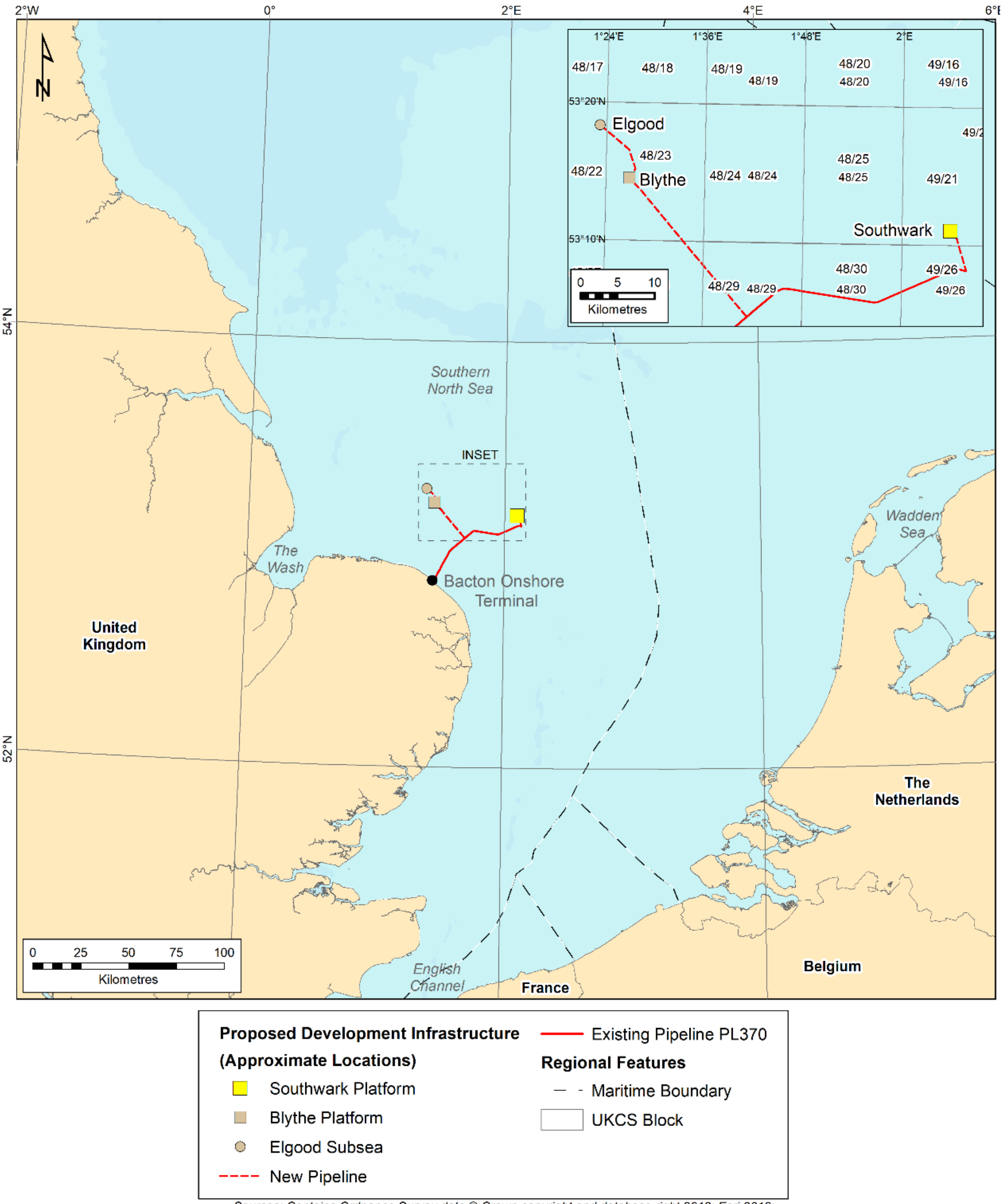
Blythe Hub Development ES Addendum
Southwark Field Development



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D/4208/2018

ENVIRONMENTAL MANAGEMENT POLICY

Independent Oil and Gas (IOG) is committed to conducting its undertakings in an environmentally responsible manner.

As an oil & gas exploration and production company, IOG appreciates that its activities can interact with the natural environment in many ways and recognises that its long-term success depends upon achieving high standards of environmental performance.

In order to achieve and sustain high standards of performance we will: -

- Integrate environmental considerations within our business processes and decision making
- Identify and comply with all applicable laws, regulation and statutory guidance applicable to our activities
- Evaluate risks of adverse environmental impacts arising from our planned activities and eliminate or minimise the risks in accordance with recognised best practice
- Specifically prevent pollution through the proper planning and conduct of our activities
- Maintain and periodically exercise suitable emergency response plans, facilities and equipment in order to deal with the occurrence and consequence of environmental incidents
- Minimise the production of waste arising from our activities by applying the recognised preference hierarchy of Reduce, Reuse, Recycle
- Co-operate with and support our contractors and suppliers in order to promote and enable compliance with this policy
- Communicate this policy and the environmental performance expectations of the company to all employees
- Develop and apply suitable environmental performance metrics for our activities
- Establish and maintain environmental management processes and systems in order to implement this policy and achieve a continual improvement in environmental performance

Ultimate responsibility for the effective implementation of this policy rests with the Chief Executive and the Board.

The policy shall be implemented by line management who are responsible for establishing clear roles and responsibilities for aspects of the policy relevant to their functional areas, including in particular, the activities of contracted services and duty holders.

In addition, individuals working for or on behalf of IOG or conducting activities at IOG premises or assets, are expected to conduct themselves in a manner that enables IOG to comply with this policy.

Andrew Hockey Chief Executive Officer – Independent Oil & Gas plc March 2018

ENVIRONMENTAL STATEMENT - SUBMISSION SUMMARY

THE OFFSHORE PETROLEUM PRODUCTION AND PIPE-LINES (ASSESSMENT OF ENVIRONMENTAL EFFECTS) REGULATIONS 1999 (AS AMENDED)

SUBMISSION OF AN ENVIRONMENTAL STATEMENT IN SUPPORT OF AN APPLICATION FOR THE CONSENT OF A PROJECT UNDER THE PETROLEUM ACT 1998 OR THE ENERGY ACT 2008

Section A: Administrative Information

A1 – Project Reference Number

Number **D/4208/2018**

A2 - Applicant Contact Details

Company name: IOG UK LTD
Contact name: Andrew Hockey
Contact title: CEO
Company name: IOG North Sea Limited
Contact name: Andrew Hockey
Contact title: CEO

A3 – ES Contact Details

Company name: AS ABOVE
Contact name: Ian Pollard
Contact title: Head of HSE (IOG UK LTD and IOG North Sea Limited)

A4 – ES Preparation

Key expert staff involved in the preparation of the ES:

Name	Company	Title	Relevant Qualifications/Experience
Jacco Veenboer	Fugro GB Marine Ltd	Environmental Consultancy Team Leader	Eighteen years in environmental consultancy role for the offshore oil and gas industry and other marine industries. MSc Marine Resource Development and Protection BEng Environmental Technology
Ian Stewart	Fugro GB Marine Ltd	Senior Environmental Consultant	Thirteen years in environmental consultancy role, in which main specialisms have been environmental impact assessment and environmental surveys. MSc Marine Environmental Protection, BSc Ecological Science
Ian Pollard	Independent Oil and Gas PLC	Head of HSE	More than 30 years' experience of international oil and gas exploration and production, in HSE management, corporate governance and risk management. BSc (Hons) CMIOSH

A5 - Licence Details

a) **Licences covering proposed activities**

Licence numbers: P1915 (Southwark)

b) **Licensees and current equity**

Company	Percentage Equity
IOG UK LTD	100%

(IOG UK LTD is a wholly owned subsidiary of INDEPENDENT OIL AND GAS PLC)

Section B: Project Information

B1 - Nature of Project

a) Name of the project: **Southwark Field Development**

b) Name of the ES: **Blythe Hub Development ES Addendum – Southwark Field Development**

c) Brief description of the project:

The applicant offshore oil & gas field developer plans to develop the Southwark field which will produce gas for onshore processing at the Bacton Gas Terminal on the north Norfolk coast.

Three gas production wells will be drilled with a jack-up drilling rig in the Southwark field, a minimum facilities offshore gas production platform installed together with an export pipeline which will be tied-in to the existing 24" Thames to Bacton pipeline (PL370) in order to deliver produced gas to the Bacton onshore Terminal.

First gas from the Southwark field is expected in July 2021.

B2 - Project Location

a) **Offshore location of the main project elements**

Geodetic datum: ED50, UTMZ31, CM 3°E					
Platform	**UKCS Block**	**Easting [m]**	**Northing [m]**	**Latitude**	**Longitude**
Southwark	49/21	439 742.0	5 893 250.0	53° 11' 02.605" N	002° 05' 53.879" E

The nearest landfall to the Southwark field is the north Norfolk coast, located 55 km to the southwest of the Southwark field.

At its nearest point, the UK/Netherlands median line is situated approximately 64 km to the east of the Southwark field.

B3 – Previous Applications

These Southwark-specific project elements were previously part of a wider field development plan, (the Vulcan Satellites Hub Development) for which an ES was submitted to OPRED in April 2018, reference D/4213/2018.

Since the submission of the Vulcan Satellites Hub Development ES the Vulcan Satellites development has been split in to two development phases, with the Southwark-specific components now scheduled to be developed as part of the Blythe Hub Development programme.

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INDEPENDENT
OIL & GAS PLC

Non-Technical Summary

NON-TECHNICAL SUMMARY

This Addendum to the Blythe Hub Development Environmental Statement (ES) presents the findings of the Environmental Impact Assessment (EIA) conducted jointly by IOG UK Ltd and IOG North Sea Limited (both referred to 'IOG' in the remainder of this addendum) for the inclusion of the proposed Southwark Field Development to the Blythe Hub Development ES. The addendum covers the drilling of production wells and installation of a minimum facilities platform. The addendum also assesses the subsequent production phase, until the field becomes economically unviable and will be decommissioned. The Southwark field is located in United Kingdom Continental Shelf (UKCS) Block 49/21, approximately 55 km from the nearest landfall (Figure 1). The purpose of this ES addendum is to provide an assessment of the potential environmental effects that may arise from the proposed drilling, installation and production operations and to identify measures which will be put in place to minimise these effects.

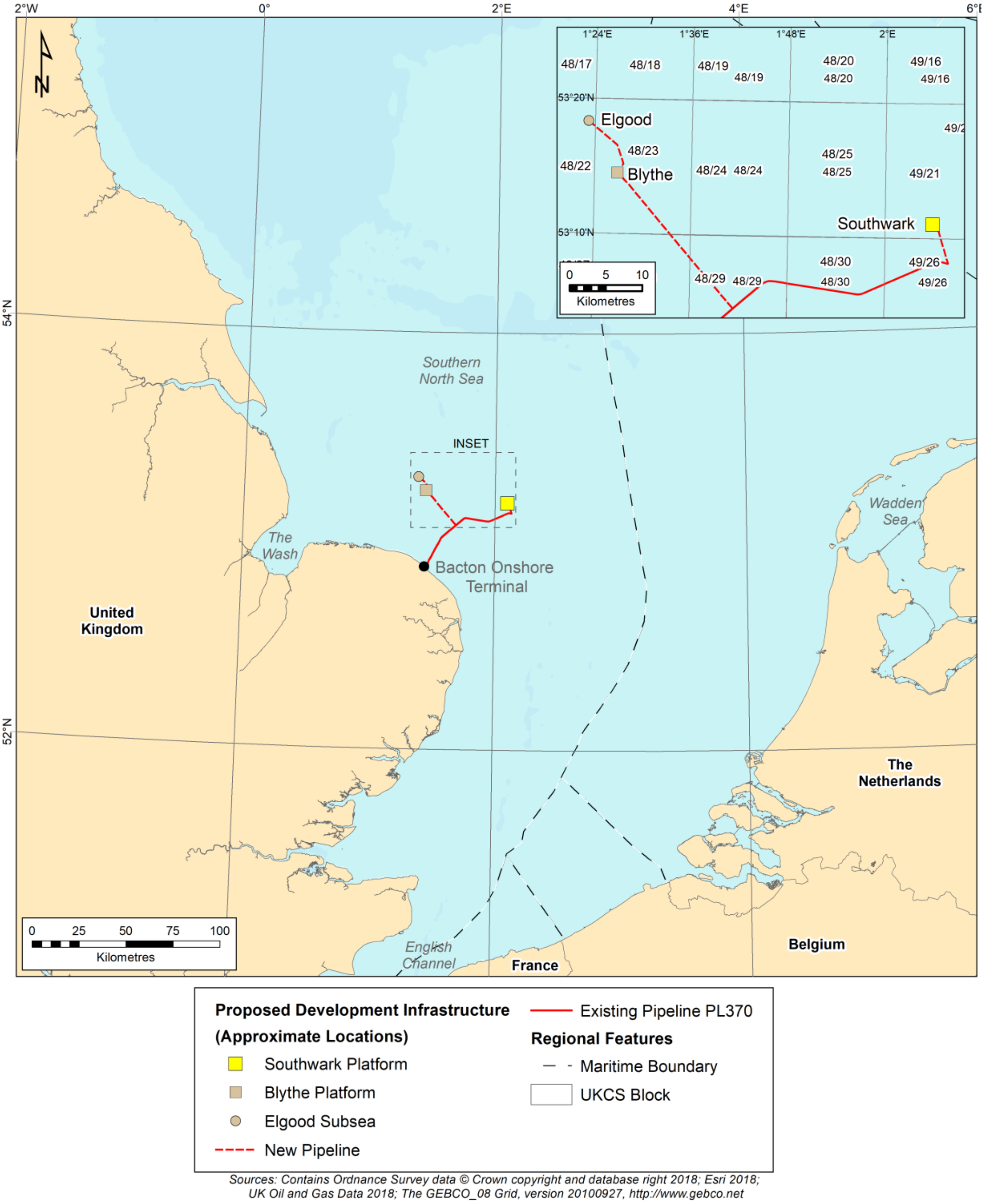


Figure 1: Location of the Southwark Field Development

The EIA Process

Offshore drilling and production activities can involve a number of environmental interactions and impacts due to, for example, operational emissions, discharges and general disturbance. The objective of the EIA process is to incorporate environmental considerations into the project planning and design activities, to ensure that best environmental practice is followed and, ultimately, to achieve a high standard of environmental performance. The process also allows for any potential concerns identified by stakeholders to be addressed appropriately. In addition, it ensures that the planned activities are compliant with legislative requirements.

Environmental Management

The IOG Main Board and Management Team recognise the critical importance of maintaining effective environmental management processes in the development and operation of UKCS offshore fields, and in maintaining their licence to develop the Southwark Field Development.

Overall responsibility and accountability for environmental practice and compliance rests with the IOG CEO, and the Board. Leadership and commitment in all HSE aspects of IOG activities are major factors in ensuring that company values, policies and performance expectations are fulfilled.

IOG recognises the recommendations of The Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention) for all operators controlling the operation of offshore installations on the UKCS to have in place an Environmental Management System designed to:

- Achieve the general objectives of the OSPAR Offshore Strategy;
- Achieve the environmental goals of the prevention and elimination of pollution from offshore sources and of the protection and conservation of the maritime area against other adverse effects of offshore activities;
- Maintain continual improvement in environmental performance.

The IOG Environmental Management System:

- Is implemented at a strategic level, being driven by the CEO as an integral part of the corporate aspirations and growth of the IOG enterprise;
- Is designed to deliver and manage compliance with environmental laws and regulations on an ongoing basis, including a register of environmental legislation which describes the key requirements of each piece of legislation relevant to IOG's activities as a licence operator on the UKCS. This includes UK legislation, industry guidelines and other standards as well as EU and other international requirements such as OSPAR and MARPOL agreements. Through the use of compliance tracking and commitment registers, IOG is able to detect potential non-compliance and initiate corrective action in a timely manner;
- Delivers suitable resource management; through the office of the IOG HSE Manager, supporting line management in the discharge of their environmental responsibilities and reporting directly to the CEO on environmental matters;
- Incorporates performance metrics that are developed according to each aspect of the particular operation, and with a view to meeting the clear public reporting requirements as administered by the Department for Business, Energy & Industrial Strategy (BEIS).

The Proposed Operations

IOG plans to develop the Southwark Field, which is located in the Southern North Sea. The Southwark field will comprise three production wells and will produce gas and condensate. A small minimum facilities platform will be installed. The minimum facilities platform will be designed not to require continual manning during normal production operations and would provide emergency accommodation as well as allowing for routine maintenance visits. The gas and condensate will be produced to the platform, from where it will be exported to the already existing Thames to Bacton pipeline PL370. The produced gas and condensate will be processed in the onshore Bacton Terminal in north Norfolk.

The complete programme of facilities construction, installation and drilling operations for the Southwark Field Development is currently planned to take place between Q1 2021 and Q2 2022. The proposed drilling programme is expected to take approximately 294 days to complete. At present, it is anticipated that the Southwark will produce gas and condensate for approximately be 18 years. However, it should be noted that the Southwark platform may be used as a future 'hub' connecting additional gas/condensate production from associated fields in this area of the Southern North Sea known as the Vulcans, which may extend the lifespan of the Southwark platform.

The Local Environment

Information about the environment at the Southwark Field and its surroundings was collated to allow an assessment of those features that might be affected by the proposed operations, or which may influence the impact of any of these operations. The key sensitivities of the areas are summarised below.

Physical Environment

The proposed Southwark Field Development is located in the Southern North Sea, a relatively shallow area of the North Sea where water depths across the site are typically 20 m to 30 m. North Atlantic water strongly influences the hydrography of the North Sea, with minor inflows from the English Channel and the Baltic Sea. The generalised pattern of water movement in the North Sea is anti-clockwise, with North Atlantic water moving south, balanced by a northerly outflow along the Norwegian coast. The Southern North Sea water moves in a broadly north easterly direction as part of this general circulation.

Wind direction and velocity in the proposed development area are variable throughout the year, although the most prevalent winds tend to be from the south and southwest. The windiest months are typically the winter ones, particularly December and January, whilst winds are typically lower between May and August.

The seabed around the Southwark Field Development consists of sand, coarse sand and gravels. A series of sand banks are present to the east where water depths decrease to less than 20 m.

Plankton

Plankton consists of microscopic plants (phytoplankton) and animals (zooplankton) including the larval stages of fish and many bottom living animals which drift with the ocean currents. Phytoplankton in the proposed development area has an annual seasonal growth cycle, which peaks in abundance during April. This phytoplankton bloom is closely followed by an increase in the zooplankton population as they feed on this increased food source. Zooplankton abundance is typically at its highest between May and September.

Benthos

Benthos is the term used for animals and plants associated with the seabed, although plants are generally limited by their light requirement to depths of less than 50 m. Benthos consists mainly of animals that burrow into the sediment or form tubes in it (known as infauna). Other species which live on the seabed, or attached to rocks or to other biota, are known as epifauna.

Typical epifauna in the area includes dead man's fingers, hydroids, bryozoans, anemones and sponges. Examples of mobile epifauna in the area include starfish, crabs and flatfish.

The reef building worm, *Sabellaria spinulosa*, has also been found to be characteristic of coarse to medium sandy sediments in the Southern North Sea. This species can form large biogenic reefs of conservation interest.

Other potentially sensitive areas include biogenic reefs created by aggregations of the horse mussel (*Modiolus modiolus*) or the common mussel (*Mytilus edulis*) and shallow sandbanks, which are both designated as Annex I habitats under the EC Habitats Directive.

IOG has completed an environmental baseline survey (EBS) and habitat assessment of the area in and around the Southwark field to confirm the species and habitats present at the exact project location. The survey used video transects and grab sampling to outline the characteristic taxa at the Southwark platform. The results found that characterising species included starfish, brittlestars, soft coral, sea anemones and hermit crabs. Isolated patches *Sabellaria spinulosa* tubes were identified, however, the areas identified were not considered extensive enough to be of particular conservation importance. The species recorded by the survey are all typical of the subtidal sandbanks that are known to be present within the Norfolk offshore area and were consistent with the findings of previous environmental surveys conducted in this area.

Fish and Shellfish

The Southwark Field Development lies within or close to predicted spawning grounds for a range of species, namely cod, herring, lemon sole, mackerel, plaice, sand eels, sole, whiting, sprat and *Nephrops*. The majority of species show peak spawning activity between January and June, although several spawn over a longer period. Most fish species release large numbers of eggs directly into the water column. Their spawning grounds cover extensive areas, leaving them less vulnerable to disturbance from point sources. However, certain species relevant to this area are more restricted in their spawning preferences, e.g. herring and sand eel. The dependency of these species on specific substrates for spawning grounds makes them particularly susceptible to impacts resulting from oil and gas exploration and production.

The Southwark Field Development lies in a year-round nursery area for cod, herring, lemon sole, mackerel, plaice, sand eel, sole, whiting, sprat and *Nephrops*.

Marine Mammals

The number and diversity of cetaceans (whales, dolphins and porpoises) decreases progressively southwards through the North Sea and the Southern North Sea supports relatively few species. The four most commonly observed species in this area are the minke whale, white beaked dolphin, Atlantic white sided dolphin and harbour porpoise. Minke whales are found in lower numbers in the Southern North Sea and those individuals observed in the proposed development area are at the southern limit of their range. White beaked dolphins are regularly recorded in the Southern North Sea, particularly towards the coast of Norfolk, although those individuals observed in the study area are thought to be at the southern limit of their range, preferring the northern sector of the Central North Sea. Atlantic white sided dolphins have been recorded in the area, although only in low numbers. The harbour porpoise is widely distributed throughout the Southern North Sea albeit in relatively small numbers occurring throughout the year with peak sightings in the summer months.

Two species of seal, the common and grey seal, are resident in the North Sea, although densities of seals at sea vary over the year in relation to different stages in their life cycle. Common seals are concentrated in The Wash, which provides ideal breeding and haul out conditions, forming the largest single colony in the UK, with additional haul out sites located at Donna Nook on the Humber and Blakeney Point and Scroby Sands in Norfolk. Grey seals are less numerous in the area than common seals. Approximately 38% of the global grey seal population is found in the UK; however, many of these are concentrated at sites around the Hebrides and Orkney, far removed from the area of interest. However, there is a significant breeding and haul out site at Donna Nook at the mouth of the Humber estuary, to the northwest of the Southwark Field Development. Given the shallow water and proximity to significant seal colonies in the Wash and Humber estuary, both grey and common seals may be encountered around the proposed development area.

Seabirds

Seabirds are present throughout the year in the Southern North Sea, with mostly low to moderate densities found in the proposed development area. The most abundant bird species recorded in the proposed development area are fulmar, gannet, kittiwake, guillemot and puffin. Offshore surveys suggest that the area is of particular importance for a variety of seabirds during the autumn and winter periods, with overall densities decreasing offshore during summer. Flamborough Head to the northwest of the Southwark Field Development supports a large Kittiwake breeding colony whilst the area to the south-west supports internationally important coastal seabird colonies for little, common and sandwich terns.

Conservation Areas

The nearshore and coastal habitats and species present along the coasts adjacent to the proposed development area are of notable conservation interest and are protected by a range of statutory and voluntary initiatives. There are several Special Protection Areas (SPA) designated along the coast due to the major seabird colonies or breeding and overwintering habitats for waders and wildfowl present. The closest SPA to the development area is the Minsmere Walberswick SPA, located 55 km to the southwest of the proposed Southwark field. The Minsmere Walberswick SPA is designated for supporting breeding and overwintering birds.

There are also numerous Special Areas of Conservation (SAC) designated to protect important inshore and coastal habitats, such as reefs and sandbanks along with significant common seal populations. The Southwark Field Development is located entirely within the North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC. This SAC is designated for the presence of sandbanks which are slightly covered by seawater all the time and biogenic reefs. Outside the proposed development, the closest SAC is Haisborough, Hammond and Winterton SAC, located approximately 60 km to the south-west of the proposed Southwark field. This SAC is also designated for the presence of sandbanks which are slightly covered by seawater all the time and reef habitat (JNCC, 2018).

Fifty MCZs have been designated in English waters to protect the range of marine wildlife and habitats found in UK waters with more to be designated after consultation. The nearest MCZ with coastal components is the Cromer Shoal Chalk Beds MCZ, located approximately 60 km to the south of the proposed Southwark Field Development location along the Norfolk Coast. This site is designated for its subtidal chalk reef and other seabed habitats and the diversity of invertebrate and vertebrate species they support (Wildlife Trusts, 2018).

Other Users of the Sea

The North Sea as a whole is a major international fishing ground. UK and international fishing fleets operate in the Southern North Sea, targeting a range of species, although fisheries landings are higher overall further north in the North Sea and around the Orkney and Shetland Islands. Fishing landings data from the area around the Southwark Field Development mainly comprise shellfish species such as crabs, whelks and lobsters. Whelks make up the largest proportion of shellfish landed with the quantities caught having increased slightly since 2012. Small quantities of demersal fish, such as plaice, are also landed from here.

The Southern North Sea region supports more intense shipping activity in general compared to the central and northern North Sea, with some major ports such as Rotterdam (in The Netherlands) located in the region. A high number of cargo vessels and ferries pass through the general area along with offshore vessels supporting the numerous gas developments present. Block 49/21 has been classed as having high shipping density. A Vessel Traffic Study (VTS) undertaken in support of the Southwark Field Development indicates that vessel traffic in the 10 nm study area around the Southwark platform averages around 11 vessels per day. Transits are fairly consistent throughout the year with a slight peak in July. Nearby shipping lanes offers convenient transit routes for vessels servicing gas facilities in the area, however these vessel movements are well beyond the theoretical 500 m safety zone which will be established around the Southwark platform. Only 20 vessels passed through the proposed safety zone during the entire 1-year study period, equivalent to 0.5% of all traffic within the 10 nm study area.

The Southwark Field Development is situated within an area of intensive pre-existing offshore gas developments and as such is surrounded by a range of surface and subsurface infrastructure. The Shell operated Leman G platform is located 7.4 km to the south of the Southwark platform, which exports its hydrocarbons west-southwest to the Leman F platform, before ultimately being exported via the Leman to Bacton pipeline. The ConocoPhillips operated Vulcan 1 platform is located 8.6 km to the northwest of Southwark platform, exporting its hydrocarbons north to the North Valiant 1 platform, before ultimately being exported to Bacton via the Shell Clipper-to-Bacton pipeline.

A range of other industries make use of the Southern North Sea area where the proposed Southwark Field development will be located. The Southwark field is located approximately 44.2 km to the east of the operational Dudgeon Wind Farm Development, 37.4 km east of the early planning phase of the Dudgeon Extension, and 30.8 km to the northwest of the Norfolk Vanguard West Wind Farm, which is in the pre-construction phase of development.

Several marine aggregate production areas are also present to the north of the proposed development area. Approximately 30.8 km to the north of the Southwark field, there is a licensed site for aggregate extraction (Area 484) which is operated by DEME Building Materials. There are other aggregate extraction areas which lie further to the north, west and south of the Southwark field.

There are few active mariculture sites situated along the Humber and Norfolk coasts adjacent to the Southwark Field Development as the coastline generally does not provide appropriate conditions for cultivation. However, there are a few sites in the Humber and more extensively the Wash which culture shellfish, mostly mussels and some pacific oysters.

There are no charted military practice and exercise areas in the vicinity of the proposed development. There are no identified wrecks or sites of archaeological interest. There are no active cables running through the proposed development area.

Assessment of Potential Impacts

To determine the activities associated with the proposed drilling and installation operations at the Southwark Field Development which could have a significant impact on the environment, IOG has undertaken the following scoping activities:

- An Environmental Issues Identification (ENVID) workshop by members of the project team and independent environmental consultants;
- A consultation meeting was held with the main consenting regulator for the UK oil and gas industry, the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED);
- An Early Consultation Document (ECD) setting out the project and main environmental receptors to be assessed was circulated to a range of statutory and non-statutory consultees and their comments were invited to help scope the EIA.

The scoping process identified the following activities which may result in impacts and therefore required further consideration:

- Physical presence of the drilling rig, platform, subsea infrastructure and protective materials impacting on the seabed environment and other users of the sea such as fisheries and shipping;
- Marine discharges from the deposition of drill cuttings, associated muds and excess cement directly on to the seabed and use and discharge of chemicals and discharge of produced water during production operations potentially impacting on the seabed environment;
- Underwater noise from platform piling operations impacting on marine mammals and fish;
- Atmospheric emissions from fuel use;
- Accidental events comprising hydrocarbon spills and vessel/rig collisions.

Each concern is fully addressed in the individual impact sections of the ES, including any residual, cumulative and transboundary impacts to the environment. Proposed mitigation measures to manage and reduce any significant impacts to an acceptable level, where required, are described. The findings of the impact sections are summarised below.

Physical Presence

The placement of the development infrastructure on the seabed is anticipated to lead to the loss of the underlying seabed communities (benthos), due to the placement of the feet (spud cans) of the jack-up drilling rig and subsequent placement of the minimum facilities platform on the seabed, the subsea wellhead structures and the installation of the export pipeline. As the Southwark field is located within both the North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC and the Southern North Sea (SNS) SAC, this has been assessed in particular detail. The direct physical disturbance of the seabed will result in the loss of the benthic communities. However, the benthic communities of the types affected are common and widespread throughout the Southern North Sea. Furthermore, the protected area that will be affected covers only a very small fraction of each SACs (i.e. between 0.000209% and 0.000214% of the North Norfolk Sandbanks and Saturn Reef SAC, and between 0.0000204% and 0.0000210% of the Southern North Sea SAC). Therefore, it is not anticipated that the conservation status of either SAC will be affected, and thus the overall effect can be considered as not significant.

The jack-up drilling rig may be just visible from the shoreline on clear days during the drilling operations (294 days), but will be imperceptible to the human eye, under most conditions. The Southwark platform will not be visible from the shore at sea level. Therefore, the potential visual impacts associated with the Southwark field development is deemed to be insignificant.

The proportion of fishing grounds lost as a result of the statutory safety zone around the Southwark platform and potential exclusion around the surface-laid Southwark to PL370 export pipeline constitutes a very small proportion of the available grounds within this part of the North Sea (ICES Rectangle 35F2). The proportional fishing area lost is more than 30 times smaller than the smallest inter-annual variation of demersal landings between 2013 and 2017. The impact is considered to be negligible, and therefore not significant.

The majority of vessel traffic in the area passes either to the east of the Southwark Field Development, well beyond the proposed 500 m safety zone which will be enforced around any infrastructure, such as the jack up drilling rig or minimum facilities platform. Therefore, any effect on shipping in the area is considered to be low and therefore not significant.

Marine Discharges

The drilling discharges from the proposed drilling operations have the potential to affect in the benthic environment in the immediate vicinity of the well location. Effects of drilling fluids and cuttings discharges on the benthic environment are related to the total quantity discharged and the energy regime encountered at the discharge site, particularly the currents close to the seabed itself.

Based on these factors, the discharge of drill cuttings, drilling fluids (mud) and cement at the production wells have the potential to cause a localised impact to the benthic environment, primarily through direct physical changes to the seabed. Cuttings dispersion modelling showed that the coarsest cuttings particles will be deposited very close to the well location, while the finest cuttings particles released at the sea surface may be transported over very large distances in excess of 100 km. However, the associated deposits have a noticeable thickness only in very close proximity (~150 m) of the well location, and very rapidly reduce to sub-millimetric scale at a distance in excess of ~500 m. the primary impacts identified with regard to water based mud (WBM) cuttings discharges relates to the burial of benthos by the discharged material as it settles on the seabed and the impairment of feeding and respiration of sensitive taxa.

The majority of constituent chemicals used in both the WBM itself and additional drilling chemicals are generally highly water soluble and show low persistence, toxicity and likelihood to be incorporated into the tissues of marine organisms. Furthermore, the hydrodynamic regime of the Southern North Sea is conducive to rapid dilution and dispersion of solutes so that the chemical additives in the WBM will dissolve and disperse naturally and rapidly in the water column.

As the physical and chemical effects of the cuttings and mud discharges are of greatest concern, the long-term recovery of affected communities will be influenced by the persistence of the discharged material itself. Cuttings piles associated with WBM are known to be significantly less persistent than those formed with oil based fluids. Cuttings piles in the Southern North Sea will disperse far more rapidly than those in the central and northern North Sea, which will typically disperse over a timescale of 1 year to 10 years. Recovery of the benthic communities in the Southern North Sea has been shown to begin soon after the discharge has ceased, via colonisation from surrounding areas and planktonic recruitment the potential for such recruitment is considered to be strong.

The maximum proportion of the NNSSR SAC predicted to be covered by drilling deposits of greater than 30 cm is 0.0000167%, and maximum proportion of the SNS SAC predicted to be covered by drilling deposits of greater than 30 cm is 0.0000016%. These proportions are more than four orders of magnitude less than 1 %. It is also important to note that this is the initial predicted area, which is expected to rapidly decrease as the strongly tidal regime disperses the cuttings and drilling fluids.

All chemicals used will be approved by Cefas and will be in accordance with UK chemicals regulations. Wherever practicable and technically feasible, chemicals without substitution warnings will be prioritised over those that do have warnings.

Bearing these factors in mind, the magnitude of environmental effects is considered to be minor and thus not significant.

Noise Generation and Wildlife Disturbance

Man-made underwater noise has the potential to impact marine animals. During the operations at the Southwark Field Development, the loudest anticipated sound source will be piling noise generated during platform installation. Once the platform is in place, underwater noise generation will be minimal and will be mainly limited to vessels and helicopters visiting the platform.

The planned piling operations to install the Southwark platform jacket firmly onto the seabed may cause avoidance response reactions in cetaceans within 26 kilometres of the platform. However, given the short duration of such operations (4 × 6 hours of piling over a 4-day period), any effects are expected to be transient with whales and dolphins returning to the area within a few days after piling operations have ceased. Seals are expected to return within a few hours after the piling operations have finished. Therefore, the impact of piling operations on whales, dolphins and seals is considered to be not significant.

The effect of piling operations on fish is strongly related to their life cycle stage. Adult and juvenile fish are rarely affected by piling operations because they are able to detect and physically avoid the area. Given the limited spatial extent of the anticipated impact and the limited (4 day) period over which the piling will take place, the proposed piling operations is not anticipated to cause any significant impacts on fish.

With regard to potential transboundary effects, the location of the Southwark Field Development is 65 km east of the UK/Netherlands transboundary line at its closest point (the Southwark field). At this distance any underwater sound will have attenuated to a low level therefore no observable effects are expected to occur.

Atmospheric Impacts

Generation of power onboard the jack-up drilling rig, all support vessels and aircraft will result in the emissions of various combustion gases. These emissions will contribute to local and global environmental effects. During the production phase, emissions will be minimal, as the power required onboard the platform will be mainly supplied by wind/solar energy.

At a local level, such impacts are mitigated by health and safety measures in place to control emissions onboard the vessels, as well as by the dispersive nature of the offshore environment (i.e. the wind and weather conditions).

Emissions will also contribute to global environmental issues such as climate change. The most commonly used general indicator of atmospheric emissions is the global warming potential (GWP), expressed in tonnes of carbon dioxide (CO_2) equivalents. The GWP can be used to estimate the potential future impacts of gaseous emissions upon the climate system.

Atmospheric emissions from the jack-up drilling rig at Southwark are predicted to total 15,430 tonnes of CO_2 equivalents, representing 0.10% of annual emissions from offshore oil and gas operations in 2017, a minor proportion of overall annual exploration and production operations undertaken on the UKCS.

The total GWP of all emissions, including the drilling and completion operations, platform and pipeline installation and all associated support vessel activity is approximately 46,768 tonnes of CO_2 equivalents which represents approximately 0.30% of the annual emissions from UK offshore oil and gas operations in 2017.

In this context, the atmospheric emissions generated by the Southwark Field Development are considered to be not significant.

Accidental Events

The risk of a large-scale hydrocarbon spill occurring during drilling operations at the proposed Southwark field is very low.

Oil spill modelling shows that a large spill, such as from a well blow-out, would, under the majority of meteorological circumstances, drift to the northeast and east of the proposed development location, although there is scope for the slick to drift to the south and west at certain times of the year mainly in the winter and spring months (December to February and March to May). This light hydrocarbon would be expected to break up and disperse very quickly. However, the modelling undertaken indicates that there is a small probability that a quantity of diesel (617 m^3), arising from the worst-case diesel spill scenario modelled, i.e. an instantaneous release of the maximum diesel inventory of the jack-up rig, may impact on the Norfolk coastline during the spring months (March to May).

Historic data suggest small diesel spills of less than 1 tonne represent the most likely diesel spill scenario. Oil spill modelling scenarios show that a large diesel release would have a small potential to reach the Norfolk coastline during the spring months (March to May), a smaller chance of a spill reaching the same coastline in the summer months (June to August). There is a very small potential for condensate to beach on other parts of the UK shoreline specifically along the East Riding of Yorkshire, Lincolnshire, Suffolk and Kent shoreline. However, the likelihood of this occurring is considered to be very small and restricted to certain times of the year.

There is a small to moderate probability that a diesel spill will cross over the Netherlands transboundary line for the majority of the seasons modelled. The summer months (June to August) have been assessed as showing the greatest potential for the transboundary line to be reached.

These modelling results assume no intervention in the slick. In practice oil spill response resources would be mobilised immediately if a spill occurred. It would be a priority to ensure no spilled oil would impact the coastline, including the protected areas that exist along the Norfolk coastline, and, therefore, all appropriate oil spill response techniques would be employed in the event of a spillage moving towards the shore.

Throughout the proposed operations, the focus will be on the prevention of oil spills. Stringent safety and operational procedures will be adhered to throughout the operations. A blow-out preventer (BOP) will be put in place, in order to prevent the uncontrolled release of hydrocarbons from the well.

In the unlikely event of a well control incident, the BOP will be closed to prevent hydrocarbons from flowing to the surface. If all attempts to close the BOP fail, attempts would be made to temporarily seal the well using a capping device, while operations to drill a relief well and permanently abandon the well would commence as soon as possible.

A detailed operation specific Oil Pollution Emergency Plan will be in place to ensure that immediate and appropriate action is taken in the event of any hydrocarbon spillage, minimising any impact to the marine environment. A robust operations and maintenance programme will be produced thereby ensuring any potential defects with the pipeline are identified before a failure occurs.

Overall Conclusion

The only potential significant impact identified in the environmental impact assessment is that of a large-scale diesel spill. However, the probability of such a spill is very low and mitigation and management procedures will be in place to prevent this from happening, as well as adequate resources to deal with any such spill should it occur. All other impacts identified in the ES are expected to only have localised impacts with good recovery potential over time.

Overall, it is concluded that the environmental impacts of the proposed Southwark Field Development will not incur any significant long-lasting environmental effects.

INDEPENDENT OIL & GAS PLC

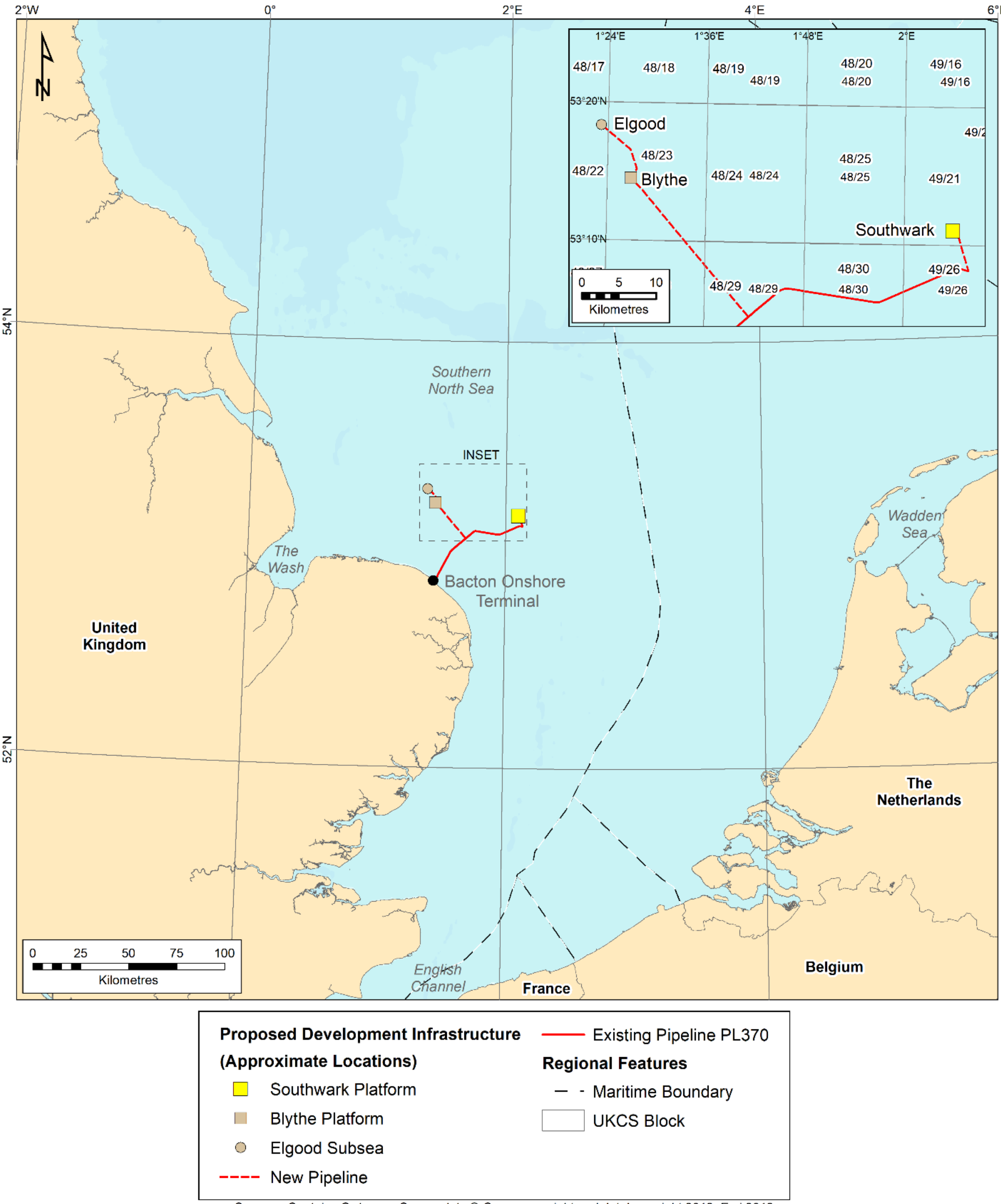
Section 1

Introduction

1. INTRODUCTION

This Addendum to the Blythe Hub Development Environmental Statement (ES) presents the findings of the Environmental Impact Assessment (EIA) conducted jointly by IOG UK Ltd and IOG North Sea Limited for the inclusion of the proposed Southwark Field Development to the Blythe Hub Development ES.

The Southwark field is located on the United Kingdom Continental Shelf (UKCS), within Block 49/21 in the Southern North Sea. Figure 1.1 shows the locations of the Southwark Field Development and the Blythe Hub Development infrastructure.



Sources: Contains Ordnance Survey data © Crown copyright and database right 2018; Esri 2018; UK Oil and Gas Data 2018; The GEBCO_08 Grid, version 20100927, http://www.gebco.net

Figure 1.1: Location of the Blythe Hub development fields plus the additional Southwark development field

The Southwark Field Development comprises the Southwark field, three production wells, a production platform, and an export pipeline and tie-in to the PL370 (Thames to Bacton) pipeline. These Southwark-specific project elements were previously part of a wider field development plan, the Vulcan Satellites Hub Development, for which an ES was submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) in April 2018, reference D/4213/2018.

Since the submission of the Vulcan Satellites Hub Development ES the Vulcan Satellites development has been split in to two development phases, with the Southwark-specific components now scheduled to be developed as part of the Blythe Hub Development programme.

The infrastructure, construction and operational activities assessed in this Addendum are the same Southwark-specific project elements that were previously assessed as part of the Vulcan Satellites Hub Development ES.

The Southwark Field Development and the Blythe Hub Development will export produced hydrocarbons to the onshore processing terminal at Bacton, Norfolk via the existing Thames export pipeline PL370. However, the onshore processing facilities and the existing Thames export pipeline are outside the scope of the Blythe Hub Development ES and this Addendum.

This ES Addendum has been produced in accordance with the Offshore Petroleum Pipeline (Assessment of Environmental Effects) Regulations 1999 and associated guidelines. It also addresses the relevant requirements associated with the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 and the Offshore Chemicals Regulations 2002.

1.1 Project Background

The Southwark field lies within Block 49/21c under licence P1915 which is presently in 100% equity ownership of IOG UK Limited, a wholly owned subsidiary of Independent Oil and Gas PLC.

The Southwark field was discovered in 2000 by well 49/21-8a drilled by Conoco and which encountered gas in the underlying Leman Sandstone Formation. In 2016 Independent Oil and Gas PLC purchased Oyster Petroleum Limited, a company whose assets included Verus Petroleum, the then licence holder of the Southwark field. The Verus Petroleum company under IOG ownership was renamed IOG UK Limited.

IOG UK Limited now plans to develop the Southwark field as part of the Blythe Hub Development, with both developments exporting through the existing subsea Thames export pipeline PL370 to onshore processing facilities at Bacton, on the north Norfolk coast.

The proposed Southwark platform is approximately 54.7 km distance from its nearest point on the north Norfolk coast, and its tie-in point to the Thames export pipeline PL370 is approximately 52 km from the shoreline. However, the closest part of the overall Blythe Hub and Southwark field development remains the proposed Blythe platform installation in the Blythe field (as described in the main ES) which is approximately 35 km from the coastline. Southwark is closest to the UK/Netherlands median line, which is situated approximately 64 km east of Southwark.

The original Blythe Hub ES was submitted to OPRED for approval (reference D/4208/2018) and subsequently issued for public consultation on 15th February 2018, in support of an FDP submitted to the OGA entitled 'IOG Blythe Hub Development'. That FDP was subsequently withdrawn and replaced by IOG in August 2018 by a new FDP entitled 'IOG SNS Hub Developments Phase 1' and which included the development of the Southwark field alongside that of the Blythe Hub. This ES Addendum has consequently been prepared in support of that addition of the Southwark field development to the Blythe Hub Development.

The Southwark field is estimated (mid case) to produce approximately 2,689 million cubic metres of gas (95 Bcf) and 11,925 cubic metres (75,009 barrels) of condensate over an expected 18-year field life.

IOG is currently planning to commence the installation of the Southwark platform and drilling the Southwark S1 well in March 2021.

1.2 Scope of this Environmental Statement Addendum

This Addendum assesses all aspects of the Southwark Field Development, including drilling operations, platform and associated infrastructure installation, export pipeline installation and tie-in to the PL370 pipeline, and production operations. The Addendum also identifies all mitigation measures which will be put in place to minimise or eliminate significant adverse effects.

However, the recommissioning of the existing Thames export pipeline and any modifications required at the onshore processing facilities at Bacton Terminal are outside the scope of both the Blythe Hub Development ES and this Addendum, as they are assessed under separate regulatory consents.

1.3 Legislative Framework

The proposed Southwark Field Development operations lie outside UK territorial waters (greater than 12 nm from land). Therefore, the majority of the activities undertaken will be governed under UK legislation regarding offshore oil and gas activities. The legislation applicable to the proposed field development operations remain as previously set out in Section 1.3 and Appendix A of the main Blythe Hub Development ES. In addition to the regulatory requirements outlined in the main Blythe Hub Development ES, a number of marine planning objectives are also relevant to the Southwark Field Development.

The Southwark field development is situated within the East Offshore Marine Plan Area. The East Offshore Marine Plan Area is currently designated as having 'Good Environmental Status' in accordance with the Marine Strategy Framework Directive, with its relevant habitats and species considered to have a 'favourable conservation status', as required under the Habitats and Wild Birds Directives. The Marine Plan acknowledges that gas production in the area is an important activity with new technologies having the ability to maximise production of hydrocarbon reserves whilst continuing to ensure minimal environmental impacts (Defra, 2014).

The proposed Southwark field development has been assessed against the following East Offshore Marine Plan objectives and oil and gas policies: 1, 2, 5, 6. 7, 8, 9, 10, 11, OG1 and OG2.

Objective 1: To promote the sustainable development of economically productive activities, taking account of spatial requirements of other activities of importance to the East Marine Plan Areas.

The Southwark field development is in line with sustainable development and considers other users of the sea and impacts upon them, as discussed in Sections 3 and 5.

Objective 2: To support activities that create employment at all skill levels, taking account of the spatial and other requirements of activities in the East marine plan areas.

The Southwark field development will provide jobs and tax revenue to the UK economy.

Objective 5: To conserve heritage assets, nationally protected landscapes and ensure that decisions consider the seascape of the local area.

There are no known wrecks or heritage sites within the development area, as discussed in Section 3.

Objective 6: To have a healthy, resilient and adaptable marine ecosystem in the East marine plan areas.

IOG will ensure that any potential impacts associated with the proposed Southwark field development will be kept to a minimum as discussed in Sections 5 to 9.

Objective 7: To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East marine plan areas.

IOG will ensure that any potential impacts associated with the proposed Southwark field development will be kept to a minimum, as discussed in Sections 4 to 9.

Objective 8: To support the objectives of Marine Protected Areas (and other designated sites around the coast that overlap, or are adjacent to the East marine plan areas), individually and as part of an ecologically coherent network.

IOG will ensure that any potential impacts to any protected species and sites, associated with the proposed development will be kept to a minimum, as discussed in Section 5 to 9.

Objective 9: To facilitate action on climate change adaptation and mitigation in the East marine plan areas.

IOG will ensure that any potential impacts to air quality and climate change associated with the proposed Southwark field development will be kept to a minimum, as discussed in Section 8.

Objective 10: To ensure integration with other plans, and in the regulation and management of key activities and issues, in the East marine plans, and adjacent areas.

IOG will ensure integration with other plans and that any potential impacts on other sea users associated with the proposed Southwark field development will be kept to a minimum as discussed in Section 5.

Objective 11: To continue to develop the marine evidence base to support implementation, monitoring and review of the East marine plans.

IOG will ensure the continued use of the most up-to-date data and research when assessing the impact of the Southwark field development, as demonstrated throughout this Addendum.

Policy OG1: Proposals within areas with existing oil and gas production should not be authorised, except where compatibility with oil and gas production and infrastructure can be satisfactorily demonstrated.

As a new oil and gas development, making use of existing infrastructure, the proposed Southwark field development is fully in line with this Policy.

Policy OG2: Proposals for new oil and gas activity should be supported over proposals for other development.

As a new oil and gas development, making use of existing infrastructure, the proposed Southwark field development is fully in line with this Policy.

1.4 Environmental Management

1.4.1 Policy and Governance

The IOG Main Board and Management Team recognise the critical importance of maintaining effective environmental management processes in the development and operation of UKCS offshore fields, and in maintaining their licence to develop the Southwark field. Arrangements for policy, governance, and the environmental management systems remain unchanged from those as set out and described in the Blythe Hub Development ES.

The following sections highlight for clarity the key aspects of environmental management arrangements as they apply to development of the Southwark field.

1.4.3 Offshore Operations

The Southwark offshore installation is to be operated by an Installation Operator Duty Holder, appointed by IOG within the terms of the Offshore Installations (Offshore Safety Directive) (Safety Case etc) Regulations 2015 (OSDSCR).

IOG also intends to appoint a Well Operator within the terms of OSDSCR for the drilling of the Southwark wells, and a Pipeline Operator within the terms of the Pipelines Safety Regulations 1996 will also be appointed by IOG to operate the Southwark field pipeline that will connect the Southwark platform to the Thames export pipeline PL370.

IOG recognises its obligations under Regulation 5 of the OSDSCR Regulations, to ensure the capability of the Duty Holder(s) and to take all reasonable steps to ensure that they satisfactorily meet their obligations.

A particular and key requirement of duty holders appointed by IOG to undertake offshore operations, is that the duty holders have an EMS in accordance with the BEIS Guidance to OSPAR 2003/5.

1.4.4 Emergency Response

IOG recognises that it has ultimate responsibility to ensure an effective response to offshore emergencies, and in particular, a responsibility to minimise the risk and impact of any environmental aspects.

IOG intends to utilise the shore-based Emergency Response facilities (i.e. Emergency Response Centre, and associated personnel and technical resources) established and maintained by its appointed duty holders, for the purposes of response. Such arrangements will be documented in emergency response plans and within the OPEP submissions that are required to be approved by BEIS OPRED prior to undertaking prescribed offshore activities.

IOG UK Limited will become a party to the OPOL Agreement in respect of the Southwark filed development and, as such, will accept strict liability for pollution damage and the cost of remedial measures and has established financial responsibility in order to meet claims arising under OPOL.

1.5 Environmental Assessment Process

The environmental assessment process cited in this ES Addendum-remain unchanged from that detailed in the Blythe Hub Development ES. The following sections summarise the key aspects of consultation and the impact assessment process relevant to the development of the Southwark field.

1.5.1 Scoping and Consultation

Informal scoping for the development of the Southwark field was undertaken by means of a meeting between IOG and OPRED on 5 October 2017. During this meeting OPRED was informed about the proposed Blythe Hub Development and the Vulcan Satellites Hub Development. An Early Consultation Document (ECD) was presented which outlined both developments, which included the entirety of the Southwark Field Development assessed in this Addendum.

The ECD was subsequently distributed in October 2017 to 41 stakeholders who were invited to comment on the proposals. Details of the informal consultation process and the comments received from consultees in relation to the Southwark Field Development are outlined in Section 4 of this Addendum.

The Southwark-specific project elements previously underwent formal statutory consultation, through the submission of the Vulcan Satellites Hub Development ES (reference D/4213/2018) to OPRED on 24 April 2018, publication of a Public Notice and issue for public consultation on 24 May 2018.

However, this Addendum incorporates relevant additional data and considerations as have arisen in the intervening time since issue of the Vulcans Satellites Hub ES, and to address observations and comments from stakeholders received. This includes relevant changes to proposed protected site designation status, conservation objectives, and regulatory or consenting requirements.

1.5.3 Surveys and Technical Studies Conducted

An Environmental Baseline Survey (EBS), a Habitat Assessment (HA), oil spill modelling, drill cuttings modelling, and a shipping and navigation study were carried out to support the impact assessments contained in this ES Addendum.

1.5.4 Identification and Assessment of Potential Environmental Impacts

The principal element of the EIA process is the identification of all environmental effects associated with proposed activities which may have a 'potentially significant' impact. The generic process applied by IOG for the Southwark field development – including an ENVID – remains as described fully in the main Blythe Hub Development ES.

Section 4 of this Addendum presents the key issues, concerns and potential impacts of the Southwark field development as identified by IOG through this process. Mitigation measures adopted are described in each of the individual impact sections (Sections 5 to 9) and summarised in Section 10.

This Addendum reports the findings of the EIA process as they relate to the Southwark Field Development and explains how the conclusions have been reached. The intention has been to present the information in such a way to allow readers to form their own opinions on the acceptability of the residual levels of impact associated with the Southwark field development. This ES Addendum covers:

- The reasons for developing the Southwark field (Section 1);
- A description of the option selection process and final proposed operations (Section 2);
- A description of the environment in the vicinity of the proposed operations (Section 3);
- Methods used to identify the environmental concerns associated with the programme (Section 4);
- Detailed assessment of each concern, including any potential cumulative and transboundary effects, and mitigation measures (Sections 5 to 9);
- Conclusions (Section 10).

In addition, this ES Addendum is summarised in a non-technical summary at the front of this document and includes a Commitments Register in Appendix C summarising the operational and mitigation measures that will be undertaken for the Southwark Field Development.

Section 2

Option Selection and Project Description

2. OPTION SELECTION AND DESCRIPTION OF THE SOUTHWARK FIELD DEVELOPMENT

This section provides a description of the options considered for the Southwark Field Development together with a detailed description and justification for the proposed development.

2.1. Introduction

Developing the Southwark field for gas extraction will support the objectives of the UK's current energy policy, as set out in the Oil & Gas Authority (OGA) document *The Maximising Economic Recovery Strategy for the UK* (OGA, 2016). The stated objectives of that strategy are to ensure the UK secures a resilient and diverse energy supply, in both the domestic and international markets, and maximises the economic recovery of the UK's existing reserves as part of the wider energy strategy. Developing the Southwark gas field also supports the objective of transitioning to cleaner forms of fossil fuels. Whilst not developing the Southwark field would avoid any potential for environmental impact, it would also prevent any economic benefit, being derived from the production of natural gas.

A particular aspect of the Southwark field development that is worthy of note from an environmental perspective is that the development concept is founded on re-use of existing Southern North Sea oil & gas infrastructure, namely the previously decommissioned Thames export pipeline PL370.

2.2. Option Selection

Various options for the development of the Southwark field were evaluated in terms of technical feasibility, environmental impact, health & safety, reputation and cost. The environmental assessment process (as referenced in Section 1.5 of this Addendum) was initiated early in the planning stage to support the option selection process. The environmental impacts of the following project options were considered by IOG as part of the option selection process for the Southwark Field Development:

- Number of wells in the Southwark reservoir;
- Well design;
- Type of surface production facilities to be used;
- Pipeline routing and sizing options;
- Pipeline installation and protection methods;
- Corrosion and hydrate prevention;
- Mobile drilling rig selection;
- Selection of drilling fluids;
- Fate of drill cuttings;
- Chemical use and discharges;
- Decommissioning.

2.2.1 Number of Wells in Each Reservoir

Historic well test data was used to develop reservoir and well performance models to determine the optimal number of wells for each reservoir and the associated infrastructure required. Options were prioritised to maximise the field productivity, minimise both the development expense and the environmental footprint, and to ensure the sustainability of the development. The reservoir and well performance modelling indicated that early stage production would be viable with three wells in the Southwark field (S1, S2 and S3).

2.2.2 Well Design

A slim hole casing design is planned for each of the three wells. A slim hole design is considered to be advantageous in comparison with other designs, for the following reasons:

- Other slim hole wells have been successfully drilled and operated in nearby formations;
- There are significant time and cost savings when compared to alternative conventional casing design schemes;
- Significantly less cuttings are produced compared with standard well bore diameters.

Each of the three wells will be drilled from the Southwark platform location.

Well data from other wells previously drilled in the area and in similar geological formations indicate that a 'tight' reservoir with poor permeability is to be expected. Consequently, it will be necessary for all three wells to be hydraulically stimulated to produce gas.

2.2.3 Production Facilities Options

Three basic surface infrastructure options were considered when determining how best to take delivery of the gas and fluids drawn from the wells, and to deliver the gas and fluids into the Thames export pipeline PL370 system for onward conveyance to the onshore Bacton Terminal. These were:

A. A subsea installation comprising necessary gas and fluids production and export equipment which sits on the seabed;
B. A production platform installed on the seabed and rising above sea level, carrying the necessary gas and fluids handling and export equipment;
C. A floating facility hosting the necessary gas and fluids handling and export equipment, anchored to the seabed.

There are numerous technical, safety, environmental and cost considerations with each option and so a comparative analysis was carried out in order to arrive at the optimum solution.

Surface and Subsea Production Options

The determining factor between the selection of a surface solution (options B and C) over a subsea solution (option A) is the nature of the anticipated gas and fluids expected from the wells, particularly the degree to which the gas- and fluids-handling and export equipment will need to be accessed for maintenance during the expected life of the field.

Analysis of the reservoir geology, and the likely dynamics of the hydrocarbons trapped within the rock formations, has indicated that chemical treatments and hydraulic stimulation of the reservoir will be required in order to promote hydrocarbon flow. This will require additional equipment and quantities of stimulation and flow-enhancing chemicals fluids to be available in the immediate vicinity of the wells, together with the ability to routinely transport materials and equipment, and to carry out maintenance of the installed equipment and storage facilities.

Reservoir studies indicated that water production from the wells is likely, but that the volumes and timing of water 'breakthrough' are uncertain. This also means that materials, equipment and maintenance personnel would all need to be readily transported to the well sites in order to achieve safe, efficient and effective hydrocarbon recovery throughout the expected field life.

Engineering studies conducted by IOG demonstrate that surface infrastructure will provide safer management and intervention options than subsea infrastructure.

Surface Production Options

The relatively shallow water depths of the Southwark Field Development and the proximity of the existing PL370 export pipeline determined that a fixed platform with a permanent export pipeline would be a safer and more cost-effective solution that a floating solution with ongoing hydrocarbon offload operations. The shallow water depths mean that the platform design can be based upon existing and proven Southern North Sea offshore platform technology.

Floating solutions are inherently mobile, and may need to weathervane around its anchoring point, depending on the floating solution selected. This is an inherently less robust engineering solution, and therefore poses higher safety and environmental risks than that provided by the fixed joint system that exists between a fixed platform and its export pipeline system.

An important consideration in the selection of a suitable offshore facility was also the intended long-term provision of a permanent gas processing hub in the Southwark area of the Southern North Sea that would enable future tie-in of other nearby gas fields. Such a permanent hub is better enabled by a fixed platform, rather than floating facilities which, in comparison, are more prone to structural degradation due to marine stresses in situ over the longer term.

Platform Production Options

Having decided upon a predominantly fixed platform philosophy for the Southwark field development, several variations on field configuration were considered in order to determine the optimum configuration for the number and location of the facilities, in terms of achieving maximum economic recovery from the reservoir at least cost.

The decision was taken to install a minimum facilities platform for the Southwark field development in order to take full advantage of existing onshore separation, processing and compression facilities together with the associated infrastructure at the onshore Bacton terminal. This would also enable production to commence immediately after the Southwark wells are completed. In addition, a minimum facilities platform would support potential future expansion in the Vulcans area, with the Southwark platform serving as a node or 'hub' for the relatively passive routing of gas production from associated fields into the nearby Thames export pipeline PL370.

As all processing will take place onshore at the Bacton terminal located on the north Norfolk coast, there will be no requirement for processing facilities on the platform.

The selected platform structure is based on a four-legged jacket supporting minimal topsides which will provide wet gas metering for all fluids and emergency overnight accommodation for vising maintenance personnel.

The Southwark field development concept is founded upon a re-use of substantial existing oil & infrastructure in the Southern North Sea, namely the decommissioned 24" pipeline that runs between Perenco's nearby Thames field and the onshore Bacton gas processing terminal. It was determined that recommissioning this pipeline – rather than laying a new pipeline - would have the lowest environmental impact, as well as being the most cost-effective option.

In summary, the optimum configuration was finally determined as:

- A single minimum facilities platform installation at Southwark, fixed and supported on the seabed by 4 legs;
- A pipeline from the Southwark platform to the Thames Export Pipeline PL370 to transport the production gas and fluids from Southwark for eventual processing at onshore Bacton terminal on the north Norfolk coast.

Platform Installation Options

The Southwark jacket will be of an existing industry standard four-leg design, which will be piled to the seabed. Two methods for installing the jacket are currently being considered:

- Driven piles;
- Suction piles.

The basic jacket design will be the same for both installation options. The environmental effects of both options re assessed in this ES Addendum.

2.2.4 Pipeline Routing, Sizing, Installation, Stabilisation and Protection Options

Options for pipeline, routing, sizing, installation, stabilisation and protection were considered by a multidisciplinary team of pipeline, marine, safety and environmental engineers as part of a study commissioned by IOG and undertaken by the Subsea & Export Systems group of Wood Group UK Ltd – an established and reputable pipeline consulting firm, selected by IOG for their specific expertise in supporting offshore oil & gas pipeline projects from concept through design and commissioning.

The engineering analysis performed by the Wood Group – which was undertaken in consultation with IOG's pipeline engineering department – considered the options for the Southwark platform export pipeline and its connection with the Thames export pipeline PL370.

A primary physical factor considered in the study is the quality of the seabed, particularly in this part of the Southern North Sea where seabed mobility can lead to unpredictable sand wave features, leaving previously buried pipelines exposed and unsupported or, conversely, leaving previously exposed pipelines buried and inaccessible for future inspection, maintenance or modification. Other factors considered, particularly with regard to pipeline sizing and routing, included flow modelling, physical limitations and seabed topography, environmentally sensitive zone demarcation, and geohazards.

Flow assurance modelling determined that a 24" pipeline (internal diameter of 24") is required for the export pipeline linking Southwark with the Thames export pipeline PL370, and two alternative pipeline routes for the pipeline were identified. These alternative route options are referred to as the eastern and the western route options, both of which tie-in to the Thames export pipeline within UKCS Block 49/26.

The eastern route was selected as the preferred option primarily in view of the comparatively higher risk of environmental damage presented by the western route which would cross the Ower Bank that rises to approximately 5 m below Lowest Astronomical Tide (LAT). This can be seen in Figure 2.1 below.

The geophysical and geotechnical surveys carried out by IOG in the area of the proposed tie-in to the Thames export pipeline PL370 identified that some spanning (i.e. exposed and unsupported sections of pipe) of the Thames export pipeline has occurred in that area, and therefore an exact location for the most appropriate tie-in point will need to be determined (and subsequently consented by BEIS and OGA) following a more detailed engineering study based on survey data.

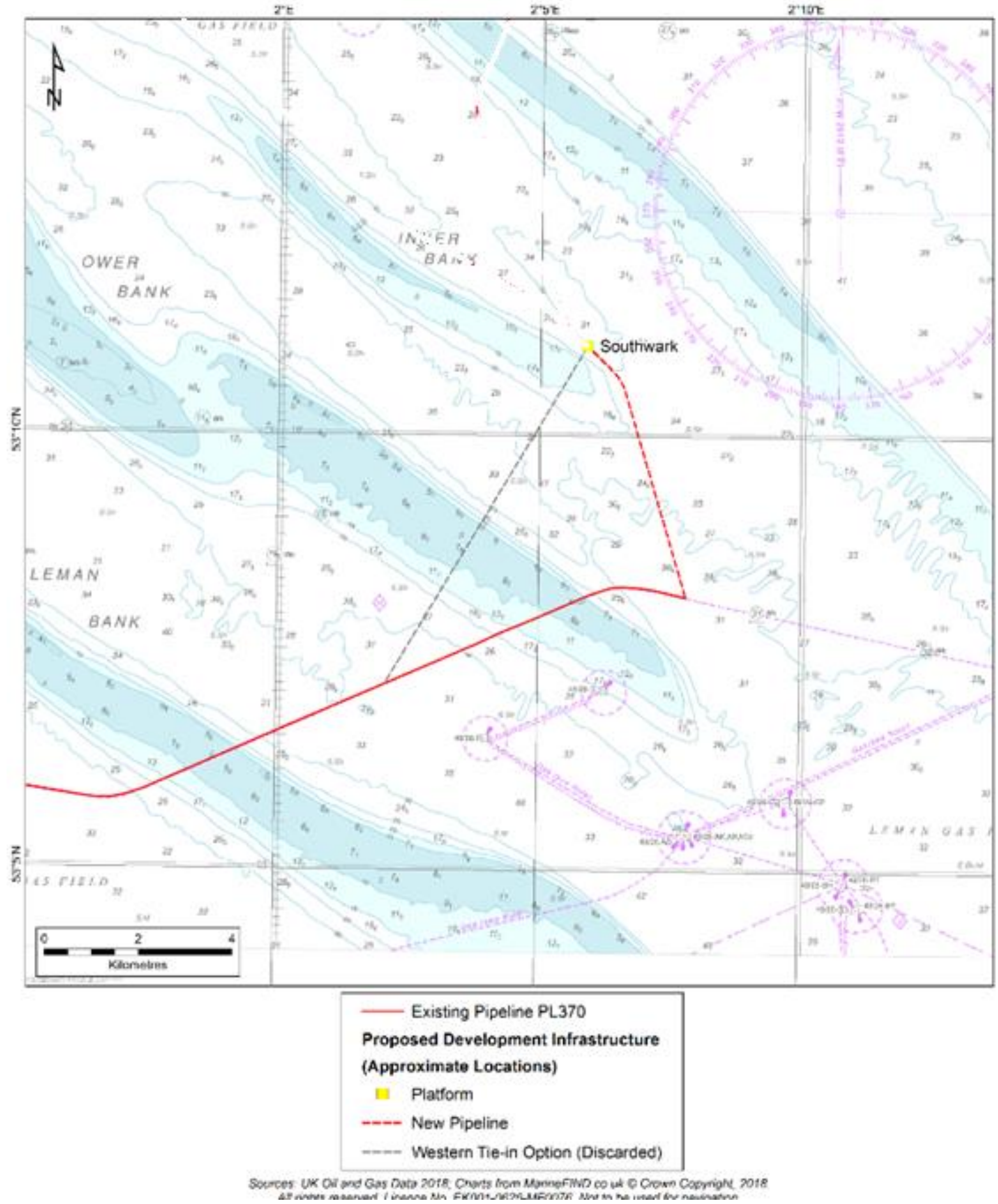


Figure 2.1: Southwark field to Thames export pipeline PL370 eastern and western tie-in route options, showing the Inner Bank and Ower Bank

Initial designs for the pipeline were carried out by desk study using available data including regional geological and navigational maps, bathymetry and fishing charts. These initial designs have been subsequently refined following the results of specifically commissioned geophysical and geotechnical route surveys and sea bed sampling carried out by IOG.

The engineering analysis performed by Wood Group indicated that the preferred option for the Southwark Field Development 24" export pipeline is to concrete coat and surface lay the pipeline from a specialist pipelay vessel and to provide stabilisation and protection using graded rock, gravel, mattress and sand or grout bag placements only at specific points necessary. The size and weight of the 24" concrete coated pipeline was demonstrated to maintain a firm and settled pipeline position on the sea bed, meaning that trenching was not required, either for stabilisation purposes or for protection.

The possibility of Southern North Sea surface laid pipelines forming free-spans due to the sea bed mobility and scouring action of waves and currents was however also taken into account in the pipeline specification, although it is widely recognised (Pidduck et al., 2017) that the complexity of variables associated with such sea bed movements and currents within the area means that there are significant uncertainties in predicting the nature and location of future free-span occurrence. As acknowledged and detailed in Section 3 of this Addendum, a pipeline monitoring regime will be required in order to mitigate these free-span risks for the pipeline.

The options of whether to provide graded rock and gravel support, or to lay mattresses are influenced by a number of considerations. First among these is the fact that mattresses invariably require divers to position mattresses subsea and also divers are required to install the sand or grout bags that are necessary to establish a robust and stable mattress installation by providing support and packing of voids in and around the mattresses. Whilst this has the benefit of enabling a precise installation, it does involve the significant personal safety risks associated with diving. By contrast, the benefit of pouring graded rock and gravel in and around the laid pipeline is that this not only provides a mechanically robust and stable structure of interlocking rock, but also the operation can be performed reasonably accurately using a delivery chute from a specialist vessel and does not require divers in the water. A further consideration at platform locations is that it may not be possible to safely position a rock placement vessel sufficiently close to the platform and so mattress placement often becomes the preferred option at such locations. At jointing points of pipelines with other infrastructure, such as for example at the tie-in with the Thames export pipeline PL370, the ability to more easily move or cut into mattresses in order to access the joint for inspection, maintenance or repair rather than excavate rock placements, tends to promote the preferred use of mattresses at such locations.

The subsequent removability of mattresses – including at the point of field decommissioning - is often cited as a beneficial aspect, particularly in view of the UK Government's stated aim of working towards a clean sea bed post decommissioning of oil and gas infrastructure. A report commissioned by DECOM North Sea (ref DNS 01 r01c 25th June 2015) observed that mattresses installed in the shallower waters of the Southern North Sea suffer degradation and tend to self-bury. The report concluded that recoverability of mattresses in the Southern North Sea remains challenging, due to a combination of shallow water depths, strong tidal currents and mobile sandy seabed, all of which contribute to the degradation of installed mattresses over time through UV exposure and surface hydrodynamic forces.

It nevertheless remains the intention of IOG to remove all laid mattresses associated with the Southwark development, thereby leaving a 'clean sea bed' at the point of decommissioning, and IOG acknowledges that the industry continues to progress in the development of mattress design and removal technologies.

Where installation of grout or sand bags are necessary, then the option is preferred - and presently required by OPRED - to use biodegradable materials.

Where a pipeline or umbilical crosses another, already installed, subsea pipeline, cable or umbilical, then it is necessary to provide a bridging structure, also typically comprising a combination of graded rock, mattresses and sand or grout bags. Current marine charts for the area, together with specific pipeline route surveys carried out by IOG have identified no such crossings for the Southwark export pipeline along its planned route. The need for designed crossing structures is therefore not anticipated.

2.2.5 Corrosion and Hydrate Prevention Options

Engineering studies and reservoir analysis together indicate that chemicals to both protect and maintain the flow of fluids through the export pipeline will be required to be introduced into the pipeline at the Southwark platform, and also that hydrate prevention by introduction of chemical treatment to the well will be required during well start-ups.

Chemicals selection and use options are systematically regulated in the UK offshore sector. As set out in the main Blythe Hub Development ES, all chemicals will be selected and used according to prevailing applicable UK chemicals regulations.

2.2.6 Drilling Rig Selection Options

The shallow water depth at the Southwark field location (approximately 30 m below LAT) are generally not suitable for a floating drilling rig or ship, and – in common with most Southern North Sea development drilling - a jack-up design drilling rig provides the best means of securing a stable surface platform location for the drilling of the wells.

2.2.7 Drilling Fluids and Chemicals Options

As set out in the main Blythe Hub Development ES, the main options in the selection of drilling muds are water-based drilling muds (WBM) and synthetic oil-based drilling muds (OBM).

Although OBM generally offers a number of advantages over drilling with WBM (eg faster drilling rates, increased stability in water-sensitive rock formations such as clays and shales) in the case of the particular Southwark wells the use of WBM is the predominant preference of IOG.

However, the possibility of geological conditions being encountered that require OBMs in order to maintain the safety of drilling operations cannot be discounted. For this reason, IOG has included the option of using OBM as a contingency only. In such a case Low Toxicity Oil-Based muds (LTOBM) would be used.

As already noted and described fully in the main Blythe Hub Development ES, all chemicals selected and used for drilling operations will be in accordance with the regulatory requirements.

2.2.8 Decommissioning Options

Well design and platform selection will take account of applicable UK Government policy and guidance on decommissioning – as are referenced more fully in Section 2.8 of this ES Addendum.

2.3. Description of the Field Development

The concept for the Southwark field development is that - In addition to providing a platform for receiving production from the Southwark field - the Southwark field is to potentially serve as a future node or 'hub' for the relatively passive routing of gas production from associated fields in the area of the Southern North Sea known as the Vulcans, onwards into the nearby Thames export pipeline PL370. This can be noted, for example, in the overall development map that is Figure 1.1 in Section 1 of this Addendum, where it can be seen that future provision is shown for a tie back of 'Phase 2' infrastructure (the 'Vulcan Satellites') to the Southwark field.

For clarity – this ES Addendum addresses only the Phase 1 development of Southwark (ie the installation of a single platform in the Southwark field and its export pipeline into the Thames export pipeline PL370)

First gas is anticipated from the Southwark field around July 2021 and the initial commercial life, based on the expected production from the Southwark field described in this Addendum, is anticipated to be 18 years. However, the potential future tie-in of fields to Southwark as a hub, as described above, may extend the commercial life of the development.

2.3.1 Southwark Platform

The Southwark Field Development will utilise a single offshore production platform in the Southwark field, located in the Southern North Sea, UKCS Block 49/21c and as detailed in Table 2.1.

Table 2.1: Platform Location

Geodetic datum: ED50, UTMZ31, CM 3°E					
Platform	**UKCS Block**	**Easting [m]**	**Northing [m]**	**Latitude**	**Longitude**
Southwark	49/21c	439 742.0	5 893 250.0	53° 11' 02.605" N	002° 05' 53.879" E

The design concept of the Southwark development is to use onshore separation, processing and compression facilities at Bacton, thereby enabling a minimum facilities offshore platform.

Although normally unmanned, the platform will include temporary living quarters and support systems for up to 12 personnel for emergency use. The platform design is based on a concept that has already been engineered to meet UK regulations and safety case acceptance. Table 2.2 shows the features and facilities that will be provided at the platform.

Table 2.2: Features and Facilities Provided at the Southwark Platform

Platform	Features and Facilities
Southwark	Hydraulically operated wellhead tree valves
	Electrically powered continuously variable, remotely controlled choke valve
	4 Well slots
	3 Production wells
	24" export pipeline to join the Thames export pipeline PL370
	24" automatic sphere launching system for servicing the export pipeline
	Wet gas multiphase flow meters for each well
	7.5 tonne rated crane
	Chemical injection package
	Vent system for maintenance purposes
	Emergency accommodation for 12 persons
	Helideck access with integral firefighting system
	Boat access/walk to work system
	Evacuation system
	Remote control system by satellite to onshore location in GT Yarmouth Norfolk
	Fire protection facilities
	Production solids handling systems

The platform jacket substructure will be constructed with a 4-leg lattice style jacket. Each of the platform legs will have seabed footings which will either be mudmats with skirt pile sleeves, or suction piles, depending on the installation method selected. Each mudmat is approximately 5.5 m × 5.5 m, totalling 121 m^2, and each suction pile would be between 7 m and 10 m in diameter, totalling 314 m^2 direct seabed footprint.

The jacket will support topsides structures comprising cellar, mezzanine and weather decks (Figure 2.2). The top deck will measure 22 m × 22 m. The helideck will be supported from the weather deck. The topsides will rise to 38.6 m above LAT at their highest elevation. This means that, with the platform being approximately 54.7 km distance from the nearest coastal point, the platform may be visible from the shore.

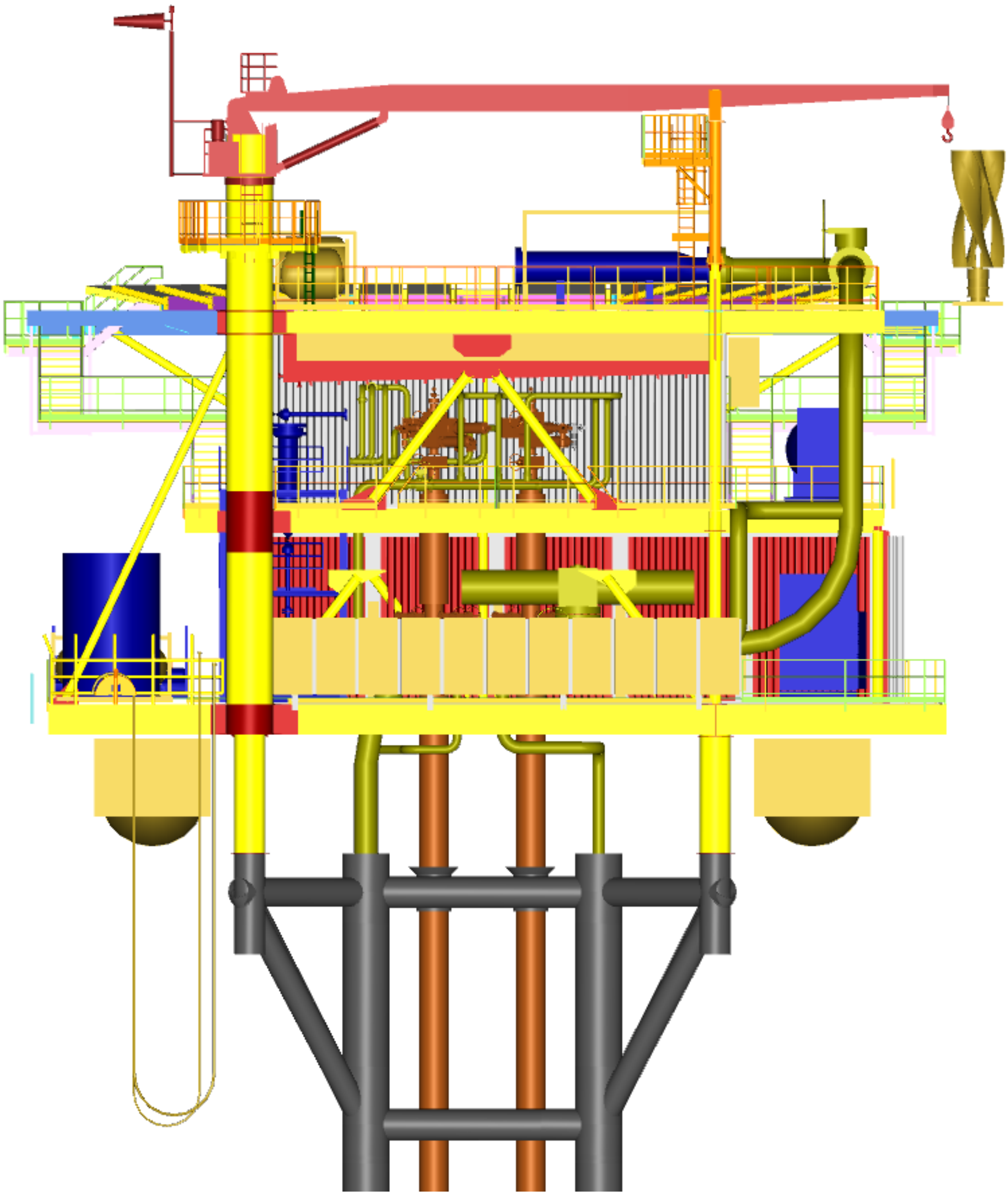


Figure 2.2: Indicative elevation of the Southwark platform

The platform is designed to operate automatically, but with the facility for remote monitoring and executive control via satellite communications from an onshore, manned, operations facility which is to be located at the offices of the appointed installation operator in Great Yarmouth. The Supervisory Control and Data Acquisition System (SCADA) provides the executive operator with remote monitoring, management and shutdown control of the following key systems:

- Emergency Shutdown System (ESD);
- Fire & Gas System (FGS);
- Process Control System (PCS);
- Pipeline Protection System (PPS).

The Great Yarmouth control room will remain in control of the platforms at all times, unless specifically required otherwise, for example during manned offshore operations or maintenance activities. The design allows the system to continue to operate and to control safely the platform production process in the event of loss of communication with the Great Yarmouth control room. In addition, the integrated control system is designed such that no single component failure will affect its overall functionality. The platform shutdown system, including Emergency Shut Down (ESD) is designed in accordance with internationally recognised standards for instrument based protective systems (typically IEC 61508 and IEC 61511). It should also be noted that there will be the facility to invoke platform ESD from the onshore Bacton Terminal gas processing terminal, and this will be achieved by a suitable tie-in between the integrated control system and the Bacton Terminal control room.

Once the 24" Southwark export pipeline has been laid, the jackets and topsides will be installed, and the pipeline tied into the existing Thames export pipeline PL370. A jack-up drilling rig will then commence drilling the first well. The first well will be put on production as soon as it is completed, and the next two wells will be drilled and completed sequentially involving simultaneous production and drilling operations. First gas from Southwark is anticipated around July 2021.

There will be no flaring from the platform, with all produced hydrocarbons being exported through the export pipeline system and via the Thames export pipeline PL370 to the onshore processing terminal at Bacton on the north Norfolk coast. All processing will be carried out onshore at the Bacton Terminal.

Corrosion and hydrate prevention chemicals will be bunkered out to Southwark by supply boat for use in dosing the export pipeline system. The chemicals will be introduced into the export system as required, from where they will flow through the pipeline system including the Thames export pipeline PL370 to be collected and handled in accordance with the relevant Permits, Consents and Licences at the onshore terminal at Bacton.

The Southwark platform will be unmanned during normal production operations. The platform will be visited periodically during daytime, as required for routine maintenance and replenishment of consumables, and will only ever be manned overnight in an emergency.

The platform installation will not support well interventions; any necessary intervention operations will be undertaken from a separate well intervention vessel or mobile drilling rig, procured when required for the purpose.

The installation of the platform is anticipated to take approximately 30 days as a single campaign, including the hook up of the platform to the export pipeline and associated platform works.

2.3.2 Southwark to PL370 Export Pipeline

All hydrocarbons and produced fluids will be exported from Southwark via a concrete-armoured 24" (internal diameter) pipeline surface laid on the seabed. The pipeline is approximately 5.86 km in length and will be connected to the existing PL370 Thames to Bacton pipeline.

The Southwark tie-in to PL370 will be at a separate location to the Blythe Hub tie-in as shown in Figure 1.1. The tie-in for Southwark is in UKCS Block 49/26 at approximately 30 m below LAT (Table 2.3).

Table 2.3: PL370 Tie-in Location

Geodetic datum: ED50, UTMZ31, CM 3°E					
Infrastructure	**UKCS Block**	**Easting [m]**	**Northing [m]**	**Latitude**	**Longitude**
PL370 Tie-in Location	49/26	441 813.9	5 887 875.0	53° 8' 6.684" N	002° 7' 43.896" E

The engineering design for the tie-in of the Southwark export pipeline with the Thames export pipeline PL370 is presented in Figure 2.5 in Section 2.5 which covers the installation and protection methods.

2.3.3 Thames Export Pipeline PL370

Production from the Southwark platform will be sent for onshore processing at the Bacton terminal on the north Norfolk coast via the existing Thames export pipeline PL370. The Thames export pipeline PL370 is a 24" diameter concrete coated pipeline laid on the seabed and is currently not in use, having been de-commissioned by the Thames field operating partners in 2012.

The commissioning and re-use of the Thames export pipeline PL370 is outside the scope of the main ES and of this Addendum. However, it should be noted that any work to PL370, and in particular re-use of the pipeline requires regulatory consent from both the Oil & Gas Authority and the Health & Safety Executive, following suitable demonstration of the structural integrity and long-term suitability of PL370.

2.3.4 Onshore Bacton Reception and Processing Terminal

As with the reservoir fluids from the Blythe Hub, and as set out in the main ES, reservoir fluids from the Southwark wells will be exported to the onshore Bacton terminal (currently operated by Perenco), where they will be processed and fiscally metered for sale.

2.3.5 Drilling Rig

Each of the three Southwark field wells will be drilled from a conventional jack-up drilling rig. The drilling rig will be towed to location by three tugs, and the rig legs lowered on to the seabed.

No specific drilling rig has yet been identified or procured for the Blythe Hub or for the Southwark Field Development, because the availability of specific rigs on the open market at the expected time of requirement cannot be anticipated. Therefore, an industry-standard jack-up drilling rig typically used in the Southern North Sea has been used in order to assess environmental impacts.

Typical jack-up rigs have three legs that are lowered to the seabed to raise the rig to a stable position above the sea surface, maintaining stability by its inherent weight. Each leg has a spudcan at its base, which is a large lens-shaped disc to inhibit seabed penetration. Each spudcan has a large spike at the bottom to ensure lateral stability in the seabed. Typical spudcans are 14 m (46 ft) in diameter.

Stable granular material will need to be placed around each leg footing for stabilisation and scour protection prior to drilling operations commencing. Well-established industry experience of safe and stable jack-up rig placement in the Southern North Sea demonstrates that approximately 1,000 tonnes of gravel deposit per leg is required for typical jack-up rigs on the seabed sediments confirmed by the results of the geophysical and geotechnical site survey in 2018.

The jack-up rig's legs will be deployed to the seabed first, before stabilisation material (typically gravel of the order of 20 mm particle size) is deposited via chute from a vessel on sea surface. The gravel acts to fill voids under the footings and forms a shallow shelf or berm around the footing. The gravel deposition will typically form a shallow 5 m wide berm around each footing. The total seabed footprint for a three-legged jack-up rig is presented in Table 2.4.

Table 2.4: Total Seabed Footprint for a Three Leg Jack-up Rig

Seabed footprint type	Area per can [m^2]	Total area [m^2]
Spudcan	154.38	463.14
Stabilising gravel	298.77	896.31
Total	453.15	**1359.45**

It is assumed that the jack-up drilling rig will have an onboard fuel capacity of approximately 1,000 tonnes, and a fuel consumption of up to 15 tonnes per day (Table 2.5).

2.3.6 Other Vessels and Helicopters

It has been assumed for the purposes of this ES Addendum that, during drilling and installation operations, three supply vessels per week will visit the site, to deliver fuel, chemicals, water, and other supplies and equipment. In addition, five helicopter round trips per week from Norwich Heliport to the development location per week could be completed for crew changes or other purposes.

2.3.7 Estimated Construction Phase Fuel Consumption

Estimates of the fuel consumption for the major construction, drilling and well stimulation activities for the Southwark field are provided in Table 2.5.

Table 2.5: Breakdown of Estimated Fuel Consumption of Construction Activities at the Southwark Field

Activity	Vessel	Fuel Type	Consumption [tonnes/day]	Duration [days]	Total Fuel Consumption [tonnes]
Mobilisation and demobilisation of drilling rig	Anchor handling tug × 3	Diesel	3 × 50	4	600
Drilling operations on location	Jack-up	Diesel	15	294	4,410
Stimulation vessel mobilisation and demobilisation	Stimulation vessel	Diesel	26	2 x 3	156
Hydraulic stimulation	Stimulation vessel	Diesel	50	30 x 3	4,500
Supply shipping (5 round trips per week, 12 hr round trips)	Supply vessels	Diesel	10	147	1,468
Safety vessel mobilisation and demobilisation	Emergency Response & Rescue Vessel	Diesel	8	2	16
Safety vessel on location	Emergency Response & Rescue Vessel	Diesel	4	296	1,184
Mobilisation and demobilisation of jacket and topsides	Tug × 2	Diesel	2 × 10	1	20
Mobilisation and demobilisation of jacket and topsides to field location	Heavy lift barge	Diesel	50	2	100
Installation of jacket and topsides	Heavy lift barge	Diesel	20	5	100
Mobilisation and demobilisation of pipelay vessel	Pipelay vessel	Diesel	8	2	16
Installation of 24" export line extension from Southwark to PL370	Pipelay vessel	Diesel	15	10	150
Mobilisation and demobilisation of Diving Support Vessel (DSV)	DSV	Diesel	22	4	88
Installation of tie-in	DSV	Diesel	18	10	180
				Total	**12,988**
Activity	**Vessel**	**Fuel Type**	**Consumption [l/hr]**	**Duration [hrs]**	**Total Fuel Consumption [tonnes]**
Personnel transport (5 round trips per week)	Helicopter	Aviation fuel	580	212	**101**

Note:
Consumption rates taken from Guidelines for the Calculation of Estimates of Energy Use and Gaseous Emissions in the Decommissioning of Offshore Structures (Institute of Petroleum, 2000)

2.4. Drilling and Completion Operations

The three Southwark field wells will be drilled horizontally and hydraulically stimulated over multiple intervals through the reservoir. IOG reservoir analysis and data from the relevant catalogue of comparable fields has determined that, in order to minimise the likelihood of water breakthrough from the underlying aquifer, the fracture design should maintain a minimum distance of 18.3 m (60 ft) from the deepest point of any fracture to the gas water contact (GWC) surface.

Each of the three wells will be completed with 4½**"** production tubing.

Drilling and completion operations are planned to be undertaken as a single continuous campaign.

2.4.1 Drilling Schedule

Drilling activity at the Southwark field location is scheduled to commence immediately after the jacket and topsides installation activities are complete. This is presently anticipated to occur in Mar 2021.

A more detailed schedule of expected drilling and completion operations for a typical Southwark field well is provided in Table 2.6.

Table 2.6: Indicative Schedule of the Proposed Drilling Operations for Each Southwark Field Well

Well	Description of Drilling and Completion Operation	Days	Cumulative Time (Days)
S-1/2/3	Mobilisation	3.5	3.5
	Prepare to spud	3.5	7
	Drill 36" section	1	8
	Run and cement 30" conductor	1.75	9.75
	Drill 17½ " section	7.75	17.5
	Run and cement 13⅜" casing	1.75	19.25
	Install wellhead and 13⅜" BOP	2.25	21.5
	Drill 12¼" section	5	26.5
	Run and cement 9⅝" casing	2.25	28.75
	Drill 8½" section	9.25	38
	Run and cement 7" liner	3	41
	Displace to reservoir drilling fluid	1.25	42.25
	Drill 6" section	12.75	55
	Run and cement 4½" liner	3.25	58.25
	Well bore clean-up	2.75	61
	Completion and run production tree	4.25	65.25
	Hydraulic stimulation	25	90.25
	Well clean up	6	96.25
	Rig down and demobilisation	1.75	98
	Indicative Per Well Total		**98**

2.4.2 Drilling, Cementing and Completion Chemicals Management

As set out in the original Blythe Hub ES, a variety of chemicals will be used to facilitate the drilling process and safe completion of the wells, including drilling fluids and cementing chemicals. Contingency chemicals will also be present on the rig in case they are required for any unexpected situations encountered during drilling. In addition, a number of chemicals will be used on the drilling rig for maintenance, such as detergents to wash the rig floors and lubricants for certain equipment and machinery.

As set out in the original ES, all chemicals will be selected and used according to the applicable chemicals regulations.

2.4.3 Drilling Muds

As with the drilling of the Blythe Hub Development wells, as described in the main ES, seawater and high viscosity sweeps will be used to drill the 36" section. Water based mud (WBM) will be used for all lower sections. The WBM will be made from a base fluid which may be seawater or brine. These WBM systems incorporate natural clays in the course of the drilling operation and any chemicals that are added to WBM are generally of low environmental risk and many are classified as Pose Little or No Risk (to the environment) (PLONOR).

As described in Section 2.2.7 above, whilst IOG's preference is to drill all sections with WBM, geological conditions encountered during drilling may necessitate the use of OBM in some lower sections of wells. In such a case, LTOBM may be used, composed of oil in the continuous phase, where they will be formulated with mineral oil, or low-toxicity linear olefins and paraffins, and water in the dispersed phase in conjunction with certain chemical additives such as emulsifiers and wetting agents.

Should the use of LTOBM be required, it will be re-circulated on the rig in a closed system. Spent LTOBM and cuttings will be shipped to shore for treatment and disposal and will not be discharged into the marine environment.

2.4.4 Cuttings and Mud Discharges

The following description of cuttings and mud discharges for the Southwark wells in this section of the ES Addendum is the same as for the Blythe Hub Development wells. The description is repeated here for clarity.

Cuttings and viscous sweeps and WBM from the 36" section will be discharged at the seabed, as is normal practice on the UKCS. Cuttings and drilling fluids from lower sections will be returned to the rig via the conductor, and passed through a mud recovery system to recover as much of the drilling mud as possible. Once reconditioned, this mud will be used again, thereby minimising the amount of drilling mud required. Cuttings from lower sections will be discharged at the sea surface. It is anticipated that the cuttings and any residual WBM will be dispersed naturally by the strong tidal currents, and that there will be no requirement for mechanical cuttings relocation or dredging.

Should the use of LTOBM be required for certain sections, cuttings and drilling fluids from those sections will be circulated back to the drilling rig via the annulus (the space between the drill stem and the wall of the bore hole) and the conductor. The mud and cuttings from these sections will also pass through the mud recovery system to recover as much of the drilling mud as possible.

LTOBM contains a number of chemical additives, as well as the oil-base, that may have an impact on the marine environment and may be listed as candidates for substitution. As such, the discharge of LTOBM is prohibited in UK waters and spent LTOBM and cuttings will be shipped to shore for treatment and disposal and will not be discharged into the marine environment.

Table 2.7 provides the combined estimated cuttings generation and associated mud discharge for the Southwark field, based on IOG's plans to drill all sections with WBM.

Table 2.7: Combined Estimated Cuttings Generation and Discharges for Southwark

Section [inches]	Mud System	Discharge Point	Combined Section Length [m]	Excess* [%]	Combined Duration of Discharge [hrs]	Total Cuttings Volume [m³]	Total Cuttings Generated [tonnes]	Total WBM Discharged [tonnes]
36"	Seawater and viscous sweeps	Seabed	264	300	75	519	1,353	990
17½"	WBM	Rig	2,542	50	396	592	1,539	2,688
12¼"	WBM	Rig	2,302	30	279	228	592	1,684
8½"	WBM	Rig	2,168	25	527	99	257	1,644
6"	WBM	Rig	4,356	10	818	87	227	979
Total			**11,632**		**2,095**	**1,525**	**3,968**	**7,985**

Note:
* The formations being drilled in the Southwark field are susceptible to washing-out. Therefore, whilst a standard nominal (e.g. 12 1/4") hole size is quoted in the table, the actual hole size is generally larger than this. The quoted 'excess %' represents the estimated additional hole volume over the quoted nominal hole size. For example, 1 metre of 12 1/4" hole would produce 0.076 m^3 of cuttings but an estimate of 30% over-gauge has been used (based on studies of wells nearby and throughout the Southern North Sea) which results in an estimated figure of 0.99 m^3 of cuttings.

For clarity the following three tables present the same data as in Table 2.7 above, but split-out to show the contribution of each of the individual 3 Southwark wells to the overall combined data, together with the estimated duration of each well section.

Table 2.8: Estimated Cuttings Generation and Discharges for Southwark Well S1

Section [inches]	Mud System	Discharge Point	Section Length [m]	Excess [%]	Cuttings Volume [m3]	Cuttings Generated [tonnes]	WBM Discharged [tonnes]	Duration of Section [hrs]
36"	Seawater and viscous sweeps	Seabed	88	300	173	451	330	25
17½"	WBM	Rig	884	50	206	535	928	138
12¼"	WBM	Rig	750	30	74	193	565	91
8½"	WBM	Rig	835	25	38	99	574	192
6"	WBM	Rig	1496	10	30	78	337	277
TOTAL			**4053**		**521**	**1356**	**2734**	**723**

Table 2.9: Estimated Cuttings Generation and Discharges for Southwark Well S2

Section [inches]	Mud System	Discharge Point	Section Length [m]	Excess [%]	Cuttings Volume [m3]	Cuttings Generated [tonnes]	WBM Discharged [tonnes]	Duration of Section [hrs]
36"	Seawater and viscous sweeps	Seabed	88	300	173	451	330	25
17½"	WBM	Rig	829	50	193	502	880	129
12¼"	WBM	Rig	746	30	74	192	550	90
8½"	WBM	Rig	666	25	30	79	530	164
6"	WBM	Rig	1490	10	30	78	323	282
TOTAL			**3819**		**500**	**1302**	**2613**	**690**

Table 2.10: Estimated Cuttings Generation and Discharges for Southwark Well S3

Section [inches]	Mud System	Discharge Point	Section Length [m]	Excess [%]	Cuttings Volume [m3]	Cuttings Generated [tonnes]	WBM Discharged [tonnes]	Duration of Section [hrs]
36"	Seawater and viscous sweeps	Seabed	88	300	173	451	330	25
17½"	WBM	Rig	829	50	193	502	880	129
12¼"	WBM	Rig	806	30	80	207	569	98
8½"	WBM	Rig	667	25	31	79	540	171
6"	WBM	Rig	1370	10	27	71	319	259
TOTAL			**3760**		**504**	**1310**	**2638**	**682**

2.4.5 Cement Discharges

The following description of cement discharges for the Southwark wells in this section of the ES Addendum is the same as for the Blythe Hub Development wells. The description is repeated here for clarity.

The casings used to prevent the well from collapsing will be cemented into place by pumping cement down the casing string, out through a hole in the bottom and back up to the surface through the annulus. For the conductor (30") and surface casing (13 ⅜") it is critical to get cement back to seabed to ensure the structural integrity of the well and therefore there is the possibility that cement will be discharged to the sea.

For the 30" conductor, the cement will be pumped down the drill string and up the conductor annulus to the seabed. Rather than mixing a large batch of cement for this job it will be mixed on demand and when cement is observed at seabed by the Remotely Operated Vehicle (ROV) mixing and pumping will be terminated to minimise the volume discharged. The worst case estimated cement discharge for this section is 31 m^3 or 60 tonnes. This is based on the entire excess reaching seabed, in the event that the hole is in gauge (so estimated excess proves to have been unnecessary) and the ROV was unable to see the cement returns due to poor visibility or poor weather preventing ROV launch.

The 13 ⅜" casing will also be cemented in place but in this case any excess cement returns will be returned to the rig before being discharged overboard in the same manner as drill cuttings. The estimated worst case for cement discharge from this section is 20 m^3 or 31 tonnes.

Subsequent casing strings will not be cemented in place, so it is highly unlikely that cement will return to the rig, however, in the event that it does, it will be captured in the skip and ship system and returned to shore for processing due to the presence of oil based mud in the well at this time.

A small volume of cement will also be discharged following each cement job during the process of cleaning the cement pump and mixing tank. The volume of cement being discharged at this time will be very small and is unlikely to exceed 2 m^3.

Any cementing chemicals which will be required as part of the proposed operations will be included in a supporting Chemical Permit (CP) Subsidiary Application Template (SAT) application submitted to BEIS. IOG anticipates that up to 10% of any cement will be discharged to sea as a result of tank and pipework cleaning and flushing. Additional cementing chemicals may be required to deal with any unplanned events and, therefore, a number of contingency chemicals will be stored on the drilling rig to manage any such eventualities to allow the operations to be completed. A similar level of discharge is anticipated for these chemicals (10%).

In the event that cement is mixed and there is a requirement for an emergency discharge of a larger volume of slurry due to an issue arising downhole then IOG will contact BEIS to discuss the best practicable environmental option for the disposal of the chemicals involved.

2.4.6 Well Clean-up

The following description of well clean-up for the Southwark wells in this section of the ES Addendum is the same as for the Blythe Hub Development wells. The description is repeated here for clarity.

The clean-up assembly comprising casing and liner scrapers, wire brushes, magnets and a circulating tool, will be run into the well to total depth (TD) whilst circulating WBM and working the string with rotation. Once the clean-up string reaches TD a clean-up train of detergent and high viscosity sweeps will be circulated into the well before the WBM is changed out to filtered brine. The clean-up string will be rotated at a high rate to ensure minimum interphase contamination with the filtered brine. Flow checks will be performed at regular intervals during the WBM displacement to check the liner/casing interface pressure integrity. All mud returns will be returned to the mud pits on the drilling at which point any hydrocarbon contamination can be removed, before water-based fluids are discharged to sea.

2.4.7 Well Completion

The following description of well completion for the Southwark wells in this section of the ES Addendum is the same as for the Blythe Hub Development wells. The description is repeated here for clarity.

The wells will be completed as gas production wells with 4½" tubing in filtered brine. After pressure testing to confirm integrity, the liner will be perforated. After perforating, the well be flowed through a temporary well clean up package until it meets the production cleanliness specifications.

If the proposed drilling operations on any of the Southwark wells are unsuccessful, to the extent that insufficient hydrocarbons are encountered to enable a commercial production from the well, then, it is anticipated that – following discussions with the OGA - the well will be abandoned in accordance with Oil and Gas UK Suspension and Abandonment of Wells Guidelines (OGUK, 2015).

2.5. Surface and Subsea Infrastructure Installation

2.5.1 Installation Vessels

No specific vessels have yet been identified or procured for the Southwark Field Development, because the availability of specific vessels on the open market at the expected time of requirement cannot be anticipated.

However, and as set out in the main Blythe Hub ES, the anticipated required vessels identified in the following sections and in Section 2.3.7 *Estimated Construction Phase Fuel Consumption* are based upon typical vessels used in the Southern North Sea for the specified work activities, and have been used in order to assess environmental impact.

2.5.2 Installation of the Southwark Platform

The Southwark jacket will be transported and installed by a heavy lift vessel. The jacket will be of an existing industry standard four-leg design, which will be piled to the seabed. Two methods for installing the jacket are still being considered:

- Driven piles;
- Suction piles.

Driven Pile Installation

For the driven pile option, the jackets will be seated on mudmats of approximately 5.5 m × 5.5 m per leg, meaning the platform has a total direct seabed footprint of approximately 121 m^2. The jacket will then be skirt piled to the seabed, with one pile per leg through each mudmat (Figure 2.3). Each pile will have a diameter of 2.13 m (84").

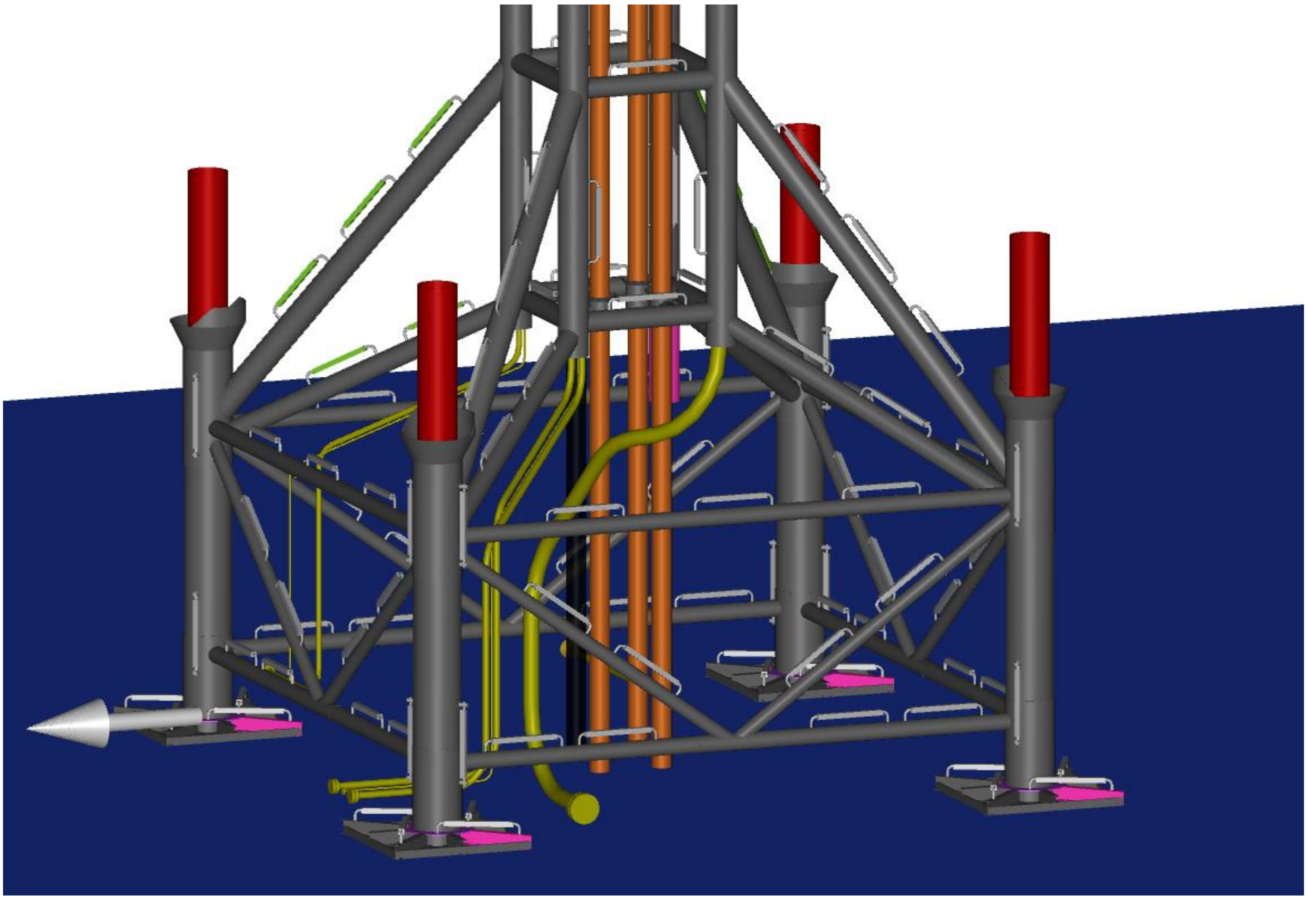


Figure 2.3: Indicative schematic of the footings and piles. North arrow shown.

Piles would be driven into the seabed by a subsea hydraulic hammer of up to 1,800 kNm. This is expected to take approximately one day per leg, during which actual piling operations may take place for up to 6 hours. Depending on seabed substrate, it is estimated that between 3,000 and 4,000 hammer blows will be required for each pile.

The impacts of pile driving are assessed in Section 7 *Noise Generation and Wildlife Disturbance*.

Suction Pile Installation

If technically possible, the current preference is to use suction piles which will be jetted into the seabed. For this option the mudmat and skirt pile configuration at the base of each leg would be replaced by suction piles. Each suction pile comprises a metal cylinder of between 7 m and 10 m diameter and up to 15 m length with a watertight cap at the top. These piles would be inserted into the seabed by pumping out the water between the seabed and the pile cap allowing hydrostatic pressure to force the suction piles into the seabed sediment.

The seabed footprint of this installation method would be up to 314 m^2 for 10 m diameter suction piles. There are not expected to be any significant underwater noise impacts from this installation method.

2.5.3 Installation and Protection of the Southwark to PL370 Export Pipeline

Export Pipeline Installation

The 24" pipeline from Southwark to the Thames Export Pipeline PL370 will be concrete coated and surface-laid into position on the seabed by a specialist pipelay vessel. The pipeline is approximately 5.86 km in length.

Protection of the pipeline along its length is afforded by 4" concrete coating which acts as an armour against physical damage. The concrete coating is also designed in order to counteract the buoyancy tendencies and the local expected hydrodynamic forces, thereby ensuring that the pipeline remains seated on the seabed at a stable location.

The total seabed footprint of the export pipeline is 4.77 km^2.

Pipeline Stabilisation and Integrity

IOG's engineering studies suggest that a worst-case scenario is that 0.25% of the pipeline length will require stabilisation at the time of installation, and that a further 0.43% of the pipeline length will require stabilisation during the expected operational lifetime.

Previous industry experience of rock dumping with fall pipe vessels demonstrates placement precision within 1 m is routinely achievable along open pipeline lengths, even in waters up to 100 m depth. For the purposes of this assessment, it is assumed that areas requiring stabilisation will comprise 2 m wide corridors along the pipeline route (1 m either side). Table 2.11 presents estimated pipeline stabilisation areas.

Table 2.11: Estimated Areas of Seabed Covered by Southwark to PL370 Export Pipeline Stabilisation Measures

Phase	Pipeline length [km]	% length	Width [m]	Area Covered [m^2]
Installation	5.86	0.25	2	29.3
Operation	5.86	0.43	2	50.4
Total		**0.68**		**79.7**

Crossing Point Protection

There are no identified pipeline or cable crossings along the planned pipeline route so additional pipeline protection for crossing points will be required.

Tie-in Point Protection

Dropped object protection for the pipeline at the Southwark platform tie-in and PL370 tie-in locations will be provided by concrete mattresses. Graded rock placement and grout or sand bags may also be used at the tie-in points to provide pipeline stabilisation where necessary.

Figure 2.4 shows the designed pipeline protection at the Southwark platform and Figure 2.5 shows the designed protection at the tie-in with the Thames export pipeline PL370.

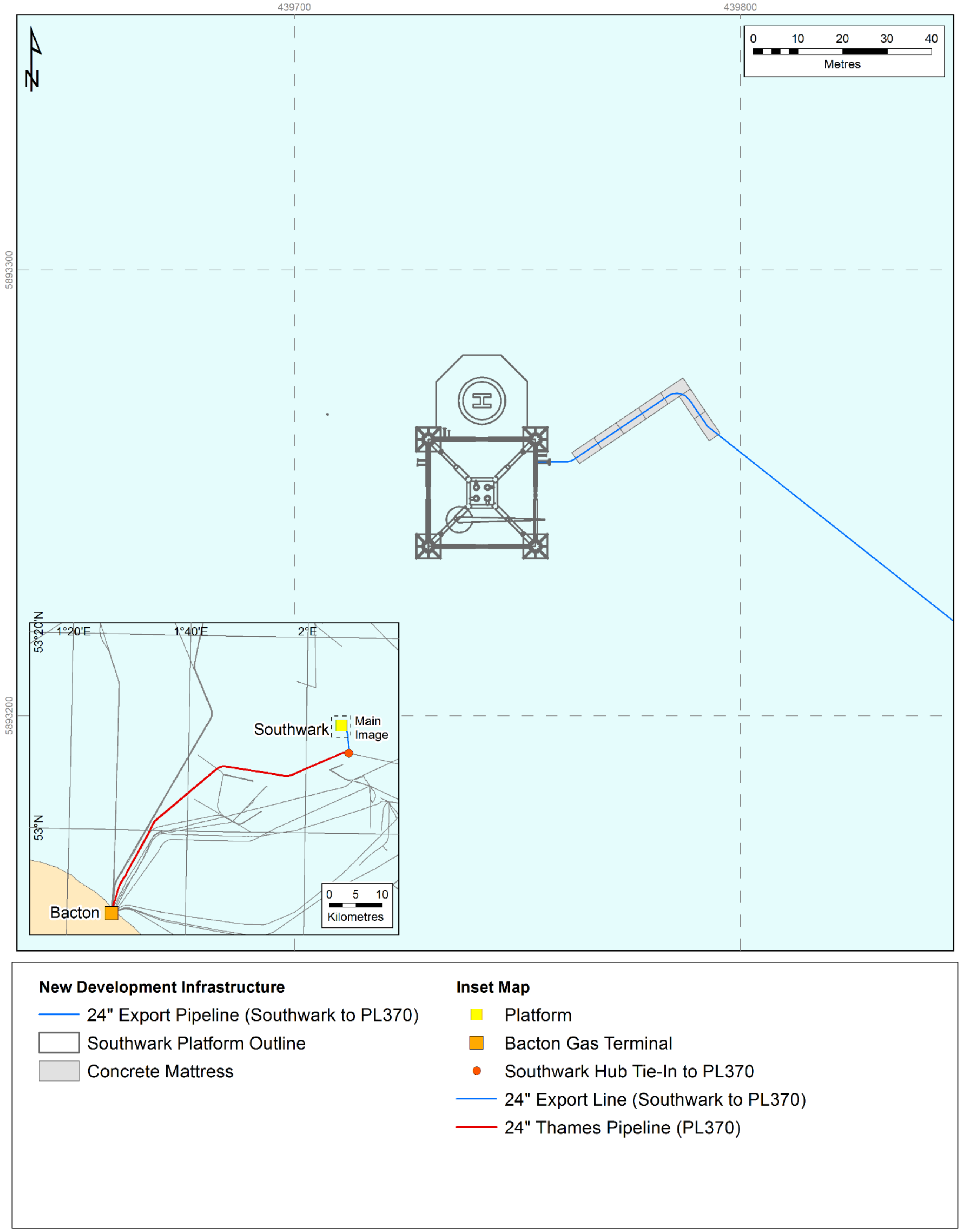


Figure 2.4: Pipeline Tie-in Protection Arrangements at Southwark

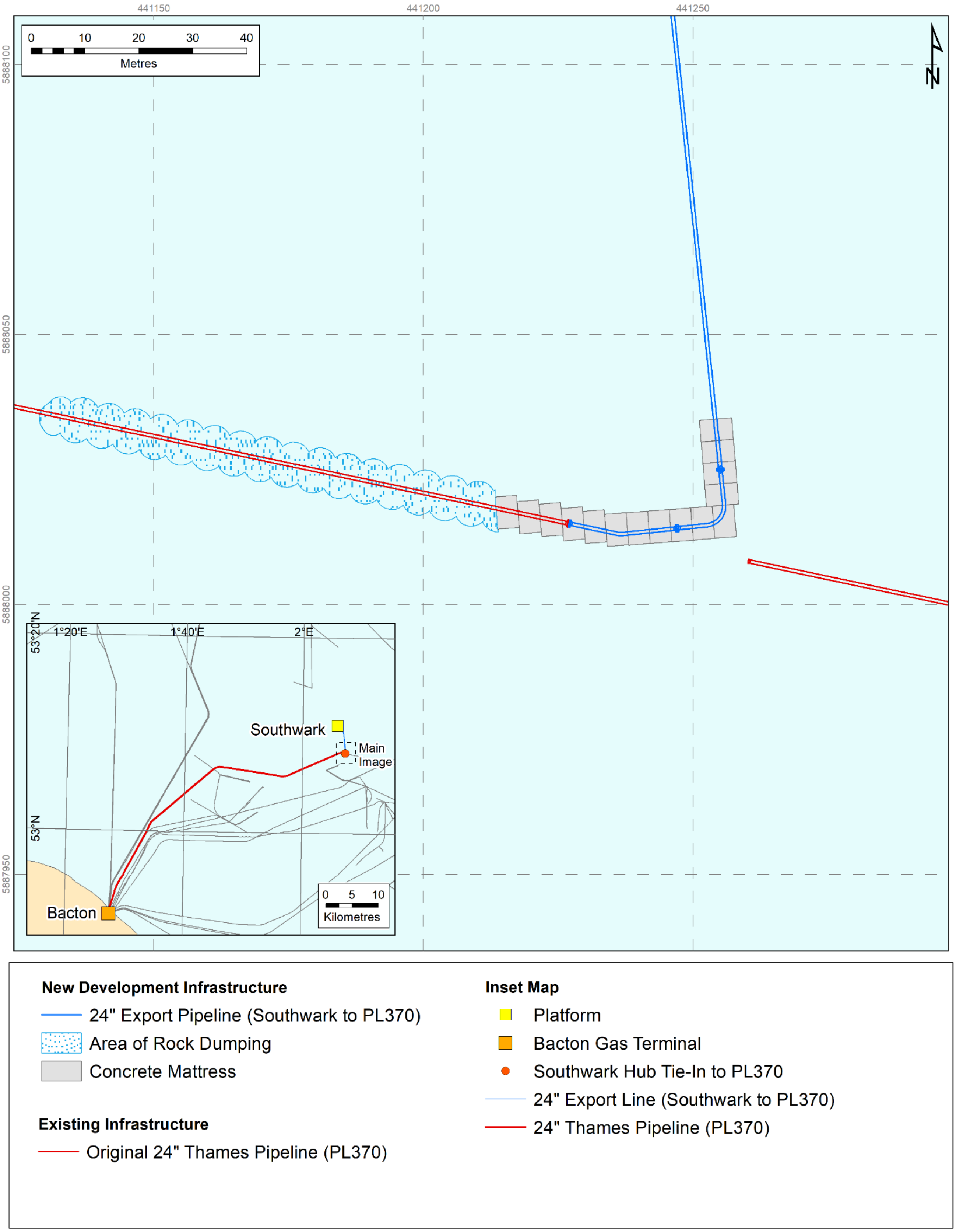


Figure 2.5: Pipeline Protection Arrangements at the Tie-in with the Thames Export Pipeline PL370

For illustration, a typical concrete mattress pipeline protection installation is shown in Figure 2.6 below and a typical rock and gravel pipeline protection installation is shown in Figure 2.7 below.

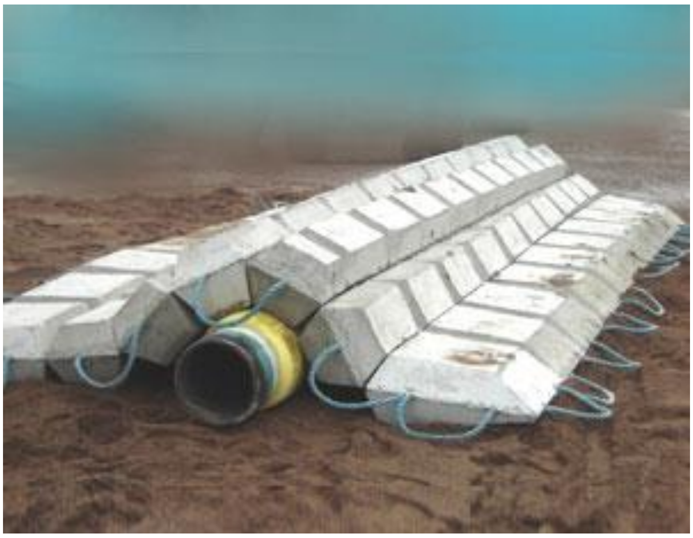


Figure 2.6: Concrete mattress of the type to be used for pipeline protection

Table 2.12 provides the estimated total areas of seabed expected to be covered by mattresses, with each mattress expected to accord to the typical design size of 6 × 4 m

Table 2.12: Areas of Seabed Expected to be Covered by Mattresses

Location	Pipeline	Number of Mattresses	Area Covered [m^2]
Tie-in to PL370	24" Southwark to PL370 gas export line	15	360
Tie-in to Southwark	24" Southwark to PL370 gas export line	7	168
Total		**22**	**528**

A short section (approximately 85 m) of PL370 will also require some graded rock placement beyond the tie-in point for stabilisation purposes. This is estimated to total approximately 4,000 tonnes and to cover an area of 665 m^2.

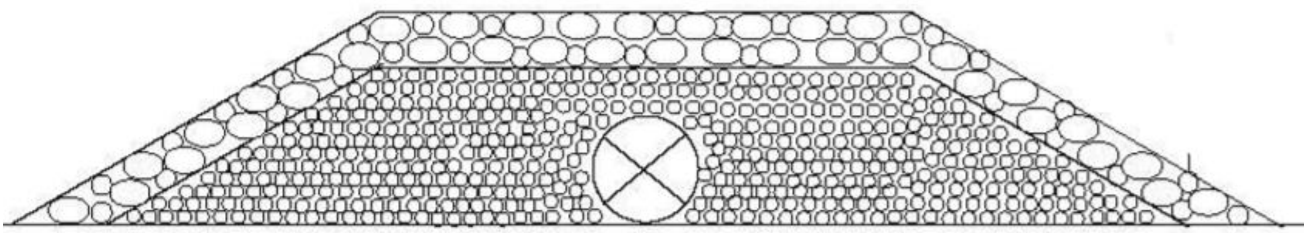


Figure 2.7: Indicative cross-section of graded rock protection method for pipeline protection

2.5.4 Potential Seabed Area Affected

Table 2.13 presents a breakdown of the potential seabed areas affected by each of the Southwark Field Development infrastructure components.

Table 2.13: Seabed footprint of Southwark Field Development infrastructure components

Development Infrastructure	Impact type	Area [m²]	Area [km²]
Platform footings - mudmat option	Temporary compression	121	0.00012
Platform footings - suction pile option	Temporary compression	314	0.00031
Jack-up rig spudcan footprint;	Temporary compression	463	0.00046
Spudcan stabilisation material;	Graded rock placement	896	0.00090
Southwark to PL370 export pipeline	Seabed compression	4,765	0.00476
Southwark tie-in mattresses;	Mattresses	168	0.00017
PL370 tie-in mattresses;	Mattresses	360	0.00036
PL370 stabilisation material;	Graded rock placement	665	0.00067
Initial pipeline stabilisation material;	Graded rock placement	29	0.00003
Lifetime pipeline stabilisation material.	Graded rock placement	50	0.00005
Total (mudmat option)		**7,518.4**	**0.00752**
Total (suction pile option)		**7,711.4**	**0.00771**

2.5.5 Pipeline Hydro-testing and Flushing

The installed pipeline from Southwark to the Thames Export Pipeline will be pressure tested using hydro-testing fluids.

All such testing fluids will be contained within the pipeline system and ultimately exported via the Thames export pipeline PL370 to the onshore Bacton terminal where they will be handled in accordance with the site permits, consents and licences.

2.6. Production Operations

As with the Blythe Hub Development, described in the main ES, the Southwark field is expected to produce a mixture of gas and condensate.

Table 2.14 presents the high, medium and low estimates of production from the three planned Southwark field wells over the initial anticipated 18-year life of the field. Condensate production estimates are based on a 1:225,453 (079 bbl/MMscf) condensate to gas ratio.

Table 2.14: Production Estimates for the Southwark Field

	Gas		Condensate	
Case	**[Millions m³]**	**[Bcf]**	**[m³]**	**Bbls**
High	3,462	122	15,358	96,597
Medium	2,689	95	11,925	75,009
Low	1,821	64	8,077	50,803

2.6.1 Platform Operations

As described in Section 2.3 of this Addendum, the Southwark platform is designed as a 'minimum facilities platform' and will be unmanned during normal production operations. The platform will be visited periodically, and as required, for routine maintenance and replenishment of consumables, and will only ever be manned overnight in an emergency situation. The platform will therefore include temporary living quarters and support systems for up to 12 personnel for such use. The platform will be accessible by both helicopter and by boat.

Wells will be configured for remote start up from the control room situated onshore.

Well intervention from the platform will not be supported, and any necessary intervention operations will be undertaken from a separate, well intervention vessel or mobile drilling rig, that will be procured for the purpose as needed.

An automatic pig launcher into the export pipeline system will be installed on the platform for routine operational purposes.

A High Integrity Pressure Protection System (HIPPS) will be provided on the platform in order to protect the safe operating pressure of the topsides and export pipeline.

Wet gas type allocation metering will be provided at the production wells prior to export, with fiscal metering provided at the onshore Bacton terminal.

2.6.2 Platform Power Requirements

Power requirements of the Southwark field platform are anticipated to be between 30 kW for unmanned operation and 67 kW for manned operations.

This power will be provided by a combined part renewable energy system (wind and solar energy) and a part traditional diesel engine system for when renewable energy is not in full supply.

Therefore, combustion emissions from each platform will be minimal and well below the 20 MW(th) threshold for the EU Greenhouse Emissions Trading Scheme (ETS).

2.6.3 Produced Water

Reservoir modelling has concluded that Produced Water is not expected for the first 6 years of production. When water breakthrough does occur, it will be exported along with all other reservoir fluids via the Southwark export pipeline system and the Thames export pipeline PL370 to the onshore Bacton Terminal where it will be handled in accordance with the relevant and applicable site consents, permits and licences.

The principal corrosion risk to pipeline integrity from the transport of produced water, is from internal pipe wall corrosion.

This risk is actively mitigated through a Corrosion and Hydrate Inhibition Strategy that is a part of the overall Pipeline Integrity Management System (PIMS). In summary, MEG is to be dosed with corrosion inhibitor, and then injected into the pipeline at the production manifold of the Southwark platform. The pipeline is to be periodically sphered (a polyurethane sphere that is inflated to provide a tight fit to the inside diameter of the pipe is sent along the pipeline) in order to both remove any static build-up of liquids within the pipeline, and also the sphere has the effect of promoting contact of the corrosion inhibitor with the internal wall surface of the pipe.

The PIMS - which is referenced in the statutory Major Accident Prevention Document (MAPD) for the pipeline – sets out the arrangements made to maintain the pipeline in an efficient state, in efficient working order and in good repair, as a demonstration of compliance with (inter alia) the OPPC Regulations. The PIMS also specifically details pipeline inspection procedures, sampling and monitoring routines, and inspection reporting and anomaly acceptance criteria, all of which contribute to the overall management of the risk of pipeline corrosion due to the transport of produced water.

2.6.4 Pipeline and Production Chemicals

As stated in Section 2.2.5 of this Addendum, Engineering study and reservoir analysis together indicate that chemicals to both protect and maintain the flow of fluids through the export pipeline will be required to be introduced into the pipeline at the Southwark platform, and also that hydrate prevention by introduction of chemical treatment to the well will be required during well start-ups.

Corrosion and hydrate prevention chemicals will be carried out to the Southwark platform by supply boat for use in dosing the export pipeline system. The chemicals will be introduced into the export system as required and will be carried through the Thames export pipeline PL370 to be collected and dealt with in accordance with the relevant onshore permits, consents and licences at the onshore terminal at Bacton.

Each of the planned 3 wells will have the facility of enabling injection with methanol to provide hydrate prevention during cold start.

As set out in the original Blythe Hub Development ES, all chemicals will be selected and used according to prevailing applicable chemicals regulations.

2.7. Project Schedule

The complete programme of facilities construction, installation and drilling operations for the Southwark Field Development is currently planned to take place between Q1 2021 and Q2 2022. A schedule of the proposed operations is provided in Table 2.15.

Table 2.15: Gantt Chart of Southwark Field Development Programme Activities by Quarter

Activity	2021				2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Installation of Platform and Facilities	■							
Drill, complete and stimulate S1 well	■	■						
Construction of Southwark tie-ins & protection materials	■	■						
Drill, complete and stimulate S2 & S3 wells				■	■			

2.8. Decommissioning

Cessation of production is estimated at circa 2038, depending on production and economic limits. In the UK, decommissioning is controlled through the Petroleum Act 1998, as amended by the Energy Act 1998. The UK's international obligations on decommissioning are governed principally by the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention).

Following grant of consent for Cessation of Production, the wells will be fully decommissioned in accordance with Oil & Gas Authority requirements, which will include complete removal of the wellheads from the seabed.

IOG will follow legislative requirements and regulatory guidance for the decommissioning of the offshore facilities and structures as will be applicable at the point of decommissioning. IOG understands that the current UK government policy is to seek to achieve effective and balanced decommissioning solutions, which are consistent with international obligations and have a proper regard for safety, the environment, other legitimate users of the sea, economic and social considerations as well as technical feasibility. Under current UK government guidelines this would mean the complete removal of the offshore installations and structures in order to aim to achieve a clear seabed. Current UK government guidelines also require the preparation, and submission to the government for prior approval, decommissioning programmes proposing detailed justification for the planned decommissioning of all offshore installations and infrastructure, including pipelines.

Decommissioning of the pipelines will be determined following a full comparative assessment of feasible options at the time, having regard to the UK Governments stated intention of moving towards achieving a 'clean sea bed'.

Early discussion and consultation will be sought with the BEIS OPRED Offshore Decommissioning Unit and the planned decommissioning methods and processes will be developed according to the prevailing regulatory and operational considerations.

It is currently anticipated that the Southwark platform will be removed completely from the seabed, and that the Southwark export pipeline to the Thames Export Pipeline PL370 will be flushed and left in situ.

Financial provision for ultimate decommissioning of the Southwark field will be maintained throughout field life in dialogue with the BEIS OPRED Offshore Decommissioning Unit and the Oil & Gas Authority.

Section 3

The Local Environment

3 THE LOCAL ENVIRONMENT

3.1. Introduction

The Blythe ES describes the local environment of the Blythe and Elgood fields however, this Addendum to the Blythe ES solely focusses on describing the local environment of the Southwark field. The Southwark field is situated within UKCS Block 49/21 in the Southern North Sea, a small section of pipeline will also transit through UKCS Block 49/26 which will connect with the 24” Thames to Bacton pipeline PL370 (Figure 3.1). The nearest landfall to the Southwark field is the north Norfolk coast, located 55 km to the southwest of the Southwark field. At its nearest point, the UK/Netherlands median line is situated approximately 64 km to the east of the Southwark field.

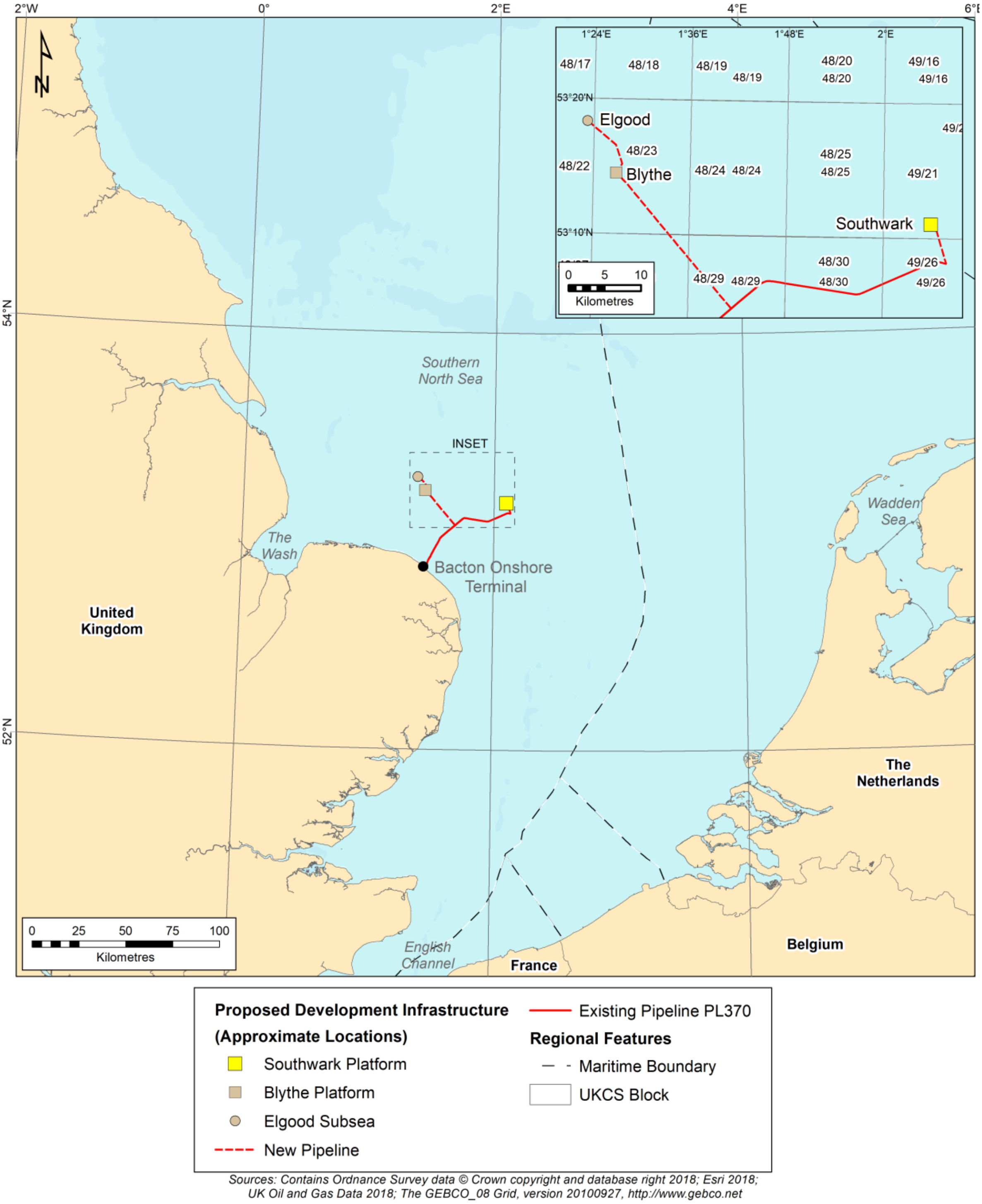


Figure 3.1: Location of the Blythe Hub development fields plus the additional Southwark development field

Information about the environment at the proposed development location and its surroundings has been collated to allow an assessment of those features that might be affected by the development of the proposed Southwark field, or may influence the behaviour of potential contaminants.

The results of the scoping process (ES Chapter 4) indicated that the majority of potential significant impacts will occur in the immediate vicinity of the development location. Any environmental receptors that may be impacted are described on a local scale. Other activities or events, such as underwater noise generation or large oil spills, could potentially affect a wider area. In these instances, the receptors that may be affected are described on a broader scale.

3.2. Environmental Baseline Survey and Habitat Assessment

The Southwark Field Development area was surveyed from the Fugro Galaxy between 12 March and 9 April 2018. Full survey details and results are presented in the *Vulcan Habitat Assessment Report* (Fugro, 2018a) and the *Vulcan Environmental Baseline Survey Report* (Fugro, 2018b).

Figure 3.2 presents the environmental survey sample array, side-scan sonar (SSS) acquisition, sandbank and other seabed features, and proposed infrastructure Locations for the Southwark platform and surrounding area, and Figure 3.3 presents the same information for the Southwark to PL370 export pipeline survey corridor.

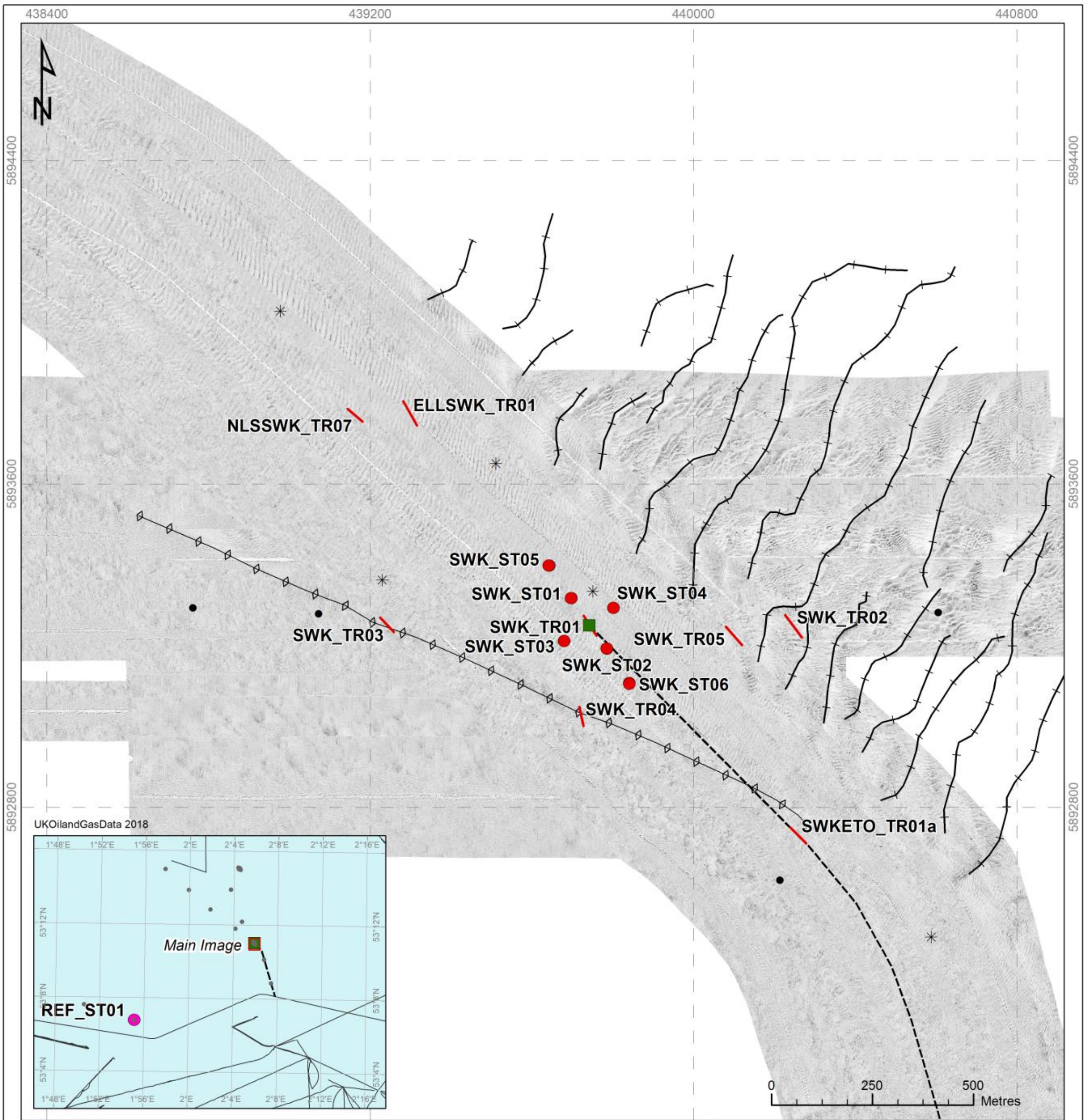


Figure 3.2: Southwark platform survey area. Figure shows side-scan sonar acquisition, sandbank and other seabed features, proposed infrastructure and sample locations.

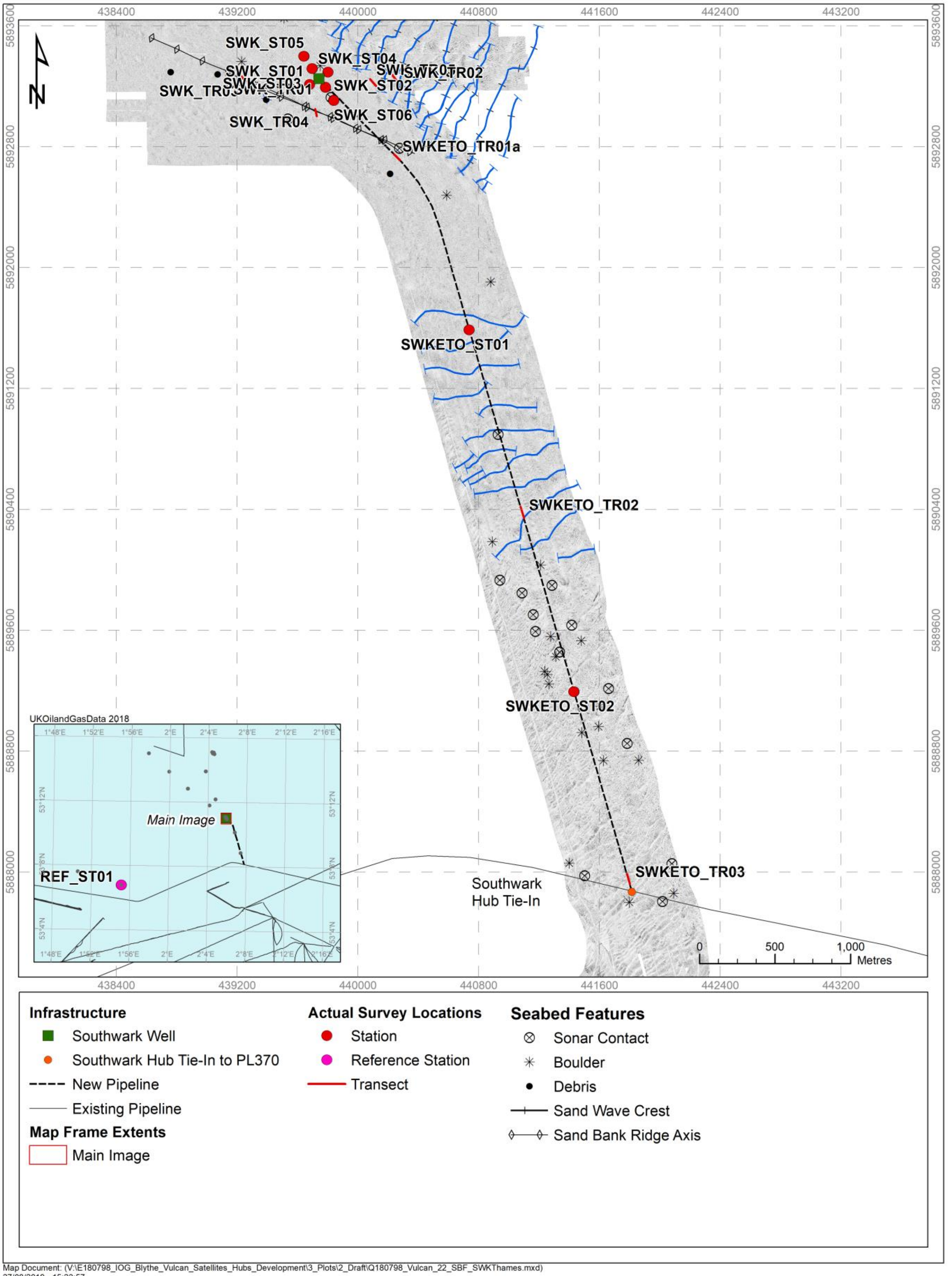


Figure 3.3: Southwark to PL370 export pipeline survey corridor. Figure shows side-scan sonar acquisition, sandbank and other seabed features, proposed infrastructure and sample locations.

The environmental survey results demonstrate that the development footprint lies on a mobile sand substrate, with a varying proportion of gravel and shell fragments. Epifauna was extremely sparsely recorded throughout the survey area (Fugro, 2018a). In general, results demonstrated very low species richness, diversity or abundance across the survey area (Fugro, 2018b).

Whilst a fragment of eroded or broken *Sabellaria alveolata* tubes was found in one grab sample, inspection of SSS data and ground-truthing with visual camera systems indicated that there are no areas of *Sabellaria alveolata* that could be classified as 'reef' within the development footprint (Fugro, 2018a and b).

3.3.1 Southwark Platform Survey Area

The seabed habitat in the Southwark survey area was characterised by mobile sands with shell fragments. No visible epifauna was recorded from these sediments, with sand eels and flatfish infrequently recorded. Transects SWK_TR04 and SWK_TR05 were selected to investigate an area of differing reflectivity. The seabed at these locations was found to be consistent with the rest of the Southwark survey area, comprising mobile sands with shell fragments and no visible epifauna. Grab samples from the Southwark survey area produced fine sands and frequently included sand eels (Ammodytidae).

3.3.2 Southwark to PL370 Export Pipeline Survey Corridor

The seabed habitat in the Southwark to Thames East survey area was characterised by mobile sands. No visible epifauna was recorded from transects SWKETO_TR01a and SWKETO_TR02, with a starfish (*Asterias rubens*) and a hermit crab (Paguroidea) recorded at SWKETO_TR03. Transect SWKETO_TR02 was selected to investigate an area of differing reflectivity. The seabed at this location was found to be consistent with the rest of the Southwark to Thames East survey area, comprising mobile sands with shell fragments and no visible epifauna. Grab samples from the Elland to Southwark survey area produced sand with shell fragments, with one fragment of broken and eroded S. spinulosa tubes at SWKETO_TR02.

3.3. Physical Environment

3.3.3 Hydrography

<u>Water Masses and Currents</u>

Inputs of North Atlantic water strongly influence the hydrography of the North Sea, with minor inflows from the English Channel and the Baltic Sea (DTI, 2002). The generalised pattern of water movement in the North Sea is anti-clockwise, with North Atlantic water moving south, balanced by a northerly outflow along the Norwegian coast. The Southern North Sea water moves in a broadly north easterly direction as part of this general circulation (DTI, 2002). The major water movements within the Southern North Sea are illustrated in Figure 3.4, and the characteristics of the main water masses are shown in Table 3.1.

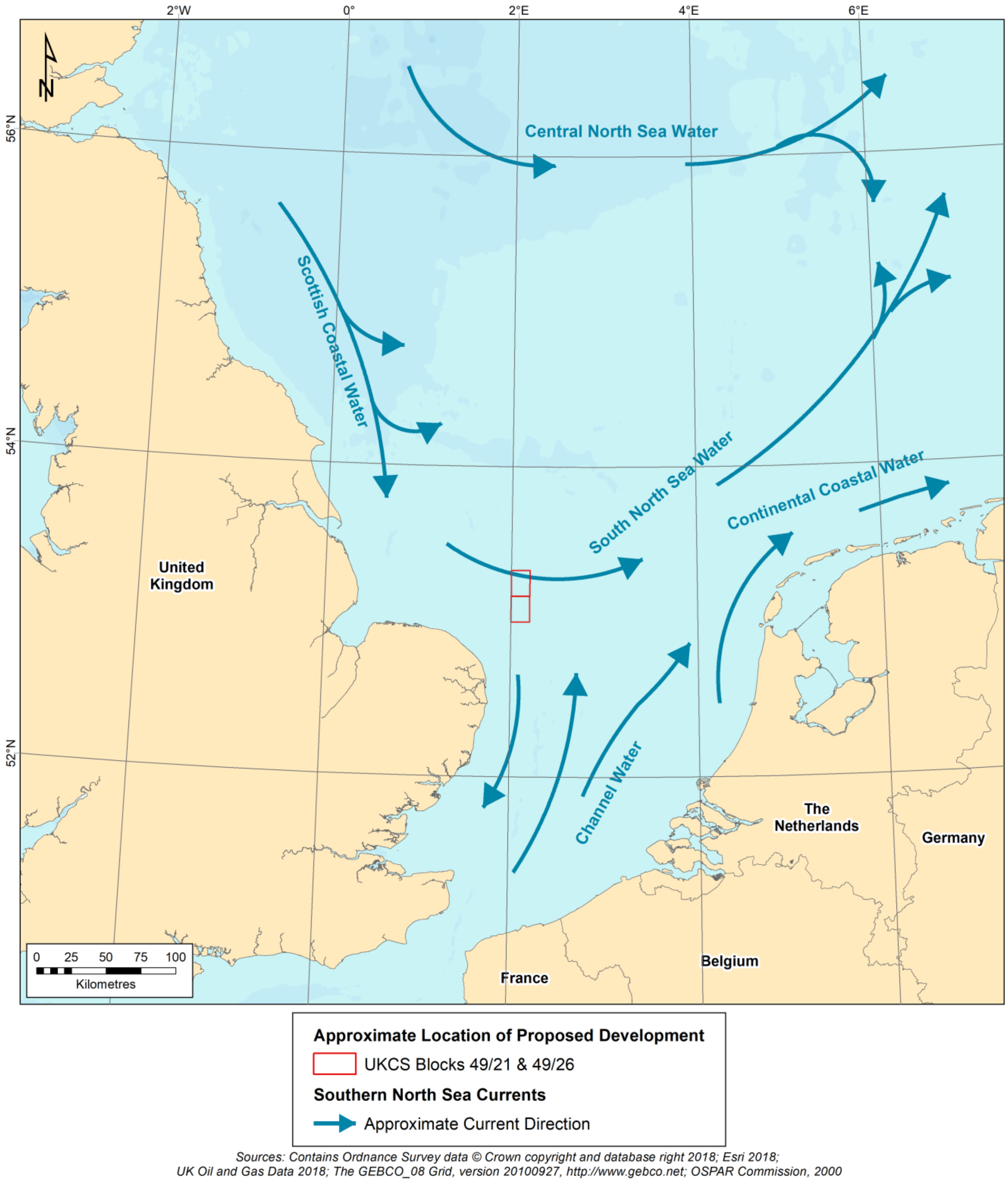


Figure 3.4: Ocean currents in the Southern North Sea (OSPAR, 2000)

Table 3.1: Typical Temperature and Salinities of Water Masses in the North Sea (OSPAR Commission, 2000)

Water Mass	Temperature [°C]	Salinity [‰]
Scottish coastal water	5 to 15	33 to 34.5
Southern North Sea water	4 to 14	34 to 34.75
Channel water	6 to 18	>35
Continental coastal water	0 to 20	31 to 34

Considerable seasonal and annual variability of water inflow to the North Sea may be influenced by short to medium term weather conditions (OSPAR Commission, 2010; DTI, 2002). This can be responsible for large-scale differences in the salinity of the North Sea from year to year, as well as having implications for the circulation of nutrients and contaminants and for the supply of oceanic planktonic species and fish larvae (DTI, 2002).

Unlike the northern and central regions of the North Sea, the shallow parts of the Southern North Sea do not show stratification in the summer months. Instead, the water column in the Southern North Sea remains well mixed throughout the year due to strong tidal action (OSPAR Commission, 2000; DTI, 2001). Frontal areas mark the boundary between different water masses, including mixed and stratified areas, and are numerous in the Southern North Sea. Thermal fronts marking the transition zones between mixed and stratified water occur from the area off Flamborough Head to the Frisian Islands, off the Dutch, German and Danish coast (DTI, 2002).

Tidal waters in the proposed development area flood to the south and ebb to the north (BGS, 1995). Tidal stream data charted from the tidal diamond in location 53°19.0'N 1°25.4'E, located west of the Southwark field, show maximum surface current speeds of 0.88 ms^{-1} during spring tides and 0.46 ms^{-1} during neap tides. The overall residual current is 0.049 ms^{-1}, flowing northeast (Hydrographer of the Navy, 2008).

Tidal range tends to increase from north to south throughout the study area, with water building up along the coast owing to the rotation of the earth. The mean spring tidal range at the Southwark field is approximately 4.5 m to 5.0 m (BGS, 1995). Low atmospheric pressure may raise the water level in this region, with dramatic effects, especially when associated with northerly winds. Tidal ranges may be up to 30 % greater during gales (BGS, 1995).

Waves

Wave climate is influenced by wind speed, wind duration and fetch (the distance over which the wind blows uninterrupted over the sea), which are in turn dependent on season and location. From October to March the North Sea south of 55°N, which includes the Southwark field, experiences significant wave heights of 4 m for <15% of the time (DTI, 2002).

Around the proposed development area, significant wave height, exceeded for 10% of the year, ranges from 2.0 m to 2.5 m (BGS, 1995). Fifty year maximum wave heights in the North Sea are estimated to range from around 32 m in the north to 12 m in the Channel (DTI, 2002).

3.3.4 Meteorology

Wind

Wind direction and velocity in the proposed development area are variable throughout the year, although the most prevalent winds tend to be from the south and south-west (DTI, 2002). Seasonal wind roses indicate that westerly winds are the most common, particularly from July to September, with winds from the west and southwest dominating. The windiest months recorded in the proposed development area are December and January when winds of 14 ms^{-1} to 16.5 ms^{-1} (Beaufort force 7) blow for more than 6 to 10 days a month. May through to August tend to be the least windy months with only 1 to 3 days reaching wind speeds of 14 ms^{-1} to 16.5 ms^{-1} (BGS, 1995 and HSE, 2001).

During the summer, there are occasional thundery squalls with wind speeds greater than 14 ms^{-1}, generally occurring near the coastline. Squalls associated with cold fronts can occur during any season, and showers of hail, sleet or snow that are common in winter and spring often give rise to sudden changes in wind speed and direction.

Precipitation

Mean annual rainfall is relatively low over much of the Southern North Sea when compared to the Atlantic seaboard and Norwegian coastal waters. Rainfall in the development area is estimated to be between 200 mm and 400 mm per annum (OSPAR Commission, 2000).

3.3.5 Seabed Characteristics

Bathymetry and Seabed Features

Water depths in the Southern North Sea are relatively shallow compared with the central and northern areas. The proposed development area is situated in the shallow, coastal waters of the Southern North Sea at water depths ranging from approximately 20 m to 30 m (OGA, 2019a). A series of sand banks are present to the east where water depths decrease to less than 20 m.

Regional seabed sampling suggests that the seabed encountered around the area of interest will consist of sand, coarse sand and gravels (DTI, 2002). The hydrodynamic regime in this area of the Southern North Sea has generated large expanses of sandbanks, some of which are slightly covered by seawater at all times resulting in a complex seabed topography. Two large areas of sandbanks of note are the Norfolk Banks and Sand Hills. The Sand Hills are a group of parallel ridges, some of which are covered in sand waves so may in part be 'active' (BGS, 2001). The Norfolk Banks sandbanks are the most extensive example of the offshore linear ridge sandbank type in UK waters and rest on a relatively flat seabed at 20 m to 30 m depth (JNCC, 2017a). The largest of the Norfolk Banks Sandbanks is over 50 km long, 1.7 km wide and rises 38 m above the seafloor, although some banks are known to be even higher at over 42 m. The banks closest to shore tend to have sand waves on their flanks and are more active than the offshore banks, possibly due to the greater tidal current velocities closer to the coast (BGS, 2001).

Geology and Seabed Sediments

East of the Norfolk coast, the underlying offshore geology is composed of an upper cretaceous fine-grained limestone, which overlays a lower cretaceous layer of mainly sandstones and mudstones (BGS, 1995).

The area surrounding the proposed development is one of complex seabed sediment distribution with Holocene sediments generally forming a veneer less than 1 m thick (BGS, 1995). The seabed sediments in the development area consist of sand, gravelly sand, and sandy gravel (BGS, 1995; Jones *et al.*, 2004).

3.4. Biological Environment

3.4.1 Plankton

Plankton consists of microscopic plants (phytoplankton) and animals (zooplankton) including the larval stages of fish and many bottom living animals which drift with the ocean currents. The abundance of plankton is strongly influenced by factors such as water depth, tidal mixing and temperature stratification which determine the vertical stability of the water column; whilst the distribution of species is affected by salinity, temperature, water flow and the presence of local benthic communities (Edwards & John, 1995).

During spring, an increase in day length and temperature results in the rapid growth of the phytoplankton population. Phytoplankton assemblages in the proposed development area are expected to be characterised mostly by the dinoflagellate genera *Ceratium* and the diatoms *Thalassiosira* and *Chaetoceros* (*Hyalochaete*, and *Phaeoceros)* (DECC, 2009; Johns & Reid, 2001). Although the size and timing of this bloom varies from year to year, in the relatively warm well mixed waters of the Southern North Sea it generally peaks in April. This phytoplankton bloom is closely followed by an increase in the zooplankton population as they feed on this increased food source.

Zooplankton abundance is typically at its highest between May and September, providing an important source of food for a range of fish species (Johns & Reid, 2001). Zooplankton communities in the Southern North Sea are dominated by copepod crustaceans such as *Calanus* and the larvae of echinoderms (Johns & Reid, 2001; DECC, 2009). Secondary phytoplankton and zooplankton blooms occur in autumn, although these are less pronounced (DTI, 2001).

3.4.2 Benthos

Benthos is the term used for animals and plants associated with the seabed, although plants are generally limited by their light requirement to depths of less than 50 m. Benthos consists mainly of animals that burrow into the sediment or form tubes in it (known as infauna). Other species which live on the seabed, or attached to rocks or to other biota, are known as epifauna. In general, the main influences on benthic communities are water depth and sediment type.

Locations to the north, east and south of the Southwark field area were sampled as part of the 1986 North Sea Benthos Survey (ICES, 2019). The results of this survey show the polychaetes *Ophelia borealis* and *Scoloplos armiger* to be abundant in the sample stations to the north and east of the development area (ICES, 2019). In the sample station to the south of the development area, the amphipod crustacean *Bathyporeis elegans*, bivalve mollusc *Fabulina fabula* and the sea urchin *Echinocardium cordatum* were abundant (ICES, 2019).

Following the North Sea Benthos Survey in 1986, the benthic infauna in the Southern North Sea were categorised by Künitzer *et al* (1992) who recorded that fine sand sediments in a depth range of 30 m to 70 m in the region tended to be characterised by species of polychaetes such as *Ophelia borealis* and *Nephtys longosetosa*. The same study identified that the seabed was found to consist of coarser sediment at depths of <30 m and was typically dominated by the polychaete *Nephtys caeca*, the burrowing sea urchin *Echinocardium cordatum* and the amphipod crustacean *Urothoe poseidonis*.

Epibenthic trawl studies in the area have shown that the starfish *Astropecten irregularis*, brittle star *Ophiura ophiura*, hermit crab *Pagurus bernhardus* and crab *Liocarcinus holsatus* are typical of the larger and more widely dispersed animals to be found in the Southern North Sea (Callaway *et al.*, 2002; Jennings *et al.*, 1999). The common seastar *Asterias rubens* is found throughout the North Sea, but the largest numbers have been found in the Southern North Sea (Dyer *et al.*, 1983). Additionally, the sea urchin *Psammechinus miliaris* is very common throughout the area in water less than 100 m (Cranmer, 1985; Jennings *et al.*, 1999). A habitat investigation survey undertaken by Fugro in 2008 observed that the benthic fauna within the development area was typical of mixed sediment habitats in the Southern North Sea. Identified fauna from the survey included dead man's fingers (*Alcyonium digitatum*), hydroids, bryozoans (*Flustra foliacea*), anenomes and sponges (Fugro, 2008). Examples of mobile epifauna identified within the survey area included seastars (*Asterias rubens*), crabs, flatfish and a seamouse polychaete (*Aphrodite aculeata*) (Fugro, 2008).

The reef building worm, *Sabellaria spinulosa*, has also been found to be characteristic of coarse to medium sandy sediments in the Southern North Sea (Rees *et al.*, 2007). This species can form large biogenic reefs of conservation interest. Favourable conditions for *Sabellaria* include areas of silty sand sediment with a high abundance of coarse material (e.g. cobbles/shells) for attachment. *Sabellaria* are often found on areas of raised topography where suspended sand supply may be high for feeding and tube formation (i.e. the edges of sandbanks and where there are sand waves) (Foster-Smith & White, 2001; Holt *et al.*, 1998). The sandy sediments and high energy currents of the Southern North Sea provide suitable conditions for the formation of extensive biogenic reefs, created by *Sabellaria*.

Reefs can persist for many years and consequently have an important physical influence on the environment. They provide a diverse 3-dimensional biogenic habitat (i.e. crevices, surfaces, hard substrata and sediments) for attachment, colonisation and establishment of many associated species in areas where they would not otherwise be found (Foster-Smith & Hendrick, 2003). For these reasons, biogenic reefs have a very rich associated flora and fauna, which is often much richer and more diverse than in surrounding areas, and may play an important role in the functioning of the wider local ecosystem.

Other sensitive benthic features in the Southern North Sea include other biogenic reefs created by aggregations of the horse mussel (*Modiolus modiolus*) and the common mussel (*Mytilus edulis*) and the shallow subtidal sandbanks. Together with the *Sabellaria* reefs, these features are designated as Annex I habitats under the EC Habitats Directive.

IOG has completed an environmental baseline survey (EBS) and habitat assessment of the area in and around the Southwark field to confirm the species and habitats present at the exact project location. The survey used video transects and grab sampling to outline the characteristic taxa at the Southwark platform. The results found that characterising species of the epibenthic community included echinoderms such as starfish *Asterias rubens* and brittlestars *Ophiura abida* and *Ophiura ophiura.* Sessile colonial epiphauna comprised of bryozoans *Flustra foliacea*, soft coral *Alcyconium digitatum* and sea anemones *Urticina genus*. Additionally, mobile species included hermit crabs of the Paguridae family. Isolated patches of the *S.spinulosa* tubes were identified, however, the areas identified were not considered extensive enough to be of importance.

The analysis of grab samples indicated that the macrobenthic community has moderate diversity. Amphipods *bathyporeia elegans* and *Urothoe elegans*, polychaetes *Ophelia borealis*, *Nephtys cirrosa* and *Aonides paucibranchiata* were the most abundant species found. The sea urchin *Echinocardium cordatum* was moderately abundant. With the bivalves *Fabulina fabula* and *Abra alba restricted to selected stations due to its preference for more compact sediment.* Furthermore*, S.spinulosa* abundance was also restricted to stations that displayed a degree of sediment heterogeneity.

The species recorded are typical of the subtidal sandbanks that are known to be present within the Norfolk offshore area. The results were consistent with the findings of previous environmental surveys conducted.

3.4.3 Fish and Shellfish

Distribution of Adults

The proposed development area will, at times, contain fish stocks of both commercial and non-commercial importance. Adult fish populations are highly dynamic and it is difficult to define fixed patterns of their presence and distribution. However, fisheries landings data suggest that adult populations of ray species, brill, plaice, sole, tub gurnards, and turbot are commercially caught in this area of the Southern North Sea (MMO, 2018). Shellfish populations are also present within the general area and include whelks, edible crabs, and lobsters (MMO, 2018). Fishing landings are discussed separately in Section 3.6.1.

Spawning and Nursery Grounds

Extensive survey programmes have been used to predict the broad distribution of spawning grounds for a range of commercially important fish and shellfish species in UK waters (Coull *et al.*, 1998). For many of these species, this has been supplemented by more recent data collation and review by CEFAS (Ellis *et al.*, 2012) and Marine Scotland (Aires *et al.*, 2014), the latter with specific reference to the distribution of juvenile individuals.

The Southwark field lies within or close to predicted spawning grounds for a range of species; cod, herring, lemon sole, mackerel, plaice, sand eels, sole, whiting, sprat and *Nephrops* (Coull *et al.*, 1998; Ellis *et al.*, 2012). The majority of species show peak spawning activity between January and June, although several spawn over a longer period (Table 3.2).

Table 3.2: Fish Spawning and Nursery Grounds in the Vicinity of the Southwark Field (Coull *et al.*, 1998; CEFAS, 2001; DTI, 2002; Ellis *et al.*, 2012)

	Fish Spawning and Nursery Grounds											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Cod	S/N	**S/N**	**S/N**	S/N	N	N	N	N	N	N	N	N
	Cod occur throughout the northern and central areas of the North Sea. Cod spawn all over the North Sea, although there are several areas where spawning is concentrated, particularly in the Northern North Sea, the central North Sea around the Dogger Bank and in the Southern North Sea and German Bight.											
Herring	N	N	N	N	N	N	N	S/N	S/N	S/N	N	N
	Herring are found throughout the shelf waters and spawn in relatively shallow, well oxygenated, water in areas of coarse sediment. Sub-populations of North Sea herring spawn at different times of year in localised areas. In the Central and Southern North Sea off the northeast English coast, spawning takes place from August to October.											
Lemon sole	N	N	N	S/N	S/N	S/N	S/N	S/N	S/N	N	N	N
	Although the centre of distribution of lemon sole is in the coastal waters of northern Scotland and the Orkney and Shetland Islands, they are also found off the northeast coast of England and throughout the Central and Southern North Sea. Little is known about the spawning habits of lemon sole.											
Mackerel	N	N	N	N	**S/N**	**S/N**	**S/N**	S/N	N	N	N	N
	Two main stocks of mackerel occur in the northeast Atlantic, the western stock and the North Sea stock. The North Sea stock has been at a very low level for years due to high fishing pressure and poor recruitment. North Sea mackerel overwinter in the deepwater to the east and north of the Shetland Islands. In spring, they migrate south to spawn in the North Sea between May and August.											
Plaice	**S/N**	**S/N**	S/N	N	N	N	N	N	N	N	N	S/N
	Plaice are a coastal species and can be found at highest abundance in the Southern part of the North Sea. Plaice spawn throughout the shallower parts of the Southern North Sea. Peak spawning occurs in early January in the eastern part of the English Channel and February in the southern Bight, German Bight and off Flamborough Head.											
Sand eel	S/N	S/N	N	N	N	N	N	N	N	N	S/N	S/N
	Sandeels are a shoaling species which lie buried in the sand at night and hunt during the day. Spawning occurs throughout the southern and Central North Sea, but especially near sandy sediments off the coast of northeast England. Spawning usually takes place between November and February.											
Sole	N	N	S/N	**S/N**	S/N	N	N	N	N	N	N	N
	Sole is a southern species that is close to the northern limits of its distribution in the North Sea. They spawn during April and May in shallow inshore areas and close to sandbanks. Nursery grounds are situated in shallow waters along the English and continental European coasts at depths of between 5 m and 10 m.											
Whiting	N	S/N	S/N	S/N	S/N	S/N	N	N	N	N	N	N
	Although it is one of the most abundant species in the North Sea, information on whiting spawning is limited. Spawning areas are located in the Central and Southern North Sea and off the coast of Scotland, although other areas may be important. Juveniles can be found throughout the North Sea, particularly off the northeast coast of England.											
Sprat	N	N	N	N	**S/N**	**S/N**	S/N	S/N	N	N	N	N
	Sprat are most abundant in the relatively shallow waters of the Southern North Sea. Important spawning areas in the North Sea include the English east coast and German Blight.											
Nephrops	S/N	S/N	S/N	S/N	S/N	S/N	S/N	S/N	S/N	S/N	S/N	S/N
	Nephrops are mud-burrowing animals and are limited in their distribution by the extent of suitable sediments which range from quite sandy mud to very soft mud. They do not migrate and spend their life in the area in which they settle as larvae. After hatching, the larval stage lasts 6 to 8 weeks, before settlement to the seabed											

S	Spawning ground (Peak spawning shown in **bold**)	N	Nursery area	S/N	Spawning and Nursery

Most fish species release large numbers of eggs directly into the water column. Their spawning grounds cover extensive areas, leaving them less vulnerable to disturbance from point sources. However, certain species relevant to this area are more restricted in their spawning preferences, e.g. herring, sand eel and *Nephrops*. The dependency of these species on specific substrates and spawning grounds makes them particularly susceptible to impacts resulting from oil and gas exploration and production.

Herring spawning takes place in relatively shallow water, at depths of approximately 15 m to 40 m. Shoals congregate on persistent spawning grounds where all members of the shoal spawn simultaneously. Herring are demersal spawners, depositing their sticky eggs on coarse sand, gravel and shells, resulting in an ‘egg carpet’ of between four and nine layers thick (DTI, 2002). In this part of the Southern North Sea, spawning takes place between August and October (Ellis *et al.*, 2012). Each female will produce a single batch of eggs every year, with the eggs taking between one and three weeks to hatch. As part of any environmental survey undertaken in support of the Southwark field, investigations will be conducted to determine the suitability of the area as a herring spawning ground.

Sand eels deposit their eggs on the sandy sediments with which they remain in close association. This dependence on sandy sediments means that the distribution of juvenile and adult sand eels is restricted by the patchy distribution of their preferred habitat. Sand eels spawn between November and February (Ellis *et al.*, 2012).

Nephrop spawning takes place from September to May and the fertilized eggs are carried by the female for about nine months while they develop (CEFAS, 2001). Hatching begins in late April and continues until August. After a relatively short pelagic phase juvenile *Nephrops* settle on the bottom and construct a burrow.

The Southwark field lies in a year-round nursery area for cod, herring, lemon sole, mackerel, plaice, sand eel, sole, whiting, sprat and *Nephrops* (Figure 3.5). Apart from sand eels and *Nephrops*, these areas form part of large continuous swathes of habitat over which nursery grounds are found. As stated above, Marine Scotland have recently published a report which provides modelled spatial representations of the predicted distribution of 0 age group fish (fish in the first year of their life) aggregations. These modelled representations are not provided in Figure 3.5. Although not all North Sea species were included in the study, a review of the associated report indicates that there is a low to moderate probability of the development area being utilised as a nursery area by whiting, herring, sprat, plaice (Aires *et al.*, 2014).

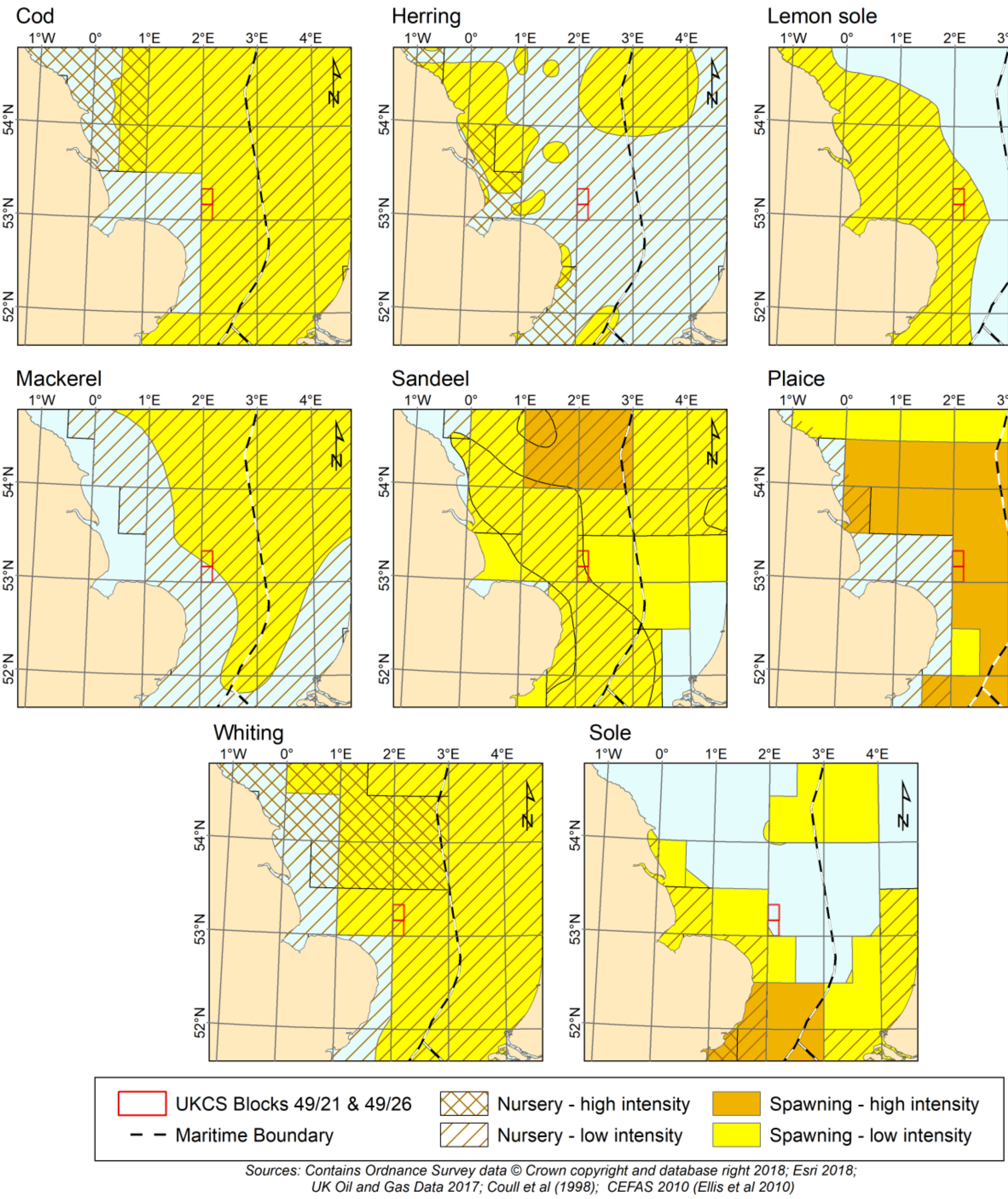


Figure 3.5: Commercially important fish spawning and nursery grounds

3.4.4 Marine Mammals

Whales, Dolphins and Porpoises

The Southwark field is located in the shallow waters of the Southern North Sea near the Norfolk coast. The number and diversity of cetaceans (whales, dolphins and porpoises) decreases progressively southwards through the North Sea and the Southern North Sea supports relatively few species (Sea Watch Foundation, 2019). The four most commonly observed species in this area are the minke whale, white beaked dolphin, Atlantic white sided dolphin and harbour porpoise (Reid *et al.*, 2003).

Minke whales occur frequently throughout the northern and central North Sea, but are found in smaller numbers in the Southern North Sea (Reid *et al.*, 2003). Those individuals observed in the proposed development area are at the southern limit of their range (Reid *et al*, 2003). Minke whale are generally present in the Southern North Sea between July and October (Evans, 1995). Minke whale are usually seen singly or in pairs, although they can aggregate in groups of 10 to 15 individuals when feeding (Reid *et al.*, 2003). Minke whales occur both on the continental shelf and in offshore waters, where they feed on a variety of schooling fish and crustaceans. Favoured feeding locations tend to include areas of upwelling and strong currents, where prey resources are increased and feeding effort is reduced (Reid *et al.*, 2003).

White beaked dolphins are present in the North Sea all year round, although sightings tend to peak between June and October (Hammond *et al.*, 2002; Northridge *et al.*, 1995; Reid *et al.*, 2003). White beaked dolphins are largely found in waters less than 100 m in depth. Individuals are regularly recorded in the Southern North Sea, particularly towards the coast of Norfolk, although those individuals observed in the study are thought to be at the southern limit of their range, preferring the northern sector of the central North Sea (Reid *et al.*, 2003). White-beaked dolphins are generally observed in small groups of less than ten individuals and feed on a range of prey species including herring, cod, haddock, whiting and hake (Northridge *et al.*, 1995; Reid *et al.*, 2003).

Atlantic white sided dolphins have been recorded in the area, although in low numbers (BODC, 1998). This species is generally concentrated to the north and north-west of Britain, but they do seem to enter the North Sea in summer (Reid *et al*, 2003). Atlantic white sided dolphin is a deep-water species, generally recorded more than 10 km from the coast (Sea Watch Foundation, 2019). However, this species has been sighted northeast of Flamborough Head between July and September, and near Dogger Bank between July and November (Sea Watch Foundation, 2019).

The harbour porpoise is the most abundant cetacean in the North Sea, with the highest densities recorded in water depths less than 100 m. In the Southern North Sea, the harbour porpoise is widely distributed in relatively small numbers. The harbour porpoise occurs throughout the year, although are sighted most frequently in the Southern North Sea during the summer months, between July and October, with a peak in September (Evans, 1995; BODC, 1998; Sea Watch Foundation, 2019). Typically, harbour porpoise occur in small groups of one to three animals. Their diet comprises a wide variety of small fish, e.g. pollock, whiting, cod, sand eels, herring and sole, dependent on the time of year and location. Sandbanks typically provide habitats for sandeels, other fish and invertebrate communities, and support rich feeding grounds for seabird and marine mammals. As such, harbour porpoises are commonly found in association with areas of shallow sandbanks, which form important nurseries and feeding grounds for a number of commonly occurring prey species such as sand eels.

Seals

Two species of seal, the common and grey seal, are resident in the North Sea, although densities of seals at sea vary over the year in relation to different stages in their life cycle.

The common seal is one of the most widely distributed seal species within the east Atlantic, and the UK is home to approximately 30% of the European population of common seals (SCOS, 2017). Common seal haul out, breeding and moulting sites are typically situated in sheltered estuaries and on sandbanks but they also utilise rocky areas. Common seals are concentrated in The Wash, which provides ideal breeding and haul out conditions, forming the largest single colony in the UK (Duck, 1995; JNCC, 2016). Additional haul out sites are located at Donna Nook on the Humber, and Blakeney Point and Scroby Sands in Norfolk (Duck, 1995). Common seals spend a high proportion of time ashore during the pupping and moulting seasons from approximately June to September (Hammond *et al.*, 2001). Recent satellite telemetry studies have found the foraging behaviour of the common seal to be very variable. Although, it is estimated that common seals spend only 3% of their time at distances greater than 50 km from the coast (Jones *et al*., 2015).

Grey seals are less numerous in the area than common seals. Approximately 38% of the global grey seal population is found in the UK; however, many of these are concentrated at sites around the Hebrides and Orkney, far removed from the area of interest (SCOS, 2017). Grey seals utilise outlying islands and remote coastlines as moulting, pupping and general haul-out sites. There are few sites of significance for grey seals along the east coast of the UK adjacent to the proposed development area. However, there is a significant breeding and haul out site at Donna Nook at the mouth of the Humber estuary, to the northwest of the Southwark field (Duck, 1995). Although grey seals have been seen to forage up to several hundred kilometres from haul out sites, it is estimated that they only spent 12% of their time at distances greater than 50 km from the coast (Jones *et al*., 2015). Grey seal densities at sea are lowest during the moulting (February to March) and pupping seasons (October to late November) (Hammond *et al.*, 2001). Given the shallow water and proximity to significant seal colonies in the Wash and Humber estuary, both grey and common seals may be encountered around the proposed development area.

3.4.5 Seabirds

Abundance and Distribution

Seabirds found in offshore areas around the UK include members of several families, most notably the petrels and shearwaters, gannets, gulls, skuas and auks. These birds breed on the coasts of the UK, but frequently feed far offshore. In winter, they become less attached to their nesting sites and travel considerable distances in search of food. Seabirds are present throughout the year in the Southern North Sea, with mostly low to moderate densities found in the proposed development area. However, some species, e.g. guillemot, occur in high densities in the proposed development area at certain times of the year. Offshore surveys suggest that the area is of particular importance for a variety of seabirds during the autumn and winter periods, with overall densities decreasing offshore during summer.

During the breeding season, generally between March and June, large numbers of seabirds congregate in coastal breeding colonies. Most seabird species prefer isolated sea cliffs as a breeding habitat. Such habitats are relatively infrequent along the coastline adjacent to the proposed development area. However, Flamborough Head to the northwest of the Southwark field supports a large Kittiwake breeding colony (Tasker, 1995). The area to the southwest of the field also supports some internationally important coastal seabird colonies for little, common and sandwich terns, with nearshore waters in the Wash, Humber estuary and adjacent coastlines heavily utilised by tern species (Tasker, 1995; Defra, 2018).

Seabirds tend to exhibit a more inshore distribution during the breeding season as they are constrained by the location of their colonies. However, juvenile seabirds are not restricted in their distribution during this period and may be more widely dispersed offshore (DTI, 2002). Once breeding is complete, seabirds disperse into areas further offshore, although the extent to which they disperse varies between species.

Seabird abundance tends to decrease with increasing distance from shore, and their distribution becomes increasing patchy in relation to many oceanographic features. The availability and distribution of prey, however, is considered to be the most important factor driving seabird distribution and abundance, particularly around colonies during the breeding season. The various seabird families also differ in the total amount of time they spend at sea, the distances they travel and how they behave when at sea, both during and outside the breeding season.

Overall, the most abundant bird species recorded in the proposed development area are fulmar, gannet, kittiwake, guillemot and puffin. Lower densities of a number of other species also occur at certain times of the year (BODC, 1998; Wakefield *et al*., 2017). Some seabirds are present in the area all year round (Table 3.3).

Table 3.3: Density of Seabirds in the vicinity of the Southwark field (BODC, 1998; Wakefield *et al.*, 2017)

<table>
<tr><th rowspan="2"></th><th colspan="12">Seabird Presence</th></tr>
<tr><th>J</th><th>F</th><th>M</th><th>A</th><th>M</th><th>J</th><th>J</th><th>A</th><th>S</th><th>O</th><th>N</th><th>D</th></tr>
<tr><td rowspan="2">Red-throated diver</td><td></td><td>L</td><td></td><td></td><td>L</td><td></td><td></td><td></td><td></td><td></td><td></td><td>L</td></tr>
<tr><td colspan="12">This diver is entirely coastal in its distribution, preferring shallow inshore waters with sandy bays. Outside the breeding season, it is numerous along the east coast of England and Scotland.</td></tr>
<tr><td rowspan="2">Black-throated diver</td><td></td><td></td><td></td><td></td><td></td><td>M</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="12">Black-throated divers are coastal in distribution, preferring shallow inshore waters with sandy bays. Outside the breeding season, it is numerous along the east coast of England and Scotland.</td></tr>
<tr><td rowspan="2">Fulmar</td><td></td><td>L</td><td>L</td><td>L</td><td>M</td><td></td><td></td><td>M</td><td>L</td><td>L</td><td></td><td>L</td></tr>
<tr><td colspan="12">Wintering densities are relatively low throughout the North Sea, due to the widespread dispersion of birds. Numbers increase in the central and Southern North Sea during the breeding season, leading to a peak in September.</td></tr>
<tr><td rowspan="2">Manx shearwater</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>L</td><td>L</td><td></td><td></td><td></td></tr>
<tr><td colspan="12">Manx shearwaters are also recorded less frequently than fulmars in the North Sea. They breed in small numbers in Orkney and Shetland, and are present in low numbers in the Northern North Sea between May and October.</td></tr>
<tr><td rowspan="2">Gannet</td><td>L</td><td>L</td><td>L</td><td></td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>M</td><td></td><td>L</td></tr>
<tr><td colspan="12">The Southern North Sea holds relatively high gannet densities during the winter months, when dispersion from breeding sites is highest. During pre-breeding and breeding seasons, gannets are concentrated inshore around breeding colonies.</td></tr>
<tr><td rowspan="2">Red breasted merganser</td><td></td><td></td><td>L</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>L</td><td></td></tr>
<tr><td colspan="12">This diving duck starts to flock on the coast from July, reaching a peak in December. Although a coastal species, the red-breasted merganser is occasionally recorded offshore in the Southern North Sea.</td></tr>
<tr><td rowspan="2">Pomarine skua</td><td></td><td></td><td></td><td></td><td>L</td><td></td><td></td><td>L</td><td>L</td><td></td><td></td><td></td></tr>
<tr><td colspan="12">The Pomarine skua is recorded offshore throughout the North Sea. This skua is an occasional passage migrant, passing through in both spring to breeding in the high Arctic and again in autumn to winter off the coast of west Africa.</td></tr>
<tr><td rowspan="2">Arctic skua</td><td></td><td></td><td></td><td></td><td>M</td><td></td><td></td><td>L</td><td>L</td><td></td><td></td><td></td></tr>
<tr><td colspan="12">Approximately 3,200 pairs of arctic skuas breed around the North Sea, mainly in Orkney and Shetland. They are recorded offshore throughout the North Sea April to December, dispersing widely in the Atlantic following breeding.</td></tr>
<tr><td rowspan="2">Great skua</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>L</td><td>L</td><td></td><td></td><td></td></tr>
<tr><td colspan="12">The great skua is recorded offshore throughout the North Sea. Pairs of great skuas breed around the North Sea, although mainly in Orkney and Shetland, where distribution is centred during the breeding season.</td></tr>
<tr><td rowspan="2">Little gull</td><td></td><td>L</td><td></td><td></td><td></td><td></td><td></td><td>M</td><td></td><td>H</td><td></td><td>M</td></tr>
<tr><td colspan="12">Little gulls are distributed throughout the North Sea at all times of year, however, they are concentrated mainly in inshore and southern areas during spring and autumn.</td></tr>
<tr><td rowspan="2">Black-headed gull</td><td></td><td></td><td>L</td><td></td><td></td><td></td><td></td><td>L</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="12">Black-headed gulls have been recorded in the North Sea at all times of year. Despite large coastal breeding populations, very few of these gulls are observed offshore.</td></tr>
<tr><td rowspan="2">Common gull</td><td></td><td>L</td><td>M</td><td></td><td>L</td><td></td><td></td><td></td><td>L</td><td></td><td></td><td>L</td></tr>
<tr><td colspan="12">Common gulls are distributed throughout the North Sea at all times of year. However, there distribution is predominantly southern and inshore. Their numbers peak in the North Sea in winter.</td></tr>
<tr><td rowspan="2">Lesser black-backed gull</td><td></td><td></td><td>L</td><td></td><td>L</td><td>L</td><td></td><td>H</td><td>L</td><td></td><td></td><td>L</td></tr>
<tr><td colspan="12">Although lesser black-backed gulls are distributed throughout the North Sea at all times of year, they are principally summer visitors, travelling through to breeding colonies around the North Sea.</td></tr>
<tr><td rowspan="2">Herring gull</td><td></td><td></td><td>L</td><td></td><td></td><td></td><td></td><td>L</td><td>L</td><td></td><td></td><td>L</td></tr>
<tr><td colspan="12">Herring gulls breed on nearly all North Sea coasts, with the exception of the Wash. Densities in offshore Southern North Sea are highest from November to March, and very low from April to October. These gulls are relatively sedentary.</td></tr>
<tr><td rowspan="2">Great black-backed gull</td><td>L</td><td>L</td><td></td><td></td><td></td><td></td><td></td><td>L</td><td>M</td><td>L</td><td></td><td>L</td></tr>
<tr><td colspan="12">The great black-backed gull breeds on northern coasts. Although distributed throughout the North Sea, numbers are highest off the north-eastern coast of England. The highest densities are recorded at sea between September and April.</td></tr>
</table>

	Seabird Presence											
	J	F	M	A	M	J	J	A	S	O	N	D
Kittiwake		H	M	L	M	L		M	M	M	L	L
	Kittiwakes are widely dispersed in the North Sea during winter. Densities increase inshore around breeding colonies in spring and summer. However, large numbers are still present offshore at this time, due to movement of juvenile birds.											
Sandwich tern					L							
	A summer visitor, Sandwich terns migrate through the offshore North Sea in the same way as Arctic terns. This species breeds around the Southern and Eastern North Sea.											
Common tern								L				
	Common terns are mainly found along the coasts of the Southern North Sea. During the summer months their distribution is mainly coastal. Very few Common terns overwinter in the UK.											
Arctic tern								L				
	Arctic terns are summer visitors to the North Sea, normally recorded between April and October. They migrate northwards through the offshore North Sea in April and May, with return passage from July to September.											
Guillemot	L	M	L	L	H			M	L	VH		H
	Between March and June, most guillemots are found close to their colonies. The birds move offshore in July, concentrating in the central Northern North Sea. The birds move gradually south, becoming more widespread by winter.											
Razorbill	L	M	M		L				L	M		M
	Razorbills follow a broadly similar seasonal distribution pattern to guillemots, although their concentrations are generally more northerly. Razorbills from more southern colonies are relatively sedentary.											
Puffin		L		L	L			L	L			L
	Information on the life history of puffins is limited. Departure from colonies commences in July with movement south and east from the northerly colonies. Winter puffin distribution in the North Sea is widespread with low densities.											

	No birds	L	Low	M	Moderate	H	High	VH	Very high

Waders and Wildfowl

Estuarine areas, including the Humber, the Wash, and the north Norfolk Marshes, are particularly important for breeding waders, with a higher species diversity than elsewhere in the UK. In addition to coastal breeding species, internationally important numbers of migrant and wintering waterfowl use this coastline. The Humber Estuary, the Wash and the north Norfolk coast are of major international importance for their waterfowl populations (Stroud & Craddock, 1995). The shelduck is the most abundant duck in the region, while the knot and the dunlin are the most abundant wader species. This region also lies on the major migratory flyway of the east Atlantic, as many birds move between wintering areas on the African and Mediterranean coasts to Arctic breeding grounds (Stroud & Craddock, 1995).

3.5. Conservation Areas

3.5.1 Nearshore and Coastal Conservation Features

The nearshore and coastal habitats and species present along the coasts adjacent to the proposed development area are of notable conservation interest and are protected by a range of statutory and voluntary initiatives. Figure 3.6 identifies designated nearshore and coastal nature conservation sites.

At an international level, there are several Special Protection Areas (SPA) designated along the coast due to the major seabird colonies or breeding and overwintering habitats for waders and wildfowl present.

The closest SPAs to the development area are the Wash SPA and the Greater Wash SPA, located 42.6 km to the southwest. These SPA's are designated to protect important areas of sea used by rare waterfowl, specifically common scoter, red-throated diver and little gull, during the non-breeding period, and for foraging by tern species in the breeding season (JNCC, 2004; JNCC, 2018a; Defra, 2019). Many of the sites of ornithological importance are conferred further protection as Important Bird Areas or Ramsar sites (RSIS, 2019).

The Minsmere Walberswick SPA is located 62.4 km to the southwest of the proposed Southwark field, which is designated for supporting breeding and overwintering birds. The Outer Thames Estuary SPA, located 63.7 km to the south of the proposed Southwark field, is designated for the largest aggregation of wintering red-throated diver (*Gavia stellata*) in the UK, wintering birds and foraging areas during the breeding season (JNCC, 2019b). The North Norfolk Coast SPA is designated for supporting breeding and overwintering birds (JNCC, 2005).

There are also numerous Special Areas of Conservation (SAC) in the wider vicinity of the proposed Southwark field which are designated to protect important inshore and coastal habitats, such as reefs and sandbanks along with significant common seal populations. The closest of these coastal SAC's include Haisborough, Hammond and Winterton SAC, located approximately 42.1 km to the south-west of the proposed Southwark field (Figure 3.7). This SAC is designated for the presence of sandbanks which are slightly covered by seawater all the time and reef habitat (JNCC, 2018c). This boundary of this SAC also extends beyond 12nm. The Wash and North Norfolk Coast SAC which is located 42.6 km from the Southwark field and is designated for sandbanks which are slightly covered by sea water all the time, mud and sand flats, large shallow inlets and bays, reefs, associated flora, coastal lagoons, common seal and otter. This area provides extensive breeding and haul-out sites for common seal (JNCC, 2016).

Many of the internationally protected sites also encompass smaller nationally designated protected areas such as Sites of Special Scientific Interest (SSSI), National Nature Reserves (NNR) and voluntary sites managed by organisations such as the Royal Society for the Protection of Birds (RSPB).

Under the Marine and Coastal Access Act (MCAA) 2009, powers have been provided to the UK government to designate new marine protected areas, known as Marine Conservation Zones (MCZ) in England and Wales, to create an ecologically coherent network of conservation sites. Ninety-one MCZs have been designated in English waters as part of protecting the range of marine wildlife and habitats found in UK waters. The nearest MCZ with coastal components is the Cromer Shoal Chalk Beds MCZ, located approximately 55.2 km to the south of the proposed Southwark field location along the Norfolk coast. This site is designated for its chalk reef habitats and the diversity of invertebrate and vertebrate species they support (Wildlife Trusts, 2019; Defra, JNCC, and Natural England, 2019).

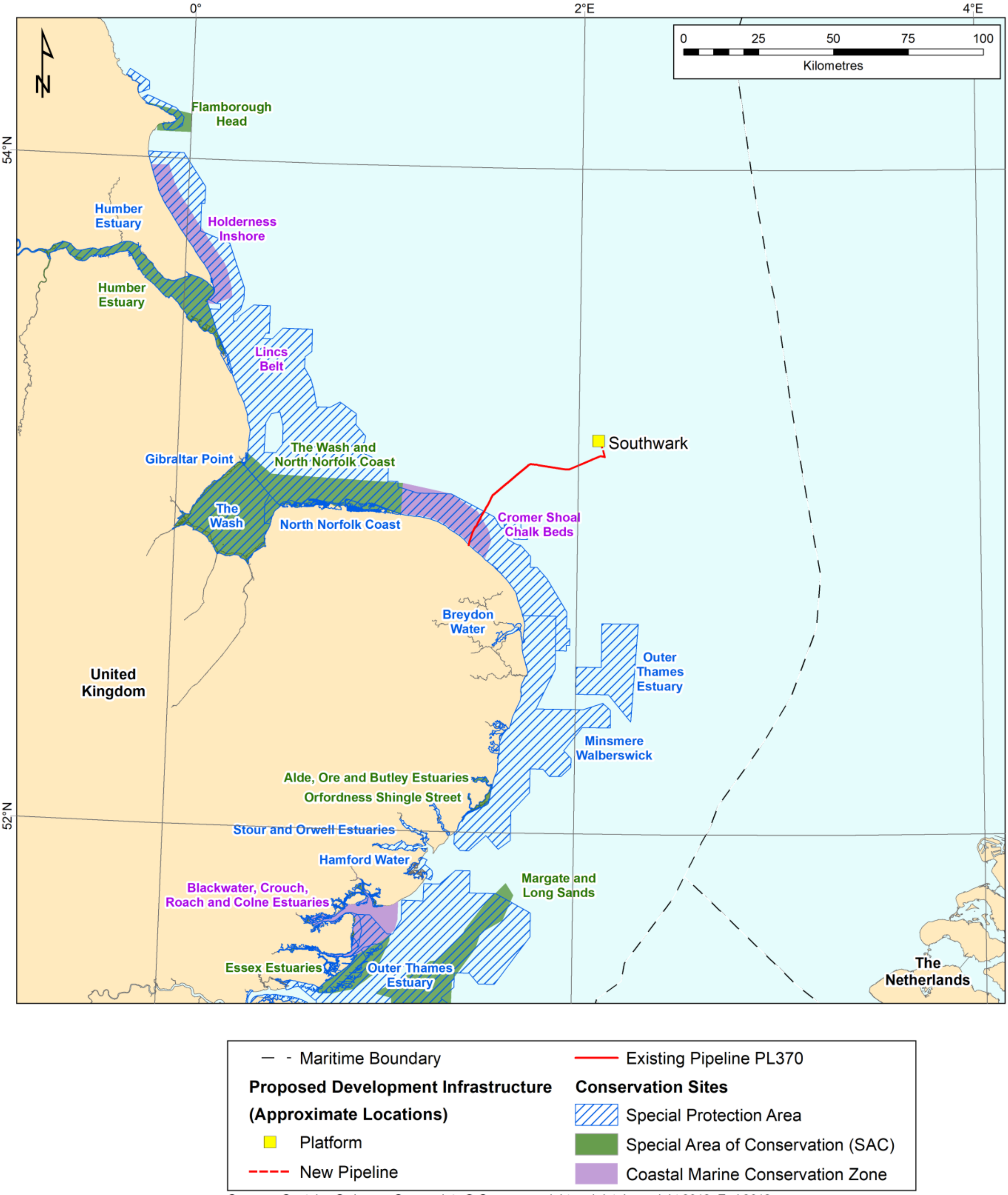


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Figure 3.6: Conservation areas with coastal components

3.5.2 Offshore Conservation Features

Offshore SACs are designated to protect fully marine habitats situated beyond the 12 nm limit of UK territorial waters. Figure 3.7 identifies the locations of offshore designated sites in relation to the proposed developments.

The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended) apply the requirements of the European Habitats Directive and Wild Birds Directive to oil and gas activities on the entire United Kingdom Continental Shelf, including within the 12 nm territorial limit. Annex I of the Habitats Directive lists three habitat types that are most likely to occur in offshore waters and be eligible for designation as offshore Special Areas of Conservation (SAC):

- Submarine structures made by leaking gases (pockmarks);
- Reefs (bedrock, stony or biogenic);
- Sandbanks that are slightly covered by water all the time.

As a result, the proposed development area is located within and surrounded by a range of offshore protected areas designated at European level for these important habitats. The Southwark field is situated within the North Norfolk Sandbanks and Saturn Reef SAC. The North Norfolk Sandbanks are the most extensive example of the offshore linear ridge sandbank type in UK waters (Graham *et al.*, 2001). They support communities of invertebrates which are typical of sandy sediments in the Southern North Sea such as polychaete worms, isopods, crabs and starfish (JNCC, 2017a). The Saturn *Sabellaria spinulosa* biogenic reef is formed from the tubes of thousands of individual *Sabellaria* worms which have consolidated together to form a solid reef like structure raised above the seabed. The reef supports a range of polychaete worms and molluscs as well as epifaunal species such as small crabs and squat lobsters which are not normally present in areas of sandy sediments (JNCC, 2017a). The conservation objectives for the North Norfolk Sandbanks and Saturn Reef SAC is:

"For the features to be in favourable condition thus ensuring site integrity in the long term and contribution to Favourable Conservation Status of Annex I Sandbanks which are slightly covered by sea water all of the time and Annex I Reefs. This contribution would be achieved by maintaining or restoring, subject to natural change:

- The extent and distribution of the qualifying habitats in the site;
- The structure and function of the qualifying habitats in the site; and
- The supporting processes on which the qualifying habitats rely." (JNCC, 2017b).

Furthermore, the Inner Dowsing, Race Bank and North Ridge SAC is located approximately 70.3 km to the west of the Southwark field, and encompasses a wide range of sandbank types and *Sabellaria* biogenic reefs supporting a variety of bryozoans, hydroids, sponges and anemones (JNCC, 2018b). The Haisborough, Hammond and Winterton SAC, 42.1 km to the south of the Southwark field, is also designated to protect a series of long-standing shallow sandbanks supporting a range of invertebrate species in sheltered areas, along with some *Sabellaria* reefs (JNCC, 2018c).

In addition to these protected areas, the JNCC has identified areas where Annex I habitats may be present. Of the three habitat types most likely to occur in UK offshore waters (reefs, sandbanks and pockmarks), sandbanks and reefs are most common in the Southern North Sea. There are no identified potential pockmark areas in the vicinity of the proposed development area. An examination of existing JNCC GIS data shows the nearest known qualifying Annex I *Sabellaria* reef lies approximately 33.8 km north-northwest from the Southwark Platform.

The proposed development lies within a known area of sandbanks which are slightly covered by seawater all the time (Figure 3.7). The Habitat Assessment commissioned by IOG confirm that the majority of the survey area is consistent with this habitat type. The Assessment classified the habitat present throughout the survey area as European Nature Information System (EUNIS) habitat type 'Sublittoral sand' (A5.2). Most of the survey area was identified as a broad scale Habitat of Priority Importance (HPI) for subtidal sands and gravels. However, this habitat is widely distributed across the North Sea.

As well as seabed features, the Habitats Directive also lists qualifying marine species (Annex II species) for which SACs should be developed. The Annex II species present in UK offshore waters are grey and common seals as well as the harbour porpoise and bottlenose dolphin. JNCC and national conservation agencies are continuously investigating the potential for designating additional sites in waters away from the coast for these species. In February 2019 the

Southern North Sea SAC was formally designated for the protection of harbour porpoise and is considered to be one of the best areas in the United Kingdom for this species (JNCC, 2019c). The Southwark field is located within the Southern North Sea SAC. The conservation objectives for the Southern North Sea SAC are to "ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining Favourable Conservation Status (FCS) for Harbour Porpoise in UK waters", this will be achieved by ensuring that "harbour porpoise is a viable component of the site; there is no significant disturbance of the species; and the condition of supporting habitats and processes, and the availability of prey is maintained" (JNCC, 2019c).

As discussed above the Inner Dowsing, Race Bank and North Ridge SAC was recommended for a series of sandbanks interspersed with cobbles, sand and gravel with *Sabellaria* reefs. A range of attached invertebrate species are found on these habitats, creating year-round harbour porpoise, grey seal and common seal feeding areas (Wildlife Trusts, 2019).

Of the MCZs designated in English waters that are either partly or entirely located offshore, none are found within the vicinity of the Southwark field (JNCC, 2019a).

The Southwark field is situated within the East Offshore Marine Plan Area, which is currently designated as having 'Good Environmental Status' in accordance with the Marine Strategy Framework Directive, with its relevant habitats and species considered to have a 'favourable conservation status', as required under the Habitats and Wild Birds Directives (DEFRA, 2014). The Southwark field development has been assessed against relevant objectives and policies set out under the East Offshore Marine Plan (Section 1), in order that both the environmental and conservation status of the area is maintained and not degraded by development.

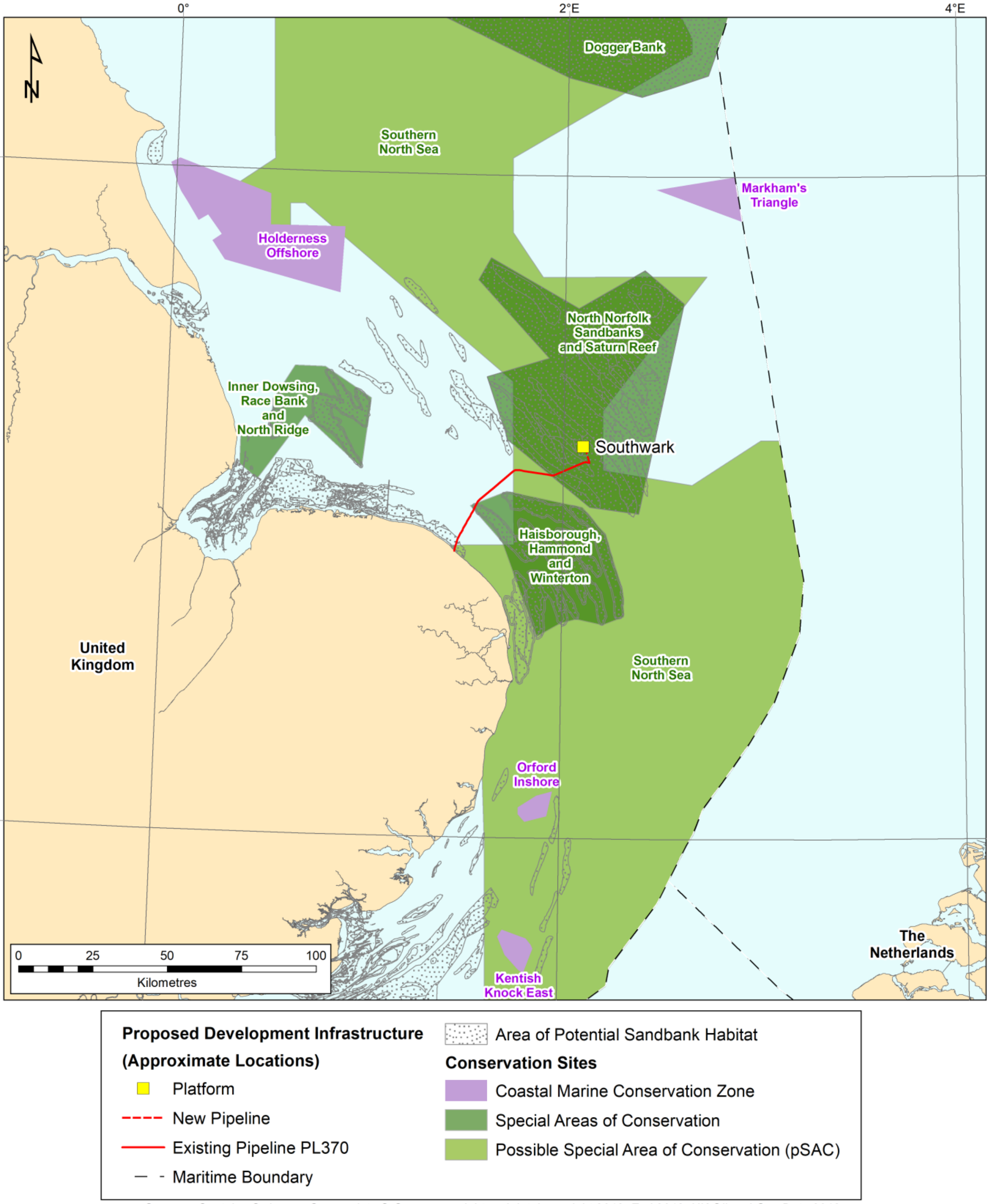

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Figure 3.7: Offshore conservation areas

3.6. Other Users of the Sea

3.6.1 Commercial Fisheries

The North Sea as a whole is a major international fishing ground. Major UK and international fishing fleets operate in the Southern North Sea, targeting a range of species, although fisheries landings are higher overall further north in the North Sea and around the Orkney and Shetland Islands (MMO, 2018, Scottish Government, 2019). For fisheries statistics purposes, the northeast Atlantic is divided into rectangles by the International Council for the Exploration of the Sea (ICES). The Southwark field lies within ICES rectangle 35F2.

Table 3.4 indicates that between 2013 and 2017, the majority of landings from ICES rectangle 35F2 were demersal fish species with some shellfish species landed also. Demersal landings largely comprise plaice, turbot and sole. Plaice make up the largest proportion of the demersal fish recorded with 256 tonnes landed between 2013 and 2017 (MMO, 2018).

Table 3.4: Landings (Tonnes) for ICES rectangle 35F2 between 2013 and 2017 (MMO, 2018)

Year	Demersal	Pelagic	Shellfish	Total
2013	141.8	-	2.3	**144.1**
2014	115.6	0.0002	3.8	**119.4**
2015	78.3	-	0.04	**78.3**
2016	80.3	-	0.03	**80.3**
2017	60.2	0.01	0.08	**60.3**
Total	**476.2**	**0.0**	**6.2**	**482.4**

Figure 3.8 below shows the seasonal distribution of catches in ICES Rectangle 35F2. Landings from ICES rectangles are made throughout the year with notable increases in landings through late spring into the autumn before a decline in the winter months to early Spring (MMO, 2018).

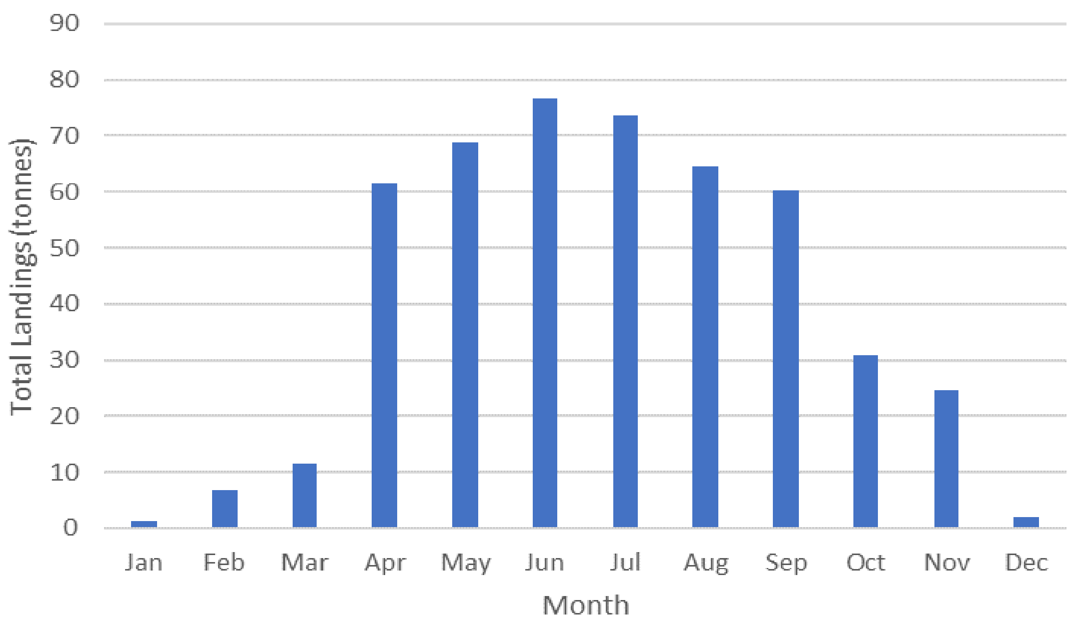


Figure 3.8: Monthly distributions of catches in ICES rectangles 35F2 (2013-2017)

<u>Shellfish Fisheries</u>

Shellfish fisheries can be broadly divided into offshore and onshore components. Static gears such as creels and pots are used in inshore areas to catch crabs and lobsters while the offshore component targets *Nephrops* and scallops using trawls. Waters off the coast of Humberside to the west and Norfolk to the south of the proposed development area make up some of the most important shellfish areas in the UK (MMO,2018). The proposed development area lies outside this area, with landings for shellfish being of little commercial importance from ICES Rectangle 35F2 in comparison to landings from closer to the Humber and Norfolk coast. Of the shellfish that are caught within the vicinity of the proposed development area, crabs are the main species. The quantity of shellfish landed from this particular area has decreased by 93% between 2013 and 2017. increased by 20% between 2012 and 2016, with the value of whelks increasing by 45%, in the same time period. This is indicative of the low fishing effort of this particular fishery in the proposed development area. The value of the shellfish fishery within ICES Rectangle 35F2 in 2017 was £417, this essentially represents 0% of the total value of UK shellfish landings.

Demersal Fisheries

Demersal fisheries target species which live on or near the seabed and generally feed on bottom-living organisms and other fish. Although these fisheries may be directed towards a particular species or species group, demersal fish are often caught together and comprise a mixed fishery. One of the most important fisheries in North Sea is the mixed demersal fishery that targets cod, haddock and whiting. However, a combination of poor stock recruitment and over-exploitation has led to a significant decline in the mixed demersal fishery in this area. Landings data suggest that shellfish landings are generally higher in the wider vicinity of ICES Rectangle 35F2 than demersal species, although within 35F2 itself, demersal species are by far the most abundant species caught by quantity and value (MMO, 2018). Plaice have been the most landed demersal species within ICES Rectangle 35F2 between 2013 and 2017, followed by smaller amounts of sole (MMO, 2018). In 2017 the demersal catch value from within ICES Rectangle 35F2 was £235,571, which represents approximately 0.06% of the total UK demersal catch value (MMO, 2018). The majority of demersal fish species are caught using beam trawlers, these are used to target flatfish during the summer months (Walmsley & Pawson, 2007).

Pelagic Fisheries

Pelagic fisheries target species which live in the water column. Pelagic fisheries in the North Sea are generally more active in deeper waters, predominantly targeting herring and mackerel. This is reflected in the available landings data which show very low levels of pelagic species. Herring forms the basis of the fishery in the southern North Sea in general, mainly caught by trawlers. Few, if any pelagic species are landed from ICES Rectangle 35F2. In 2017 the pelagic fishery within these rectangles had little to no commercial value (MMO, 2018).

3.6.2 Shipping and Other Vessel Traffic

The Southern North Sea region supports more intense shipping activity in general compared to the Central and Northern North Sea, with some major ports such as Rotterdam located in the region. A high number of cargo vessels and ferries pass through this area along with offshore vessels supporting the numerous gas developments present (DTI, 2001). Block 49/21 (Southwark field) has been classed as having high shipping density (OGA, 2016).

A Vessel Traffic Study (VTS) was previously conducted for the wider Vulcan Satellites Hub Development based on vessel tracks derived from AIS data between 26 February 2017 and 25 February 2018 (Xodus, 2018). These AIS tracks were clipped to a 10 nm radius study area around the Southwark platform location exclusively for the purposes of this ES Addendum.

During this period an average of 10.92 vessels per day passed through the 1077.53 km^2 study area. The majority of this traffic passed through two narrow shipping lanes, one approximately 5 km to the northeast, and one approximately 14 km to the southwest (Figure 3.9). Both shipping lanes are well outside the 500 m platform safety zone.

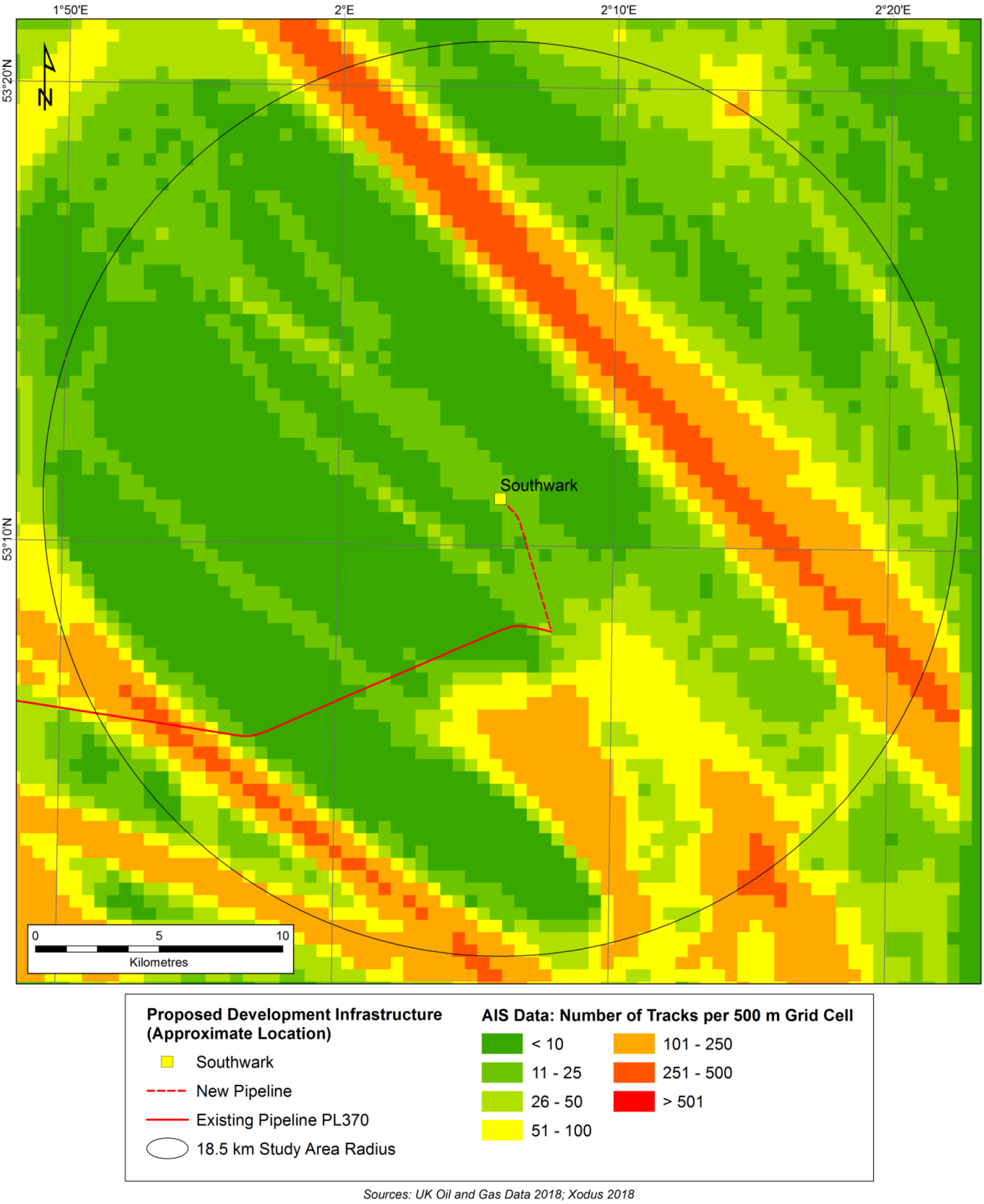


Figure 3.9: Annual vessel tracks per 500 m grid cell

A breakdown of the vessel types transiting the study area is provided in Table 3.5. 87.2% of the total vessel transits through the study area are conducted by oil and gas vessels and cargo or tanker vessels.

Table 3.5: Breakdown of vessel types transiting within 18.52 km (10 nm) of the Southwark platform location.

Vessel type	Percentage
Oil & Gas	44.3%
Cargo/Tankers	42.9%
Fishing	5.8%
Other/Unspecified	2.5%
Dredging	2.3%
Renewables	1.4%
Passenger	0.6%
Military	0.1%
Recreation	0.1%
Total	**100.0%**

A breakdown of the vessel size classes transiting the study area is provided in Table 3.6. The most common size class of vessels transiting within 10 nm of the Southwark field is between 1,000 DWT and 5,000 DWT.

Table 3.6: Breakdown of vessel size classes transiting within 18.52 km (10 nm) of the Southwark platform location.

Vessel size class	Percentage
Small/Unknown	4.8%
< 1,000 DWT	12.3%
1,000 - 5,000 DWT	47.9%
> 5,000 DWT	35.0%
Total	**100.0%**

3.6.3 Oil and Gas Infrastructure

The Southwark field is situated within an area of intensive pre-existing offshore gas developments and as such is surrounded by a range of surface and subsurface infrastructure (Figure 3.10). The Shell operated Leman G platform is located 7.4 km to the south of the Southwark platform, which exports its hydrocarbons west-southwest to the Leman F platform, before ultimately being exported via the Leman to Bacton pipeline (OGA, 2019a). The ConocoPhillips operated Vulcan 1 platform is located 8.6 km to the northwest of Southwark platform, and exports its hydrocarbons north to the North Valiant 1 platform, before ultimately being exported to Bacton via the Shell Clipper-to-Bacton pipeline (OGA, 2019a).

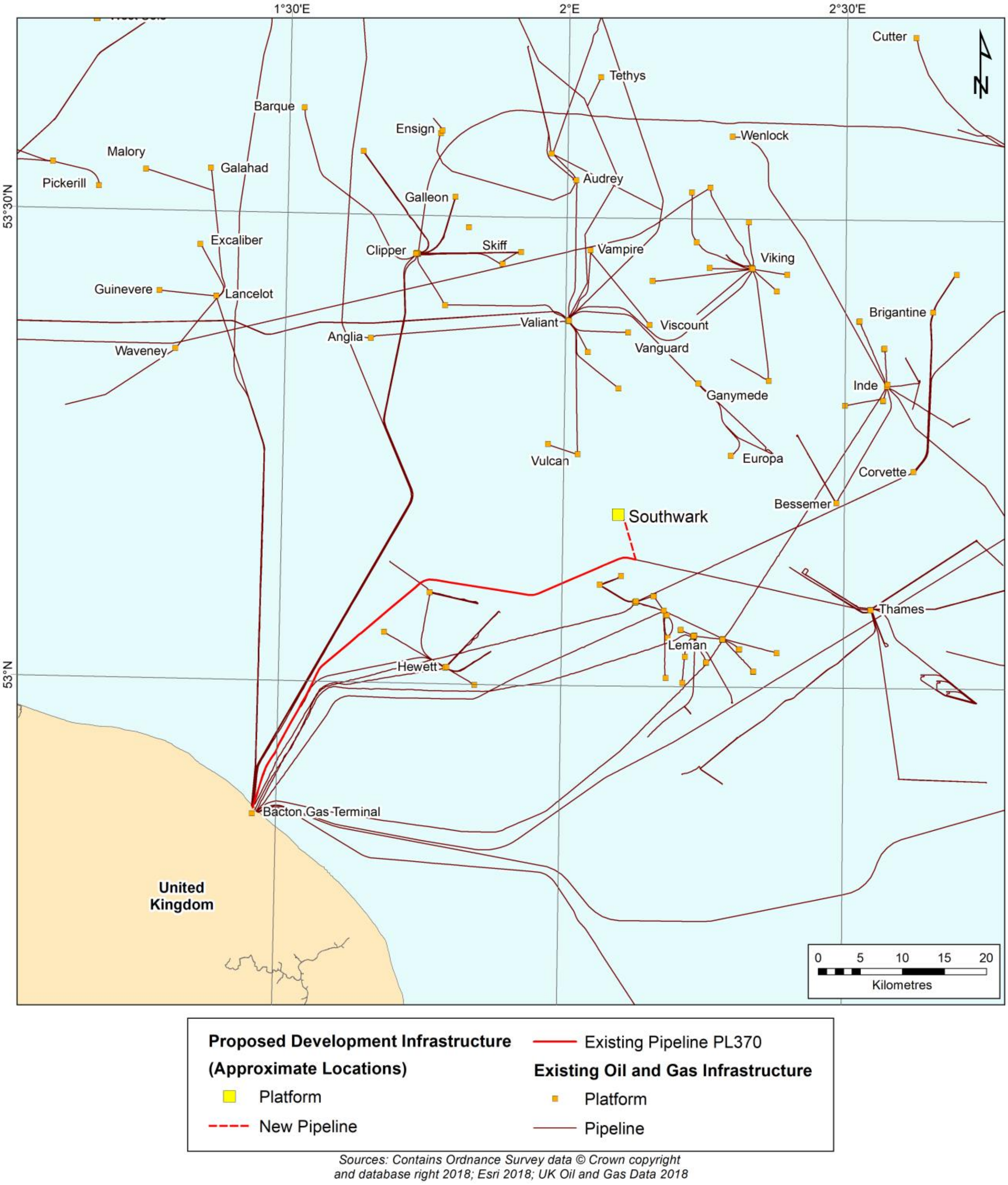


Figure 3.10: Oil and gas infrastructure in the vicinity of the Southwark Field

3.6.4 Offshore Wind, Aggregates and Submarine Cables

This area of the Southern North Sea provides good conditions for offshore wind farm development and has been subject to a range of licensing rounds for offshore wind. There are many wind farms development sites at various stages of planning or operation immediately around the proposed development area (Figure 3.11).

The Southwark field is located approximately 44.2 km to the east of the operational Dudgeon Wind Farm Development (Crown Estate, 2019), 37.4 km east of the early planning phase of the Dudgeon Extension, and 30.8 km to the northwest of the Norfolk Vanguard West Wind Farm, which is in the pre-construction phase of development.

Several marine aggregate production areas are also present to the north of the proposed development area. Approximately 30.8 km to the north of the Southwark field, there is a licensed site for aggregate extraction (Area 484) which is operated by DEME Building Materials (Crown Estate, 2019). There are other aggregate extraction areas which lie further to the north, west and south of the Southwark field.

There are no active cables running through the proposed development area (Crown Estate, 2019; KIS-ORCA, 2019).

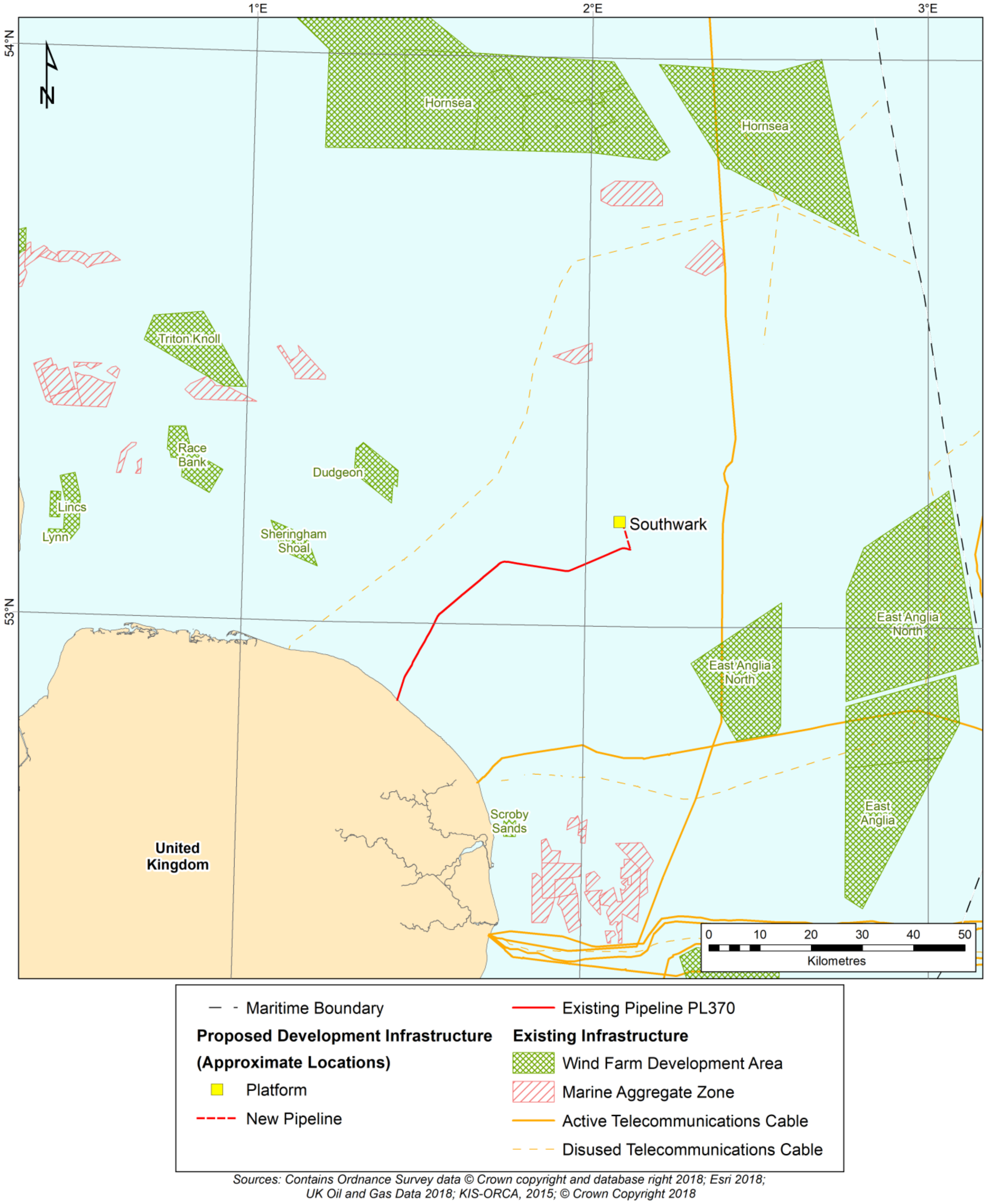


Figure 3.11: Distribution of offshore wind developments, aggregate zones and cables around the Southwark Field

3.6.5 Mariculture

There are few active mariculture sites situated along the Humber and Norfolk coasts adjacent to the Southwark field as the coastline generally does not provide appropriate conditions for cultivation. However, there are a few sites in the Humber and more extensively the Wash which culture shellfish, mostly mussels and some pacific oysters (DTI, 2002; UKMMAS, 2010).

3.6.6 Wrecks and Archaeological Sites

There are no protected wrecks designated around the proposed development area (Historic England, 2019). There may be additional uncharted wrecks located within the area. A study by Wessex Archaeology in support of the development of the Dudgeon offshore wind farm identified several potential wreck sites at the eastern edge of the windfarm lease area however none of the wrecks so identified were Designated (Wessex Archaeology, 2009). Furthermore, submerged remains of ancient human settlements have been uncovered from around the Leman Bank to the east of the proposed Southwark field (Fleming, 2002).

3.6.7 Ministry of Defence

The Southwark field is out-with any Ministry of Defence (MoD) training ranges, according to the licensing restrictions released as part of information provided for the 32nd Licensing Round (OGA, 2019b).

3.7. Summary of Key Offshore Sensitivities

Table 3.7 provides a summary of the key environmental sensitivities identified throughout this chapter for the proposed development.

Table 3.7: Seasonal Variation of Key Environmental Sensitivities

	Environmental sensitivity											
	J	F	M	A	M	J	J	A	S	O	N	D
Plankton												
	Phytoplankton productivity in the Southern North Sea is highest in the spring and autumn with a major peak starting in March and a lesser peak in August. Zooplankton productivity follows a similar pattern, but the blooms follow approximately one month later.											
Benthos												
	Life cycles of organisms within the seabed communities are not well understood. Based on the characteristic species, a spawning period for those with a planktotrophic life phase and larger macrofaunal species is thought to be between July and October, with possible winter recruitment sensitivity in November or December.											
Fish and shellfish												
	The proposed development area lies within or close to known spawning grounds for lemon sole, sole, sand eels, plaice, cod, mackerel and whiting. The proposed development area is located in a year-round nursery area for whiting, lemon sole, sand eel, mackerel, cod, plaice and tope shark.											
Marine mammals												
	Four species of cetacean are recorded as occurring regularly in the Southern North Sea, including minke whales, Atlantic white-sided dolphin, white-beaked dolphin and harbour porpoise. Common and grey seals may also be found in the proposed development area.											
Seabirds												
	Seabird vulnerability is high to very high following the breeding season. Vulnerability remains high throughout the winter months, due to the large number of wintering and migratory birds. As the birds congregate in their colonies, vulnerability decreases slightly during the breeding season, falling to low to moderate. Seabird species undergoing a full moult at sea are rendered flightless, leaving them highly susceptible to surface pollution.											
Offshore conservation												
	The proposed development lies within the North Norfolk Sandbanks and Saturn Reef SAC, designated for its linear ridge sandbanks and *Sabellaria spinulosa* biogenic reef, and Southern North Sea SAC designated for harbour porpoise. The offshore conservation areas are designated to conserve the associated biological communities or species of specific conservation value. Therefore, the vulnerability of this SAC is thought to be very high throughout the year.											
Coastal conservation												
	Most of the coastal conservation areas are designated for the presence of birds, thus vulnerability is highest during the breeding season. Those designated for other reasons (e.g. vegetation) may also be more vulnerable in the summer months for the same reasons. However, vulnerability reduces throughout the winter months, when birds move offshore.											
Other users of the sea												
	Other users are likely to concentrate any activities within the better months of weather in the year (fisheries, offshore development or construction) but in general, fishing, oil and gas operation, shipping and aggregate extraction are the main marine activities all year round.											

L	Low	M	Moderate	H	High	VH	Very high	EH	Extremely high

As part of the 32nd Licensing Round, DEFRA, JNCC, CEFAS and MS have also identified seasonal concerns for certain Blocks, regarding particularly environmentally sensitive periods during each year for drilling operations (Table 3.8; OGA, 2019b). Seasonal concerns for Block 49/21c are set out in Table 3.8 below.

Table 3.8: Southwark Block Seasonal Drilling Concerns (OGA, 2019b)

Block (Drilling Location)	Herring Spawning Periods of Concern	Seabird Periods of Concern
49/21c (Southwark)	None	Jan*, Feb, Mar, Apr*, Nov*, Dec
* Interpolated by JNCC		

4. IDENTIFICATION OF CONCERNS AND POTENTIAL IMPACTS

4.1 Introduction

This section describes the scoping methods used to identify the environmental aspects and concerns of the proposals which could have potentially significant environmental effects that should be scoped into the Environmental Impact Assessment (EIA). The following scoping methods were used:

- An Environmental Issues Identification (ENVID) workshop by members of the project team;
- An informal consultation meeting was held with the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) on 5 October 2017;
- An Early Consultation Document (ECD) which outlined the project and main environmental receptors to be assessed was circulated to a range of statutory and non-statutory consultees and comments invited.

The purpose of these scoping activities was to identify the main environmental concerns at an early stage of the project, so that they could be addressed and mitigated during the EIA process.

4.2 ENVID Workshop

The first scoping activity undertaken for this project was an Environmental Issues Identification (ENVID) workshop, which was attended by key members of the IOG Southwark Field Development project team.

4.2.1 ENVID Methodology

The proposed operations can be divided into office-based activities, geophysical and environmental surveys, offshore exploration and appraisal drilling and offshore production activities. Each of these operations can be further divided into sub categories of planned and accidental events, with the individual activities therein further classified as normal, abnormal (non-routine) and emergency events. Prior to the commencement of any field development operations, IOG will prepare an appropriate Environmental Management System (EMS) listing all activities undertaken by IOG (or those undertaken on behalf of IOG) that may interact with the environment. Such activities/environmental interactions are referred to as 'environmental aspects'.

Aspects relevant to the proposed Southwark Field Development were identified and evaluated as part of the ENVID, the results of which are detailed within the appropriate Environmental Aspects and Impacts Register (Appendix B). For each individual activity, aspects which may have an impact on one or more of the following general environmental issues were identified:

- Marine environment
- Land contamination
- Water pollution
- Air pollution
- Climate change
- Resource use
- Other users of the sea

As part of the ENVID, the significance of each environmental aspect was systematically assessed using the significance matrix set out in Table 4.1 and the receptor sensitivity (value) criteria set out in Table 4.2 below.

For all planned operations and accidental events, the potential significance of aspects was scored based on the relation between the Magnitude of the Effect and the Value of the Receptor. To ensure that scoring was consistent, the matrix in Table 4.1 was used to score the Magnitude of Effect against the Value of the Receptor. Table 4.2 was used to define the value of each receptor.

Where the final significance score is less than 10, the potential aspect was deemed to be insignificant, and as such did not require further assessment or control and was 'scoped out' of the EIA. Where the significance score is 10 and above, the aspect was regarded as potentially significant and would require identification of management measures to reduce the significance to acceptable levels and thus remained 'scoped in' the EIA.

The exception to this is climate change (Section 8), as the scoring system described above is not appropriate to quantify the potential effects which are comparatively so small that they are impossible to assess on an individual basis. However, it is acknowledged that they will contribute to the overall cumulative issue of climate change and are therefore of key concern to overall sustainability objectives. Therefore, those environmental aspects identified to contribute to climate change have been automatically scoped in to be discussed further in the detailed impact assessment.

Table 4.1: Environmental Aspect Significance Matrix

Magnitude of Effect		Nature Conservation, Socio-economic or Heritage Value	Negligible 1	Low 2	Medium 3	High 4	Very High 5
Negligible	a. Minor change to the natural environment which is unlikely to be noticed or measurable against background variation. b. An environmental effect not likely to last more than a few days. c. Effects that are only detectable at source. d. No implications to other users of the sea or local communities. e. No risk to reputation of the company or commercial success. f. No discernible change in the existing view or other landscape characteristics. g. Usage of renewable or non-supply-limited resources with no measurable effect on current or future supply.	1	1	2	3	4	5
Minor	a. A detectable change to the natural environment which is within scope of existing variability. b. A transient environmental effect not lasting more than a few weeks. c. Unlikely to contribute to cumulative effects. d. May affect behaviour, but not a nuisance to other users of the sea or general public. e. Transient issues regarding external relationships but with no long term reputational consequences. f. Virtually imperceptible change in landscape receptors causing very minor changes to the view or other landscape characteristics over a wide area or minor changes over a limited area. g. Usage of finite resources with no measurable effect on current supply and not affecting market price.	2	2	4	6	8	10
Moderate	a. Change in habitats and biological communities within the footprint of the development. b. Change in habitats and biological communities leading to short term (< 2 years) damage with a good recovery potential. c. Similar scale of effect to existing variability, but may have cumulative implications. d. May cause measurable nuisance to some other users of the sea or local communities. e. Risk of undermining reputation of the company within industry or with regulators. f. Moderate change in localised areas causing minor changes to the existing view or other landscape characteristics over a wide area or noticeable change over a limited area. g. Usage of finite resources that may affect short-term availability and local market price.	4	4	8	12	16	20
Major	a. Change in habitats and biological communities extending beyond the immediate footprint of the development. b. Change in habitats and biological communities leading to medium term (>2 years) damage, but with a likelihood of recovery within 10 years. c. Cumulative implications are understood to occur in relation to activities of this type. d. Financial loss or safety implications to other users of the sea or local communities. e. Undermining the reputation of the company with serious commercial implications. f. Notable change in landscape characteristics over an extensive area ranging to a very intensive change over a more limited area. g. Reduction in stock resource, affecting national availability and market price.	6	6	12	18	24	30
Severe	a. Widescale change to the offshore environment or effects on coastal receptors. b. Change in the natural environment leading to long term (>10 years) damage and poor potential for recovery to baseline conditions. c. Will make a significant contribution to national or global issues, individually or cumulatively. d. Long-term economic loss or strategic business changes for other users of the sea or local communities e. Damage to company reputation of sufficient gravity to incur irreparable damage to the business. f. Extensive long lasting (>10 years) to permanent change in landscape characteristics over an extensive area. g. Reduction in stock resource, affecting global availability and market price.	10	10	20	30	40	50

Table 4.2: Environmental Receptor Significance Matrix

	Receptor Category	Selected Examples
Very High (5)	Natural Environment (marine, coastal, terrestrial)	1. Internationally designated site or protected species. 2. A regularly occurring, globally threatened species or habitat essential for maintaining such species. 3. Species and habitats essential to conserve biodiversity at an international level.
	Socio-economic Other Users of the sea	4. A major fishing area contributing at a national level. 5. An internationally defined shipping lane. 6. Any areas licensed for use by other industries.
	Landscape	7. Internationally designated or recognised landscape of exceptional quality and distinctive intact character with a large number of features and strong sense of place, and uninterrupted views (visual amenity).
	Resource use	8. Rare, finite and non-reusable resource only scarcely available on the world market
High (4)	Natural Environment (marine, coastal, terrestrial)	1. Nationally designated site or protected species. 2. A nationally threatened species or habitat essential for maintaining such species. 3. Species and habitats of principal importance for the conservation of biodiversity at a national level.
	Other Users	4. An area of regional importance for fisheries or of local importance but with no nearby alternatives. 5. Major shipping activity located in a restricted area. 6. Extensive use by multiple other industries.
	Landscape	7. Nationally designated or recognised landscape of high quality and distinctive character, with a strong sense of place, and susceptible to change which would permanently alter key characteristics and elements of the landscape (National Parks and AONBs). Partial or interrupted views (visual amenity).
	Resource use	8. Finite resource with restricted availability on the world market.
Medium (3)	Natural Environment (marine, coastal, terrestrial)	1. Sites or species protected on a local level, or of acknowledged conservation value. 2. The presence of a locally threatened species or habitat. 3. Species and habitats of importance for the conservation of biodiversity at a local level.
	Other Users	4. Areas used by local fisheries, but with nearby alternatives. 5. Areas of moderate-high commercial shipping intensity 6. Multiple other stakeholder interest or extensive use for a single purpose.
	Landscape	7. Locally designated or recognised landscape with some distinctive character and features in reasonable condition. Capable of tolerating low levels of change without affecting key characteristics and elements (e.g. Local Green Space). Partial or interrupted views (visual amenity).
	Resource use	8. Non-reusable finite resource presently plentiful/abundantly available on world market
Low (2)	Natural Environment (marine, coastal, terrestrial)	1. No sites or species of conservation interest. 2. No resident or regularly occurring threatened species or habitat present. 3. A natural and diverse habitat supporting widespread and common species.
	Other Users	4. Areas of low intensity fishing, not essential for supporting local communities. 5. Areas of low shipping intensity. 6. Areas of low intensity anthropogenic use.
	Landscape	7. Undesignated landscape of defined character type, but of low quality. Capable of tolerating moderate levels of change/improvement/enhancement. Views lack distinctive characteristics and/or are of low quality (visual amenity).
	Resource Use	8. Reusable or recyclable resource, abundantly available on world market.
Negligible (1)	Natural Environment (marine, coastal, terrestrial)	1. No sites or species of conservation interest. 2. Not capable of supporting any threatened species or conservation interest. 3. A poor habitat with low biodiversity and productivity.
	Other Users	4. No commercially exploitable fisheries present. 5. Areas of very low shipping intensity. 6. Areas of no discernible anthropogenic use or socio-economic benefits.
	Landscape	7. Poor quality landscape, not representative of a wider type within the local area and capable of accommodating high levels of change/improvement/enhancement, with few or no views (visual amenity).
	Resource use	8. Renewable or non-supply-limited resource, readily available at point of use
Adapted from Ratcliffe, 1977; Hill et al., 2005; IEEM, 2006; Langhammer et al., 2007; Highways Agency, 2007; IEEM, 2010; Seafish, 2012		

4.2.2 Results of the ENVID Workshop

During the ENVID, the significance of each environmental aspect was systematically assessed using the methodology described in Section 4.2.1 and noted in the ENVID scoring matrix. The ENVID matrices generated for planned operations and accidental events are presented in full in Appendix B. The following environmental aspects associated with the proposed Southwark Field Development were found to have a potentially significant impact:

- Underwater noise from the jack up rig, the platforms, vessels and helicopters, as well as from the proposed piling operations during platform installation and fixing infrastructure to the seabed impacting on marine mammals and fish;
- Disturbance to the seabed due to the installation and removal of spud cans impacting on the seabed environment;
- The physical presence of the rig which may impact on other users of the sea such as fishing vessels and other shipping activity;
- The installation and physical presence of subsea infrastructure such as pipelines and flowlines on the seabed impacting on other users of the sea (fisheries) and the seabed environment;
- The installation and physical presence of protective materials such as concrete mattresses or rock on the seabed impacting on other users of the sea (fisheries) and the seabed environment;
- Deposition of drill cuttings, associated muds and excess cement directly on to the seabed potentially impacting on the seabed environment;
- Use and discharge of chemicals and discharge of produced water during production operations;
- Atmospheric emissions from fuel use;
- Accidental events comprising hydrocarbon spills and the catastrophic loss of vessel/rig.

4.3 Informal Scoping and Consultation

An informal scoping meeting was undertaken between representatives from IOG and OPRED on 5 October 2017. During this meeting IOG apprised OPRED of the proposed Vulcan Satellites Hub Development. IOG subsequently issued an ECD outlining the proposed development and summarising environmental sensitivities of concern that incorporated the advice of OPRED.

This ECD was subsequently circulated to a range of statutory and non-statutory stakeholders who were invited to comment on the proposals. Details of the comments and concerns raised by the consultees are summarised in Table 4.3, with the text in italics reflecting IOG's response.

Consultee responses for the Vulcan Satellites Hub Development have been reviewed with respect to this Southwark Field Development ES Addendum. As the Southwark Field Development is a subset of the Vulcan Satellites Hub Development it is considered that the concerns raised during the initial Vulcan Satellites consultation should capture all relevant concerns for the Southwark Field Development.

Table 4.3: Informal Consultation Comments and Concerns

Consultee	Consultee Comment and IOG Response
ConocoPhillips	ConocoPhillips advised that it is actively decommissioning Southern North Sea (SNS) infrastructure including installations and subsea pipelines in the wider SNS area and, because of the potential for the decommissioning activities to impact on protected sites, BEIS is undertaking a strategic Habitats Regulations Assessment (HRA) to determine whether the decommissioning activities may cause likely significant effects on the designated features of the protected sites. ConocoPhillips is required to consider the potential impacts associated with their decommissioning activities and other proposed activities by other users of the sea and therefore anticipate similar undertaking from IOG. *IOG notes the comments from ConocoPhillips and will undertake necessary assessments as may be required for any decommissioning activities associated with the Southwark Field Development.*
DEME Building Materials	DEME advised that it does not believe that the proposed Vulcan Satellites Hub Development will interfere with any proposed dredging activities at its licensed sites. However, DEME requests to be kept informed of the project as it develops. *IOG notes the comments from DEME and commits to ensuring DEME is kept informed of the project as it progresses.*

Consultee	Consultee Comment and IOG Response
Dudgeon Offshore Wind Farm Limited (DOWFL)	DOWFL requested further information on the proposed development including more information on the drilling, construction and maintenance phases of the proposed operations, as well as further details of the installations, pipelines and wells proposed to be installed as part of the development with particular focus on the proposed Blythe Hub Development which is located adjacent to the Dudgeon offshore wind farm. *IOG recognises DOWFL as a consultee in the process and will maintain ongoing dialogue regarding proposed developments as may impact DOWFL. Further information on the particular infrastructure associated with the Southwark Field Development is detailed in Section 2 of this ES Addendum.*
DOWFL	DOWFL enquired as to whether there is a minimum safety zone requested by IOG for the construction of the project. *IOG undertakes to advise DOWFL of any statutory safety zones as may impact upon DOWFL.*
DOWFL	DOWFL requested that the appropriate channels of communication are followed at all times when any works are ongoing such as maintaining normal radio contact with any vessels that may be working on the wind farm. *IOG undertakes to liaise with DOWFL of any maritime activities as may impact upon DOWFL.*
Environment Agency	The Environment Agency advises that any near-shore works to facilitate recommissioning of the Thames to Bacton pipeline should consider the requirements of the Water Framework Directive (within 1nm of the coast), and potential impacts on coastal processes or flood risk management. Regard should be given to the Anglian river basin district River Basin Management Plan (RBMP) and the North Norfolk Shoreline Management Plan (SMP). *No near-shore works are proposed to be undertaken as part of the refurbishment of the pipeline. An overview of all the operations covered by this EIA is detailed in Section 2.*
Health and Safety Executive (HSE)	The HSE advised that IOG may have certain responsibilities, particularly with respect to design and operational notifications, under the Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015. *IOG will ensure that any design and operational notifications associated with the development of the Southwark Field are undertaken.*
Historic England	Historic England advised that there is the potential for unknown archaeological materials to be present within the areas of sandbank located to the east of the proposed development and therefore any proposed site and route surveys should support archaeological analysis and interpretation of survey data collected. Historic England also recommended that visual inspection methodologies are used to support inspection of seabed anomalies with surface expression to determine whether they are of archaeological interest. *IOG conducted a geophysical survey across the site and proposed pipeline route in 2018. All anomalies observed during the survey were ground-truthed by visual inspection (i.e. video or stills photography), where possible. No archaeological materials were observed.*
Historic England	Historic England confirmed that there are no historic shipwrecks in the project area designated under the Protection of Wrecks Act 1973. However, whilst no designated archaeological sites exist within the proposed development site, known and unknown features of the historic environment may still be present. *IOG conducted a geophysical survey across the site and proposed pipeline route in 2018. No signs were observed that would potentially indicate any features of the historic environment.*
Historic England	Historic England recommended that the EIA considers the likelihood of encountering submerged and buried elements of prehistoric landscapes containing archaeological materials and that any acquisition programmes for geophysical and geotechnical data should capture the setting of archaeological artefacts. *IOG conducted a geophysical survey across the site and proposed pipeline route in 2018. All anomalies observed during the survey were ground-truthed by visual inspection (i.e. video or stills photography), where possible. No archaeological materials were observed.*

Consultee	Consultee Comment and IOG Response
JNCC	JNCC welcomed further discussion with IOG to ensure that the correct information regarding protected habitats is included in the ES and whether any of the proposed operations may adversely affect habitats of conservation importance. *The impacts of the proposed operations on protected sites and species are considered within the ES in Sections 5 to 9.*
JNCC	JNCC advised that IOG check the status of all European sites discussed in the ES prior to submission and refer to them accordingly. *In the preparation of this ES, IOG has used the most up to date information available regarding protected sites as presented in Section 3.4.*
JNCC	JNCC advised that seabed disturbance is likely to occur during the installation of subsea infrastructure, drilling operations, deposition of drill cuttings and anchor placement and recommended that best practices are followed to minimise the footprint of operations and reduce potential disturbance. *IOG will observe best practice and guidance during any operations associated with the development of the Southwark Field. Impacts from physical presence are considered in Section 5 of this ES Addendum.*
JNCC	JNCC requested that reports detailing relevant specialist studies undertaken in support of the EIA should be provided to them for review to help better understand the site. *A copy of the habitat and site survey reports will be made available to JNCC.*
JNCC	JNCC provided advice on reference material that may be useful when compiling the ES. *IOG has made use of the suggested data sources proposed by JNCC and, where appropriate, included them in the ES.*
Maritime Coastguard Agency (MCA)	The MCA stated that the potential for navigation and collision risk should be considered as part of the EIA particularly from a cumulative perspective given other activities in the area. Information on mitigation options in respect of pipeline trenching, mattressing and over-trawlability should be discussed within the ES. *The potential for impacts on navigation are considered in Section 5 where mitigation measures are also discussed. Information on pipeline trenching and use of mattresses is also detailed in Section 2 of the ES.*
Natural England	Natural England advised that there are ongoing issues with pipelines becoming exposed in the area around the Cromer Shoals Chalk Beds MCZ and recommend that a sustainable plan for management of the pipeline is developed in consultation with Natural England as part of this development. *IOG is developing operations and maintenance practices for the pipeline in consultation with the HSE and industry specialists.*
Norfolk County Council	The EIA should provide an assessment of the impact of the development on the landscape and seascape character (where visible from onshore), visual intrusion caused by the development including a Zone of Visual Intrusion map, photomontages, cumulative impact of the development together with other operational developments such as wind farms and an assessment on the heritage landscape. *Assessments of the impact of the development on the landscape and seascape character are discussed in this EIA in Section 5.*
Norfolk County Council	The EIA should consider potential impacts on a range of receptors including ecological, cultural heritage and archaeology and socio-economic. *Assessments of relevant receptors are discussed in this EIA in Sections 5 to 9 and summarised in Section 10.*
RSPB	Recommended a potentially useful study on tracking of seabirds around the UK and Ireland. *IOG has considered the Wakefield et al., 2017 study as part of this EIA.*

Consultee	Consultee Comment and IOG Response
Sea Watch Foundation	The Sea Watch Foundation provided advice on useful sources of data for consideration in the EIA. *Consideration of potential impacts from the proposed operations on marine mammals has been considered in Section 7 of the ES.*
Trinity House	Trinity House advised that all the platforms should comply with the Standard Marking requirements for Offshore Installations and confirmation provided when submitting the Consent to Locate application BEIS. The positions of the subsea wellheads should be provided to Trinity House as marking will be dependent on location and water depths. Any vessels used in the laying of any new pipeline should exhibit signals as per COLREGs. *IOG will ensure that any infrastructure is appropriately marked and lit and positions of subsea infrastructure provided to Trinity House. Any vessels will be marked and lit in accordance with the International Regulations for Preventing Collisions at Sea 1972 (COLREGs).*
The Crown Estate	The Crown Estate recommended liaison with additional stakeholders who might be interested in the Vulcan Satellites Hub Development. *In October 2017, IOG provided an Early Consultation Document (ECD) to a wide range of stakeholders as detailed in this ES. The ES will be subject to 28 days of public consultation during which any interested parties may comment on the proposed operations.*
The Crown Estate	The Crown Estate noted that that the pipeline within 12 nm would require permissions from The Crown Estate and that IOG will be required to enter into a lease agreement for the appropriate rights to construct and operate the pipeline. *IOG has engaged with TCE with a view to establishing all necessary agreements and permissions.*
Westminster Gravels	Advised that the proposed operations at the Vulcan Satellites Hub Development would not impact on their operations at marine aggregate extractions site Areas 515/1 and 515/2. *IOG notes the comments from Westminster Gravels.*
The Wildlife Trusts (TWT)	TWT queried what survey work will be undertaken to ascertain the suitability of the Thames to Bacton 24" pipeline for recommissioning and whether any survey work would damage the features of the Cromer Shoal Chalk Beds MCZ. *IOG has developed an inspection programme to ascertain the suitability of the 24" pipeline PL370 in consultation with the HSE and industry specialists. The proposed survey methods do not involve physical disturbance of the Cromer Shoal Chalk Beds MCZ.*
The Wildlife Trusts (TWT)	TWT recommend a full and comprehensive HRA to be undertaken and further survey work undertaken to determine the presence of *Sabellaria spinulosa* within the development site. *If an HRA proves necessary IOG will provide supporting information for the regulator to undertake the Appropriate Assessment. Environmental survey work was conducted in 2018 to establish the environmental baseline at the proposed project location.*
UK Hydrographic Office (UKHO)	The UKHO offered advice on when any notifications relating to the proposed operations should be provided to them to allow adequate time to inform other users of the sea. *IOG will ensure that any required notifications are provided timeously to the UKHO and any other appropriate body.*

4.4 Concerns Identified for Further Assessment

The results from the ENVID workshop and the issues raised during the informal consultation process together identified the potentially significant concerns associated with the proposed Southwark Field Development to be scoped into the EIA. These concerns have driven the environmental considerations throughout the project and have helped guide appropriate mitigation measures to be incorporated into the project planning in order to reduce, or eliminate, the potentially significant environmental impacts. Each concern is fully addressed in the subsequent sections of the ES and any residual impacts, once mitigation measures have been applied, are described.

The key concerns relating to this project are addressed under the following headings:

- Physical Presence (Section 5);
- Marine Discharges (Section 6);
- Underwater Noise Generation and Wildlife Disturbance (Section 7);
- Atmospheric Emissions (Section 8);
- Accidental Events (Section 9).

In line with the requirements of the Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999, any potential cumulative and transboundary impacts derived from this project have also been assessed, in the individual impact sections. Cumulative impacts are those from activities or events which individually may not be significant, but when combined with impacts arising from different sources that have an overlapping sphere of influence to the activities and events under consideration, may produce potentially significant impacts. Transboundary impacts comprise any potential environmental impacts on the seabed, water column and/or atmosphere, which extend beyond the boundaries of the UKCS.

4.5 Detailed Impact Assessment Methodology

As detailed in Section 4.2.1, each issue raised during the ENVID is assessed in the same manner, in Sections 5 to 9 of the ES. Each impact assessment describing IOGs understanding of the concern, describing and quantifying the effects from the proposed development, recognising any gaps in understanding and explaining how these are dealt with, and defining measures taken to mitigate the impacts. The assessment also considers potential cumulative, in combination and/or transboundary effects.

The first step of the detailed impact assessment assesses the magnitude of the potential environmental impact for each receptor, independently of its value or designated status, using the magnitude criteria defined in Table 4.1. The sensitivity of each receptor is considered when assessing the likely magnitude of the impact. Ecological sensitivity is defined as the relative change of a system or population in relation to the level of disturbance (Miller *et al*., 2010). The sensitivity of socio-economic and socio-ecological systems may be defined in a similar manner (Holling, 2001).

For the Southwark Field Development, the types of operations were broken down into general operations, drilling operations, installation and commissioning, production operations and accidental events. The environmental aspects were identified for each of these operations and scored against environmental receptor value to determine their level of impact and whether further detailed assessment and mitigation was required. This was calculated by multiplying the magnitude of effect Table 4.1 and the value of the receptor Table 4.2.

Whilst this approach is considered appropriate for specific environmental and socio-economic receptors, climate change impacts from IOG's planned operations are comparatively so small that they are impossible to assess. However, it is acknowledged that they will contribute to the overall cumulative issue of climate change and are therefore of key concern to overall sustainability objectives. Therefore, environmental issues identified to contribute to climate change have been considered in the detailed impact assessment.

INDEPENDENT OIL & GAS PLC

Section 5

Physical Presence

5 PHYSICAL PRESENCE

The following issues and concerns were raised during the ENVID and informal consultation, and will therefore be considered in this section on physical presence:

- Physical presence of the rig, installation and infrastructure impacting other users of the sea;
- Stabilisation and protection of infrastructure impacting seabed communities and other users;
- Installation and presence of subsea infrastructure impacting seabed communities;
- Vessel movements;
- Visual impact of the development from the shore.

This section assesses the potential impacts of the presence of the subsea infrastructure, and drilling and construction activities upon the seabed, benthic communities and other users of the sea, as well as the visual impact from the shore.

5.1 Seabed and Associated Communities

5.1.1 Physical Extent of the Area Affected by the Proposed Operations

Jack-up Drilling Rig

All three wells will be drilled by a conventional jack-up drilling rig. The jack-up drilling rig will be towed to location and the legs lowered on to the seabed. At present, no specific drilling rig has been contracted, therefore the features of a typical jack-up drilling rig commonly used for operations in the Southern North Sea (SNS) have been used to inform this impact assessment. The drilling rig will be towed into position, and the legs placed on the seabed.

A typical jack-up drilling rig spudcan has a footprint of approximately 154.4 m^2 (46 feet diameter), totalling around 463.1 m^2 for all three legs. Before drilling operations commence, stabilisation and scour protection will be provided by graded rock placement, with approximately 1,000 tonnes deposited around each leg. Assuming that the stabilising material is deposited within 5 m of each spudcan, the rock placement should cover an additional area of around 896.3 m^2 per platform location. (see Section 2.3.4). Therefore, the total seabed impacted by the spudcan placement and rock placement is approximately 1359.4 m^2 for the Southwark drilling location.

Southwark Platform

The platform jacket substructure will be constructed with a 4-leg lattice style jacket. Each of the platform legs will have seabed footings which will either be mudmats with skirt pile sleeves, or suction piles, depending on the installation method selected. Each mudmat is approximately 5.5 m × 5.5 m, totalling 121 m^2, and each suction pile would be between 7 m and 10 m in diameter, totalling 314 m^2 direct seabed footprint.

Three production wells will be drilled through the Southwark platform. The extent of the conductor footprint per well is approximately less than 1 m^2. A wellhead will be installed on the platform and will have no seabed footprint.

Southwark to PL370 Export Pipeline

The 24" pipeline from Southwark to the Thames Export Pipeline PL370 will be concrete coated and surface-laid into position on the seabed by a specialist pipelay vessel. The pipeline is approximately 5.86 km in length. Protection of the pipeline along its length is afforded by 4" concrete coating which acts as an armour against physical damage.

The export pipeline will be laid into position from a surface pipelay vessel. Details of the direct footprint of this pipeline installation option is provided in Table 5.1.

Table 5.1: Footprint of Surface-laid Pipeline Installation Option

Pipeline	Length [km]	Installation Method	Pipe Width [inch]	Armour Thickness [inch]	Total Pipeline Width [m]	Total Area Affected [m^2]
Southwark to PL370 24" Export Line	5.86	Laid on seabed surface	24	4	0.81	4,765
Total	5.86					**4,765**

Pipeline Stabilisation and Integrity

IOG's engineering studies suggest that a worst-case scenario is that 0.25% of the pipeline length will require stabilisation at the time of installation, and that a further 0.43% of the pipeline length will require stabilisation during the expected operational lifetime. For the purposes of this assessment, it is assumed that areas requiring stabilisation will comprise 2 m wide corridors along the pipeline route (1 m either side). Table 5.2 presents estimated pipeline stabilisation areas.

Table 5.2: Estimated Areas of Seabed Covered by Southwark to PL370 Export Pipeline Stabilisation Measures

Phase	Pipeline length [km]	% length	Width [m]	Area Covered [m²]
Installation	5.86	0.25	2	29.3
Operation	5.86	0.43	2	50.4
Total		**0.68**		**79.7**

Tie-in Point Protection

Dropped object protection for the pipeline at the Southwark platform tie-in and PL370 tie-in locations will be provided by concrete mattresses.

Table 5.3 provides the estimated total areas of seabed expected to be covered by mattresses, with each mattress expected to accord to the typical design size of 6 × 4 m

Table 5.3: Areas of Seabed Expected to be Covered by Mattresses

Location	Pipeline	Number of Mattresses	Area Covered [m²]
Tie-in to PL370	24" Southwark to PL370 gas export line	15	360
Tie-in to Southwark	24" Southwark to PL370 gas export line	7	168
Total		**22**	**528**

A short section (approximately 85 m) of PL370 will also require some graded rock placement beyond the tie-in point for stabilisation purposes. This is estimated to total approximately 4,000 tonnes and to cover an area of 665 m².

Summary of Total Area of Seabed Impacted

A summary of the seabed area impacted by the infrastructure is shown in Table 5.4. The maximum total amount of seabed potentially affected by the jack-up drilling rig, Southwark platform, subsea infrastructure and pipelines will be approximately 0.0077 km². The jack-up drilling rig will be on site for approximately 294 days, with the overall lifespan of the Southwark field expected to be approximately 18 years.

The area of the North Norfolk Sandbanks and Saturn Reef (NNSSR) Special Area of Conservation (SAC) is 3,603.41 km², and the area of the Southern North Sea (SNS) SAC is 36,796 km². Table 5.4 presents the percentage of the SAC affected.

Table 5.4: Area of Seabed Impacted by the Southwark Development Infrastructure and Percentage of NNSSR SAC and SNS SAC Impacted

Development Infrastructure	Impact type	Area [m²]	Area [km²]	% NNSSR SAC Area	% SNS SAC Area
Platform footings - mudmat option	Seabed compression	121.0	0.00012	0.0000034%	0.00000033%
Platform footings - suction pile option	Seabed compression	314.0	0.00031	0.0000087%	0.00000085%
Jack-up rig spudcan footprint	Seabed compression	463.1	0.00046	0.0000129%	0.00000126%
Spudcan stabilisation material	Graded rock placement	896.3	0.00090	0.0000249%	0.00000244%
Southwark to PL370 export pipeline	Seabed compression	4,765.2	0.00477	0.0001322%	0.00001295%
Southwark tie-in mattresses	Mattresses	168.0	0.00017	0.0000047%	0.00000046%
PL370 tie-in mattresses	Mattresses	360.0	0.00036	0.0000100%	0.00000098%
PL370 stabilisation material	Graded rock placement	665.0	0.00067	0.0000185%	0.00000181%

Development Infrastructure	Impact type	Area [m²]	Area [km²]	% NNSSR SAC Area	% SNS SAC Area
Initial pipeline stabilisation material	Graded rock placement	29.3	0.00003	0.0000008%	0.00000008%
Lifetime pipeline stabilisation material	Graded rock placement	50.4	0.00005	0.0000014%	0.00000014%
Total (mudmat option)		**7,518.4**	**0.00752**	**0.0002086%**	**0.00002043%**
Total (suction pile option)		**7,711.4**	**0.00771**	**0.0002140%**	**0.00002096%**

5.1.2 Potential Effects on the Seabed Communities

The placement of the development infrastructure on the seabed is anticipated to lead to the loss of the underlying seabed communities in an area of up to 0.0077 km^2. Some of this loss will be reversible with the completion of the installation operations (removal of jack-up footings) and recovery is expected after time through sediment deposition and re-colonisation, which will restore many disturbed areas.

This direct physical disturbance of the seabed through compression is likely to result in a temporary loss of the benthic communities beneath the spudcans, within an overall area of approximately 461.1m^2. As the sandy sediments within the area are highly mobile, it is expected that the re-sedimentation processes will start to fill these depressions immediately after the rig has vacated the drilling locations, to be quickly followed by re-colonisation of benthos. There is however little published information on the likely recovery time from such physical disturbance. The closest indications are to be derived from studies carried out on the physical and biological impacts to the seabed caused by towed fishing gear (e.g. as reviewed by Løkkeborg, 2005). Such research indicates that the longevity of the physical scars in the seabed left in the wake of towed gear depends on the sediment type and the energy of the local benthic environment. Scars in higher energy sandy and shallow environments, such as those present at the Southwark field location, can generally be expected to disappear within days or months of the initial disturbance.

Scars from spud disturbance around the proposed well locations will be deeper, but significantly smaller in area than those observed following trawling. Because of their small size, there is a strong potential for recovery via species recruitment from the surrounding areas of seabed once the jack-up drilling rig is removed.

The area of seabed compressed by the placement of spudcans totals 0.00046 km^2 and will be confined to the immediate vicinity of the platform installation locations. This represents a proportion of 0.000013% of the total area of the NNSSR SAC. The relatively small area affected, coupled with the high potential for recovery, means that spudcan placement is not anticipated to cause a significant effect. Turbidity caused by the placement and removal of the drilling rig spudcans is expected to be within the natural variability of seabed sediment re-suspended by the local tidal regime.

The JNCC has commissioned a report identifying possible impacts of rock placement from oil and gas decommissioning on Annex I mobile sandbanks, using the NNSSR SAC as a case study. This study identified the likely impacts on Annex I Habitat 'Sandbanks slightly covered by water all the time' as current and tidal flow disturbance, suspended sediment dispersion and deposition, increase scour, changes in biodiversity from new substrate and recoverability of soft bottom communities (Pidduck *et al*., 2017).

Rock placement has the potential to alter water flow speed and direction which in turn may affect the sediment supply/transport to an area due to associated seabed elevation changes (Tillin & Tyler-Walters 2015). Furthermore, alterations to soft bottom sediments can affect current patterns causing scour and changes in sand ripple patterns and sediment grain size (Davis *et al*., 1982). The Pidduck *et al*., (2017) study reports the findings of a decommissioning Environmental Statement (ES) by ConocoPhillips (2015) situated within the NNSSR SAC where rock placement for the stabilisation of jack-up legs was used. Side-scan sonar data collected for this ES identified no apparent damage to the form and function of the sandbank or the appearance of surface features such as ripple marks. Therefore, it was concluded that the presence of rock placement was unlikely to compromise the integrity of the NNSSR SAC through alteration of seabed morphology. These findings are also comparable to that of the placement of wind farm infrastructure on the Scroby Sands mobile sandbank, which also found overall form and function of the sandbank was unaltered (CEFAS, 2006).

Rock placement can generate a localised and temporary sediment plume in the area. Turbidity caused by rock placement is expected to be within the natural variability of seabed sediment re-suspended by the local tidal regime Any impacts resulting from sediment suspension during the rock placement operations are anticipated to be of a similar magnitude to those caused by the spudcans, and thus not expected to result in any significant effects. Suspended sediment dispersion and deposition as a result of rock placement within areas of soft sediments was assessed for the Cygnus Field Development ES. Results from this ES found that rock placement in soft sediments has the potential to be buried naturally by sediment, suggesting little or no impacts to sediment dispersion and deposition (GDF SUEZ, 2009). However, there is limited data, thus no firm conclusions can be drawn from this data alone (Pidduck *et al*., 2017).

The placement of artificial structures creates the potential for scour pits to form around the base of structures. However, a study at the North Hoyle offshore windfarm found that the addition of rock placement for infrastructure protection failed to identify any environmental implications to the regional sediment transport regime within the site, with no distinct scour pits identified within the site (OSPAR, 2008). The OSPAR (2008) report describes offshore windfarm foundations as having a relatively small area of impact in terms of direct impact on the seabed from the foundation pieces, scour pits and scour protection. The total seabed area that would be affected by all rock placement operations as part of the Southwark Field Development (0.0016 km^2) is several orders of magnitude smaller than the area of windfarm foundations considered in the OSPAR report (3.67 km^2 to 29.78 km^2). Sandbanks within the NNSSR SAC are described as an energetic environment (Jenkins *et al*., 2015), with scour and sediment deposition a continual process with the potential to reduce the height of sandbank areas naturally (Pidduck *et al*., 2017).

Rock placement will lead to the loss and change of the current habitat and potential mortality of benthic fauna creating a different habitat for benthic organisms. There is potential for rock placement to act as an artificial reef, supporting reef associated species, increasing the biodiversity of the area (Pidduck *et al*., 2017). One study on macrobenthos around offshore wind turbines in soft sediments found that at distances of 1 m and 7 m from rock placement, the benthic community to be similar to that of hard substrate fauna, with juvenile starfish, brittle stars and hydroid and tube dwelling crustaceans (Coates *et al*., 2011). This study also recounts an increase in less common soft sediment macrofauna, suggesting the creation of potential microhabitats. Other studies have however described a reduction of densities of some species near artificial structures. This reduction is thought to have been associated with an increase of predation from reef associated fish or as a result of creating a less suitable habitat for certain species associated with soft sediments (Pidduck *et al*., 2017). A study into the effects of man-made structures on benthic communities found that there was no measurable decrease in adjacent infaunal densities at distances of 4 m from the artificial structures (Davis *et al.*, 1982). However, potential biotope changes have been recorded within 7 m of scour protection in sandbank habitats (Coates *et al*.,2011). Within the NNSSR SAC there is therefore a potential that rock placement will change the existing sandbank biotope of 'infralittoral mobile clean sand with sparse fauna' and support the colonisation of hard-substrate dwelling organisms, such as tubeworms, hydroids, tunicates, bryozoans, anemones and crustaceans, which may affect the Annex I sandbank features, for which it was designated. However, there is little information currently available documenting these changes within sandbanks as a result of rock placement (Pidduck *et al*., 2017). Physical disturbance by rock placement to soft sediment communities is thought to be localised, with communities of less stable habitats (coarse, clean sands) able to recover quicker than stable (muddy sands and muds) habitats following a minor disturbance, in comparison to the complete removal of sediment (Dernie *et al*., 2003). Environmental impacts are expected as a result of rock placement operations. However, any seabed disturbance and alteration impacts from rock placement will be confined to the immediate vicinity of the area of operations (0.0016 km^2), approximately 0.000046% of the total NNSSR SAC area, and are therefore not anticipated to cause a significant effect.

Laying of pipelines and installation of other infrastructure could result in the burying of benthic fauna in the immediate area through the temporary re-suspension of sediments, causing smothering. Effects associated with the possible smothering of benthos in the surrounding area include the disruption of feeding and respiratory functions of some animals, particularly filter feeding organisms leading to increased mortality and reduced reproductive rates. However, in higher energy locations, such as the NNSSR SAC, the associated fauna tends to be well-adapted to disturbance and changes to suspended sediments (Dernie *et al*., 2003). The disturbance incurred by pipe laying will be limited to the initial operation. Re-colonisation of affected benthic communities within the soft sediments is expected within one to two years (OSPAR, 2009). Due to the expected high rate of recovery, laying of infrastructure on the seabed surface is not anticipated to cause a significant effect.

As the 24" pipeline extension from Southwark will be surface laid, like rock placement, this will create an artificial habitat which may result in species exclusion, increased predation and the colonisation of hard substrate fauna. This has the potential to change the features for which the NNSSR SAC was designated. Environmental impacts are therefore expected as a result of the installation of the pipelines. However, any seabed disturbance and alteration impacts from the presence of the surface pipeline will be confined to a maximum extent of 0.00477 km^2, approximately 0.00013% of the total NNSSR SAC area and are therefore not anticipated to cause a significant effect.

Concrete mattresses will be put in place to cover the tie-in points identified in Table 5.3. The placement of the mattresses will have similar impacts to rock placement. As with rock placement and surface laid pipeline, this will create a different habitat for benthic organisms, with a similar colonisation by hard-substrate dwelling organisms, with the potential to change the features for which the NNSSR SAC was designated. Environmental impacts are therefore expected as a result of the placement of mattresses. However, any seabed disturbance and alteration impacts due to the placement of mattresses will be confined to the immediate vicinity of the pipelines (0.00053 km^2), in areas already disturbed. Approximately 0.000015% of the total NNSSR SAC will be affected, therefore the placement of concrete mattresses is not anticipated to cause a significant effect.

The placement of the development infrastructure will incur the loss of NNSSR SAC habitat and may affect the Annex I sandbank feature for which it was designated, together with loss benthic communities for the duration of the development. However, the maximum potential development area impacted (0.0077 km^2), makes up only 0.00021% of the NNSSR SAC.

The presence of the exclusion zones around the development will prohibit trawling in the area, thus protecting the local benthos from physical impacts associated with such activities over the duration of the development. In consideration of the above factors, disturbance of seabed communities in the local area is seen as minor, and thus is not anticipated to cause a significant effect.

5.1.3 Operational Impacts on Features of Interest within Special Areas of Conservation

The Southwark field is located within the North Norfolk Sandbanks and Saturn Reef SAC (JNCC, 2019a), which is designated for sandbanks which are slightly covered by sea water all the time, and for biogenic reefs.

The JNCC Advice on Operations (AoO) Guidance has been developed as part of the JNCC's formal conservation advice package for individual offshore Special Areas of Conservation (JNCC, 2017a). The Advice on Operations provides information on those human activities that, if taking place within or near the NNSSR SAC, can affect it and present a risk to the achievement of the conservation objectives. The NNSSR AoO has been used to determine the sensitive features and corresponding relevant physical pressures to the conservation features of the NNSSR SAC from the proposed operations.

Within the NNSSR AoO Guidance, a number of pressures on specific Annex I habitats, namely those of biogenic reefs (*Sabellaria spinulosa*), subtidal coarse sediment, subtidal mixed sediments and on subtidal sands, have been identified which are associated with the presence of the subsea infrastructure, and drilling and construction activities relevant to the Southwark Development. The NNSSR AoO Guidance separates oil and gas operations into activities, consisting of oil and gas exploration and installation, production and pipelines. Vessel movements activity has also been selected as relevant to the physical impacts of the Southwark Development and has therefore been included within the assessment. Within each of these activities, associated pressures have been assigned in Table 5.5, Table 5.6, Table 5.7 and Table 5.8.

The NNSSR AoO Guidance sensitivity category descriptions are described below:

- Sensitive: the evidence base suggests the feature is sensitive to the pressure at the benchmark. This activity-pressure-feature combination should therefore be taken to further assessment;
- Insufficient Evidence to Assess: the evidence base is not considered to be developed enough for assessment to be made of sensitivity at the pressure benchmark. This activity-pressure-feature combination should therefore be taken to further assessment;
- Not Assessed: a sensitivity assessment has not been made for this feature to this pressure. However, this activity-pressure-feature combination should not be precluded from consideration;
- Not Sensitive at the Benchmark: the evidence base suggests the feature is not sensitive to the pressure at benchmark. However, this activity-pressure-feature combination should not be precluded from consideration (e.g. thought needs to be given to activity specific variations in pressure intensity and exposure, in-combination and indirect effects);
- Not Relevant: the evidence base suggests that there is no interaction of concern between the pressure and the feature or the activity and the feature could not interact.

Oil and Gas Exploration and Installation

By selecting pressures associated with the activity *oil and gas exploration and installation* in the NNSSR AoO Workbook (JNCC, 2017a), the corresponding pressures exerted on biogenic reefs (*Sabellaria spinulosa*) and sandbanks which are slightly covered by sea water all the time within the NNSSR SAC are described in Table 5.5.

Table 5.5: NNSSR AoO Outcome of Pressures Exerted on the Biogenic Reefs and Sandbanks by Oil and Gas Exploration and Installation

Pressure Name	Feature Sensitivity
Abrasion/disturbance of the substrate on the surface of the seabed	Sensitive
Barrier to species movement	Not relevant
Collision ABOVE water with static or moving objects not naturally found in the marine environment (e.g. boats, machinery, and structures)	Not relevant
Collision BELOW water with static or moving objects not naturally found in the marine environment (e.g. boats, machinery, and structures)	Not relevant
Habitat structure changes – removal of substratum (extraction)	Sensitive
Introduction of light	Not relevant
Introduction of other substances (solid, liquid, gas)	Insufficient evidence to assess
Penetration and/or disturbance of substrate below the surface of the seabed, including abrasion	Sensitive
Siltation rate changes (low), including smothering (depth of vertical sediment overburden)	Sensitive
Visual disturbance	Not relevant

As discussed in section 5.1.2 the placement and removal of the rig spudcans, rock placement, and the installation of the surface pipelines and concrete mattresses will result in the loss of habitat and temporary re-suspension of sediments and associated re-suspension of fine particles into the water column and possible smothering. As previously described, the fauna of high energy environments, such as the NNSSR SAC, tend to be well-adapted to disturbance and changes to suspended sediments (Dernie *et al.*, 2003). The placement of the development infrastructure on the seabed is anticipated to lead to the loss of the underlying seabed communities. However, once the jack-up drilling rig has vacated the drilling locations, and pipeline laying is complete, it is expected that recovery will occur through sediment deposition and species recruitment from the surrounding areas of seabed. As described, the installation of concrete mattresses and rock placement will create an artificial habitat which may result in species exclusion, increased predation and the colonisation of hard substrate fauna. This has the potential to change the features for which the NNSSR SAC was designated. However, there is little information currently available documenting these changes within sandbanks as a result of rock placement, surface laid pipeline or the placement of concrete mattresses. The maximum total direct physical disturbance within the NNSSR SAC is approximately 0.0077 km^2, approximately 0.00021% of the overall NNSSR SAC area, and therefore is not anticipated to cause a significant effect.

Oil and Gas Production

By selecting pressures associated with the activity *oil and gas production* in the NNSSR AoO Workbook (JNCC, 2017a), the corresponding pressures exerted on biogenic reefs (*Sabellaria spinulosa*) and sandbanks which are slightly covered by sea water all the time within the NNSSR SAC are described in Table 5.6.

Table 5.6: NNSSR AoO Outcome of Pressures Exerted on the Biogenic Reefs and Sandbanks by Oil and Gas Production

Pressure Name	Feature Sensitivity
Barrier to species movement	Not relevant
Collision ABOVE water with static or moving objects not naturally found in the marine environment (e.g. boats, machinery, and structures)	Not relevant
Collision BELOW water with static or moving objects not naturally found in the marine environment (e.g. boats, machinery, and structures)	Not relevant
Introduction of light	Not relevant
Introduction of other substances (solid, liquid, gas)	Insufficient evidence to assess
Penetration and/or disturbance of substrate below the surface of the seabed,	Sensitive

Pressure Name	Feature Sensitivity
including abrasion	
Siltation rate changes (low), including smothering (depth of vertical sediment overburden)	Sensitive
Visual disturbance	Not relevant
Water flow (tidal current) changes- local, including sediment transport considerations.	Sensitive

As discussed in section 5.1.2 rock placement, pipeline laying, and the installation of concrete mattresses will be conducted during the installation phase, therefore the effects exerted on the NNSSR SAC will be minimal during production. Rock placement, the surface pipeline and concrete mattresses do have the potential to alter water flow speed and direction, which may affect sediment transport. However, long term studies have found that rock placement for the support of structures was not found to damage the form or function of the sandbanks as a result of changes to water flow, as discussed in section 5.1.2 (ConocoPhillips, 2015; CEFAS, 2006). Therefore, the pressures exerted on the biogenic reefs and sandbanks by oil and gas production is thought to be minimal, and therefore is not anticipated to cause a significant effect.

<u>Pipelines</u>

By selecting pressures associated with the activity *pipelines* in the NNSSR AoO Workbook (JNCC, 2017a), the corresponding pressures exerted on biogenic reefs (*Sabellaria spinulosa*) and sandbanks which are slightly covered by sea water all the time within the NNSSR SAC are described in Table 5.7.

Table 5.7: NNSSR AoO Outcome of Pressures Exerted on the biogenic reefs and sandbanks by pipelines

Pressure Name	Feature Sensitivity
Abrasion/disturbance of the substrate on the surface of the seabed	Sensitive
Collision BELOW water with static or moving objects not naturally found in the marine environment (e.g. boats, machinery, and structures)	Not relevant
Habitat structure changes – removal of substratum (extraction)	Sensitive
Introduction of light	Not relevant
Introduction of other substances (solid, liquid, gas)	Insufficient evidence to assess
Penetration and/or disturbance of substrate below the surface of the seabed, including abrasion	Sensitive
Physical changes (to another seabed type)	Sensitive
Siltation rate changes (low), including smothering (depth of vertical sediment overburden)	Sensitive
Visual disturbance	Not relevant
Water flow (tidal current) changes- local, including sediment transport considerations	Sensitive

As discussed in Section 5.1.2, the laying of the pipelines and placement of concrete mattresses over tie-in points will lead to loss of natural habitat in the immediate area and the temporary re-suspension of sediments. The disturbance incurred by pipe laying will be limited to the initial operation.

The surface laid pipelines and concrete mattresses will create artificial habitats which may result in species exclusion, increased predation and the colonisation of hard substrate fauna. The surface laid pipelines and concrete mattresses also have the potential to change the features for which the NNSSR SAC was designated.

The maximum areal extent of surface-laid pipelines and mattresses is 0.00529 km^2, which is 0.000147% of the NNSSR SAC. Due to this relatively small footprint, the presence of surface-laid pipelines and mattresses is not expected to significantly alter current speed or direction, and therefore should not affect sediment transport within the area.

Vessel Movements

By selecting pressures associated with the activity *vessel movements* in the NNSSR AoO Workbook (JNCC, 2017a), the corresponding pressures exerted on biogenic reefs (*Sabellaria spinulosa*) and sandbanks which are slightly covered by sea water all the time within the NNSSR SAC are described in Table 5.8.

Table 5.8: NNSSR AoO Outcome of Pressures Exerted on the Biogenic Reefs and Sandbanks by Vessel Movements

Pressure Name	Feature Sensitivity
Abrasion/disturbance of the substrate on the surface of the seabed	Sensitive
Collision ABOVE water with static or moving objects not naturally found in the marine environment (e.g. boats, machinery, and structures)	Not relevant
Collision BELOW water with static or moving objects not naturally found in the marine environment (e.g. boats, machinery, and structures)	Not relevant
Introduction of light	Not relevant
Introduction or spread of non-indigenous species	Sensitive
Penetration and/or disturbance of substrate below the surface of the seabed, including abrasion	Sensitive
Siltation rate changes (low), including smothering (depth of vertical sediment overburden)	Sensitive
Wave exposure changes - local	Sensitive

During the drilling and installation operations, vessel activity will include movements of the tugs, stimulation vessel, supply vessels, Emergency Response & Rescue Vessels (ERRV), heavy lift barge, pipelay vessel and Diving Support Vessel (DSV). The Option Selection and Project Description (Section 2.3.6) details the duration of each vessel per location. Vessels will only be active at each site when required and will not deploy anchors, reducing the threat of seabed disturbance. The impacts are therefore considered to be minor due to the temporary and limited duration. Impacts from the vessel propellers and local wave exposure changes will be negligible due to the water depth and the low levels of vessel activity at the installation location. All relevant biosecurity and ballast water management practices will be adhered to, in line with international and national legislation and guidance.

5.1.4 Cumulative and Transboundary Impacts

The Southern North Sea has high levels of anthropogenic activity, with multiple developments in the region of the Southwark field location, including oil and gas, renewable energy, fishing, shipping and aggregates extraction (see Section 3.5 for details on other users of the sea in the area). The physical disturbance from the placement and removal of structures will add to the physical disturbance caused by drilling discharges, as described in Section 6, and the disturbance in the wider area. The impacts on the NNSSR SAC and seabed communities as a result of physical presence of the Southwark field Development are considered to be minor and therefore not likely to constitute a significant additional impact. Cumulatively, the activities of the oil and gas industry, offshore wind industry and marine aggregate industry do have the potential to change to the existing Annex I sandbank feature within the NNSSR SAC, therefore appropriate mitigation measures must be in place for all industries utilising the NNSSR SAC, to keep impacts to a minimum. This will be aided by all industries following the advice provided by JNCC which provides measures to support the achievements of the NNSSR SACs conversation objectives.

At its nearest point, the UK/Netherlands median line is situated approximately 64 km east of the proposed development area. As any physical impacts will be limited in extent to the area immediately surrounding the development location there will be no transboundary effects caused by the physical presence of the Southwark field Development and its associated activities.

5.1.5 Mitigation Measures

The Southwark field is located within the North Norfolk Sandbanks and Saturn Reef SAC, designated for sandbanks and reefs. IOG will ensure that any disturbance to the seabed is kept to a minimum. Following operations, a seabed debris survey will be carried out to ensure no objects are left on the seabed that could impede seabed recovery.

Pipeline routing and the volumes and locations of rock placement and mattress installations will be designed to minimise the footprint on the seabed and impacts on the Annex I habitats, as far as practicable. The rock material to be used for the rock placement will be clean, inert and contain few entrained fines.

An environmental baseline survey and habitat assessment has been commissioned to characterise the seabed and identify the presence of any potential Annex I habitats within the development area prior to operations commencing.

5.1.6 Conclusions

Areas of the seabed affected by the long term development footprint will not be able to fully recover until cessation of the development and removal of the associated infrastructure. However, the disturbance will be localised, and the area affected small in relation to the surrounding undisturbed areas. There is expected to be strong potential for the recovery of the seabed over time via re-sedimentation and re-colonisation of benthos from the surrounding areas. The closest known biogenic reef (*Sabellaria*) lies approximately 33.8 km to the north-northwest of the Southwark platform. Due to the small area of seabed affected and the wide distribution of sandbanks within the NNSSR SAC and the SNS SAC, this effect is considered to be minor. No effects are anticipated in the surrounding SACs, due to distance from the development location.

5.2 Visual Impacts from the Shore

The Southwark field Development, at its closest point, is located approximately 55 km from the nearest shoreline. During drilling operations, the maximum elevation of the platform legs of the jack-up drilling rig will be approximately 82 m, resulting in a geometric horizon of 37 km for a person standing on the shore. Due to the refraction of light under certain atmospheric conditions, the theoretical visual actual horizon may be even slightly further away. However, as the legs of the drilling rig only make up a small part of the overall structure, in practice it would be very hard to resolve any discernible shape at this distance, as the structure would be imperceptible to the human eye.

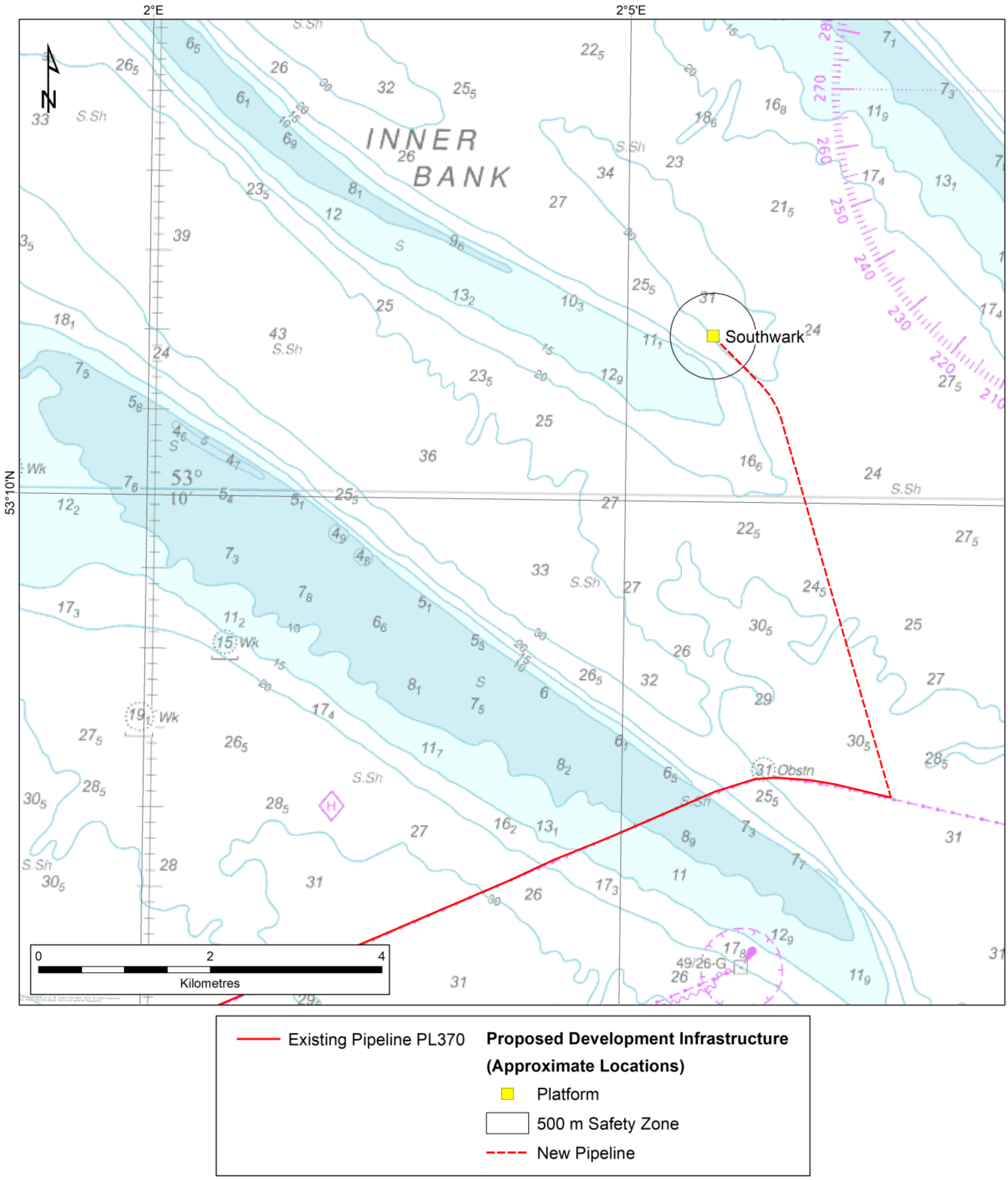
The maximum elevation of the Southwark platform will be 38.6 m above LAT, resulting in a geometric horizon of approximately 27 km, meaning the platform will not be visible from the shore at sea level. From higher vantage points, such as cliffs along the coast, the platform may be visible on clear days with very good visibility, however, given the size and shape of the platform it would be very hard to resolve any discernible shape at these distances.

In conclusion, the jack-up drilling rig may be just visible on clear days during the drilling operations (between 198 days and 296 days), but will be imperceptible to the human eye, under most conditions. The Southwark platform will not be visible from the shore at sea level. Therefore, the potential visual impacts associated with the Southwark field Development are deemed to be insignificant.

5.3 Fishing, Shipping and Navigation

5.3.1 Physical Extent of the Area Affected by the Proposed Operations

During the drilling and production phases, 500 m statutory safety zones will be established around the Southwark platform, prohibiting non-operational marine traffic for the lifetime of the development. This safety zone measures 0.785 km^2 for the platform at the Southwark field development. Therefore, there will be small navigational risk to general shipping activity.



Sources: UK Oil and Gas Data 2018; Charts from MarineFIND.co.uk © Crown Copyright, 2018.
All rights reserved. Licence No. EK001-0626-MF0076. Not to be used for navigation.

Figure 5.1: Safety zones during drilling and production phases

5.3.2 Impacts on Fisheries

For fisheries statistics purposes, the north-east Atlantic is divided into rectangles by the International Council for the Exploration of the Sea (ICES). The Southwark field lies within ICES rectangle 35F2. Each ICES statistical rectangle is 30' latitude by 1° longitude in size. ICES rectangle 35F2 is approximately 3,700 km² in area.

Section 3, The Local Environment provides a detailed breakdown of the landings for the demersal, pelagic and shellfish fisheries for ICES rectangle 35F2 between 2013 and 2017. Demersal fisheries contributed to 0.06% of the total UK demersal catch value in 2017, with shellfish and pelagic fish contributing to an even smaller amount (Section 3.5.1).

Fishing vessels will be prohibited from entering the 500 m safety zones around the Southwark platform, amounting to 0.785 km^2 in total. In addition, any subsea infrastructure extending above the seabed surface will effectively reduce the area of fishing grounds available.

The Southwark to PL370 export pipeline will be surface laid and is 5.86 km in length. For the purposes of this assessment it is assumed that areas within 200 m of the pipeline will be lost as fishing grounds. Consequently, the overall area rendered unavailable to fishing beyond the platform safety zone is calculated to be 2.149 km^2. The potential fishing area unavailable totals 2.935 km^2, which represents 0.079% of ICES rectangle 35F2.

Fisheries landings vary between years for many complex, often natural, reasons, so any reduction in fishing grounds should be placed in context to the inter-annual variation. Table 3.4 shows that proportional inter-annual variation for the demersal landings weight in ICES Rectangle 35F2 varies between -32.3% (2014 to 2015) and +2.6% (2015 to 2016). The inter-annual variation for the shellfish landings weight varies between -98.9% (2014-2015) and +166.7% (2016-2017).

The proportion of fishing ground lost within ICES rectangle 35F2 (0.079%) is significantly smaller (more than 30 times smaller) than the smallest unsigned inter-annual variation (2.6%) between 2013 and 2017. The impact on commercial fisheries in the region is assessed as negligible, and therefore not significant.

The duration of the exclusion will remain in place for the lifetime of the development (anticipated to be approximately 18 years).

5.3.3 Impacts on Shipping and Navigation

The Vessel Traffic Study (VTS) carried out for the Southwark Field Development showed that 3987 vessels passed within 10 nautical miles (18.5 km) of the proposed Southwark platform location between 26/02/2017 00:00 and 25/02/2018 00:00 (Xodus, 2018). This is an average of approximately 10.92 vessels per day. The VTS identified that around 44.3% of the vessels transiting the study area were associated with offshore oil and gas activities, and a further 42.9% of transits represented cargo vessels or tankers.

Approximately 5.8% of AIS recorded transits across the study area were fishing-related. The remaining 7% represents a range of other purposes, including dredging, renewables, passenger, military and recreational uses (Xodus, 2018). The majority of vessels transiting within the 10 nm study area are sized between 1,000 DWT and 5,000 DWT (Xodus, 2018).

The majority of vessels in the wider area transit further inland to the west of the Southwark field (Chapter 3, Figure 3.7). Vessel traffic is heavily concentrated to the west of the Dudgeon Offshore Windfarm which is located 44.2 km west of Southwark (Xodus, 2018). Another area of higher shipping intensity, although significantly less busy than the area described above, is located approximately 5 km to the northeast of the Southwark platform (Chapter 3, Figure 3.7). Vessel transits are fairly consistent throughout the year, with a slight peak recorded in July (Xodus, 2018).

During the study period, only 20 vessels transited through the proposed 500 m platform safety zone, representing only 0.5% of the total traffic in the study area. Table 5.9 provides a breakdown of the vessel types.

Table 5.9: Breakdown of vessel types transiting the proposed 500 m platform safety zone.

Vessel type	Count
Research/Survey Vessel	7
Fishing Vessel	5
Offshore Supply Ship	3
Tug	3
General Cargo	1
Standby Safety Vessel	1
Total	**20**

As the majority of vessels in the Southwark Field Development VTS area are already transiting around the proposed Southwark field location (and outside the Southwark platform safety zone) it is considered that any impact on shipping and navigation in the area will be minimal and therefore not significant.

5.3.4 Impacts on Other Users of the Sea

No military practice and exercise areas (PEXA) have been highlighted in the vicinity of the development and the Ministry of Defence raised no objections during the consultation process. No other significant user groups known to use the project area were identified during the ENVID and informal consultation.

5.3.5 Cumulative and Transboundary Impacts

The infrastructure and activities associated with the Southwark field will contribute a very small incremental increase in existing fishing and shipping intensity in surrounding areas, due to displacement from the project area. However, the NA identified that the vast majority of vessel traffic in the area already transits further inland than the Southwark field, closer to the Dudgeon Offshore Windfarm which is located approximately 40 km to the west. An area of less intense shipping density is recorded to the north east of Southwark. As the majority of shipping activity in the area already routes around the proposed development area, it is considered that any potential cumulative impacts on shipping and navigation from the development and required safety zones would be low and therefore not significant.

The closest existing platforms are the ConocoPhillips operated Vulcan platform, located 8.6 km to the northwest of Southwark and the Shell operated Leman G platform located 7.4 km south of Southwark. The NA undertaken for the Dudgeon Offshore Wind Farm (OWF) considered platform supply vessel traffic across the proposed OWF footprint and predicted that this was likely to produce a new route to the west of the OWF boundary. Therefore, no significant cumulative impacts on platform supply traffic in the surrounding area are predicted.

At its nearest point, the UK/Netherlands median line is situated approximately 64 km east of the development area. As any physical impacts will be limited in extent, there will be no transboundary impacts incurred by the physical presence of the drilling rig, platform or the subsea wells.

5.3.6 Mitigation Measures

The statutory safety zones around the drilling rig will be enforced by an ERRV for the duration of drilling operations, preventing vessels from moving too close to the drilling rig. The drilling rig and other vessels operating in the area will be highly visible and have appropriate lighting, and other means of alerting all vessels of their presence.

To aid navigational safety, a Notice to Mariners will be posted prior to the drilling rig moving onto location, ensuring that all vessels, including fishing vessels, will be aware of their presence in advance and for the duration of operations. In addition, Kingfisher will be notified of the exact location of the platform and subsea infrastructure, allowing their inclusion in their fortnightly bulletin to fishing vessels. The UK Hydrographic Office (UKHO) will be notified so that charts can be amended to mark the position of the platform and subsea infrastructure.

The Southwark platform will have appropriate safety and navigational lighting permanently installed to alert other vessels and craft of its presence.

5.4 Conclusions

As the Southwark field is located within both the North Norfolk Sandbanks and Saturn Reef SAC and the Southern North Sea SAC, it is suggested that the receptor vale is 'very high', and the the magnitude of effect in this small area is moderate. However, as the area that will be affected is comparatively very small (i.e. between 0.000209% and 0.000214% of the North Norfolk Sandbanks and Saturn Reef SAC, and between 0.0000204% and 0.0000210% of the Southern North Sea SAC), it is not anticipated that the conservation status of either SAC will be affected, and thus the overall effect can be considered as not significant.

The jack-up drilling rig may be just visible from the shoreline on clear days during the drilling operations (between 198 days and 296 days), but will be imperceptible to the human eye, under most conditions. The Southwark platform will not be visible from the shore at sea level. Therefore, the potential visual impacts associated with the Southwark field development is deemed to be insignificant.

The majority of vessel traffic in the study area already transits more than 5 km around the proposed development and platform safety zones. The VTS identifies an intense area of shipping approximately 30 km southwest of the Vulcan Satellites Hub Development adjacent to the Dudgeon OWF. A less busy shipping route is present approximately 5 km north east of the proposed Southwark field. As only 20 vessels passed through the proposed 500 m safety zone during the year-long VTS, it is considered that the impact of the safety zone around Southwark would have a minor effect, and is therefore not significant.

The proportion of fishing grounds lost as a result of the statutory safety zone around the Southwark platform and potential exclusion around the surface-laid Southwark to PL370 export pipeline constitutes a very small proportion of the available grounds within ICES Rectangle 35F2. The proportional fishing area lost is more than 40 times smaller than the smallest inter-annual variation of demersal landings between 2013 and 2017. The impact is considered to be negligible, and therefore not significant.

No other users of the sea have been identified during the consultation stage that could be significantly affected by the development.

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Section 6

Marine Discharges

6 MARINE DISCHARGES

A limited number of the proposed operations at the Southwark field will result in discharges to the marine environment, either close to the seabed or at the sea surface. During the ENVID the following potential issues were scoped in for further assessment:

- Deposition of drill cuttings and associated muds directly to the seabed;
- Deposition of excess cement directly to the seabed.

These discharges have the potential to affect the marine environment through both physical and chemical mechanisms. This section will quantify the extent of these discharges and assess the potential significance of their associated effects.

6.1 Drilling and Cement Discharges

A detailed description of the well designs, section diameters and lengths, and drilling and cementing methods for all wells are provided in Section 2, Project Description. The drilling, cementing and discharge methods used will be the same for all wells.

Drill cuttings consist of the chips of crushed rock broken off by the drill bit as it extends the wellbore. Drill cuttings therefore vary in nature depending on the characteristics of the rock layers present and the drill bit used, but generally range in size between very fine clay sized particles (<2 µm) to coarse gravels (>30 mm) (Neff, 2005).

Seawater and high viscosity sweeps are used to clear the cuttings from the 36" top-hole sections. Sweeps are similar to drilling muds, but have a higher viscosity, and may incorporate agents such as bentonite or guar gum. These types of sweeps are of low environmental risk.

Drilling muds are fluids pumped down to the drill pipe to lubricate and cool the drill bit and to carry the cuttings to the surface. IOG plans to use water based muds (WBM) for all lower sections. WBM typically consist of a base fluid, either seawater or brine, within which clays and other mineral weighting agents such as bentonite are suspended. Additional chemical additives, including organic polymers such as glycol, may also be used to maintain the optimal performance of the mud. These chemicals are generally of low environmental risk and many are classified as PLONOR.

Whilst IOG's preference is to drill all lower sections with WBM, geological conditions encountered during drilling may necessitate the use of OBM in some lower sections of wells. The discharge of LTOBM is prohibited in UK waters therefore, should the use of LTOBM be required, it will be used in a closed system where cuttings and drilling fluids will be circulated back to the rig via the conductor, passed through a mud recovery system, and then shipped to shore for treatment and disposal. Spent LTOBM and cuttings will not be discharged into the marine environment. In addition, should LTOBM be used, completion chemicals and well bore clean-up chemicals will also be returned to the rig, and shipped to shore for treatment and disposal.

The casings used to prevent the well from collapsing will be cemented into place by pumping cement down the casing string, out through the bottom, and back up to the surface through the annulus. For the conductor (30") and surface casing (13⅜") it is critical to get cement back to seabed to ensure the structural integrity of the well and therefore some cement will be discharged to sea.

6.1.1 Discharges at the Seabed

Cuttings

Cuttings and viscous sweeps from the 36" sections will be discharged at the seabed, as is normal practice on the UKCS. Table 6.1 provides the estimated volumes and masses of drill cuttings and fluids that may be discharged from the 36" Sections at Southwark. It is estimated that between 902 and 1,353 tonnes of cuttings and 660 and 990 tonnes of sweeps will be discharged at the platform location.

Table 6.1: Estimated Combined Cuttings and Drilling Fluids Discharges at the Seabed from 36" Sections at the Southwark Platform

Platform	Section	Mud System	Discharge Point	Combined Duration of Discharge [hrs]	Cuttings Volume [m³]	Cuttings Generated [Tonnes]	Sweeps Discharged [Tonnes]
Southwark	36"	Seawater and viscous sweeps	Seabed	75	519	1,353	990

It is anticipated that over time the WBM and cuttings will be dispersed naturally by the strong tidal currents present. Cuttings dispersion modelling predicts that muds and cuttings are mainly transported along a northwest-southeast axis aligned with the sandbanks and dominant currents, with a net residual towards the southeast direction.

Cement

For the 30" conductors, the cement will be pumped down the drill string and up the conductor annulus to the seabed. Rather than mixing a large batch of cement at the outset, it will be mixed on demand and when cement is observed at seabed by the Remotely Operated Vehicle (ROV) mixing and pumping will be terminated to minimise the volume discharged. Table 6.2 provides estimates of the cement discharges at the seabed for the Southwark platform.

Table 6.2: Estimated Combined Cement Discharges at the Seabed from 36" Sections at the Southwark Platform

Platform	Section	Average Cement Pump Rate Per Well [m³/min]	Average Cement Discharge Duration Per Well [min]	Combined Potential Volume (All Wells) [m³]	Combined Potential Mass (All Wells) [t]
Southwark	36"	1.5	35	53	101

The proportions of excess cement that may set on the seabed or that may be washed away are highly variable, and depend on complex factors including the current speed and the chemical composition of the specific cement batch used. However, it is likely a proportion will set on the seabed, and the rest will be washed away.

6.1.2 Discharges at the Sea Surface

Cuttings

Cuttings and drilling fluids from lower sections will be returned to the rig via the conductor, and passed through a mud recovery system to recover as much of the drilling mud as possible. Once reconditioned, this mud will be used again, thereby minimising the amount of drilling mud required. Cuttings from lower sections will be discharged at the sea surface. Table 6.3 provides the estimated combined durations, volumes and masses of drill cuttings and fluids that are expected to be discharged at the sea surface for all wells at the Southwark platform.

Table 6.3: Estimated Combined Cuttings and Drilling Fluids Discharges at the Sea Surface from Lower Sections at Southwark

Section	Mud System	Discharge Point	Combined Duration of Discharge [hrs]	Total Cuttings Volume [m³]	Total Cuttings Generated [t]	Total WBM Discharged [t]
17½"	WBM	Rig	396	592	1,539	2,688
12¼"	WBM	Rig	279	228	592	1,684
8½"	WBM	Rig	527	99	257	1,644
6"	WBM	Rig	818	87	227	979
Total			**2020**	**1006**	**2,615**	**6,995**

It is anticipated that the cuttings and any residual WBM will be dispersed naturally by the strong tidal currents, and that there will be no requirement for mechanical cuttings relocation or dredging. Cuttings dispersion modelling predicts that cuttings will be predominantly distributed along the prevailing tidal current direction i.e. northwest-southeast. Section 6.1.3 *Modelled Extent of Discharges* provides details about the modelling scenarios and the model outputs.

<u>Cement</u>

The 13⅜" casing will be cemented to seabed but for this section any excess cement returns will be returned to the rig before being discharged overboard in the same manner as drill cuttings. The liners of lower sections will not be cemented back to seabed, however it is anticipated that small quantities of cement will be circulated back to the rig from the 8½" and 6" sections, processed through the rig's fluid handling system, and discharged at the sea surface. Table 6.4 provide the estimated combined volumes and masses of cement that are expected to be discharged at the sea surface for all wells at the Southwark platform.

Table 6.4: Estimated Combined Cement Discharges at the Sea Surface at Southwark Platform

Section	Discharge Point	Average Cement Pump Rate Per Well [m³/min]	Average Cement Discharge Duration Per Well [min]	Combined Potential Volume (All Wells) [m³]	Combined Potential Mass (All Wells) [t]
17½"	Rig/Sea surface	1.5	17	26	39
8.5"	Rig/Sea surface	1	3	5	11
6"	Rig/Sea surface	1	4	4	7
Total				**35**	**57**

As the cement is being discharged at the sea surface into well mixed and strongly tidal waters, it is anticipated that the majority of the cement will be dispersed more widely to the marine environment. Emitted cement will react with the seawater and is expected to settle through the water column over time.

6.1.3 Modelled Extent of Discharges

Cuttings dispersion modelling was undertaken for the proposed drilling operations (Fugro, 2018), in order to delineate the physical extent of the discharged drill cuttings. To get a realistic representation of the nature of the current circulation in the Southwark area, the dispersion modelling was based on a time series of 3D currents obtained with the Delft3D-FLOW model over a 1-year period. Modelling scenarios at each platform location used the combined durations, volumes and masses for all wells at the platform.

The potential dispersion of the drill cuttings is predicted by an advection-diffusion model, whereby two scenarios were modelled:

- Scenario 1 – Estimation of (maximum) anticipated thickness of deposition;
- Scenario 2 – Estimation of (maximum) anticipated extent of cuttings deposition.

For Scenario 1 the drill cuttings are released according to the planned drilling schedule, and an instant is selected for the start of the modelling period. Scenario 1 provides the best estimate on the thickness of the cuttings deposits on the seafloor at increasing distances from the well location. However, as the conditions at the actual time of drilling will differ from those considered at the time of modelling, this scenario will not capture the (full) range of directional spreading of the deposits, because the zone of deposition will be influenced by the magnitude and orientation of the currents over the selected modelling period.

Therefore, Scenario 2 was run to account for the variability associated with the tidal cycles and residual currents. It considers that the drill cuttings are released continuously during a much longer total discharge duration of 6 months. This approach ensures that the dispersion modelling captures the variability of the currents over that period in both intensity and orientation. It provides the best estimate for the maximum directional spreading of the drill cuttings away from the well location. However, the modelling results from Scenario 2 will underestimate the deposit thickness, as the drill cuttings are being dispersed over a wider area.

The results of the cuttings dispersion modelling show that the coarsest cuttings particles will be deposited very close to the well location, while the fraction of finest cuttings particles released at the sea surface may be transported over very large distances in excess of 100 km. However, the associated deposits have a noticeable thickness only in very close proximity (~150 m) of the well location, and very rapidly reduce to sub-millimetric scale at a distance in excess of ~500 m.

Figure 6.1 shows the model outputs for the maximum thickness deposition scenario for all wells combined and Figure 6.2 shows the model outputs for the maximum extent of deposition scenario for all wells combined.

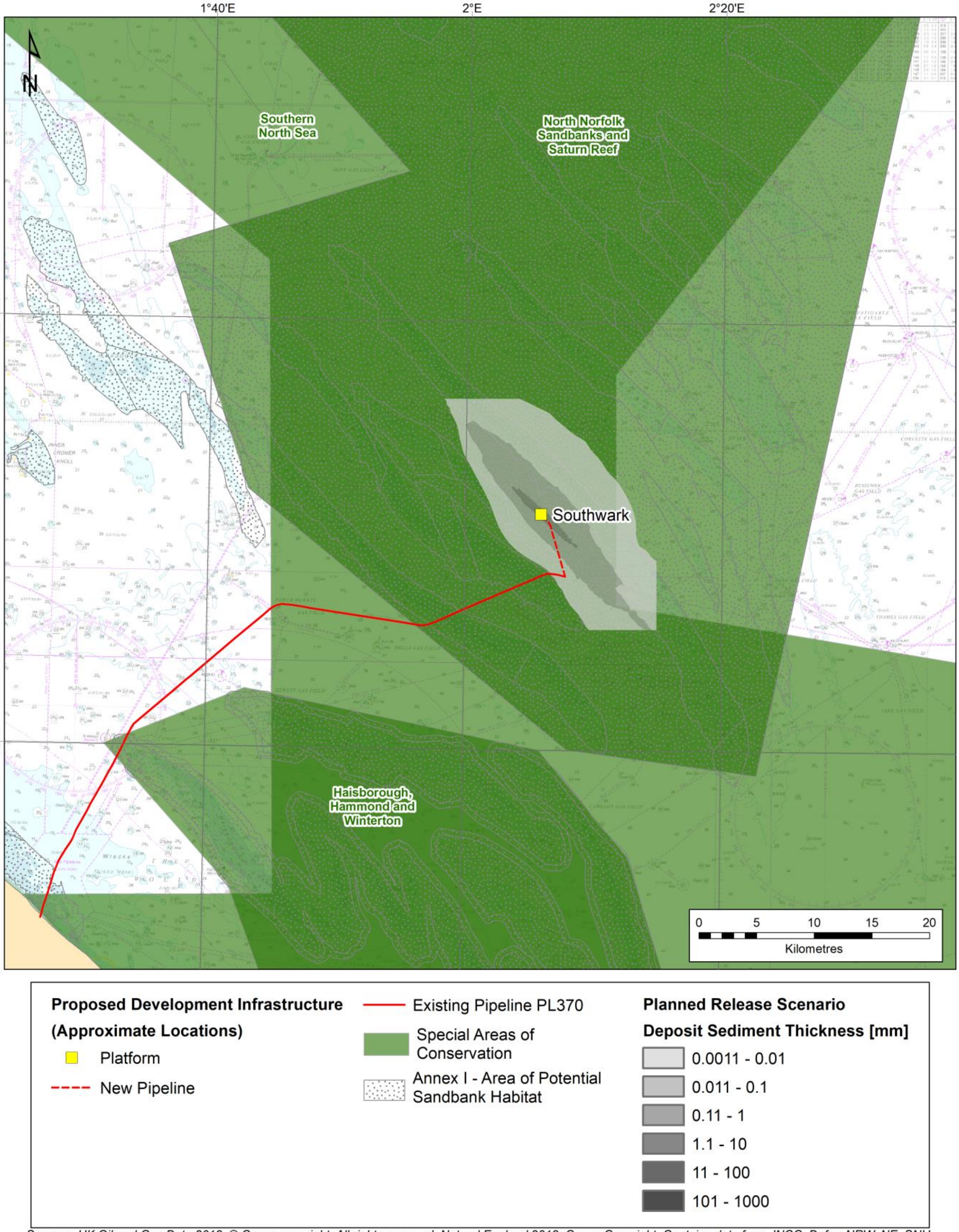

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Figure 6.1: Modelling results of maximum predicted thickness of deposition of drilling discharges

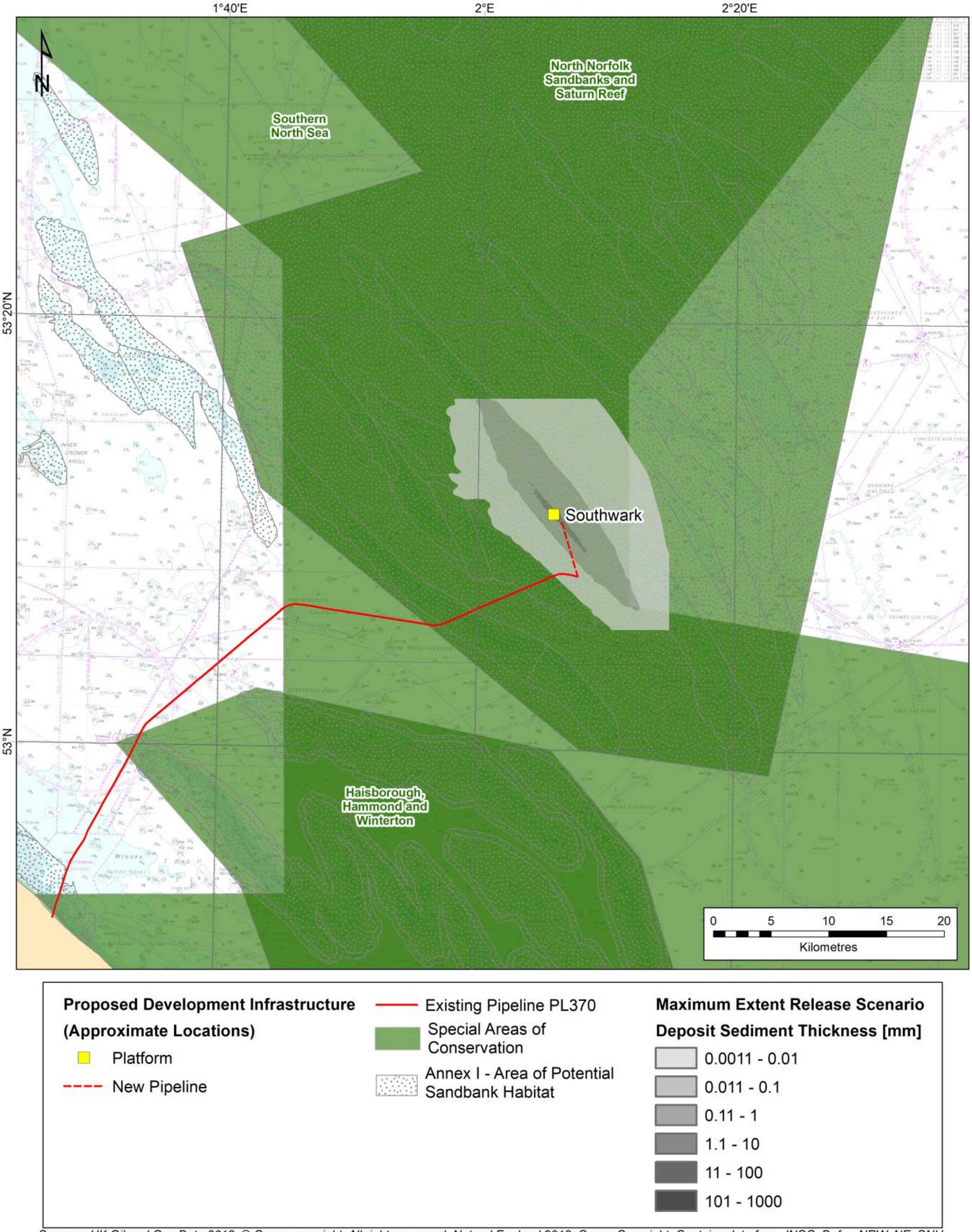

Figure 6.2: Modelling results of maximum predicted extent of deposition of drilling discharges

Figure 6.3 shows the contour plot for the modelled cuttings piles at Southwark.

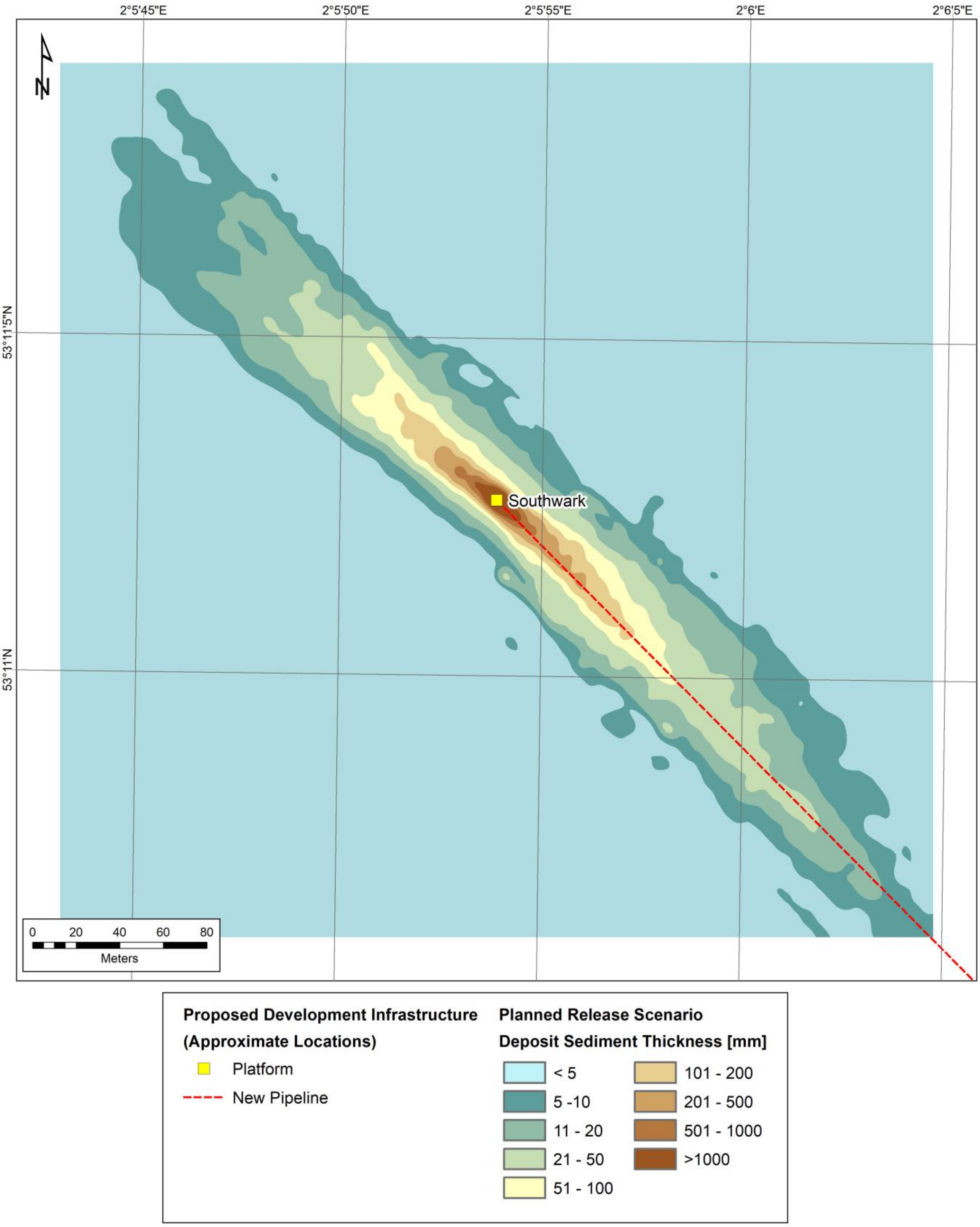

Figure 6.3: Contour plot of modelled drill cuttings pile at Southwark

Table 6.5 provides the areal extent of different thicknesses of modelled deposited cuttings, the maximum distance from the top holes of each thickness class and the maximum height of each cuttings pile for Southwark.

Table 6.5: Topographical Metrics of the Modelled Southwark Cuttings Pile

Thickness [mm]	Area [km²]	Max Distance from Top Holes [m]
>5	0.0299	283
>10	0.0182	253
>20	0.0099	211
>50	0.0040	118
>100	0.0020	89
>200	0.0009	58
>300	0.0006	35
>500	0.0003	24
>1000	0.0002	14
Max Thickness [m]		**6.80**

6.1.4 Environmental Effects

Extent and Persistence, and Proximity to Protected Sites and Annex 1 Habitats

Near-bed current velocities and sediment mobility in the Southern North Sea are generally sufficient to prevent detectable local accumulation of cuttings after drilling has ceased (DTI, 2001; OSPAR, 2007; Henry *et al.*, 2017). Any immediate local accumulation of cuttings would be short term in duration and very quickly dispersed to the wider environment.

The modelling study, and observations of other wells drilled in the southern North Sea, demonstrate that dispersion of cuttings is expected to occur whilst drilling is performed and immediately after the cessation of drilling (Gerard et al., 1999; Fugro, 2018c). Various studies have observed that the strong current regime of the southern North Sea means that drilling cuttings piles do not persist (Gerrard, 1999; DECC, 2015; Henry et al., 2017). Gerrard et al. (1999) noted that southern North Sea "drill cuttings and muds are rapidly dispersed and piles do not typically form in this area", DECC (2015) stated that WBM cuttings "have been shown to disperse rapidly and to have minimal ecological effects", and Henry et al. (2017) found that benthic recovery may have been faster "due to the stronger current regime in this region, which prevents cutting piles to build up".

Daan and Mulder (1996) sampled the benthic fauna around a well drilled with WBM in the Dutch sector of the southern North Sea at two months after drilling and one year after drilling. No effect on the benthic community was detectable at two months, even within 25 m of the top hole.

An OSPAR review of environmental monitoring results from the United Kingdom, the Netherlands and Norway concluded that the effects of WBM cuttings discharge on the seabed fauna tend to be very subtle or undetectable. Any disturbance of the fauna typically only occurs within 50 m from single well locations, and is most likely caused by the physical impact of the cuttings (OSPAR, 2007). Whilst the wells considered were at a deeper depth than at Southwark, this impact distance provided as a worst-case scenario for the purposes of this impact assessment. However, this figure is likely to represent an overestimate of the potential extent of disturbance to benthic fauna from the discharge of WBM cuttings in the stronger current regime of the southern North Sea, given the rapid dispersal of cuttings.

The Marine Evidence-based Sensitivity Assessment (MarESA) pressure benchmarks for assessment purposes (Tillin, 2015; Tyler-Walters et al., 2018) are based on previous studies by the OSPAR Intercessional Correspondence Group on Cumulative Effects (ICG-C) (OSPAR, 2011). These benchmarks describe deposition of fine sediment up to 5 cm depth as "light" smothering, and anything between 5 cm and 30 cm as "heavy" smothering. These levels of smothering are defined as temporary and reversible.

Therefore, for the purposes of this assessment, cuttings deposition of greater than 30 cm is deemed to have a temporary adverse effect on benthic communities. The Southwark field lies within the boundaries of the North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC, which is designated for the Annex I habitats *Sandbanks which are slightly covered by sea water all the time* and *Reefs*, specifically *Sabellaria spinulosa* biogenic reefs. The total area of the NNSSR SAC is 3,603 km^2, and the total area of the SNS SAC is 36,796.42 km^2. Table 6.6 provides the maximum area of seabed covered by drilling discharges of greater than 30 cm thickness predicted from the cuttings dispersion modelling, and the relative proportions of each SAC which will be temporarily affected.

Table 6.6: Maximum Area of Seabed Covered by Drilling Discharges of > 30 cm thickness and Proportion of the SAC Affected

SAC	Max Area of Thickness Exceeding 30 cm [km²]	Proportion of NNSSR SAC Area [%]
North Norfolk Sandbanks and Saturn Reef	0.0006	0.0000167%
Southern North Sea	0.0006	0.0000016%

Cuttings thickness drops below the 30 cm level beyond 35 m from the top hole (Table 6.5).

<u>Physical Effects on Benthic Communities</u>

Considerable data have been gathered from studies into the effects of drill cuttings and WBM on benthic communities, conducted at various sites on the UKCS and worldwide as part of academic research and general environmental monitoring of the oil and gas industry including DTI, 2001; Neff, 2005; OSPAR, 2007. This work has led to a broad consensus on the potential effects that discharged cuttings and associated fluids can have on benthic organisms and communities.

The primary impact identified with regard to WBM cuttings discharges is the direct smothering effect of burial by material discharged as it settles on the seabed (Neff, 2005; OSPAR, 2007; Gates and Jones, 2012). Vulnerability to the impact caused by cuttings discharge varies between different benthic groups, depending on their physiology and ecology, and some species (such as sessile species) are likely to be more sensitive than others. For example, in the case of burrowing organisms, which feed on subsurface sediments, many such species are capable of burrowing up through deposited sediment ranging from 10 mm to 300 mm in thickness to live at the new sediment surface (e.g. Maurer *et al*., 1979; Kukert, 1991). However, it is unlikely that whole communities would survive prolonged burial under more than a few centimetres.

The presence of cuttings material on the seabed also prevents the flow of oxygen and nutrients to the affected areas. This oxygen depletion and associated disruption of nutrient flow can be sufficient to reduce the abundance and diversity of the benthos (Neff, 2005; Trannum *et al*., 2010).

Although there are no studies available into the specific effects of cement discharges, it is anticipated that the primary effects of particulate discharges will also arise from the physical smothering of organisms within the area of cement deposition.

Increased concentrations of suspended particles in the water near the seabed may also cause damage to feeding and respiratory organs, causing metabolic stress and reducing growth, and also affecting reproductive and survival rates. This, for example, has been demonstrated in scallops and other bivalves (Cranford *et al*., 1999; Bechmann *et al*., 2006). Larger individuals are generally more resistant to elevated levels of suspended solids in the water column, and some species are likely to be more sensitive than others. It should also be noted that effects related to increased suspended sediment levels will mostly take place close to the well location and for a limited time period.

The accumulation of cuttings, WBM particles and cement in the vicinity of the Southwark field is therefore, likely to chiefly affect the local benthic community by burying animals and also by impairing the feeding and respiration activities of others.

<u>Chemical Effects on Benthic Communities</u>

The majority of constituent chemicals used in both the WBM itself and additional drilling chemicals are generally highly water soluble and show low persistence, toxicity and likelihood to be incorporated into the tissues of marine organisms. Weighting agents found in drilling muds, such as barite, may contain naturally occurring elevated levels of barium and other metals, which will typically be higher than those found in local seabed sediments.

However, field studies have found that the metals and metal salts associated with barite, clay, and cuttings particles are not readily bio-accumulated by animals living in close association with cuttings piles and the metals are not passed efficiently through marine food chains (Neff, 1987; Neff *et al*, 1989; URS, 2002; Neff, 2010). Field studies of organisms around cuttings piles have observed that upon intake by ingestion or adhesion to epithelial surfaces, the majority of metals remain bound to cuttings grains in an insoluble form and are not bioavailable. Jenkins *et al*. (1989) found that around 97 % of the barium content remained in granular form and were not assimilated into the study species' tissues. In general, any toxic effects of WBM associated with cuttings discharge have been generally deemed to be negligible (Neff, 2005; Neff, 2010; OSPAR, 2007).

The hydrodynamic regime of the Southern North Sea is conducive to rapid dilution and dispersion of solutes. The chemical additives in the WBM are generally water-soluble and will therefore dissolve and disperse naturally in the water column.

6.1.5 Potential for Recovery

As the physical and chemical effects of the cuttings and mud discharges are of greatest concern, the long-term recovery of affected communities will be influenced by the persistence of the discharged material itself. Cuttings piles associated with WBM are known to be significantly less persistent than those formed with oil based fluids. Cuttings piles in the Southern North Sea will disperse far more rapidly than those in the central and northern North Sea, which will typically disperse over a timescale of 1 year to 10 years (DTI, 2001). The process of cuttings dispersion would begin during drilling and would continue after the cessation of drilling (DTI, 2001; Henry *et al*., 2017).

Recovery of the benthic communities in the Southern North Sea has been shown to begin soon after the discharge has ceased, via colonisation from surrounding areas and planktonic recruitment (Daan and Mulder, 1996). A review of historical cuttings pile data concluded that benthos in the southern North Sea could be acceptably monitored for a period of one year after drilling, and that the small footprint of effects on benthos meant that the zone of influence is likely to be limited to within 200 m (Henry *et al*., 2017). This evidence base indicates that the dispersion of cuttings and the recolonisation by surrounding benthic communities over one year should promote the reestablishment of pre-drill species richness and relative abundance.

As mentioned in Section 3 Local Environment, the seabed communities at the Southwark field are typical of those found in surrounding areas of the Southern North Sea, therefore the potential for such recruitment from representative reproducing populations is likely to be strong. The altered substrate will be dispersed relatively quickly, particularly where it is more thinly deposited, allowing communities consistent with those present pre-drilling to be re-established.

Therefore, the temporary accumulation of drill cuttings > 30 cm in a strongly tidal and highly mobile coarse and mixed sediment environment is assessed as having a short-term and reversible effect on benthic communities.

6.2 Production Discharges

6.2.1 Produced Water and Production Chemical Discharges

No produced water will be discharged from the Southwark platform, with all reservoir fluids and production chemicals being exported to Bacton Terminal for treatment. Fluids and materials mobilised by pipeline pigging operations will also be exported along PL370 for treatment at the Bacton Terminal.

6.2.2 Discharges at the Sea Surface

A number of chemicals will be used on the drilling rig for maintenance, such as detergents to wash the rig floors and lubricants for certain equipment and machinery. The use and subsequent potential discharge of these chemicals were considered to have negligible environmental effects and were scoped out at the ENVID stage and will be managed and regulated under the existing chemical and oil discharge permitting regimes.

6.3 Cumulative and Transboundary Impacts

The closest existing platforms are the Shell operated Leman G platform located 7.4 km to the south of the Southwark platform and the ConocoPhillips operated Vulcan 1 platform located 8.6 km to the northwest of Southwark platform. The nearest existing marine infrastructure to the development is the Dudgeon OWF, with the closest individual turbine approximately 44.2 km to the west, along with the planning phase Dudgeon extension 37.4 km to the west, and the under-construction Norfolk Vanguard West Wind Farm 30.8 km to the southeast.

There are also several marine aggregate licence areas within the region with the closest to Southwark being Area 484 at a distance of 30.8 km to the north. At its nearest point, the UK/Netherlands median line is situated approximately 64 km east of the development area. As the zone of influence of the drilling discharges is anticipated to be limited to within 150 m from each individual well, no cumulative and transboundary impacts are anticipated.

6.4 Mitigation Measures

All chemicals used for the drilling operations are regulated under the Offshore Chemicals Regulations 2002 (as amended), which aims to replace chemicals with poor environmental characteristics by more environmentally friendly chemicals. Selection of all chemicals that may be used in drilling the proposed well will be based upon both their technical specifications, including their environmental performance. The use of all chemicals will be minimised where practicable.

For cement discharges, the amount discharged onto the seabed during installation of the conductor casing will be minimised by visual monitoring of the operation by a ROV. Once returns are observed, pumping will be stopped in order to minimise discharged volume.

Should any of the lower well sections be drilled with LTOBM, all cuttings and drilling fluids returned to the drilling rig, and shipped to shore for appropriate treatment and disposal. No LTOBM and associated cuttings will be discharged at sea.

In addition, the drilling mud, cuttings and minor quantities of cement discharged from the drilling rig will be discharged at the sea surface, allowing dilution and dispersion over a larger area and thereby minimising the overall environmental impact.

6.5 Conclusions

All chemicals to be used will be Offshore Chemical Notification Scheme (OCNS) registered by Cefas, which means they are approved for use on the UKCS. A permit for the use and discharge of these chemicals will be applied for to OPRED, in accordance with the Offshore Chemicals Regulations 2002 (as amended). Wherever practicable and technically feasible, chemicals without substitution warnings will be prioritised over those that do have warnings.

The effects of WBM and cuttings discharges on the benthic environment are related to the total quantity discharged and the oceanic energy regime encountered at the discharge site, particularly the currents close to the seabed itself (Neff, 2005).

Based on these factors, the discharge of cuttings and drilling fluids at the Southwark field well locations have the potential to cause a temporary localised impact to the benthic environment, primarily through direct physical changes to the seabed. This effect is expected to be chiefly limited to within 50 m of the well location. These effects will be temporary and are expected to reduce rapidly as the cuttings and associated fluids are dispersed by local currents. Recovery of the benthos is expected to begin soon after discharges cease.

The maximum proportion of the NNSSR SAC predicted to be covered by drilling deposits of greater than 30 cm is 0.0000167%, and maximum proportion of the SNS SAC predicted to be covered by drilling deposits of greater than 30 cm is 0.0000016%. These proportions are more than four orders of magnitude less than 1 %.

It is important to note that this is the initial predicted area, which is expected to rapidly decrease as the strongly tidal regime disperses the cuttings and drilling fluids. Given the proportionally small area affected, the highly mobile nature of the sand bank systems and the ephemeral nature of the *Sabellaria spinulosa* reefs, drilling discharges are anticipated to have minor, short term effects, and are not considered significant. These drilling discharges are not anticipated to have adverse effects on the integrity of the NNSSR SAC, the SNS SAC or the wider network or European sites, either alone or in combination with other plans and projects, and with regard to their conservation objectives.

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Section 7

Noise Generation and Wildlife Disturbance

7 NOISE GENERATION AND WILDLIFE DISTURBANCE

The following issues and concerns were raised during the ENVID and informal consultation, and will therefore be considered in this section on noise generation and wildlife disturbance:

- Sound produced by vessels, jack-up rig and helicopters including thrusters, propellers and engines resonating through the water column may have a significant effect on the marine environment, specifically marine mammals and fish;
- Sound produced by (potential) piling operations associated with the installation of the platform and fixing infrastructure to the seabed may have a significant effect on the marine environment, specifically marine mammals and fish.

During the drilling operations in the Southwark field, noise will be generated by the jack up drilling rig during drilling and also by support vessels (i.e. the standby vessel, supply vessels and well stimulation vessel) and helicopters. Additional (shipping) noise will be generated by the vessels used for laying the pipeline and the installation of the platform.

As mentioned in section 2.5.2, the preferred option to secure the platform legs is by using suction piles. However, if this proves to be not technically feasible then the four platform legs will be piled into the seabed instead, using a hydraulic hammer. Therefore, the loudest potential sound source will be the piling noise generated during platform installation. Once the platform is in place, underwater noise generation will be minimal and will be mainly limited to that generated by vessels and helicopters visiting the platform. The remainder of this section will therefore primarily focus on the piling noise, which has the potential to affect behaviour, and in extreme cases even injure local wildlife.

This section further assesses the requirement for a wildlife disturbance licence, using the criteria for undertaking such an assessment outlined in the latest version of the JNCC draft guidance notes (JNCC, 2010a).

7.1. Quantification of Noise

7.1.1. Ambient Noise

Ambient or background noise in the ocean consists of a broad range of individual sound sources and is made up of natural, as well as manmade sources (Hildebrand, 2004). The ambient acoustic environment of the ocean is highly variable.

The dominant source of naturally occurring noise is associated with ocean surface waves generated by the wind. This noise occurs across a range of frequencies from 1 Hz to 100 kHz (NRC, 2003). Other natural sounds in the sea include currents, rain, echo-location and communication noises generated by cetaceans and fish and other natural sources such as tectonic activity.

In addition to naturally occurring sounds, there is anthropogenic noise generated by air traffic, shipping activity and the oil and gas industry, amongst other activities. Of these, shipping is the dominant source of sound in the world's oceans, generally within a range from five to a few hundred Hertz (NRC, 2003). These anthropogenic noise levels in the oceans have increased significantly over the last few decades (e.g. Hatch & Wright, 2007; Andrew *et al.*, 2002) giving marine animals little time to adapt to these changes in an evolutionary sense. Table 7.1 shows various examples of anthropogenic sources and received levels of sound in the marine environment.

Table 7.1: Sound Sources from Various Examples of Maritime Activities

Activity	Dominant Frequency Range [kHz]	Average Source Level [dB re 1µPa at 1 m]	Estimated Received Level at Different Ranges [km]			
			0.1 km	1 km	10 km	100 km
High resolution geophysical survey; pingers, sidescan, fathometer	10 - 200	<230	190	169	144	69
Low resolution geophysical seismic survey; seismic air gun	0.008 - 0.2	248	210	144	118	102
			208	187	162	87
Production drilling	0.25	163	123	102	77	2
Jack-up drilling rig	0.005 - 1.2	85 - 127	45 - 87	24 - 66	<41	0
Semi-submersible rig	0.016 - 0.2	167 - 171	127 - 131	106 - 110	81 - 85	6 - 10
Drill ship	0.01 - 10	179 - 191	139 - 151	118 - 130	93 - 105	18 - 30
Large merchant vessel	0.005 - 0.9	160 - 190	120 - 150	99 - 129	74 - 104	<29
Military vessel	Not known	190 - 203	150 - 163	129 - 142	104 - 117	29 - 42
Super tanker	0.02 - 0.1	187 - 232	147 - 192	126 - 171	101 - 146	26 - 71

Adapted from: Evans & Nice, 1996 and Richardson *et al.*, 1995.

Figure 7.1 represents ambient noise as a function of frequency; the ambient noise spectrum normally lies between the two thick green lines shown.

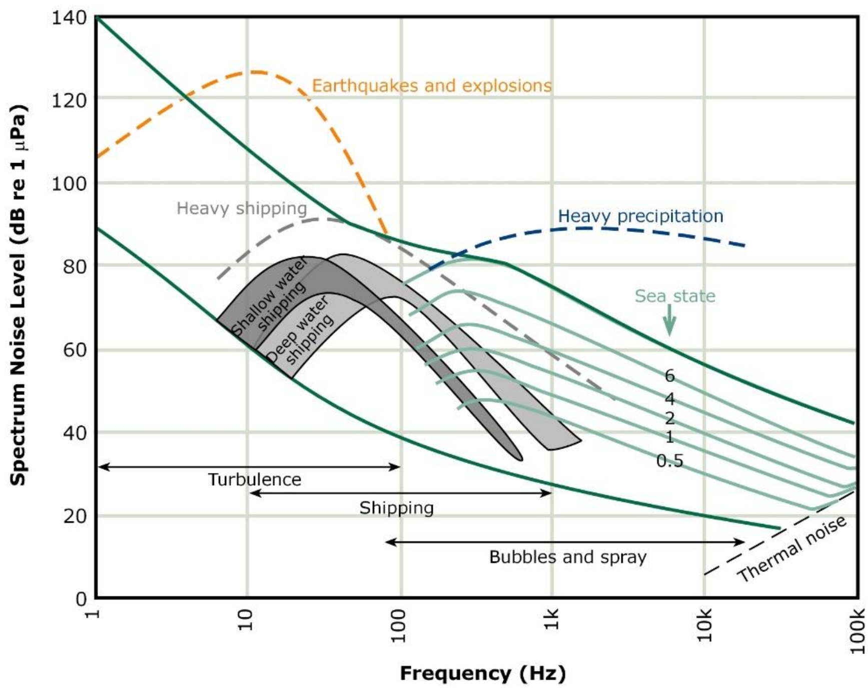

Figure 7.1: Ambient noise spectra in the open ocean

Source: Adapted from Wenz, 1962; NRC, 2003; and Harland *et al.*, 2005.

7.1.2. Underwater Noise from Piling During Platform Installation

The amount of underwater sound generated during the proposed piling operations depends on many factors, including size (length and diameter) and material of the pile itself, properties of the hammer, water depth, and underlying geology, and is therefore very hard to estimate. Wyatt (2008) shows there is a strong correlation between the diameter of the pile and the piling noise generated. Section 2.5.2 describes the piling operations required to install the Southwark platform jacket on the seabed. The piles for the Southwark platform will have a diameter of 2.13 m (84”), corresponding to an estimated peak to peak sound pressure level of 244 dB re 1µPa at 1 m, based on the correlation between pile diameter and generated piling noise presented in Wyatt (2008). Consequently, the associated or ‘flat peak’ or ‘0-peak’ value will be approximately 238 dB re 1µPa at 1 m.

Piling generates underwater sound over a wide frequency range, however, the peak frequency levels of piling noise can be expected between 200 Hz and 500 Hz, with a significant roll off in pulse energy above 8 kHz, with low intensity levels reaching frequencies up to 22 kHz (Lepper *et al.*, 2007). The Southwark platform will have four legs, with each platform leg requiring one single pile. Installation of the jacket structure is anticipated to take up to 1 day per pile, thus 4 days in total. However, it should be noted that the actual piling operations itself will only take up to 6 hours per pile.

7.1.3. Underwater Sound Behaviour

As sound spreads underwater, it decreases in strength with distance from the source. This transmission loss is the sum of spreading loss and attenuation loss. Spreading loss is the geometric weakening of a sound signal as it spreads outwards from a source. Attenuation losses are the physical processes in the sea that distort the mathematical spreading laws. A number of factors including sound absorption or scattering by organisms in the water column, reflection or scattering at the seabed and sea surface, and the effects of temperature, pressure, stratification and salinity affect these physical processes. Variations in temperature and salinity with depth cause sound waves to be refracted downwards or upwards causing increases or decreases in sound attenuation and absorption. Actual sound transmission therefore has considerable temporal and spatial variability that is difficult to quantify.

Formula 1 describes the spreading loss applicable for piling sound in this part of the North Sea, which is based on the intermediate between spherical and cylindrical spreading to reflect the relatively shallow water (<50 m) interspersed with sand banks in the area.

$$SPL_R = SPL_{Source} - 15 \cdot Log_{10}(R) + A \cdot R \qquad (Formula\ 1)$$

SPL_R	=	Sound pressure Level (at distance ‘R’ from the sound source)
SPL_{Source}	=	Source level
R	=	Distance from sound source (in metres)
A	=	Attenuation loss / absorption loss coefficient (0.00043 dB/m)

7.2. Impacts from Sound Generated by the Proposed Activities

This section assesses potential impacts from underwater sound, focussing on marine mammals and fish which are the species believed to be most at risk from noise impacts which may arise from the proposed Southwark platform installation.

Sound is a particularly efficient way to propagate energy through the ocean, and many marine animals use hearing as their primary sense. Cetaceans are heavily dependent on sound for food-finding, communication, reproduction, detection of predators and navigation (Weilgart, 2007; Hildebrand, 2004).

As described in Section 7.1, the ocean is a naturally noisy environment and cetaceans in particular have evolved hearing that functions well within this context. A review of anatomical and behavioural studies by Ketten (2004) indicated that whales and dolphins may be more resistant than many land mammals to temporary threshold shifts. However, these data also show that they are subject to disease and aging processes and are therefore not immune to hearing loss. Increasing ambient noise via human activities is a potential candidate for exacerbating or accelerating such losses.

The introduction of additional noise into the marine environment could potentially interfere with an animal’s ability to determine the presence of other individuals, predators, prey and underwater features and obstructions. Significant adverse noise could also cause behavioural changes, such as avoidance of preferred feeding areas or migration routes and, in more extreme cases, cause auditory damage.

7.2.1. Effects on Marine Mammals

Marine mammals use sound in various important contexts, such as in social interactions, foraging, and response to predators (Southall *et al.*, 2007). Hearing is the primary sensory system for marine mammals, which is clearly shown by their level of ear and neural auditory centre development (Ketten, 2004). As the sea has never been a silent place, the ears of marine mammals, and those of whales and dolphins in particular, have evolved to function well within this context of ambient noise. However, little information exists to describe how marine mammals respond physically and behaviourally to intense sounds and to long term increases in ambient noise levels (NRC, 2003).

Marine mammals vary in regard to their hearing sensitivities and in order to assess the impacts of sound can be classed into functional hearing groups (Southall et al, 2007; NOAA, 2016; NOAA, 2018; and most recently Southall et al, 2019). The classification into functional hearing groups takes into account that not all marine mammal species have identical hearing or susceptibility to noise-induced hearing loss. Table 7.2 applies the most up to date classification by Southall et al (2019) to the species that may be present in the wider area around the Southwark Platform. Outside their generalized hearing ranges, the risk of auditory impacts from sounds is considered highly unlikely or very low. According to this classification, harbour porpoises are regarded as 'very high-frequency cetaceans', white-beaked dolphins and Atlantic white-sided dolphins are classified as 'high-frequency cetaceans'. This classification is based on the fact that odontocetes have highly advanced echolocation systems that use intermediate to very high frequencies. They also produce social sounds in a lower-frequency band, including generally low to intermediate frequencies (1 kHz to tens of kHz). Consequently, their functional hearing is expected to cover this whole range; however, their hearing sensitivity typically peaks at or near the frequency where echolocation signals are strongest (Southall et al, 2019).

All mysticetes (i.e. the large baleen whales) are all categorised as 'low-frequency cetaceans'. No direct measurements of hearing exist for these animals and theories regarding their sensory capabilities are consequently speculative. In these species, hearing sensitivity has been estimated from behavioural responses (or lack thereof) to sounds at various frequencies, most common vocalisation frequencies, body size, ambient noise levels at the frequencies they use most, and cochlear morphology. At present, the lower and upper frequencies for functional hearing in mysticetes, collectively, are estimated to be 7 Hz and 35 kHz (NOAA, 2016).

Table 7.2: Functional Hearing Groups for Marine Mammals Potentially Present at the Southwark Platform Location

Functional Hearing Group	Frequency of Best Hearing (kHz)	Species Potentially Present
Low-frequency cetaceans	5.6	Minke whale
High-frequency cetaceans	55	Atlantic white-sided dolphin, White-beaked dolphin
Very High-frequency cetaceans	105	Harbour porpoise
Phocid Pinnipeds in water	8.6	Grey seals, Common seal

Sources: Southall et al, 2019; Pollock *et al.*, 2000; Reid *et al.*, 2003; DECC, 2016.

Research indicates that marine mammals can react differently to the introduction of additional noise into the marine environment. Reactions may vary depending on sound source level, propagation conditions and ambient noise, in addition to species, age, sex, habitat, individual variation, and previous habituation to noise (Richardson *et al.*, 1995). It should also be noted that marine mammals react differently to stationary noise, compared to sudden bursts of noise and noises that appear to be coming towards them. Studies suggest that most cetaceans will alter their course or display avoidance reactions to a noise that appears to be moving directly towards them. Stationary noises, such as drilling noises, outwith an immediate zone of discomfort to the animal, seem to have a lesser effect in disturbing migration patterns and animal feeding, although data and observations on this matter are limited (Davis *et al.*, 1990).

Injury Thresholds for Cetaceans and Pinnipeds

The planned piling operations will produce intermittent sound pulses, which are considerably more intense than the continuous noise emitted by most industrial noises in the ocean, including those generated during the planned drilling and production operations. There are few direct data regarding the effects of intense sound on cetaceans, making it difficult to predict accurate safe exposure levels for these mammals (Finneran *et al.*, 2000). Nonetheless attempts have been made to create a set of injury criteria for individual marine mammals exposed to discrete noise events, such as piling operations by Southall *et al.* (2007), and more recently by the US National Oceanic and Atmospheric Administration (NOAA) which introduced a new set of injury criteria in 2016 (NOAA, 2016), which were updated in 2018 (NOAA, 2018) and are maintained in Southall et al (2019). These dual metric criteria aim to set acoustic thresholds, at which individual marine mammals are predicted to experience changes in their hearing sensitivity (either temporary or permanent) for acute, incidental exposure to underwater anthropogenic sound sources. These thresholds are referred as 'Temporary Threshold Shift' (TTS) and Permanent Threshold Shift (PTS), respectively.

The first metric used by NOAA to assess PTS and TTS onset, is the unweighted, or 'flat', threshold value for impulsive sounds. This metric is based on the 0-peak sound pressure level (SPL) of a single exposure (i.e. in this case one single hammer blow) and is expressed in dB re 1µPa at 1 m. Using the spreading model presented in Section 7.1.3, the distances to the PTS and TTS thresholds can be calculated. Table 7.3 below shows that harbour porpoises within a few tens of metres (up to 63 m) from the piling hammer would be at risk of exceeding their PTS thresholds. PTS thresholds for all other species are within 10 m of the piling. Similarly, the thresholds for TTS for all species can be expected to be breached at distances between 2 and 126 m from the piling.

Table 7.3: PTS and TTS Isopleths for Single Hammer Strike

PTS/TTS Isopleths	NOAA PTS/TTS thresholds and distance from sound source in which these threshold values are exceeded per species			
	Minke whale	**Atlantic white-sided & white beaked dolphin**	**Harbour porpoise**	**Grey and common seals**
PTS Isopleth to Threshold 'flat' peak	219 dB at 18 m	230 dB at 3 m	202 dB at 251 m	218 dB at 22 m
TTS Isopleth to Threshold 'flat' peak	213 dB at 46 m	224 dB at 9 m	196 dB at 631 m	212 dB at 54 m

The second metric used by NOAA (2018) are the weighted auditory thresholds for the cumulative exposure of marine mammals during the piling operations, based on the Sound Exposure Level (SEL), which is the integrated square pressure expressed in dB re 1µPa²s. SEL effectively averages the total acoustic energy released over a one second period and is a particular useful metric for estimating the (cumulative) impact of multiple successive hammer blows over a set period of time.

The cumulative SEL is calculated as the summation of the total sound energy to which the receptor is exposed during a set period of time (in this case 24 hrs). The SEL_{CUM} can be calculated as:

$$SEL_{CUM} = 10 \cdot Log_{10} \sum_{i=1}^{n} 10^{\frac{SEL_{Max} - 15 \cdot \log(R_i) + A \cdot R_i}{10}} \qquad (Formula\ 2)$$

SEL_{CUM} = Cumulative Sound Exposure Level received by the receptor

SEL_R = Source Exposure Level of a single hammer blow at distance 'R' from the sound source

Although SEL can be measured in the field fairly easily, it is very hard to predict accurately beforehand, and cannot be readily derived from the estimated sound pressure level, for example. Therefore, in order to predict the anticipated SEL_{CUM} PTS and TTS thresholds for the various animal groups, underwater sound measurement results from similar operations in similar water depths have been reviewed to derive an analogue to estimate cumulative SEL thresholds for PTS and TTS. Betke (2008) reviewed piling noise from various offshore wind farms and presents data can be used to estimate the SEL_{Max} at Southwark. Using a linear regression on the normalised SEL_{Max} values of 7 offshore windfarm construction projects covering pile sizes from 1.6 m to 4.7 m in water depths ranging between 20 to 30 m, the SEL_{Max} for piling operations at Southwark has been estimated at 208 dB re 1µPa²s for a single strike at 1 m distance.

Table 7.4 presents the acoustic PTS and TTS thresholds for peak sound pressure level measured at distance R (SPL_R) and the weighed cumulative sound exposure level (SEL_{cum}), for an accumulation period of 24 hrs (in line with the NOAA guidance). The SEL_{CUM} values have been adjusted ('weighted') for a peak frequency at 500 Hz.

Table 7.4 PTS and TTS onset thresholds (NOAA, 2018) for marine mammals in the area around Southwark

	PTS onset, SPL_R, 0-pk, flat (dB re 1µPa)	**PTS onset SEL_{cum}, weighted*, 24hr (dB re 1µPa²s)**	**TTS onset, SPL_R, 0-pk, flat (dB re 1µPa)**	**TTS onset SEL_{cum}, weighted*, 24hr (dB re 1µPa²s)**
Minke whale	219	184	213	169
Atlantic white-sided & White beaked dolphin	230	224	224	209
Harbour porpoise	202	203	196	188
Grey and Common seals	218	196	212	181

* SEL_{CUM} values have been adjusted for peak frequency at 500 Hz

Any animal experiencing high sound levels is expected to (temporarily) move out of the area causing them discomfort. For example, Brandt et al., (2011) found a clear negative impact of pile driving during wind farm construction on porpoise acoustic activity within several kilometres from the piling operations. No effect was observed between 16 to 22 km from the piling operations at two separate locations. Effects lasted up to 70 hrs after pile driving had stopped. The same authors quote a study by Tougaard et al., (2009) finding effects up to a similar distance of ~20 km. BEIS (2018) and JNCC (2017a) use an Effective Deterrent Radius (EDR) of 26 km within Sites of Community Importance (SCI), based on the empirically derived displacement range of harbour porpoise from pile driving operations.

Consequently, the 24 hr cumulative SEL_{CUM} values have been calculated by employing Formula 2 above, as a 'fleeing animal model', by assuming that any cetacean or pinniped in the area would swim away from the sound source at a constant speed of 1.5 m/s to a distance of at least 26 km. The model further assumes that piling power will be built up gradually throughout the piling operations, as is common practice in piling operations.

Assuming the piling operations will only be started with no marine mammals present within 500 m from the piling location (in line with the JNCC guidelines on underwater piling noise), the cumulative SEL over 24 hours received by any animal swimming away from the sound source would be approximately 179 dB re $1\mu Pa^2s$, which is below the NOAA PTS and TTS threshold values quoted in Table 7.4 above for most marine mammal species. The only exception is the TTS onset value for minke whales, which may be breached using the modelling parameters described above. However, as referred in Section 3.4.4 minke whales tend to be only be present in the southern North Sea from July to October (Evans, 1995), and even then sporadically. This is further confirmed by the observational data recorded by Reid at al (2003) and Hammond et al (2017), which show the actual recorded minke whale sightings significantly further northwards from the Southwark location. The piling operations at Southwark are planned to take place earlier in the year (Q1, 2021), hence it is very unlikely any minke whales would be affected by the proposed piling operations.

Therefore, taking into account the above assessment for a single strike as well as cumulatively over a 24 hour period, together with the use marine mammal observers (MMOs) to ensure there are no marine mammals present with 500 m at the commencement of the piling operations, it is deemed unlikely that the piling operations would cause any physical injury to marine mammals in the area.

Behavioural Responses to Piling Operations

Although it is unlikely that the proposed piling operations will cause injury, they may evoke a certain level of behavioural responses from any cetaceans in the vicinity of such operations, as referred to above.

There is limited other information available of the behavioural effects of the larger baleen whale species to piling operations. However, as sound levels and dominant frequencies of piling sound are in many ways quite similar to the sound generated during offshore geophysical (i.e. seismic) surveys, the following examples have been used as a proxy to describe some of the anticipated effects and spatial extent.

Baleen whales have hearing sensitivity ranges between 10 Hz and 10 kHz, with greatest sensitivities usually below 1 kHz (Evans, 1998; Southall *et al.*, 2007). This hearing range overlaps the low frequency sounds produced by the planned piling operations, which may mask long distance communication between whales and prevent the detection of other faint sounds (Evans & Nice, 1996).

Most studies on low-frequency cetaceans report behavioural responses to 'pulsed sound', such as that produced by piling operations or seismic surveys, at received sound levels around 140 to 160 dB re 1 µPa, and sometimes even higher (e.g. Southall *et al.*, 2007; Richardson *et al.*, 1995). These responses typically consist of subtle effects on surfacing and respiration patterns. Sound levels of 150 dB to 180 dB will generally evoke behavioural avoidance reactions (Richardson *et al.*, 1995).

Given the intermittent nature and short overall duration of the piling operations (4 days), the fact that the impact on cetaceans is expected to be limited to some potential avoidance responses for individual animals up to a distance of 26 km from the platform piling operations and that mitigation measures outlined in the JNCC Guidelines for piling operations (JNCC, 2010b) will be followed, the impact of piling operations on cetaceans is considered to be not significant.

Behavioural Responses of Pinnipeds

Pinnipeds (seals, sea lions and walruses) also produce a diversity of sounds, although generally over a lower and more restricted bandwidth (generally from 100 Hz to several tens of kHz). Their sounds are used primarily in critical social and reproductive interactions (Southall *et al.*, 2007). Most pinniped species have peak sensitivities between 1 and 20 kHz (NRC, 2003). Common seals are most sensitive to sounds between 6 kHz to 12 kHz (Wolski *et al.*, 2003), although their threshold for hearing and responding to sound lies at much lower frequencies. Kastak & Shusterman (1998) measured the underwater sound detection threshold of a common seal to be between 101.9 dB and 62.8 dB for frequencies between 75 Hz and 6,400 Hz respectively. The audiograms of common and grey seals are very similar (Thompson, 1998), and their reaction to anthropogenic underwater sound is therefore also expected to be similar.

Very few studies have been conducted on the effects of impulsive noise on pinnipeds, even though they are known to have good underwater hearing and their feeding grounds often overlap with areas subject to manmade high intensity underwater noise activities.

Russell *et al*. (2016) found that seal usage (abundance) was significantly reduced up to 25 km from piling operations at a wind farm location in the southern North Sea. Within 25 km of the centre of the wind farm, there was a 19% to 83% decrease in usage of the area compared to during breaks in piling. This amounted to significant displacement starting from predicted received levels of between 166 and 178 dB re 1 µPa(p-p). Within 2 hours of cessation of pile driving, seals were distributed as per the non-piling scenario.

A review of the effects of seismic survey impacts on marine mammals by Gordon *et al.* (2004) quotes one single study by Thompson *et al.* (1998) on the behavioural and physiological responses of grey and common seals to small airguns. The study indicated that reactions observed in common seals included initial fright responses as the air guns were switched on, generally followed by strong avoidance behaviour, demonstrated by swimming rapidly away from the sound source. However, the study also reported that one seal showed no detectable response and approached to within 300 m of the airgun (source levels of the airgun were 215 to 224 dB re 1 µPa at 1 m peak-to-peak). The seals ceased feeding during this time. The behaviour of the common seals seemed to return to normal soon after the air guns were switched off.

Bearing in mind that the piling operations will be intermittent over a short overall period of 4 days, and any affected seals are expected to return to the area quickly after piling operations have seized, the overall impacts from piling are not believed to cause any long-term effects on pinnipeds and therefore are deemed insignificant.

7.2.2. Effects on Fish

The inner ear of fish including elasmobranchs (sharks, skates and rays), is very similar to that of terrestrial vertebrates, and hearing is understood to be present in virtually all fish (NRC, 2003). Most species of fish are able to detect sounds from below 50 Hz (some as low as 10 Hz or 15 Hz) to upward of 1,000 Hz. Moreover, a number of fish species have auditory adaptations that enhance sound detection and enable them to detect sounds of 3 kHz and above, giving them better sensitivity than non-specialist species at lower frequencies (NRC, 2003; Popper, 2003). Many species of fish use sound to find prey, to avoid predators, and for social interactions. In addition, the sensory systems used by fish to detect sounds are very similar to those of marine (and terrestrial) mammals, and, as a consequence, sounds that damage or affect marine mammals could in other ways have similar consequences for fish (Popper, 2003). Some fish species, such as herring, have swim bladders which may be susceptible to damage by underwater high noise levels, making these species comparatively more sensitive.

The effect of piling operations on fish is strongly related to their life cycle stage. Adult and juvenile fish are rarely affected by piling operations because they are able to detect and physically avoid the area but fish eggs and larvae may be more vulnerable. Fish can detect impulsive sound sources over large distances (up to 30 km), yet they seldom react to the sound before it is above a certain threshold. Alarm responses in adult or juvenile fish can be expected at distances of 1 km to 5 km from the piling operations, depending upon their auditory thresholds and the level of sound transmission loss (Nakken, 1992). Given the limited spatial extent of the anticipated impact and the limited (4 day) period over which the piling will take place, and the ability of fish to temporarily avoid areas of adverse noise, the proposed piling operations is not anticipated to cause any significant impacts on fish.

7.3. Assessment of the Requirement for a Wildlife Disturbance Licence

Under the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (or Offshore Marine Regulations, OMR), as amended by the Offshore Marine Conservation (Natural Habitats, &c.) (Amendment) Regulations 2009 and 2010, it is an offence to deliberately disturb European Protected Species (EPS; species listed in Annex IV of the Habitats Directive), in such a way that is likely to:

- Impair their ability to survive, to breed or reproduce, or to rear or nurture their young; or in the case of a hibernating or migratory species, to hibernate or migrate; or
- Affect significantly the local distribution or abundance of the species to which they belong.

IOG has therefore assessed if any of the proposed piling operations would potentially cause a 'disturbance offence' to any EPS, and subsequently would require a disturbance licence under these regulations. The potential disturbance caused by the proposed piling operations mainly refers to (underwater) noise.

The EPS include all cetaceans, turtles and sturgeon. In UK waters, the latter two are at the limits of their global distributions (which are centred elsewhere in the West Atlantic or Europe) and only occur in low numbers around the UK. It is therefore extremely unlikely that a significant group of these animals would be present, or that their local abundance or distribution would be significantly affected by marine impacts (JNCC, 2010a). Therefore, only cetaceans will be considered.

As described in Section 7.2.1, none of the proposed piling operations at the Southwark platform are considered likely to cause any (permanent) injury to cetaceans, and only a certain level of avoidance responses is expected within a 26 km radius of the platform during piling operations. Therefore, this assessment is based on whether these behavioural responses could potentially result in a disturbance offence in relation to marine EPS, as defined under Regulations 41(1)(b) and 39(1)(b) of the Habitats Regulations and Offshore Marine Regulations, respectively.

Table 7.5 identifies the cetacean species that may be present in the wider area and, therefore, may be affected by underwater noise from the proposed piling operations. It also specifies the number of individuals per species that can be expected to be in the area in which potential 'disturbance' effects could be expected to occur. Further information about each of these species is presented in Section 3.4.4. As explained above in Section 7.1.2, the SCANS III abundance data for minke whales in this table is believed to overestimate the abundance of minke whales in the direct vicinity of the Southwark platform the area, particularly during the proposed time of year (Q1, 2021) for which the piling operations are planned to take place.

Table 7.5: Numbers of Cetaceans Estimated to be Present in the Area around the Southwark Platform

Cetacean Species	Abundance Data (Animals/km^2)	Data Source	Estimated Number of Animals Within 26 km Radius of the Southwark platform	Percentage of the population affected
Harbour porpoise	0.888	SCANS III	1,886	0.55%
White beaked dolphin	0.002	SCANS III	4.2	0.01%
Atlantic white sided dolphin	No data	SCANS III	Not observed in area O during SCANS III survey	
Minke whale	0.01	SCANS III	21.2	0.14%

Table 7.5 shows that harbour porpoise is recorded as being the most abundant of the species identified in the area, and as such are considered further below in order to determine the requirement for a species disturbance licence.

Only very low numbers of white beaked dolphins and no Atlantic white sided dolphins have been recorded in this area, and thus a potential 'disturbance' effect on these species is not anticipated.

As mentioned previously in this chapter, the abundance data for minke whales presented in Table 7.5 is believed to be a potential over-estimation for the area around Southwark, as it is based on a relatively large area (Block O in the SCANS III data), in which Southwark lies on the very southern end of. During the SCANS III survey, minke whales were only observed further north of Southwark, which also demarcated the southern-most point in the North Sea where minke whales were observed. No minke whales were recorded in the Block L, which lies directly south of Southwark. Furthermore, the planned piling operations are scheduled to take place in Q1, 2021, which is outside the period (July to October) when minke whales are typically observed in the southern North Sea (Evans, 1995).

The abundance data in Table 7.5 is based on the mean values and does not take into account the fact that certain cetacean species live in larger pods or groups and therefore their distribution in reality will be much more clustered. For example, harbour porpoises typically occur in small groups of up to three individuals (Reid et al., 2003). The harbour porpoise is the most abundant cetacean species in the North Sea, with an estimated population size of 345,373 individuals (Hammond *et al.*, 2017). Therefore, only 0.55% of the Harbour porpoise population would be expected to show temporary avoidance behaviour, with animals expected to return to the area within 3 days once the piling operations have been completed. As referred to in Section 3.5.2, the Southwark also falls within the Southern North Sea SAC which has been formally designated for the protection of harbour porpoise (JNCC, 2019c). The 26 km Effective Deterrent Radius, marking the temporary avoidance area of porpoises overlaps with approximately 1,590 km^2 of the SAC, corresponding to 4.30% of the whole SAC.

No physical injuries are expected as a result of the piling operations at the Southwark platform, and the predicted impacts will be limited to temporary behavioural effects. The type and intensity of an animal's individual response to underwater noise is believed to vary depending on the ratio between the anthropogenic sound and ambient noise levels, the rate of change of the sound; and also the behavioural context and motivations at the time, the previous experience of exposed individuals and how the animal interprets the sound, i.e. as a predator/threat or just as an annoying stimulus (JNCC, 2010a).

Piling operations will only take place intermittently over a period of 4 days, with any effects not expected to last over 3 days after piling has been completed. Only a small fraction (0.55%) of the harbour porpoise population will be affected. Harbour porpoises will be temporarily displaced from a small area (4.30%) of the Southern North Sea SAC. Therefore, it is considered unlikely that the proposed piling operations would adversely affect any animals in such a way as to cause 'deliberate disturbance' of an EPS.

7.4. Cumulative and Transboundary Impacts

Noise is transmitted through water very efficiently and may be detectable over many kilometres from its source. This has led to concerns that increasing anthropogenic activity in the sea, and consequent increasing noise levels, may have effects on marine mammals through interruption of their communication and hearing mechanisms. The potential outcomes of having multiple noise sources in the sea include more frequent masking, behavioural disruptions and short-term displacement, although potentially this could be mitigated by a certain level of habituation. Prolonged or repeated disturbance is generally considered to be of more concern than isolated short-term disturbance.

The piling operations during the installation of the Southwark platform will temporarily add to the ambient noise in the Southern North Sea which includes various sources of industrial noise such as shipping and fishing activity, windfarms, other oil and gas installations and aggregate extraction.

As described above, the ambient noise around in this part of the southern North Sea is likely to be dominated by shipping sound. Furthermore, the Southwark platform will be situated close to the ConocoPhillips operated Vulcan platforms which may be another source of manmade sound in the wider area.

The long term, synergistic and cumulative impact of sound sources is not known, and the introduction of additional low-frequency noise into the marine environment from the proposed piling operations at the Southwark platform should be considered to have the potential to contribute to the overall cumulative effect of anthropogenic generated underwater noise. However, the risks in this instance are considered to be low, as noise generation associated with the proposed piling operations will be intermittent and transitory; occurring over a short period of up to 4 days.

There are currently no applications on the Oil & Gas Authority's UK Energy Portal for any other construction or other high intensity activities within a 100 km radius of the Southwark platform for Q1,2021. Similarly, there are no Cases or Marine Licensing Applications listed on the Public Register of the Marine Management Organisation for any activities in this area for Q1, 2021 either. As such, at this time, IOG is not aware of any piling operations (or any other type of high intensity sound producing activities) proposed to take place within a 100 km radius of the Southwark platform during platform installation.

Therefore, the cumulative impacts of the temporary increase in local anthropogenic underwater noise from the planned piling operations in the area are considered to be not significant.

With regard to potential transboundary effects, the location of the Southwark platform is approximately 64 km east of the UK/Netherlands transboundary line. At this distance any underwater sound will have attenuated to an insignificant low level therefore no observable effects are expected to occur. Consequently, no significant cumulative and/or transboundary impacts from noise generated during the piling operations are anticipated.

7.5. Mitigation Measures

The amount of underwater sound generated during piling operations will be kept to a minimum, where possible. The main priority is to minimise the time over which sound energy is emitted into the marine environment. Only 4 piles will be hammered into the seabed, over a period of 4 days. Therefore, any noise associated with the operations will be transitory. It should be noted that piling will not take place continuously during this 4-day period, with piling operations at each pile expected to take up to 6 hours per pile.

Piling activity will take place during Q1, 2021, outside the period when minke whales may be present in the area.

The planned operations will be conducted in accordance with the latest JNCC guidelines for minimising acoustic disturbance to marine mammals to mitigate potential impacts to cetaceans, at all times (JNCC, 2010b). This will include the use of marine mammal observers to ensure no marine mammals are present within a 500 m radius, before piling operations can commence. ‘Soft start’ procedures will be adhered to during piling operations to allow any marine mammals in close proximity to safely move out of the area.

7.6. Conclusions

Anthropogenic noise from shipping is currently believed to be the main source of background noise in the southern North Sea. The planned piling operations to install the Southwark platform jacket firmly onto the seabed may cause avoidance response reactions in cetaceans within 26 kilometres of the platform. However, given the short duration of such operations (4 × 6 hours of piling over a 4-day period), any effects are expected to be transient and are not considered to be significant.

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Section 8

Atmospheric Impacts

8 ATMOSPHERIC IMPACTS

During the proposed drilling and installation operations at the Southwark field, atmospheric emissions will be produced as a result of power generation onboard the jack-up drilling rig, as well as from the pipe-lay vessel (PLV), heavy lift barge, well stimulation vessel, supply vessels, standby vessels and helicopter activity. Such emissions contribute to a variety of environmental effects and associated impacts, including climate change.

During the production phase, power generation for the platform installed at the Southwark field will be provided by a combined part renewable energy system (wind and solar energy), supplemented by a traditional diesel engine system for when renewable energy is not in full supply. Overall power requirements for the platforms will be low, i.e. between 30 kW for unmanned operation and 67 kW for manned operations. Therefore, combustion emissions from the platforms will be minimal and have not been considered further in this ES.

Although the individual climate change impact of the planned drilling and installation operations at the Southwark field are comparatively so small that they are impossible to assess on their individual merit, it is acknowledged that they will contribute to the overall cumulative issue of climate change, which is of key concern to overall sustainability objectives and atmospheric emissions are therefore considered in this section of the ES.

However, it should be noted that the overall strategy to address cumulative global environmental issues, such as climate change, from a UK perspective, ultimately lies with the Government. Individual climate change effects from a single operation cannot be assessed. Therefore, the estimated atmospheric emissions and their associated Global Warming Potential (GWP) in this chapter are only presented to provide context to the proposed drilling operations and to allow for generic comparison with the overall values for emissions for the UK offshore oil and gas industry.

8.1 Quantification of Atmospheric Emissions

The quantification of emissions in this section of the ES is based on generic emission factors and should be used as an indication of the order of magnitude only. The calculations are based on the fuel consumption estimates presented in Table 2.1 and Table 2.2 of the project description.

8.1.1 Atmospheric Emissions from Drilling Operations at Southwark

Generation of power onboard the jack-up drilling rig and support vessels will result in the emissions of various combustion gases.

Diesel consumption onboard the jack-up drilling rig during drilling operations will be around 15 m^3 per day (based on general industry figures for 116-C Class jack-up rigs). With a total operational time of approximately 296 days for Southwark, this will amount to approximately 4,440 m^3 of diesel being used by the jack-up rig for power generation for the drilling and completion operations at the platform. During transit to the well location, consumption onboard the Anchor Handling Tug(s) will be approximately 50 m^3/day per tug. In addition to the fuel used by the jack-up drilling rig itself, all support vessels (anchor handling tugs, supply vessels and the standby vessel), together with aircraft support, will also consume fuel and produce exhaust emissions. Table 8.1 lists the predicted emissions from these sources, based on their total fuel consumption.

Table 8.1: Estimated Emissions from the Jack-up Drilling Rig and Associated Vessels at Southwark

		Supply Vessel	ERRV Vessel	Helicopter Flights*	3 x Anchor Handling Tugs	Jack-up Drilling Rig	Stimulation Vessel	Total
Consumption [tonnes]		1,468	1,200	101	600	4,410	4,656	12,363
Emissions [tonnes]	CO_2	4,704.00	3,840.00	323.10	1,920.00	14,208.00	14,566.40	39,561.50
	CO	11.76	9.60	0.53	4.80	36.85	36.42	99.95
	NO_x	86.73	70.80	1.26	35.40	161.62	268.57	624.38
	N_2O	0.32	0.26	0.02	0.13	0.98	1.00	2.72
	SO_2	5.88	4.80	0.40	2.40	17.76	18.21	49.45
	CH_4	0.40	0.32	0.01	0.16	0.49	1.23	2.61
	VOC	3.53	2.88	0.08	1.44	5.33	10.92	24.18
	CO_2e	**5,279.23**	**4,309.57**	**899.47**	**2,154.79**	**15,429.93**	**16,347.64**	**44,420.63**

Notes:
* NO_x factor of 450 for aircraft

Calculations according to UKOOA atmospheric emissions guidance (1999) and the GWP conversion factors as shown in Table 8.5.

8.1.2 Atmospheric Emissions During Southwark Platform Installation

Emissions of various combustion gases will also occur during the installation of the jacket foundations and the platform topsides. Vessels involved in the installation of the field infrastructure will include a heavy lift barge, supply vessels and tugs. Diesel consumption onboard the heavy lift vessel during platform installation operations is around 20 m^3 per day (based on general industry figures for heavy lift vessels). During transit to the platform location this increases to 50 m^3/day. With a total operational time of approximately 8 days (including transit time to and from the site), this will amount to a total of approximately 220 m^3 of diesel being used for power generation during platform installation activities per field.

In addition to the fuel used by the heavy lift vessel itself, support vessels (tugs and supply vessels), together with any aircraft support, will also consume fuel and produce exhaust emissions. Table 8.2 lists the predicted emissions from these sources, based on their total fuel consumption, at Southwark.

Table 8.2: Estimated Emissions During Platform Installation at Southwark

		Heavy Lift Barge	2 x Tugs	Total
Consumption [tonnes]		200	20	220
Emissions [tonnes]	CO_2	640.00	64.00	704.00
	CO	1.60	0.16	1.76
	NO_x	11.80	1.18	12.98
	N_2O	0.04	0.00	0.05
	SO_2	0.80	0.08	0.88
	CH_4	0.05	0.01	0.06
	VOC	0.48	0.05	0.53
	CO_2e	**716.97**	**70.63**	**787.6**

Calculations according to UKOOA atmospheric emissions guidance (1999) and the GWP conversion factors as shown in Table 8.5.

8.1.3 Atmospheric Emissions from Southwark to PL370 Export Pipeline Installation

Emissions of various combustion gases will occur during the installation of the field infrastructure such as the pipelines and manifolds. Vessels involved in the installation of the field infrastructure will include pipelay vessels and Diving Support Vessels (DSVs) which will consume fuel and produce exhaust emissions. Table 8.3 lists the predicted emissions from these sources, based on their total fuel consumption.

Table 8.3: Estimated Emissions During Pipeline Installation at Southwark

		PLV	DSV	Total
Consumption [tonnes]		166	268	434
Emissions [tonnes]	CO_2	531.20	857.60	1,388.80
	CO	1.33	2.14	3.47
	NO_x	9.79	15.81	25.61
	N_2O	0.04	0.06	0.10
	SO_2	0.66	1.07	1.74
	CH_4	0.04	0.07	0.12
	VOC	0.40	0.64	1.04
	CO_2e	**597.06**	**962.70**	**1559.76**

Calculations according to UKOOA atmospheric emissions guidance (1999) and the GWP conversion factors as shown in Table 8.5.

8.1.4 Total Estimated Atmospheric Emissions from Drilling and Installation Operations at Southwark

The total estimated emissions of various combustion gases arising during the drilling and installation operations at Southwark are listed in Table 8.4.

Table 8.4: Total Estimated Emissions from Drilling and Installation Operations at Southwark

		Supply Vessel	ERRV Vessel	Helicopter Flights*	3 x Anchor Handling Tugs	Jack-up Drilling Rig	Stimulation Vessel	Heavy Lift Barge	2 x Tugs	PLV	DSV	Total
Consumption [tonnes]		1,468	1,200	101	600	4,440	4,656	200	20	166	268	13,119
Emissions [tonnes]	CO_2	4,704.00	3,840.00	323.10	1,920.00	14,208.00	14,566.40	640.00	64.00	531.20	857.60	41,654.30
	CO	11.76	9.60	0.53	4.80	36.85	36.42	1.60	0.16	1.33	2.14	105.19
	NO_x	86.73	70.80	1.26	35.40	161.62	268.57	11.80	1.18	9.79	15.81	662.96
	N_2O	0.32	0.26	0.02	0.13	0.98	1.00	0.04	-	0.04	0.06	2.85
	SO_2	5.88	4.80	0.40	2.40	17.76	18.21	0.80	0.08	0.66	1.07	52.06
	CH_4	0.40	0.32	0.01	0.16	0.49	1.23	0.05	0.01	0.04	0.07	2.78
	VOC	3.53	2.88	0.08	1.44	5.33	10.92	0.48	0.05	0.40	0.64	25.75
	CO_2e	**5,279.23**	**4,309.57**	**899.47**	**2,154.79**	**15,429.93**	**16,347.64**	**716.97**	**70.63**	**597.06**	**962.70**	**46,767.99**

Notes:
* NO_x factor of 450 for aircraft

Calculations according to UKOOA atmospheric emissions guidance (1999) and the GWP conversion factors as shown in Table 8.11.

8.2 Environmental Impacts Resulting from Atmospheric Emissions

The exhaust gases produced from the planned operations are known to have the potential to contribute to a number of environmental processes and impacts including global warming (greenhouse gases), acidification (acid rain), the formation of low level ozone, and local air pollution.

The most commonly used general indicator of atmospheric emissions is the Global Warming Potential (GWP), expressed in tonnes of carbon dioxide (CO_2) equivalents. GWP is a measure of the relative radiative effect of a given gas compared to that of CO_2, integrated over a chosen time horizon (often a 100-year time period). Simply stated, the GWP of a specific gas is a measure of its climate change impact relative to that of carbon dioxide (AEA, 2007). All gaseous substances that contribute towards global warming (e.g. CO_2, CH_4, N_2O, CO, and NO_x) have a GWP factor that allows the conversion of individual emissions into CO_2 equivalents. As such, GWP can be used to estimate the potential future impacts of gaseous emissions upon the climate system. The GWP factor of each of the most common combustion gases is given in Table 8.5.

Table 8.5: Environmental Effects of Atmospheric Emissions

Gaseous Emission	Environmental Effect	100-year GWP Factor*
Direct Greenhouse Gases		
Carbon dioxide (CO_2)	CO_2 is a greenhouse gas.	1
Methane (CH_4)	CH_4 is a greenhouse gas.	25
Nitrous oxide (N_2O)	N_2O is a greenhouse gas.	298
Indirect Greenhouse Gases		
Carbon monoxide (CO)	CO is an indirect greenhouse gas. Also has a direct effect upon human health as an asphyxiant.	3
Oxides of nitrogen (NO_x)	NO_x are indirect greenhouse gases. NO_2 has direct effects upon human health and vegetation and has the potential to cause respiratory illness and irritation of the mucous membranes. NO_x acts as a precursor to low-level ozone formation. NO_x contributes to acid deposition (wet and dry) which impacts both freshwater and terrestrial ecosystems.	5/450**
Volatile organic compounds (VOC)	Volatile organic compounds (VOCs), which include non-methane hydrocarbons (NMHC) and oxygenated NMHC (e.g. alcohols, aldehydes and organic acids), have short atmospheric lifetimes (fractions of a day to months) and small direct impact on radiative forcing. VOCs influence climate through their production of organic aerosols and their involvement in photochemistry, i.e. production of ozone (O_3) in the presence of NO_x and light. Generally, fossil VOC sources have already been accounted for as the release of fossil C in the CO_2 budgets and therefore are not counted as a source of CO_2.	-
Sulphur dioxide (SO_2)	SO_2 has direct health effects - it causes respiratory illness. SO_2 also contributes to acid deposition (wet and dry) which impacts both freshwater and terrestrial ecosystems.	-
Other		
Particulate matter (PM)	The environmental effects of particulate matter are mainly determined by the size (and shape) of the particles. Particles emitted from modern diesel engines (commonly referred to as Diesel Particulate Matter, or DPM) are typically in the size range of 100 nanometres (0.1 micrometre) and can penetrate the deepest part of the lungs. In addition, these soot particles also carry carcinogenic components. In high concentrations particulate matter can also affect plant growth.	-

Notes:
* *Direct GWPs are from IPCC (2007) and indirect from IPPC (2001) and refer to the 100-year horizon values.*
** *The GWP factor of 5 is for surface emissions. Higher altitude emissions (i.e. from aircraft) have greater impacts both because of longer NO_x residence times and more efficient tropospheric O_3 production, as well as enhanced radiative forcing sensitivity. NO_x emissions from aircraft can therefore have GWPs in the order of 450 for considering a 100-year time horizon. It must be noted however that these numerical values are subject to very large quantitative uncertainties.*

Greenhouse gases can be divided into 'direct' and 'indirect' greenhouse gases. Direct greenhouse gases have an effect on the balance of energy entering and exiting the atmosphere ('radiative forcing') and include combustion gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as well as naturally occurring gases such as tropospheric ozone (O_3). Reactive gases such as carbon monoxide (CO), volatile organic compounds (VOC), nitrogen oxides (NO and NO_2) and sulphur dioxide (SO_2) are termed indirect greenhouse gases. These pollutants are not significant as direct greenhouse gases but, through atmospheric chemistry, they impact upon the abundance of the direct greenhouse gases thereby increasing the overall greenhouse effect. The environmental effects of the most common combustion gases are presented in Table 8.5.

8.3 Wider Scale Impacts

The estimated GWP of the emissions associated with the proposed operations is presented in Table 8.1 to Table 8.4. All UK operators report their atmospheric emissions to the Environmental Emissions Monitoring System (EEMS). The EEMS report does not account for emissions from support vessels and helicopters, hence those values are not included in the following comparison. In 2017, atmospheric emissions from UK upstream operations totalled 15.7 million tonnes of CO_2 equivalents (Oil and Gas UK, 2018). Atmospheric emissions from the jack-up drilling rig at Southwark are predicted to total 15,430 tonnes of CO_2 equivalents, representing 0.10% of the 2017 annual emissions from upstream operations, a minor proportion of overall annual exploration and production operations undertaken on the UKCS.

The total GWP of all emissions, including the drilling and completion operations, platform and pipeline installation and all associated support vessel activity is approximately 46,768 tonnes of CO_2 equivalents (Table 8.4), which represents approximately 0.30% of the 2017 annual emissions from UK upstream operations. In this context, the atmospheric emissions generated during the Southwark Field Development are not considered to be significant.

8.4 Localised Impacts

Combustion emissions have the potential to reduce local air quality through the introduction of contaminants such as oxides of nitrogen (NO_x), volatile organic compounds (VOCs) and particulates which contribute to the formation of local low-level ozone and photochemical smog. However, seafaring vessels, including those proposed to be used here, are built and operated to standards that preclude impacts to the health of crews, whilst other environmental receptors present in the immediate vicinity of the operations (e.g. flora and fauna) tend to be sparsely distributed and/or mobile in their distribution. Local impacts are further mitigated by the open and dispersive nature of the offshore environment. Any impacts at this level are therefore difficult to measure and to distinguish from background variation. On this basis, localised impacts from combustion emissions at the Southwark Field Development are considered to be negligible, and thus not significant.

8.5 Cumulative and Transboundary Impacts

The assessment of the impacts of atmospheric emissions, as discussed above, is unchanged by the consideration of other emission sources local to the proposed operations. Whilst emissions from the proposed drilling and installation operations have the potential to combine with those from local shipping, and oil and gas infrastructure in the Southern North Sea region, this is unlikely to increase any local impacts significantly due to the distance between these developments and the highly dispersive nature of the offshore environment. The proposed operations are therefore not expected to have any significant cumulative effects in combination with other local sources of emissions.

As indicated in Section 8.3 above, on a wider scale the additive contribution to the emissions of the overall UK oil and gas industry from the proposed operations can be viewed as of little significance and therefore their cumulative effect is also expected to be minimal. It would be impossible, however, to assess the cumulative impact of atmospheric emissions from the proposed operations to potential global environmental impacts such as global climate change.

Local wind conditions may result in the transboundary transport of atmospheric emissions generated at the proposed well location. However, as the quantities involved are minimal in relation to national scale emissions and of a relative short duration, the resulting incremental effects of transboundary emissions on other nation's total emissions levels are not expected to be detectable. Transboundary atmospheric emissions require international collaborative action to control their formation and effects.

8.6 Mitigation Measures

All equipment will be well maintained according to a strict maintenance regime. This will ensure all equipment will operate at optimum efficiency, and thus minimise the overall fuel consumption. Only low sulphur diesel will be used onboard the jack-up drilling rig as standard. When scheduling the operations, the effect of weather down time with regard to additional fuel use was considered. Operations will be planned in conjunction with appropriate weather windows therefore reducing the potential for weather down time thus avoiding unnecessary fuel use. In addition, all fuel use onboard the jack up drilling rig, together with its associated atmospheric emissions, will be monitored and reported under the environmental EEMS reporting scheme.

8.7 Conclusions

Atmospheric emissions will be produced during drilling and installation operations, as a result of power generation onboard the jack-up drilling rig and all other vessels and aircraft involved in these operations. These emissions will contribute to local and global environmental effects. At a local level, impacts are mitigated by health and safety measures in place to control emissions and by the dispersive nature of the offshore environment. As such, any local air pollution effects are expected to be negligible, and thus not significant.

Emissions will also contribute to global environmental issues, including climate change. The contribution of the proposed drilling programme is comparable to similar operations, and small in comparison to emissions at an industry wide level. Therefore, it may be concluded that the individual GWP generated by the drilling operations and its resulting impacts are too small to be assessed. The ultimate cumulative global implications of global climate change are still poorly understood and therefore very hard to assess. The overall strategy to address this issue ultimately lies with national and international governance.

Section 9

Accidental Events

9 ACCIDENTAL EVENTS

As well as assessing operational processes, the EIA process also examines potential accidental events that may result in impacts upon the environment and for which mitigation measures may be implemented. The following issues and concerns were raised during the ENVID workshop and informal consultation, and are considered in this section which addresses the potential impacts from accidental events that could occur during installation, drilling and production operations at the proposed Southwark Field Development:

- Potential impacts on the marine and coastal environment, and other users of the sea, from a large hydrocarbon spill to sea. This refers to a large spill with the potential to reach the shore, thus requiring additional onshore response personnel and equipment;
- The potential impacts on the marine environment or other users of the sea from the catastrophic loss of rig, platform, support vessel(s) or helicopter.

The remainder of this section describes the potential impacts of hydrocarbon spills and from the catastrophic loss of the jack-up drilling rig, a vessel or helicopter.

9.1. Sources of Hydrocarbon Spills

The risk of an accidental hydrocarbon spillage to sea is often one of the main environmental concerns associated with oil-industry activities. Spilled oil at sea can have a number of environmental and economic impacts, the most conspicuous of which are on seabirds and coastal areas. The actual impacts depend on many factors, including the volume and type of hydrocarbon spilled, the sea and weather conditions at the time of the spill, and the oil spill response.

During the proposed installation, drilling and production operations at the Southwark Field Development, the following events have been identified as having the potential to cause a large hydrocarbon spill:

- Release of hydrocarbons from a well blow out;
- Release of hydrocarbons from complete rupturing of diesel storage tanks(s) or associated system(s);
- Release of hydrocarbons from a pipeline failure.

The expected hydrocarbons from the Southwark production wells is natural gas and condensate. Therefore, in the event of a well blow-out or pipeline failure, the risk of a surface spill would arise due to the condensate fraction.

As described in Section 2.2.8, the wells at the proposed Southwark Field Development will be drilled using WBM. LTOBM will only be used as a contingency. If LTOBM is used it will be recycled throughout the drilling programme as it is used in a closed system, therefore minimising the overall amount required.

9.1.1 Potential Condensate Spillages

The only potential source of a large hydrocarbon spill during the proposed drilling operations would come from an uncontrolled well blow-out incident. For a blow-out to occur, the primary well control element, the hydrostatic pressure exerted by the drilling mud, would have to be overcome by the inflowing hydrocarbons. The secondary well control measure, the blow-out preventer (BOP), would also have to fail to close off the well. The actual flow rate and duration of any such event, and hence the severity of the incident, are dependent upon the pressure and geology of the well, which vary with each well.

The Southwark Field Development wells will target the Leman Sandstone Formation. The expected hydrocarbons are gas and condensate (61°API; ITOPF Group I).

The flow rate encountered during an uncontrolled blow-out event may be very different from that expected during production, as there may not be equipment or other measures in place to restrict the flow. Reservoir and flow modelling of Southwark S2 was performed using PROSPER and tNavigator to predict the potential flow rate during an uncontrolled blow-out. It was assumed that there would be no physical restriction to the flow inside the well, such as drill string or tubing obstructing the wellbore, chemical build-up coating in the wellbore, a disconnected riser, or damaged wellhead and well control equipment on top of the well.

The modelling showed that well Southwark S2 would be expected to flow at an initial rate of 10.57 m^3/day condensate and that this rate would be expected to continue for at least 81 days the time it would be expected to take to drill a relief well. Over the 81 days it would take to drill a relief well a total of 856 m^3 condensate would be expected to be released.

9.1.2 Potential Diesel (Fuel Oil) Spillages

The exact drilling rig which will be used in the proposed operations has not been confirmed. Therefore, for the purposes of the modelling study, the ENCSO 92 jack-up drilling rig has been used as a proxy. Diesel will be the main fuel used for power generation during the proposed drilling operations and, with a maximum capacity of approximately 1,138.35 m^3, will be the largest volume of hydrocarbons stored on the jack-up drilling rig whilst on site. The worst-case diesel spill scenario considered for the purposes of this EIA is the complete loss of the diesel inventory from the fuel tank(s).

Smaller diesel spills can result from equipment failures, such as the rupture of pipes or open valves. As explained in Section 9.2.3, small spills most frequently occur during bunkering operations and are generally caused by hose failures.

To allow operations to continue without interruption, offshore drilling units are reliant on refuelling in field. This is facilitated by the regular transfer of diesel from a supply vessel to the drilling unit, via a flexible hose. As the hose is suspended between the two vessels, there is the potential for a direct diesel release to sea, if there is a problem with the hose. The requirement for, and frequency of, diesel bunkering is dependent on the expected duration of operations and the drilling unit used. It is anticipated that the jack-up rig will at least be bunkering once, whilst at Southwark.

9.1.3 Potential Condensate Leakage from a Pipeline Failure

As no condensate will be stored onboard the Southwark platform, the only source of condensate will be from the pipelines linking the field to the Thames to Bacton PL370 pipeline. If a pipeline was to become damaged and rupture, it could result in the release of condensate into the sea. For a pipeline to fail and rupture it would most likely be the result of pipeline spanning where the sediment beneath the pipeline is eroded or scoured away and the pipeline is no longer supported by the seabed. When this occurs, the pipeline is placed under stresses which may result in the pipeline rupturing and condensate flowing into the sea. Due to the sandy nature of the seabed in the area of the proposed Southwark Field Development it may be surmised that there is increased scope for erosion and scouring to occur compared to an area where the substrata is harder.

The spill modelling assumes that, in the event of a pipeline failure, an instantaneous release of 0.63 m^3 of condensate will occur which is based on the loss of the complete pipeline inventory of the pipeline between Southwark and PL370.

9.1.4 Other Potential Sources of Oil

The amounts of helicopter fuel and lubricating, hydraulic and waste oil will be stored onboard the jack-up drilling rig, however, the amounts will be very small in comparison to the main fuel supply. The probability of a 'large' spillage of any of these sources is considered to be minimal, as the containers are relatively small, sealed and stored in bunded areas. Therefore, the risk to the environment from these oils is regarded as negligible and is not considered further within this section.

9.2. Likelihood of a Hydrocarbon Spill

Historical data, covering the period between 1990 and 2016, reveal that the vast majority of hydrocarbon releases on the UKCS are less than 1 tonne (Figure 9.1). During this period more than 81% of releases from MODUs, 91% of releases from fixed platforms, 85% of releases from pipelines and 66% of releases from wells were all less than 1 tonne. Given IOG's use of existing and proven Safety Case approved infrastructure, the probability of a large hydrocarbon spill from the installation, drilling and production phases of the Southwark Field Development is anticipated to be very low. Furthermore, IOG will ensure the following controls/procedures are followed

- An environmental, technical and competency audit will be undertaken on the drilling rig prior to hire;

- The well design will be based on current best practices and will be examined by an independent well examiner to ensure compliance with the latest well integrity guidelines;
- Detailed procedures will be put in place covering all operations where there is the potential risk of a hydrocarbon spill;
- A safety management system interface document will be in place between the well operator and drilling contractor; and
- When the platform is in production mode Combined Operations procedures will be in place.

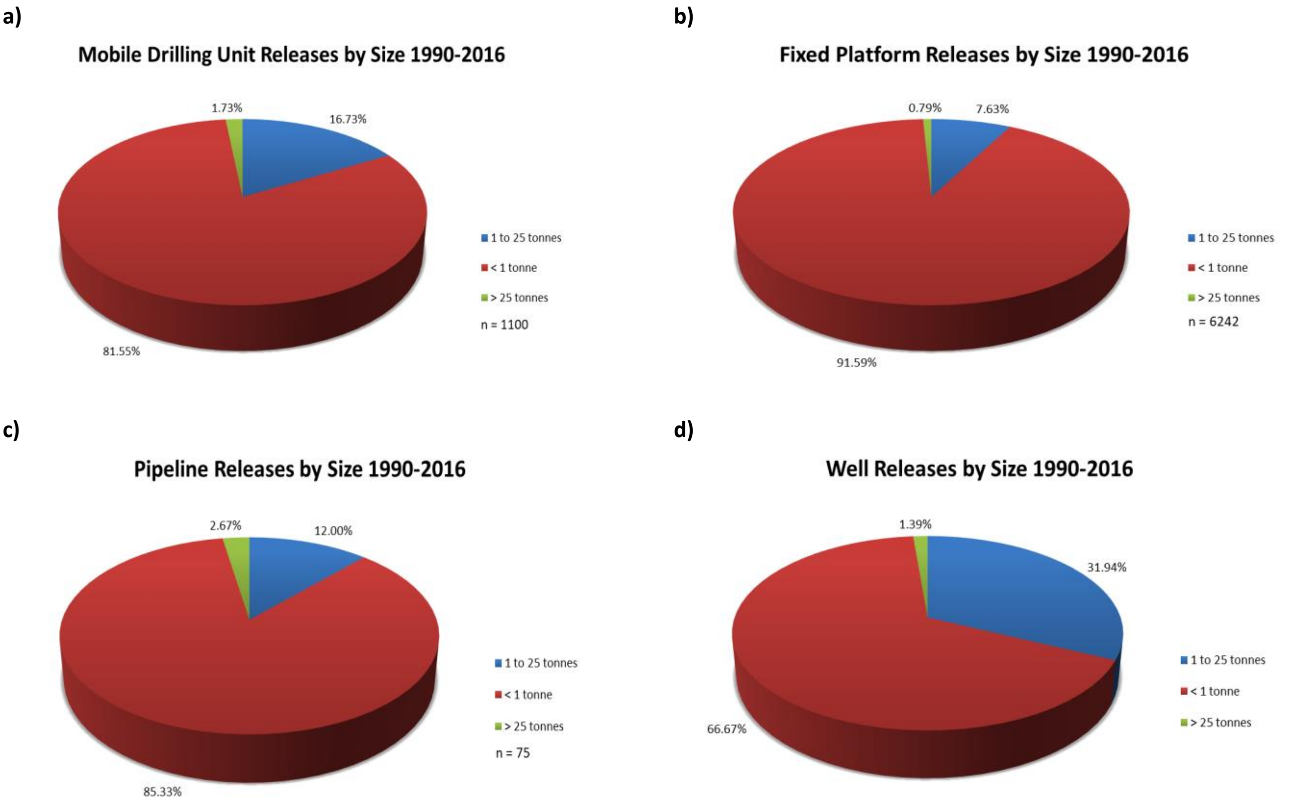

Figure 9.1 Hydrocarbon releases by Size for a) Mobile Drilling Units, b) Fixed Platforms, c) Pipelines, and d) Wells
Source: Fugro, 2017.

9.2.1 Condensate Spills

Figure 9.1 shows that just 18 condensate spills from mobile drilling rigs were recorded during the period 1990 to 2016, comprising 1.64% of the total number of MODU condensate spills (Fugro, 2017). All recorded condensate spills from mobile drilling rigs between 1990 and 2016 were of less than 1 tonne (Fugro, 2017).

9.2.2 Uncontrolled Well Blow-Out

The probability of an uncontrolled well blow-out event occurring is very low. Well blow-outs resulting in the uncontrolled release of hydrocarbons have happened too infrequently on the UKCS for a meaningful analysis of the historic frequency to be carried out. However, the following paragraphs give a brief overview on historic well control events on the UKCS.

Prior to 1990, only two significant uncontrolled blow-outs occurred in the North Sea. These events occurred during drilling operations on the West Vanguard semi-submersible on the Norwegian continental shelf and on the Ocean Odyssey semi-submersible on the UKCS, during 1985 and 1988 respectively (DTI, 2007). Both blow-outs involved gas, and did not result in hydrocarbon spills to sea. Moreover, lessons learnt from these events resulted in major legislative and operational changes for offshore drilling on the UKCS to prevent such events from happening again.

Between 1990 and 2007, a total of 343 well incidents were recorded from MODUs (both drilling and production). These incidents included several issues of varying severity, but only 17 resulted in loss of well control. Furthermore, none of the 17 recorded incidents resulted in an uncontrolled well blow-out with a crude oil spill of any size (OGUK, 2009).

The most recent well control incident in the North Sea involved a gas and condensate blow-out from Well 22/30c-G4, located close to the Elgin Platform, in March 2012. This incident resulted in the temporary cessation of production from the Elgin/Franklin area. IOG will review the lessons learnt from this incident, with consideration to the proposed drilling operations at the Southwark Field Development.

9.2.3 Diesel Spills

Diesel spills from mobile drilling units account for 14.63% of oil spilled on the UKCS from MODUs (Figure 9.1). Diesel will be the main fuel used for power generation during the proposed drilling operations and, therefore, will be the largest volume of hydrocarbons stored on the jack-up rig, whilst on site.

Spill records indicate that most diesel spills tend to occur during bunkering operations and that they are mostly caused by hose failures. Therefore, the volumes of diesel spilled tend to be relatively small. For example, of the 123 recorded diesel spills, 92.7% were of 1 tonne or less (Fugro, 2017). If a diesel spill of this size were to occur, it is likely that only onsite response personnel and equipment would be required to control the incident, due to the tendency of diesel to evaporate and disperse relatively quickly from the sea surface (see Section 9.3). Only three of the recorded diesel spills were greater than 5 tonnes, and each of these also occurred during bunkering operations.

The jack-up drilling rig will have a maximum storage capacity of approximately 1,138.4 m^3, which constitutes enough fuel for approximately 80 days during drilling operations. With an estimated duration of 296 days activity at the Southwark field, it is expected that bunkering will be required for up to 4 times.

The worst-case scenario, complete loss of the diesel inventory, will only occur as a result of a major accident, such as a catastrophic collision with another vessel. The probability of such an event occurring is very low, as discussed in section 9.6.

9.3. Fate and Behaviour or a Hydrocarbon Spill at Sea

<u>Oil Spill Movement</u>

A Spill on the Sea Surface

The fate of hydrocarbons spilled to the sea surface is relatively well understood. As soon as oil is released, the weathering process begins and the oil begins to move across the sea surface. Oil characteristics, spill location and wave and wind conditions govern the fate of the spilled oil. These processes are described below.

Spreading

Due to the influence of gravity, oil starts to spread out over the sea surface as soon as it is spilled. Oil slicks can spread very quickly to cover extensive areas of the sea surface, the speed of which depends mainly on the viscosity of the oil. Lighter oils spread out more quickly and, therefore, a spill of condensate could be expected to spread more quickly than a spill of crude oil. Although a spill will spread quickly in the first few days, the processes of evaporation and dispersion quickly remove the lighter, more volatile and water soluble, fractions of a slick from the sea surface. Then, as only the heavier, more viscous fractions are left, slick spreading will slow down.

Initially an oil spill will spread out as a single slick, covering an increasingly larger area while the slick becomes correspondingly thinner. However, as the slick spreads further, it will start to break up into smaller breakaway slicks due to the wind and water movement. Wind, wave and tidal conditions across the Southern North Sea can be regarded as dynamic, due to a combination of strongly tidal water movements and the local wind climate. As such, it is expected that a large condensate slick in this area would tend to break up quickly into smaller patches.

Direction of Movement

Wind and surface current speed and direction are the main factors influencing the movement of an oil slick. Any oil slick will travel roughly at the same speed and direction as the surface water current, while the prevailing wind drives a slick downwind at 3% to 4% of the wind speed.

Water depths in the Southern North Sea are relatively shallow compared with the central and northern areas. The proposed development area is situated in the shallow, coastal waters of the Southern North Sea at water depths ranging from approximately 20 to 30 m. Inputs of North Atlantic water strongly influence the hydrography of the North Sea, with minor inflows from the English Channel and the Baltic Sea. The generalised pattern of water movement in the North Sea is anti-clockwise, with North Atlantic water moving south, along the east coast of the UK, balanced by a northerly outflow along the Norwegian coast. The southern North Sea water moves in a broadly north easterly direction as part of this general circulation. This means that the current vector would, under most circumstances, move any surface slick in a general easterly or north easterly direction.

Although offshore winds in the area may blow from any direction, they most frequently originate from the south and south-west (Section 3.1.2). Therefore, the wind vector would also direct any surface slick to the north and north-east, under prevailing wind conditions.

The Weathering Process

When oil is released into the marine environment it undergoes a number of physico-chemical changes, some of which assist in the degradation of the spill, while others may cause it to persist. These changes are dependent upon the type and volume of oil spilled, and the prevailing weather and sea conditions. An overview of the main processes influencing the fate and behaviour of spilled oil at sea is given in Figure 9.2. Evaporation and dispersion are the two main mechanisms that act to remove oil from the sea surface.

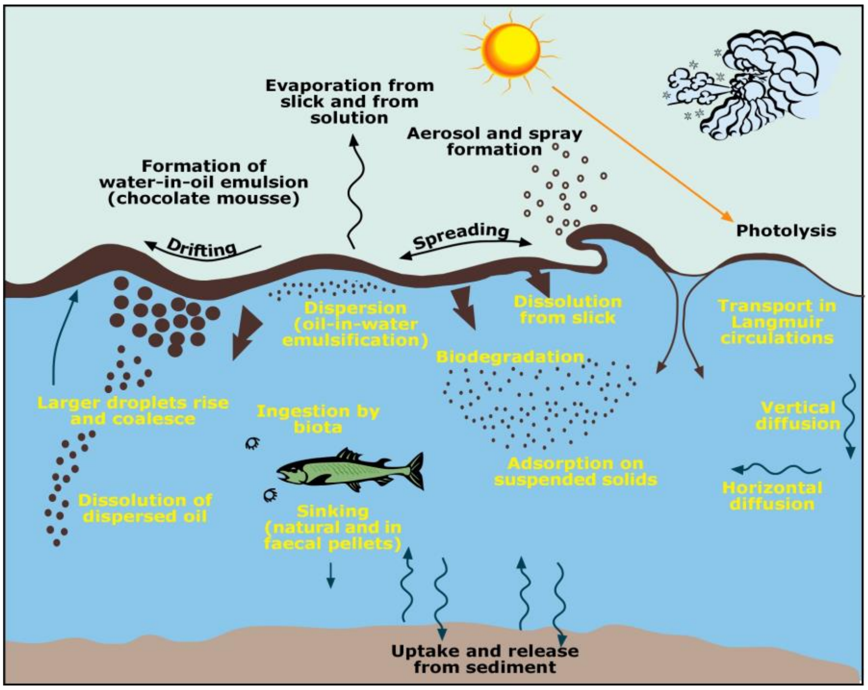

Figure 9.2: Fate and behaviour of spilled oil at sea

Evaporation

Following a hydrocarbon spill, evaporation is the initial predominant mechanism of reducing the mass of oil, as the light fractions (including aromatic compounds such benzene and toluene) evaporate quickly. Evaporation can cause considerable changes in the density, viscosity and volume of the spill. If the spilled oil contains a high percentage of light hydrocarbon fractions, a large part of it will evaporate relatively quickly in comparison to heavier oil.

Both condensate and diesel display very high evaporative losses upon exposure to air. Under ideal environmental conditions, i.e. a warm, sunny day with only moderate wind, a large proportion of the spill volume may be lost by evaporation in the first few hours after release. The evaporation process is enhanced by warm temperatures and moderate winds. Winds in the Southern North Sea are strongest during the winter months, falling to moderate wind speeds in summer.

Dispersion

After the light fractions have evaporated from the slick, natural dispersion becomes the dominant mechanism in reducing slick volume. The speed at which oil disperses is largely dependent upon the nature of the oil and the sea state. Lighter and less viscous oils tend to have more water-soluble components, allowing them to mix and remain suspended within the water column.

The process of dispersion is dependent upon waves and turbulence at the sea surface, which can cause a slick to break up into fragments and droplets of varying sizes. This turbulence mixes these droplets into the upper levels of the water column, where some of the smaller droplets will remain suspended, while the larger ones will tend to rise back to the surface. Therefore, rough seas will break up a slick and disperse the oil at a faster rate than calm seas. In the North Sea, there have been incidences of large oil spills being broken up and dispersed into the water column during large storm events, with little visible effect on the surrounding environment. As oil droplets are dispersed into the water column, the oil has a greater surface area which encourages the natural processes of dissolution, biodegradation and sedimentation.

Water movement at the sea surface is affected by wind speed. The Southern North Sea is a highly variable environment with wind speeds typically highest in the winter months and the sea state reaches a Beaufort Force 7 (sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind) for around 30% of the time. Water movement and wave size is also related to fetch, the distance over which the wind can blow without being interrupted.

Emulsification

The immiscible components of an oil spill may either emulsify and disperse as small droplets in the water column (an oil-water emulsion) or aggregate into tight water-in-oil emulsions, often referred to as 'chocolate mousse'. The rate at which this happens, and the type of emulsion formed, is dependent upon the oil type, sea state and the thickness of the oil slick. Large, thick oil slicks tend to form water-in-oil emulsions, while smaller thinner slicks tend to form oil-in-water emulsions that usually disappear by natural dispersion. In practice, usually only one of the two processes will dominate.

When a water-in-oil emulsion (chocolate mousse) is formed, the overall volume of the slick increases significantly, as it may contain up to 70% or 80% water. This chocolate mousse will form a thick layer on the sea surface reducing slick spreading and inhibiting natural dispersion. The formation of this thick layer causes the surface area available to weathering and degradation processes to diminish, which can make 'chocolate mousses' difficult to break up using dispersants. In their emulsified form, and with their drastically increased volume, they can also cause difficulties for mechanical recovery devices. A water-in-oil emulsion is very unlikely to occur in spills of condensate or diesel, due to the very light properties of these oils.

9.4 Oil Spill Modelling

The amount of time a hydrocarbon spill remains on the sea surface before becoming insignificant, and the extent to which it spreads from the point of release, may dictate the severity of any impacts on the marine life, particularly seabirds. Whether it reaches the shore is also a major consideration, due to the sensitivity of the coastline, and the additional clean up resources required. Oil spill modelling has been conducted to provide information on whether a spill might beach and, if so, how much time this would take to occur. In view of this, the end points for the oil spill risk assessment are considered to be:

- Probability of oil reaching a shoreline, or crossing a median line to reach international waters;
- Minimum time taken for oil to reach a shoreline, or crossing a median line to reach international waters.

Stochastic oil spill modelling has been conducted to assess these two criteria. Stochastic oil spill modelling is based on actual statistical wind speed and direction frequency data, and provides a probability range of sea surface oil and beaching, representative of the prevailing conditions.

All modelling has been undertaken using SINTEF's Oil Spill Contingency and Response (OSCAR) model (Version 9.0.1). As discussed in Section 9.1, the three scenarios which may result in a large release of hydrocarbons to sea are an uncontrolled well blow-out, resulting in a release of gas and condensate, a rupture of the jack-up rig's fuel tanks, resulting in a large diesel release and loss from a pipeline rupture resulting in an instantaneous release of the total pipeline inventory. Modelling has therefore been undertaken for each of these scenarios.

The proposed Southwark Field Development operations are planned to take place throughout the year. Therefore, oil spill modelling for all three scenarios has been carried out for all four seasons. This provides a range of risk profiles throughout the year which covers the field(s) during operations as well as the drilling and installation phases of the development.

9.4.1 Uncontrolled Well Blow-out

The worst-case scenario maximum release of hydrocarbons in the event of a well blow-out from Southwark Well S2, the well with the highest potential flow rate in any of the three fields, is discussed in Section 9.1.1. The parameters used in the modelling are detailed in Table 9.1, whilst Table 9.2 provides a justification for the parameters selected for the modelling.

Table 9.1: Condensate Blow-Out Modelling Parameters

Condensate Blow-out Parameters								
Loss from Well/ FPSO / Rig / Other		Well blowout			Instantaneous Loss?		No	
Worst Case [m³]		856 m³ / 81 days			Will the Well Self-Kill?		No	
Flow Rate [m³/day]		10.57 m³						
Justification for Predicted Worst Case Volume		It would be expected to take 81 days to drill a relief well						
Location								
Spill Source Point		53° 11' 02.605" N, 02° 05' 53.879" E						
Installation / Facility Name		Southwark S2			Quad/Block		49/21c	
Hydrocarbon Properties								
Hydrocarbon Name		Southwark condensate						
Assay Available		No			Was an Analogue used for Spill Modelling?			Yes
	Name	ITOPF Category	Specific Gravity	API	Viscosity [cP]	Pour Point [°C]	Wax Content [%]	Asphaltene Content
Hydrocarbon	Condensate	1	0.7782	50.33	1.6	-	-	-
Analogue	Modelled oil	1	0.785	48.8	2.0	10	-	-
Metocean Parameters								
Air Temperature (°C)		7°C – 19°C			Sea Temperature (°C)		2°C – 15°C	
Wind Data		7 years' (2008 – 2014) UK Oil & Gas data from the European Centre for Medium-Range Weather Forecasts (ECMWF)						
Current Data		3 years' (2011 – 2014) UK Oil & Gas (Shelf daily currents data)						
Modelled Release Parameters								
Surface or Subsurface		Surface			Depth [m]		0 m (surface)	
Release Duration [days]		81 days			Instantaneous?		No	
Persistence Duration [days]		15 days			Release Rate [m³/day]		10.57 m³/day	
Total Simulation Time [days]		96 days			Total Release [m³]		856.17 m³	
Oil Spill Modelling Software								
Name of Software		MEMW-OSCAR			Version		10.0.1	

Source: OSRL, 2019.

Table 9.2: Justification for Condensate Blow-out Modelling Parameters

Parameter	Justification
Flow rate	The initial expected flow rate of 10.57 m^3/day condensate has been used for the duration of the model.
Hydrocarbon properties	Southwark expected condensate is not available in OSCAR's database of known oils. Therefore, a modelled oil, which most closely matches the expected properties for Southwark condensate, was used in the modelling.
Metocean parameters	Oil and Gas UK dataset approved for use in oil spill modelling on UKCS.
Depth of release	The most likely release location for hydrocarbons in the event of an uncontrolled well blow-out would be at the surface, and so this release depth has been modelled.
Release duration	In the event of an uncontrolled well blow-out, if initial actions to regain control of the well failed, it may be necessary to drill a relief well. This procedure is expected to take up to 81 days, and so this duration has been used for the release.
Model duration	Following the 81 day release period, the model was allowed to continue to run for a further 15 days, in order to assess the ongoing dispersion of hydrocarbons.

The results of the condensate well blow-out modelling scenario are provided in Table 9.3. Minimum arrival time of surface oiling is shown in Figure 9.3 and probability of surface oiling in Figure 9.4. It should be noted that surface oiling is shown with a thickness threshold of 0.3 µm, in accordance with OPRED's oil spill modelling requirements.

Potential impacts relating to the modelling results are described in Section 9.5.

Table 9.3: Condensate Blow-Out Modelling Results

Condensate Well Blow-out Modelling Summary				
Spill Scenario / Descriptor	Southwark S2 exploration well blow-out			
Median Crossing				
Identified Median Line	**Highest Probability and Shortest Time to Reach**			
	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
Does not leave United Kingdom waters	-	-	-	-
Landfall				
Predicted Locations	**Highest Probability and Shortest Time to Reach**			
	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
No shoreline impact	-	-	-	-
Shoreline Impact				
No shoreline impact	-	-	-	-
Key Sensitivities At Risk				
Sensitivities / Sites of Concern	**Highest Probability and Shortest Time to Reach**			
Southern North Sea SAC	100 %	100 %	100 %	100 %
	0 hours	0 hours	0 hours	0 hours
Cromer Shoal Chalk Beds MCZ	0 %	11 %	15 %	0 %
	N/A	52 days, 3 hours	9 days, 18 hours	N/A
Haisborough, Hammond and Winterton SAC	39 %	69 %	63 %	19 %
	7 days, 12 hours	1 day, 21 hours	1 day, 18 hours	3 day, 9 hours
North Norfolk Sandbanks and Saturn Reef SAC	100 %	100 %	100 %	100 %
	0 hours	0 hours	0 hours	0 hours

Source: OSRL, 2019.

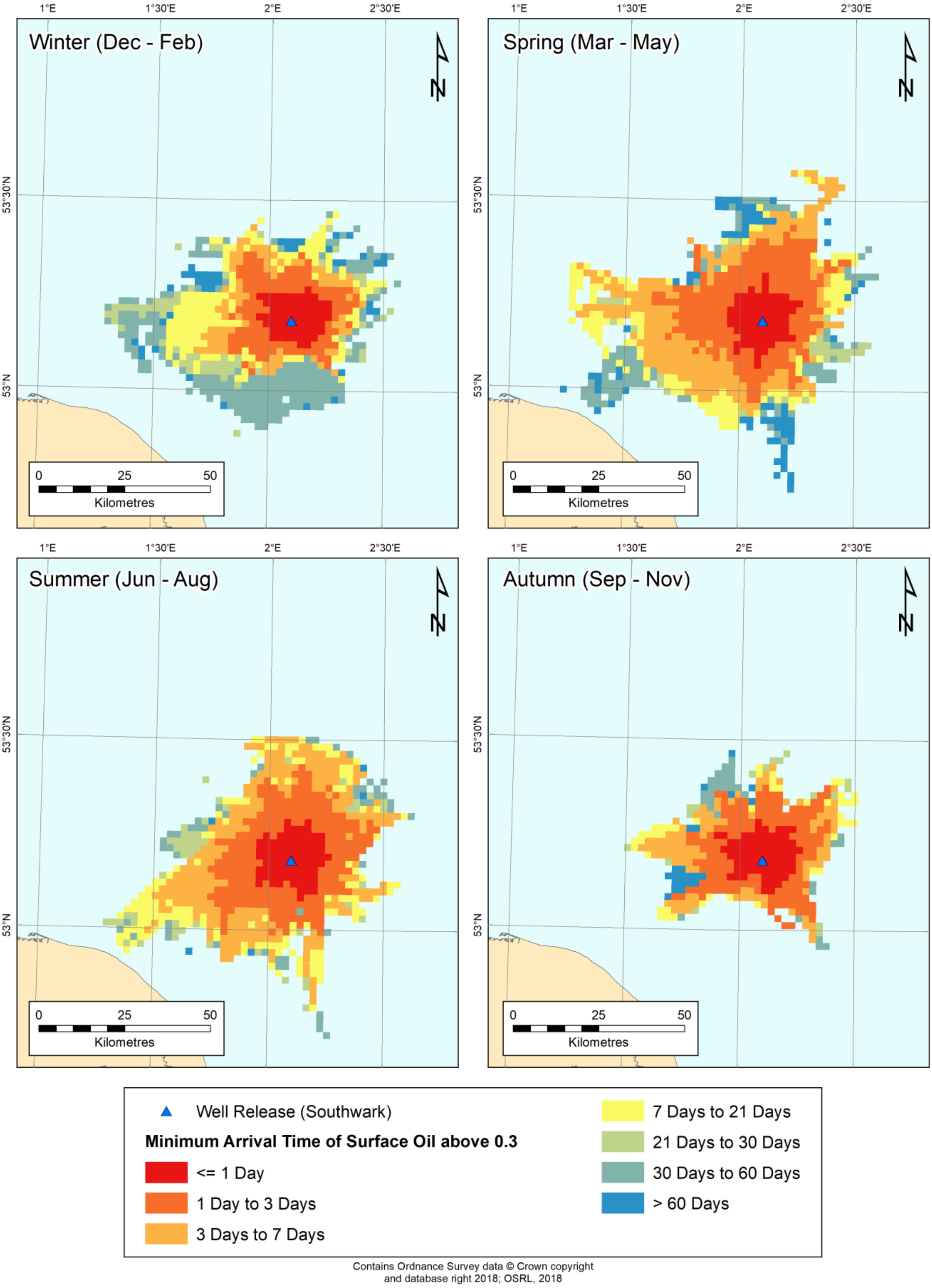

Figure 9.3: Southwark S2 well condensate blow-out modelling: arrival time plot
Source: OSRL, 2019.

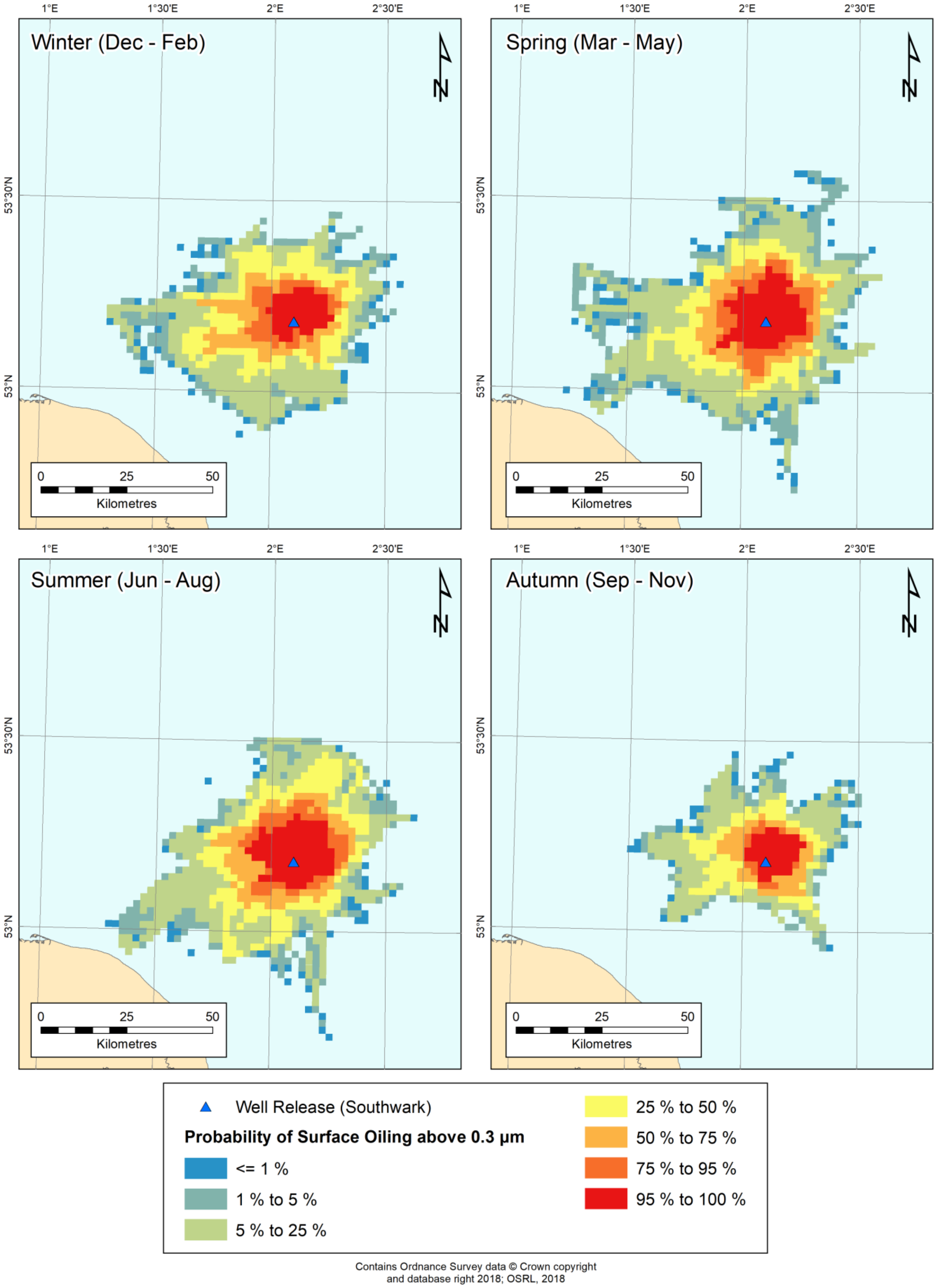

Figure 9.4: Southwark S2 well condensate blow-out modelling: probability of surface condensate

Source: OSRL, 2019.

9.4.2 Diesel Spill

The worst-case scenario release of diesel from the proposed Southwark Field Development is discussed in Section 9.1.2. The parameters used in the modelling are detailed in Table 9.4, whilst Table 9.5 provides a justification for the parameters selected for the modelling.

Table 9.4: Diesel Spill Modelling Parameters

Diesel Spill Parameters								
Loss from Well/ FPSO / Rig / Other		Diesel release			Instantaneous Loss?		Yes	
Worst Case [m^3]		1,138.35 m^3			Will the Well Self-Kill?		NA	
Flow Rate [m^3/day]		Instantaneous						
Justification for Predicted Worst Case Volume		Maximum diesel inventory of jack-up drilling rig (ENSCO 92 used as a proxy)						
Location								
Spill Source Point		53° 11'02.605" N, 002° 05' 53.879" W						
Installation / Facility Name		*Southwark*			Quad/Block		49/21c	
Hydrocarbon Properties								
Hydrocarbon Name		Diesel						
Assay Available		No			Was an analogue used for Spill Modelling?			Yes
	Name	ITOPF Category	Specific Gravity	API	Viscosity [cP]	Pour Point [°C]	Wax Content [%]	Asphaltene Content
Hydrocarbon	Diesel	2	0.843	36.4	3.9 cP	-36 °C	-	-
Metocean Parameters								
Air Temperature (°C)		2°C – 15°C			Sea Temperature (°C)		7°C – 14°C	
Wind Data		2 years' (2012 – 2013) European Centre for Medium-Range Weather Forecasts (ECMWF) wind data						
Current Data		2 years' (2012 – 2013) UK Oil & Gas (Shelf daily currents data)						
Modelled Release Parameters								
Surface or Subsurface		Surface			Depth [m]		0 m (surface)	
Release Duration [days]		1 hour			Instantaneous?		Yes	
Persistence Duration [days]		6 days, 20 hours			Release Rate [m^3/hour]		1,138.35 m^3/hour	
Total Simulation Time [days]		15 days			Total Release [m^3]		1,138.35 m^3	
Oil Spill Modelling Software								
Name of Software		MEMW-OSCAR			Version		9.0.1	

Table 9.5: Justification for Diesel Spill Modelling Parameters

Parameter	Justification
Flow rate	The maximum diesel capacity of the jack-up drilling rig, ENSCO 92, has been modelled as an industry standard example jack-up rig.
Hydrocarbon properties	The modelling has been based on the known properties of diesel.
Metocean parameters	The Oil and Gas UK dataset, which is approved for use in oil spill modelling on UKCS, has been used.
Depth of release	The most likely release location for hydrocarbons in the event of a large diesel spill would be at the sea surface, and so this release depth has been modelled.
Release duration	A worst-case scenario diesel release would involve a rupture of the diesel tanks resulting in an instantaneous release of the complete inventory.
Model duration	Following the instantaneous release, the model was allowed to continue to run for a further 15 days, in order to assess the ongoing dispersion of hydrocarbons.

The results of the diesel spill modelling scenario are provided in Table 9.6. Minimum arrival time of surface oiling is shown in Figure 9.5 and probability of surface oiling in Figure 9.6. It should be noted that surface oiling is shown with a thickness threshold of 0.3 µm, in accordance with OPRED's oil spill modelling requirements.

Table 9.6: Diesel Spill Modelling Results

Diesel Spill Modelling Summary				
Spill Scenario / Descriptor	Maximum diesel inventory of example jack-up drilling rig, ENSCO92			
Median Crossing				
Identified Median Line	**Highest Probability and Shortest Time to Reach**			
	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
Netherland	30%	18%	51%	28%
	1 day, 10 hours	2 days,40 hours	2 days	1 day, 12 hours
Landfall				
Predicted Locations	**Highest Probability and Shortest Time to Reach**			
	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
United Kingdom	10 %	24 %	13 %	7 %
	2 days, 4 hours	1 day, 16 hours	2 day, 14 hours	2 day, 9 hours
Shoreline Oiling by County				
East Riding of Yorkshire				<1%
				9 days, 8 hours
Lincolnshire	2%	2%		2%
	7 days, 20 hours	5 days, 12 hours		6 days, 5 hours
Norfolk	8%	18%	12%	5%
	2 days, 4 hours	1 day, 16 hours	2 days, 14 hours	2 days, 9 hours
Suffolk		5%	<1%	
		5 days, 10 hours	5 days, 20 hours	
Kent		<1%		
		10 days, 6 hours		
Shoreline Impact				
Mass of oil onshore	551 MT	520 MT	649 MT	566 MT
Volume of oil onshore	654 m^3	617 m^3	770 m^3	671 m^3
Water content	1 %	1 %	1 %	1 %
Volume of emulsion onshore	660 m^3	622 m^3	777 m^3	678 m^3
Key Sensitivities At Risk				
Sensitivities / Sites of Concern	**Highest Probability and Shortest Time to Reach**			
Doggar Bank (GBR) SAC	-	-	2 %	
	-	-	5 days, 18 hours	
Dogger Bank (NLD) SAC	-	-	1 %	-
	-	-	10 days, 17 hour	-
Southern North Sea SAC	100 %	100 %	100 %	100 %
	0 hours	0 hours	0 hours	0 hours

Source: OSRL, 2018

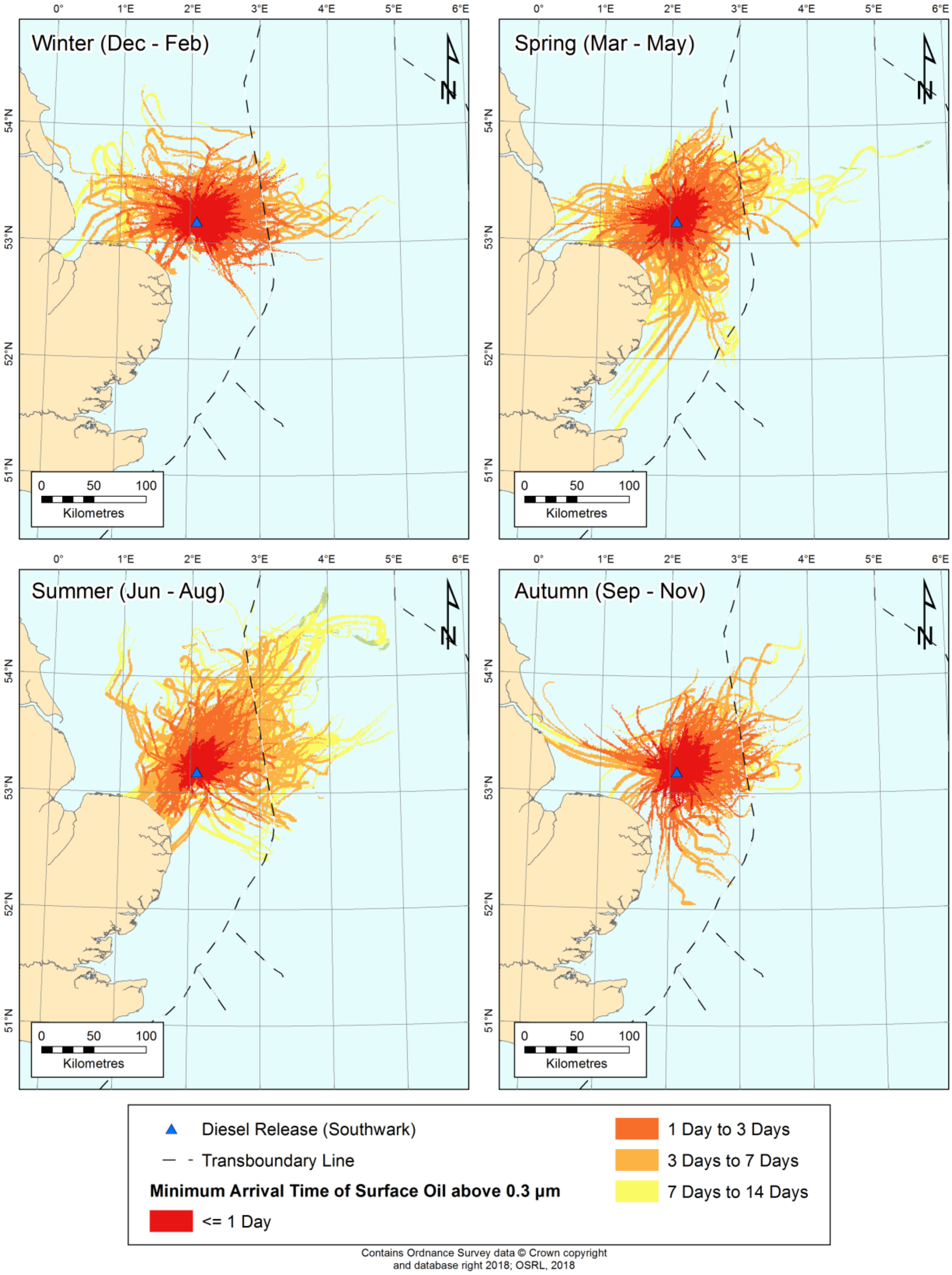

Figure 9.5: Diesel spill modelling: arrival time plot

Source: OSRL, 2018

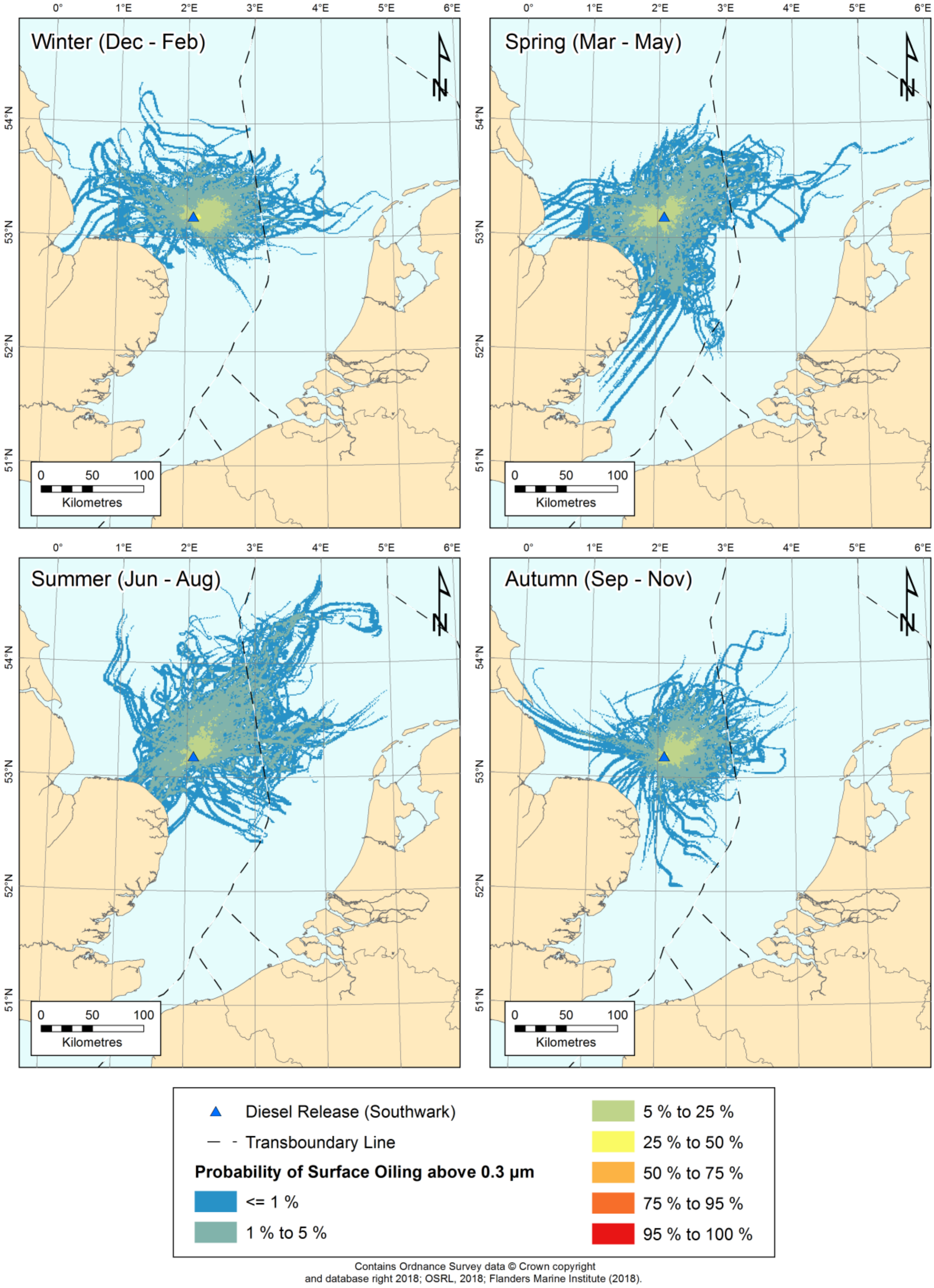

Figure 9.6: Diesel Spill Modelling: Probability of Surface Diesel

Source: OSRL, 2018

9.4.3 Pipeline Inventory Loss

The worst-case scenario release from a pipeline inventory loss as a result of the planned Southwark Field Development is discussed in Section 9.1.3. The parameters used in the modelling are detailed in Table 9.7, whilst Table 9.8 provides a justification for the parameters selected for the modelling.

Table 9.7: Pipeline Loss Modelling Parameters

Diesel Spill Parameters								
Loss from Well/ FPSO / Rig / Other		Pipeline			Instantaneous Loss?		Yes	
Worst Case [m^3]		0.63 m^3			Will the Well Self-Kill?		N/A	
Flow Rate [m^3/day]		Instantaneous						
Justification for Predicted Worst Case Volume		Maximum pipeline inventory loss from infield pipeline						
Location								
Spill Source Point		53° 09' 36.900" N, 02° 06' 58.176" W						
Installation / Facility Name		*Southwark to PL370 pipeline*			Quad/Block		49/26	
Hydrocarbon Properties								
Hydrocarbon Name		Condensate						
Assay Available		No		Was an Analogue used for Spill Modelling?				Yes
	Name	ITOPF Category	Specific Gravity	API	Viscosity [cP]	Pour Point [°C]	Wax Content [%]	Asphaltene Content
Hydrocarbon	Condensate	1	0.7782	50.3	1.6	-	-	-
Analogue	Modelled oil	1	0.785	48.8	2.0	10 °C	-	-
Metocean Parameters								
Air Temperature (°C)		2°C – 19°C			Sea Temperature (°C)		2°C – 15°C	
Wind Data		2 years' (2008 – 2014) UK Oil & Gas data from the European Centre for Medium-Range Weather Forecasts (ECMWF)						
Current Data		3 years' (2011 – 2014) UK Oil & Gas (Shelf daily currents data)						
Modelled Release Parameters								
Surface or Subsurface		Subsurface			Depth [m]		30 m	
Release Duration [days]		1 hour			Instantaneous?		Yes	
Persistence Duration [days]		15 days			Release Rate [m^3/hour]		0.63 m^3/hour	
Total Simulation Time [days]		15 days			Total Release [m^3]		0.63 m^3	
Oil Spill Modelling Software								
Name of Software		MEMW-OSCAR			Version		10.0.1	

Table 9.8: Justification for Pipeline Loss Modelling Parameters

Parameter	Justification
Flow rate	The maximum volume of condensate likely to be released has been modelled
Hydrocarbon properties	The modelling has been based on the known properties of condensate
Metocean parameters	Oil and Gas UK dataset approved for use in oil spill modelling on UKCS
Depth of release	The most likely release location for hydrocarbons in the event of a pipeline loss is at the seabed, and so this release depth has been modelled
Release duration	A worst-case scenario release would involve an instantaneous release of condensate
Model duration	Following the instantaneous release, the model was allowed to continue to run for a further 15 days, in order to assess the ongoing dispersion of hydrocarbons
Location	The largest in-field pipeline was selected for modelling.

The results of the pipeline loss modelling scenario are provided in Table 9.9. The minimum time for condensate to arrive at the sea surface is shown in Figure 9.7 and the probability of surface oiling is shown in Figure 9.8. It should be noted that surface condensate is shown with a thickness threshold of 0.3 µm, in accordance with OPRED's oil spill modelling requirements.

Table 9.9: Pipeline Loss Modelling Results

Condensate Spill Modelling Summary				
Spill Scenario / Descriptor	Pipeline condensate release			
Median Crossing				
Identified Median Line	**Highest Probability and Shortest Time to Reach**			
	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
Does not leave United Kingdom Waters	-	-	-	-
	-	-	-	-
Landfall				
Predicted Locations	**Highest Probability and Shortest Time to Reach**			
	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
No shoreline impact	-	-	-	-
	-	-	-	-
Shoreline Impact				
Mass of oil onshore	-	-	-	-
Volume of oil onshore	-	-	-	-
Water content	-	-	-	-
Volume of emulsion onshore	-	-	-	-
Key Sensitivities At Risk				
Sensitivities / Sites of Concern	**Highest Probability and Shortest Time to Reach**			
Southern North Sea SAC	100%	100%	100%	100%
	0 hours	0 hours	0 hours	0 hours
North Norfolk Sandbanks and Saturn Reef SAC	100%	100%	100%	100%
	0 hours	0 hours	0 hours	0 hours

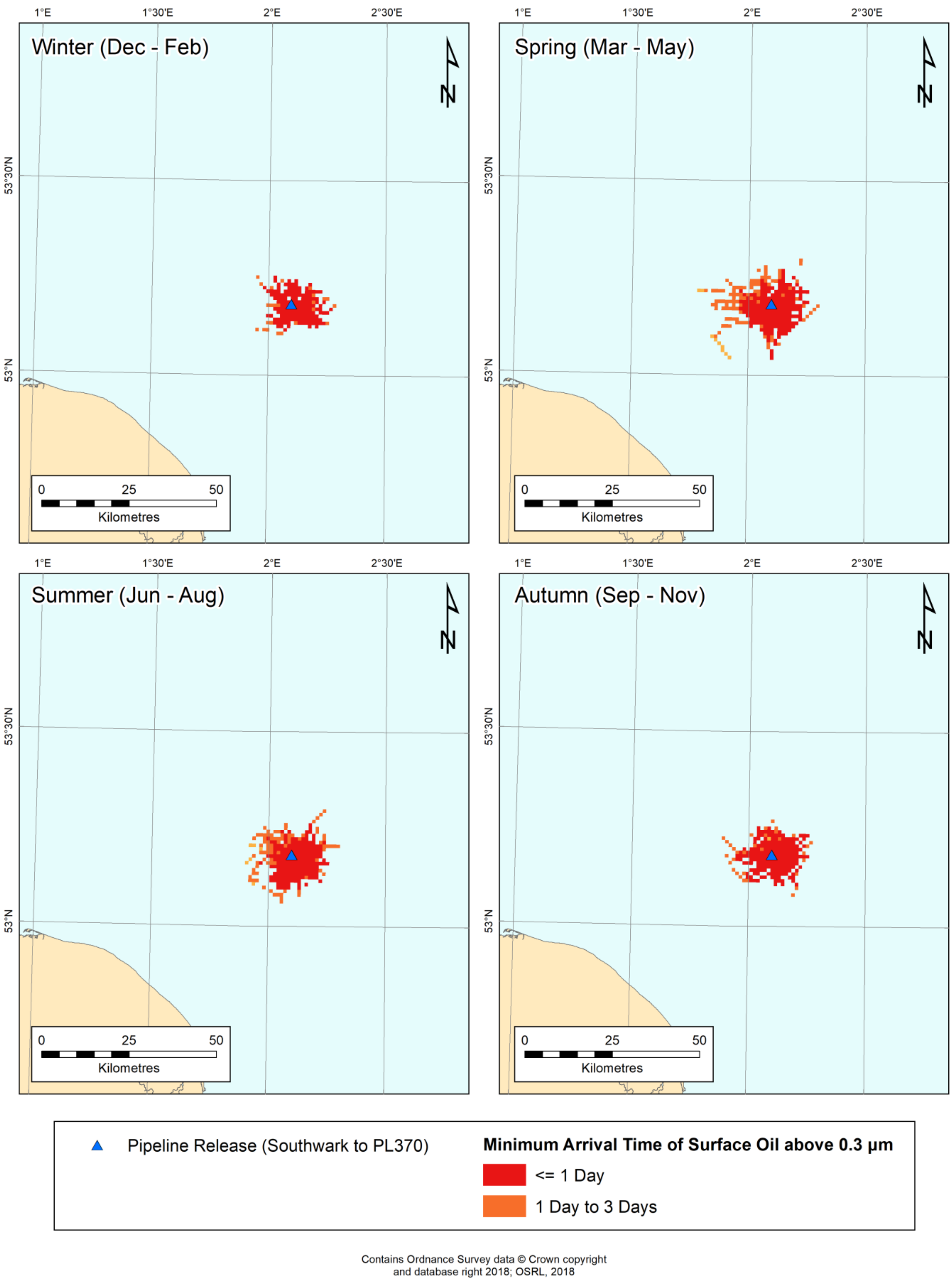

Figure 9.7: Pipeline release modelling: arrival time plot

Source: OSRL, 2019

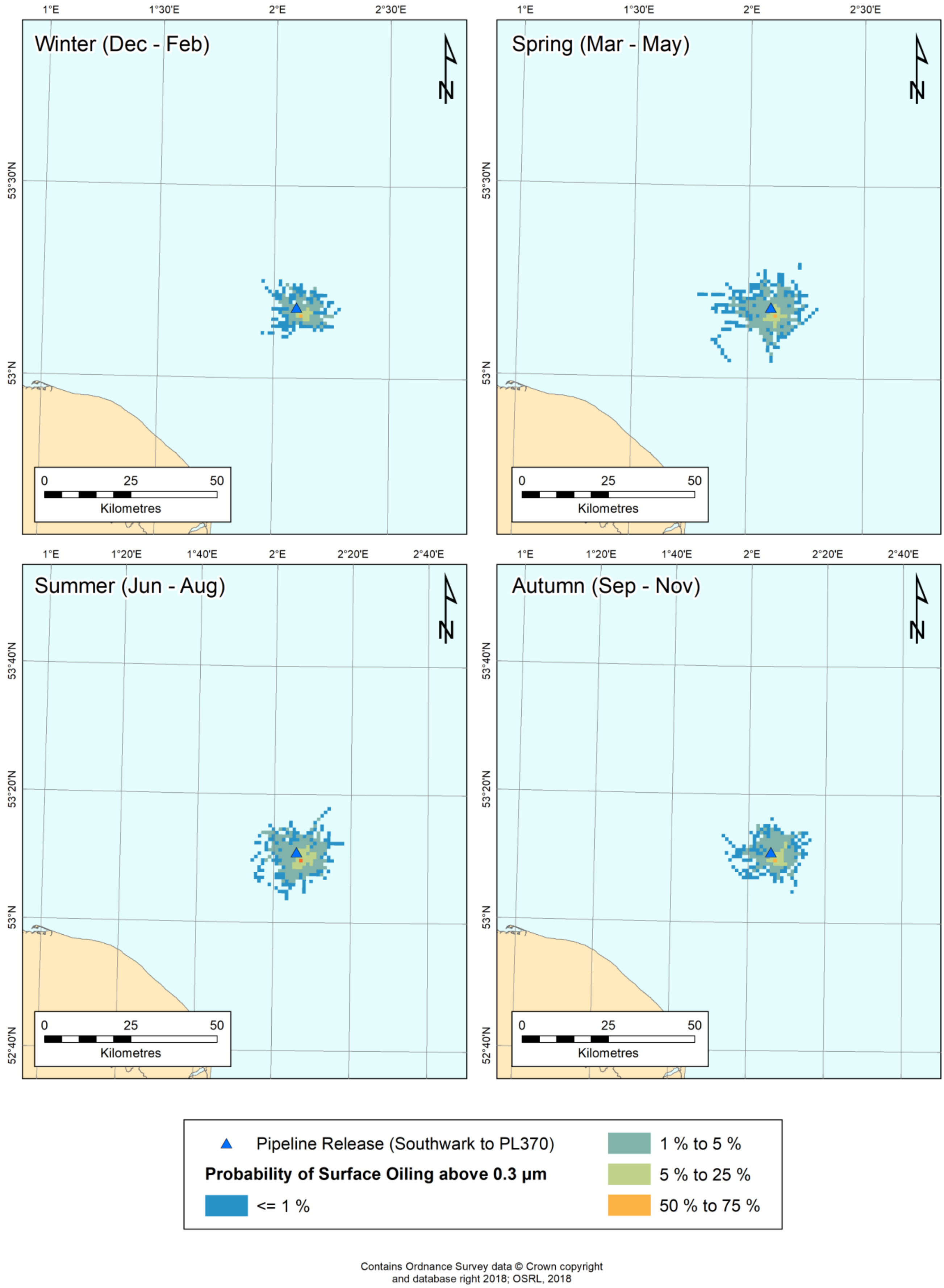

Figure 9.8: Pipeline release modelling: Probability of surface condensate

Source: OSRL, 2019

9.5 Potential Environmental Impacts

9.5.1 Impacts on Marine Life

The risk of accidental hydrocarbon spillage to the marine environment is one of the main environmental concerns associated with oil-industry activities. Although the effects of hydrocarbon spills are well understood, the effects of each individual spill are unique and some assumptions have been made with regards to predicting the effects of a large condensate or diesel spill from the operations at the Southwark Field Development.

Plankton

Oil, particularly diesel, is toxic to a wide range of planktonic organisms. Those living near the sea surface are particularly at risk, as water-soluble components leach from floating oil. Although oil spills may kill individuals, the effects on whole plankton communities generally appear to be short-term. Following an oil spill incident, plankton biomass may fall dramatically, due either to animal deaths or small scale, local avoidance of the area (Brussard et al. 2016 and Seuront, 2010). However, after only a few weeks, populations would be expected to return to previous levels through a combination of high reproductive rates and immigration from outside the affected area.

Benthos

It is generally assumed those animals associated with the seabed will remain unaffected by a surface slick as the floating oil moves above them. However, a fraction of the water soluble components of a slick may dissolve into the water column, assisted by rough seas or agitation of the sea surface, where these could potentially be harmful to benthic organisms. Parameters such as local bathymetry and sediments types would significantly influence the distribution of oil contamination at the seabed.

If the spilled oil drifts inshore, the benthic communities of the shallow coastal areas may be affected. However, it should be noted that any hydrocarbons that reach these shallow areas will have travelled a considerable distance through the water column and across the sea surface, and will therefore have been affected by the range of degradation processes described in Section 9.3. These mechanisms will have contributed to reduce the various toxic components of the hydrocarbons and the primary impact of the oil deposition on benthic communities is anticipated to be related to smothering. As released hydrocarbons will also have become widely dispersed by this point, the physical effects of smothering are also expected to be limited.

The shoreline itself is particularly susceptible to oil beaching, and heavy mortalities of intertidal benthic organisms could result if coated with oil. The potential impacts arising from beached oil in coastal habitats are discussed separately in Section 9.5.2.

Fish

Offshore fish populations remain relatively unaffected by oil pollution, as oil concentrations below the surface slick are generally low (Clark, 2001). There is also evidence that fish are able to detect and avoid oil-contaminated waters. This avoidance may, however, cause disruption to migration or spawning patterns. Cod, lemon sole, mackerel, sandeel, plaice, whiting and sole are known to spawn in the area of the proposed Southwark Field Development whilst these same species in addition to herring have been identified as potential users of the area for nursery grounds (Section 3.3.3).

Rather than impacting the fish directly, heavily contaminated sediments may have an adverse effect on local populations of demersal fish species, due to the impacts it has lower down the food chain. However, as described in the benthos section above, heavy contamination of the sediments is not expected both due to the water depth and the expected behaviour of the condensate.

Fish eggs and larvae are more vulnerable to oil pollution than adult fish. In many fish species, these stages float to the surface where contact with spilt oil is more likely. Certain fish stocks may be more affected than others particularly if the spill is very large and coincides with specific spawning periods or encroaches on areas with species which have restricted spawning areas.

Shellfish

If hydrocarbons reach the seabed, shellfish species that cannot swim away from contaminated sediments are susceptible to its effects. Mortalities may occur if shellfish become smothered by settling hydrocarbons. Only low levels of hydrocarbons in seawater may cause tainting in shellfish, which may be commercially damaging to shellfish fisheries. This is more common in filter feeding shellfish, principally bivalves, as they would take up fine oil droplets from the water column. In the Southern North Sea, shellfish make up the vast majority of landings from ICES rectangle 35F2 where the Southwark field is located. The main shellfish species landed are crabs, whelks and lobsters (Section 3.5.1) and therefore the shellfish fishery may be at risk if a spill was to occur.

Marine Mammals

Whales, dolphins, porpoises and seals are generally able to avoid a spill and are rarely affected significantly. However, if they do come into contact with a spill, possibly by surfacing in a slick to breathe, they may suffer from irritation of the eyes, mouth, nasal passages and skin. Volatile hydrocarbon fractions may also cause respiratory problems.

A thick layer of blubber protects cetaceans and adult seals from the cold and these animals are less vulnerable to the physical impacts of hydrocarbons lowering their resistance to the cold. However, seal pups are at risk from hypothermia if their fur becomes oiled and loses its thermal properties, as they do not have sufficient blubber underneath their fur to keep them warm. Both common and grey seals species are known to make use of haul out sites in the wider area (Section 3.3.4) and are specifically vulnerable during their pupping seasons, i.e. June to September (common seals) and October to late November (grey seals).

Seabirds

Seabirds are particularly susceptible to hydrocarbon pollution on the sea surface and, during large hydrocarbon spills, seabird mortality often attracts the greatest levels of public concern. Following contact with hydrocarbons, seabirds risk loss of buoyancy and thermal insulation as the water-repellent properties of their plumage is lost. In an attempt to clean their plumage, seabirds can also ingest the oil when preening, which may lead to an array of physiological effects. In addition to the direct mortality of adult birds, only small quantities of ingested hydrocarbons can have an indirect effect on reproduction, with depressed egg production and reduced hatching success.

The aerial habits of the fulmar and gulls, together with their large populations and widespread distribution, reduce vulnerability of these species. Gannets, skuas and auk species are considered to be most vulnerable to oil pollution due to a combination of heavy reliance on the marine environment, low breeding output with a long period of immaturity before breeding, and the regional presence of a large percentage of the biogeographical population (DTI, 2003).

The vulnerability of bird species to oil pollution is dependent on several factors and varies considerably throughout the year. The JNCC has produced a Seabird Oil Sensitivity Index (SOSI) which identifies areas at sea where seabirds are likely to be most sensitive to oil pollution. The SOSI uses seabird survey data collected between 1995 and 2015, in addition to individual species sensitivity index values, combined at each location to create a single measure of seabird sensitivity to oil pollution (JNCC, 2017c).

Monthly vulnerability for seabirds in the area around the Southwark Field Development are presented in Table 9.10 and Figure 9.9. With increasing distance from shore, seabird abundance decreases and their distribution becomes increasingly patchy. These patterns are generally governed by the availability and distribution of prey, and also oceanographic features such as water depth and sea temperature. As a result, in the shallower waters of the Southern North Sea, approximately 35 km from the Norfolk Coast, seabirds are present throughout the year however most are typically low in abundance with the exception of fulmar, gannet, kittiwake, guillemot and puffin which have been recorded in greater numbers than other species (Section 3.3.5).

Table 9.10: Seabird Vulnerability to Surface Pollution near Blocks 49/21 and 49/26 (JNCC, 2018)

UKCS Block	Seabird Vulnerability											
	J	F	M	A	M	J	J	A	S	O	N	D
48/20	1*	1	1*	ND	3	1	5	5	5	ND	1*	1
48/25	1*	1	1	ND	3	1	4	4	4*	2*	2	2
48/30	1*	1	3	ND	4	4	5	4	5	3	3	2
49/16	2*	2	2*	ND	ND	5	5*	5	5*	ND	2*	1
49/17	ND	1*	2*	ND	ND	5	2	5	5	ND	ND	1
49/21	ND	1	2	ND	ND	ND	5*	5	5*	ND	1*	1
49/22	1*	3*	3	ND	ND	5	5*	5	3	ND	1*	1
49/26	1*	1	4	ND	5	5	5*	5	5	ND	3	2
49/27	2*	4*	4	ND	ND	5	5*	5	5*	ND	1*	1
52/5	1	1	3	5*	5	5	5	4	5	3*	3	2
53/1	1	2	3	ND	5	3	5*	5	5	3*	3	2
53/2	1	3	3	ND*	3*	3*	5*	5	ND*	4*	4	2

1 Extremely high; 2 Very high; 3 High; 4 Medium; 5 Low; ND No data

* Indicates blocks for which no data was available, and therefore score has been calculated using that of an adjacent month or block

The vulnerability of birds in the vicinity of the proposed Southwark field is low to very high as the breeding season progresses, generally between March and June, when large numbers of birds congregate in coastal breeding colonies (RSPB, 2018; Table 9.4; Figure 9.6). Seabird vulnerability in the area is generally low in September, potentially in response to seabirds moving away from colonies after breeding. The vulnerability is slightly increased by numbers of auks, primarily guillemots, found at sea during this time (BODC, 1998; DTI 2003). Congregating into large groups referred to as 'rafts', these birds undergo a full moult at sea, rendering them flightless and leaving them highly susceptible to surface pollution (RSPB, 2018).

Both the density and diversity of bird species sighted in the vicinity of the proposed development area increases during the winter months. Vulnerability remains very high during this time, due to the presence of overwintering and migratory species. The area is important for auk species, which remain vulnerable to surface pollution while at sea, as they swim on the surface prior to diving for prey (Mitchell *et al*, 2004). Gannets, which feed by plunging into the sea, are also present is small numbers (BODC, 1998). Spreading out from inland breeding sites, several species of gull have been observed in high numbers around the blocks from October through to March. However, these birds are much less reliant on the sea as either their habitat or source of food, eating insects, worms, rubbish and other birds (RSPB, 2018).

Overall, seabirds within Blocks 48/25, 49/21 and 49/26 show a high to very high vulnerability to oil and surface pollutants following the breeding season and throughout the winter with a decrease in vulnerability during the breeding season (JNCC, 2018).

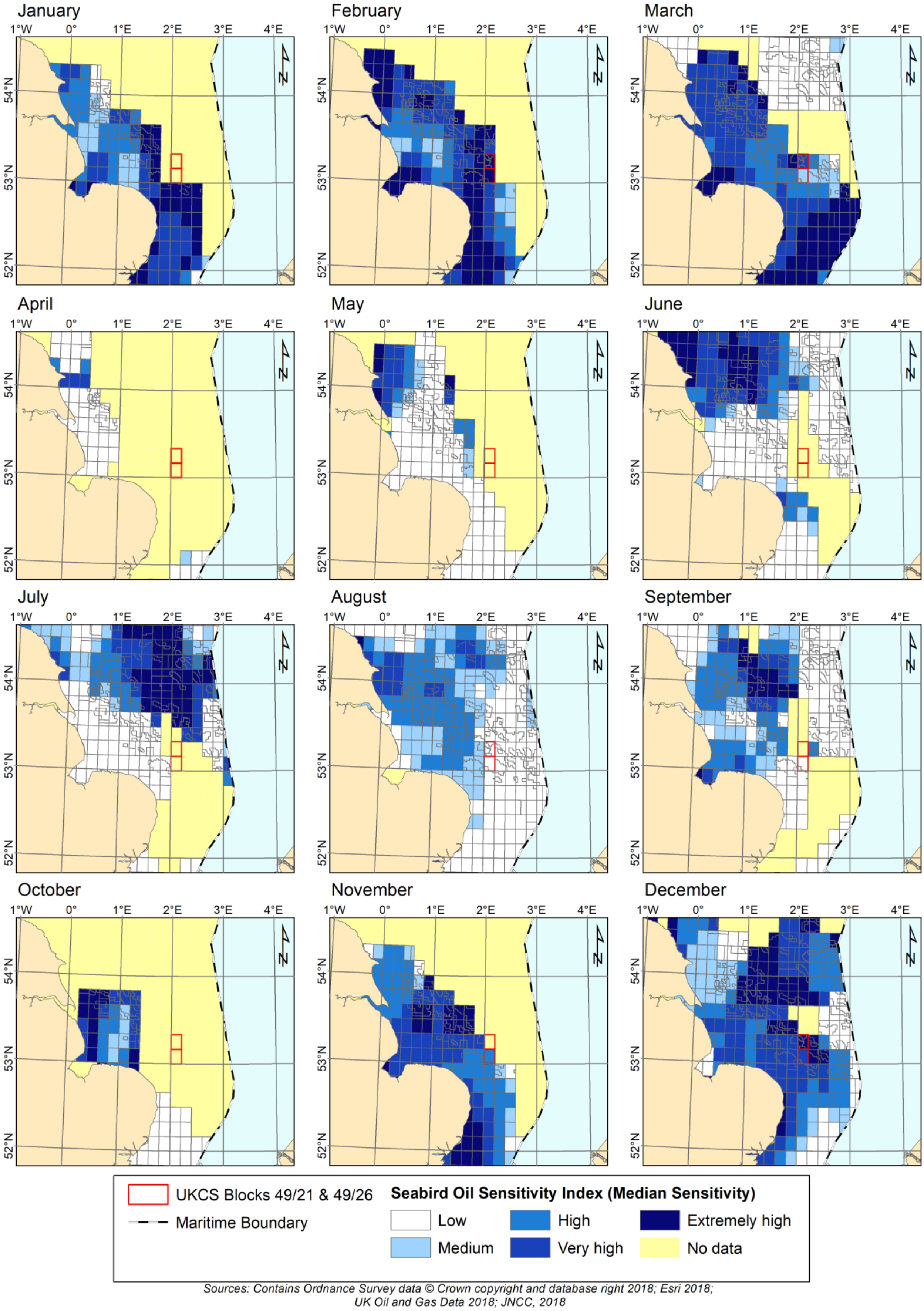

Figure 9.9: Seabird vulnerability to surface pollution

Inshore of the Southwark Field Development location, seabird vulnerability is classified as high to very high throughout the winter months with a marked decrease in seabird vulnerability in the summer months. The south-east of England is of international importance for the seabird breeding colonies supported at many coastal sites and their surrounding inshore waters which have been designated as Special Protection Areas (SPAs) under the European Birds Directive. These colonies may be at risk from a large surface slick.

9.5.2 Impacts on Coastal and Inshore Habitats

The coastlines of the Norfolk support a range of different habitat types and is important for nature conservation, with numerous sites along the coastline designated under national and international legislation (Section 3.4).

In the unlikely event of a large spill, these coastlines are potentially at risk. The probability of a spill reaching the shore, and the amount of condensate that would do so, is considered to be very low in the majority of the modelled scenarios which assume no remedial action is taken by IOG.

However, the assessment of a potential spill resulting from a complete release of diesel from the jack-up rig indicates that there is a relatively small probability (18%) of a large quantity of diesel (617 m^3) impacting on the Norfolk shoreline during the spring season (Mar to May). In addition, the modelling indicates that there is a smaller probability (12%) that a slightly larger quantity of diesel (770 m^3) may impact on the Norfolk coastline during the summer months (June to August). Any potential for diesel to impact on any other UK shorelines is considered to be very small (OSRL, 2018).

The assessment concluded that there was no potential for condensate released from either a well blowout or a pipeline failure to impact on any shoreline.

Sedimentary Shores

The fate of oil stranded on sediment shores depends on the nature of the substratum (IPIECA, 2008). Due to the increased sediment movement and relatively large gaps between the particles, beached heavy oil can penetrate further into the more mobile shingle or coarse sand shores. These coarse sediment shores tend to be less productive than sheltered mudflats, where waterlogged sediments, rich in organic matter, can accommodate huge numbers of invertebrates. Gaps between the shingle or sand grains allow the water to drain away quickly between the tides and the movement of the sediment itself is very abrasive, meaning few animals can survive in it. If the beaching of an oil spill becomes inevitable, sandy beaches have in the past been considered as sacrificial areas. A spill may be directed towards a sandy beach in order to protect other, more sensitive, shorelines. Soft sediment areas are common along the Norfolk coastline with sandy beaches a frequent occurrence along the coastline.

In contrast, oil does not readily penetrate the sediments in areas of firm waterlogged mud or fine sand, and tends to be carried away with the next tide (Clark, 2001). However, there is a concern over oil beaching on sheltered mudflats or associated sensitive areas of saltmarsh and these are often priority areas for protection following oil spills. These are generally highly productive areas, with high numbers of invertebrates living within the sediments which may provide a valuable food source for juvenile fish and birds (Little, 2000). Recovery times tend to be longer in these sheltered areas, due to the reduced bacterial degradation and persistence of the oil, particularly if it penetrates into the sediment (IPIECA, 2008). The process of cleaning the sediments and vegetation can be very difficult in these areas and could potentially exacerbate any damage to the habitat. In the most sheltered of intertidal areas, where very fine sediments accumulate, saltmarshes may be found. The presence of mud flats and salt marshes along the Norfolk coast means that these areas would likely be a priority for protection measures following any spill as these are typically highly productive area with high numbers of invertebrates providing a food source for fish and birds. Indeed, the North Norfolk Coast is an important breeding ground for a range of migratory and overwintering bird species such as pink footed geese (Natural England, 2018).

Rocky Shores

Rocky shores and sea cliffs are not especially commonplace along the Norfolk coastline, compared to soft sediment areas. However, where present, they present a valuable habitat.

Rocky shores can be very varied in structure, ranging from exposed vertical walls to flat bedrock, or stable boulder fields to aggregations of cobbles. These shores can support a variety of sessile animal and plant communities which live attached to the rock surface, as well as a range of associated mobile invertebrates and fish. More exposed rocky shores are generally dominated by sessile animals and smaller more robust seaweeds, while the more sheltered shores are characterised by the large brown kelps.

Rocky shores are generally high energy beaches and, while hydrocarbons may have an impact on the animals and plants which live on them, stranded oil is often quickly removed by wave action and water movement. The vulnerability of rocky shore habitats to oiling is dependent on the type of rocky shore and its exposure. The action of the waves may start to remove the oil from an exposed vertical wall almost immediately, but the oil may remain for longer in more sheltered, kelp dominated areas.

Many of the animals and small seaweeds found on rocky shores would be killed by exposure to fresh and light oils, but much of the diesel potentially reaching the shore from a large spill from any of the wells drilled as part of the Southwark Field Development would have been at sea for approximately 30 hours and therefore will have lost some of its toxic constituents. Various shoreline species have been observed to survive shoreline oiling and continue feeding in oiled areas, suggesting that the toxic impacts would be minimal (Clark, 2001). However, even if the beached oil is relatively non-toxic, heavily weathered oil may still cause damage due to its physical properties. Large amounts of stranded oil may impact upon shoreline animals by smothering them. Those animal species that are large enough to protrude above the oil or can move away quickly may survive, but smaller species would be killed by inhibition of their feeding and respiration mechanisms. Many of the larger brown seaweeds which dominate the more sheltered rocky shores secrete mucus which would prevent oil adhering to them. However, if oil does adhere to the seaweed fronds, instead of killing the seaweeds directly, the oil will increase their overall weight causing them to be pulled from the rocks by the wave action. In the event of a diesel spill, such impacts would be very unlikely due to the very light nature of this oil.

The rate of recovery and the form it takes will depend upon the type of rocky shore and the animals and plants that live on it. The general pattern of hydrocarbon spills on rocky shores is that substantial recovery can be achieved within two years, but biological factors may intervene and cause a prolonged change. Rocky shores are high energy, highly productive environments, where the physical and biological factors exerted upon them lead to intense competition between the species which live there. The physical factors, such as desiccation, extremes of temperature and changes in salinity, can cause mortalities in rocky shore communities, while the severe winter storms can dislodge many animals and plants from the shore each year (Little & Kitching, 1996). As a result, these communities have the capability to regenerate quickly in order to take advantage of the newly available space.

9.5.3 Impacts on Other Users of the Sea

<u>Commercial Fisheries</u>

The effects of hydrocarbon spills on commercial fish and shellfish, and the indirect impacts on their habitats, are described above. Fish and shellfish exposed to hydrocarbons may become tainted which could prevent an entire catch from being sold (Clark, 2001). There is evidence that fish are able to detect and avoid oil-contaminated waters, therefore tainting is more a concern for immobile shellfish which cannot swim away. This is more common in filter feeding shellfish, such as whelks, as they could take up fine hydrocarbon droplets from the water column. Shellfish make up the vast majority of landings from ICES rectangle 35F2 where the Southwark field is located particularly crabs, lobsters and whelks (Section 3.4.1).

If fishing in the area of a hydrocarbon spill, nets may become fouled with floating oil. This not only causes damage to the nets themselves, but contact with fouled fishing gear may also contaminate subsequent catches. Fishing activity in the area immediately around Blocks 49/21 and 49/26 for non-shellfish species is very low and very few if any pelagic species are landed from ICES rectangle 35F2 (Section 3.5.1; Scottish Government, 2017).

Demersal fish catches around the proposed location are slightly higher than landings for pelagic species but still significantly lower than landings of shellfish species. due to over exploitation of fish stocks in the area. Static gill and trammel nets are used to catch both cod family species (gadoids) and flatfish such as plaice.

Major spills may also result in loss of fishing opportunities with boats unable or unwilling to fish due to the risk of fouling causing a temporary financial loss to commercial fishermen. If a major spill were to occur from any of the wells at the Southwark field it would be anticipated that shellfish landings would most likely be affected.

Aquaculture

There are few active mariculture sites situated along the Humber and Norfolk coasts as the coastline generally does not provide appropriate conditions for cultivation. However, there are a few sites in the Humber and more extensively the Wash which culture shellfish, mostly mussels and some pacific oysters. The probability of a condensate spill from the wells installed at the Southwark field reaching any aquaculture sites is considered to be low based on the results of the modelling undertaken (OSRL, 2018).

9.6 Potential for a Major Environmental Incident

The Offshore Safety Directive (2013/30/EU) came into force via UK Regulations on 19 July 2015. These Regulations require that a Safety Case defining Major Accident Hazards (MAH) with the potential to cause Major Accidents (MA) must be in place to cover all drilling operations. The potential for MAs to cause a Major Environmental Incident (MEI) must also be defined in the Safety Case. For the Southwark Field Development, three MA scenarios with the potential to cause a MEI have been identified (Section 9.1):

- Spillage of hydrocarbons in the event of an uncontrolled well blow-out;
- Rupture of fuel oil storage tanks;
- Uncontrolled release from a pipeline.

Section 9.4 details the oil spill modelling carried out for these three scenarios. For each scenario, the results show that the majority of condensate or diesel would be expected to move in all directions with a greater likelihood of a spill moving to the north east and east however some movement to the south and west is also predicted at certain times of the year. There is considered to be a small potential for hydrocarbons to beach on the Norfolk coastline at certain times of the year from one of the scenarios modelled (rupture of fuel storage tanks; Section 9.4.2). This same scenario also considers there to be a very small potential for hydrocarbons to beach on the East Riding of Yorkshire, Lincolnshire, Suffolk or Kent coastlines at certain parts of the year (OSRL, 2018).

Figure 9.11 shows the maximum extent of sea surface and shoreline oiling according to the condensate (a), pipeline (b) and diesel (c) modelling results, overlain with protected sites in the area affected by the modelling. Each image is presented as a composite, representing the maximum area oiled over the four seasons which were modelled.

There is no defined threshold for the minimum hydrocarbon concentration that would cause an impact to the protected sites depicted in Figure 9.11. Therefore, a precautionary approach has been used in this assessment with regards to coastal protected areas, with the assumption that any beached volume would have the potential to cause an impact to the highlighted conservation objectives for each protected site. Using this approach, it cannot be ruled out that a well blow-out resulting in an uncontrolled condensate release, an instant pipeline inventory release or a diesel tank rupture resulting in a large diesel spill, would have the potential to cause a MEI, although the likelihood of a MA occurring is low.

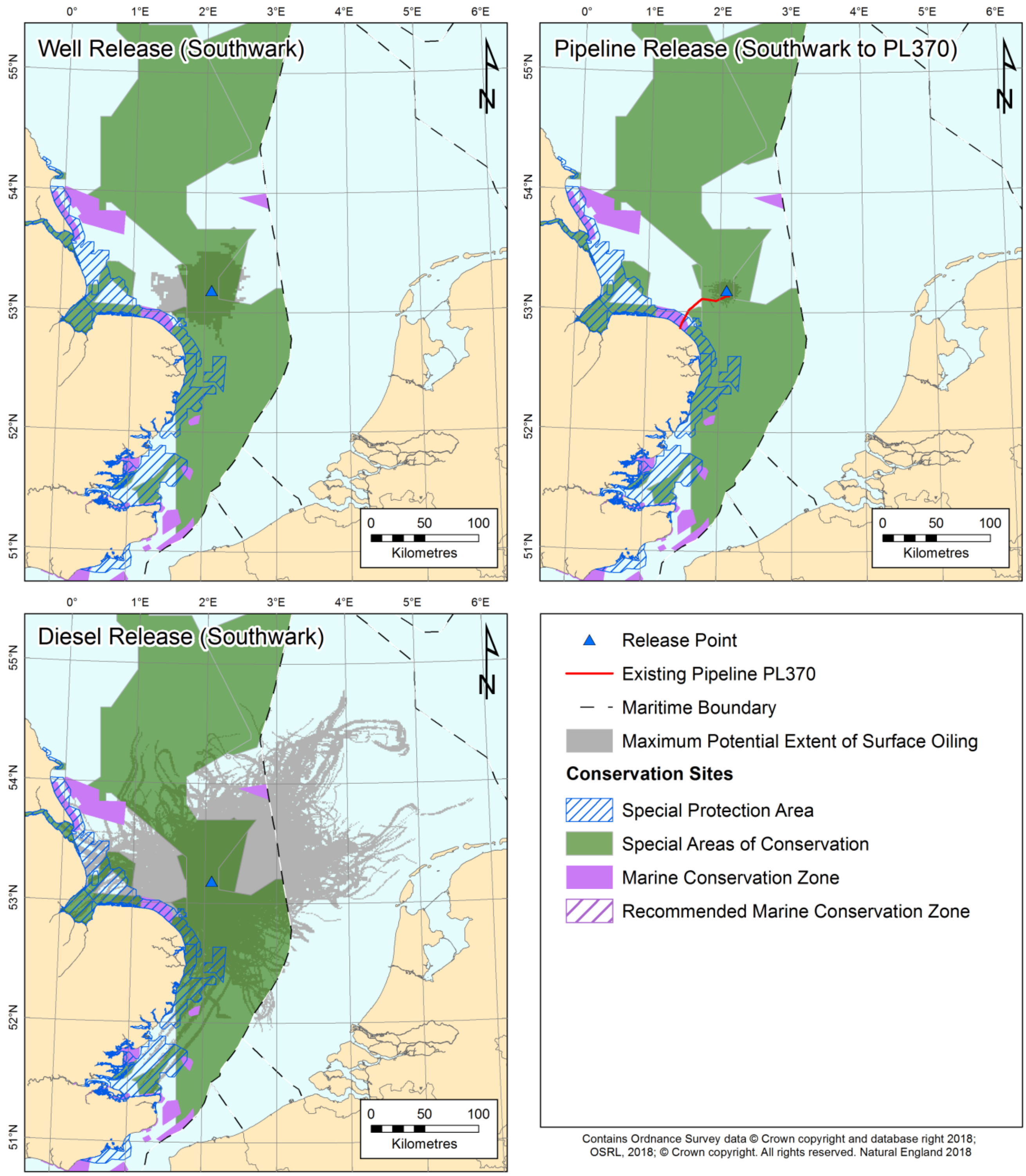

Figure 9.10: Maximum potential surface or shoreline oiling from a condensate spill, pipeline release and diesel spill overlain with protected sites
Source: OSRL, 2018.

Table 9.11 presents the percentage probabilities of surface or shoreline oiling within protected sites predicted by the modelling assessment under one or more of the modelled hydrocarbon release scenarios. The table provides all the conservation objectives for each protected site. Objectives that could be potentially affected by oiling are in bold text.

Table 9.11: Probabilities of Surface or Shoreline Oiling within Protected Sites Predicted by the Modelling Assessment

Name of Site	Max Probability of Surface / Shoreline Oiling [%]	Qualifying Features*	Conservation Objectives**
The Wash and North Norfolk Coast SAC	2	Annex I habitats that are a primary reason for selection of this site: • Sandbanks which are slightly covered by sea water all the time • Mudflats and sandflats not covered by seawater at low tide • Large shallow inlets and bays • Reefs • Salicornia and other annuals colonizing mud and sand • Atlantic salt meadows • Mediterranean and thermo-Atlantic halophilous scrubs Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site: • Coastal lagoons * Priority feature Annex II species that are a primary reason for selection of this site: • Harbour seal Annex II species present as a qualifying feature, but not a primary reason for site selection: • Otter	Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring: • The extent and distribution of qualifying natural habitats and habitats of qualifying species; • **The structure and function (including typical species) of qualifying natural habitats;** • The structure and function of the habitats of qualifying species; • **The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;** • The populations of qualifying species, and, • The distribution of qualifying species within the site.

Name of Site	Max Probability of Surface / Shoreline Oiling [%]	Qualifying Features*	Conservation Objectives**
North Norfolk Coast SAC	2	Annex I habitats that are a primary reason for selection of this site: • Coastal lagoons * Priority feature • Perennial vegetation of stony banks • Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) • Embryonic shifting dunes • Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes") • Fixed coastal dunes with herbaceous vegetation ("grey dunes")" * Priority feature • Humid dune slacks Annex II species present as a qualifying feature, but not a primary reason for site selection: • Otter • Petalwort	Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring: • The extent and distribution of qualifying natural habitats and habitats of qualifying species; • **The structure and function (including typical species) of qualifying natural habitats;** • The structure and function of the habitats of qualifying species; • **The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;** • The populations of qualifying species, and, • The distribution of qualifying species within the site.
Dogger Bank SAC	1	Annex I habitats that are a primary reason for selection of this site: • Sandbanks which are slightly covered by sea water all the time	Subject to natural change, restore the sandbanks to favourable condition, such that: • The natural environmental quality is restored: • The natural environmental processes and the extent are maintained; • **The physical structure, diversity, community structure and typical species, representative of sandbanks which are slightly covered by seawater all the time, in the Southern North Sea, are restored.**
North Norfolk Sandbanks and Saturn Reef SAC	100	Annex I habitats that are a primary reason for selection of this site: • Sandbanks which are slightly covered by sea water all the time • Reefs	For the features to be in favourable condition thus ensuring site integrity in the long term and contribution to Favourable Conservation Status of Annex I Sandbanks which are slightly covered by sea water all of the time and Annex I Reefs. This contribution would be achieved by maintaining or restoring, subject to natural change: • The extent and distribution of the qualifying habitats in the site; • **The structure and function of the qualifying habitats in the site; and** • **The supporting processes on which the qualifying habitats rely**.

Name of Site	Max Probability of Surface / Shoreline Oiling [%]	Qualifying Features*	Conservation Objectives**
Haisborough, Hammond and Winterton SAC	54	Annex I habitats that are a primary reason for selection of this site: • Sandbanks which are slightly covered by sea water all the time • Reefs	Ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring: • The extent and distribution of qualifying natural habitats and habitats of the qualifying species; • **The structure and function (including typical species) of qualifying natural habitats;** • The structure and function of the habitats of the qualifying species; • **The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely;** • The populations of qualifying species; • The distribution of qualifying species within the site.
Inner Dowsing, Race Bank and North Ridge SAC	1.5	Annex I habitats that are a primary reason for selection of this site: • Sandbanks which are slightly covered by sea water all the time • Reefs	The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring: • The extent and distribution of qualifying natural habitats and habitats of the qualifying species • **The structure and function (including typical species) of qualifying natural habitats** • The structure and function of the habitats of the qualifying species • **The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely** • The populations of qualifying species • The distribution of qualifying species within the site
Margate and Long Sands SAC	0.5	Annex I habitats that are a primary reason for selection of this site: • Sandbanks which are slightly covered by sea water all the time	The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring: • The extent and distribution of qualifying natural habitats and habitats of the qualifying species • **The structure and function (including typical species) of qualifying natural habitats** • The structure and function of the habitats of the qualifying species • **The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely** • The populations of qualifying species • The distribution of qualifying species within the site

Name of Site	Max Probability of Surface / Shoreline Oiling [%]	Qualifying Features*	Conservation Objectives**
Humber Estuary SAC	1	Annex I habitats that are a primary reason for selection of this site: • Estuaries • Mudflats and sandflats not covered by seawater at low tide Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site: • Sandbanks which are slightly covered by sea water all the time • Coastal lagoons * Priority feature • Salicornia and other annuals colonizing mud and sand • Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) • Embryonic shifting dunes • Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes") • Fixed coastal dunes with herbaceous vegetation ("grey dunes") * Priority feature • Dunes with *Hippopha rhamnoides* Annex II species present as a qualifying feature, but not a primary reason for site selection: • Sea lamprey • River lamprey • Grey seal	Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring: • The extent and distribution of qualifying natural habitats and habitats of qualifying species • **The structure and function (including typical species) of qualifying natural habitats** • **The structure and function of the habitats of qualifying species** • **The supporting processes on which qualifying natural habitats and habitats of qualifying species rely** • **The populations of qualifying species, and,** • **The distribution of qualifying species within the site.**

Name of Site	Max Probability of Surface / Shoreline Oiling [%]	Qualifying Features*	Conservation Objectives**
Thanet Coast SAC	0.5	Annex I habitats that are a primary reason for selection of this site: • Reefs • Submerged or partially submerged sea caves	The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring: • The extent and distribution of qualifying natural habitats and habitats of the qualifying species • **The structure and function (including typical species) of qualifying natural habitats** • The structure and function of the habitats of the qualifying species • **The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely** • The populations of qualifying species • The distribution of qualifying species within the site
Southern North Sea SAC	100	• Harbour porpoise	The conservation objectives for the Southern North Sea SAC are as follows: To ensure that the integrity of the site is maintained and that it makes an appropriate contribution to maintaining Favourable Conservation Status (FCS) for harbour porpoise in UK waters. In the context of natural change, this will be achieved by ensuring that: 1. Harbour porpoise is a viable component of the site; 2. There is no significant disturbance of the species within the site; and 3. The condition of supporting habitats and processes, and the availability of prey is maintained.

Name of Site	Max Probability of Surface / Shoreline Oiling [%]	Qualifying Features*	Conservation Objectives**
The Wash SPA	0.5	During the breeding season: • Common Tern • Little Tern • Marsh Harrier Over winter: • Avocet • Bar-tailed Godwit • Black-tailed Godwit • Curlew • Dark-bellied Brent Goose • Dunlin • Golden Plover • Grey Plover • Knot • Oystercatcher • Pink-footed Goose • Pintail • Redshank • Shelduck • Turnstone • Whooper Swan On passage: • Ringed Plover • Sanderling Assemblage qualification: • A wetland of international importance	To ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring; • The extent and distribution of the habitats of the qualifying features: • **The structure and function of the habitats of the qualifying features;** • **The supporting processes on which the habitats of the qualifying features rely;** • **The population of each of the qualifying features**; and • The distribution of the qualifying features within the site.

Name of Site	Max Probability of Surface / Shoreline Oiling [%]	Qualifying Features*	Conservation Objectives**
North Norfolk Coast SPA	2	During the breeding season: • Avocet • Bittern • Common Tern • Little Tern • Marsh Harrier • Mediterranean Gull • Redshank • Ringed Plover • Roseate Tern • Sandwich Tern Over winter: • Avocet • Bar-tailed Godwit • Bittern • Dark-bellied Brent Goose • Golden Plover • Hen Harrier • Knot • Pink-footed Goose • Pintail • Redshank • Ruff • Shelduck • Turnstone • Wigeon On passage: • Ringed Plover Assemblage qualification: • A wetland of international importance	To ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring: • The extent and distribution of the habitats of the qualifying features; • **The structure and function of the habitats of the qualifying features;** • **The supporting processes on which the habitats of the qualifying features rely;** • **The population of each of the qualifying features**; and • The distribution of the qualifying features within the site.

Name of Site	Max Probability of Surface / Shoreline Oiling [%]	Qualifying Features*	Conservation Objectives**
Humber Estuary SPA	0.5	During the breeding season: • Avocet • Bittern • Little tern • Marsh harrier Over winter: • Avocet • Bar-tailed godwit • Bittern • Black-tailed godwit • Dunlin • Golden plover • Hen harrier • Knot • Redshank • Shelduck On passage: • Black-tailed godwit • Dunlin • Knot • Redshank • Ruff Assemblage qualification: • A wetland of international importance	To ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring: • The extent and distribution of the habitats of the qualifying features; • **The structure and function of the habitats of the qualifying features;** • **The supporting processes on which the habitats of the qualifying features rely;** • **The population of each of the qualifying features**; and • The distribution of the qualifying features within the site.
Thanet Coast and Sandwich Bay SPA	0.5	Over winter: • Turnstone	To ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring: • The extent and distribution of the habitats of the qualifying features; • **The structure and function of the habitats of the qualifying features;** • **The supporting processes on which the habitats of the qualifying features rely;** • **The population of each of the qualifying features**; and • The distribution of the qualifying features within the site.

Name of Site	Max Probability of Surface / Shoreline Oiling [%]	Qualifying Features*	Conservation Objectives**
Outer Thames Estuary SPA	2	• Red-throated diver • Common tern • Little tern	To ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring: • The extent and distribution of the habitats of the qualifying features; • **The structure and function of the habitats of the qualifying features;** • **The supporting processes on which the habitats of the qualifying features rely;** • **The population of each of the qualifying features**; and • The distribution of the qualifying features within the site.
Greater Wash SPA	13.3	• Red-throated diver • Little gull • Common scoter • Sandwich tern • Common tern • Little tern	To ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring: • The extent and distribution of the habitats of the qualifying features; • **The structure and function of the habitats of the qualifying features;** • **The supporting processes on which the habitats of the qualifying features rely;** • **The population of each of the qualifying features**; and The distribution of the qualifying features within the site.
Minsmere Walberswick SPA	1	During the breeding season: • Avocet • Bittern • Little Tern • Marsh Harrier • Nightjar • Woodlark Over winter: • Avocet • Bittern • Hen Harrier	To ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring: • The extent and distribution of the habitats of the qualifying features; • **The structure and function of the habitats of the qualifying features;** • **The supporting processes on which the habitats of the qualifying features rely;** • **The population of each of the qualifying features**; and • The distribution of the qualifying features within the site.

Name of Site	Max Probability of Surface / Shoreline Oiling [%]	Qualifying Features*	Conservation Objectives**
Holderness Inshore MCZ	0.5	• Intertidal sand and muddy sand • Moderate energy circalittoral rock • High energy circalittoral rock • Subtidal coarse sediment • Subtidal mixed sediments • Subtidal sand • Subtidal mud	That the protected features: a) **So far as already in favourable condition, remain in such condition**; and b) So far as not already in favourable condition, be brought into such condition, and remain in such condition. “Favourable condition” with respect to a habitat within the Zone, means that: i) Its extent is stable or increasing; and ii) **Its structures and functions, its quality, and the composition of its characteristic biological communities are such as to ensure that it remains in a condition which is healthy and not deteriorating**.
Cromer Shoal Chalk Beds MCZ	11.3	• Moderate energy infralittoral rock • High energy infralittoral rock • Moderate energy circalittoral rock • High energy circalittoral rock • Subtidal chalk • Subtidal coarse sediment • Subtidal mixed sediments • Subtidal sand • Peat and clay exposures	That the protected features: a) **So far as already in favourable condition, remain in such condition**; and b) So far as not already in favourable condition, be brought into such condition, and remain in such condition. “Favourable condition” with respect to a habitat within the Zone, means that: i) Its extent is stable or increasing; and ii) **Its structures and functions, its quality, and the composition of its characteristic biological communities are such as to ensure that it remains in a condition which is healthy and not deteriorating**.
Thanet Coast MCZ	0.5	• Subtidal coarse sediment • Subtidal mixed sediments • Subtidal sand • Moderate energy infralittoral rock • Moderate energy circalittoral rock • Blue mussel (*Mytilus edulis*) beds • Peat and clay exposures • Ross worm (*Sabellaria spinulosa*) reefs • Subtidal chalk • Stalked jellyfish (*Haliclystus auricula*) • Stalked jellyfish (*Lucernariopsis cruxmelitensis*)	Conservation Objectives are not available for the Thanet Coast MCZ. Therefore, objectives for similar adjacent MCZs are taken to be relevant to this site, as follows: That the protected features: a) **So far as already in favourable condition, remain in such condition**; and b) So far as not already in favourable condition, be brought into such condition, and remain in such condition. “Favourable condition” with respect to a habitat within the Zone, means that: i) Its extent is stable or increasing; and ii) **Its structures and functions, its quality, and the composition of its characteristic biological communities are such as to ensure that it remains in a condition which is healthy and not deteriorating.**

* Geomorphological features and objectives are not considered to be at risk of impact from a hydrocarbon spill, and so are not listed.

** Conservation Objectives which may be affected by hydrocarbons are indicated in bold. Geomorphological objectives are not listed.

The following sites have been recommended as MCZs, but have not been designated to date:

1. Lincs Belt Recommended MCZ
2. Markham's Triangle Recommended MCZ
3. Holderness Offshore Recommended MCZ
4. Silver Pit Recommended MCZ
5. Wash Approach Recommended MCZ
6. Orford Inshore Recommended MCZ
7. Kentish Knock East MCZ

Apart from the NNSSR SAC and the Southern North Sea SAC sites, the probability of surface or shoreline oiling is very low (no more than 4%) for all other protected sites. Although the possibility of an MEI cannot be ruled out, the risk of significant effects upon these protected sites from oiling is considered to be negligible.

Any potential impacts on these protected sites is predicated on a worst scenario for a hydrocarbon release where the greatest possible volume of condensate or diesel is released and no containment or protection action is taken. In the event of an accidental hydrocarbon release, IOG will deploy rapid containment and protection measures to control the extent of the spill.

Effective intervention measures would further reduce the likelihood of widespread and significant adverse effects on the NNSSR SAC and the Southern North Sea SAC. Therefore, the possibility of an MEI affecting the conservation objectives of these sites is considered to be low.

9.7 Mitigation Measures

9.7.1 Preventative Measures

In order to prevent a condensate or diesel spill occurring, stringent safety and operational procedures will be followed throughout activities at the proposed Southwark Field Development.

<u>Training, Experience and Suitability of Equipment</u>

IOG is aware of the risk of a hydrocarbon spill occurring during operations at the proposed Southwark Field Development. Before offshore operations commence, the Well Operator, appointed by IOG, will fully assess the competence and experience of all contractors, and the suitability of all equipment to operate in the Southern North Sea. The jack-up drilling rig selected for the drilling operations will be one which has been designed to operate in relative shallow water conditions such as those found in the Southern North Sea region where the Southwark Field Development infrastructure is to be located and will be well suited to the planned drilling operations. All offshore personnel will be appropriately trained, experienced and certified to carry out their specific duties. The crew of the jack-up drilling rig and other vessels will also undergo environmental awareness and safety training.

<u>Well Design</u>

The wells which will be installed at Southwark have been designed to minimise the potential for well control problems and take into account all specific safety design parameters associated with production wells. The wells have been designed to be fully abandoned upon cessation of production. Measures adopted include the following:

- A detailed review of nearby "offset" wells has been undertaken to identify high risk formations and to generate a pore pressure and fracture gradient curve/graph
- Mud weights designed to provide primary well control throughout the drilling process
- Casing design performed to ensure suitable casing specification and kick tolerance
- Appropriate well control equipment (diverter/BOP) installed on well prior to drilling into formations with a well control risk
- Well control equipment, well head and casing pressure tested to an appropriate value to contain expected wellbore pressures.

A thorough and formal peer-review approach will be used to review all critical elements of the well design and the execution of drilling and completion of the wells. In addition, the well designs will be independently reviewed by a Well Examiner, as is required for all wells in the UK. The Well Examiner will also monitor the actual construction and any modifications to the well.

<u>Well Control</u>

Well control procedures will be in place to prevent uncontrolled well flow to the surface and a full risk assessment will be performed as part of the planning phase of the well. Data on well pressure will be monitored throughout the drilling operations, to allow suitable mud composition and mud weights to be used to maintain sufficient bottom hole over balance to prevent well flow.

A wellhead and blow out preventer (BOP) will be installed at the top of the 13⅜" section, once the casing is cemented in place, to prevent the uncontrolled release of hydrocarbons from the well. The BOP design meets all UKCS safety and regulatory requirements.

The BOP stack, and the associated well control equipment on the jack-up drilling rig, are rated to 103.42 MPa (15000 psi) working pressure. Prior to installation the BOPs will be fully inspected, function tested and pressure tested. Once installed on the well regular testing of the BOP and its back up systems takes place onboard the jack-up rig at regular intervals.

The BOP is fully redundant, with three separate power systems that can deliver full closing of the BOP, air hydraulic system, electric hydraulic system and stored hydraulic pressure in accumulators. The BOP stack is located on the MODU and is controlled from the drilling rig.

The BOP will be independently inspected and verified periodically. Regular testing of the BOP and its back up systems takes place onboard the jack-up rig at regular intervals.

Diesel Bunkering Procedures

The highest risk of a diesel spillage occurs during fuel bunkering operations between the jack-up drilling rig and supply vessels. It is expected that bunkering may be required up to four times at each field during installation operations. Vessel audits will be performed to confirm sea worthiness, and Dynamically Positioned (DP) vessels only will be used for supply duties, thus reducing likelihood of collision and potential tank rupturing. Bunkering operations will only take place during hours of good visibility, in suitable weather conditions, and with a dedicated and continuous watch posted at both ends of the fuel hose. All hoses used during bunkering are segmented with pressure valves that will close automatically in the event of a drop in pressure, such as might be caused by a broken connection or a leaking hose. In addition, the bunkering hoses will be stored in a manner which minimises potential for wear and damage. These hoses will be visually inspected and their connections tested prior to every loading operation. Bunkering procedures will be followed throughout all bunkering operations.

Loss of Diesel Containment

The loss of diesel from one or all of the diesel tanks onboard the jack-up drilling rig is extremely unlikely, and would only be expected to occur during a major collision with another vessel, or similar event, whereby the integrity of the jack-up drilling rig itself would be compromised. Section 9.6describes the potential for a major environmental incident in the case of a catastrophic loss of the jack up drilling rig. Mitigation measures which would be employed in response to such an incident are described in Section 9.8.

Other Safety Measures

All equipment used on the jack-up drilling rig will have safety measures built in to minimise the risks of any hydrocarbon spillage. The jack-up drilling rig will have open and closed drain systems in place that will route any operational spills onboard the rig itself to the slop tanks where they can be contained and recovered. There will also be a number of spill kits available to deal with (smaller) spillages that may occur onboard the rig.

9.7.2 Action to Stop a Blow-out

Initial Actions

If an unexpected inflow of hydrocarbons into the well occurs, there may be various methods available to control the flow of hydrocarbons to the surface. These include varying the pump rate of the mud pump and the use of various chemicals, such as weighting material (barite or calcium carbonate) and cement. Therefore, a contingency stock of cement and barite will be kept onboard the rig. Although the time required to kill the well will be dependent on the how and why it has failed, a standard well kill operation takes between 12 and 48 hours. Once control of the well has been regained, the well can be fully abandoned with cement plugs.

Drilling a Relief Well

In the extremely unlikely event where a blow-out situation occurred and all options to kill the well failed, the only remaining option to bring the well back under control to stop the spill may be to drill a relief well. In this situation, IOG and the Well Operator will comply with the Oil and Gas UK “Guidelines on Relief Well Planning – Subsea Wells” (currently Issue 2, January 2013) which has been prepared by the OGUK Well Life Cycle Practices Forum.

Securing Required Equipment

As a worst-case scenario, it is assumed that an additional suitable jack-up drilling rig, would be required to conduct the relief well operations. The availability of suitable drilling rigs will to be monitored throughout the operations. It has been estimated that it would take between four and six weeks to source an alternative suitable drilling unit, for the current operations to be suspended, and to move the unit onto the well location.

In addition to the drilling unit, all of the required drilling equipment will also have to be sourced and mobilised. In order to minimise the time involved, equipment would be sourced from off the shelf supplies and borrowed from other operators. Throughout this planning and preparation process, it is assumed that other license holders, drilling rig contractors and the government agencies would co-operate, where necessary.

Planning for the relief well will include a review of the original well design and the reasons for the uncontrolled well blow-out, allowing any required changes to well design, equipment and operating procedures to be implemented. Preparation of equipment, procedures and consent applications will all be conducted in parallel with the activities required to gain access to a suitable replacement drilling unit.

Drilling the Relief Well

Alternative relief well locations around each of the wells proposed to be drilled as part of the Southwark Field Development have been identified and surveyed by IOG. A well path will be created to ensure that the suggested well surface locations are suitable and can be quickly tailored to the actual relief well programme if required in a blow-out situation. In order to optimise the relief well design, planning at the time of an incident will include a review of the current location and directional plans, along with the reasons for well failure and the resultant uncontrolled blow-out. This will allow any required changes to be made to relief well design and equipment, and additional operating procedures to be implemented if required.

It is anticipated that it would then take approximately 81 days to source and mobilise a suitable jack up drilling rig to site to drill a relief well and kill the original well. This is slightly longer than the estimated time required to reach the reservoir sections of the production wells at the Southwark field, and is potentially required due to the ranging surveys and additional measurements necessary to ensure the relief well is positioned correctly and in close proximity to the original well. Once the relief well reaches the original well, well kill operations would be carried out to permanently abandon it.

A full timetable for the drilling of a relief well will be provided in the Well Operator's Temporary Operations Oil Pollution Emergency Plan (TOOPEP) for the planned operations at the Southwark Field Development, and in the subsequent OPEP to be prepared to cover the Southwark Field Development once it is in production.

9.7.3 Oil Spill Response

If a large spill were to occur, it would be a priority to avoid spilled hydrocarbons impacting the coastline and, therefore, all available and suitable oil spill response techniques would be employed in the event of a spillage moving towards the shore.

Oil Pollution Emergency Plan

The Well Operator will have an TOOPEP in place to cover the planned development drilling operations, after which a Production Installation / Field OPEP will be put in place to cover all platform based production operations within the Southwark Field Development. The TOOPEP and OPEP will both conform to the Merchant Shipping (Oil Pollution, Preparedness, Response and Co-operation Convention) (Amendment) Regulations 2015 and the Offshore Installations (Emergency Pollution Control) Regulations 2002. The TOOPEP and OPEP will fully consider the oil spill response requirements of the Southwark Field Development, taking into account the location, the prevailing meteorological conditions and the environmental sensitivities of the area. The TOOPEP and OPEP have been designed to assist the decision-making process during a hydrocarbon spill, indicate what resources are required to combat the spill, minimise any further discharges and mitigate its effects.

Training, Exercises and Experience

Offshore Personnel

Specific members of the jack-up drilling rig and standby vessel crew will have undertaken Oil Pollution Emergency Plan (OPEP) oil spill response training.

As a minimum, the TOOPEP/OPEP will be distributed to personnel with designated duties in the event that an oil spill response is required, and to the regulatory authorities and statutory consultees. On receipt of the TOOPEP/OPEP, personnel will undergo awareness training in oil spill response prior to the commencement of drilling and production operations. The aim of this training is to familiarise offshore personnel with the oil spill procedures, levels of response effort, equipment orientation and use, and communication and reporting during an oil spill of any size.

The jack-up drilling rig will regularly undertake training exercises, including vessel-based oil spill response exercises for the crew and an Offshore TOOPEP Exercise while on site, to ensure that offshore personnel are familiar with the TOOPEP and their responsibilities during a response.

Onshore Personnel

External oil spill response training will be organised for key onshore personnel, in line with the OPRED requirements. Relevant IOG, Well Operator and Installation Operator Duty Managers will, as a minimum, have attended the OPRED recommended course for Corporate Management oil spill response awareness (OPEP Level 2). IOG will ensure that the well operator is a member of Oil Spill Response Ltd (OSRL), with activation rights being provided to key emergency response personnel. A response advisor with OPEP Level 4 training will also be provided by OSRL.

The appointed Well Operator will conduct an oil spill response exercise prior to drilling to ensure that all personnel are aware of their roles in an actual oil spill incident. These exercises will also familiarise personnel with the lines of communication between the jack-up drilling rig, offshore, the appointed Well Operator onshore and IOG. The exercise will also include familiarisation of the roles and responsibilities of the various interested parties, and the chosen response strategies. If necessary, the TOOPEP/OPEP will be updated to reflect any changes required as a result of the exercise.

9.7.4 Oil Spill Response Strategies

The most appropriate response to a hydrocarbon spill from the planned drilling operations will be determined by oil type, logistics and prevailing physical conditions. A precise response strategy, which may employ one or more of the response options described below, can only be decided at the time of the spill. Oil spill response personnel must be prepared to adapt their actions as the spill develops as changes in both the prevailing conditions and the oil properties dictate.

In general, there are several response strategies which could be deployed in the event of a spill:

- Natural dispersion and monitoring;
- Application of chemical dispersants;
- Containment and recovery (surface and subsea);
- Shoreline protection and clean-up.

Natural Dispersion and Monitoring

Condensate and diesel spills are often best monitored but otherwise left to naturally degrade. The natural evaporation and dispersion processes described in Section 9.3 will often be enough to successfully disperse condensate or diesel. These processes can be enhanced, where practicable, by physical agitation of the slick by the standby vessel and other vessels on site.

It is proposed that, in the event of a condensate or diesel spill incident from any proposed production well drilled as part of the Southwark Field Development, the principal response strategy will be the monitoring and surveillance of the slick, where evaporation and natural dispersion will be the principle mechanisms for removal of oil from the sea surface.

On-site and Aerial Surveillance

A standby vessel will be on site throughout the drilling operations. In the early stages of the incident, the slick may be monitored by this onsite standby vessel, provided it can still meet its safety function. For larger, ongoing spills, aircraft may be mobilised to undertake aerial surveillance. However, in the short term, aerial surveillance may be undertaken by the helicopter contractor.

Dedicated aerial surveillance aircraft will be available through OSRL. The use of aerial surveillance in the monitoring of oil spills, as opposed to sea level vessels, allows for a more accurate picture of spill size and movement to be formed, especially in the monitoring of larger, more mobile spills. This would enable the development of various response options, including the decision to monitor the spill as it disperses naturally.

Oil Spill Modelling

Tracking and monitoring of the spilled oil would commence as soon as possible after the incident has occurred and continue for the duration of the response. This will be used to evaluate the extent of the slick, monitor its movement and dispersal, and decide on the appropriate response.

Initially, manual predictions can be used to estimate the movement of the oil on the sea surface as a function of the wind and current speed and direction. Oil spill modelling would also be employed to gain a more accurate indication of oil spill movement, using real time parameters to assist the predictions.

Chemical Dispersants

The use of chemical dispersants on a spill of condensate or of diesel is generally not recommended, and therefore dispersants are unlikely to be considered as a viable response strategy in the event of a spill at the Southwark Field Development.

The natural processes of evaporation and dispersion will usually remove light oils, such as condensate and diesel, from the sea surface rapidly, without the need for chemical treatment. The use of chemical dispersants on condensate or diesel will result in increased concentrations of toxic components within the upper water column. Many spawning species have pelagic eggs and larvae which are vulnerable to oil which is chemically dispersed into the water column. These eggs and larvae would become exposed to higher concentrations of oil if dispersants were used, than if the oil had been allowed to evaporate and disperse naturally. In addition, dispersants are generally less effective on very light oils, as the dispersants are thought to sink through the oil, reducing the contact time between the oil and water interface. As a result, chemical dispersants should generally not be used on these spilled light oils. However, the chemical dispersion of condensate or diesel spills, which are observed not to be dispersing naturally, may sometimes be necessary to protect vulnerable concentrations of seabirds. Although this may be an appropriate response, it will be necessary to balance the outcomes against each other, at the time of the spill.

Containment and Recovery

Booms may be used to contain a large slick on the sea surface, concentrating the oil for recovery by skimmers. The effectiveness of both booms and skimmers depends on the sea and weather conditions, with the most efficient containment and recovery of oil only achieved under calm conditions. In order to create a barrier with which to prevent the oil escaping, booms must move with the surface water. However, with the increasing flexibility required to achieve this in rougher seas, comes reduced boom rigidity and a corresponding reduction in its ability to contain oil. As skimmers float on the sea surface, they also experience many of the operational difficulties that apply to booms.

Recovery equipment requires the spilled oil to be of sufficient thickness to allow it to be lifted and sucked from the surface while disturbing the underlying water as little as possible. If the slick is too thin large quantities of water will be taken up by the process not only reducing the effectiveness of oil collection, but also causing additional issues for containment and disposal of the oily water. As the slick becomes increasingly spread out and broken up, the effectiveness of this response option decreases. Condensate is a very light hydrocarbon and would be expected to spread and disperse very quickly. A large condensate spill released near the seabed would spread out very thinly by the time it had risen through the water column to the sea surface. Therefore, it would not be expected that condensate from a subsea release would be of appropriate thickness to allow for this recovery response option to be wholly effective.

Shoreline Protection and Clean-Up

Shoreline Protection

Where possible, the first priority should be to prevent spilled hydrocarbons from reaching coastal areas. As described above, a number of different response options are available to contain the spilled oil offshore or to limit the movement of the slick across the sea surface. However, there remains the potential for a large slick to threaten the shoreline communities.

The initial response to any spill will be onsite and aerial surveillance to track its movement, supplemented by modelling to predict which shorelines the spilled oil may threaten. With a better understanding of the shorelines at risk from the spill, information will be gathered on the coastal habitats present in these areas and their associated communities. Any coastal sensitivities, including vulnerable shoreline types, coastal and inshore protected areas (including those designated under the European Habitats and Birds Directives), areas of inshore fisheries or aquaculture, coastal tourist or recreational areas, and other coastal industries, will be identified. Throughout the well planning process, basic information has been gathered on the surrounding coastal sensitivities and this will be included within the TOOPEP and subsequent OPEP to assist in any required oil spill response. This will be supplemented by the OSRL GIS facility (which maps coastal sensitivities around the UK), local authority plans, strategy documents, maps, and other available resources. The closest coastline to the proposed Southwark Field Development is the Norfolk coastline. Broad-scale surveys, from vehicles, inshore vessels or helicopters, will be mobilised to gain an overview of the shoreline types and main sensitivities along the potentially affected stretch of coast, and consideration will be given to carrying out more detailed surveys of particularly environmentally sensitive or commercial important areas of shoreline prior to any oil beaching.

Once the coastal sensitivities under immediate threat have been identified, coastal protection resources will be deployed to protect priority areas. Although IOG and the Well Operator/Platform Operator will provide all necessary assistance as required, all shoreline protection strategies will be determined by the local authority in consultation with their environmental advisors. Details of local equipment suitable and available for shoreline booming will be available through coastal strategy documents. Additional response personnel and appropriate shoreline protection equipment will be provided by IOG and the Well Operator/Platform Operator, through their oil spill response contractor, OSRL.

Oil spill modelling has indicated that, whilst the potential for any condensate or oil to make landfall with the UK shoreline is very small, the coastlines of south-east England, specifically the Norfolk coastline would be the most likely shoreline at risk from beaching condensate or diesel (Section 9.3.3). The Norfolk coastline features a variety of coastal habitats including extensive intertidal sand and mud flats, saltmarshes, shingle and sand dunes as well as areas of freshwater grazing marsh and reedbeds. Containment and protection measures would be focused on the more sensitive tidal mud flats and saltmarshes, as well as, areas which have been designated for their conservation status.

Shoreline Clean-Up

Should any protection measures not be successful in preventing oil or condensate from washing ashore every effort would be made to clean-up up any oil that does reach the shoreline. Depending on the type of coastline affected, various methods exist to remove oil from the shore. Sediment shores are generally more amenable to methods that will physically 'scoop' the oil from the beach, whereas appropriate washing and rinsing techniques are likely to be more effective on rocky substrata.

If a spill does reach the shoreline, aerial surveillance will be used to gain a broad overview of where it has beached, while vehicles or vessels will be used to make a more detailed, shore specific assessment. Stretches of shoreline will be surveyed, recording the type of shoreline (sediment type, slope, exposure etc), its use (tourism, recreation, etc), and any environmental sensitivities (protected areas, seal breeding sites, otter holts, etc), as well as the severity of any oiling (mobile oil, surface or subsurface oil, stranded oil, sheen etc). Information on access arrangements, parking and storage arrangements, and proximity to other facilities will also be recorded. This information will be used to determine where to focus the clean-up effort by making the optimum use of the available clean-up resources.

In certain circumstances the physical disturbances caused by some clean-up methods may be more damaging to shorelines and their associated communities than the direct effects of an oil spill. This is particularly true in more sensitive, less dynamic habitats, such as mudflats or saltmarsh. In addition, steeply sloping and unstable rocky shores or large soft mudflats are often difficult to access. Therefore, if oil does reach the shore, clean-up methods should be chosen carefully so as to not cause a greater degree of damage.

With all required assistance and information provided by IOG and the appointed Well Operator, the strategy for shoreline clean-up ultimately will be directed by the affected local authorities. Adequate trained personnel and clean-up equipment will be made available to assist any clean-up operations, through OSRL.

9.8 Catastrophic Loss of the Jack-up Rig, a Platform, a Vessel or Helicopter

Under extreme circumstances, the jack-up drilling rig, a platform, a support vessel or a helicopter may sink. This could be caused by a variety of reasons, such as a serious blow-out situation, shallow gas release, a collision with another vessel or a freak weather event. These events are extremely rare, and happen so infrequently that no reliable statistics could be obtained to quantify them.

A raft of mitigation measures is in place for preventing such an event from happening. These include:

- The jack-up drilling rig will be inspected for sea worthiness and the drilling contractors audited prior to operations commencing;
- The platform will be inspected for sea worthiness and the drilling contractors audited prior to operations commencing;
- A blow-out preventer will be installed on top of the 13⅜" casing, once it has been cemented in place;
- Well control procedures will be in place and an appropriate mud programme will be designed in order to maintain well control at all times;
- Personnel will be appropriately trained, experienced and certified;
- The competence and experience of all contractors will be assessed before they are contracted;
- All supply vessels will operate via DP, to reduce the likelihood of a collision;
- A digital site survey for drilling hazards has been carried out to confirm that there is no shallow gas in the area;
- A 500 m statutory exclusion zone will be enforced around the jack-up rig and subsequently around each platform for general shipping in the area;
- A standby vessel will be on site to enforce the 500 m statutory exclusion zone during drilling operations;
- The jack-up drilling rig, platform and associated vessels will use appropriate lighting;
- The suitability of supply, other support vessels and the helicopter will be assessed before they are contracted.
- The standby vessel will be equipped with radar and communication equipment so that any vessel in the area can be detected and contacted, if required;
- The United Kingdom Hydrographic Office (UKHO) and Ministry of Defence (MoD) will be kept informed of drilling and infrastructure installation activities.

In the event of the loss of the jack-up drilling rig, a platform, a vessel or a helicopter it would is likely that the vessel or aircraft would be salvageable in this relatively shallow water environment. Attempts would be made to salvage any remaining hydrocarbons and other potentially harmful products onboard the wreck. The potential impact of the release of oil to the marine environment is described above in Section 9.4, and impacts of chemical discharge are reviewed in Section 6.

Should it not be possible or unsafe to recover a lost rig, platform, vessel or helicopter, the wreck would be marked on navigational charts to prevent the snagging of fishing nets and other towed equipment. Shipwrecks UK (2018) has identified more than 46,000 wrecks in the waters around the UK and Ireland. In general the presence of wrecks on the seabed is not considered to have any long lasting negative environmental effects. Therefore, given the remote chance of such an event happening due to appropriate mitigation measures in place, and minimal negative long term environmental impacts, the residual impact of a loss of rig is considered to be insignificant.

9.9 Major Disasters

The most recent EIA Directive 2014/52/EU requires that the vulnerability of projects to risks of major accidents or natural disasters relevant to the project are considered. The potential for a hydrocarbon or condensate release from a well blow out, diesel release or pipeline release is described in detail above and is considered to be the most likely major accidental event which could occur at the proposed Southwark Field Development. The potential for natural disasters such as earthquakes and tsunamis is very low as these events are themselves rare (DEFRA, 2005).

Nonetheless, the platform which will be erected during the installation operations must be able to withstand the rigours of the North Sea environment.

To this end, the Southwark platform will be structurally sound, designed to withstand a number of different loads. The platform will be capable of withstanding a hundred-year wave event as well as the forces generated by gale or hurricane force winds in the area. The platform will also be constructed in such a way so as to tolerate earthquakes of magnitudes typically recorded in the North Sea.

9.10 Conclusions

The risk of a large-scale condensate spill during drilling operations at the proposed Southwark Field Development is very low. The condensate spill modelling scenario shows that a large spill, such as from a well blow-out, would, under the majority of meteorological circumstances, drift to the north east and east of the proposed development location, although there is scope for the slick to drift to the south and west at certain times of the year mainly in the winter and spring months (December to February and March to May).

This light hydrocarbon would be expected to break up and disperse very quickly. However, the modelling undertaken indicates that there is a small probability that a quantity of diesel (617 m^3), arising from a diesel spill, may impact on the Norfolk coastline during the spring months (March to May). In addition, the modelling indicates that there is a smaller probability that a slightly larger quantity of diesel (770 m^3) may impact on the Norfolk coastline during the summer months (June to August).

These conclusions are based on modelling results that assume no intervention actions are undertaken in response to a slick. In practice, oil spill response resources would be mobilised immediately in the event of a spill. It would be a priority for IOG and the appointed Well Operator to ensure no spilled oil would impact the coastline, including the protected areas that exist along the Norfolk coastline or any other part of the coastline, and, therefore, all appropriate oil spill response techniques would be employed in the event of a spillage moving towards the shore.

Historic data suggest small diesel spills of less than 1 tonne represent the most likely diesel spill scenario. Oil spill modelling scenarios show that a large diesel release would have the potential to reach the Norfolk coastline during the spring months (March to May), and a smaller chance of a spill reaching the same coastline in the summer months (June to August). There is a very small potential for diesel to beach on other parts of the UK shoreline specifically along the East Riding of Yorkshire, Lincolnshire, Suffolk and Kent shoreline. However, the likelihood of this occurring is considered to be very low and restricted to certain times of the year.

There is a small to moderate probability that a diesel spill will cross over the Netherlands transboundary line for the majority of the seasons modelled. The summer months (June to August) have been assessed as showing the greatest potential for the transboundary line to be reached.

The volatility of the diesel would, however, result in quick evaporation and dispersal of such a spill. The majority of diesel spills occur during bunkering operations and, therefore, bunkering will only take place under appropriate conditions and with equipment used that has been manufactured, maintained and operated in order to minimise the risk of any spillage and in the event of a spill immediate action would be taken to minimise the potential for any impact on the shoreline. Therefore, any potential diesel spill would have only a minor local environmental impact.

The potential loss of condensate from a pipeline failure is not considered likely to have any significant environmental impact owing to the highly localised spread of any condensate and the low potential for shoreline interaction. A robust operations and maintenance programme will be produced thereby ensuring any potential defects with the pipeline are identified before a failure occurs.

Throughout the proposed operations, the focus would be on the prevention of oil spills. Stringent safety and operational procedures will be adhered to throughout the operations. A robust well design has been developed to minimise the potential for well control issues, and all critical elements of this design and the execution operations will have been both peer and independently reviewed. Well pressure will be monitored throughout the operations, allowing suitable mud weights to be used throughout drilling. A blow-out preventer (BOP) will be put in place, in order to prevent the uncontrolled release of hydrocarbons from the well.

In the unlikely event of a well control incident, the BOP will be closed to prevent hydrocarbons from flowing to the surface. If all attempts to close the BOP fail, attempts would be made to drill a relief well and operations to permanently abandon the well would commence as soon as possible. Any hydrocarbons spilled at sea would be closely monitored with information gathered on spill size and behaviour, the direction and speed of travel, how quickly the slick was being broken down, and the environmental sensitivities at risk.

There will be detailed operation specific TOOPEP/OPEPs in place to ensure that immediate and appropriate action is taken in the event of any hydrocarbon spillage, minimising any impact to the marine environment. A contract with OSRL is in place, allowing the rapid deployment of oil spill response equipment and personnel in the event of a large oil spill incident. This equipment would be sourced through OSRL. Specific response equipment would be available including booms to contain surface spills at sea or protect sensitive shorelines. Ultimately, the type and size of spill, along with the metocean conditions at the time of the spill, will dictate which of these resources is most suitable for the spill event. Additional shore clean-up equipment is also available.

With the measures in place to prevent an oil spill incident from happening and the oil spill contingency planning and response resources available in the event of a large oil spill event, the residual environmental risk posed by the proposed Southwark Field Development is considered to be reduced to an acceptable level.

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Section 10

Conclusions

10 Conclusions

IOG proposes to develop the Southwark field Development in the Southern North Sea located approximately 55 km from the North Norfolk Coast, in UKCS Blocks 49/21 and 49/26. The proposed development comprises one field, the drilling of three production wells, and connection to the 24” Thames to Bacton pipeline PL370.

The wells will be drilled using a jack-up drilling rig. IOG proposes to appoint a Well Operator to drill and operate the wells on behalf of IOG. Drilling operations are proposed to commence in Q1 2021. Drilling operations are planned to take 294 days at Southwark.

It is IOG’s preference is to drill all sections with WBM however, geological conditions encountered during drilling may necessitate the use of OBM in some lower sections of wells. In such a case, LTOBM may be used. All cuttings and associated WBM will be discharged to sea, as is normal practice on the UKCS. No LTOBM will be discharged to sea. Instead, all spent LTOBM and associated cuttings will be skipped and shipped to shore for appropriate treatment and disposal. The expected hydrocarbons from the wells are gas and condensate.

A minimum facilities platform and export pipeline will be installed. The development will connect to the existing Thames to Bacton pipeline.

The proposed activities and available options have been described (Section 2), together with a description of the local environment (Section 3). The interactions between the project and the environment have been identified (Section 4) and all potentially significant environmental impacts assessed (Sections 5 to 9). The key environmental concerns identified as requiring consideration for impact assessment were:

- Physical Presence (Section 5);
- Marine Discharges (Section 6);
- Noise generation and Wildlife Disturbance (Section 7);
- Atmospheric Impacts (Section 8);
- Accidental Events (Section 9).

The main issues identified and conclusions on their residual impacts following the incorporation of mitigation measures are summarised below.

10.1. Physical Presence

Areas of the seabed affected by the development will not be able to fully recover until cessation of the development and removal of the associated infrastructure. However, the disturbance will be localised, and the area affected small in relation to the surrounding undisturbed areas. There is expected to be strong potential for the recovery of the seabed over time via re-sedimentation and re-colonisation of benthos from the surrounding areas.

The jack-up drilling rig may be just visible from shore on clear days and under certain atmospheric conditions during the drilling operations, but will be imperceptible to the human eye under most conditions. The minimum facilities platform, which will be installed at the Southwark field, will not be visible from the shore at sea level. At higher vantage points along the coast the Southwark platform may be visible on clear days with very good visibility however, due to the size and shape of the minimum facilities platform, it would be very difficult to resolve any discernible shape at such distance.

A Vessel Traffic Study (VTS) was conducted for the Southwark Field Development area which indicates that vessel traffic already navigates around the development area and only 20 vessels passed through the proposed 500 m safety zone during the 1-year study period. Most of the local transits are made by vessels serving offshore gas fields, wind farms and dredging sites, along with smaller numbers of tankers and cargo vessels, and a small number of fishing vessels. It is considered that only a very small proportion of the vessel traffic in the area will therefore be directly affected by the statutory safety zones around the Southwark field.

During the life of the fields (approximately 18 years), fisheries are expected to lose access to a total area of 3.13 km^2 around the platform (0.79 km^2) and pipelines (2.34 km^2) at the Southwark field due to the enforcement of 500 m safety zone, and the surface-laid pipelines excluding fishing activities. This area is very small compared to the wider area available for fishing in ICES Rectangle 35F2, with the excluded area representing approximately 0.085% of the total area of ICES Rectangle 35F2. It is expected that the exclusion from this relatively small area will lead to the redirection of fishing effort to another area, rather than any loss of fishing effort in the general area around the well location. Very small amounts of pelagic fish species and shellfish species are landed from this area. Demersal fish species such as plaice, turbot and sole, make up the vast majority of landings. The proportion of area lost is approximately 30 times smaller than the smallest inter-annual variation of landings for shellfish between 2013 and 2017.

Impacts from the physical presence of the rig and infrastructure on seabed take, viewsheds and other users have been considered to be low to negligible, and thus not significant.

10.2. Marine Discharges

The effects of WBM and cuttings discharges on the benthic environment are related to the total quantity discharged and the oceanic energy regime encountered at the discharge site, particularly the currents close to the seabed itself. Any disturbance of the fauna typically only occurs within 50 m from single well locations, and the presence of drilling material on the seabed is often only chemically detectable at distances beyond this.

The results of the cuttings dispersion modelling show that the coarsest cuttings particles will be deposited very close to the well location, while the fraction of finest cuttings particles released at the sea surface may be transported over very large distances in excess of 100 km. However, the associated deposits have a noticeable thickness only in very close proximity (~150 m) of the well location, and very rapidly reduce to sub-millimetric scale at a distance in excess of ~500 m.

Based on these factors, the discharge of cuttings and drilling fluids at the well locations have the potential to cause temporary localised impacts to the benthic environment, primarily through direct physical changes to the seabed however this effect is expected to be chiefly limited to within 50 m of the well location. Recovery of the physical nature of the seabed and associated benthos is expected to begin soon after discharges cease due to natural processes. The Southwark field is located within the North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC which is designated for Annex I habitats “Sandbanks which are slightly covered by sea water all the time and reefs”, specifically *Sabellaria spinulosa* biogenic reefs. The maximum proportion of the NNSSR SAC predicted to be covered by drilling deposits of greater than 30 cm is 0.0000167%. The maximum proportion of the SNS SAC predicted to be covered by drilling deposits of greater than 30 cm is 0.0000016%.

These proportions are more than four orders of magnitude less than 1 %. Given the proportionally small area affected, the highly mobile nature of the sand wave systems and the ephemeral nature of the *Sabellaria spinulosa* reefs, drilling discharges are anticipated to have a minor, short term effect, and are not considered significant. These drilling discharges are not anticipated to have adverse effects on the integrity of the NNSSR SAC, the SNS SAC or the wider network of European protected sites, either alone or in combination with other plans and projects, and with regard to their conservation objectives.

All chemicals to be used will be Offshore Chemical Notification Scheme (OCNS) registered by Cefas, which means they are approved for use on the UKCS. A permit for the use and discharge of these chemicals will be applied for to OPRED, in accordance with the Offshore Chemicals Regulations 2002 (as amended). Wherever practicable and technically feasible, chemicals without substitution warnings will be prioritised over those that do have warnings.

The drilling discharges from the proposed drilling operations at the Southwark production wells are anticipated to have minor, short term effects within the immediate vicinity of platform location, and are not considered a significant impact. There will be no production discharges, as all fluids will be produced to the onshore Bacton Terminal.

10.3. Noise Generation and Wildlife Disturbance

Anthropogenic noises from shipping are currently believed to be the main source of background noise in the area of the proposed well locations. During the drilling operations at the Southwark field, noise will be generated by the jack-up drilling rig and also by support vessels (i.e. the standby vessel, well stimulation vessel and supply vessels) and helicopters. However, the loudest anticipated sound source will be piling noise generated during platform installation.

An assessment of the requirement for a wildlife disturbance licence was undertaken for the Southwark field Development, in line with the Offshore Marine Regulations 2007 (amended 2009). This assessment concluded that it is extremely unlikely that piling operations at the Southwark field would cause a disturbance offence in relation to any Marine European Protected Species and, therefore, IOG considers it is not necessary to apply for a wildlife disturbance licence.

The main noise and disturbance impacts from the development of the Southwark field is expected to be limited to avoidance behavioural responses of individual animals within 26 km of the platform piling operations, for the duration of the piling activities, i.e. up to 4 days for the Southwark platform. Given the intermittent nature and short duration of the piling operations, any effects are expected to only last for a short period of time and are, therefore, not considered to be significant.

Many species of fish use sound to find prey, to avoid predators, and for social interactions. In addition, the sensory systems used by fishes to detect sounds are very similar to those of marine (and terrestrial) mammals, and, as a consequence, sounds that damage or affect marine mammals could in other ways have similar consequences for fish. Adult and juvenile fish are rarely affected by piling operations because they are able to detect and physically avoid the area, but fish eggs and larvae may be more vulnerable. Given the limited spatial extent of the anticipated impact and the limited (4 day) period over which the piling will take place, and the ability of fish to temporarily avoid areas of adverse noise, the proposed piling operations is not anticipated to cause any significant impacts on fish.

The piling operations during the installation of the platform at the Southwark field will temporarily add to the ambient noise in the Southern North Sea which includes various sources of industrial noise such as shipping and fishing activity, windfarms, other oil and gas installations and aggregate extraction.

The long-term, synergistic and cumulative impact of sound sources is not known. However, the risks in this instance are considered to be low, for the following reasons:

- Noise generation associated with the proposed piling operations will be intermittent and transitory; occurring over a period of up to 4 days;
- Although the Southern North Sea can be regarded as important for certain species of cetacean, the highest densities of cetaceans present in the Southwark Field Development area are classed as “high-frequency” cetaceans, which are generally regarded to be more sensitive to higher sound frequencies than the dominant frequencies produced by the piling operations.

With regard to potential transboundary effects, the location of the Southwark Field Development is 64 km west of the UK/Netherlands transboundary line. At this distance any underwater sound will have attenuated to a low level therefore no observable effects are expected to occur. Consequently, no significant cumulative and/or transboundary impacts from noise generated during the piling operations are anticipated.

10.4. Atmospheric Emissions

Atmospheric emissions will be produced during drilling and installation operations, as a result of power generation, supply vessels and helicopter activity, there will be no flaring from the platform. However, it should be noted that atmospheric emissions during the production phase will be minimal, as the power required onboard the minimum facilities platforms will be provided by a combined part renewable energy system (wind and solar energy) and a part traditional diesel engine system for when renewable energy is not in full supply. Therefore, this has not been considered further in the ES.

Emissions will contribute to local and global environmental effects. At a local level, impacts are mitigated by health and safety measures in place to control emissions and by the dispersive nature of the offshore environment. Emissions will also contribute to global environmental issues such as climate change. The contribution of the proposed drilling and installation programme is comparable to similar operations, and small in comparison to emissions at a national level. Therefore, the individual atmospheric emissions generated at the Southwark field and its resultant impacts are considered to be negligible and therefore not significant.

The ultimate cumulative global implications, such as the contribution to global climate change, are more difficult to assess, and the overall strategy to tackle such issues ultimately lies with national and international governance. As such, the mitigation of the potential cumulative impacts involved is considered to lie outside the scope of this ES.

10.5. Accidental Events

The risk of a large-scale hydrocarbon spill occurring during drilling operations at the proposed Southwark field is very low. The only potential sources of a large spill would be an uncontrolled well blow-out leading to a release of condensate from the well, catastrophic failure of the MODU's diesel tanks or a release of condensate from pipeline failure.

Modelling undertaken indicates that a large spill from a well blow-out is most likely to drift to the northeast and east of the Southwark field location under the majority of meteorological conditions, however the model also predicts an increase in the probability that the slick drift to the west between December and May. This light hydrocarbon would be expected to break up and disperse very quickly. The modelling indicates that there would be a small probability of a large amount of condensate (617 m^3) to make landfall on the Norfolk coastline during the spring months (March to May). In addition, the modelling indicates that there is a smaller probability that a slightly larger quantity of diesel (770 m^3) may impact on the Norfolk coastline during the summer months (June to August).

However, these predictions assume no intervention in response to the slick. In practice oil spill response resources would be mobilised immediately if a spill occurred. It would be a priority to ensure no spilled oil would impact the coastline, including the protected areas that exist along the Norfolk coastline, and, therefore, all appropriate oil spill response techniques would be employed in the event of a spillage moving towards the shore.

Historic data suggest small diesel spills of less than 1 tonne represent the most likely diesel spill scenario. Oil spill modelling scenarios show that a large diesel release would have a small potential to reach the Norfolk coastline during the spring months (March to May), a smaller chance of reaching the same coastline in the summer months (June to August). There is a very small potential for condensate to beach on other parts of the UK shoreline specifically along the East Riding of Yorkshire, Lincolnshire, Suffolk, and Kent shoreline. However, the likelihood of this occurring is considered to be very small and restricted to certain times of the year.

There is a small to moderate probability that a diesel spill will cross over the UK/Netherlands transboundary line for the majority of the seasons modelled. The summer months (June to August) have been modelled as having the greatest potential for the transboundary line to be reached.

The volatility of the diesel would, however, result in quick evaporation and dispersal of such a spill. The majority of diesel spills occur during bunkering operations and, therefore, bunkering will only take place under appropriate conditions and with equipment used that has been manufactured, maintained and operated in order to minimise the risk of any spillage and in the event of a spill immediate action would be taken to minimise the potential for any impact on the shoreline. Therefore, any potential diesel spill would have only a minor local environmental impact.

The potential loss of condensate from a pipeline failure is not considered likely to have any significant environmental impact owing to the highly localised spread of any condensate and the low potential for shoreline interaction. A robust operations and maintenance programme will be produced thereby ensuring any potential defects with the pipeline are identified before a failure occurs.

Throughout the proposed operations, the focus would be on the prevention of oil spills. Stringent safety and operational procedures will be adhered to throughout the operations. In the unlikely event of a well control incident, the blow-out preventer (BOP) will be closed to prevent hydrocarbons from flowing to the surface. If all attempts to close the BOP fail, attempts would be made to drill a relief well and permanently abandon the well as soon as possible. Any hydrocarbons spilled at sea would be closely monitored with information gathered on spill size and behaviour, the direction and speed of travel, how quickly the slick was being broken down, and the environmental sensitivities at risk.

A detailed operation specific TOOPEP/OPEP will be in place to ensure that immediate and appropriate action is taken in the event of any hydrocarbon spillage, minimising any impact to the marine environment. A contract with OSRL is in place, allowing the rapid deployment of oil spill response equipment and personnel in the event of a large oil spill incident. Specific response equipment would be available including booms to contain surface spills at sea or protect sensitive shorelines.

With the measures in place to prevent an oil spill incident from happening and the oil spill contingency planning and response resources available to the appointed Well Operator in the event of a large oil spill event, the residual environmental risk posed by the proposed Southwark field development operations is judged to be reduced to an acceptable level.

The potential for a hydrocarbon or condensate release is considered the most likely major accidental event to occur at the proposed Southwark field development as described above. Whilst major disasters such as earthquakes and tsunamis are rare in the North Sea the platform which will be installed at the Southwark field will be designed to withstand a variety of loads including environmental factors such as wind, wave and earthquakes.

10.6. Overall Conclusion

The only potential significant impact identified in the environmental impact assessment is that of a large-scale condensate or diesel spill. However, the probability of such a spill is very low and mitigation and management procedures will be put in place to prevent this from happening, as well as adequate resources to deal with any such spill should it occur. All other impacts identified in the ES are expected to only have localised and temporary impacts with good recovery potential over time following cessation of operations.

Overall, it is concluded that the environmental impacts of the proposed Southwark Field Development will not incur any significant long-lasting environmental effects.

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Section 11

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Section 12

Abbreviations

12 ABBREVIATIONS

"	Imperial inch
AIS	Automatic Identification System
AoO	Advice on Operations
AONBs	Areas of Outstanding Natural Beauty
API	American Petroleum Institute
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
BAT	Best Available Techniques
Bcf	Billion Cubic Feet
BEIS	Department of Business, Energy and Industrial Strategy
BI	Birdlife International
bbl	Barrel
BODC	British Oceanographic Data Centre
BOP	Blow-out preventer
bwpd	Barrels of Water per Day
^oC	Degrees Celsius
C	Carbon
CEO	Chief Executive Officer
CH_4	Methane
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
cm	Centimetre
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
COLREGS	International Regulations for Preventing Collisions at Sea 1972
CP	Chemical Permit
cSAC	Candidate Special Area of Conservation
dB	Decibel
DECC	Department of Energy and Climate Change
DEPCON	Consent to deposit of materials on the Seabed
DOWFL	Dudgeon Offshore Wind Farm Limited
DP	Dynamic positioning / Dynamically positioned
DPM	Diesel particulate matter
DRA	Drilling Operations Master Application Template
DSV	Diving Support Vessel
EBS	Environmental Baseline Survey
EC	European Commission
ECD	Early Consultation Document
EEMS	Environmental Emissions Monitoring System
EHD	European Habitats Directive
EIA	Environmental Impact Assessment
EMS	Environmental Management System
ENVID	Environmental Issues Identification Workshop
EPS	European Protected Species
ERRV	Emergency Response and Rescue Vessel
ES	Environmental Statement
ESD	Emergency Shutdown System
ETS	Emission Trading Scheme
EU	European Union
FDP	Field Development Plan

FEED	Front End Engineering Design
FEPA	Food and Environment Protection Act 1985
FGS	Fire & Gas System
ft	Imperial feet
GHG	Greenhouse gas
GWC	Gas water contact
GWP	Global warming potential
HIPPS	High-Integrity Pressure Protection System
HMCS	Harmonised Mandatory Control System
HRA	Habitats Regulations Assessment
HSE	Health, Safety, Environment
Hz	Hertz
ICES	International Council for the Exploration of the Seas
IOG	IOG UK Ltd
IPPC	Integrated Pollution Prevention and Control
ITOPF	International Tanker Owners Pollution Federation
JNCC	Joint Nature Conservation Committee
kHz	Kilohertz
KIS-ORCA	Kingfisher Information Service- Offshore Renewable and Cable Awareness Project
km	Kilometre
km^2	Kilometre squared
kNm	Kilonewton Metres
kW	Kilowatt
LAT	Lowest Astronomical Tide
LTOBM	Low-Toxicity Oil Base Mud
M	Metre
mm	Millimetre
m^2	Metre squared
m^3	Metre cubed
MA	Major Accident
MAH	Major Accident Hazard
MARPOL	International Convention for the Prevention of Pollution from Ships
MAT	Master Application Template
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
MEG	Monoethylene Glycol
MEI	Major Environmental Incident
MMO	Marine Management Organisation
MMscfd	Million standard cubic feet per day
MoD	Ministry of Defence
MODU	Mobile Drilling Unit
MPA	Marine Protected Area
ms^{-1}	Metre per Second
MT	Metric Tonne
MW(th)	Megawatt Thermal
N_2O	Nitrous Oxide
NAP	National Allocation Plan
nm	Nautical Mile
NMHC	Non-Methane Hydrocarbons
NMP	National Marine Plan
NNR	National Nature Reserve

NNSSR	North Norfolk Sandbanks and Saturn Reef
NO_x	Nitrogen Oxides
O_3	Ozone
OBM	Oil Base Mud
OGA	Oil and Gas Authority
OMR	Offshore Marine Regulations
OPEP	Oil Pollution Emergency Plan
OPPC	Oil Pollution Prevention and Control
OPOL	Offshore Pollution Liability Association Limited
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSCAR	Oil Spill Contingency and Response
OSD	Offshore Safety Directive
OSDSCR	Offshore Safety Directive (Safety Case etc) Regulations 2015
OSPAR	The Convention for the Protection of the Marine Environment of the north-east Atlantic
OSPRAG	Oil Spill Prevention and Response Advisory Group
OSRL	Oil Spill Response Limited
OWF	Offshore Wind Farm
PCS	Process Control System
PEXA	Practice and Exercise Areas
PL	Pipeline
PLONOR	Pose Little or No Risk (to the environment)
PM	Particulate Matter
PON	Petroleum Operations Notice
PPS	Pipeline Protection System
PLV	Pipeline Laying Vessel
PRA	Production Operations Master Application Template
PWA	Pipeline Works Authorisation
R	Distance from Sound Source
RBMP	River Basin Management Plan
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
ROV	Remotely Operated Vehicle
SAC	Special Area of Conservation
SAT	Subsidiary Application Template
SCOS	Special Committee on Seals
SEA	Strategic Environmental Assessment
SL	Source Level
SMP	Shoreline Management Plan
SNS	Southern North Sea
SO_2	Sulphur Dioxide
SoS	Secretary of State
SOSI	Seabird Oil Sensitivity Index
SPA	Special Protection Area
SPL	Sound Pressure Level
SSSI	Sites of Special Scientific Interest
t	Tonne
TCE	The Crown Estate
TD	Total depth
TOOPEP	Temporary Operations Oil Pollution Emergency Plan
TWT	The Wildlife Trust
UK	United Kingdom
UKCS	United Kingdom Continental Shelf

UKHO	United Kingdom Hydrographic Office
UKOOA	United Kingdom Offshore Operators
VMS	Vessel Monitoring Systems
VOC	Volatile Organic Compound
VTS	Vessel Traffic Study
WBD	Wild Birds Directive
WBM	Water Base mud
WONS	Well Operations Notification System
ZSS	Zero discharge, skip and ship

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Section 13

Glossary

13 GLOSSARY

Abandonment	To cease work on a well which is non-productive, to plug off the well with cement plugs and salvage all recoverable equipment. Also used in the context of field abandonment.
Acid rain	Precipitation of acidic pollutants, chiefly sulphur dioxide and nitrogen oxide, released into the atmosphere by the burning of fossil fuels such as oil.
Acidification	The decrease in pH of the oceans, caused by their uptake of atmospheric carbon dioxide.
Amphipod	A small flat-bodied crustacean of the group Amphipod.
Annex I Habitat	A rare or characteristic habitat which is affords protection under on the EU Habitats Directive.
Annex II Species	A rare, threatened or endemic species (not including birds), which is affords protection under on the EU Habitats Directive.
Annulus	The space between well bore and casing.
Atmospheric emissions	A collective term for gases and particulates released to the atmosphere.
Baleen whales	Whales of the suborder Mysticeti. They have plates of whalebone (a baleen) along the upper jaw for filtering plankton from the water.
Barite	Barium sulphate ($BaSO_4$).
Bathymetry	The measurement of underwater depth in ocean, seas or lakes.
Benthic	Of or relating to the seabed.
Benthos	Animals that occur on or in the seabed.
Biogenic reef	This reef may be composed almost entirely of the reef building organisms and their tubes or shells, or may include sediments, stones and shells bound together by the organism.
Bivalve	A class of marine and freshwater molluscs with laterally compressed bodies enclosed by a shell in two hinges.
Block	Sub-division of territorial seas for the purpose of licensing to a company or group of companies for exploration and production rights. A UK block is approximately 200 to 250 km^2.
Blow-out	A blow-out occurs when gas, oil or saltwater escapes in an uncontrolled manner from a well.
Blow-out preventer (BOP)	A hydraulically operated wellhead device that can be actuated to close a well in order to prevent an uncontrolled release of fluids (a blow-out).
Casing	Steel lining inserted into a well as drilling progresses to prevent the wall of the hole from caving in during drilling, to prevent the inflow of unwanted fluids from surrounding formations and to provide a means of extracting oil (and gas) if a well is productive.
Cetacean	Aquatic mammals of the order Cetacea, which comprise porpoises, dolphins, and whales.
Condensate	A low-density, high-API gravity liquid hydrocarbon phase that generally occurs in association with natural gas. Its presence as a liquid phase depends on temperature and pressure conditions in the reservoir allowing condensation of liquid from vapor.
Conductor	First string of casing to be inserted and cemented into the borehole. Its purpose is to prevent the soft formations near the surface from caving in and to conduct drilling mud from the bottom of the hole to the surface when drilling starts.
Continental shelf	The Continental shelf refers to the extension of the continent into the ocean.
Copepods	Small free-living or parasitic crustaceans of the subclass Copepoda, living in marine and fresh waters. The free-living forms are an important constituent of plankton.
Crude Oil	A general term for unrefined naturally occurring oil.
Cuttings	Rock chips produced by chipping and crushing action of the drill bit.
Cuttings pile	An accumulation of rock chips or formation debris, produced by the action of the drill bit, and deposited on the seabed.

dB re 1µPa-m	The sound source level measured on the decibel (dB) logarithmic scale at 1 m from the source.
Demersal	Living in the water column at or near seabed. Usually in relation to fish.
Diatoms	Unicellular planktonic algae with silica shells.
Dinoflagellates	Unicellular planktonic organisms often bearing a tough cellulose shell (theca).
Dispersant	A chemical that breaks up concentrations of oil in water, reducing the oil to small droplets (an emulsion).
Drilling mud/fluid	A mixture of base substance and additives used to lubricate the drill bit and to counteract the natural pressure of the formation.
Dynamic Positioning	A system of sensors and thrusters on a vessel which allows it to maintain position using satellite telemetry to adjust thrusters' direction and power.
Echinoderm	A marine invertebrate of the phylum Echinodermata, including starfishes and sea urchins, characterized by a five-part radially symmetrical body and a calcareous endoskeleton.
Environmental Impact Assessment	A process to identify and assess the impacts associated with a particular activity, plan or project.
Environmental Management System	A formal system which ensures that a company has control of its environmental performance.
Epifauna	Benthic organisms that live on the surface of the seabed, either sessile or free moving.
European protected species	Species listed in Annex IV of the Habitats Directive.
Field	An accumulation of hydrocarbons in the subsurface. Consists of a reservoir in a shape that will trap hydrocarbons and that is covered by an impermeable, sealing rock.
Gadoids	Fish belonging to the family Gadidae, which includes cod, haddock and whiting.
Global warming potential	A measure of how much a given mass of gas is estimated to contribute to global warming, relative to the same mass of carbon dioxide.
Greenhouse gas	Gas that contributes to the greenhouse effect. Includes gases such as carbon dioxide (CO_2) and methane (CH_4). The greenhouse effect results in a rise in temperature due to incoming solar radiation being trapped by carbon dioxide and water vapour in the Earth's atmosphere.
Hydrocarbon	A compound containing only the elements hydrogen and carbon. May exist as a solid, a liquid or a gas. The term is mainly used in a catch-all sense for crude oil, natural gas, condensate and their derivatives.
Important Bird Areas	A global network of sites for the conservation of birds and bird habitats, set up by BirdLife International.
Infauna	Animals living within seabed sediments mostly within the top 10 to 15 cm.
Macrobenthos	Animals that occur on or in the seabed and are large enough to be retained on a 500 µm or 1 mm mesh.
MEG line	Pipeline/flowline which transports hydrate and scale inhibitor chemicals, typically MEG, to the wells however the line may be used to transport other, smaller quantities of chemicals.
Nautical mile	Nautical measurement of distance, equivalent to 1.852 km or 1.15 miles.
Nephrops	Burrowing crustacean also known as Norway lobster, Langoustine, Dublin Bay prawn or scampi.
Odontocetes	Toothed whales, a suborder of cetaceans. Examples include sperm whales, beaked whales and dolphins.
Oil base mud	Drilling mud with oil as the fluid continuous phase.
Ozone	Atmospheric gas which acts as a pollutant creating smog at ground level, and in the upper atmosphere filters out ultra violet light from reaching the earth.
Pelagic	Inhabiting the water column of the sea.
Phytoplankton	Free floating microscopic plants.
Plankton	Free floating organisms found in the oceans and other aquatic systems.

Pockmarks	Craters in the seabed formed by fluids such as liquid and gas, erupting and streaming through the sediments. They can be classed as Annex 1 habitats "Submarine structures made by leaking gasses", by the Joint Nature Conservation Committee.
Polychaete	A class of marine annelid worms.
Pseudo-oil/synthetic based mud	Synthetic alternative to oil based mud, created from esters or vegetable oil.
Ramsar sites	Wetlands of international importance.
Reservoir	The underground formation where oil and gas has accumulated. It consists of a porous rock to hold the oil or gas, and a cap rock that prevents its escape.
Riser	A pipe which connects an offshore installation to a subsea wellhead or pipeline during drilling or production operations.
Site of Special Scientific Interest	Sites designated by Natural England, Scottish Natural Heritage, or the Countryside Council for Wales as being of conservational importance because of their flora, fauna, or geological and physiographical features.
Spawning	The production and release of gametes (eggs or sperm) by animals.
Special Area of Conservation	Protected sites designated under the EC Habitats Directive in order to conserve important habitats and species (excluding birds).
Special Protection Area	Sites designated by the UK Government under the EC Birds Directive to protect certain rare, vulnerable, and regularly occurring migratory species of birds.
Water base mud	A type of drilling fluid (mud) consisting mainly of water, which has additives to modify it and make it more effective.
Zooplankton	Animals which drift in the water column along with prevailing currents, mostly microscopic.

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Appendix A

Summary of Legislation

APPENDIX A SUMMARY OF LEGISLATION

The main environmental legislation regulatory requirements relevant to the proposed Southwark Field Development.

Topic	Legislation
Consenting	
Environmental Statement	Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999, as amended; Offshore Petroleum and Pipelines (Environmental Impact Assessment and other Miscellaneous Provisions) (Amendment) Regulations 2017; Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001, as amended; Marine Works (Environmental Impact Assessment) (Amendment) Regulations 2017 (SI 2017/588); Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007, as amended; Pollution Prevention and Control (Fees) (Miscellaneous Amendments) Regulations 2016 (SI 2016/529); Pollution Prevention and Control (Fees) (Miscellaneous Amendments) (No. 2) Regulations 2016 (SI 2016/1042); Pollution Prevention and Control (Fees) (Miscellaneous Amendments) Regulations 2017 (SI 2017/404) Convention on Environmental Assessment in the Transboundary Context (Espoo Convention) 1991.
Well Consent	The Petroleum Act 1998; Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999, as amended; Well Operations Notification System (WONS); Offshore Petroleum Licensing (Offshore Safety Directive) Regulations 2015 (2015 licensing regulations); Drilling Operations MAT (DRA), Chemical Permit SAT (CP), and EIA Direction for Drilling Operations SAT (DR).
Well Test Consent	Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999, as amended; Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended; Petroleum Licensing (Exploration & Production) (Seaward and Landward) Regulations 2004; Petroleum Licensing (Production) (Seaward Areas) Regulations 2008; Convention on the Protection of the Marine Environment of the North East Atlantic 1992 (OSPAR Convention); Drilling Operations MAT (DRA), Chemical Permit SAT (CP), EIA Direction for Extended Well Test SAT (EWT).
Pipeline Consent	Petroleum Act 1998; Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999, as amended; Pipeline Safety Regulations 1996, as amended; Marine and Coastal Access Act 2009; Pipeline Works Authorisation (PWA) and consent to deposit of materials on the Seabed (DEPCON); Pipeline Operations MAT (PLA), Chemical Permit SAT (CP), EIA Direction for Pipeline Operations SAT (PL), and EIA Direction for Deposits SAT (DEP).
Consent to Locate	Marine and Coastal Access Act 2009 (MCAA); Energy Act 2008 Part 4.

Topic	Legislation
Consenting	
Platform Consents	Petroleum Act 1998; Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999, as amended; Offshore Petroleum Licensing (Offshore Safety Directive) Regulations 2015 (2015 licensing regulations); Production Operations MAT (PRA) and EIA Direction for Commencement of Production SAT (SP).
Production Consent	Petroleum Act 1998; Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999, as amended; Offshore Petroleum Licensing (Offshore Safety Directive) Regulations 2015 (2015 licensing regulations); Production Operations MAT (PRA) and EIA Direction for Commencement of Production SAT (SP).
Produced Water	Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended; Production Operations MAT (PRA) and Oil Discharge Permit (Life) SAT (OLP);
Routine Drilling Operations	
Sewage from drilling rig	MARPOL 73/78 Annex IV Prevention of Pollution by Sewage from Ships; Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008; Food and Environment Protection Act 1985 (FEPA), as amended Deposits in the Sea (Exemption) Order 1985; Convention on the Protection of the Marine Environment of the North East Atlantic 1992 (OSPAR Convention).
Oil contaminated discharges	Offshore Chemical Regulations 2002, as amended; Offshore Petroleum Activities (Oil Pollution Prevention and Control) (OPPC) Regulations 2005, as amended; Food and Environment Protection Act 1985 (FEPA), as amended; Convention on the Protection of the Marine Environment of the North East Atlantic 1992 (OSPAR Convention); OSPAR Decision 2000/3 on the Use of Organic-phase Drilling Fluids (OPF) and the Discharge of OPF-Contaminated Cuttings; OSPAR Recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles.
Water based mud (WBM) cuttings	Offshore Chemical Regulations 2002, as amended; Offshore Petroleum Activities (Oil Pollution Prevention and Control) (OPPC) Regulations 2005, as amended; Food and Environment Protection Act 1985 (FEPA), as amended; Deposits in the Sea (Exemptions) Order 1985; OSPAR Recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles.

Topic	Legislation
Routine Drilling Operations	
Chemical use	Pollution Prevention and Control Act 1999; Offshore Chemicals Regulations 2002, as amended; The REACH Enforcement Regulations 2008, as amended; Convention on the Protection of the Marine Environment of the North East Atlantic 1992 (OSPAR Convention); OSPAR Recommendation 2006/3 on Environmental Goals for the Discharge by the Offshore Industry of Chemicals that are, or which contain Substances Identified as Candidates for Substitution; OSPAR Recommendation 2005/2 on Environmental Goals for the Discharge by the Offshore Industry of Chemicals that Are, or Contain Added Substances, Listed in the OSPAR 2004 List of Chemicals for Priority Action; OSPAR Recommendation 2000/2 on a harmonised mandatory control system for the use and reduction of the discharge of offshore chemicals as amended by OSPAR Decision 2005/1; Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended (OPPC); Food and Environment Protection Act 1985 (FEPA), as amended; Deposits in the Sea (Exemptions) Order 1985.
Rig drainage water	Offshore Petroleum Activities (Oil Pollution Prevention and Control) (OPPC) Regulations 2005, as amended; Convention on the Protection of the Marine Environment of the North East Atlantic 1992 (OSPAR Convention); PARCOM Recommendation 86/1 of a 40 mg/l Emission Standard for Platforms; Merchant Shipping (Prevention of Oil Pollution) Regulations 1996, as amended; Merchant Shipping Act 1995; International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78; Merchant Shipping (Prevention of Oil Pollution) (Amendment) Regulations 1994.
Atmospheric Emissions from the Rig	
Turbine/combustion emissions	MARPOL 73/78 Annex VI Prevention of Air Pollution from Ships; The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, as amended; Offshore Combustion Installations (Prevention and Control of Pollution) Regulations 2001, as amended; Climate Change Act 2008; National Emission Ceilings Regulations 2002; Pollution Prevention and Control Act 1999.

Topic	Legislation
Atmospheric Emissions from the Rig	
Halocarbons (halons, CFCs)	Ozone Depleting Substances Regulations 2015; Fluorinated Greenhouse Gases Regulations 2015; MARPOL 73/78 Annex VI Prevention of Air Pollution from Ships; The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, as amended.
Flaring and venting	Energy Act 1976, as amended; Petroleum Act 1998, as amended; Petroleum Licensing (Exploration & Production) (Seaward and Landward) Regulations 2004; The Petroleum (Current Model Clauses) Order 1999; Climate Change Act 2008; Greenhouse Gas Emissions Trading Scheme Regulations 2005; National Emission Ceilings Regulations 2002; Waste and Emissions Trading Act 2003.
Chemical Transport	
Bulked chemicals	Environmental Protection Act 1990; Merchant Shipping (Dangerous or Noxious Liquid Substances in Bulk) Regulations 1996, as amended.
Dangerous goods	Environmental Protection Act 1990; Controlled Waste Regulations 1992, as amended; The Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997; The Waste (England and Wales) Regulations 2011.
Hazardous chemicals	Environmental Protection Act 1990; Controlled Waste Regulations 1992, as amended; Chemicals (Hazard Information and Packaging for Supply) Regulations 2009; The Waste (England and Wales) Regulations 2011.
Wildlife Protection (Offshore)	
Habitats and species	Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007, as amended; The Conservation of Habitats and Species Regulation 2010, as amended; The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001; The UK Marine and Coastal Access Act 2009.
Cetaceans	The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001, as amended; Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas 1991 (ASCOBANS); Wildlife and Countryside Act (1981); Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007, as amended.

Topic	Legislation
Waste Handling	
Transfer of oil contaminated wastes	Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended; Merchant Shipping (Prevention of Oil Pollution) Regulations 1996; Prevention of Pollution (Reception Facilities) Order 1984; Merchant Shipping and Maritime Security Act 1997.
Garbage	Food and Environment Protection Act 1985, as amended; Deposits in the Sea (Exemptions) Order 1985; Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008.
Transfer of waste/garbage from installations	Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008; Food and Environment Protection Act 1985, as amended; Deposits in the Sea (Exemptions) Order 1985; The Waste (England and Wales) Regulations 2011.
Transfer of special waste	Environmental Protection Act 1990; Controlled Waste Regulations 1992, as amended; Special Waste Regulations 1996, as amended; The Waste (England and Wales) Regulations 2011.
Radioactive waste	Radioactive Substances Act 1993 (RSA 93), as amended; Environmental Permitting (England and Wales) Regulations 2010; Radioactive Substances (Phosphatic Substances, Rare Earths etc.) Exemptions Order 1962; Radioactive Substances (Substances of Low Activity) Exemption Order 1986, as amended; Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997.
Support Vessels	
Machinery space drainage from shipping	The Merchant Shipping (Prevention of Oil Pollution) Regulations 1996, as amended; Merchant Shipping Act 1995; International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78.
Sewage from vessels	MARPOL 73/78 Annex IV Regulations for the Prevention of Pollution by Sewage from Ships; Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008; Deposits in the Sea (Exemption) Order 1985; Food and Environment Protection Act 1985, as amended.
Garbage from vessels	Food and Environment Protection Act 1985, as amended; Deposits in the Sea (Exemption) Order 1985; Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008.

Topic	Legislation
Support Vessels	
Atmospheric emissions from vessels	The Merchant Shipping (Prevention of Air Pollution from Ships) Order 2006; MARPOL 73/78 Annex VI - Prevention of Air Pollution from Ships, the regulations in this annex set limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibit deliberate emissions of ozone depleting substances; The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008.
Accidental Events (Installations)	
Oil pollution emergency planning	Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998, as amended; Offshore Installations (Emergency Pollution Control) Regulations 2002; Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995; The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended.
Spill reporting	Model Clauses of Licence; Petroleum Operations Notice no 1.
Accidental Events (Vessels)	
Spills, release or possible escape of oil, noxious substance or marine pollutant	Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998, as amended; Merchant Shipping (Reporting of Pollution Incidents) Regulations 1987; Merchant Shipping (Reporting Requirements for Ships Carrying Dangerous Polluting Goods) Regulations 1995; Petroleum Operations Notice no 1.
Decommissioning	
Well suspension and abandonment	Petroleum Act 1998, as amended; Energy Act 2008, as amended; The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended; Offshore Chemicals Regulations 2002, as amended; Offshore Chemicals (Amendment) Regulations 2011; Marine and Coastal Access Act 2009 (MCAA); Marine Scotland Act 2010; Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001, as amended; The Offshore Petroleum Activities (Conservation of Habitats) (Amendment) Regulations 2007; Petroleum (Production) (Seaward Areas) Regulations 1988, as amended; Offshore Installations and Wells (Design and Construction etc) Regulations 1996; Food and Environment Protection Act 1985, as amended; Well intervention Permit via the UK Oil Portal, FEPA licence may be required, or a Marine Licence for deposits on the seabed. A MCAA licence via the UK Oil Portal.

Appendix B

ENVID Matrices

Appendix B – ENVID Matrices

B.1 Impact Scoping Matrix (Southwark Field Development)

	Operational Activity	Environmental Aspects (or Sub-operational Activity)	Environmental Impacts	Receptor	Magnitude of Effect (1 to 10)	Receptor Value (1 to 5)	Significance	Comments
General Operations	**Platform and Vessel Use** (drilling rig, platform, support vessels and helicopters)							
	Fuel consumption	Fuel use by the drilling rig, platform, support vessels and helicopters	Climate change	Marine environment; coastal environment; terrestrial environment; Society as a whole	n/a	n/a	Scoped in	As set out in Section 4.2.1.
			Resource use	Society as a whole (potential future users of given resource)	2	3	6	
			Air pollution	Other users of the sea (passing vessels); marine environment (birds and marine mammals)	2	4	8	
	Vessel noise (rig, platform, vessels and helicopters)	Production of sound below sea level (thrusters, propellers, engines etc)	Noise (under water)	Marine environment (marine mammals and fish)	4	5	20	
		Production of engine and machinery noise on the surface (including transfer routes)	Noise (in air)	Marine environment (seabirds and marine mammals)	2	3	6	
	Other rig/vessel activities	Use and discharge of other chemicals (e.g. rig wash)	Marine pollution	Marine environment (water column)	2	3	6	
		Resource use by the crew (consumables such as furniture, electrical equipment, stationery, food, etc)	Resource use	Society as a whole (potential future users of given resource)	2	2	4	
		Generation of artificial light from drilling rig, platform and support vessels	Light pollution	Marine environment (seabirds)	2	3	6	
	Waste Management							
	Waste generation and disposal	Disposal of wastes to marine environment (macerated sewage and food waste, and bilge water)	Marine pollution	Marine environment (water column)	2	3	6	
		Disposal of general wastes onshore (non-hazardous)	Waste generation	Landscape (landfill sites)	2	1	2	Strict planning regulations prevent waste disposal sites being located in sensitive ecological locations.
			Resource use	Society as a whole (potential future users of given resource)	2	2	4	
		Disposal of hazardous wastes onshore (e.g. chemical containers)	Waste generation	Landscape (landfill sites)	2	1	2	As per comment above for onshore general waste disposal.
			Resource use	Society as a whole (potential future users of given resource)	2	2	4	

	Operational Activity	Environmental Aspects (or Sub-operational Activity)	Environmental Issue	Receptor	Magnitude of Effect (1 to 10)	Receptor Value (1 to 5)	Significance	Comments
Drilling Operations	**Mooring the Drilling Rig**							
	Installation and removal of spud cans	Disturbance to seabed	Seabed impacts	Marine environment (seabed communities)	4	5	20	
	Physical presence of the rig	Physical Presence of the rig	Socio-economic impacts	Other users of the sea (shipping and fisheries)	3	4	12	
	Drilling Activities							
	General drilling activities	Use of steel, pipes, drill bits, etc	Resource use	Society as a whole (Potential future users of given resource)	2	3	3	
	Drilling of the tophole sections	Deposition of drill cuttings and associated base mud directly to the seabed	Marine pollution	Marine environment (seabed communities)	4	5	20	
		Deposition of excess cement directly to the seabed	Marine pollution	Marine environment (seabed communities)	4	5	20	
	Drilling of deeper well sections	Discharge of drill cuttings and associated base mud at the surface	Marine pollution	Marine environment (seabed communities and water column)	4	5	20	
		Discharge of waste cement at the sea surface	Marine pollution	Marine environment (seabed communities and water column)	2	5	10	
	Wireline, logging while drilling etc	Use of radioactive sources	Electromagnetic radiation	Resource use	2	3	6	

	Operational Activity	Environmental Aspects (or Sub-operational Activity)	Environmental Issue	Receptor	Magnitude of Effect (1 to 10)	Receptor Value (1 to 5)	Significance	Comments
Installation and Commissioning	**Laying of Flowlines and Associated Infrastructure**							
	Laying of flowlines (pipelines, flowlines and umbilicals)	Trenching and laying of flowlines (including any backfilling)	Seabed impact	Natural environment (seabed communities)	4	5	20	
	Installation of template, manifolds and other seabed infrastructure	Positioning of infrastructure on the seabed	Seabed impact	Natural environment (seabed communities)	4	5	20	
	Stabilisation and protection of infrastructure	Rock dumping for protection of flowlines or other infrastructure	Seabed impact	Natural environment (seabed communities)	4	5	20	
			Socio-economic impact	Other users	2	4	8	
		Laying of concrete mattresses, grout bags etc for protection of flowlines or other infrastructure	Socio-economic impact	Other users	4	5	20	
			Seabed impact	Natural environment (seabed communities)	4	5	20	
	Installation of the Platform							
	Installation of platform	Underwater noise associated with piling operations	Noise	Natural environment (marine mammals)	6	5	30	

	Operational Activity	Environmental Aspects (or Sub-operational Activity)	Environmental Issue	Receptor	Magnitude of Effect (1 to 10)	Receptor Value (1 to 5)	Significance	Comments
Production Operations	**Physical Presence of Development Infrastructure and Standby Vessels**							
	Physical presence of the installation and infrastructure	Ongoing presence of the installations	Socio-economic impact	Other users of the sea (wind farm, shipping and fisheries)	4	5	20	
		Ongoing presence of the flowlines and other seabed infrastructure	Socio-economic impact	Other users of the sea (fisheries)	6	4	24	
	Ongoing Production Activities							
	Discharges to sea during production	Deck discharges to sea	Marine pollution	Marine environment (plankton and water column)	2	3	6	
		Discharge of hydraulic fluids at wellhead	Marine pollution	Marine environment (seabed communities and water column)	1	3	3	
	Maintenance, Shutdown and Well Intervention Activities							
	Discharges to sea	Use and discharge of chemicals during maintenance and well intervention	Marine pollution	Marine environment (plankton and water column)	2	3	6	
		Discharge of reservoir oil contaminated fluids during maintenance and well intervention	Marine pollution	Marine environment (plankton and water column)	2	3	6	

	Operational activity	Environmental aspects (or sub-operational activity)	Environmental issue	Receptor	Magnitude of effect (1 to 10)	Receptor Value (1 to 5)	Significance	Comments
Accidental Events	**Small to medium oil or chemical spills**							
	Spillage of diesel or other oils	Diesel spill during bunkering	Marine pollution	Marine environment (All marine biota present)	4	5	20	
		Condensate spill	Marine pollution	Marine environment (All marine biota present)	4	5	20	
		Hydraulic fluid, lube, helifuel, waste oil spill	Marine pollution	Marine environment (All marine biota present)	2	5	10	
	Large hydrocarbon spill /release							
	Diesel spill	Rupture of a diesel storage tank or associated system	Marine pollution	Marine environment (All marine biota present)	6	5	30	
			Marine pollution	Coastal environment (All coastal biota present)	6	5	30	
			Socio-economic impact	Other users of the sea (Fishing and shipping)	6	4	24	
			Marine pollution	Other users of the sea (Other industries)	6	5	30	
	Gas/Condensate spill	Well blow-out or pipeline failure	Marine pollution	Marine environment (All marine biota present)	10	5	50	
			Marine pollution	Coastal environment (All coastal biota present)	10	5	50	
			Marine pollution	Other users of the sea (Fishing and shipping)	10	4	40	
			Marine pollution	Other users of the sea (Other industries)	10	5	50	

	Operational Activity	Environmental Aspects (or Sub-operational Activity)	Environmental Issue	Receptor	Magnitude of Effect (1 to 10)	Receptor Value (1 to 5)	Significance	Comments
Accidental Events (continued)	**Other Accidental Events**							
	Loss of vessel	Catastrophic loss of rig, platform, support vessel(s) or helicopter	Resource use	Society as a whole (Potential future users of given resource)	4	2	8	
			Socio-economic impact	Other users of the sea (Fishing and shipping)	4	4	16	
			Marine pollution	Marine environment (Seabed communities)	4	5	20	
	Dropped objects	Loss of objects overboard (e.g. containers or pipes)	Marine pollution	Other users of the sea	2	4	8	
	Fire	Fire on platform, drilling rig or vessel	Air pollution	Other users of the sea (passing vessels); marine environment (birds and marine mammals)	2	4	8	
			Resource use	Society as a whole (Potential future users of given resource)	2	2	4	
		Use of firefighting equipment including fire water run off	Marine pollution	Marine environment (water column)	2	3	6	

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Appendix C

Commitments Register

Appendix C – Commitments Register

Table C.1 summarises the mitigation commitments made in each of the impact sections of this ES Addendum (Chapters 5 to 9) in addition to any commitments identified in the ENVID and consultation exercises with stakeholders as detailed in Chapter 4. These commitments will inform the planning stages and will form the basis for the environmental management of operations for the Southwark Field Development, and the Blythe Hub Development.

All commitments have been shown, including both regulatory requirements and IOG's application of more extensive good practice. All regulatory commitments are clearly marked.

C.1 Commitments Register

Identification of Concerns and Potential Impacts (Chapter 4)

Impact	Mitigation	Regulatory Commitment	Phase		
			Planning/ Preparation	Installation/ Drilling	Production
Construction of the Southwark, Blythe and Elgood Field Developments	• Construction of the development will not commence until all necessary permissions are secured for the relevant regulatory organisations;	Y	✓		
	• Notification of any planned activities relating to the proposed development will be provided to interested parties ensuring appropriate notice is given prior to the commence of operations;	Y	✓	✓	✓
	• Best practice and guidance will be observed at all times during any operations associated with the construction of the Southwark, Blythe and Elgood Field Developments;		✓	✓	✓
	• An Operations and Maintenance plan for the pipeline will be developed in conjunction with the HSE and industry specialists;	Y	✓		
	• All infrastructure installed will be appropriately marked and lit where required and the positions of subsea infrastructure provided to Trinity House. Vessels will be marked and lit in accordance with the International Regulations for Preventing Collisions at Sea 1972 (COLREGs).	Y	✓	✓	✓
Provision of survey information	• Copies of the habitat and site survey reports may be provided to JNCC if needed.		✓		

Physical Presence (Chapter 5)

Impact	Mitigation	Regulatory Commitment	Phase		
			Planning/ Preparation	Installation/ Drilling	Production
Presence of jack-up drilling rig, platform and seabed infrastructure on seabed communities	• Physical disturbance to the seabed will kept to a minimum where practicable;		✓	✓	✓
	• Following operations, a seabed debris survey will be carried out to ensure no objects are left on the seabed that could impede seabed recovery;	Y		✓	✓
	• Pipeline routing and the volumes and locations of rock dump and mattress placement will be designed to reduce to footprint on the seabed and impacts on the Annex I habitats as far as practicable;	Y	✓	✓	✓
	• The rock material to be used for the rock dump will be clean, inert and contain few entrained fines;		✓	✓	
	• An environmental baseline survey and habitat assessment has been commissioned to characterise the seabed and identify the presence of any potential Annex I habitats within the development area prior to operations commencing.	Y	✓		
Presence of jack-up drilling rig, platform and seabed infrastructure on other users of the sea	• 500 m exclusion zone will be established around the drilling rig and platform for the duration of operations;	Y		✓	✓
	• ERRV will be on location for the duration of drilling operations;	Y		✓	
	• The drilling rig and other vessels operating in the area will be highly visible and have appropriate lighting, and other means of alerting all vessels of their presence;	Y		✓	
	• A Vessel Traffic Study has been carried out for the proposed platform locations;	Y	✓		
	• A Collision Frequency Assessment will be carried out in support of the Consent to Locate;	Y	✓		
	• Notice to mariners will be posted prior to the drilling rig moving onto location, ensuring that all vessels, including fishing vessels, will be aware of its presence in advance and for the duration of operations;	Y	✓	✓	
	• Kingfisher will be notified of the exact location of the platforms and subsea infrastructure allowing its inclusion in their fortnightly bulletin to fishing vessels;	Y	✓	✓	✓
	• The UK Hydrographic Office (UKHO) will be notified so that charts can be amended to mark the position of the platforms and subsea infrastructure;	Y	✓	✓	✓
	• All platforms will have appropriate safety lighting permanently installed to alert other vessels of its presence.	Y		✓	✓

Marine Discharges (Chapter 6)

Impact	Mitigation	Regulatory Commitment	Phase		
			Planning/ Preparation	Installation/ Drilling	Production
Discharge of cement into the marine environment	• Use of ROV to visually monitor cement returns to seabed surface for 36" tophole;			✓	
	• Once returns are observed, pumping will be stopped in order to minimise discharged volume;	Y		✓	
Discharge of chemicals into the marine environment	• Use and discharge of chemicals will be minimised where practicable;	Y	✓	✓	✓
	• Selection of all chemical additives will be conducted with reference to the CEFAS templates to ensure the most environmentally benign chemicals will be chosen wherever technically possible.	Y	✓		✓
Discharge of cuttings and Water Based Muds (lower well sections)	• A closed mud circulation system will be used, so the returned drilling fluids can be reused, reducing total fluid volumes.			✓	
	• Drill cuttings contaminated with mud will be discharged close to the sea surface, allowing dilution and dispersion over a large area and thereby minimising the overall environmental impact.			✓	
Use of Low-Toxicity Oil Based Mud (lower well sections)	• Water Based Muds will be used to drill the lower section wherever technically possible. Low-Toxicity Oil Based Mud will only be used if geological conditions necessitate;			✓	
	• A closed mud circulation system will be used, where cuttings and drilling fluids will be circulated back to the rig, passed through a mud recovery system, and then shipped to shore for treatment and disposal;	Y		✓	
	• Should LTOBM be used, completion chemicals and well bore clean-up chemicals will also be returned to the rig and shipped to shore for treatment and disposal.	Y		✓	
Discharge of Produced Water into the marine environment	• No produced water will be discharged.				✓

Noise Generation and Wildlife Disturbance (Chapter 7)

Impact	Mitigation	Regulatory Commitment	Phase		
			Planning/ Preparation	Installation/ Drilling	Production
Sound produced by piling operations associated with the installation of the platform and fixing infrastructure to the seabed	• The amount of underwater sound generated during piling operations will be kept to a minimum, by optimising hammer size and energy for the size of piles to be used; • Use of 'soft start' procedures during piling operations.			✓ ✓	
Sound produced by vessels, jack up rig platform and helicopters	• The amount of underwater sound generated during operations will be kept to a minimum, by careful logistics planning in order to minimise the amount of time any vessel, jack up rig or helicopter is used in the field.			✓	✓

Atmospheric Emissions (Chapter 8)

Impact	Mitigation	Regulatory Commitment	Phase		
			Planning/ Preparation	Installation/ Drilling	Production
Emissions to the atmosphere from power generation on the jack-up rig/support and supply vessels	• Operational scheduling and the selection of a jack-up rig for drilling operations will reduce the potential for weather down time, thus avoiding unnecessary fuel use, as it does not require fuel consumption to maintain positioning; • All equipment will operate at optimum efficiency and be well maintained according to a strict maintenance regime; • Only low sulphur diesel will be used onboard the jack-up rig; • Emissions will be monitored and reported under the environmental EEMS reporting scheme.	Y	✓	✓ ✓ ✓	
Emissions to the atmosphere during pipeline installation	• The relatively short pipeline installation periods allow operational scheduling for the PLV that will reduce the potential for weather down time, thus avoiding unnecessary fuel use for pipeline installation; • All equipment will operate at optimum efficiency and be well maintained according to a strict maintenance regime.		✓	✓ ✓	
Emissions to the atmosphere during platform operations	• All equipment will operate at optimum efficiency and be well maintained according to a strict maintenance regime; • Emissions will be monitored and reported under the environmental EEMS reporting scheme.	Y			✓ ✓

Accidental Events (Chapter 9)

Impact	Mitigation	Regulatory Commitment	Phase		
			Planning/ Preparation	Installation/ Drilling	Production
Well blow-out leading to uncontrolled flow of reservoir hydrocarbons	• The competence and experience of all contractors will be assessed before they are contracted;	Y	✓		
	• Personnel will be appropriately trained, experienced and certified;	Y	✓		
	• The suitability of all equipment to operate in the Southern North Sea region will be assessed by IOG prior to operations commencing;	Y	✓		
	• The crew of drilling rig, and other vessel will undergo environmental awareness, safety and oil spill response training;	Y	✓		
	• The Southwark, Blythe and Elgood wells have been designed to minimise the potential for well control problems and all specific safety design parameters associated with production wells;		✓		
	• The Southwark, Blythe and Elgood wells have been designed to be fully abandoned upon cessation of production;	Y	✓		
	• There will be a thorough approach to review all critical elements of the well design and the execution of drilling and completion of the wells;		✓		
	• All well designs will be independently reviewed by a Well Examiner;	Y	✓		
	• The Well Examiner will monitor the actual construction and any modifications to the well;	Y	✓	✓	
	• Data on well pressure will be monitored throughout the drilling operations, to allow suitable mud composition and mud weights to be used.	Y	✓	✓	
	• An assessment of available MODUs suitable for carrying out relief well drilling operations in the southern North Sea region will be carried out.	Y	✓		
	• A relief well plan will be developed and potential relief well locations have been selected;	Y	✓		
	• An approved Temporary Operations Oil Pollution Emergency Plan (TOOPEP) will be put in place to cover the proposed operations;	Y	✓		
	• All relevant offshore and onshore personnel will have the appropriate level of Oil Pollution Emergency Plan (OPEP) training;	Y	✓		
	• A contract will be in place for the OSPRAG well capping device;	Y	✓		
	• A contract will be in place with Oil Spill Response Limited for oil spill response personnel and equipment;	Y	✓		
	• Well control procedures will be in place and an appropriate mud programme will be designed in order to maintain well control at all times;	Y	✓	✓	

Impact	Mitigation	Regulatory Commitment	Phase		
			Planning/ Preparation	Installation/ Drilling	Production
Well blow-out leading to uncontrolled flow of reservoir hydrocarbons (Continued)	• A TOOPEP exercise will be carried out prior to operations commencing;	Y	✓		
	• A contingency stock of cement and barite will be kept onboard the jack-up rig;	Y		✓	
	• A Risk Assessment will be performed to ensure that jack-up drilling rig, blow out preventers (BOPs) and all associated well control equipment complies with all relevant UKCS safety and regulatory requirements, and is fit for their purpose for the planned well operations;	Y	✓		
	• Prior to installation the BOPs will be fully inspected, function-tested and pressure tested;	Y	✓		
	• BOPs will be installed at the top of every 13⅜" section, once the casings are cemented in place. The BOP design is fully redundant, with three separate power systems that can fully close the BOP. The BOPs on all platforms can be controlled remotely from IOG's onshore control centre in Great Yarmouth. The BOP also has redundant control on the platforms with two physically separated control panels, one located on the drill floor and the other in the accommodation block;			✓	
	• Testing of the BOP and back-up systems will take place at regular intervals.	Y		✓	✓
Potential diesel (fuel oil) spillage	• The fuel bunkering operations will be scheduled to minimise the number of operations required;		✓		
	• Vessel audits will be performed to confirm sea worthiness, and DP vessels only will be used for supply duties, thus reducing likelihood of collision and potential tank rupturing;	Y	✓		
	• Bunkering operations will only take place during hours of good visibility, in suitable weather conditions, and with a dedicated and continuous watch posted at both ends of the fuel hose;	Y		✓	
	• The process for fuel bunkering will be audited and witnessed by offshore HSEQ personnel;	Y		✓	
	• All hoses will be inspected visually and their connections tested prior to every loading operation;	Y		✓	
	• The jack-up drilling rig will have open and closed drain systems in place that will route any operational spills onboard the rig itself to the slop tanks where they can be contained and recovered	Y		✓	
	• Spill kits will be located at appropriate points to deal with (smaller) spillages that may occur onboard the jack-up rig.	Y		✓	
Potential condensate leakage from a pipeline failure	• A pre-installation site survey has been undertaken which will assist in informing the pipeline laying operations.	Y	✓		
	• A robust operations and maintenance programme will be produced which will help to ensure that any potential pipeline faults are identified and action take to prevent any possible condensate leakage. The programme will be adhered to at all times.	Y	✓	✓	✓

Impact	Mitigation	Regulatory Commitment	Phase		
			Planning/ Preparation	Installation/ Drilling	Production
Catastrophic loss of MODU, vessels or helicopters	• The jack-up drilling rig will be inspected for sea worthiness and the drilling contractors audited prior to operations commencing.	Y	✓		
	• All three platforms will be inspected for sea worthiness prior to operations commencing.	Y	✓	✓	
	• The suitability of supply, other support vessels and the helicopter will be assessed before they are contracted.	Y	✓		
	• All supply vessels will operate via DP, to reduce the likelihood of collision.		✓		
	• A site survey for drilling hazards has been carried out to confirm that there is no shallow gas in the area.	Y	✓		
	• The United Kingdom Hydrographic Office (UKHO) and Ministry of Defence (MoD) will be kept informed of drilling activities.	Y	✓	✓	
	• A 500 m exclusion zone will be enforced around the jack-up rig for general shipping in the area.	Y	✓	✓	
	• A standby vessel will be on site throughout operations to enforce the 500 m exclusion zone.	Y		✓	
	• The jack-up rig, and associated vessels will use appropriate lighting.	Y		✓	
	• The standby vessel will be equipped with radar and communication equipment so that any vessel in the area can be detected and contacted, if required.	Y		✓	