant over 237 km length of coastline.This would cause persistent severe environmental damage and is likely to have a major impact on the conservation objectives of the coastal SPAs. Therefore, the Magnitude of Effect on birds is considered Critical (5) such that the Impact Significance of a inventory release on birds is considered High. With the application of standard industry mitigation the likelihood of a inventory release occurring is considered Remote therefore the environmental risk is considered to be Medium.
5-28		Refrigerant use. Unplanned release of HFCs to atmosphere from HVAC system. Unplanned release of SF6	Receptor: Climate change. Emissions to atmosphere result in a minor contribution to global warming, acidification and photochemical smog (compared to overall activity in the North Sea).	Maintenance by suitably qualified engineers. Leak detection systems in place if required.	D	1	Low	Likely	Low	As described in Row 3 the Sensitivity of climate change as a receptor is considered Very High (D). NEO, acknowledges that the unplanned release of HFCs will contribute to climate change, however the relatively small amounts that would be lost, means the Magnitude of Effect of the incremental increase in emissions to the atmosphere is considered Negligible (1) such that the overall Impact Significance is considered Low. Regular maintenance of the HVAC system will reduce the likelihood of a release to Remote therefore the Environmental Risk is considered to be Low.
5-29		Dropped objects resulting in disturbance to seabed.	Receptor: marine flora and fauna. Loss of seabed habitat, smothering of benthic organisms.	Dropped objects retrieved where possible. Risk assessment prior to equipment transfer.	C	1	Low	Unlikely	Low	Sensitivity is ranked high (C) due to the presence of the OSPAR 'Seapen and burrowing megafauna communities' habitat (also a Scottish Priority marine Feature (PMF), listed as 'Burrowed Mud') noted during the 2021 Benthic Solutions environmental surveys (Benthic solutions, 2021a, b and c).The Magnitude of Effect on benthic fauna and flora of the dropped object is considered to be Negligible (1) given that this habitat is not unique to this area of the North Sea and recolonisation of the area will occur once the object is retrieved or colonisation of the object will occur if it is not possible to retrieve such that the Impact Significance is considered Low.
5-30		Dropped objects resulting in damage to subsea infrastructure and small hydrocarbon releases.		Dropped objects study for installation. Risk assessment prior to equipment transfer. Mattresses over the tie-in spools. Limit lift length. Subsea Isolation Valve in operation. Safe lifting area.	C	2	Moderate	Remote	Low	Note that if a dropped object did damage a pipeline, it would be expected to be a crack and small leak until flow can be stopped, as oppose to a full rupture. Sensitivity is ranked high (C) due to the presence of the OSPAR 'Seapen and burrowing megafauna communities' habitat (also a Scottish Priority marine Feature (PMF), listed as 'Burrowed Mud') noted during the 2021 Benthic Solutions environmental surveys (Benthic solutions, 2021a, b and c). The Magnitude of Effect is considered to be Minor (2) given that only a small leak would occur and any changes to the receptor would be low and barely detectable. The Likelihood of a dropped object damaging a live line is considered Remote such that the Environmental Risk is considered Low.

Appendix C - Drill Cuttings Dispersion Modelling Report

REPORT

Drill Cuttings Modelling

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ABBREVIATIONS

'	Minute
"	Second/Inch
%	Percent
‰	Parts per thousand
<	Less Than
>	More Than
°	Degrees
°C	Degrees centigrade
µg/l	Microgram per litre
µm	Micrometre
atm	Atmosphere
BEIS	Department for Business, Energy and Industrial Strategy (now Department for Energy Security and Net Zero, DESNZ)
bsl	Below sea level
CHARM	Chemical Hazard Assessment and Risk Method
CNS	Central North Sea
DREAM	Dose-related Risk and Effects Assessment Model
ED	European Datum
kg/m^3	Kilogram per cubic metre
km	Kilometre
km^2	Square kilometre
km^3	Cubic kilometre
Kow	Octanol-water partition coefficient
LC_{50}	Lethal Concentration 50 %
LTOBM	Low toxicity oil based mud
m	Metre
MEMW	Marine Environmental Modelling Workbench
mm	Millimetre
NMPi	National Marine Plan interactive
NOEC	No Observed Effect Concentration
OBM	Oil based mud

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OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PEC	Predicted Environmental Concentration
PEC_{sed}	Predicted Environmental Change
PLONOR	Pose little or no risk
PNEC	Predicted No Effect Concentration
$PNEC_{sed}$	Predicted No Effect Change
ppb	Parts per billion
PSD	Particle Size Distribution
SW	Sea water
t	Tonnes
t/hr	Tonnes per hour
TCC	Thermo mechanical cuttings cleaner
TWMA	Total Waste Management Alliance
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
UTM	Universal Transverse Mercator
WBM	Water-Based Mud
WGS84	World Geodetic System 1984

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1.0 INTRODUCTION

NEO Energy propose to redevelop the Buchan Horst field which is located in UK Continental Shelf (UKCS) Blocks 20/5 and 21/1 in the Central North Sea (CNS) and lies *c.* 115 km northeast of the Aberdeenshire coastline and *c.* 100 km west of the UK/Norway median line (Figure 1.1).

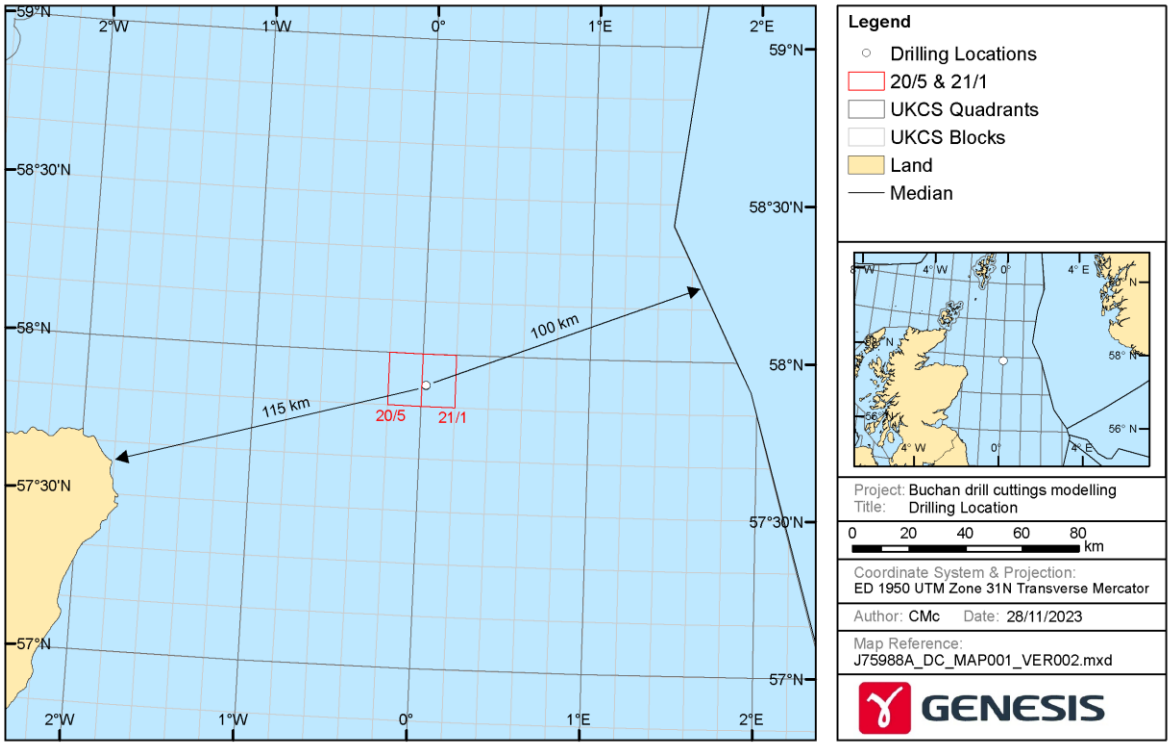


Figure 1.1: Drilling Location

NEO are proposing to drill up to seven development wells: five production wells and two water injection wells.

This report documents the drill cuttings modelling which was used to predict the fate of discharged cuttings from the wells in terms of:

- Depositional thickness on the seabed;
- Environmental risk to the seabed resulting from burial thickness, grain size change, toxicity and pore water oxygen depletion; and
- Environmental risk in the water column resulting from toxicity and particle stresses.

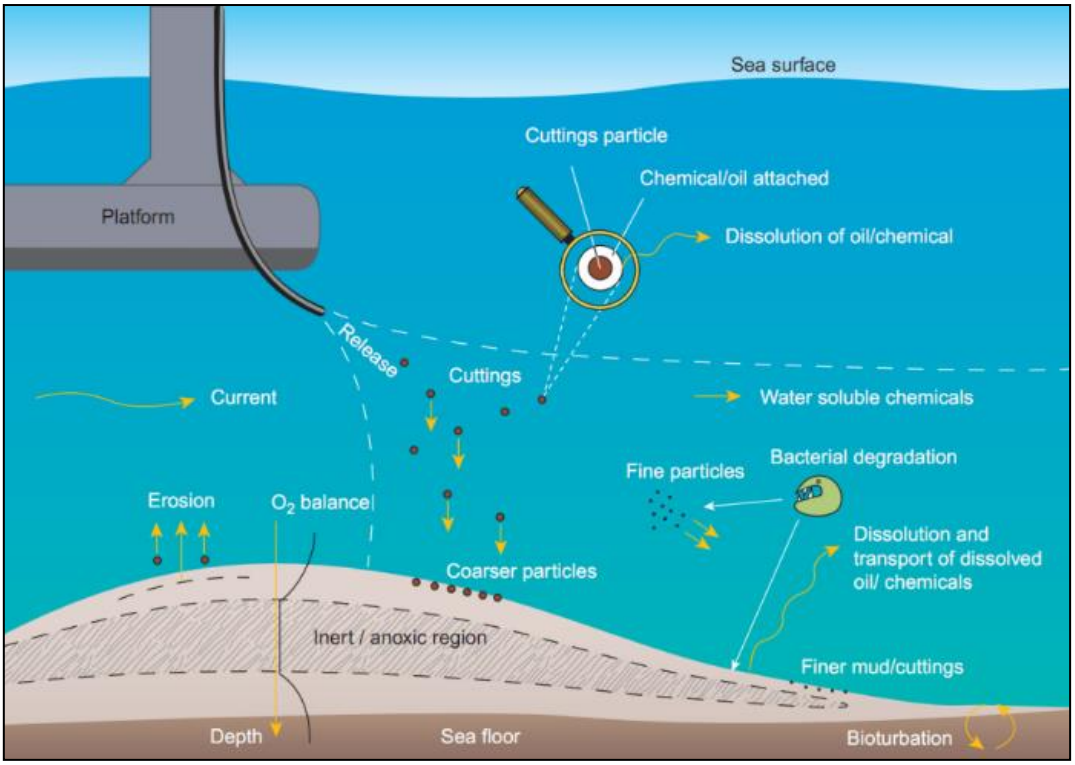
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2.0 OVERVIEW OF THE MODELLING METHODOLOGY

2.1 DREAM/ParTrack

The cuttings discharges were modelled using the Dose-related Risk and Effects Assessment Model (DREAM) published by Sintef, as part of the Marine Environmental Modelling Workbench (MEMW) suite of models, version 14.1.0. This incorporates the ParTrack sub-model for modelling dispersion and settlement of solids. The model predicts the fate of materials discharged to the marine environment, specifically their dispersion and changes to their physicochemical composition.

The model has been developed to calculate the dispersion and deposition on the seabed of drilling mud and cuttings as well as the dispersion of chemicals in free water masses. The model consists of a plume model and a far-field model. The calculations are based on the "particle" approach, combined with a near field plume model and the application of external current fields for the horizontal advection of the particles. The plume model takes into account effects from water stratification on the near-field mixing, ambient currents and geometrical configuration of the outlet. Once plume advection ceases, particles fall out of the plume and deposit on the seabed. Vertical velocity (rise/fall) of the particles depends on their size and density as well as on the agglomeration of solids in the presence of oil-related components. The far-field model includes the downstream transport and spreading of particles and dissolved matter, once the plume mode is terminated. The processes involved are illustrated in Figure 2.1.



Source: Rye *et al.* (2006)

Note: In this case part of the release will be directly at the seafloor and part at the platform.

Figure 2.1: Processes involved in the DREAM model

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Model predictions have been validated through field measurements at the Troll-A field in the Norwegian Sea, where reasonably good correspondence was obtained between measured and simulated deposition of the cuttings on the sea floor (Rye, 2010; Jødestøl and Furuholt, 2010).

2.2 Risk Assessment Method

The risk assessment method was initially developed for assessing impacts due to the discharge of toxic stressors (i.e. chemicals) to the marine environment or particle stressors (e.g. barite and bentonite) and was primarily intended for the assessment of produced water and other chemical discharges.

The methodology is based on a comparison of modelled concentrations of chemicals in the water column (termed the Predicted Environmental Concentration, (PEC)) and the highest theoretical concentration of the same chemicals at which harmful effects are not expected to occur in marine organisms (termed the Predicted No Effect Concentration, (PNEC)). In cases where the ratio PEC:PNEC exceeds 1, a risk to at least 5% of the most sensitive species occurs. This methodology is used by the DREAM/ParTrack model to calculate the risk to the water column due to toxicity from chemicals in drill cuttings discharges.

The protocol for assessing risks from drill cuttings discharges was further developed by the Environmental Risk Management System joint industry project to include the assessment of risk to seabed sediment and was founded on well-established scientific studies such as those in Smit *et al*. (2006), Trannum (2004), Kjeilen-Eilertsen *et al.* (2004) and Neff (2005). The assessment methodology for sediments is similar to that for the water column and is based on a combined risk approach using the PEC_{sed}:$PNEC_{sed}$ ratio. However, for sediments PEC_{sed} represents the Predicted Environmental Change (as opposed to predicted environmental concentration used for water column), and $PNEC_{sed}$ is the Predicted No Effect Change (as opposed to Predicted No Effect Concentration used for water column). Where PEC_{sed}: $PNEC_{sed}$ exceeds 1, a risk to at least 5% of the most sensitive species occurs. Where there is a risk to less than 5% of the most sensitive species, this is considered a tolerable risk level.

Trannum (2004), Kjeilen-Eilertsen *et al*. (2004) and Neff (2005) established that in the absence of any other stressors sediment risk would exceed 5% when:

- Chemical concentrations in pore water exceeded the PNEC;
- Burial thickness exceeded 6.5 mm;
- Median grain size change exceeded 52.7 µm; and
- Oxygen content was depleted by more than 20%.

The effects of burial include mortality of organisms, reduced growth of some species, reduced larval settlement and changed fauna composition. Effects can be short-term and mainly on an individual level, or they can be more long-term and affecting whole populations (Kjeilen-Eilertsen *et al*., 2004). In general, the effect of burial mainly depends on the mobility of organisms in the sediment matrix and on the settling rate of particles. Sedentary organisms, which have no or very limited abilities to move, such as attached barnacles or mussels, are very sensitive (Smit *et al*., 2006).

Following the settlement of drilling particles, benthic communities have been observed to be dominated by opportunistic species which generally are small, with short life spans and high population growth rates. There is considerable variability in species responses to specific sediment characteristics. The factors ultimately controlling infauna distributions may not be

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sediment grain size *per se* or factors linked to grain size such as organic content, but rather interactions between hydrodynamics, sediments and infauna and how these affect sediment distribution, larval supply, particle flux and pore water chemistry (Smit *et al*., 2006). DREAM uses the change in median grain size to represent the overall changes in sediment characteristics.

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3.0 MODEL INPUT DATA

3.1 Metocean Data

3.1.1 Currents and Winds

The study uses three-dimensional current data (2 hourly resolution) obtained from Sintef for 1990 to 1992. The drilling start date is currently unknown but drilling will take place over a period of nearly two years. An arbitrary model start date of Feb 1990 was selected, which means the model run includes the months of May and June when currents are generally weakest, resulting in conservative results (less dispersion, greater accumulation of cuttings).

The study uses two-dimensional wind data obtained from Sintef for the same period.

The wind data is used to generate wave height predictions within the model that feed into surface dispersion and resurfacing calculations.

3.1.2 Temperature and Salinity

Water column temperature and salinity profile information is used in the modelling. Local salinity and temperature data for surface and bottom waters was obtained from Scottish Government's National Marine Plan Interactive (NMPi) maps (Berx and Hughes, 2009). As the drilling campaign will run for a period of nearly two years, annual averages for the area were used.

The average sea temperature varies from 7.66°C at the seabed to 9.59°C at the sea surface. Salinity variation in the water column is minimal and an average value of 35.00‰ was used at the surface and the seabed.

3.2 Bathymetry

Bathymetry data used in the DREAM model is based on the Sea Topo 8.2 database (Jakobsson *et al*., 2008).

3.3 Seabed Sediments

DREAM requires an average grain size of surrounding sediments to evaluate the change in grain size distribution as a result of the drill cutting discharge. The sediments around the well are predominantly fine sand (Repsol, 2019), with a median background sediment grain size of 0.048 mm.

3.4 Well Design and Drilling Discharges

Cuttings are discharged from each drilled section of the well. The model inputs include:

- The well locations;
- The well design and geometry of each section (a single well design has been assumed for all seven wells);
- The mass of the mud components discharged from each section; and

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- An assumed drilling schedule showing the likely drilling duration per section.

3.4.1 Well and Discharge Locations

The wells will be drilled either from a semi-submersible rig or a heavy duty jack up rig. The coordinates of each well are shown in Table 3-1 (these may vary slightly but not sufficiently to impact the dispersion modelling results).

Table 3-1: Coordinates of the wells

Well no	Latitude	Longitude
P1	57°53'51.43"N	00°01'18.57"E
P2	57°53'51.76"N	00°01'17.89"E
P3	57°53'52.12"N	00°01'18.51"E
P4	57°53'54.18"N	00°01'23.28"E
P5	57°53'54.50"N	00°01'22.61"E
W1	57°53'51.79"N	00°01'19.18"E
W2	57°53'54.53"N	00°01'23.89"E

Coordinate reference system – World Geodetic System 1984 (WGS84)

The rig will drill each well consecutively therefore, all cuttings from each well will be discharged at the well location.

3.4.2 Well Design

The well design comprises six sections as summarised in Table 3-2. The first two sections will be drilled using sea water (SW) sweeps and discharged directly to the seabed. Low toxicity oil based mud (LTOBM) will be used for subsequent sections of the well and the resulting cuttings are treated at the drill rig using a thermo mechanical cuttings cleaner (TCC) prior to being discharged 10 m below the sea surface.

It is possible that the section diameters and lengths may change slightly prior to drilling however, this is not expected to significantly change the overall volume of cuttings discharged and therefore would not significantly impact the results of the modelling.

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Table 3-2: Well design

Section Diameter (“)	Section Length (m)	Mud Type	Release Depth (m bsl)
42	105	SW	Seabed
26	631	SW	Seabed
17.5	1,036	LTOBM	10
12.25	700	LTOBM	10
8.5	214	LTOBM	10
6	457	LTOBM	10

The following contingencies have been included in the modelling:

- Requirement for re-spuds for each well in the event of unplanned shallow hazards, i.e., additional discharge from 42” and 26” sections x 7;
- Requirement for an additional shallow sidetrack (on the lower section with the greatest volume of cuttings) for each well in the event of unplanned geological findings or critical equipment failure i.e., additional discharge from the 17.5” section x 7.

These contingencies have been modelled after the seven full wells.

3.4.3 Thermal Desorption Process

During thermal desorption cuttings are heated to the distillation temperature of the base oil and this temperature is maintained until all the oil is vapourised. Thermal desorption units typically use a TCC, also known as a hammermill system, which uses a series of hammer arms mounted on a central drive shaft rotating at high speed in a process chamber. Friction from the hammers and cuttings generates enough heat (240°C to 260°C) to evaporate the water and then the oil from the cuttings. The oil can then be condensed and separated for recovery/recycling. The processed powder typically contains under 0.1 % hydrocarbon content by weight (Kirkness *et al.,* 2008) and can be discharged. The recovered water has a hydrocarbon content of less than 30 µg/l and can also be discharged. A conservative value of 0.2% oil on cuttings was used in this assessment. This is well within the regulatory requirements of 1% oil on cuttings and is considered a realistic worst case based on previous wells.

An overview of the rotomill process is shown in Figure 3-1. The Roto*Mill*™ can process cuttings at speeds of up to 10 t/hr (TWMA, 2019), though rates of 8 t/hr are more typical.

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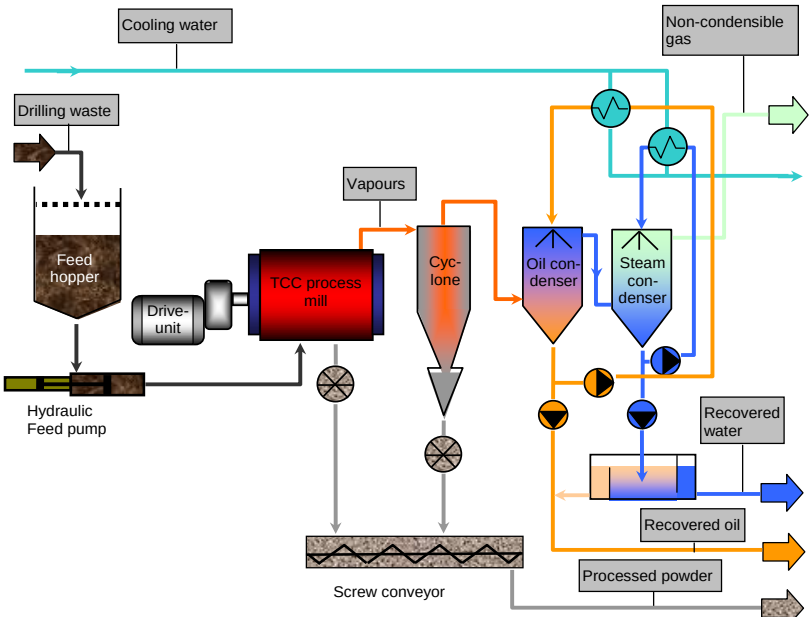


Figure 3-1: Schematic showing rotomill process

3.4.4 Mud Components

A summary of mud compositions and the discharged components is shown in Table 3-3.

Table 3-3: Mud components modelled for each section

Well	Section Diameter (")	Rock Cuttings (t)	Bentonite (t)	Barite (t)	Total solids discharged from rotomill (t)	Base Oil on solids discharged from rotomill[2] (t)	Reservoir oil on solids discharged[2] (t)
Single well design	42	270.3	48.0	216	-	-	-
	26	622.5	122.6	438	-	-	-
	17.5	424.4	0	328	752	0.85	-
	12.25	140.5	0	138	279	0.28	-
	8.5	20.7	0	5	26	0.04	-
	6	22.0	0	22	44	0.04	0.04
	Total	**1,500.4**	**170.6**	**1,147**	**1,101**	**1.21**	**0.04**

Notes:

[1] Sections 42” & 26” include a 20% well bore washout., remaining sections include 10% well bore washout

[2] Oil on solids based on 0.2% cuttings weight as discussed in section 3.4.3.

The base oil for the LTOBM is Saraline 185V. Its physico-chemical and toxicological properties were obtained from the product data sheet and are shown in Table 3-4. These properties were entered into the DREAM component database.

The PNEC is calculated by dividing the lowest short-term Lethal Concentration 50% (LC_{50}) or long-term No Observed Effect Concentration (NOEC) value by an appropriate assessment

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factor, which is the established approach for assessing chemical toxicity under the OSPAR Harmonised Mandatory Control System (OSPAR, 2014). The assessment factors reflect the degree of uncertainty in extrapolation from laboratory toxicity test data for a limited number of species to the 'real' environment. The greater the uncertainty, the higher the assessment factor used. Under the UK Risk Based Approach Programme for the management of produced water discharges from offshore installations, an assessment factor of 1,000 is recommended as a conservative approach to assessing the risk due to these discharges (BEIS, 2020). This was the approach used to derive the PNECs for the LTOBM. The PNEC value of 1,000 µg/l (including a 1,000 assessment factor) is relatively high, suggesting Saraline 185V has a relatively low level of toxicity.

Table 3-4: Toxicity and physico-chemical data for base oil (Saraline 185V)

Component Name	PNEC (µg/l)	Biodegradation (%, days)	Density (kg/m^3)	Soluble?	Vapour pressure (atm)	logKow
Saraline 185V	1,000	62, 28	779	No	0.01	>6.5

Source: Saraline 185V brochure (Shell, 2013).

3.4.5 Added Chemicals and Reservoir Oil

All chemicals added to the 46” and 26” sections are either contingency chemicals, pose little or no risk to the environment (PLONOR) and/or are not amenable to the Chemical Hazard Assessment and Risk Method (CHARM) model i.e., non-CHARMable chemicals. Therefore, no chemicals have been included in the model for the top two sections.

A number of chemicals are added to the LTOBM. However, these are assumed to be destroyed by the TCC (Vik *et al*., 2014) and have therefore not been included in the rotomill discharge. Vik *et al.* investigated the chemical and ecotoxicity of treated oil-based mud (OBM) cuttings by carrying out detailed tests on four treated cuttings’ samples. They concluded that the environmental risk associated with discharges of thermally treated OBM cuttings corresponds to that seen with discharges of water-based mud (WBM) cuttings. The levels of oil, polycyclic aromatic hydrocarbons, and metals are expected to be similar to those in WBM cuttings and chemical pollution is expected to have a negligible effect on pelagic and benthic organisms. No information is given in the report in relation to specific chemicals present in the OBM.

Reservoir oil has been included in the model scope for the 6” section where drilling passes through the reservoir. The oil fraction of C15-C16 was selected to represent reservoir oil in the model. This is conservative in respect to toxicity with a chronic PNEC of 5 ppb. As the cuttings of these sections are processed through the rotomill, a conservative value of 0.2% oil on cuttings was used in this assessment as discussed in Section 3.4.3 for the base oil.

3.4.6 Particle Size Distribution

The model has a default particle size distribution (PSD) for drill cuttings that was obtained from a review of data from drilling in Norwegian waters during the development of the DREAM/ParTrack model (Saga, 1994). PSDs for barite and bentonite in the model are based on industry standard distributions. When the cuttings are passed through the thermal desorption unit they are ground down to a much finer size than standard drill cuttings. The PSD was previously determined for the TWMA *RotoMill*^{TM} desorption unit for typical North Sea cuttings. The results are shown in Appendix A and were used to develop a PSD for the cuttings

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discharged from the lower sections of each well. Table 3-5 and Table 3-6 summarise the cuttings PSDs used in the model.

Table 3-5: Cuttings PSD (model default)

Approximate% In Each Size Class[1]	Size Interval (µm)	Fraction (%)	Cumulative Fraction (%)
Fines (silt/clay) Up to 62.5 µm ~50%	1–10	10	10
	10–20	10	20
	20–30	10	30
	30– 45	10	40
	45–60	10	50
Sand 62.5 µm to 2,000 µm ~35%	60–100	10	60
	100–400	10	70
	400–1,000	10	80
Gravel 2000 to 6000 µm ~15% Cobbles >6,000 µm (% included in gravel)	1,000–4,000	10	90
	4,000–7,000	10	100

[1] Wentworth Scale (Wentworth, 1922) – note that size intervals used do not exactly match the divisions on the Wentworth scale therefore percentage within each size class is approximate.

Table 3-6: Cuttings PSD for lower well sections after thermal desorption (TWMA, 2018)

Approximate% In Each Size Class[1]	Size Interval (µm)	Fraction[2] (%)	Cumulative Fraction (%)
Fines (silt/clay) Up to 62.5 µm ~75%	< 1	10	10
	1–3	10	20
	3–5	10	30
	5–8	10	40
	8–16	10	50
	16–25	10	60
	25–45	10	70
	45–71	10	80
Sand 62.5 µm to 2000 µm ~25%	71–159	10	90
	159–564	10	100

Notes:

[1] Wentworth Scale (Wentworth, 1922) – note that size intervals used do not exactly match the divisions on the Wentworth scale therefore percentage within each size class is approximate.

[2] Fractions have been rounded to nearest 5 %

3.4.7 Drilling Schedule

The proposed drilling schedule for seven wells and two contingency wells extends over a period of approximately 684 days (sum of time taken to drill each section and time to shift drilling rig between wells).

The modelled drilling schedule is shown in Table 3-7 and is compressed to optimise model run time. The modelled schedule is based on the following assumptions:

- Drilling durations for the two tophole sections were calculated by the model based on section length;

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- Discharge durations for the lower hole sections are not based on drilling rate. They were calculated based on the mass of cuttings requiring treatment and assuming a rotomill treatment rate of 8 t/h;
- The cuttings in the *Rotomill*^{TM} are processed consecutively and discharged concurrently, whereas in reality they would be processed and discharged in batches.
- A 24-hour time gap has been allowed between sections and three days between each well; and
- The model runs for a further 5 days after drilling is completed to allow for dispersion in the water column.

This gives an overall model run duration of 186 days.

Table 3-7: Modelled drilling sequence and schedule

Discharge type	Section diameter (“)	Discharge duration (hours)
Direct discharge	42	10.5
	26	31.55
Via TCC	17.5	94.05
	12.25	34.81
	8.5	3.21
	6	5.5
Total for 7 wells:		**52.4 days**
Total including contingency respuds and sidetracks:		**91.6 days**
Total including 24 hours between each section and 5 days post final discharge:		**186 days**

The wells will take significantly longer to be drilled in reality than in the model and allow more time for dispersion between discharges from individual sections. The model set up is conservative in that it will potentially result in slightly greater impacts in the water column because there is less time for dispersion between the discharges. Impacts on the seabed are unlikely to be significantly different as a result of the shorter modelled discharge timings, given that seabed recovery takes place over much longer timescales.

3.5 Model Configuration

A range of grid sizes and model timesteps have been used in order to optimise specific outputs, whilst not resulting in unmanageable model run times.

Different grid sizes were used to evaluate particle dispersion:

- Larger, coarser grid to evaluate risk of impacts to the water column; and

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- Smaller, finer grids to evaluate impacts on the seabed.

This reflects the likely extent of particle dispersion. Water column dispersion of dissolved and suspended particles occurs over a wide area, whereas deposition of drill cuttings is a more localised event.

Different timesteps and overall model durations were used to allow short-term and long-term impacts to be investigated. A description of each configuration used is summarised in Table 3-8.

Table 3-8: Model configuration

Aspect	Domain Size	Cell Size	Time Step	Model Duration	Sediment risk model?
Water column	40 km × 40 km	100 m × 100 m	30 mins	186 days	Not included
Seabed (risk)	1 km × 3 km	20 m × 20 m	90 mins	186 days plus 10 years[1]	Included
Seabed (thickness)	2 km × 2 km	10 m × 10 m	30 mins	186 days	Not included

[1] Main DREAM model runs for 186 days using timestep shown, followed by the sediment model which was run for 10 years using a 24-hour timestep.

3.6 Model Uncertainties

3.6.1 Metocean Data

Metocean data used was for the year 1992, starting in February. Use of a different start date or a different set of current data would result in small changes to the precise pattern of cuttings deposition, but the predicted extent of risk is likely to be of a similar magnitude.

3.6.2 Sediment Grain Size

Grain size change is an important parameter, and it should be noted that the thresholds for this parameter within the risk assessment are based on the analysis of environmental monitoring data from the Dutch section of the North Sea, the Norwegian Sea and the Barents Sea covering 300 species (Smit *et al*., 2006). There may be regional differences in prevailing fauna that would give different thresholds for the drilling location. However, the basis of the threshold is considered to represent the best available data and covers a wide range of benthic fauna.

The threshold for burial thickness is based on the probability that a specific species will escape a given depth of burial with both exotic (e.g. drill cuttings) and native sediments. The threshold was derived from the burial sensitivity of 33 species (Smit *et al*., 2006 and Kjeilen Eilersten *et al*., 2004).

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3.6.3 Oil Sheen

DREAM does not model the formation of oily sheens on the sea surface. This process is modelled using OSCAR (Oil Spill Contingency And Response), another model under the MEMW suite. Therefore, the absence of a sheen as a result from this drilling discharge cannot be verified with modelling in DREAM alone. However, given the high value of the partition coefficient for the oil on cuttings, most of the oil is retained on cuttings particles and an oil sheen is unlikely to form.

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4.0 RESULTS

4.1 Terminology

The results of the modelling runs are presented in the following sections in relation to seabed sediment impacts and water column impacts.

The following terms are used throughout:

- The maximum instantaneous risk is the area (in the case of seabed sediment) or the volume (in the case of the water column) where the risk to over 5% of the most sensitive species is greatest at a specific point in time during the simulation;
- The total risk is the overall area (seabed) or volume (water column) where there has been a risk to over 5% of the most sensitive species at any point in time during the simulation. This can also be referred to as the cumulative risk or swept path; and
- The maximum instantaneous risk and the total risk can be computed for individual stressors or for all stressors combined. Thus, combined sediment risk is the sum of the individual risks resulting from burial thickness, grain size change, oxygen depletion and toxicity of the cuttings.

4.2 Cuttings Thickness

The model predicts a maximum estimated thickness of cuttings around the wells of 4.650 m (4,650 mm) (Figure 4.1 and Figure 4.2). Significant thicknesses (over 6.5 mm) are predicted to occur over an area of 0.1847 km^2 (up to approximately 950 m from the discharge locations). To put this into context, a typical exclusion zone around a platform of 500 m radius is equivalent to an area of 0.785 km^2. Over time the area where thickness is greater than 6.5 mm gradually reduces, this is discussed in Section 4.3.

Very fine particles (<0.5 mm grain size) will spread over much larger distances, extending beyond the model domain. The distribution of these very fine particles does not change significantly over time.

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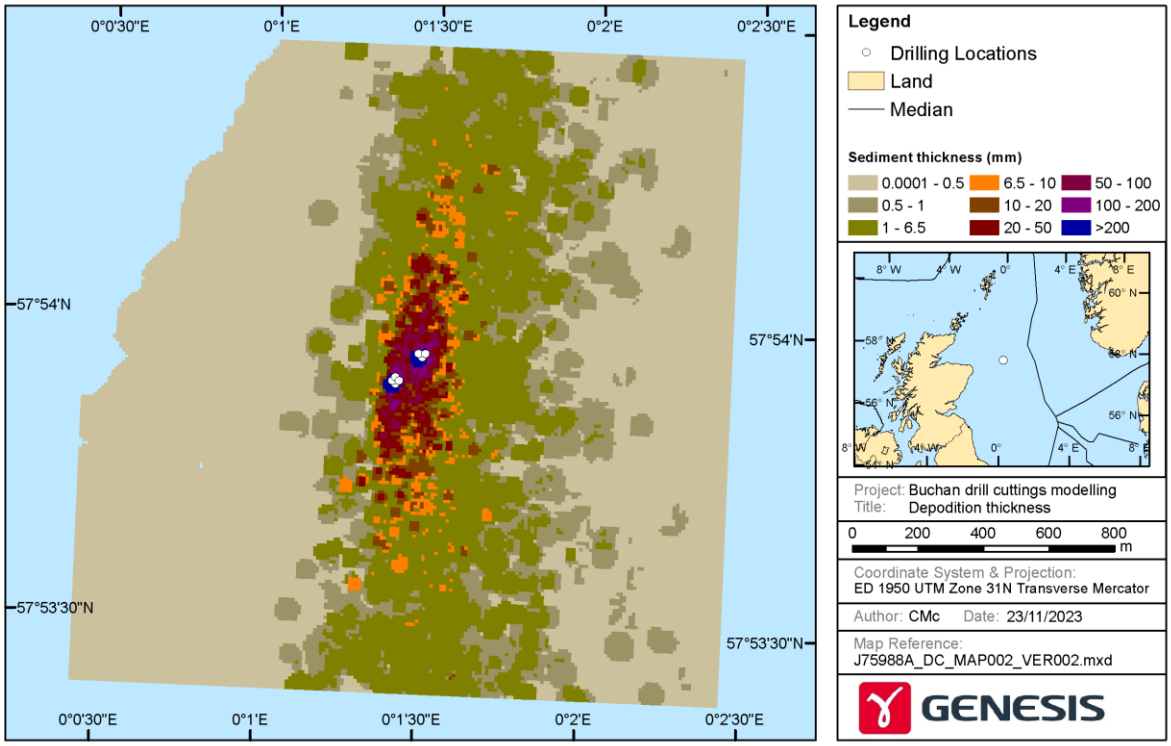
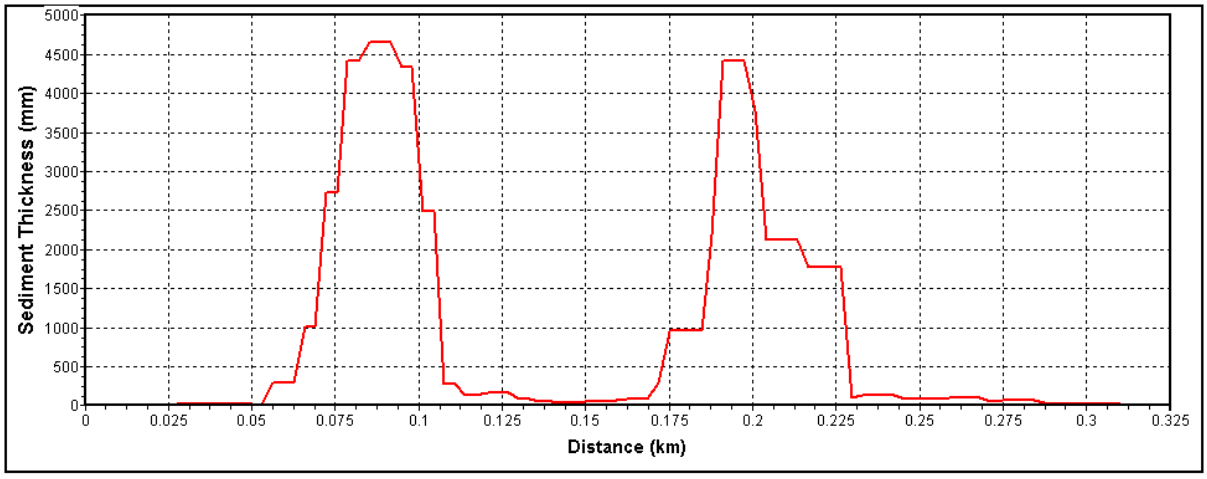


Figure 4.1: Deposition thickness around the drilling location at the end of drilling



Note: Coordinates of cross section: start point (0°01'15"E, 57°53'49"N) and end point (0°01'28"E, 57°53'57"N)

Figure 4.2: Southwest to northeast cross section of deposition thickness at the end of drilling

4.3 Risk to the Seabed Sediment

Risk to the sediment has been modelled for the duration of drilling and over a 10-year period post drilling. The following sections summarise the predicted risk around the well locations as well as the components making up that risk.

As noted in Section 2.2, combined risk to the seabed sediment is made up of risk contributions resulting from the following stressors:

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- Burial thicknesses greater than 6.5 mm;
- A median grain size change greater than 52.7 µm;
- Oxygen content depletion greater than 20%; and
- Toxicity where chemical concentration exceeds the PNEC.

A risk of less than 5% to the most sensitive species is considered to be tolerable. Figure 4.3 shows the total combined risk around the drilling location.

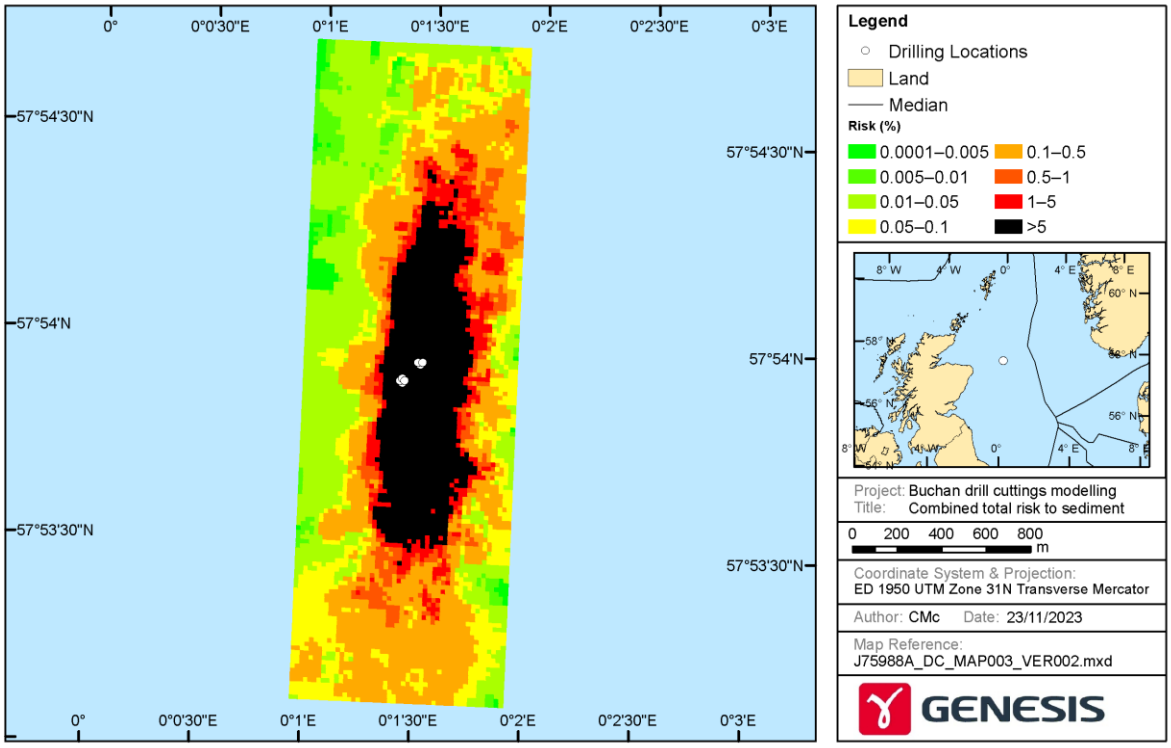


Figure 4.3: Predicted total combined risk to sediments (swept path)

The contribution to the combined risk can be broken down to establish which stressors are the key contributors. This is shown in Figure 4.4.

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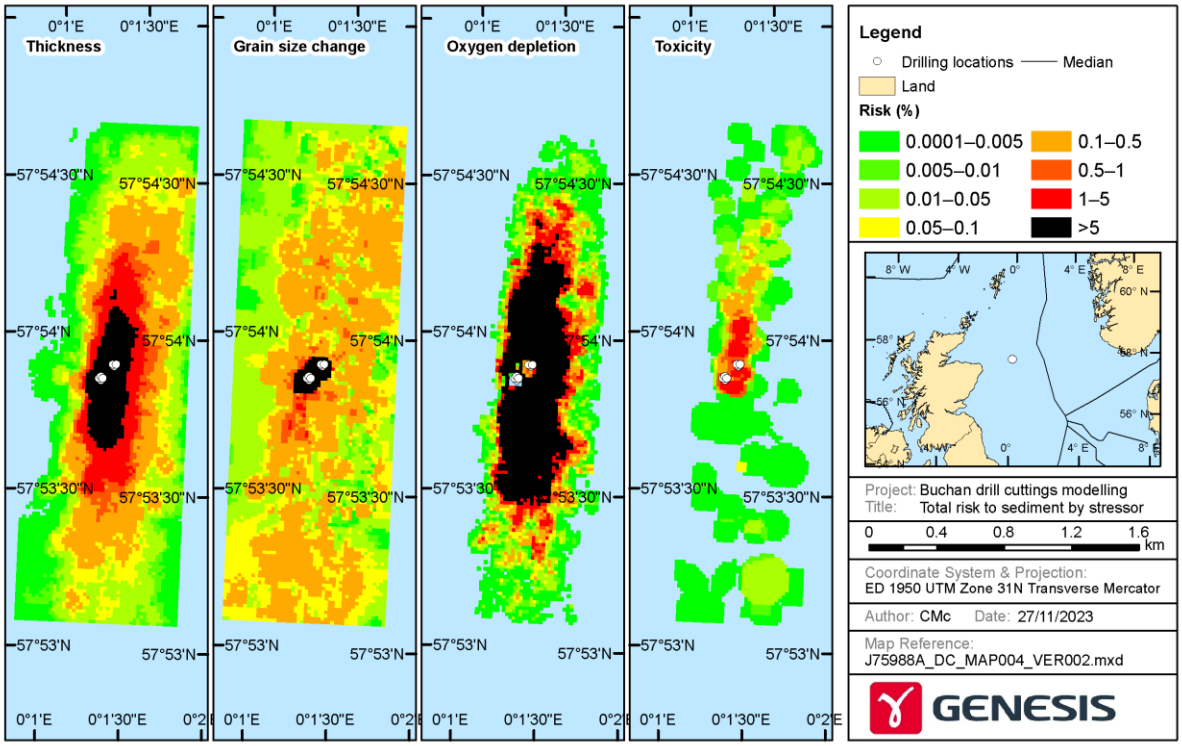


Figure 4.4: Predicted total risk contributions from individual seabed stressors (swept path)

Time-averaged contributions to risk are summarised in Figure 4.5 and Figure 4.6. The main contributor to the risk is oxygen depletion (57.5%). Burial thickness and sediment grain size change contribute to 24.4% and 18.1% respectively. There is minimal contribution (0.1%) from toxicity, from the reservoir oil. This contribution is very limited as there are no added chemicals and only a small mass of SARALINE 185V is discharged after treatment through the rotomill.

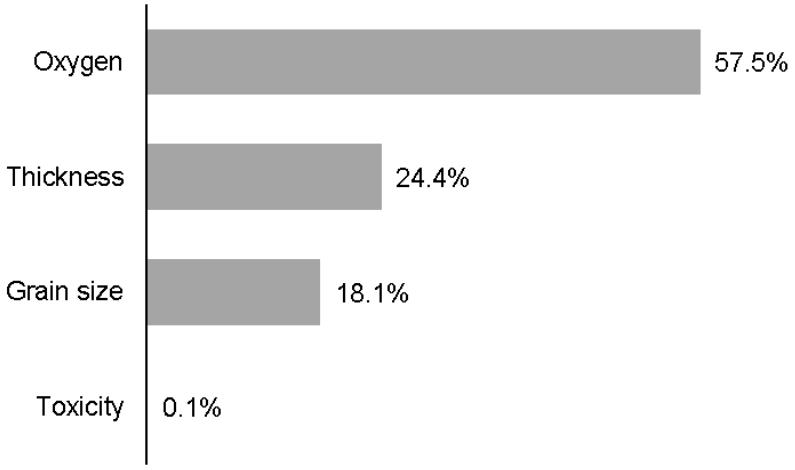


Figure 4.5: Weighted contributions to time-averaged risk

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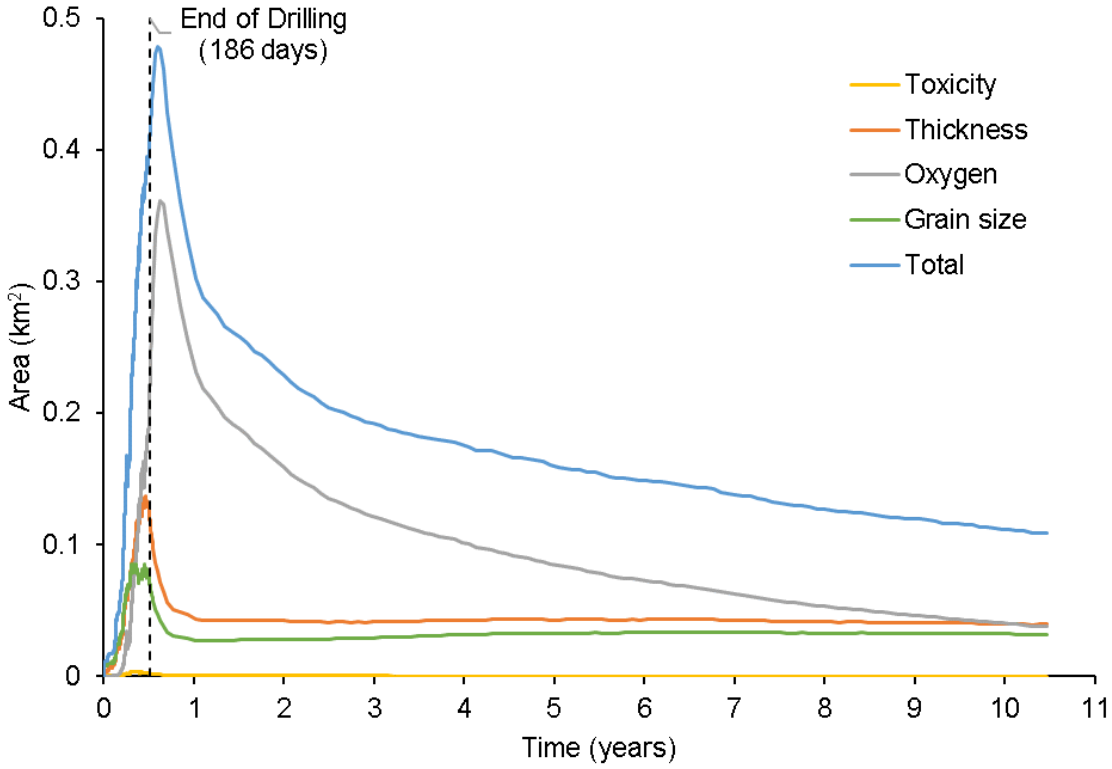


Figure 4.6: Contribution to area where there is risk to more than 5% of sensitive species over whole model period for each sediment stressor

The evolution of predicted combined risk (at 32 days, two years, five years and ten years after the end of drilling) is shown in Figure 4.7 and summarised in Table 4-1.

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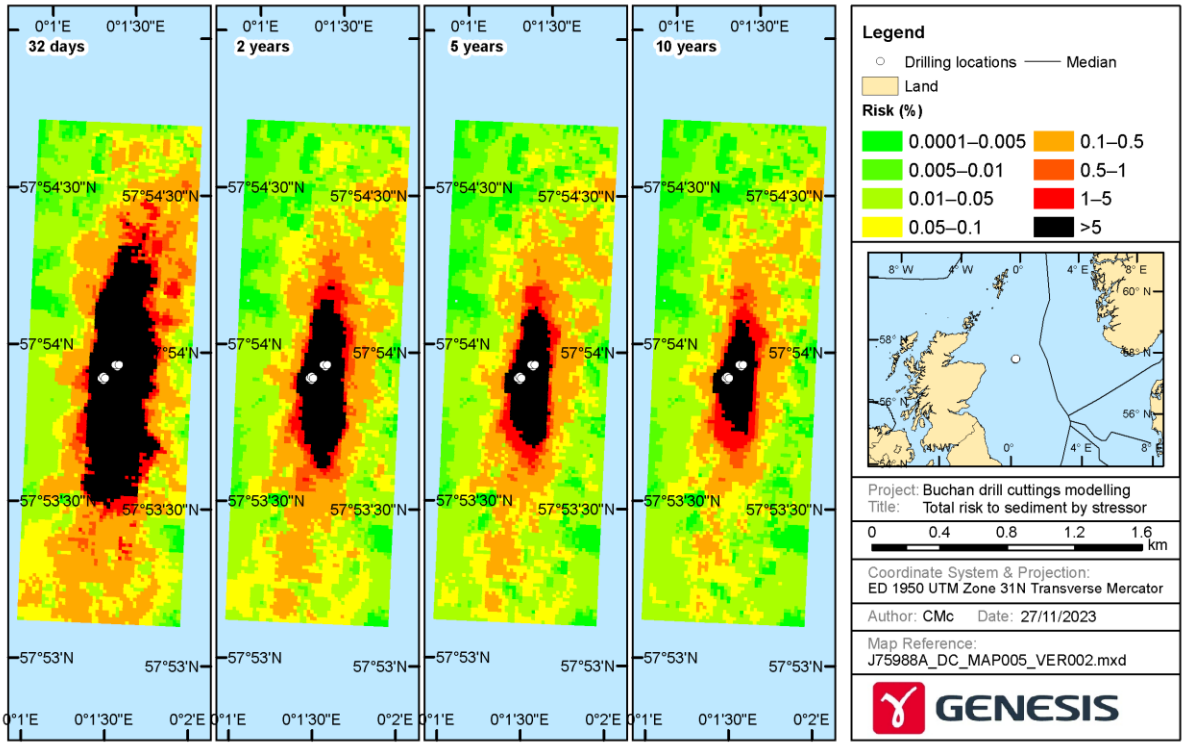


Figure 4.7: Predicted combined risk to the sediment over time

The maximum area where there is a risk to more than 5% sensitive species is 0.478 km^2 32 days after drilling discharges end. The area reduces to 0.204 km^2 after two years, 0.153 km^2 after five years and 0.108 km^2 after ten years.

Table 4-1: Predicted combined risk over time

Time period	Units	Description	Area where combined risk is >5% (km^2)	Percentage change in area (%)
218	days	32 days post drilling (maximum combined risk)	0.478	-
2	years	2 years post drilling	0.204	57.3
5	years	5 years post drilling	0.153	68.0
10	years	10 years post drilling	0.108	77.4

As noted above the main risk stressor as a result of the modelled drilling discharges is oxygen depletion. The maximum extent of risk occurs 32 days after drilling ends and is driven by a continued increase in oxygen depletion (the most dominant stressor) after the end of drilling. This is a result of oxygen being consumed as the reservoir oil breaks down.

It is worth noting that the model calculates the risk resulting from burial thickness based on the areas of the seabed where the thickness of cuttings exceeds 6.5 mm (see Section 2.2). This thickness reduces over time as a result of bioturbation and re-suspension. Both these processes are included in the model. However, the model does not account for recolonization of the sediment over time. Therefore, the area where there is a risk to over 5% of the species is likely to reduce faster than shown and the areas shown in Table 4-1 are conservative.

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4.4 Risk to the Water Column

The total risk in the water column is shown in Figure 4.8. Although the area where the risk to the most sensitive species exceeds 5% appears extensive (14.49 km^3), it should be noted that this plot shows the swept path (that is all areas where risk is greater than 5% at any point in time during the entire model run). In practice the area where risk exceeds 5% at any instance in time would be much smaller than that shown in Figure 4.8. The area of 5% risk and above mostly occurs in the lower water column, as shown in the cross section (Figure 4.9).

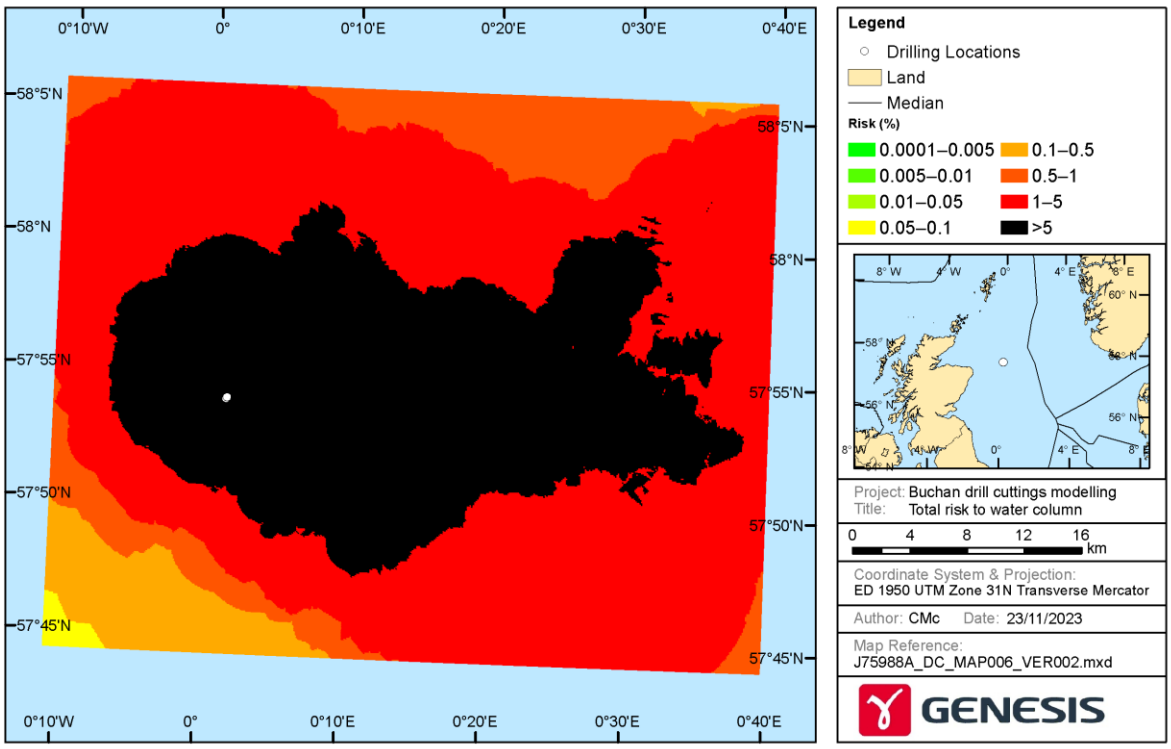


Figure 4.8: Total risk to the water column (swept path)

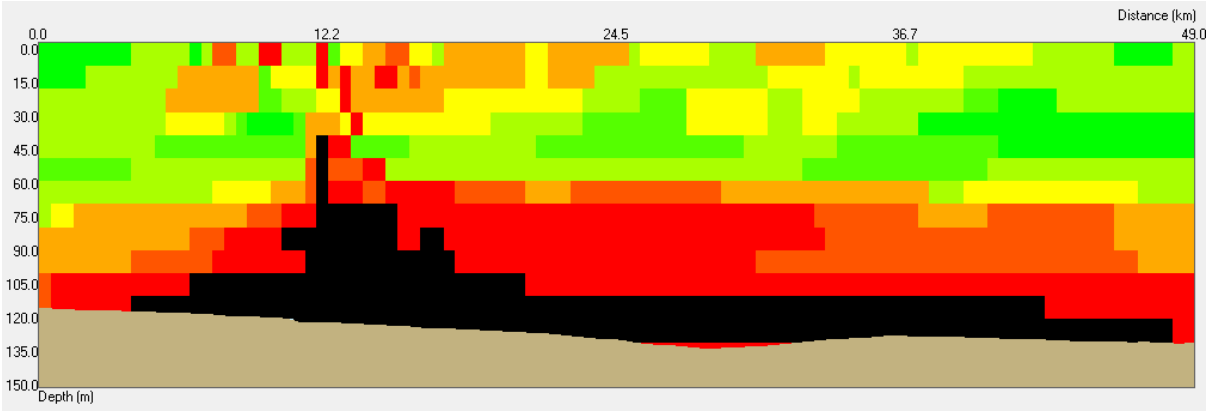


Figure 4.9: West to east cross-section of total risk

Figure 4.10 and Figure 4.11 show a snapshot of risk in the water column at 124 days, 9 hours from the start of drilling. The maximum instantaneous volume where there is a risk to more than 5% of sensitive species is 1.13 km^3. This occurs at 124 days, 9 hours and the risk occurs

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in the lower part of the water column where the cuttings from the tophole section are discharged.

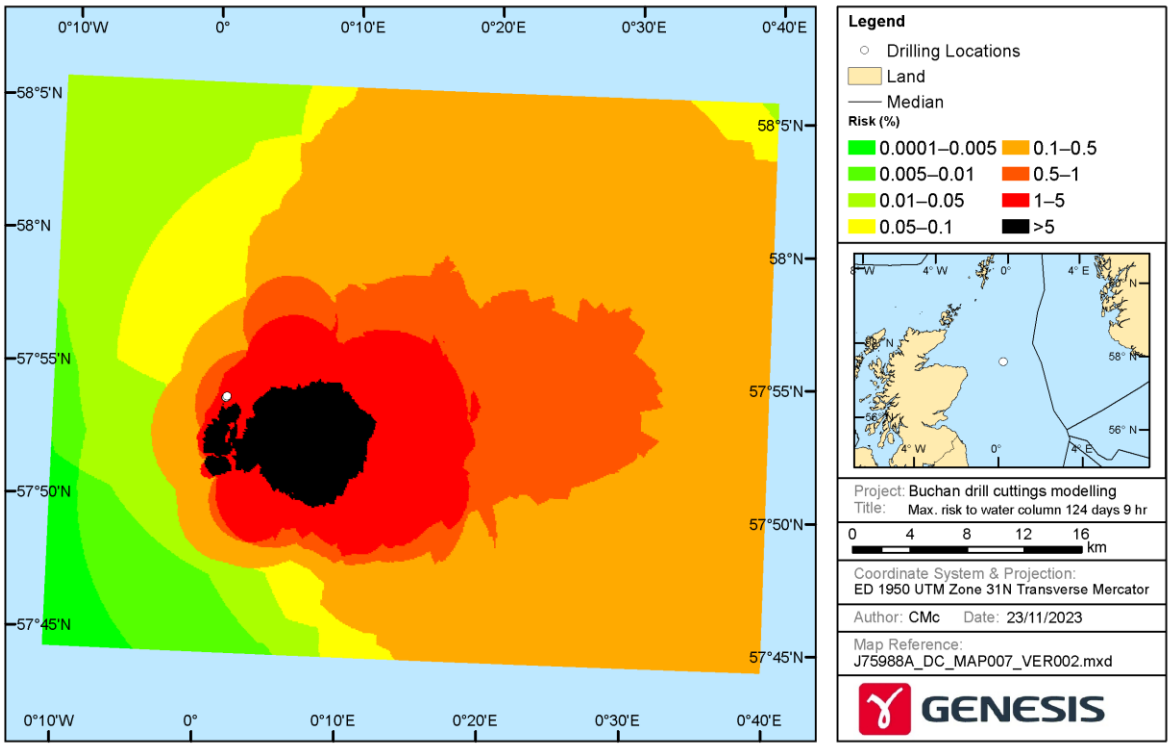


Figure 4.10: Instantaneous risk to the water column after 124 days, 9 hours

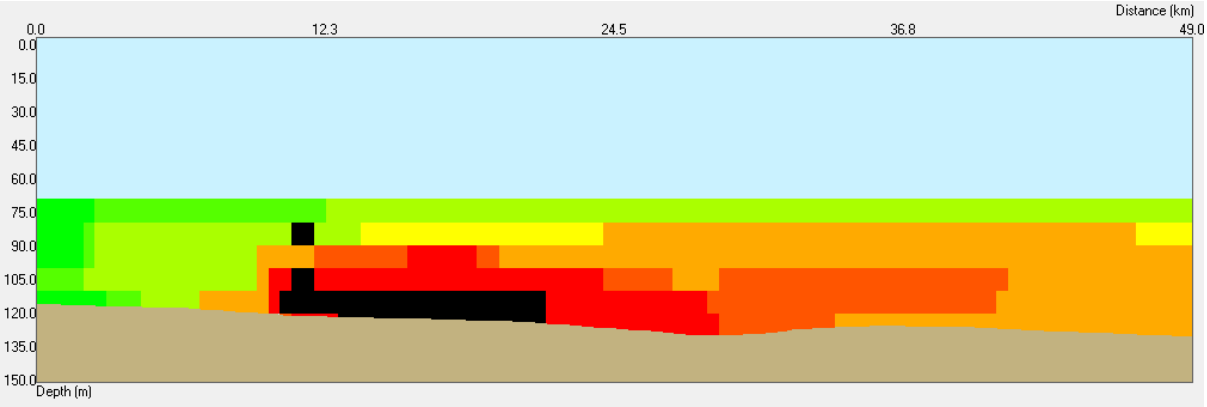


Figure 4.11: West to east cross-sections of instantaneous risk after 124 days, 9 hours

The primary contributors to the water column risk are from barite particles (42.0%), bentonite particles (34.09%) and barite discharged from the rotomill (23.1%) as shown in Figure 4.12.

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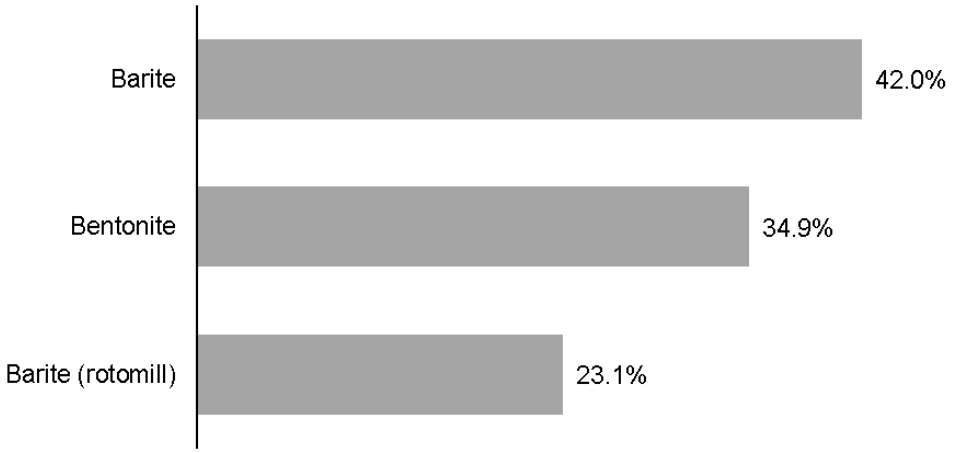


Figure 4.12: Time-averaged contributions to risk in the water column

The volume of water column where there is a risk to over 5% of sensitive species varies over time (Figure 4.13). There is a peak, shortly after drilling each section. The volume at risk reduces to zero after each well and disappears completely within 24 hours of the end of drilling.

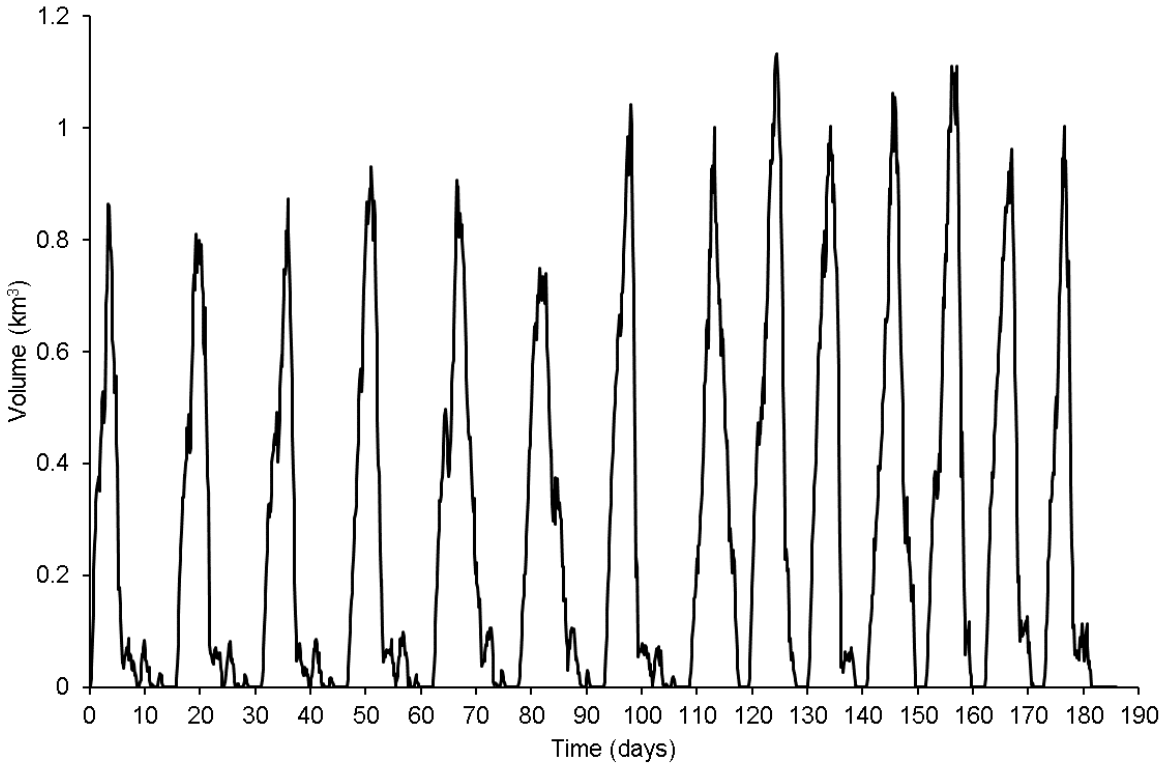


Figure 4.13: Volume of water where there is risk to over 5% of species over time

4.5 Summary of Outputs

Model outputs are summarised in Table 4-2. The potential impact to the seabed covers a relatively small area. The key contributor to risk in sediments is oxygen depletion. Ten years

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after the end of drilling the risk to the seabed is reduced to an area of 0.108 km^2. The potential risk to the water column is transient, disappearing shortly after the discharge stops.

Table 4-2: Summary of model outputs

Model output	Criteria	Value
Cuttings deposition		
Thickness	Maximum thickness - end of drilling (m)	4.650
	Area where thickness >6.5 mm - end of drilling (km^2)	0.1847
Risk to sediment		
Thickness (%)	>6.5 mm	24.37
Grain size (%)	>52 µm	18.07
Oxygen depletion (%)	>20%	57.48
Toxicity (reservoir oil) (%)	Toxicity (PNEC exceeded)	0.08
Toxicity (base oil, SARALINE 185V) (%)	Toxicity (PNEC exceeded)	0.00
Area where there is a total combined risk (>5%) to the most sensitive species (km^2)	32 days (after end of drilling)	0.478
	2 years (after end of drilling)	0.204
	5 years (after end of drilling)	0.153
	10 years (after end of drilling)	0.108
Risk to water column		
Bentonite (%)	Physical effect of particles	34.86
Barite (%)	Physical effect of particles	41.99
Cuttings (%)	Physical effect of particles	0.00
Rotomill barite (%)	Physical effect of particles	23.11
Rotomill cuttings (%)	Physical effect of particles	0.02
Toxicity of base oil (SARALINE 185V) (%)	Toxicity (PNEC exceeded)	0.00
Toxicity of reservoir oil (%)	Toxicity (PNEC exceeded)	0.02
Volume where combined risk to >5% most sensitive species (km^3)	Maximum instantaneous volume	1.13
	Total volume (swept path)	14.49

Note: for comparison 500 m safety zone area is equivalent to 0.785 km^2

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5.0 CONCLUSIONS

Cuttings modelling was undertaken using DREAM to predict environmental risks to the seabed and the water column as a result of the discharge of cuttings during drilling of seven proposed development wells (five production and two water injection) in Block 21/1 using SW sweeps in the top two sections and LTOBM for subsequent sections of the well and the resulting cuttings are treated using a TCC prior to being discharged 10 m below the sea surface.

The maximum estimated deposited sediment thickness (cuttings pile height) was 4.65 m, in the immediate vicinity of the wells, reducing rapidly with distance from the discharges.

The following risks were predicted:

- The model predicted that the deposited cuttings from drilling could result in a risk to more than 5% sensitive species in a maximum area of seabed sediment of 0.478 km^2 32 days after the end of drilling. This represents a relatively small area of seabed (always within the 500 m safety zone), which reduces significantly over time, to 0.153 km^2 five years after drilling ends then to 0.108 km^2 ten years after drilling ends; though in reality re-colonisation by benthic organisms would result in a faster seabed recovery.
- The risk to the sediment mainly results from oxygen depletion (57.5%).
- The volume of the water column where there is a risk to over 5% sensitive species reaches up to 1.13 km^3 at any one point in time but is transient in time and space. The risk to the water column disappears within 24 hours of the cessation of drilling.
- The primary contributors to the water column risk are from barite (42.0%), bentonite (34.09%) and rotomill barite (23.1%).

The risks identified from the modelling are used within the ES to assess environmental impacts (see Sections 8 and 9).

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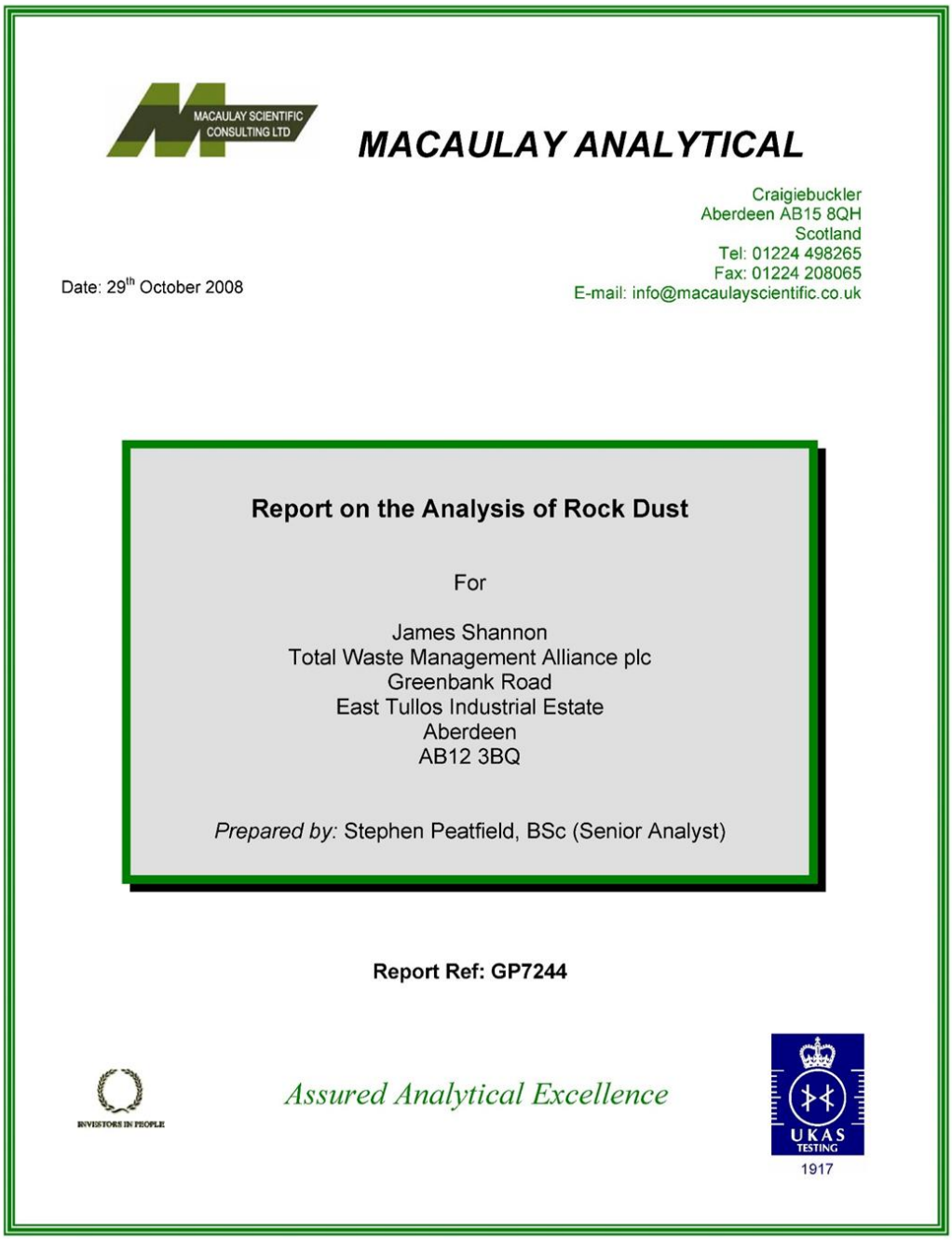
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APPENDIX A PARTICLE SIZE DISTRIBUTION FOR CUTTINGS AFTER THERMAL DESORPTION



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Date: 29th October 2008

Report on the Analysis of Rock Dust

For

James Shannon
Total Waste Management Alliance plc
Greenbank Road
East Tullos Industrial Estate
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AB12 3BQ

Prepared by: Stephen Peatfield, BSc (Senior Analyst)

Report Ref: GP7244

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Result Analysis Report

Laboratory Code
PHD Powder 22/10 952015

Measured:
24 October 2008 08:25:17

Sample Source & type:
Supplier = Total Waste Management

Measured by:
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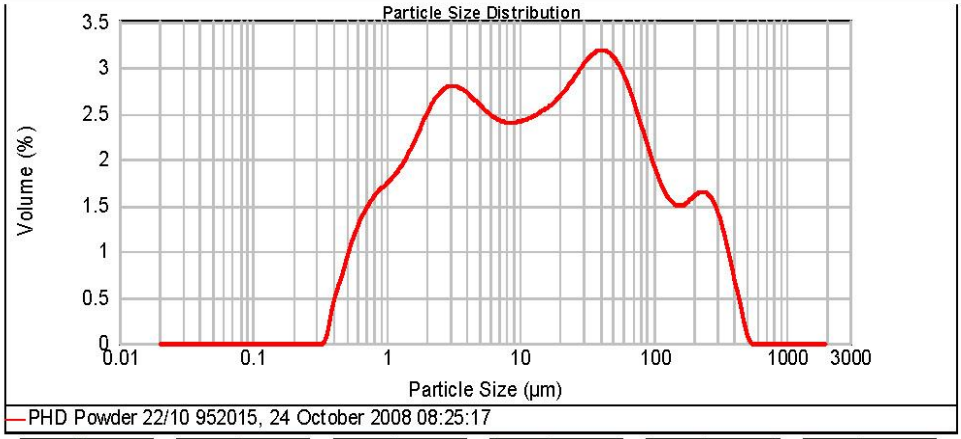
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Sample bulk lot ref:
952015 = Run 1

Result Source:
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Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 11.81 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.612 %	**Result Emulation:** Off
Concentration: 0.0075 %Vol	**Span :** 10.408	**Uniformity:** 3.11	**Result units:** Volume
Specific Surface Area: 1.61 m²/g	**Surface Weighted Mean D[3,2]:** 3.715 um	**Vol. Weighted Mean D[4,3]:** 48.725 um	

d(0.1): 1.219 um **d(0.5): 14.249 um** **d(0.9): 149.525 um**



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	7.70	7.096	38.91	50.238	73.90	355.656	98.62
0.022	0.00	0.159	0.00	1.125	9.04	7.962	40.73	56.368	76.21	399.052	99.32
0.025	0.00	0.178	0.00	1.262	10.43	8.934	42.53	63.246	78.42	447.744	99.78
0.028	0.00	0.200	0.00	1.416	11.90	10.024	44.35	70.963	80.48	502.377	99.99
0.032	0.00	0.224	0.00	1.589	13.47	11.247	46.17	79.621	82.38	563.677	100.00
0.036	0.00	0.252	0.00	1.783	15.15	12.619	48.02	89.337	84.11	632.456	100.00
0.040	0.00	0.283	0.00	2.000	16.96	14.159	49.90	100.237	85.66	709.627	100.00
0.045	0.00	0.317	0.00	2.244	18.89	15.887	51.80	112.468	87.04	796.214	100.00
0.050	0.00	0.356	0.00	2.518	20.90	17.825	53.74	126.191	88.30	893.367	100.00
0.056	0.00	0.399	0.19	2.825	22.98	20.000	55.73	141.589	89.46	1002.374	100.00
0.063	0.00	0.448	0.62	3.170	25.09	22.440	57.78	158.866	90.59	1124.683	100.00
0.071	0.00	0.502	1.22	3.557	27.19	25.179	59.90	178.250	91.73	1261.915	100.00
0.080	0.00	0.564	2.01	3.991	29.27	28.251	62.10	200.000	92.90	1415.892	100.00
0.089	0.00	0.632	2.95	4.477	31.30	31.698	64.38	224.404	94.12	1588.656	100.00
0.100	0.00	0.710	4.02	5.024	33.28	35.566	66.73	251.785	95.36	1782.502	100.00
0.112	0.00	0.796	5.18	5.637	35.20	39.905	69.12	282.508	96.57	2000.000	100.00
0.126	0.00	0.893	6.42	6.325	37.08	44.774	71.52	316.979	97.68		

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Appendix D – Underwater Noise Modelling Report

REPORT

Underwater Noise Modelling Report

Prepared for: **NEO Energy**

Prepared by: **Genesis Energies**
www.genesisenergies.com

Project Title: **Buchan Redevelopment Project Environmental Statement**
Document/Rev No: 215914C-000-RT-6200-0002/0
Client Document No.: BUC000-BUC-EV-RE-0002

Rev	Date	Description	Issued by	Checked by	Approved by	Client Approval
1A	20/09/2023	Issued for IDC	RFr	AMi	AMi	
A	21/09/2023	Issued for client review	RFr	AMi	AMi	
0	11/10/2023	Issued for use	RFr	AMi	AMi	

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ABBREVIATIONS

°C	Degrees centigrade
dB	Decibel
dB re 1 µPa	Decibels relative to one micropascal
dB re 1 µPa m	Decibels relative to one micropascal metre
dB re 1 µPa^{2}s	Decibels relative to one micropascal square second
dB re 1 µPa^2 m^2 s	Decibels relative to one micropascal metre square second
EMODnet	European Marine Observation Data network
FARAM	Faunal Acoustic Risk Assessment Model
FPSO	Floating, Production, Storage and Offloading
g/kg	Grams per kilogram
HESS	High Energy Seismic Survey
HF	High Frequency
Hz	Hertz
JNCC	Joint Nature Conservation Committee
kg/m^3	Kilograms per cubic metre
kJ	Kilojoule
km	Kilometres
km^2	Square kilometre
LF	Low Frequency
m	Metre
m/s	Metres per second
MF	Mid Frequency
MMO	Marine Mammal Observer
ms	Milliseconds
MWA	Mid-water Arch
NMFS	National Marine Fisheries Service
PAM	Passive Acoustic Monitoring
PLEM	Pipeline End Manifold
PTS	Permanent Threshold Shift
RAM	Range-dependent Acoustic Model
rms	Root Mean Square
SEL	Sound Exposure Level

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SPL	Sound Pressure Level
UTM	Universal Transverse Mercator
VHF	Very High Frequency
WOA	World Ocean Atlas

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1.0 INTRODUCTION

1.1 Project Background

As part of the Buchan Redevelopment Project, piling will be required for the installation of anchors for the Floating, Production, Storage and Offloading (FPSO) vessel, mid-water arch (MWA) foundation, subsea manifold, riser base, and Ettrick pipeline end manifold (PLEM). It is estimated that installation of the FPSO anchors will require the largest hammer energy and will therefore have the largest potential impact to marine receptors. The location of the FPSO anchor piling is shown in Figure 1-1.

This report presents underwater noise modelling results for assessing potential impacts that the FPSO anchor piling may have on marine mammals and fish in the region of the project location.

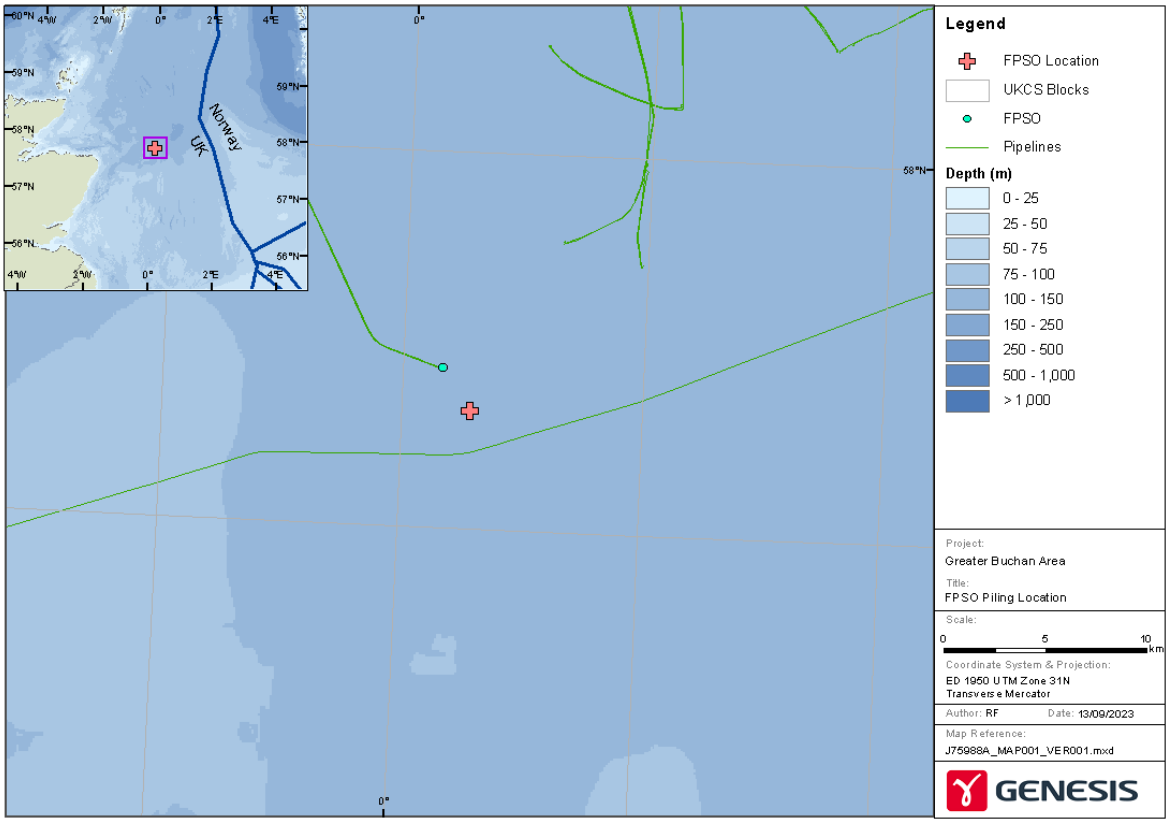


Figure 1-1: Buchan Redevelopment Project location.

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1.2 FPSO Anchors Piling

The hammer energy required to drive the FPSO anchor piles is expected to be larger than that required for other piling operations associated with the Buchan Redevelopment Project and is expected to generate the highest levels of underwater noise. The underwater noise modelling therefore focuses on predicting received noise levels from the FPSO anchor piling. Details of the modelled piling scenario are shown in Table 1-1. Twelve FPSO anchor piles will be installed, with each pile being 35 m in length and driven to a required penetration depth of 35 m. It is expected that each pile will be installed in 75 minutes, and that a maximum of five piles will be installed in a single day. The maximum hammer energy used throughout the piling will be 1,200 kJ. In the modelling it has been assumed that the impact hammer will commence at a soft start hammer energy of 120 kJ for a duration of 20 minutes.

Table 1-1: Details of modelled piling scenario.

Parameter	Value
Number of piles to be installed	12
Duration to install a single pile	75 minutes
Maximum number of piles installed in any 24-hour period	5
Pile diameter	2.0 m
Pile length	35 m
Pile penetration depth	35 m
Soft start hammer energy	120 kJ
Soft start duration	20 minutes
Maximum hammer energy	1,200 kJ

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2.0 MODELLING METHODOLOGY

This section discusses the modelling methodology adopted to estimate potential impacts from the FPSO anchor piling associated with the Buchan Redevelopment Project.

2.1 Source Characterisation

A pile under percussive driving is a complex underwater acoustic source. The noise levels generated during piling depend on many factors, such as hammer energy, mechanical properties and dimensions of the pile, water depth, and seabed properties. The hammer energy has the biggest influence on the underwater noise levels generated, with higher energy hammers generating higher noise levels (Robinson *et al*., 2007).

To derive source levels for use in the piling noise modelling, a representative third octave band sound exposure level (SEL) frequency spectrum measured during piling with an 800 kJ hammer (Ainslie *et al*., 2012) has been used. The SEL frequency spectrum from Ainslie *et al*., (2012) has been scaled to account for the different hammer energies that will be used during piling of the FPSO anchors for the Buchan Redevelopment Project. It has been assumed that the SEL scales linearly with hammer energy, which has been demonstrated by measurements made throughout the soft start and energy ramp up during piling (Robinson *et al.*, 2007). In the modelling, it has been assumed that the piling will commence with a soft start where the hammer operates at 10% of the maximum hammer energy (i.e., at 120 kJ). The soft start is assumed to be conducted for a period of 20 minutes in line with the Joint Nature Conservation Committee (JNCC) guidelines for minimising impacts from piling noise (JNCC, 2010). After the soft start, the hammer energy is assumed to be periodically increased until maximum energy is reached. The scaled third octave band SEL spectra for the different hammer energies that have been used in the modelling are shown in Figure 2-1.

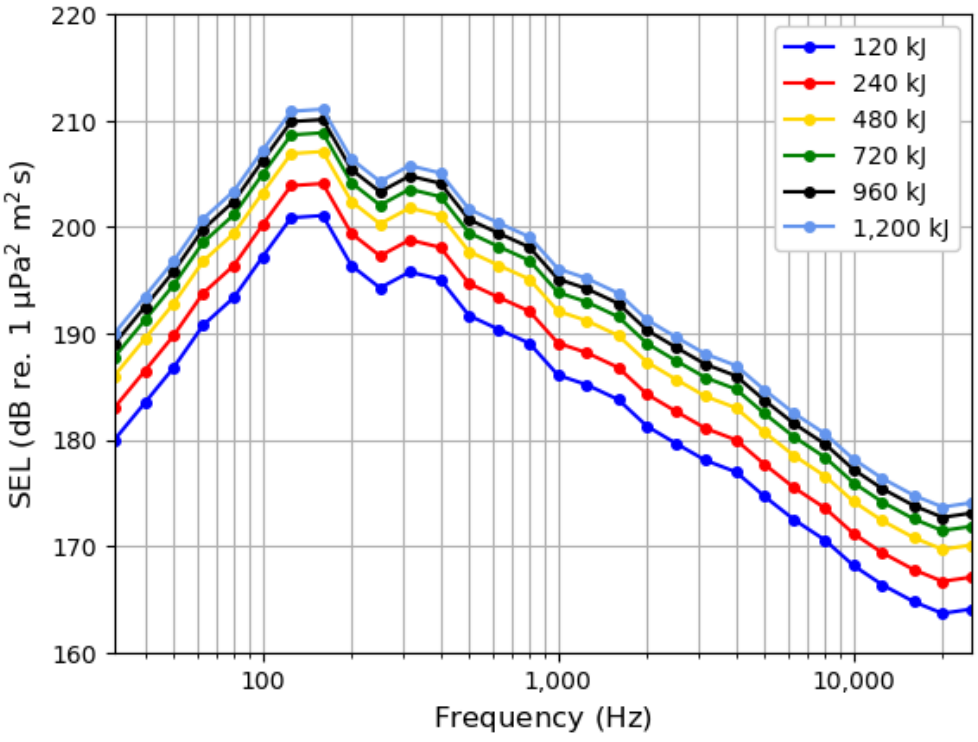


Figure 2-1: Third octave band SEL spectra used in the piling modelling.

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The piling soft start and ramp up procedure used in the modelling is shown in Table 2-1, which shows the SEL and zero-to-peak sound pressure level (SPL) source levels used in the modelling for different hammer energies. The maximum blow rate of 38 blows/minute is based on the blow rate of an IHC S-1200 hammer (IHC Merwede, 2023).

Table 2-1: Piling procedures and broadband source levels assumed in the modelling.

Hammer Energy (kJ)	Duration (minutes)	Strike Rate (blows/minute)	Source Level	
			Zero-to-peak SPL (dB re 1 µPa m)	SEL (dB re 1 μPa^2m^2s)
120	20	10	232.2	207.2
240	10	38	235.2	210.3
460	10	38	238.2	213.3
720	10	38	240.0	215.0
960	10	38	241.3	216.3
1,200	34	38	242.2	217.2

2.2 Noise Propagation Modelling

There are various algorithms that can be used for underwater noise propagation modelling such as parabolic equation, ray tracing, normal mode, wavenumber integration, energy flux density and semi-empirical algorithms (Jensen *et al.,* 2011). The Genesis in-house modelling software FARAM (Faunal Acoustic Risk Assessment Model) has been used in this study. FARAM employs the parabolic equation and ray tracing algorithms developed by Collins (1993) and Porter and Liu (1994), respectively, for estimating received sound levels from various noise sources. When estimating received sound levels, FARAM incorporates:

- A site-specific bathymetric grid to account for the influence of varying bathymetry on noise propagation;
- Site-specific range and depth dependent water column temperature, salinity, and sound speed profiles based on modelled hydrological conditions;
- Acoustic properties of the predominant seabed sediments in the modelling area;
- Frequency dependent propagation effects (e.g., volume attenuation, reflection, scattering at different frequencies);
- Specific properties of the airgun array under consideration (e.g., spectral content, directivity, pulse interval, tow speed and trajectory);
- Auditory weighting functions that characterise the hearing ability of different marine mammal hearing groups;
- Movement of mobile marine receptors (e.g., swim speed, depth and trajectory) when calculating received cumulative SEL; and
- The most up-to-date thresholds for assessing potential impacts to marine fauna.

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2.2.1 Parabolic Equation Algorithm

Parabolic Equation models approximate the wave equation, allowing a solution to be found computationally (Jensen *et al.,* 2011). This is one of the most popular wave-theory techniques for modelling sound propagation in spatially varying environments (Jensen *et al.,* 2011). The computational scheme used in FARAM is the Range-dependent Acoustic Model (RAM) developed by Collins (1993). The RAM algorithm incorporates acoustic propagation effects resulting from varying bathymetry, range dependent sound speed depth profiles, and geo-acoustic properties.

The RAM algorithm is best suited to calculation of low frequency sound propagation since the computational complexity and implementation time significantly increases with frequency. The RAM algorithm is therefore generally restricted to modelling the propagation characteristics of low frequency sound sources, since modelling of high frequencies becomes prohibitively time consuming. Given this restriction, the RAM algorithm has been used for computation of very low frequency (<100 Hz) sound propagation. For higher frequencies (≥ 100 Hz), a ray tracing algorithm has been utilised for sound propagation. The ray tracing method that has been used for modelling higher frequencies is the Bellhop Gaussian beam ray tracing model (Porter and Liu, 1994).

2.2.2 Ray Tracing Algorithm

For modelling sound propagation of higher frequencies, the Bellhop Gaussian beam ray tracing algorithm (Porter and Liu, 1994) has been used. Bellhop is a ray tracing algorithm that is well suited for the modelling of higher frequency sound sources. However, it can also provide accurate results for low frequency propagation in certain circumstances. Bellhop incorporates acoustic propagation effects resulting from varying bathymetry, range dependent sound speed depth profiles, and geo-acoustic properties. Bellhop also accounts for increased sound attenuation due to volume absorption at higher frequencies.

2.2.3 Environmental Data

FARAM accounts for various site-specific environmental properties including a bathymetric grid, geographically and depth varying sound speed profiles and geo-acoustic properties of the sediment. To model the effects of these properties, input data is required that describes the surrounding environment.

2.2.3.1 Bathymetry

Accurate bathymetry data is important for propagation modelling since the seabed strongly influences the propagation characteristics of sound. In shallow water regions, there is significant interaction of the sound with the seabed through reflections and scattering effects, and strong attenuation may occur as sound penetrates the seabed. In deep water regions, there is typically less interaction of sound with the seabed and attenuation due to bottom loss is small, which can result in longer propagation distances.

The bathymetry data that has been used in FARAM (Figure 2-2) is provided by EMODnet, which is a high-resolution digital terrain model for European Seas (EMODnet Bathymetry Consortium, 2020). The EMODnet bathymetry is based on almost 10,000 datasets obtained from bathymetric surveys, with bathymetric data provided at a spatial resolution of 1/16 arc minutes.

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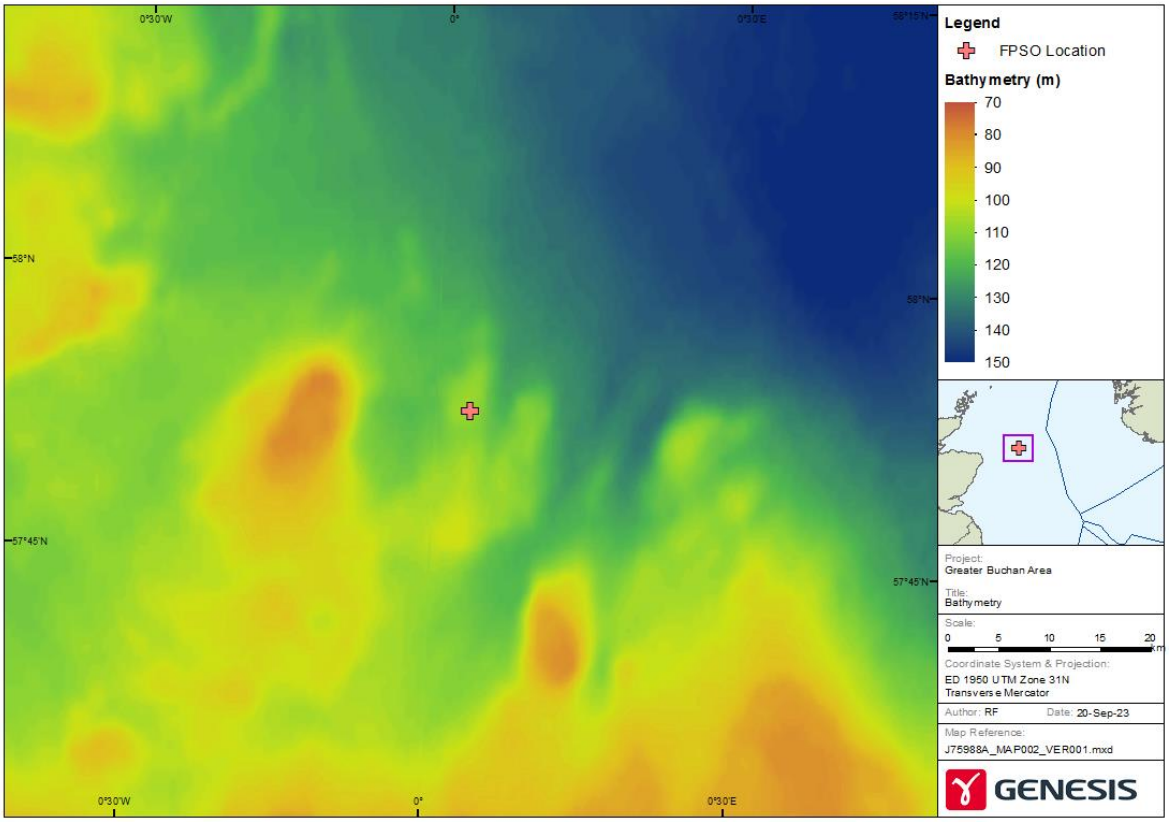


Figure 2-2: Bathymetry in the region of the FPSO anchor piling location.

2.2.3.2 Seabed Properties

FARAM accounts for attenuation effects due to interactions with the seabed. Sediments in the region of the FPSO anchor piling location are shown in Figure 2-3 (Vasquez *et al.,* 2021). The main sediment types in the region are muds and sands. FARAM is limited to modelling a single seabed substrate. A sandy seabed has been assumed in the model. This is likely to be conservative since harder sediments such as sands typically result in longer range propagation compared to softer sediments such as silts and muds (Jensen *et al.*, 2011). The geo-acoustic properties associated with the seabed that have been used in the modelling are shown in Table 2-2 (Jensen *et al.*, 2011).

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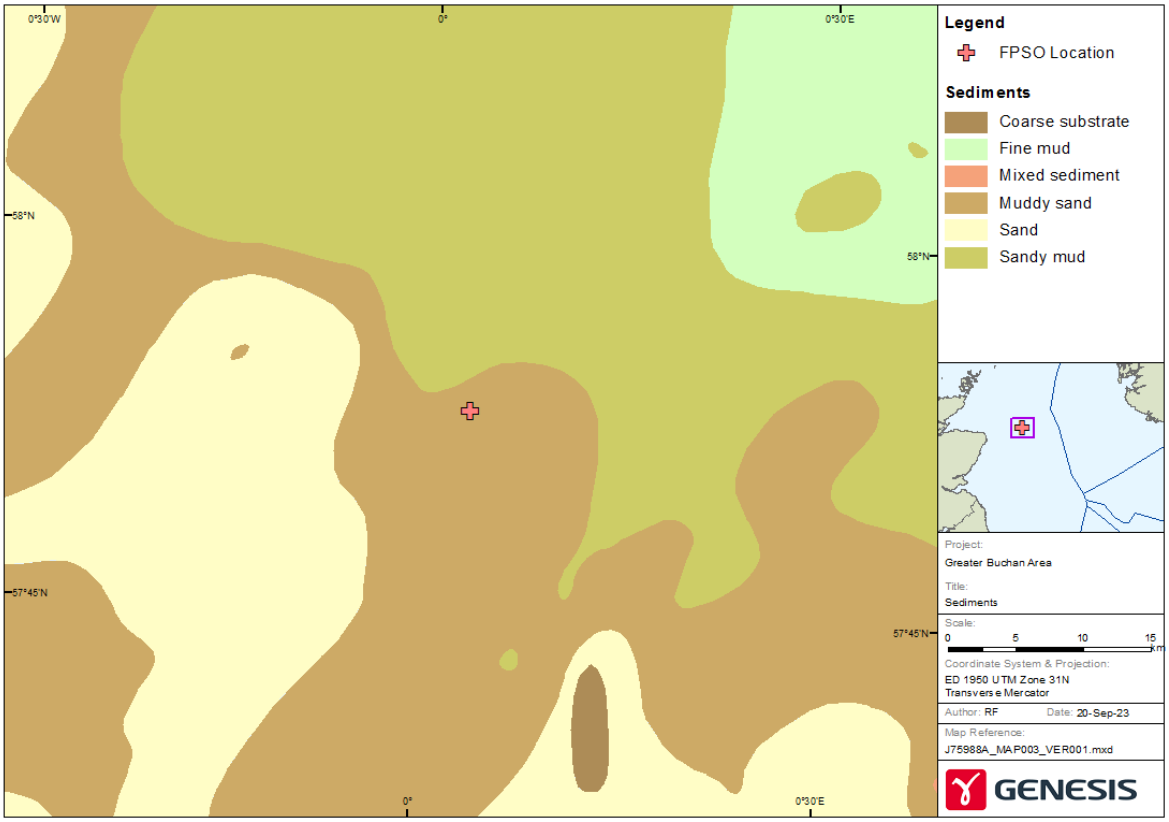


Figure 2-3: Sediments in the region of the FPSO anchor piling location.

Table 2-2: Geo-acoustic parameters of the seabed that have been used in the model.

Parameter	Value
Sediment type	Sand
Sound speed in sediment	1,650 m/s
Sound attenuation in sediment	0.8 dB/wavelength
Sediment density	1,900 kg/m^3

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2.2.3.3 Sound Speed

A major factor that influences sound propagation in water is the speed of sound through the water column, which influences how sound refracts as it propagates through the water. FARAM allows for geographically and depth varying sound speed profiles. Sound speed profiles can be derived from water column temperature and salinity profiles (Jensen *et al*., 2011). Sound speed profiles for the model location were derived from temperature and salinity profiles taken from the World Ocean Atlas (WOA, 2013) database. Example temperature, salinity, and sound speed profiles used in the modelling are shown in Figure 2-4.

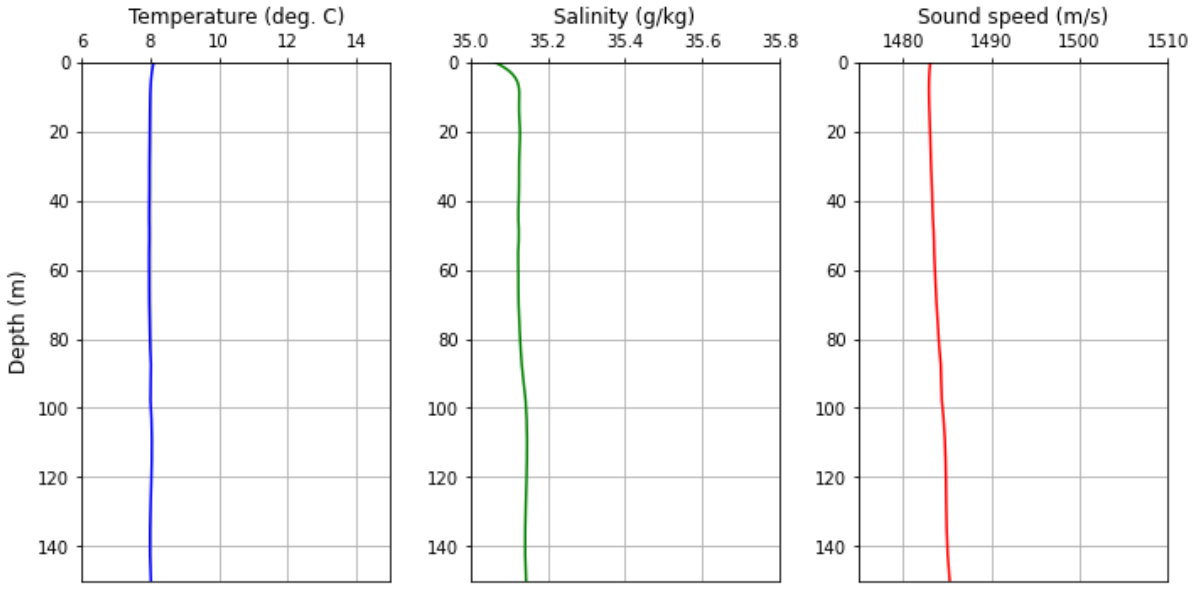


Figure 2-4: Example temperature, salinity, and sound speed depth profiles used in the modelling.

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3.0 IMPACT ASSESSMENT METHODOLOGY

Sound is important to marine mammals and fish for navigation, communication, predator avoidance and prey detection. Underwater noise generated by human activities can have an adverse impact on marine mammals and fish (Richardson *et al.,* 1995; Southall *et al.,* 2007, 2019, 2021; National Marine Fisheries Service (NMFS), 2018; Popper *et al.,* 2014). The thresholds adopted in this report for assessing potential impacts to marine mammals and fish are based on a comprehensive review of evidence of underwater noise impacts.

3.1 Marine Mammals

Potential impacts to marine mammals have been assessed in this report using thresholds for permanent threshold shift (PTS) and behavioural disturbance. PTS is a permanent change in a marine mammal's hearing sensitivity, whilst behavioural disturbance can vary from low level disturbance such as small changes in normal behaviour to higher levels of disturbance such as displacement from a favourable area.

3.1.1 PTS

Thresholds for PTS been suggested by NMFS (2018) and Southall *et al.* (2019). The PTS thresholds proposed by NMFS (2018) and Southall *et al.* (2019) are based on the most recent studies and are recognised as appropriate criteria for assessing potential impacts to marine mammals from underwater noise.

Both NMFS (2018) and Southall *et al.* (2019) proposed grouping marine mammals into different hearing groups for assessing potential impacts. NMFS (2018) group marine mammals into low-frequency (LF) cetaceans, mid-frequency (MF) cetaceans, high-frequency (HF) cetaceans, phocid pinnipeds, otariid pinnipeds, and sirenians. Southall *et al.* (2019) proposed equivalent hearing groups but named the cetaceans groups as LF cetaceans, HF cetaceans, and very high-frequency (VHF) cetaceans. Despite the difference in naming, the hearing groups proposed by NMFS (2018) and Southall *et al.* (2019) are equivalent and include the same marine mammal species. Furthermore, the PTS thresholds proposed by NMFS (2018) and Southall *et al.,* (2019) are identical. The PTS thresholds proposed by NMFS (2018) and Southall *et al.* (2019) are shown in Table 3-1 for the hearing groups that are relevant to the North Sea. The most sighted marine mammal species in the North Sea (Reid *et al.,* 2003; Hammond *et al.,* 2021; Waggitt *et al.,* 2019; Russel *et al.,* 2017) are also shown in Table 3-1 categorised according to the different hearing groups.

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Table 3-1: Marine mammal hearing groups and PTS thresholds.

Hearing Group		Species [1]	PTS Threshold	
NMFS (2018)	Southall *et al.* (2019)		Zero-to-peak SPL (dB re 1 µPa)	Cumulative SEL (dB re 1 µPa^{2}s)
LF cetaceans	LF cetaceans	Minke whale	219	183
MF cetaceans	HF cetaceans	White-beaked dolphin, white-sided dolphin, bottlenose dolphin, Risso's dolphin, striped dolphin, pilot whale, beaked whale, common dolphin, killer whale	230	185
HF cetaceans	VHF cetaceans	Harbour porpoise	202	155
Phocid pinnipeds	Phocid pinnipeds	Grey seal, harbour seal	218	185

[1] Species listed are the most sighted marine mammal species in the North Sea (Hammond *et al.*, 2017; Waggitt *et al.*, 2019; Reid *et al.*, 2003; Russell *et al.*, 2017). Species highlighted in bold are those that are more likely to be present in the region of the project area.

The PTS thresholds shown in Table 3-1 are expressed in terms of both zero-to-peak SPL and cumulative SEL metrics. As dual-metric criteria, the onset of PTS is considered to potentially occur when either of the thresholds are exceeded (NMFS, 2018; Southall *et al.,* 2019). The zero-to-peak SPL thresholds are 'unweighted' and do not take into consideration the hearing range of any marine mammals. In contrast, the cumulative SEL threshold is 'weighted' (considers the hearing capabilities of the marine mammal hearing groups by weighting received SEL using generalised auditory weighting filters) and accumulated over a 24-hour period. The auditory weighting functions proposed by NMFS (2018) and Southall *et al.* (2019) for the different marine mammal hearing groups are the same and are shown in Figure 3-1 (note that the Southall *et al.* (2019) nomenclature is used in this figure).

In the remainder of this report, the Southall *et al.* (2019) terminology with regards to the naming of marine mammal hearing groups is used. However, it is important to note that the NMFS (2018) threshold values and auditory weighting functions are the same for the comparative groups as those proposed in Southall *et al.* (2019). Therefore, the adoption of the Southall *et al.* (2019) guidance or NMFS (2018) guidance provides the same impact assessment results.

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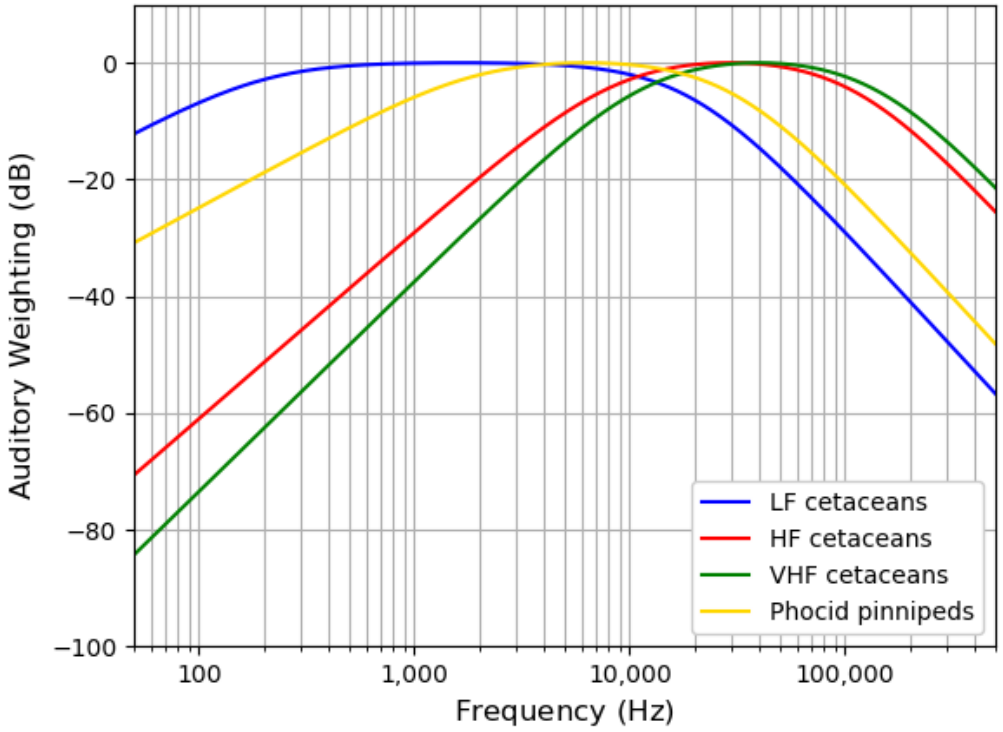


Figure 3-1: Auditory weighting functions for different marine mammal hearing groups.

3.1.2 Disturbance

Thresholds for behavioural disturbance to marine mammals are less well defined compared to PTS thresholds. Numerous studies on marine mammal behavioural responses to noise exposure have not resulted in consensus regarding the appropriate metric or thresholds for assessing behavioural reactions. Southall *et al.* (2007; 2021) concluded that the available data on marine mammal behavioural responses were too variable and context-specific to justify proposing single value disturbance criteria for all marine mammals. Instead, Southall *et al.* (2007; 2021) recommended assessing whether noise from a specific source could cause disturbance to a particular species by comparing the circumstances of the situation with empirical studies. It is noted that NMFS (2018) and Southall *et al*. (2019) did not attempt to define thresholds for behavioural disturbance to marine mammals.

Guidance by Tougaard (2016) suggests a single-pulse unweighted SEL threshold of 145 dB re 1 µPa^{2}s for assessing disturbance impacts to all marine mammals from seismic surveys and other impulsive noise sources such as piling. Thompson *et al.* (2013) showed that harbour porpoises exhibited avoidance from a seismic survey at unweighted SELs between 145 - 151 dB re 1 µPa^{2}s. Lucke *et al.* (2009) also reported that a captive harbour porpoise consistently showed behavioural responses at unweighted SELs exceeding 145 dB re 1 µPa^{2}s. Brandt *et al.* (2016) analysed the impact of piling on harbour porpoises from the construction of eight offshore wind farms within the German North Sea between 2009 and 2013. Monitoring data from passive acoustic monitoring (PAM) using porpoise detectors was combined with data from aerial surveys and noise level measurements. The results showed that detections of harbour porpoises during piling declined by less than 20% at SELs below 145 dB re 1 µPa^{2}s and that displacement of harbour porpoise at SELs below 145 dB re 1 µPa^{2}s could not clearly be related to noise from piling. Based on the guidance of Tougaard (2016) and the observations of Thompson *et al.* (2013), Lucke *et al.* (2009) and Brandt *et al.* (2016), a single-

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pulse unweighted SEL threshold of 145 dB re 1 µPa^{2}s has been used in this assessment for signifying displacement of marine mammals from the FPSO anchor piling (Table 3-2). Although this threshold has been derived from observations of displacement of harbour porpoises, it is adopted in this assessment to signify potential displacement of all marine mammals. The adoption of this threshold may overestimate behavioural disturbance impacts to marine mammal species other than harbour porpoise since harbour porpoises may be more sensitive to underwater noise than many other species. This is supported by the fact that the PTS thresholds for VHF cetaceans (the hearing group which harbour porpoise belong to) are significantly lower than the thresholds for all other hearing groups (see Table 3-1), suggesting that they are more sensitive to underwater noise than other species.

NMFS currently adopt an unweighted root mean square (rms) SPL of 160 dB re 1 µPa as a threshold for signifying significant behavioural disturbance (referred to as 'Level B Harassment') to all marine mammals. This threshold was derived from the High Energy Seismic Survey (HESS) report (HESS, 1999), which was based on the responses of migrating mysticete whales (LF cetaceans) to airgun noise (Malme *et al.* 1983, 1984). The NMFS 'Level B Harassment' unweighted rms SPL threshold of 160 dB re 1 µPa is also used in this assessment for estimating behavioural disturbance to all marine mammals. The rms SPL threshold of 160 dB re 1 µPa has been converted to an SEL threshold of 150 dB re 1 µPa^{2}s assuming an integration time of 100 ms. The integration time of most marine mammals' ears is approximately 125 ms (Tougaard *et al.,* 2015). As a conservative measure, a smaller integration time of 100 ms has been used to convert the NMFS 'Level B Harassment' rms SPL threshold to an SEL threshold.

Behavioural disturbance thresholds are difficult to conclusively define since different marine mammal species and even different individuals from the same species can exhibit a range of responses to the same sound (Southall *et al.*, 2007, 2021; NMFS, 2018). Furthermore, for many species there is also a lack of sufficient evidence to define appropriate thresholds (Southall *et al.,* 2021). Therefore, in this assessment two different threshold values have been adopted to assess potential disturbance (Table 3-2). This will provide a range of distances and areas at which behavioural disturbance to marine mammals may occur.

Table 3-2: Marine mammal behavioural disturbance thresholds.

Criteria	Behavioural Disturbance Threshold	
	Rms SPL (dB re 1 µPa)	SEL (dB re 1 µPa^{2}s)
NMFS 'Level B Harassment' criteria for behavioural disturbance to all marine mammals	160	150 [1]
Tougaard (2016) criteria for behavioural disturbance to all marine mammals	N/A	145
[1] The NMFS 'Level B Harassment' rms SPL threshold of 160 dB re 1 µPa has been converted to an SEL threshold of 150 dB re 1 µPa^{2}s assuming a conservative integration time of 100 ms.		

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3.2 Fish

3.2.1 Injury

Popper *et al*. (2014) have defined criteria for injury to fish based on a comprehensive review of publications related to impacts from various high-energy sources including piling. Injury thresholds are derived in Popper *et al*. (2014) for:

- Fishes with no swim bladder or other gas chamber;
- Fishes with swim bladders in which hearing involves a swim bladder or other gas volume;
- Fishes with swim bladders in which hearing does not involve the swim bladder or other gas volume; and
- Fish eggs and larvae.

The thresholds for potential injury to fish species, eggs and larvae proposed in Popper *et al*. (2014) are shown in Table 3-3.

Table 3-3: Thresholds for potential injury to fish, and fish eggs and larvae.

Fish Group	Potential Mortal Injury Thresholds	
	Zero-to-peak SPL (dB re 1 µPa)	Cumulative SEL (dB re 1 µPa^{2}s)
Fishes with no swim bladder	213	219
Fishes with swim bladder involved in hearing	207	207
Fishes with swim bladder not involved in hearing	207	210
Eggs and larvae	207	210

3.2.2 Behavioural Disturbance

Documented disturbance effects of underwater noise on fish behaviour are variable, ranging from no discernible effect (Wardle *et al.,* 2001) to startle reactions followed by immediate resumption of normal behaviour (Wardle *et al.,* 2001; Hassel *et al.,* 2004). Despite some documented behavioural disturbance effects, there are no well-established criteria or thresholds for assessing behavioural disturbance to fish from underwater noise. In fact, it was concluded by Popper *et al*. (2014) that there lacked sufficient evidence to recommend specific thresholds that correspond to behavioural disturbance for fish. Therefore, a quantitative assessment of behavioural disturbance to fish is not considered in this report.

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4.0 MODELLING RESULTS AND IMPACT ASSESSMENT

4.1 Marine Mammals

4.1.1 PTS

Received noise levels from piling of the FPSO anchors have been predicted in terms of unweighted zero-to-peak SPL to identify potential areas where the instantaneous onset of PTS may occur to marine mammals. Figure 4-1 shows the predicted zero-to-peak SPL with the hammer operating at maximum energy of 1,200 kJ. The contours in Figure 4-1 highlight the zero-to-peak SPL thresholds for the potential onset of PTS to marine mammals.

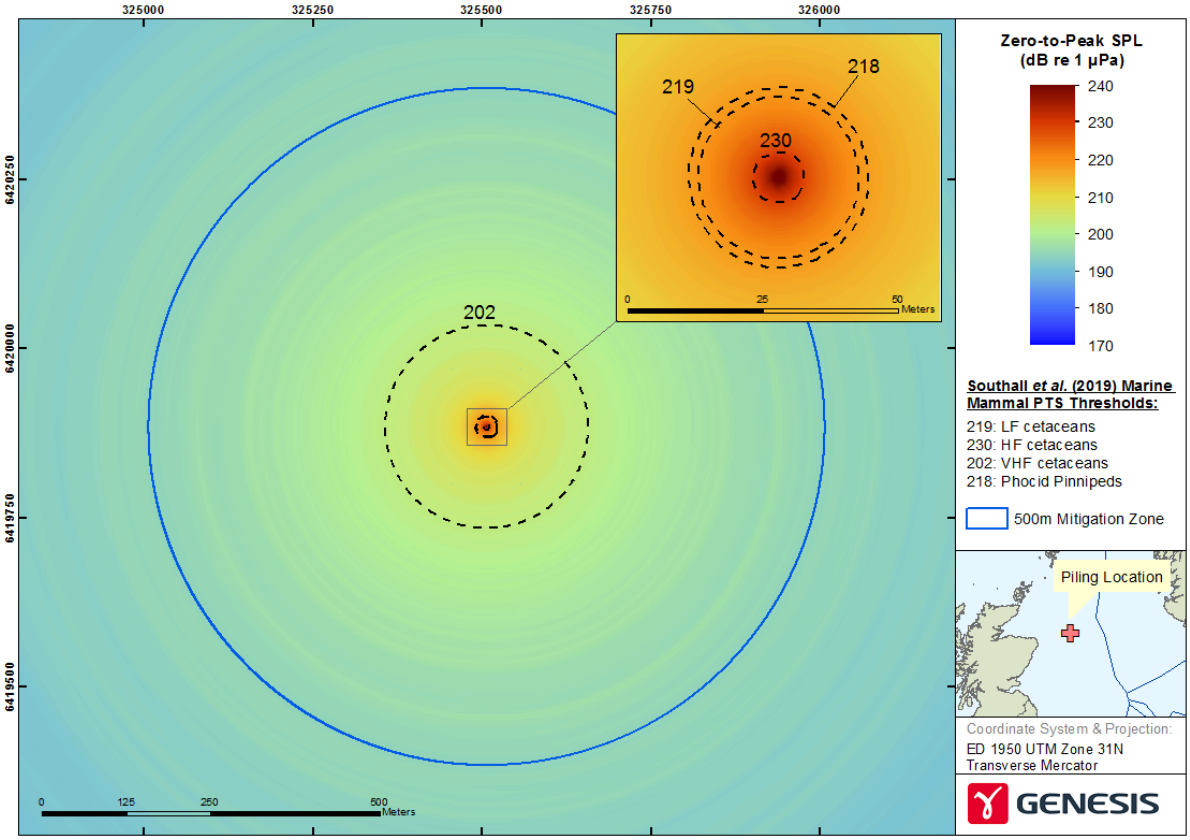


Figure 4-1: Predicted zero-to-peak SPL received by marine mammals during piling with the hammer operating at maximum energy of 1,200 kJ.

The predicted maximum distances where the zero-to-peak SPL thresholds for PTS onset are exceeded during the piling are summarised in Table 4-1. It is predicted that the zero-to-peak SPL generated throughout the piling will not exceed the PTS thresholds for any marine mammal hearing group outside the standard 500 m mitigation zone that will be employed during the piling operations (JNCC, 2010). If any marine mammals are observed in the 500 m mitigation zone before the start of piling, the piling will be delayed until all marine mammals have vacated the mitigation zone. With this mitigation measure in place, the probability of zero-to-peak SPLs generated during the piling causing PTS to marine mammals is predicted to be low.

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Table 4-1: Predicted maximum distances from the piling location where the zero-to-peak SPL thresholds for PTS onset to marine mammals are exceeded.

Marine Mammal Hearing Group	Zero-to-peak SPL PTS Threshold (dB re 1 µPa)	Maximum Distance to Threshold Exceedance (m) [1]
LF cetaceans	219	20
HF cetaceans	230	10
VHF cetaceans	202	150
Phocid pinnipeds	218	20
[1] Predicted distances have been rounded up to the nearest 10 m.		

The cumulative SEL received by marine mammals during piling has been predicted and compared to the PTS thresholds. In the modelled piling scenario, it has been assumed that piling will commence with a soft start where the hammer will operate at a reduced energy of 120 kJ for 20 minutes. Thereafter, the hammer energy is progressively increased at discrete intervals until the maximum hammer energy is reached (see Table 2-1).

Following the guidance of Southall *et al.* (2019), the cumulative SELs received by marine mammals have been calculated by weighting the received SELs from each pile strike using the auditory weighting functions shown in Figure 3-1 and integrating over the exposure period. Marine mammals have been modelled as swimming away from the piling location at the onset of piling, which has been observed during piling activities (Brandt *et al.,* 2011, 2016, 2018; Carstensen *et al.,* 2006; Dahne *et al.,* 2013). The received cumulative SEL has been calculated for marine mammals swimming away from the piling location at different swim speeds. Results are presented showing the furthest distance that marine mammals must be from the piling location at the start of the piling in order to not be exposed to cumulative SEL exceeding the PTS threshold when they swim away.

The predicted initial distances that marine mammals must be from the piling location at the start of piling in order to not be exposed to cumulative SELs exceeding the PTS thresholds after they swim away are shown in Table 4-2. The modelling predicts that the PTS thresholds will not be exceeded for any marine mammals assuming that they are outside the 500 m mitigation zone at the start of piling and swim away from the piling location at a minimum speed of 1.5 m/s. A swim speed of 1.5 m/s is relatively conservative since marine mammals exposed to high noise levels would likely swim sway at faster speeds. The 500 m mitigation zone and associated mitigation measures (e.g., marine mammal observers (MMOs) and PAM) is expected to be sufficient to mitigate against PTS occurring to any marine mammals.

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Table 4-2: Predicted maximum distances that marine mammals must be from the piling location at the start of piling in order to not be exposed to cumulative SEL exceeding the PTS threshold when they swim away at different swim speeds.

Marine Mammal Hearing Group	Cumulative SEL Threshold for PTS (dB re 1 µPa^{2}s)	Swim Speed (m/s)	Maximum Distance to Threshold Exceedance (m) [1]
LF cetaceans	183	1.5	70
		2.0	10
		2.5	10
HF cetaceans	185	1.5	Threshold not exceeded
		2.0	Threshold not exceeded
		2.5	Threshold not exceeded
VHF cetaceans	155	1.5	Threshold not exceeded
		2.0	Threshold not exceeded
		2.5	Threshold not exceeded
Phocid pinnipeds	185	1.5	Threshold not exceeded
		2.0	Threshold not exceeded
		2.5	Threshold not exceeded

[1] Predicted distances have been rounded up to the nearest 10 m.

4.1.2 Disturbance

As discussed previously, it is difficult to conclusively define behavioural disturbance thresholds for marine mammals since different marine mammal species and even individuals from the same species could exhibit a range of behaviours from underwater noise. Furthermore, there is insufficient evidence for many species to define appropriate thresholds (Southall *et al.,* 2021). Therefore, two different thresholds for behavioural disturbance have been adopted in this assessment (see Table 3-2), which provide a range of distances and areas where behavioural disturbance may occur to marine mammals.

Figure 4-2 shows the maximum predicted unweighted SEL from single pile strikes during piling of the FPSO anchors with the hammer operating at maximum hammer energy of 1,200 kJ. The contours highlighted in Figure 4-2 signify the thresholds that have been adopted for assessing potential disturbance to all marine mammals.

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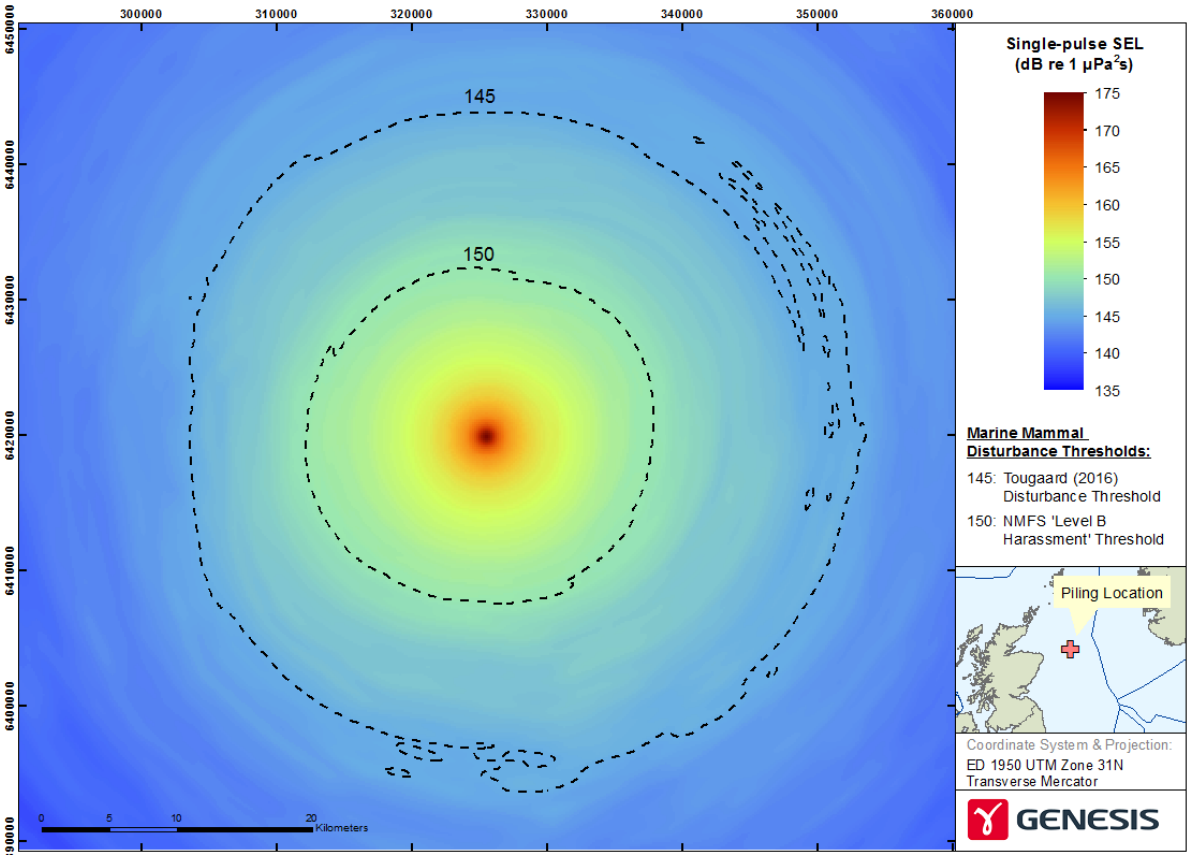


Figure 4-2: Predicted unweighted SEL received by marine mammals during piling with the hammer operating at maximum energy of 1,200 kJ.

Table 4-3 summarises the predicted distances and areas where behavioural disturbance might occur to marine mammals from the FPSO anchor piling. The NMFS 'Level B Harassment' threshold suggests that disturbance to marine mammals could occur at a distance of 13 km, whilst the Tougaard (2016) threshold suggests that disturbance could occur out to 27 km.

Using noise measurements and harbour porpoise monitoring data during the piling of seven offshore wind farms in the German North Sea, Brandt *et al.* (2018) showed that significant disturbance to harbour porpoises could occur at distances of 17 km with effect ranges up to and beyond 33 km. The predicted disturbance distances for the FPSO anchor piling for the Buchan Redevelopment Project (13 – 27 km) align with the observations of disturbance to harbour porpoises by Brandt *et al.* (2018).

Studies based on impacts from piling noise have indicated that marine mammals displaced by noise return to the area within relatively short periods of time, usually within three days once the piling has ceased (Brandt *et al.,* 2011, 2016, 2018; Carstensen *et al.,* 2006). It has been demonstrated that even long-term piling over several months or years (e.g., during the construction of wind farms) is unlikely to have a significant long-term impact on marine mammal populations levels (Nabe-Nielsen *et al.,* 2018; Nabe-Nielsen, 2020). It is expected that any marine mammals disturbed by piling associated with the Buchan Redevelopment Project will return to the area within a short period of time after the piling has finished. The piling is therefore not expected to have a significant adverse impact on any marine mammal population.

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Table 4-3: Predicted distance and areas where the adopted marine mammal behavioural disturbance thresholds are exceeded.

Criteria	SEL Behavioural Disturbance Threshold (dB re 1 μPa²s)	Maximum Distance to Threshold Exceedance (km) [1]	Area of Threshold Exceedance (km²) [2]
NMFS 'Level B Harassment' criteria for behavioural disturbance to all marine mammals	150 [3]	13	506
Tougaard (2016) criteria for behavioural disturbance to all marine mammals	145	27	1,893

[1] Predicted distances have been rounded up to the nearest 1 km.

[2] Predicted areas have been rounded up to the nearest 1 km².

[3] The NMFS 'Level B Harassment' rms SPL threshold of 160 dB re 1 μPa has been converted to an SEL threshold of 150 dB re 1 μPa²s assuming a conservative integration time of 100 ms.

4.2 Fish

4.2.1 Injury

To quantitatively assess any potential injury to fish and fish eggs and larvae from the FPSO anchor piling, received noise levels in terms of unweighted zero-to-peak SPL and unweighted cumulative SEL have been predicted and compared to the Popper *et al*. (2014) thresholds for injury.

Figure 4-3 shows the predicted zero-to-peak SPL with the hammer operating at the maximum hammer energy of 1,200 kJ. The contours in Figure 4-3 highlight the Popper *et al*. (2014) zero-to-peak SPL thresholds for potential injury to fish species and fish eggs and larvae.

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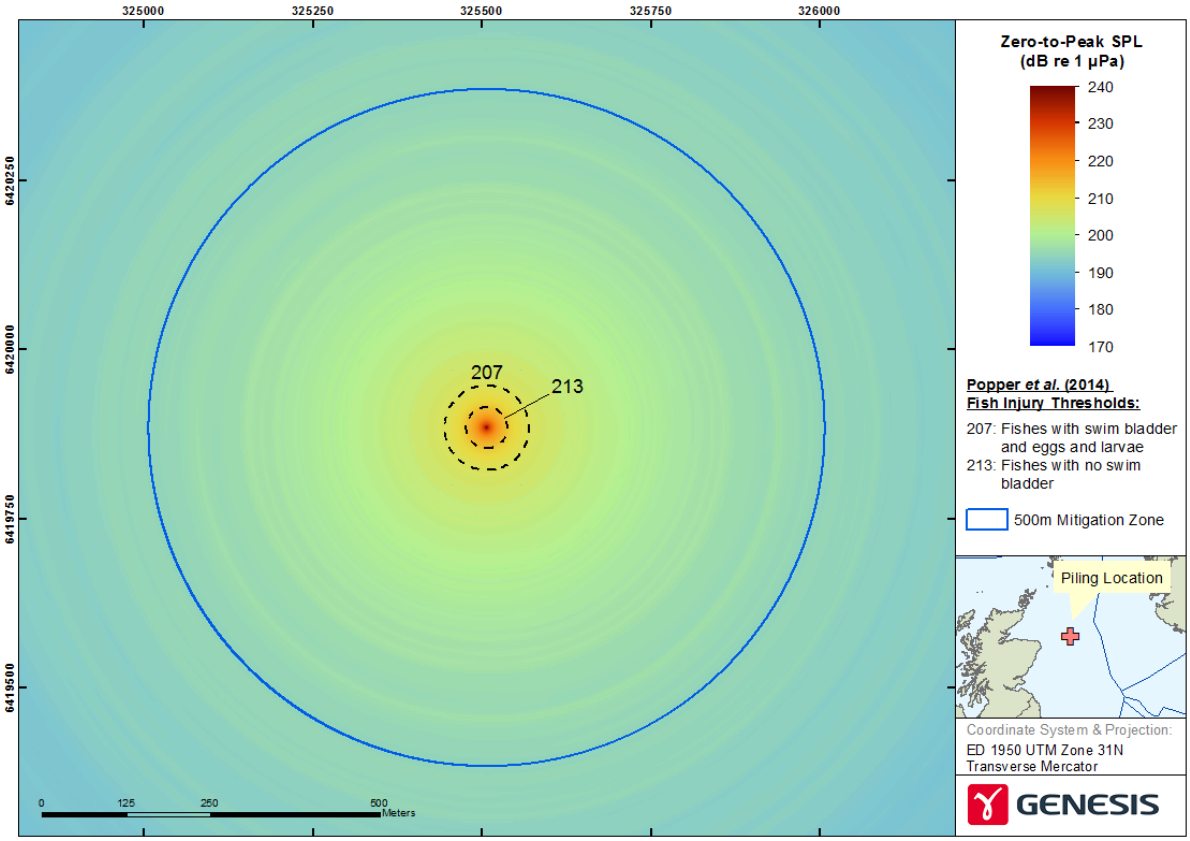


Figure 4-3: Predicted zero-to-peak SPL received by fish during piling with the hammer operating at maximum energy of 1,200 kJ.

The predicted distances where the zero-to-peak SPL thresholds for injury to fish species and fish eggs and larvae are exceeded are shown in Table 4-4. When the hammer is operating at maximum energy, the zero-to-peak SPL is predicted to potentially cause injury to the most sensitive fish species and fish eggs and larvae within 60 m from the piling location. It is expected that the hammer soft start and gradual ramp up of hammer energy throughout the piling should allow mobile fish sufficient time to move away from the piling location to distances where the zero-to-peak SPLs generated will not cause injury. However, it is acknowledged that fish eggs and larvae will not be able to move away.

The cumulative SEL received by fish species and fish eggs and larvae has also been calculated. In the cumulative SEL modelling it is assumed that mobile fish will swim away from the piling location at 0.5 m/s, whilst fish eggs and larvae are assumed to remain stationary throughout the piling. The predicted minimum initial distances that fish must be from the pile sound source at the start of pile driving operations (i.e., safety distances) in order to not be exposed to cumulative SELs above the Popper *et al*. (2014) thresholds for potential injury are summarised in Table 4-5. The modelling predicts that the cumulative SEL injury thresholds will not be exceeded if fish swim away from the piling location at 0.5 m/s. This indicates that the hammer soft start and gradual ramp up in energy allows sufficient time for mobile fish to move to safe distances where they will not suffer injury. It is predicted that fish eggs and larvae that cannot move away from the piling may potentially be injured at distances of up to 130 m from the piling location. However, given the relatively small impact area compared to the large spawning grounds in the North Sea, it is not expected that the piling operations associated

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with the Buchan Redevelopment Project will have a significantly adverse effect on any spawning fish.

Table 4-4: Predicted maximum distances from the piling location where the zero-to-peak SPL thresholds for injury to fish and fish eggs and larvae are exceeded.

Fish Group	Zero-to-peak SPL Injury Threshold (dB re 1 µPa)	Maximum Distance to Threshold Exceedance (m) [1]
Fishes with no swim bladder	213	30
Fishes with swim bladder involved in hearing	207	60
Fishes with swim bladder not involved in hearing	207	60
Eggs and larvae	207	60
[1] Predicted distances have been rounded up to the nearest 10 m.		

Table 4-5: Predicted maximum distances that fish species and fish eggs and larvae must be from the piling location at the start of piling in order to not be exposed to cumulative SEL exceeding injury thresholds.

Fish Group	Cumulative SEL Injury Threshold (dB re 1 µPa^{2}s)	Swim Speed (m/s)	Maximum Distance to Threshold Exceedance (m) [1]
Fishes with no swim bladder	219	0.5	Threshold not exceeded
Fishes with swim bladder involved in hearing	207	0.5	Threshold not exceeded
Fishes with swim bladder not involved in hearing	210	0.5	Threshold not exceeded
Eggs and larvae	210	Stationary	130
[1] Predicted distances have been rounded up to the nearest 10 m.			

4.2.2 Disturbance

A quantitative assessment of behavioural disturbance to fish could not be conducted since there are no well-established disturbance thresholds for fish. However, if fish are disturbed by sound, evidence suggests they will return to an area once the activity generating the sound has ceased (Slabbekoorn *et al*., 2010). Any disturbance to fish is expected to be of a short duration and therefore it is concluded that the Buchan Redevelopment Project piling will not have a significant impact on any fish species.

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5.0 MITIGATION MEASURES

To minimise the risk of potential impacts of sound from the piling, the following mitigation measures recommended by the JNCC (2010) guidelines for minimising the risk of injury to marine mammals from piling noise are suggested:

- A qualified, trained and equipped MMO should be present and dedicated to the observation of marine mammals. The MMO should carry out a pre-piling survey of a 500 m mitigation zone and, if an animal is detected, the piling should be delayed until all marine mammals vacate the 500 m mitigation zone;
- A soft start and ramp up of hammer energy should employed where the hammer should commence at a low energy at the start of piling. The soft start should be conducted over a period of at least 20 minutes; and
- PAM should be employed during periods of low visibility to detect marine mammal presence.

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6.0 CONCLUSIONS

This report has presented underwater noise propagation modelling results for assessing the potential impacts that piling associated with the Buchan Redevelopment Project may have on marine mammals and fish species and fish eggs and larvae. The modelling results were used to assess any potential impacts to marine mammals based on a comparison of estimated noise levels with the Southall *et al.* (2019) thresholds for potential PTS onset and relevant thresholds for behavioural disturbance. Potential injury to fish species and fish eggs and larvae was also assessed by comparing predicted sound levels to the injury thresholds established by Popper *et al*. (2014).

The modelling results indicate that the likelihood of marine mammals being exposed to noise levels that may cause PTS during the piling is low provided that the standard JNCC (2010) guidelines for minimising the risk of injury to marine mammals from piling noise are followed. The modelling predicts that behavioural disturbance to marine mammals could potentially occur at 13 – 27 km from the piling location. However, any behavioural disturbance that may occur will only be temporary. If any marine mammals are disturbed, they will return to the area once the piling has been completed. Therefore, it is not expected that the piling associated with the Buchan Redevelopment Project will have any long-term significant effects on any marine mammal populations.

The modelling results indicate that injury to fish species and fish eggs and larvae during the piling will be localised to small areas (within 60 m) around the piling location. The soft start and ramp up of the hammer energy during piling should allow mobile fish species time to move away to distances where they are unlikely to suffer injury. Fish eggs and larvae will not be able to move away from the piling location and will therefore be more susceptible to injury. However, given the predicted small areas where fish eggs and larvae may suffer injury relative the large spawning areas across the North Sea, it is not expected that the piling will have a significant effect on spawning fish.

It is concluded that the Buchan Redevelopment Project piling activities will not have a significant impact on marine mammals, fish, and fish eggs and larvae.

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Appendix E – Oil Spill Modelling Report

REPORT

Oil Spill Modelling

Prepared for: **NEO Energy**

Prepared by: **Genesis Energies**
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Project Title: **Buchan Redevelopment Project Environmental Statement**
Document/Rev No: 215914C-000-RT-6200-0003/0
Client Document No.: BUC000-BUC-EV-RE-003

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ABBREVIATIONS

%	Percent
°C	Degrees centigrade
µm	Micrometre
3D	Three-dimensional
BEIS	Department for Business, Energy & Industrial Strategy
CNS	Central North Sea
cP	Centipoise
DESNZ	Department of Energy, Security and Net Zero
ECMWF	European Centre for Medium-Range Weather Forecasts
ED	European Datum
ES	Environmental Statement
FPSO	Floating, Production, Storage and Offloading
g	Gram
g/m^2	Grams per square metre
GBA	Greater Buchan Area
HYCOM	Hybrid Coordinate Ocean Model
ITOPF	International Tanker Owners Pollution Federation
kg/m^2	Kilograms per square metre
km	Kilometres
km^2	Square kilometre
km^3	Cubic kilometre
m	Metre
m^2	Square metre
m^3	Cubic metre
m^3/day	Cubic metre per day
mg/kg	Milligrams per kilogram
mm	Millimetre
NMPi	National Marine Plan interactive
NOEC	No Observed Effect Concentration
OPEP	Oil Pollution Emergency Plan
OSCAR	Oil Spill Contingency And Response
OSPAR	Oslo and Paris Convention

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PNEC	Predicted No Effect Concentration
ppb	Parts per billion
ppt	Parts per thousand
t	Tonnes
t/m^3	Tonnes per cubic metre
TPH	Total Petroleum Hydrocarbons
UKCS	United Kingdom Continental Shelf
UKOOA	UK Offshore Operators Association
UTM	Universal Transverse Mercator

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EXECUTIVE SUMMARY

Modelling of the worst-case release of crude oil was undertaken using the Oil Spill Contingency and Response (OSCAR) model developed by Sintef. Stochastic and deterministic modelling was undertaken.

Two scenarios were modelled:

- A well blowout with a duration of 86 days and a release rate of 1,400 bbl/day (19,142 m^3 in total); and
- Release of the full inventory from the Floating Production Storage and Offloading (FPSO) vessel (63,509 m^3 released over a one-hour period).

The oil spill modelling results presented in this report have been used to inform the Buchan Redevelopment Project Environmental Statement (ES).

The primary aims of this modelling study were to understand:

- The probability of hydrocarbons accumulating on the sea surface, in the water column and reaching the shoreline;
- Where hydrocarbon concentrations could exceed certain thresholds on the sea surface, water column and in sediments; and
- The minimum time taken for hydrocarbons to reach the shoreline.

Ocean currents data were sourced from the Hybrid Coordinate Ocean Model (HYCOM) and wind data sets were obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF). Other environmental factors and conditions, such as ocean temperature and salinity, were obtained from the Scottish Government's National Marine Plan interactive (NMPi) (Berx, B. and Hughes, S., 2009).

The modelling concludes that there is a low probability of oil reaching the coast of the UK (3%) and Norway (5%) in the event of a full inventory release from the FPSO but a higher probability of oil reaching the coastline in the event of a blow out (25% probability of reaching the UK coastline and 42% probability of reaching the coast of Norway).

The thresholds for surface sheen thickness, shoreline oiling and hydrocarbon concentration in the water column would all be exceeded over relatively large areas/volumes for both scenarios. The threshold for hydrocarbon concentration in seabed sediment is not exceeded for either scenario.

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Table 1: Summary of modelling results.

Modelling parameter	Well blowout	FPSO inventory release
Minimum time to beaching [a]	9.8 days	7.9 days
Area of sea surface impacted by oil with thickness > 0.3 µm [b]	85,400 km^2	31,837 km^2
Volume of water column impacted by oil at concentrations > 10 ppb [b]	1,960 km^3	271 km^3
Area of seabed sediment impacted at > 5 g/m^2 [b]	0 km^3	0 km^2
Length of coastline impacted by oil at concentration > 100 g/m^2 [a]	650.0 km	237 km
Maximum mass of oil on shore [b]	1,739 t	7,486 t

[a] Values extracted from stochastic simulation

[b] Values extracted from deterministic simulation

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1.0 INTRODUCTION

The proposed Buchan Redevelopment Project will be located in UK Continental Shelf (UKCS) Blocks 20/5 and 21/1 in the Central North Sea (CNS). The proposed project is centered on the Buchan Horst Field (a redevelopment of the Buchan oil field), which lies *c.* 115 km northeast of the Aberdeenshire coastline and *c.* 100 km west of the UK/Norway median line.

This report documents the oil spill modelling carried out to determine the environmental risk associated from two scenarios:

- Well blowout with a release rate of 1,400 bbl/d (222.58 m^3/d) for 86 days (equivalent to a total release of 19,142 m^3); and
- Accidental release of full crude oil inventory from the Floating Production Storage and Offloading (FPSO), equivalent to 63,509 m^3 in one hour.

The results of the modelling have been used to inform the Environmental Statement (ES) (see Chapter 12).

The modelling was carried out using the Oil Spill Contingency and Response (OSCAR) model developed by Sintef and undertaken in line with the regulatory guidance provided in BEIS, 2022.

The objectives of the modelling were to understand:

- How the hydrocarbons are likely to disperse over time (both on the sea surface and in the water column);
- The extent to which hydrocarbons are likely to arrive on any shoreline; and
- Where hydrocarbon concentrations could exceed certain thresholds on the sea surface, in the water column and in sediments.

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2.0 OVERVIEW OF MODELLING METHODOLOGY

When crude oil is spilled on the surface of the sea it is subjected to a number of processes including: spreading, evaporation, dissolution, emulsification, natural dispersion, photooxidation, sedimentation and biodegradation. The fate and effect of crude oil are dependent on the chemical and physical properties of the oil, and the physico-chemical changes to which the oil is subjected. These vary depending on the oil type, the volume spilled and the prevailing weather and sea conditions. Some of these changes lead to its disappearance from the sea surface while others, for example emulsification, may cause it to become more persistent.

Figure 2-1 highlights the various processes oil is subjected to after being released at sea. These processes are all modelled in the OSCAR modelling software to predict the fate and behaviour of discharged hydrocarbons over time.

Two different types of simulation are supported in OSCAR: stochastic (probabilistic) and deterministic simulations. The stochastic modelling feature of OSCAR allows for a spill scenario to be modelled multiple times over different weather conditions, with the results from each individual stochastic run being aggregated, and a number of statistical parameters computed. The stochastic modelling results presented in this report examine:

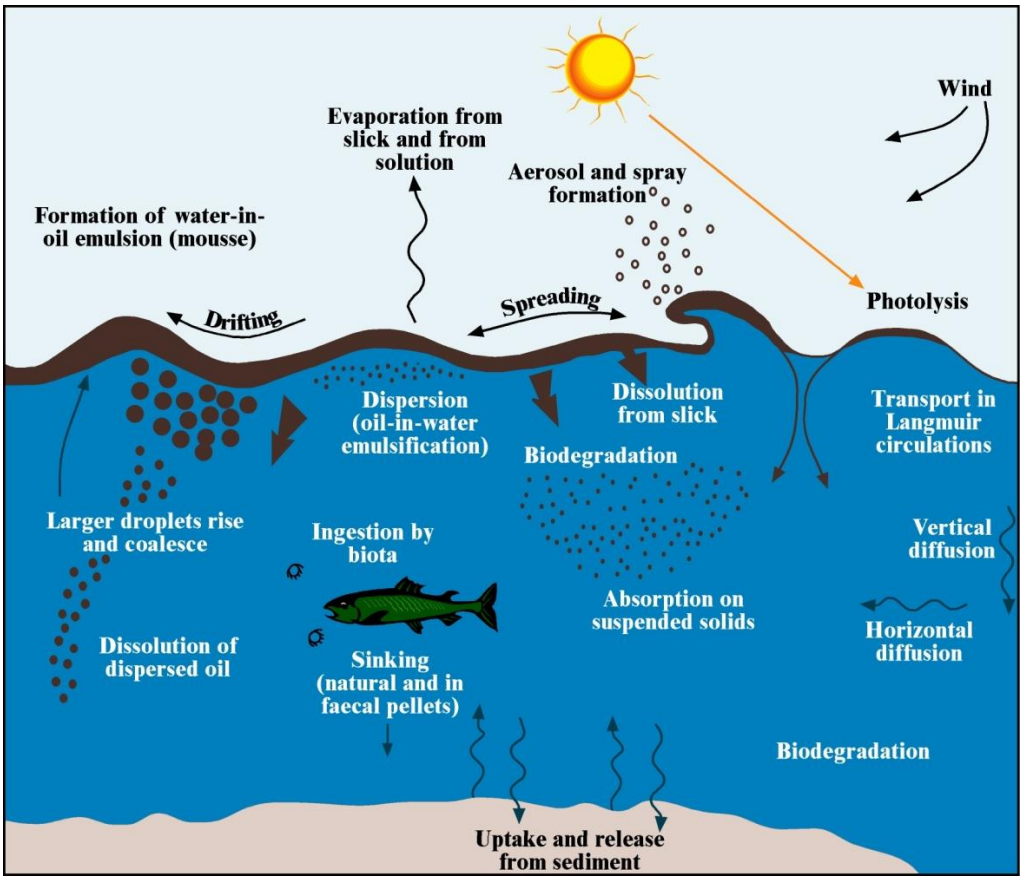
- The probability of oil above a predefined threshold appearing on the sea surface;
- The probability of oil above a predefined threshold being present throughout the water column; and
- The probability of oil arriving on the shoreline.

It is important to note that the stochastic modelling results do not represent a single spill scenario but rather show the aggregation of results computed by running the spill scenario multiple times over different weather conditions.

To analyse a single spill scenario, the deterministic mode of OSCAR allows for the spill scenario to be modelled over a single specified time interval and outputs can be presented in terms of key parameters such as oil thickness on the sea surface, concentrations on the shoreline, in the sediment and in the water column. One deterministic scenario is selected based on the individual stochastic run which gives the worst-case shoreline oiling (i.e., the greatest mass of oil arriving onshore). The deterministic model results presented in this report examine:

- The maximum thickness of hydrocarbon appearing on the sea surface;
- The maximum concentrations of hydrocarbon present in the water column;
- The maximum concentrations of hydrocarbon reaching the shoreline; and
- The maximum concentrations of hydrocarbon being deposited in the sediment.

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Source: adapted from Koops *et al.* (1985)

Figure 2-1: Fate and behaviour of spilled hydrocarbons at sea.

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3.0 INPUT DATA

The OSCAR model considers the properties of the hydrocarbons being released as well as a range of environmental factors such as bathymetry, current and wind speed and direction, water column salinity and temperature, as well as seabed and coastal sediment types.

3.1 Modelling Parameters

The main release parameters for the two spill scenarios, as outlined in Section 2.0, are summarised in Table 3-1. The OSCAR modelling parameters adopted for this study are outlined in Table 3-2.

The well blowout has been modelled from the sea surface based on the assumption that the well will be drilled using a jack-up rig and therefore the blowout preventer will be located on the sea surface.

A worst-case duration of 86 days has been modelled based on the time it would take to drill a relief well. The proposed wells will be drilled through the Andrew reservoir (12 ¼" hole) into the Buchan Horst reservoir (6" hole). Integrated subsurface analysis suggests presence of oil accumulation at the Andrew level. Production rates assumed for this study have been taken from the Competent Person's Report on Licence P2498 (Rockflow Resources Limited, 2019). A steady (rather than declining) blow out rate has been modelled, based on flow rates in the Andrew reservoir as the Buchan Horst reservoir would not flow naturally so there cannot be a blow out from the Buchan Horst reservoir.

The release of the crude inventory from the FPSO is assumed to occur on the sea surface with a release duration of 1 hour.

The model assumed no intervention (i.e., no response efforts were included in the modelling). The results in terms of estimated impacts can therefore be considered conservative.

Table 3-1: Scenario release parameters.

Scenario	Release location (projection: WGS 84)	Release rate	Release depth (m below sea level)	Release duration	Release temperature (°C)
Well Blowout	57° 53' 52.95" N 00° 01' 21.13" E	1,400 (bbl/day) (220.58 m^3/d)	0.5	86 days	50.0
Crude inventory release	57° 53' 04.73" N 00° 03' 19.19" E	63,509 m^3/hr	0.5	1 hour	9.6

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Table 3-2: OSCAR modelling parameters.

Modelling parameter		Well blowout	Crude inventory release
Model duration (days)		116	30
Model time step (hours)		0.5	0.5
Output interval (hours)		3	3
Grid resolution (cell size)	Cell size	1,000 m × 1,000 m	1,000 m × 1,000 m
	Grid size	1,000 km × 1,000 km	800 km × 1,000 km
	Depth (m)	400	400
Number of particles	Liquid/ Solid	20,000	20,000
	Dissolved	20,000	20,000
	Gas	100	100

It is normal to run scenarios for the entire duration of the spill, and for sufficient time afterwards to determine the behaviour and location of the oil, before taking a view on whether this poses a risk to receptors. Often some dispersed and surface oil remains at sea at the end of the scenarios. This is in a very dispersed form and less likely to cause acute pollution than during or shortly after the releases. Thus, for the blowout, the model was run for 116 day (86 days duration of blowout plus a further 30 days to allow sufficient time for dispersion). For the inventory release from the FPSO the spill is assumed to be virtually instantaneous (1 hour) so the model was run for 30 days to allow sufficient time for dispersion.

Hydrocarbon Properties

OSCAR includes a database that contains various oil types. A suitable analogue was selected from this database to represent the Buchan crude. Although the blow out (if one occurred) would be from the Andrew reservoir, no oil properties were available, hence an analogue for the Buchan oil was selected. Buchan crude and analogue properties are shown in Table 3-3.

The Oseberg Ost analogue has similar wax and asphaltene content to that of Buchan Horst reservoir oil and will emulsify if released to the marine environment (typically this happens for oils with >0.5% asphaltene content). Viscosity and pour point are also a good match.

The specific gravity of the analogue is slightly greater than that of Buchan crude but will behave in a similar manner at the sea surface and in the water column.

Table 3-3: Buchan oil properties and selected OSCAR analogues.

Property	Buchan Crude	Oscar Analogue (Oseberg Ost 13°C)
API (°)	33.5	-
Specific gravity	0.7759	0.835
Viscosity (cP)	11.6 (at 15°C)	16 (at 13°C)
Pour Point (°C)	<0	3.0
Asphaltene content (% weight)	1.78 to 2.1	1.1
Wax content (% weight)	7.5	7.2

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3.2 Bathymetry

The bathymetry data used in the OSCAR model is Sea Topo 8.2 as supplied by Sinfef with the OSCAR model.

3.3 Metocean Data

3.3.1 Ocean Currents

Three-dimensional ocean currents data for the region was obtained from the Hybrid Coordinate Ocean Model (HYCOM) covering the years 2009–2013. The dataset contains 3D ocean currents with a temporal resolution of one day, in other words the currents change speed and direction at daily intervals.

3.3.2 Winds

Wind data sets have been obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF) for the same period as the currents were used. OSCAR uses wind data to generate waves for surface turbulent mixing processes.

3.3.3 Ocean Temperature and Salinity

Annual average salinity and temperature values were obtained from the Scottish Government's NMPi (Berx, B. and Hughes, S., 2009):

- Surface water temperature: 9.6°C
- Bottom water temperature: 7.7°C
- Salinity: 35.0 ppt

3.4 Model Uncertainties

There are uncertainties associated with simulation of oil spills and therefore conservative assumptions have been used to take account of these uncertainties. Results should be treated as indicative and used to draw conclusions at a high level.

3.4.1 Oil Characterisation

Oil weathering properties have been adopted from an analogue which is closest to the Buchan crude properties provided. Oseberg Ost (Sintef) was selected as a suitable analogue based on its properties as shown in Table 3-3. The match is considered representative for the purposes of this assessment.

3.4.2 Metocean Data

Currents and wind data used here are modelled for the years 2009–2013. Therefore, future currents and winds may differ from those used for the simulations.

A simulation with more recent data (days before the event if possible) or forecasting data should ideally be used in the event of a real oil spill to aid the response effort. However, for the purposes of this modelling exercise, which uses currents and winds across multiple years to calculate probabilities, the variation is considered acceptable.

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3.5 Output Thresholds

The OSCAR model can track the fate of oil in smaller and smaller concentrations and masses (over time and space), beyond the point where oil represents a significant risk or is even detectable against background levels. To ensure the model outputs are proportionate to the risks, while still retaining a precautionary approach, output thresholds are normally applied, prior to modelling, to thicknesses of surface oil and to concentrations in the water column. The thresholds adopted in the modelling are discussed in the following sections.

3.5.1 Surface Thickness

A surface thickness threshold of 0.3 µm has been adopted. This threshold is based on the Bonn Agreement oil appearance code (Bonn Agreement, 2016), which states that a rainbow sheen could be visible above this threshold (see Table 3-4). Oil at thicknesses below this value becomes unlikely to be visible in many conditions and oil thicknesses lower than 0.04 µm are considered “not visible” even under good conditions. The Department for Business, Energy & Industrial Strategy (BEIS) Oil Pollution Emergency Plan (OPEP) guidelines (2022) for the UKCS state that oil spill model results must be displayed to a minimum oil thickness of 0.3 µm and therefore out of best practice this threshold has been adopted.

Table 3-4: Bonn agreement oil appearance code.

Code	Appearance description	Layer thickness (µm)
1	Sheen (silver/grey)	0.04–0.3
2	Rainbow	0.3–5.0
3	Metallic	5.0–50

Source: Bonn agreement (2016)

3.5.2 Oil in Water Concentration

A range of standards for concentration of oil in water have been considered, which are summarised in Table 3-5.

Table 3-5: Standards for oil concentration in the water column.

Region	Source	Context	Parameter	Standard
North Sea and North East Atlantic	OSPAR Agreement 2014/05 (OSPAR, 2014)	Predicted no-effect concentrations (PNEC) of substances in produced water	Dispersed oil	No Observed Effect Concentration (NOEC) 70.5 µg/l (70.5 ppb)
International	Patin (2004)	Fate and effect of crude oil spills	Total Petroleum Hydrocarbons (TPH)	NOEC 10 µg/l (10 ppb)
Norway	Sintef	Pre-defined toxicity levels of oil components in OSCAR database	Any hydrocarbon component	Acute toxicity PNEC 50–15,500 ppb. Chronic toxicity PNEC 5–1,550 ppb

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A total oil in seawater (in the water column) concentration above 10 ppb has been used as the threshold for the current model. This is based on the NOEC highlighted by Patin (2004). The NOEC is the level at which biological effects are either absent or manifest themselves as primary (mostly reversible) physiological and biochemical responses. A threshold of 10 ppb is considered conservative given it is at the lower end of the range of standards shown in Table 3-5.

3.5.3 Shoreline Oil Concentration

No threshold has been applied within the model to the shoreline oil density as in the interest of transparency it is considered best practice to report all shoreline oiling (however small) in the results.

3.5.4 Oil in Sediment

No threshold has been applied to sediment concentrations in the model.

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4.0 RESULTS AND DISCUSSION

This section presents the results obtained from the OSCAR simulations for the scenario detailed in Table 3-1. For each scenario, both stochastic and deterministic simulation results are presented. The stochastic simulations comprised 100 individual deterministic simulations, which were evenly spread throughout the 4 years of ocean currents and wind data. Based on the results from the stochastic simulations, a deterministic simulation was undertaken. The time period for the deterministic simulation was selected to highlight the worst-case mass of oil arriving on shore.

The deterministic simulation allows oil deposition on the seabed, maximum surface area coverage and maximum concentration of oil in the water column to be estimated.

Calculations of maxima are reported as the total area impacted over the duration of the simulation and do not represent a single instance in time (they represent the swept path). Mass balance figures are obtained from the deterministic simulations of spill scenarios rather than the stochastic simulations to include the concentration of oil in the sediment (oil deposition in the seabed is not calculated in stochastic simulations) and maximum sheen thicknesses on the sea surface.

4.1 Well Blowout Scenario

4.1.1 Fate of Hydrocarbons (Mass Balance)

Figure 4-1 shows the mass balance over time both as (A) tonnes and as (B) a percentage and that at the end of the simulation (day 116) the mass balance of the spilled oil was:

- Evaporated: 52.6% (9,129 t)
- Biodegraded: 13.6% (2,367 t)
- Water column: 21.5% (3,738 t)
- Deposited on the seabed: 1.8% (318.3 t)
- Shoreline: 9.5% (1,657 t)
- Sea surface: 0.9% (160.5 t)

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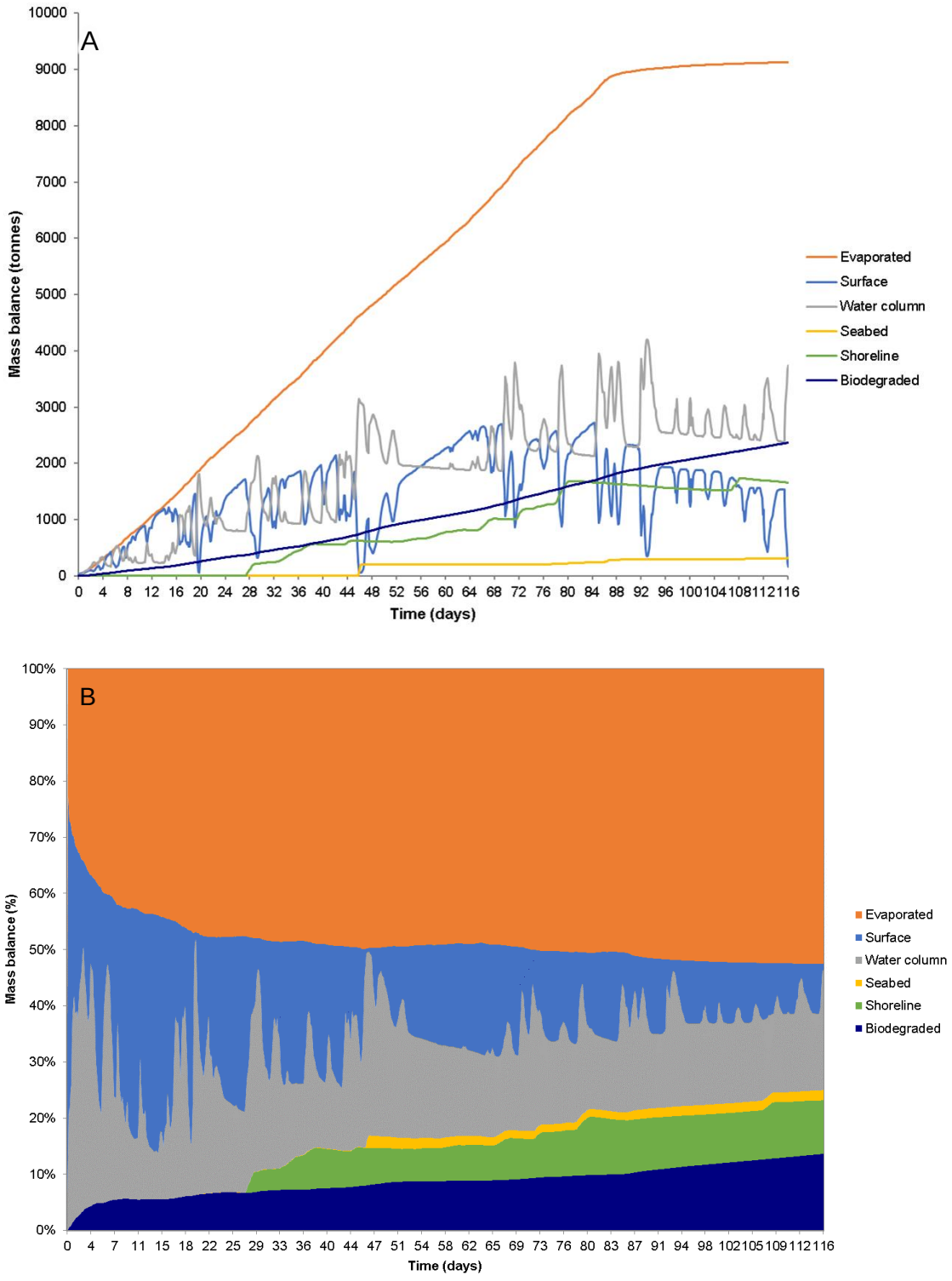


Figure 4-1: Mass Balance (well blowout, deterministic) by mass (A) and % of total release (B)

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4.1.2 Oil on the sea surface

The probability of a visible surface sheen with a thickness ≥ 0.3 µm is shown in Figure 4-2. This visible surface sheen could extend to a maximum distance of 220 km with a 50% probability and a maximum distance of 315 km with a 20% probability, from the spill location.

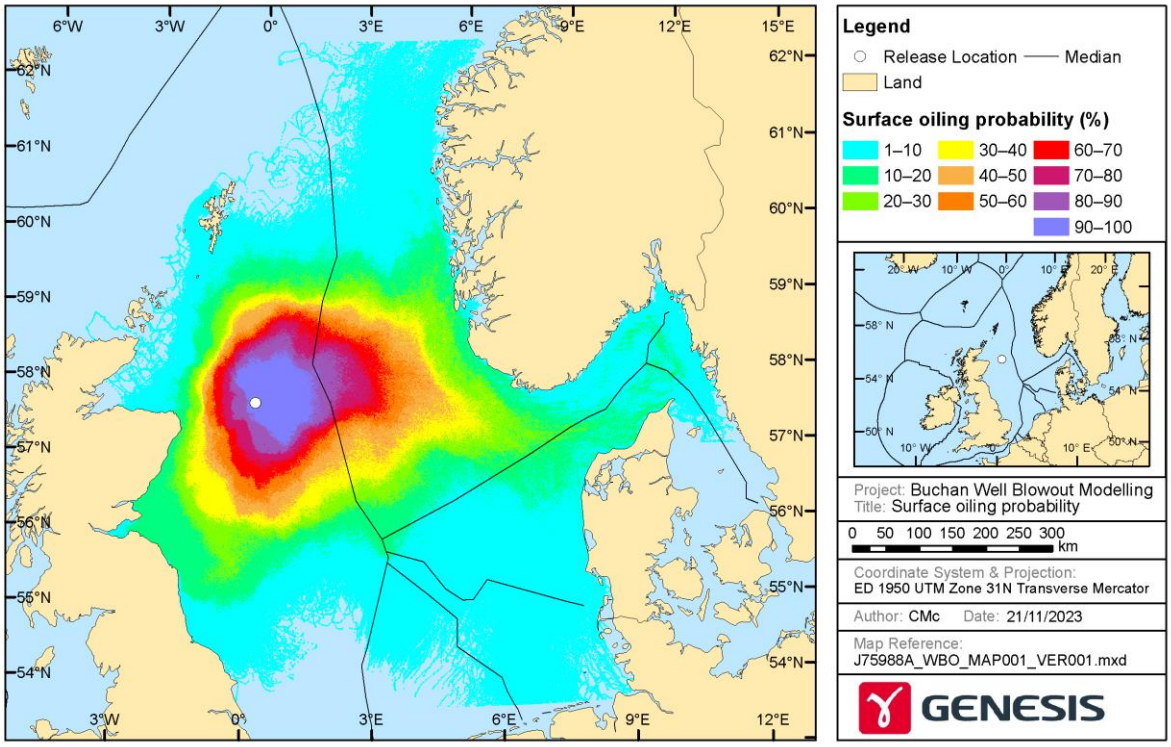


Figure 4-2: Probability of a surface sheen > 0.3 µm (well blowout, stochastic)

The minimum arrival time of oil on the sea surface is shown in Figure 4-3. The oil was estimated to reach the UK-Norway median line with a minimum arrival time of 2.9 days.

The probability and minimum time of arrival of oil to median lines is shown in Table 4-1.

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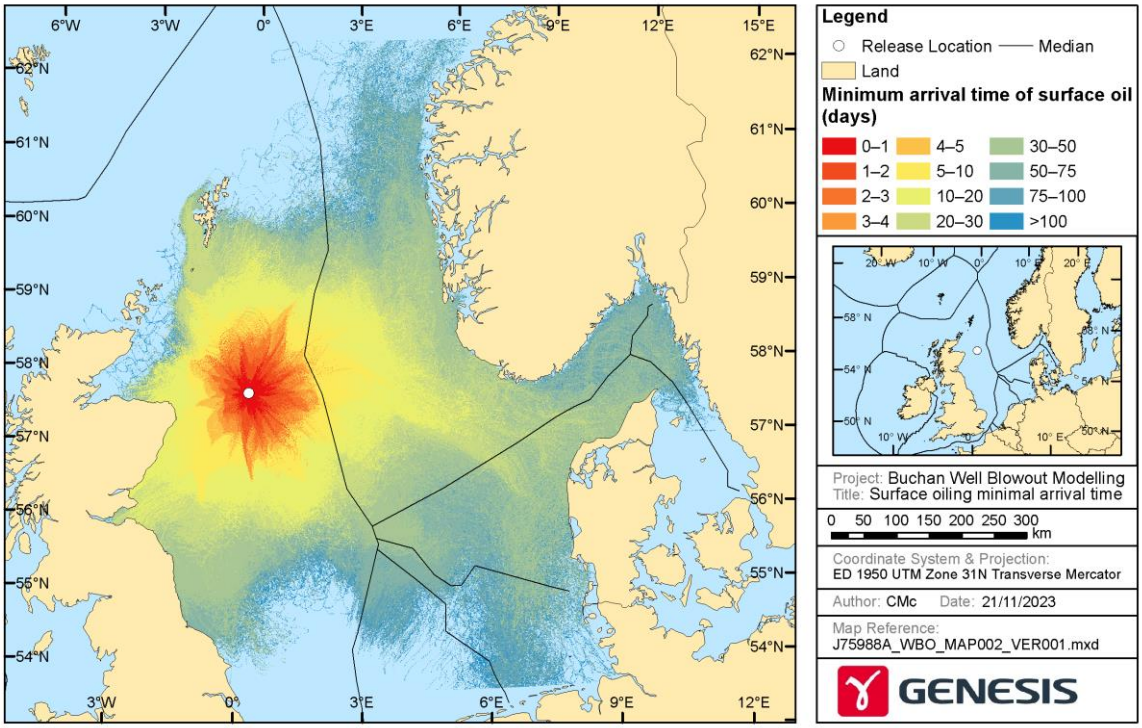


Figure 4-3: Minimum arrival time of a surface sheen > 0.3 µm (well blowout, stochastic)

Table 4-1: Probability and minimum time of arrival of surface sheen > 0.3 µm to median lines (well blowout, stochastic)

Location	Probability (%)	Minimum time of arrival (days)
UK-Norway	100	2.9
UK-Denmark	14	31.6
UK-Germany	13	35.4
UK-Netherlands	8	55.3
Norway-Denmark	29	16.5
Norway-Sweden	16	28.0
Denmark-Sweden	21	32.8
Denmark-Germany	13	34.1
Germany-Netherlands	8	49.4

Note: probability refers to the maximum probability oil reaching each median line and the minimum time of arrival refers to the minimum time taken for oil to reach that median line on any given simulation.

A deterministic simulation was run to further assess the impact to the sea surface. Figure 4-4 shows the total sea surface area impacted by oil over the duration of the entire simulation (swept path). The simulation estimated that the total sea surface impacted by oil with a thickness > 0.3 µm (over the entire course of the simulation) is approximately 85,400 km^2. The

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maximum thickness estimated anywhere at the sea surface is 14.5 µm (0.145 mm). By the end of the deterministic simulation (day 116) only 0.9% of the oil remained on the sea surface.

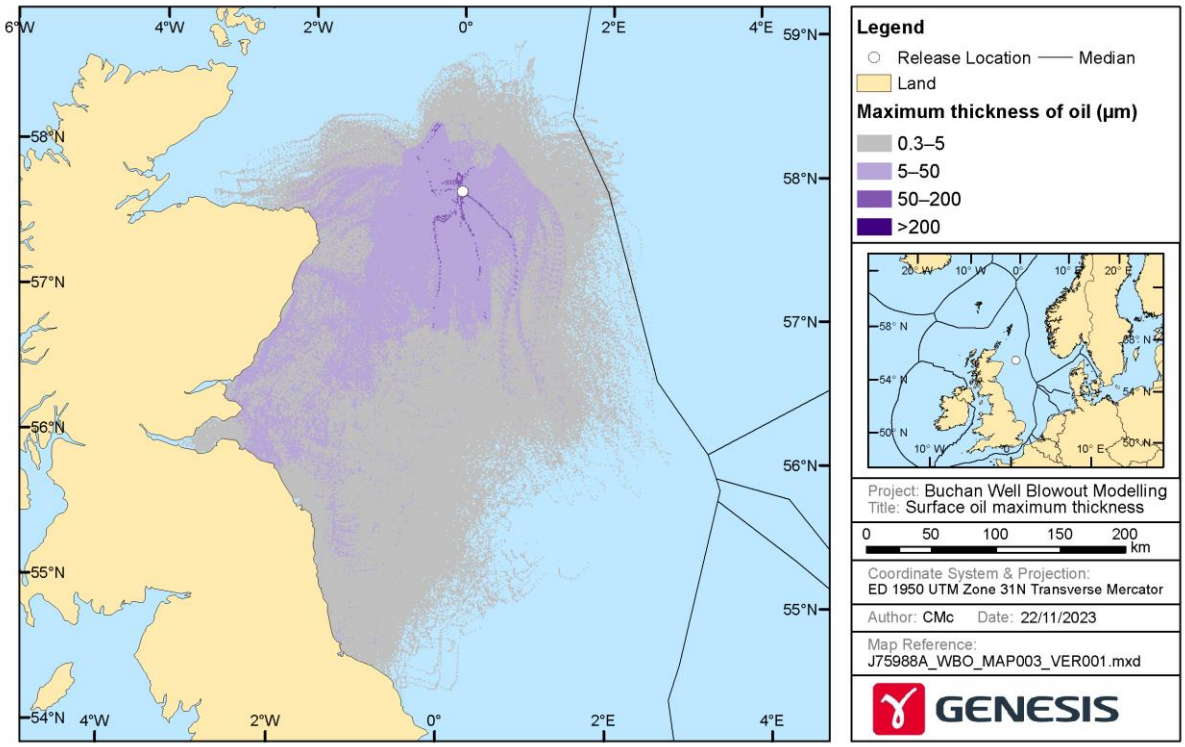


Figure 4-4: Maximum thickness of oil sheen at sea surface (blow out, deterministic)

4.1.3 Shoreline Stranding of Oil

The simulation estimated that there is the possibility of oil reaching the coastline. The probability of shoreline oiling is shown in Figure 4-5 and the minimum time of arrival of oil to shore is shown in Figure 4-6. Table 4-2 details the values for the probability of shoreline oiling and minimum time of arrival to shore along various sections of the coastline.

The coast of Northeast of Scotland has the lowest minimum arrival time (9.8 days) with a probability of shoreline oiling of 25% whereas the coast of Western Norway has the highest probability (42%) but with a slightly longer minimum arrival time (15.1 days).

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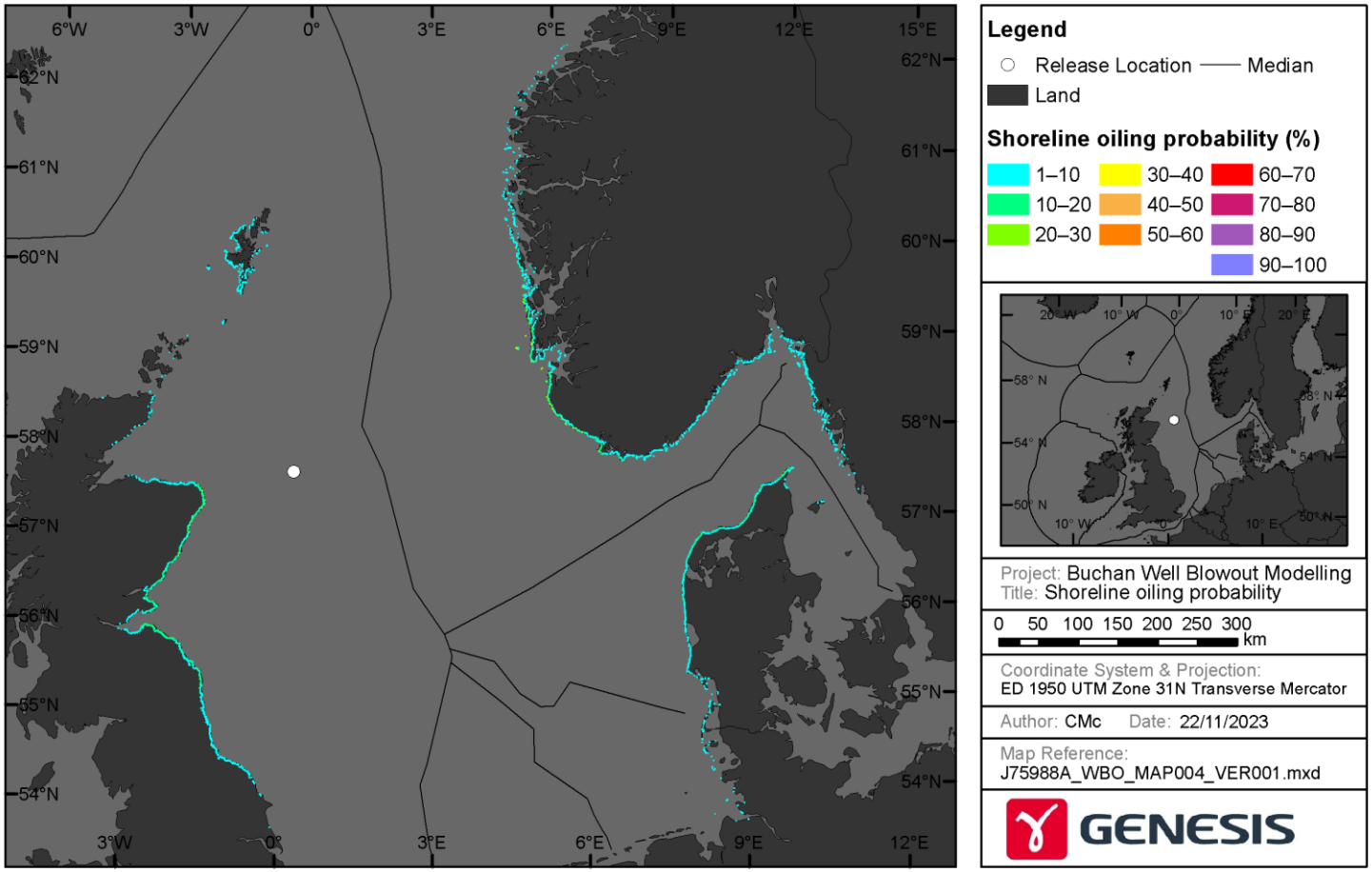


Figure 4-5: Probability of oil on shoreline (no threshold, well blowout, stochastic)

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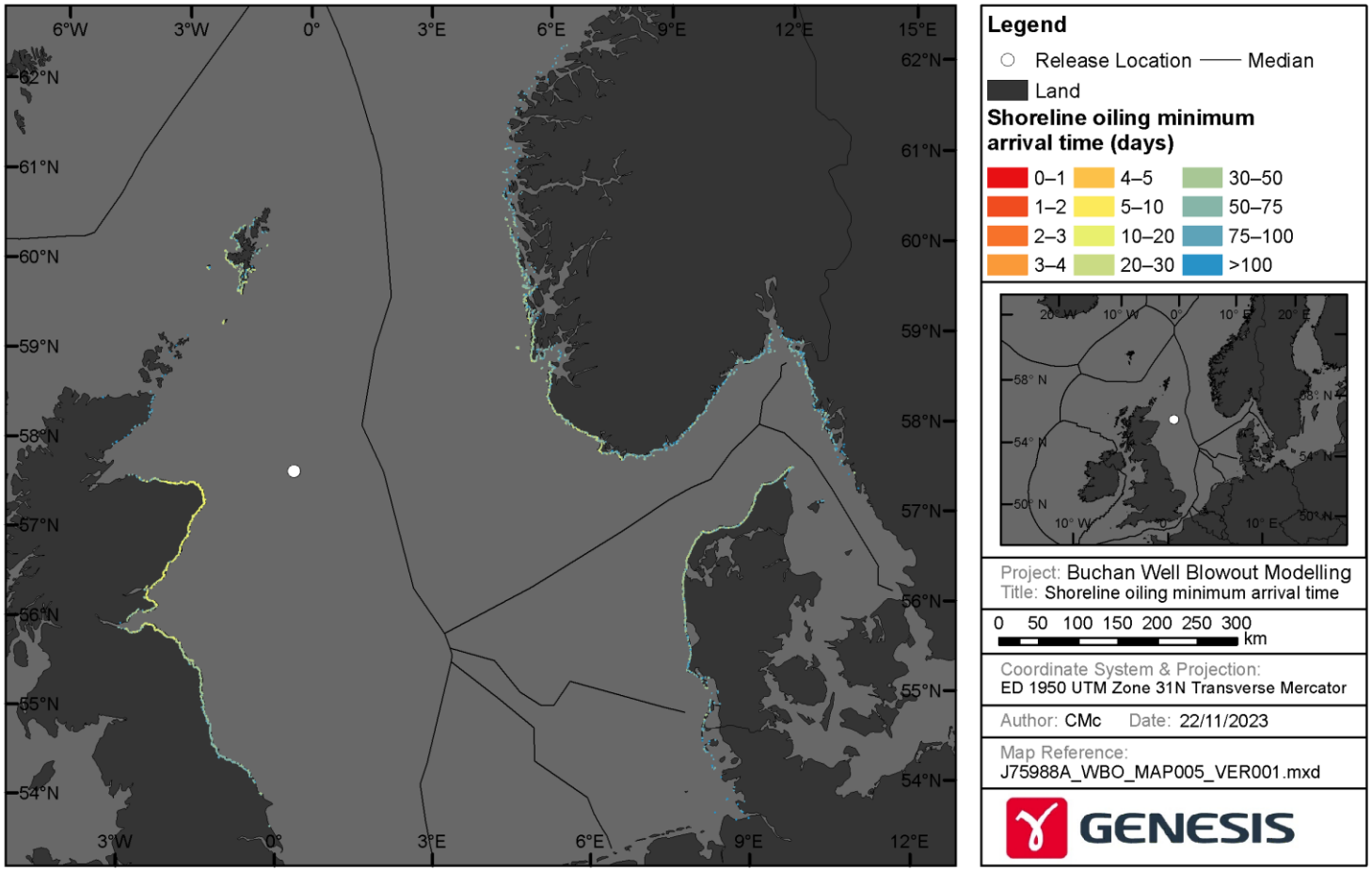


Figure 4-6: Minimum time of arrival of oil to shore (no threshold, well blowout, stochastic)

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Table 4-2: Probability and minimum time of arrival to shore (well blowout, stochastic)

Location	Probability (%)	Minimum time of arrival (days)
Highlands and Island	13	21.6
Northeast Scotland	25	9.8
Eastern Scotland	20	11.6
Southern Scotland	16	19.1
Northumberland and Tyne and Wear	17	22.7
Tees Valley and Durham	7	42.7
North Yorkshire	9	35.7
East Yorkshire and Northern Lincolnshire	1	71.6
Western Norway	42	15.1
Southern Norway	25	22.2
Eastern Norway	15	42.1
Sweden	12	29.4
Denmark	20	19.0
Germany	2	48.6

Note: probability refers to the maximum probability oil reaching each shoreline and the minimum time of arrival refers to the minimum time taken for oil to reach that shoreline on any given simulation.

To allow an assessment of impacts when reviewing model outputs, a mass of oil on the shoreline above 0.1 kg/m^2 has been considered as potentially significant. This is considered to be an impact threshold for oiling of birds by the US Army Corps of Engineers (2003) and is reinforced by McCay (2009), who notes that 0.1 kg/m^2 would be enough to coat benthic epifaunal invertebrates living in intertidal habitats on hard substrates. It is also inferred from the level of 'light' oiling defined by the International Tanker Owners Pollution Federation (ITOPF) Technical Information Paper 6 (ITOPF, 2014).

In the deterministic simulation the maximum concentration of oil estimated to reach the shoreline is shown in Figure 4-7. The maximum concentration reaching the shoreline is approximately 8,080 g/m^2, which is above the threshold of 100 g/m^2 where impacts are considered to be potentially significant. The maximum mass onshore from this scenario is 1,739 t (for timestep 108.2 days). The length of coast where the threshold of 100 g/m^2 is exceeded is approximately 650.0 km running from the Northeast Scotland to East Yorkshire. Note that these values are not for the last time step of the simulation but rather for timestep 108.2 days and therefore this mass onshore decreases thereafter as seen in Figure 4-1. It is also worth noting that in the event of a spill, the trajectory of the oil will depend on the prevailing metocean conditions at the time of the spill and this will not necessarily be towards the coast of Scotland.

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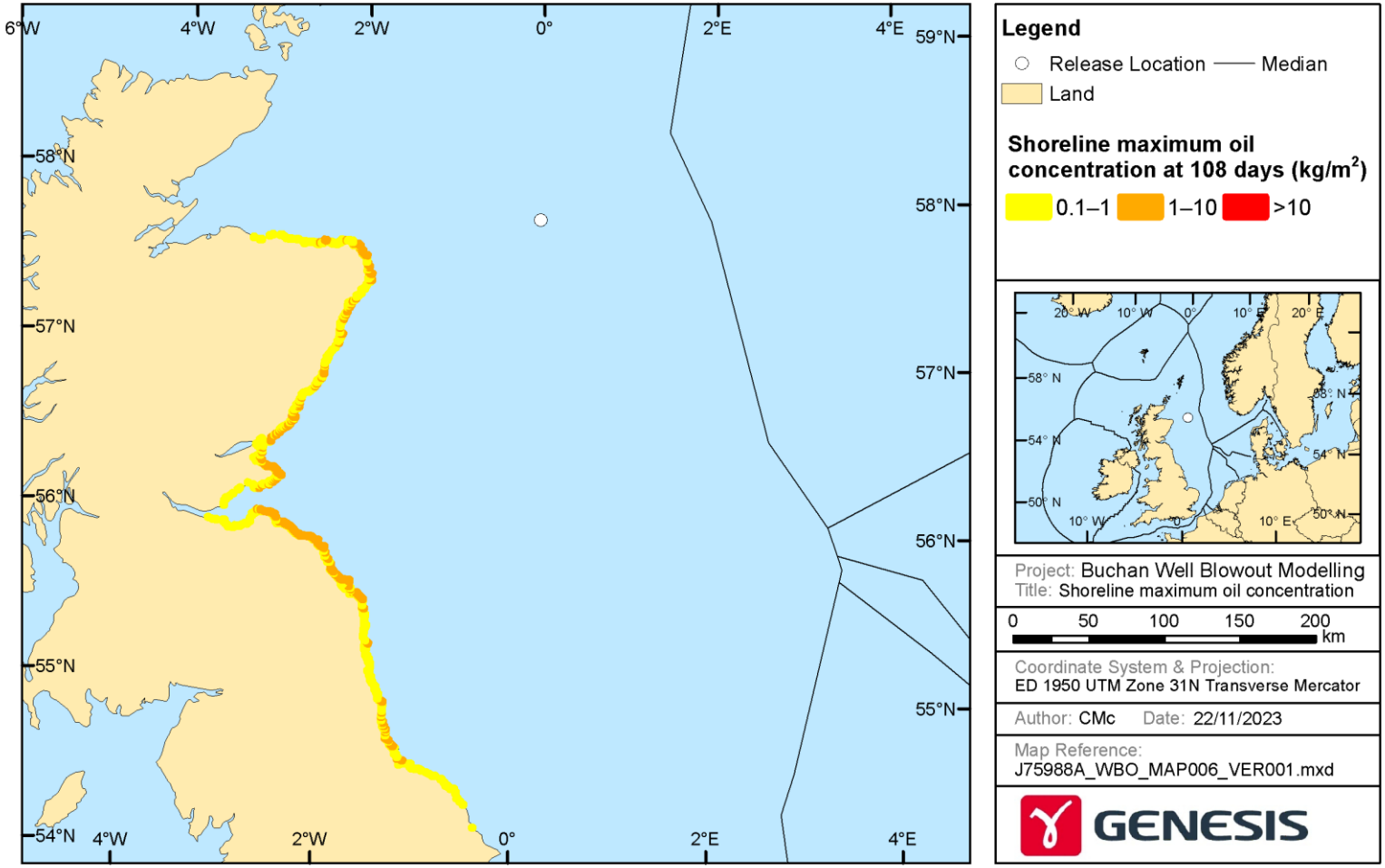
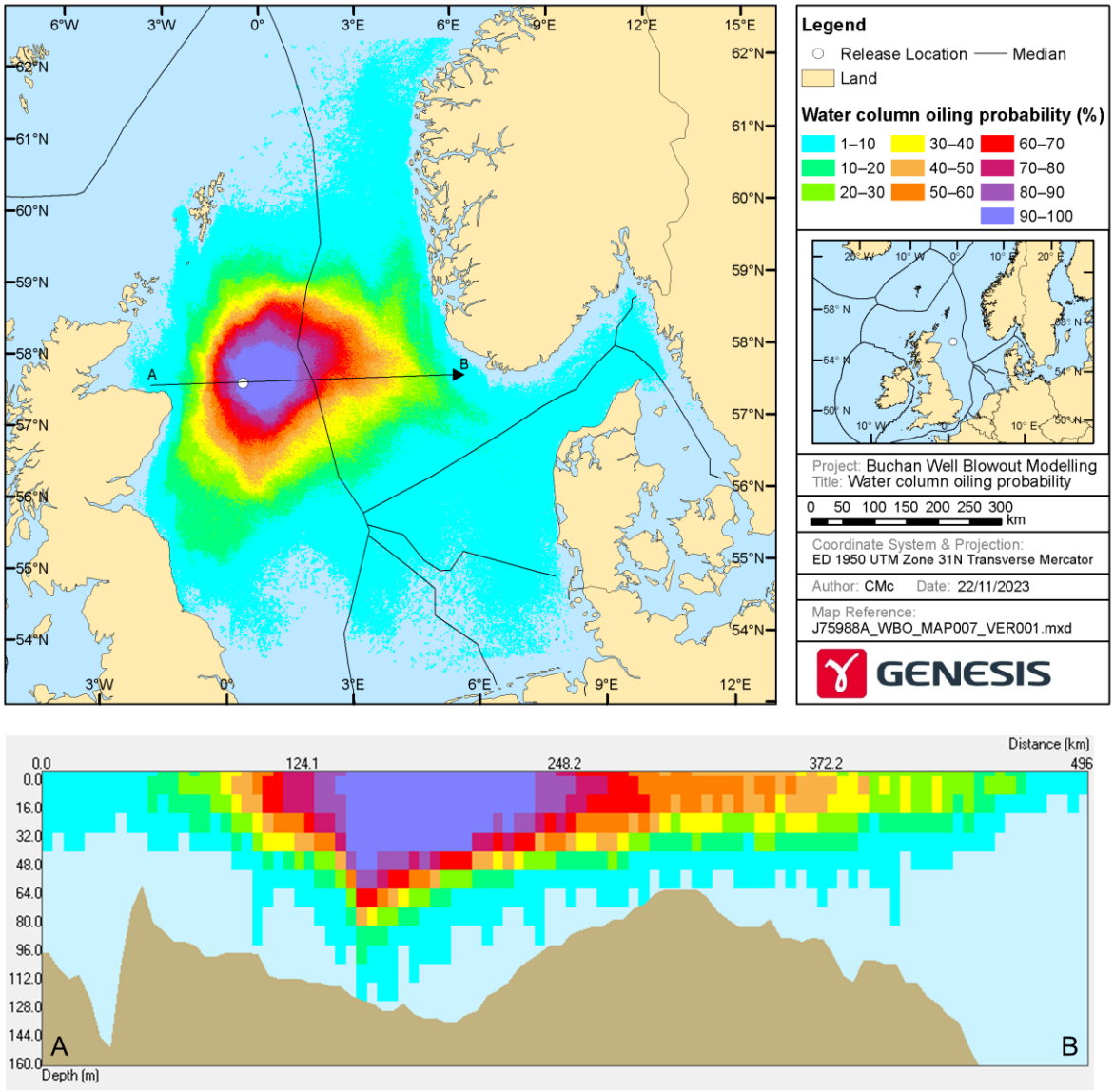


Figure 4-7: Maximum shoreline oil concentrations (well blowout, deterministic, snapshot at 108.2 days)

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4.1.4 Water Column Concentrations

The probabilities of hydrocarbon concentrations ≥ 10 ppb (see Section 3.5.2) in the water column are shown in Figure 4-8. The simulation estimated that water column concentrations above the threshold of 10 ppb could occur up to a maximum distance of 225 km and depth of approximately 65 m with a probability of 50% and a maximum distance of 325 km with a probability of 20%, from the release location.



Note: Points A and B denote the start and finish of the cross-section.

Figure 4-8: Probability of water column concentrations ≥ 10 ppb (well blowout, stochastic)

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A deterministic simulation was run to further assess the impact to the water column. Figure 4-9 shows the maximum total water column concentrations that were observed at any point in time through the water column for the deterministic simulation. The deterministic simulation estimated that the total water column volume impacted by concentrations ≥ 10 ppb oil concentration (over the entire simulation duration) would be approximately 1,960 km^3.

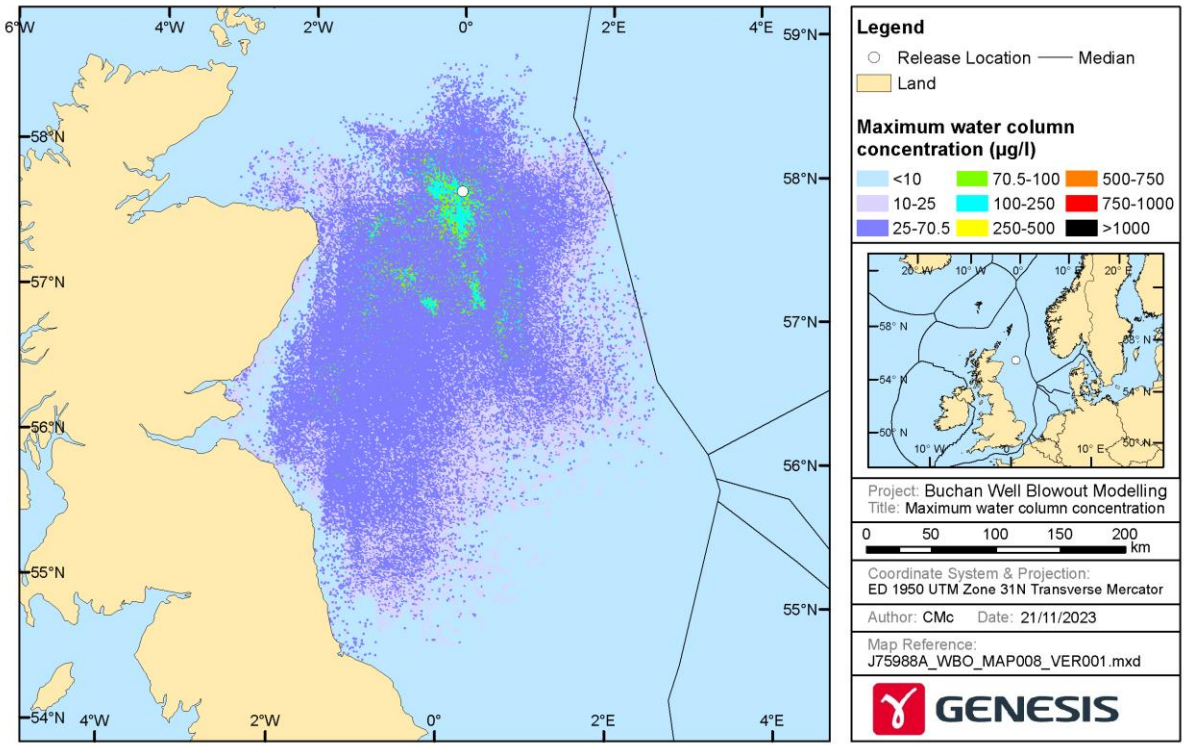


Figure 4-9: Maximum oil concentration in the water column (well blowout, deterministic)

4.1.5 Deposition of Oil on Sediment

To allow an assessment of impacts when reviewing model outputs, 50 mg/kg has been taken as the level above which toxic effects on benthic fauna may begin to be discernible. This threshold was adopted by OSPAR (2006) and UK Offshore Operators Association (1999) in the context of oil-based mud contamination. Given that deposition will distribute vertically through the surface of the seabed, this equates 5 g/m^2 assuming that the oil will distribute through a 5 cm sediment layer and assuming a sediment density of 2.0 t/m^3. Thus, 5 g/m^2 is adopted as the threshold above which toxic effects are considered to begin to be discernible.

The deterministic simulation estimated that the threshold of 5 g/m^2 would not be exceeded. In fact, concentrations of oil in the sediment never exceed 1 g/m^2 as shown in Figure 4-10

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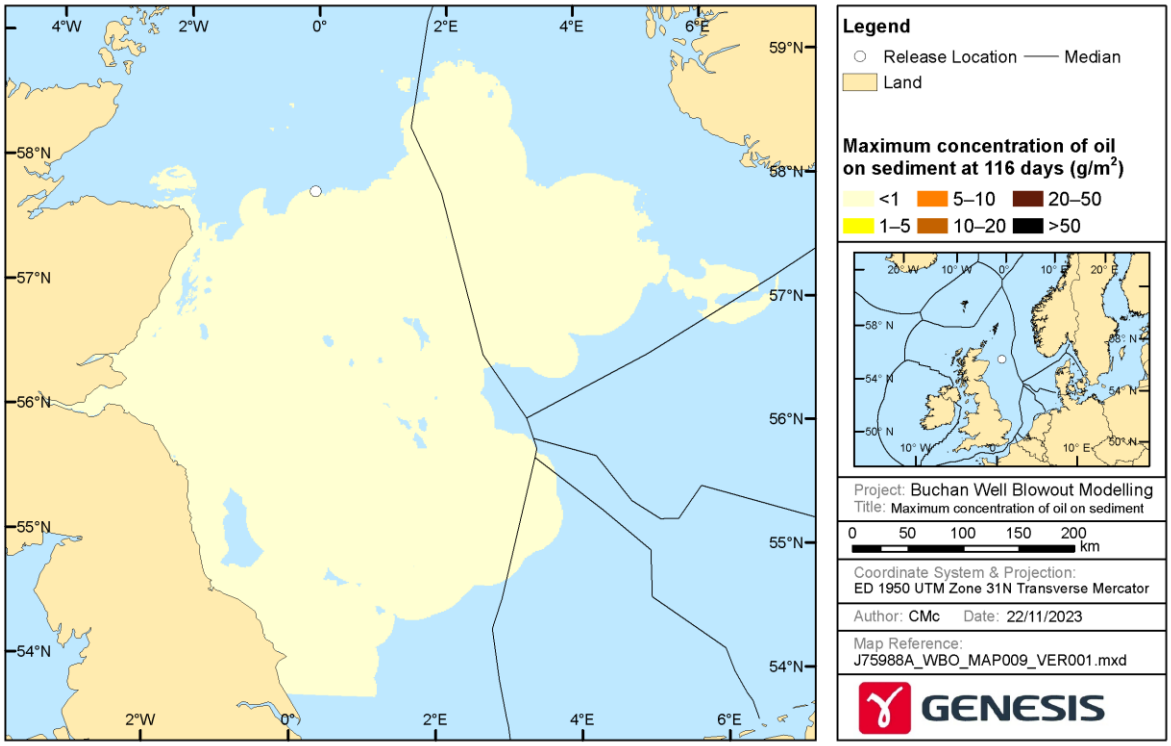


Figure 4-10: Deposited oil in sediment (well blowout, deterministic)

4.2 FPSO Inventory Release

4.2.1 Fate of Hydrocarbons (Mass Balance)

Figure 4-11 shows the mass balance over time both as (A) tonnes and as (B) a percentage. Mass balance plots in Figure 4-11 show that, at the end of the simulation (at day 30) the mass balance of spilled crude was:

- Evaporated: 51.6% (28,060 t);
- Biodegraded: 8.7% (4,753 t);
- Water column: 15.8% (8,599 t);
- Sea surface: 8.8% (4,794 t);
- Shoreline: 13.8% (7,475t);
- Sediment: 1.2% (679 t).

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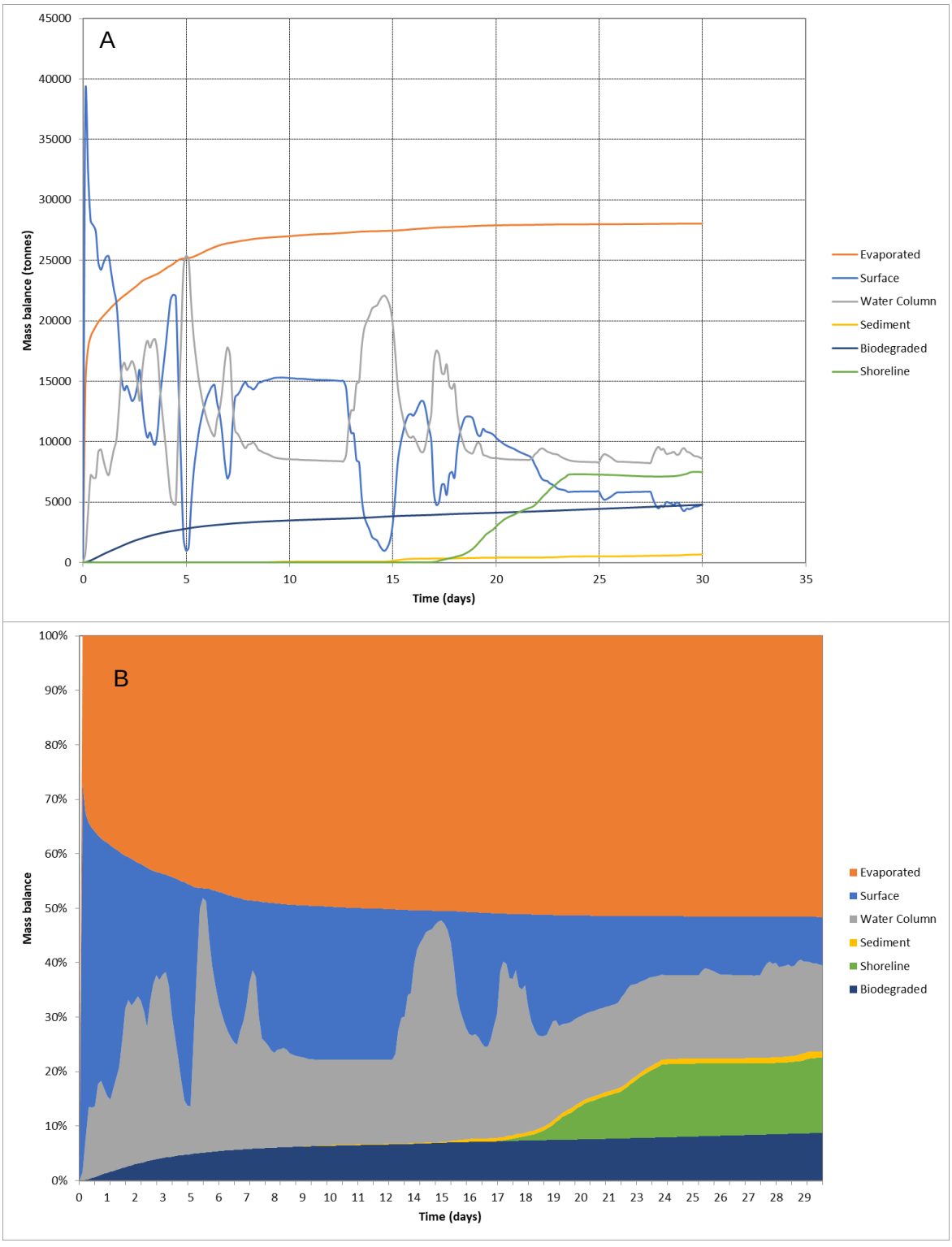


Figure 4-11: Mass Balance (FPSO, deterministic) by mass (A) and % of total release (B).

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4.2.2 Oil on the Sea Surface

The probability of a visible surface sheen with a thickness ≥ 0.3 µm is shown in Figure 4-12, based on results from the stochastic simulation. This visible surface sheen could extend to a maximum distance of 75 km with a 50% probability.

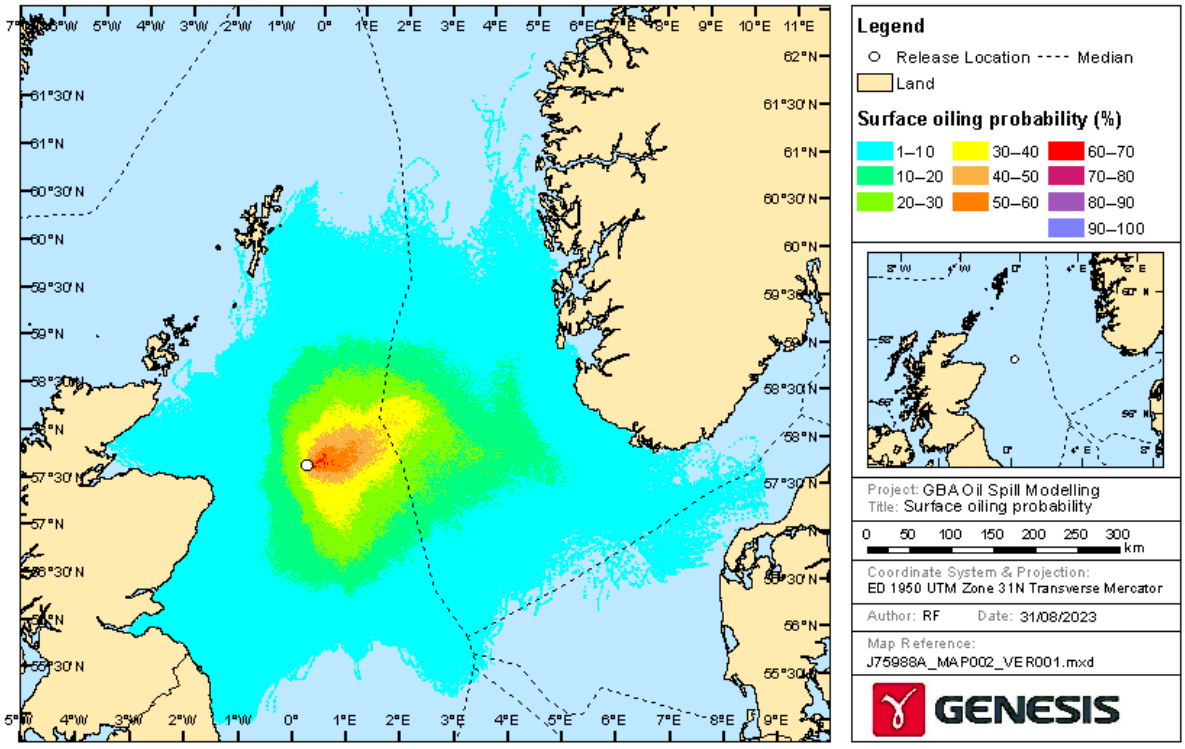


Figure 4-12: Probability of a surface sheen > 0.3 µm (FPSO, stochastic).

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The minimum arrival time of oil on the sea surface is shown in Figure 4-13. The modelled spill reaches the UK-Norway median line, with a maximum probability of 42% and a minimum arrival time of 1.75 days. Probabilities and minimum arrival times for all relevant median lines are shown in Table 4-3.

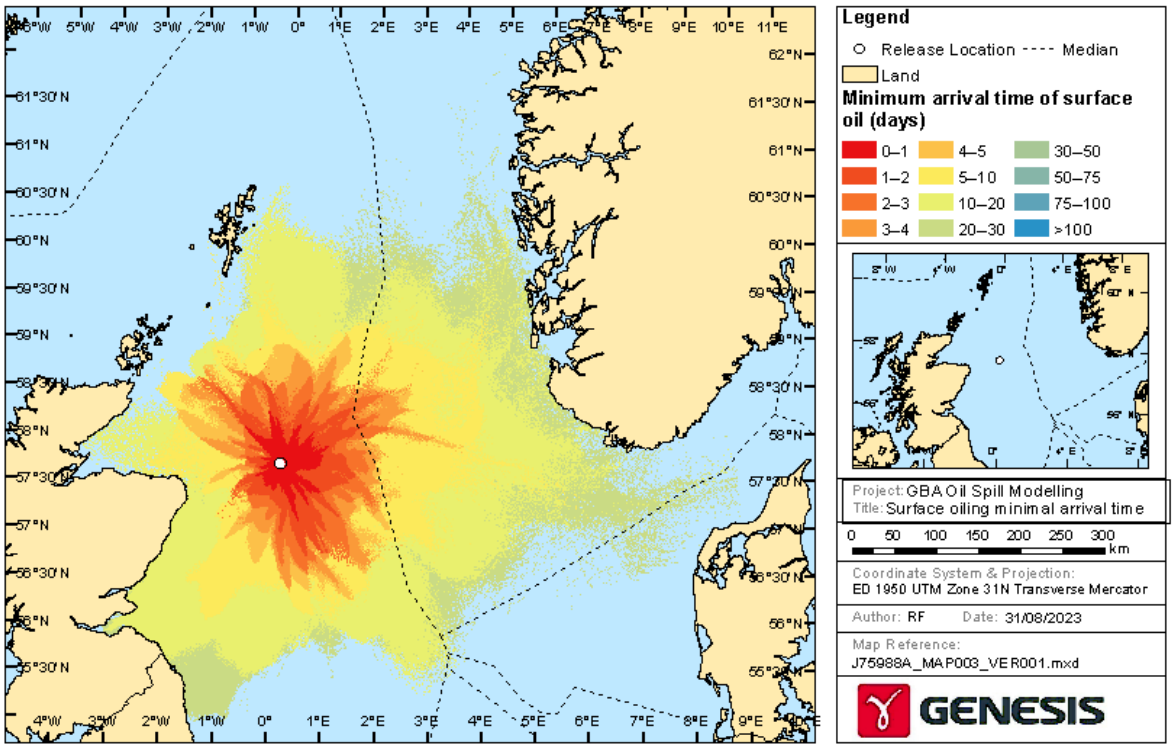


Figure 4-13: Minimum arrival time of a surface sheen > 0.3 µm (FPSO, stochastic).

Table 4-3:Probability and minimum time of arrival of surface sheen > 0.3 µm to median lines (FPSO, stochastic).

Location	Probability (%)	Minimum time of arrival (days)
UK-Norway	42	1.75
UK-Denmark	2	18.38
UK-Germany	1	18.63
UK-Netherlands	1	19.13
Norway-Denmark	3	14.25
Germany- Denmark	1	18.63
Germany - Netherlands	1	19.13

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A deterministic simulation was run to further assess the impact to the sea surface. Figure 4-14 shows the maximum sea surface area impacted by oil. The simulation estimated that the total sea surface impacted by oil with a thickness > 0.3 µm is approximately 31,837 km^2. The maximum thickness estimated anywhere at the sea surface is 72,000 µm (72 mm). It is worth noting that although the potential area impacted by the spill is smaller than for the blow out scenario, the overall oil thickness and total quantity of oil at the surface is significantly greater for FPSO scenario.

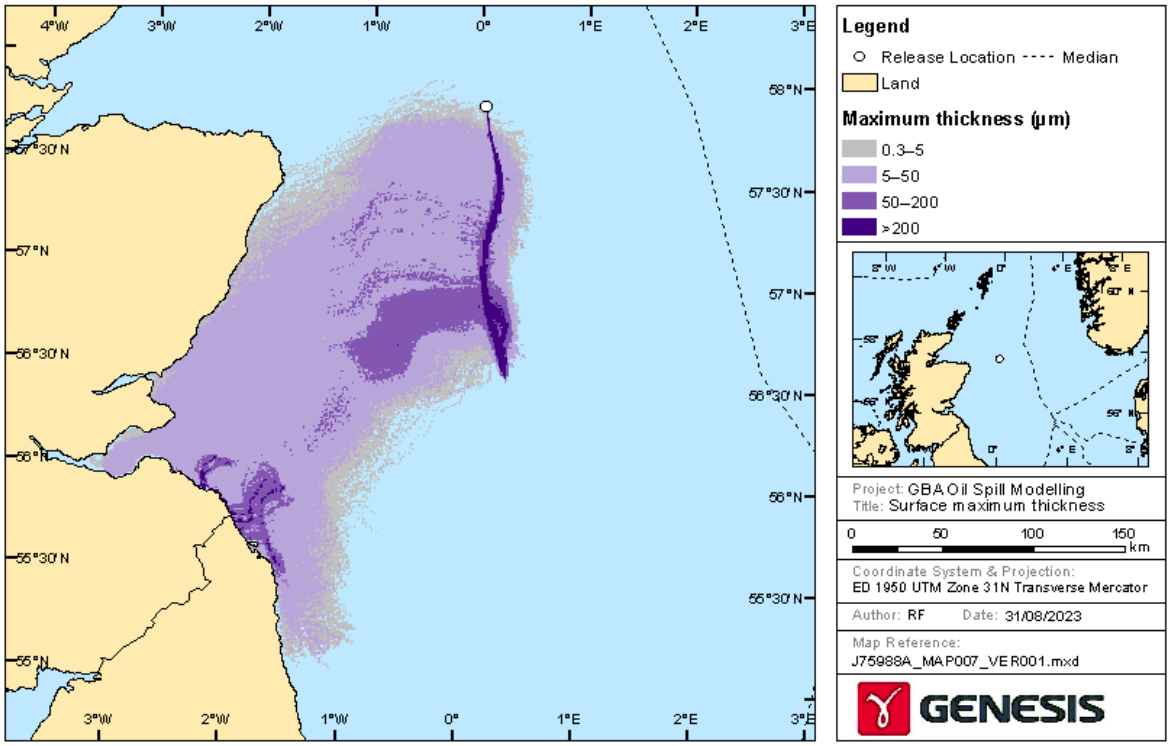


Figure 4-14: Thickness of oil at sea surface (FPSO, deterministic).

4.2.3 Shoreline Stranding of Oil

The probability of shoreline oiling is shown in Figure 4-15 and the minimum time of arrival of oil to shore is shown in Figure 4-16. Table 4-4 details the values for the probability of shoreline oiling and minimum time of arrival to shore along various sections of the coastline. The simulation indicated that there is a low probability of oil reaching the coastline of the UK (3%) with a minimum arrival time of 7.9 days and Norway (5%) with a minimum arrival time of 13.7 days.

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Table 4-4:Probability and minimum time of arrival to shore (FPSO, stochastic).

Location	Probability (%)	Minimum time of arrival (days)
Highlands and Island	1	10.6
Northeast Scotland	3	7.9
Eastern Scotland	2	11.5
Southern Scotland	2	16.8
Northumberland and Tyne and Wear	3	17.0
South western Norway	5	13.7
Southern Norway	4	19.9

Note: probability refers to the maximum probability oil reaching each shoreline and the minimum time of arrival refers to the minimum time taken for oil to reach that shoreline on any given simulation.

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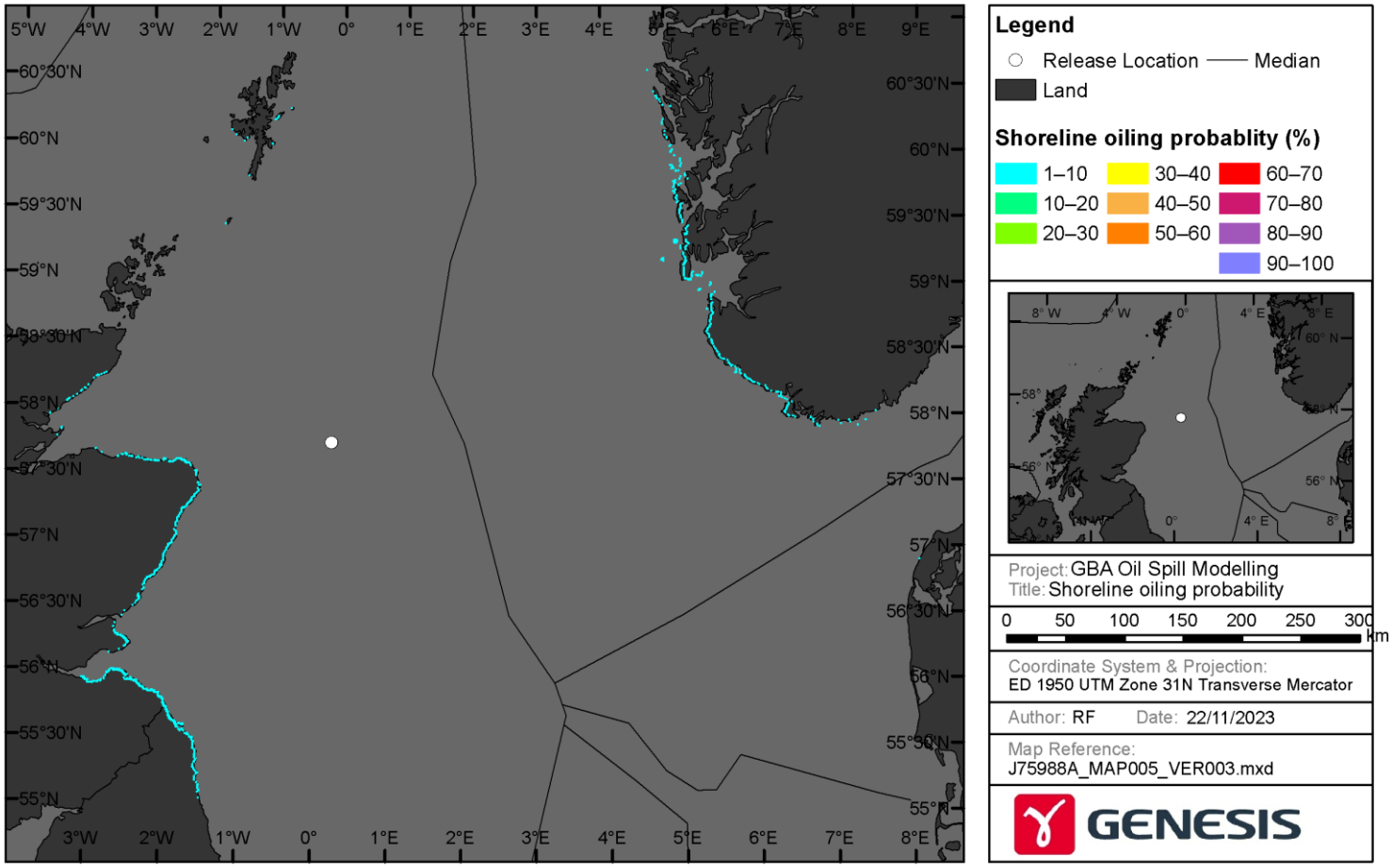


Figure 4-15: Probability of oil reaching the coast (FPSO, stochastic).

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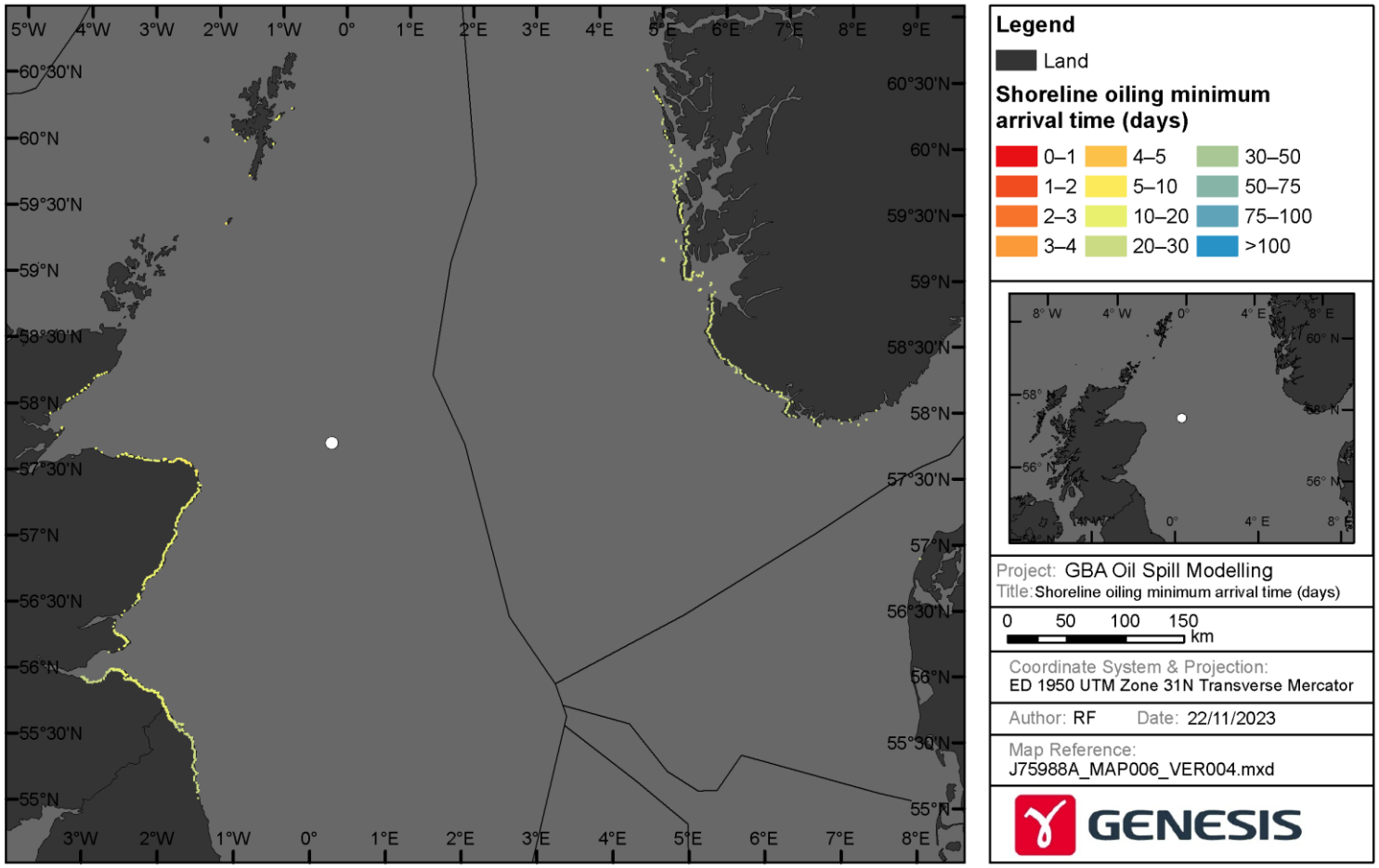


Figure 4-16: Minimal arrival time for oil to reach the coast (FPSO, stochastic).

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To allow an assessment of impacts when reviewing model outputs, a concentration of oil on the shoreline above 0.1 kg/m^2 has been considered as potentially significant. This is the impact threshold for oiling of birds used by the US Army Corps of Engineers (2003) and is reinforced by McCay (2009), who notes that 0.1 kg/m^2 would be enough to coat benthic epifaunal invertebrates living in intertidal habitats on hard substrates. It is also inferred from the level of 'light' oiling defined by the International Tanker Owners Pollution Federation (ITOPF) Technical Information Paper 6 (ITOPF, 2014).

The maximum oil reaching the coast based on the deterministic simulation is shown in Figure 4-17. The model estimates that approximately 237 km of the UK coastline would have a mass of oil of more than 0.1 kg/m^2. which is above the threshold of 100 g/m^2 where impacts are considered to be potentially significant. The maximum mass onshore from this scenario is 7,486 t at 29.62 days. This is greater than the mass onshore following a blow out, even though it potentially impacts a shorter section of coastline.

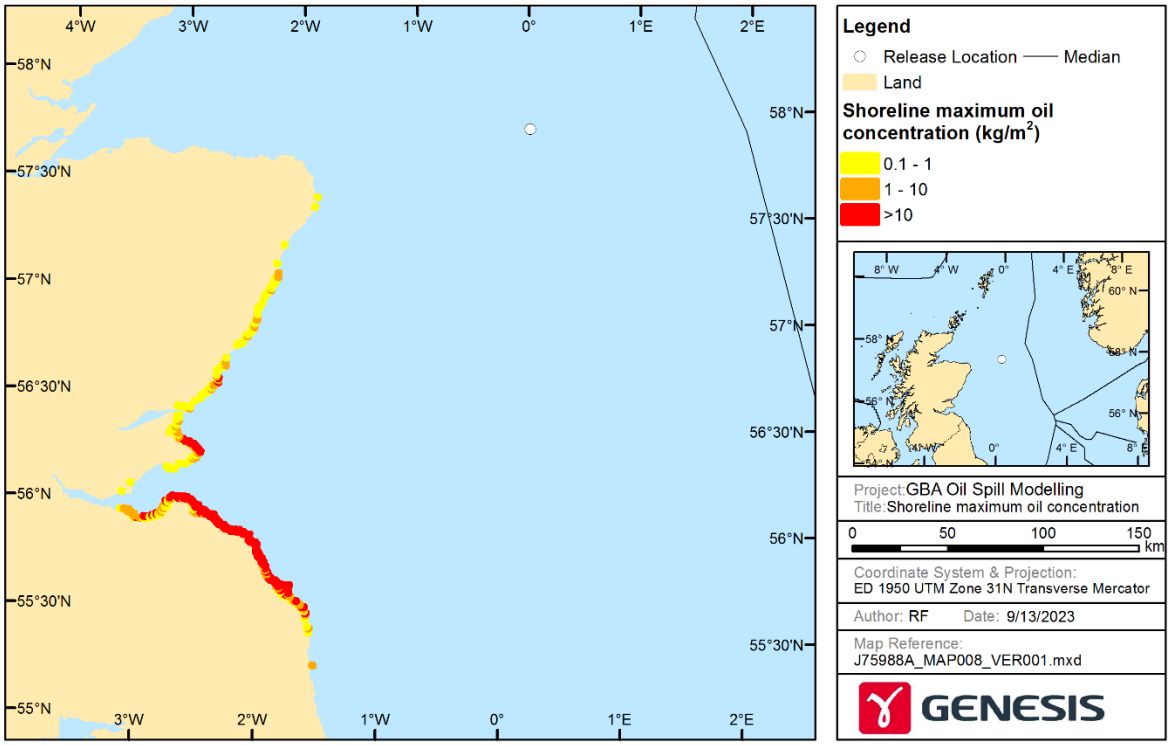
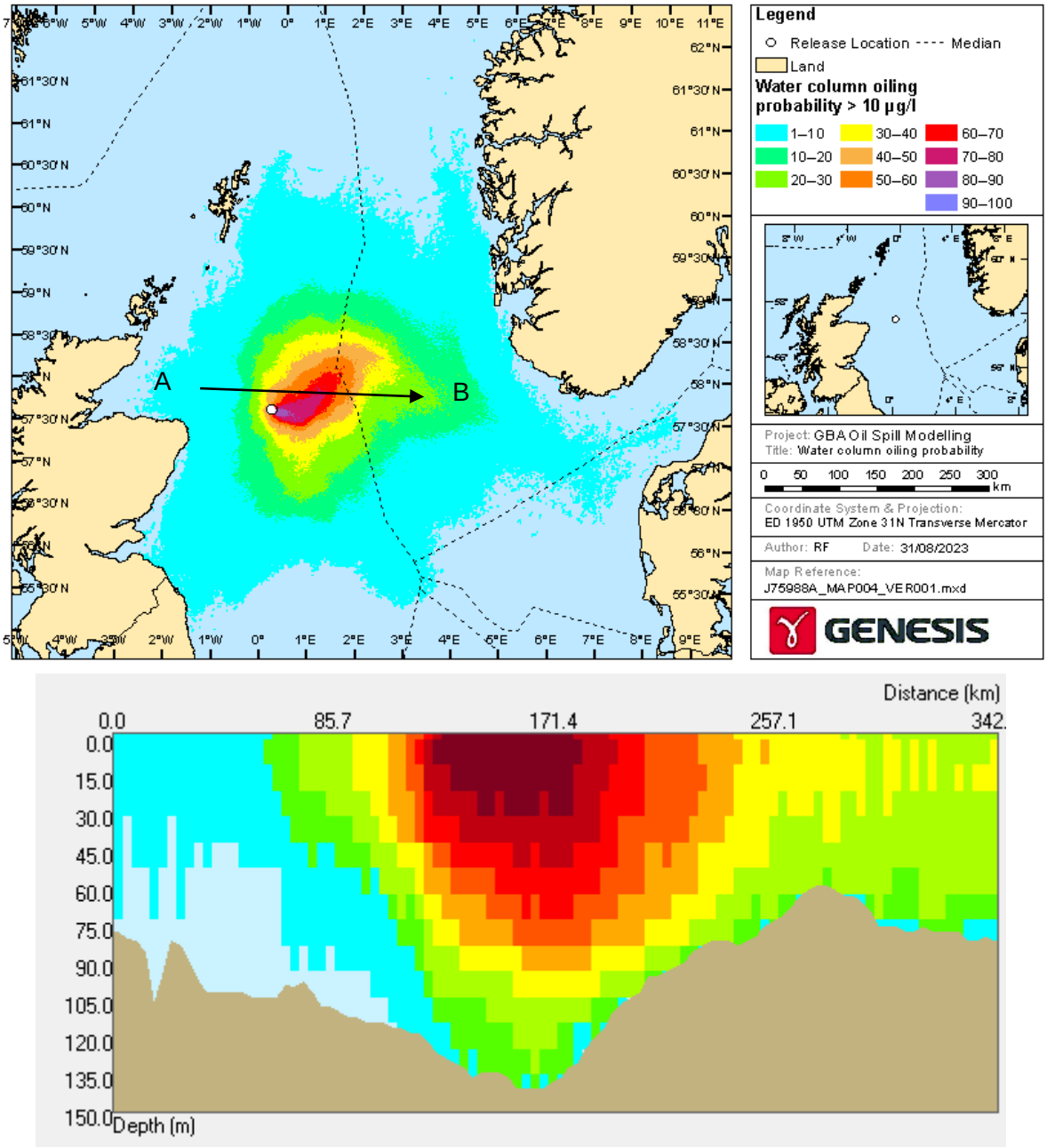


Figure 4-17: Concentration of oil at the coast (FPSO, deterministic, snapshot at 29.62 days).

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4.2.4 Water Column Concentrations

The probabilities of hydrocarbon concentrations ≥ 10 ppb (see Section 3.5.2) in the water column are shown in Figure 4-18. The simulation estimated that water column concentrations above the threshold of 10 ppb could occur up to a maximum distance of 130 km and depth of approximately 50 m with a probability of 50%.



Note: Points A and B denote approximate start and finish of the cross-section.

Figure 4-18: Probability of water column concentrations ≥ 10 ppb (FPSO, stochastic).

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The results shown in Figure 4-18 were obtained from the stochastic simulation. A deterministic simulation was run to further assess the impact to the water column. Figure 4-19 shows the maximum total water column concentrations that were observed at any point in time through the water column for the deterministic simulation. The deterministic simulation estimated that the total water column volume impacted by concentrations ≥ 10 ppb oil concentration would be approximately 271 km^3.

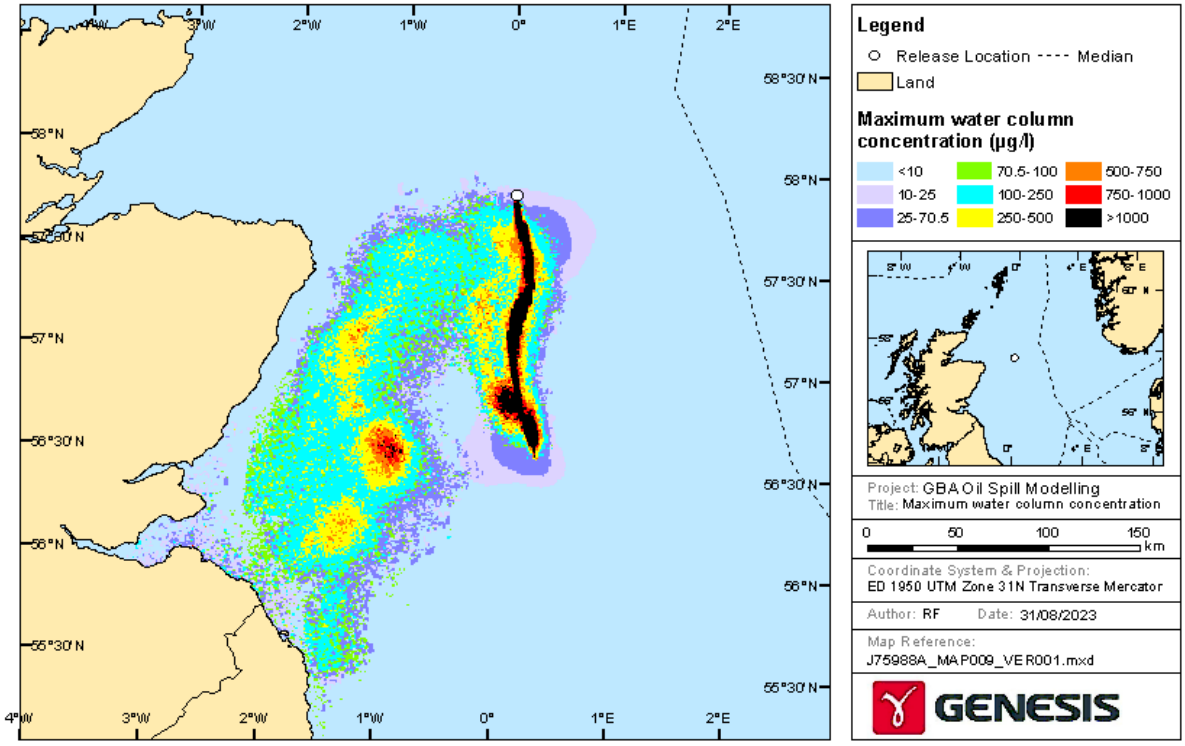


Figure 4-19: Maximum oil concentration in water column (FPSO, deterministic).

4.2.5 Deposition of Oil on Sediment

To allow an assessment of impacts when reviewing model outputs, 50 mg/kg has been taken as the level above which toxic effects on benthic fauna may begin to be discernible. This threshold was adopted by the Oslo and Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR, 2006) and UK Offshore Operators Association (UKOOA, 1999) in the context of oil-based mud contamination. Given that deposition will distribute vertically through the surface of the seabed, this equates 5 g/m^2 assuming that the oil will distribute through a 5 cm sediment layer and assuming a sediment density of 2.0 t/m^3. Thus, 5 g/m^2 is adopted as the threshold above which toxic effects are considered to begin to be discernible.

The deterministic simulation estimated that the concentration of oil on the seabed would always be below the threshold of 5 g/m^2. In fact, concentrations of oil in the sediment never exceed 1 g/m^2 as shown in Figure 4-20.

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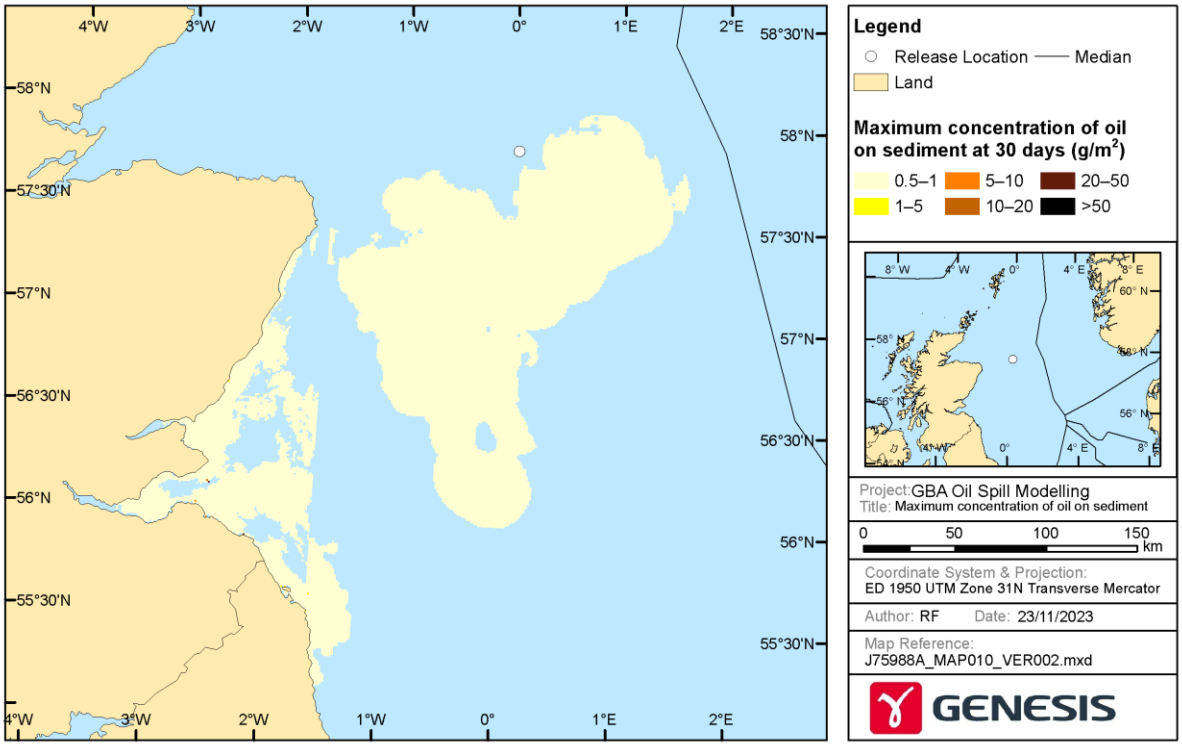


Figure 4-20: Maximum oil concentration in sediment (FPSO, deterministic).

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5.0 CONCLUSION

Two oil spill scenarios were modelled:

- A well blow out lasting 86 days, resulting in an overall release of 19,142 m^3; and
- A release of the full FPSO inventory, lasting 1 hour, resulting in an overall release of 63,509 m^3.

The model estimated that for the well blowout scenario there is a probability that oil will reach the coastline of the United Kingdom (25%) and Norway (42%). For the FPSO inventory release, the probabilities are lower: 3% probability of reaching the coast of the UK and 5% probability of reaching the coast of Norway.

A summary of the main deterministic simulation outputs for the two scenarios are detailed in Table 5-1. It is worth noting that although the modelling results for the FPSO appear to indicate that less sea surface is impacted, the oil thickness within that area is significantly thicker. Given more time to disperse within the model it is likely that a wider area would be covered, but with a lower thickness. Similarly, although a shorter stretch of coastline exceeds the threshold for the FPSO scenario, the actual quantity of oil reaching the shore overall is much larger. This is because the FPSO spill takes place over a much shorter period than the blow out so there is less time for dispersion to take place.

The thresholds for surface sheen thickness, shoreline oiling and hydrocarbon concentration in the water column are all exceeded over relatively large areas/volumes. This was expected given that the scenarios simulate worst-case hydrocarbon releases.

The threshold for hydrocarbon concentration in seabed sediment is not exceeded for either scenario.

Table 5-1: Summary of deterministic simulation outputs.

Environmental fraction	% and mass total oil in environmental fraction[1]		Threshold	Extent above threshold	
	Well blowout	FPSO inventory release		Well blowout	FPSO inventory release
Sea surface	0.9% (160.5 t)	8.8% (4,794 t)	0.3 µm	85,400 km^2 (max thickness 14.5 µm)	31,837 km^2 (max thickness 72,000 µm)
Shoreline	9.5% (1,657 t)[2]	13.8% (7,475t)[2]	0.1 kg/m^2 (100 g/m^2)	650.0 km	237 km
Water column	21.5% (3,738 t)	15.8% (8,599 t);	10 ppb	1,960 km^3	271 km^3
Seabed Sediment	1.8% (318.3 t)	1.2% (679 t)	50 mg/kg (5 g/m^2)	0 km^2	0 km^2
Atmosphere	52.6% (9,129 t)	51.6% (28,060 t)	N/A	N/A	N/A
Biodegraded	13.6% (2,367 t)	8.7% (4,753 t);	N/A	N/A	N/A

Notes: [1] given for end of the simulation (116 days); [2] max oil onshore of 1,739 t occurs at 108.2 days (blowout), max oil onshore of 7,486 t occurs at 29.6 days (FPSO)

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