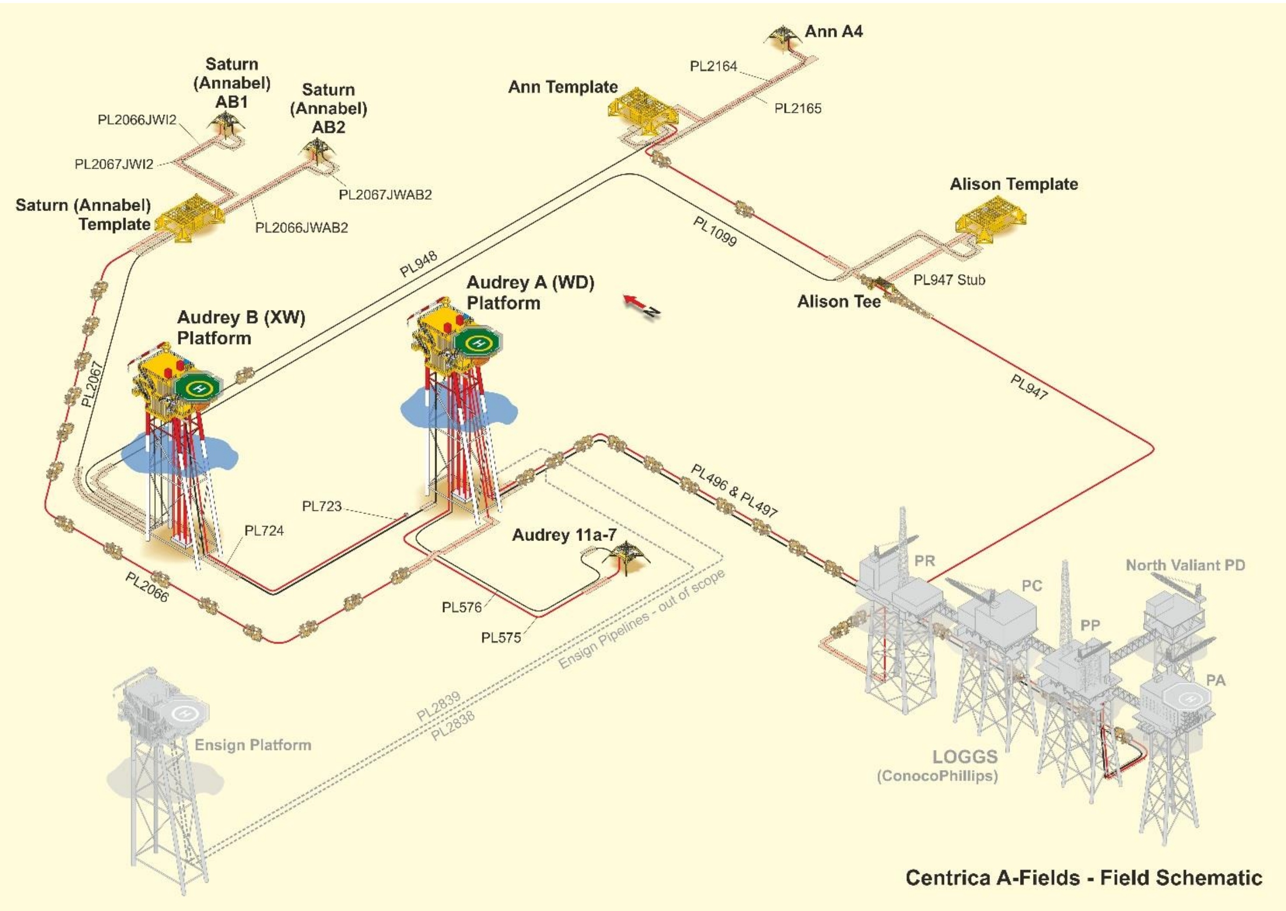
A-Fields Decommissioning
Saturn (Annabel) and Audrey Fields
Environmental Impact Assessment



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AMENDMENT RECORD

All amendments to this document shall be recorded on the Amendment Record sheet below. No changes to this document are to be made without approval from the document Approver.

DATE	INCORPORATED BY	VERSION	SECTION	DESCRIPTION

DOCUMENT 'HOLD' REGISTER

All 'HOLDS' in this document are recorded here.

HOLD No.	DESCRIPTION	Initial Actionee

INFORMATION SHEET

Project name:	Saturn (Annabel) and Audrey Fields Decommissioning.	
Type of project:	Decommissioning.	
Undertaker name:	Centrica North Sea Limited.	
Undertaker address:	Millstream, Maidenhead Road, Windsor SL4 5GD.	
Centrica doc. ref. no:	CEU-DCM-SNS0096-REP-0009	
Section of UKCS:	Southern.	
Distance from English Coast:	112km due east of Theddlethorpe Gas Terminal (TGT).	
Water depth (LAT):	Saturn (Annabel) (*c.*27-27.5m), Audrey A (WD) (*c.*22.4-26m), Audrey B (XW) (*c.*24.5m)	
Licence Blocks:	Annabel (48/10a) - first production 2005. Audrey (49/11a and 48/15a) - first production 1988.	
Licences/owners:	Centrica North Sea Limited is the nominated operator.	
	Centrica North Sea Limited.	100%
Short description:	Production from Saturn (Annabel) and Audrey Fields ceased on the 1st May 2016 and preparations are underway to decommission the installations and associated subsea infrastructure. The Annabel template, the Annabel AB1 and AB2 WHPS, the Audrey A (WD) platform, the Audrey B (XW) platform and the Audrey 11a-7 WHPS will be completely removed. The Annabel electro-hydraulic jumpers (PL2067JWAB2 and PL2067JW12) and spool pieces (PL2066JW12 and PL2066JWAB2) all of which are surface laid, will be completely removed. The Audrey 11a-7 export line (PL575) and umbilical (PL576) will be completely removed. End sections which are not sufficiently buried of the Annabel export pipeline (PL2066) and umbilical (PL2067), the Audrey A (WD) export pipeline (PL496) and methanol line (PL497) and the Audrey B (XW) export line PL723 and methanol line (PL724) will be removed. The majority of the pipelines and umbilicals, will be decommissioned *in situ* under existing burial cover. Concrete mattresses and grout bags will be completely removed. Deposited rock and frond mattresses will be decommissioned *in situ*.	
Anticipated date for commencement of works:	2017	
Significant environmental impacts identified:	Assessment of activities identified no significant environmental effects.	
EIA prepared by:	Genesis Oil and Gas Consultants Limited and Centrica.	

ACRONYMS

ACRONYM	DESCRIPTION
"	Inch (25.4mm)
%	Percentage parts per hundred
µPa	Micro-Pascal
µg	Microgram
‰	Parts per thousand
AET	Apparent Effect Threshold
Al	Aluminium
ALARP	As low as reasonably practicable
As	Arsenic
Ba	Barium
BAC	Background Assessment Criteria
BAP	Biodiversity Action Plan
BC	Background Concentration
BEIS	Department for Business, Energy and Industrial Strategy
BMS	Business Management System
BRC	Background/Reference Concentrations
BT	British Telecom
c.	circa (when referring to a distance or length)
CA	Comparative Assessment
Cd	Cadmium
Centrica	Centrica North Sea Limited
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CoP	Cessation of Production
CP	(LOGGS) Compression Platform
Cr	Chromium
cSAC	Candidate Special Area of Conservation
CSV	Construction Support Vessel

ACRONYM	DESCRIPTION
dB	Decibel
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DOB	Depth of Burial
DP	Decommissioning Programme
DSV	Dive Support Vessel
E&P	Exploration and Production
EC	European Commission
EIA	Environmental Impact Assessment
EMS	Environmental Management System
EPR	Environmental Permitting Regulations
EPS	European Protected Species
ERL	Effects Range Low
EU	European Union
FCS	Favourable Conservation Status
FBE	Fusion Bonded Epoxy
Fe	Iron
FOCI	Features of Conservation Importance
GC	Gas Chromatography
GE	Gas export
GJ	Gigajoule
Ha	Hectare
HAB	Harmful Algal Bloom
HMW	High Molecular Weight
HSE	Health & Safety Executive
Hz	Hertz
ICES	International Council for the Exploration of the Sea
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
ICP-OES	Inductively Coupled Plasma Optical Emission Spectrometry
IoP	Institute of Petroleum
ISO	International Standardisation

ACRONYM	DESCRIPTION
	Organisation
JNCC	Joint Nature Conservation Committee
Kg	Kilogramme
kHz	KiloHertz
Km	Kilometre
KP	Kilometre Point
LAT	Lowest Astronomical Tide
Li	Lithium
LOGGS	Lincolnshire Offshore Gas Gathering System
m	Metre
m/s	Metres per second
MARPOL	International Convention for the Prevention of Pollution from Ships
MAT	Master Application Template
MBES	Multibeam Echo Sounder
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
MEG	Mono Ethylene Glycol
MeOH	Methanol
Mg	Magnesium
mm	Millimetre
MMO	Marine Management Organisation
MP	Minister of Parliament
MPA	Marine Protected Area
MS	Marine Standard
N/A	Not Applicable
N_2O	Nitrous Oxide
NAO	North Atlantic Oscillation
NB	Nominal Bore
NERC	National Environmental Research Council
NFFO	National Federation of Fishermen's Organisations
Ni	Nickel
NL	Netherlands
NNS	Northern North Sea

ACRONYM	DESCRIPTION
Nm	Nautical miles
NMPI	National Marine Plan Interactive
NORM	Naturally Occurring Radioactive Material
NOx	Oxides of Nitrogen
NPD	Naphthalenes, Phenanthrenes and Dibenzothiophenes
ºC	Degrees Celsius
OCR	Offshore Chemicals Regulations
OGA	Oil and Gas Authority
OGUK	Oil and Gas UK
OPEP	Oil Pollution Emergency Plan
OPPC	Oil Pollution Prevention Control
OSCAR	Oil Spill Contingency and Response model
OSPAR	OSlo and PARis Convention
OVI	Offshore Vulnerability Index
P&A	Plug and Abandon
PAH	Polycyclic Aromatic Hydrocarbon
Pb	Lead
PP	(LOGGS) Production Platform
ppm	parts per million
PR	(LOGGS) Riser Platform
PSA	Particle Size Analysis
QHSE	Quality, Health, Safety, Environment
rms	Root mean square
ROV	Remotely Operated Vehicle
ROVSV	Remotely Operated Vehicle Support Vessel
RSA	Radioactive Substances Act
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SAT	Subsidiary Application Template
SBES	Single Beam Echo Sounder
SCI	Site of Community Importance

ACRONYM	DESCRIPTION
Se	Selenium
SEI	Significant Environmental Impact
Sn	Tin
SNS	Southern North Sea
SO_2	Sulphur dioxide
SOPEP	Ship Oil Pollution Emergency Plan
SPA	Special Protection Area
SPL	Sound Pressure Level
Sr	Strontium
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
SUTU	Subsea Umbilical Termination Unit
TBT	Tributyltin
Te	Tonne
TGT	Theddlethorpe Gas Terminal
THC	Total Hydrocarbon Content
TUTU	Topside Umbilical Termination Unit
UCM	Unresolved Complex Mixture
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
US EPA	United States Environmental Protection Agency
V	Vanadium
VMS	Vessel Monitoring System
VOC	Volatile Organic Compound
WFD	Water Framework Directive
WHPS	Wellhead Protection Structure
WMP	Waste Management Plan
Zn	Zinc

GLOSSARY

TERM	DESCRIPTION
49/6a-A4z	Ann A4 production well.
A-Fields	The collective term for the Audrey, Ann, Alison and Annabel Fields.
Approach	Initial or final stretch of pipeline (or umbilical) as it leaves its point of origin or reaches its destination.
Exposure	A pipeline can be seen on the surface of the seabed but is not free-spanning.
FishSAFE	FishSAFE charts offshore surface and subsea oil and gas structures on the UK Continental Shelf (http://www.fishsafe.eu/en/home.aspx)
Free span	A free span occurs when a pipe segment is not supported by the seabed.
Jack-up	A self-contained combination drilling rig and floating barge, fitted with long support legs that can be raised or lowered independently of each other.
Kingfisher Information Service	Kingfisher work with all the offshore industries, including oil and gas, subsea cable, renewable energy and marine aggregates to provide fishermen with two updates a year of the most accurate and up-to-date positions regarding subsea structures and the seabed.
Metocean	A contraction of the words 'meteorology' and 'oceanology' referring to the wave, wind and current conditions that affect offshore operations.
Pipespool(s)	Short sections of pipe that are typically flanged and bolted together.
SAC	Special Areas of Conservation (SACs) are granted different statuses throughout the designation process. They progress from a pSAC (potential SAC), to a cSAC (candidate SAC), to a Site of Community Importance before finally being designated a full SAC. Throughout this document, the term SAC will be used to describe a site at any stage throughout the designation process.
Saturn (Annabel)	The Section 29 and Pipeline Works Authorisation (PWA) documentation for the Annabel Field uses the name Saturn (Annabel). The Saturn (Annabel) Field is referred to as the Annabel Field through this document.
Spool pieces	Short sections of pipe that are typically flanged and bolted together (aka. Pipespools).
Template	Structure protecting wellheads, Xmas trees and piping manifolds inside.
Umbilical	Various cables or fluid tubes attached to a subsea Xmas tree to provide hydraulic or electrical control, or to inject chemicals.
Xmas tree	An assembly of valves, spools, pressure gauges and chokes fitted to the wellhead of a completed well to control production.

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1. NON TECHNICAL SUMMARY

This summary outlines the findings of the Environmental Impact Assessment (EIA) conducted by Centrica North Sea Limited (Centrica) for the proposed decommissioning of the Saturn (Annabel) Field subsea infrastructure and the Audrey Field platforms and subsea infrastructure. The assessment concludes that the overall significance of the impacts from the proposed decommissioning would be **low**.

The purpose of the report is to record and communicate the findings of the EIA, which assesses the potential for environmental impacts as a result of the decommissioning activities. The EIA report has been prepared to support the four Annabel and Audrey Decommissioning Programmes which are contained in two documents. A number of studies and surveys were undertaken to support the proposed decommissioning and have been considered during the EIA, as appropriate.

The EIA report and the Comparative Assessment (CA) report are supporting documents to the Decommissioning Programmes and will be submitted to the Department for Business, Energy and Industrial Strategy (BEIS) for consideration under the regulatory approval process.

1.1 Background to the project

'A-Fields' is a collective term used to describe the, Ann, Alison, Annabel and Audrey Fields. The A-Fields, situated on the United Kingdom Continental Shelf (UKCS) lie 112km due east of Theddlethorpe Gas Terminal (TGT), in the southern sector of the North Sea.

The A-Fields extend over UKCS quadrants 48 and 49. The nearest jurisdictional boundary to the A-Fields is the United Kingdom (UK)/Netherlands (NL) median line.

Gas was first discovered in 1966 with exploration well 49/06-1 at the Ann Field. Progressive development over the period 1988 (when first production from the Audrey Field was achieved) to 2005 (first production from the Annabel Field) has resulted in the present complex arrangement of subsea tie-backs centred on the infrastructure hub of the Audrey Field platforms. All production from the A-Fields has now ceased. The Ensign Field, which continues to produce over the Audrey A (WD) platform, is not part of the A-Fields development (nor A-Fields decommissioning), and does not form part of this assessment.

A-Fields area infrastructure comprises two platforms, Audrey A (WD) and Audrey B (XW), supporting fourteen topsides production wells and four subsea tie-backs, Audrey 11a-7, Ann, Alison and Annabel supporting seven production wells. All production over the entire field life was by natural depletion and routed to ConocoPhillips' Lincolnshire Offshore Gas Gathering System (LOGGS) platform complex which exported gas, after treatment, to the TGT on the Lincolnshire coast. Cessation of Production (CoP) from the A-Fields was achieved on 1st May 2016.

Three separate EIAs have been undertaken to support the decommissioning of the A-Fields: The Ann A4 Installation Decommissioning EIA; the Ann and Alison Fields Decommissioning EIA and the Annabel and Audrey Fields Decommissioning EIA.

This EIA report supports four Decommissioning Programmes:

1. The Annabel Installations Decommissioning Programme covers:

- Removal and recovery of the Annabel template;
- Removal and recovery of the Annabel AB1 wellhead protection structure (WHPS); and
- Removal and recovery of the Annabel AB2 WHPS.

2. The Annabel Pipelines Decommissioning Programme covers:

- Decommissioning of the 10" pipeline (PL2066);
- Decommissioning of the 8" pipe spools (PL2066JW12);
- Decommissioning of the 8" pipe spools (PL2066JWAB2);
- Decommissioning of the 4½" umbilical (PL2067);
- Decommissioning of the 4½" umbilical (PL2067JW12);
- Decommissioning of the electro-hydraulic bundle (PL20167JWAB2); and
- Recovery of protection and stabilisation features.

3. The Audrey Installations Decommissioning Programme covers:

- Complete removal and recovery of the Audrey A (WD) platform topsides and jacket;
- Complete removal and recovery of the Audrey B (XW) platform topsides and jacket;
- Complete removal and recovery of the Audrey A (WD) and Audrey B (XW) drilling templates;
- Complete removal and recovery of the Audrey 11a-7 WHPS;
- Complete removal and recovery of the top section of platform piles;
- Complete removal and recovery of the top section of drilling template piles; and
- Complete removal and recovery of the top section of WHPS piles; and
- Decommissioning of the drill cuttings piles.

4. The Audrey Pipelines Decommissioning Programme covers:

- Decommissioning of the 20" gas export line (PL496);
- Decommissioning of the 3" methanol line (PL497);
- Decommissioning of the 8" gas export line (PL575);
- Decommissioning of the 4" umbilical (PL576);
- Decommissioning of the 14" gas pipeline (PL723);
- Decommissioning of the 3" methanol line (PL724); and
- Recovery of protection and stabilisation features.

1.2 Decommissioning activities

In accordance with the Petroleum Act 1998, as operator of the Annabel and Audrey Fields, Centrica are applying to BEIS to obtain approval for decommissioning the installations detailed in Section 2 of this document.

Centrica plan to completely remove and recover the Annabel template, the Annabel AB1 and AB2 WHPSs, the Audrey platforms and the Audrey 11-a7 WHPS.

The short ends of PL496, PL497, PL723, PL724, PL2066 and PL2067 exposed on the seabed will be removed but the majority of the pipelines and umbilicals will be left *in situ* underneath existing burial cover. PL575, PL576, PL2066JW12, PL2066JWAB2, PL2067JW12 and PL2067JWAB2 will be completely removed and recovered to shore for recycling of their component materials. All concrete mattresses and grout bags where not buried will be removed. Deposited rock will be left *in situ*. A summary of the decommissioning activities at Annabel and Audrey is shown in Table 1-1.

ITEM	METHOD
Annabel template	Complete removal and recovery to shore.
Annabel AB1 and AB2 WHPS	Complete removal and recovery to shore.
Audrey A (WD) and Audrey B (XW) platform and piles	Complete removal and recovery to shore. The platform piles will be cut to 3m below the seabed and removed.
Audrey A (WD) and Audrey B (XW) drilling templates and piles	Complete removal and recovery to shore. The template piles will be cut to 3m below the seabed and removed.
Audrey 11-a7 WHPS	Complete removal and recovery to shore. The WHPS piles will be cut to 0.6m below the seabed and removed[1].
PL2066; PL2067	Removal of those sections that are not sufficiently buried. *In situ* decommissioning of those sections under sufficient and stable existing burial cover.
PL2066JW12; PL2066JWAB2; PL2067JW12; PL2067JWAB2	Complete removal and recovery.
PL496; PL497	Removal of those sections that are not sufficiently buried. *In situ* decommissioning of those sections under sufficient and stable existing burial cover.
PL575; PL576	Complete removal and recovery.
PL723; PL724	Removal of those sections that are not sufficiently buried. *In situ* decommissioning of those sections under sufficient and stable existing burial cover.
Deposited rock	Decommission *in situ.*
Concrete mattresses (244 no)[2], grout bags and gabion bags	Complete removal and recovery (where not buried).
Frond mattresses	Decommission *in situ.*
Audrey A (WD) and Audrey B (XW) drill cuttings piles	Decommission *in situ* for natural degradation.
Note: complete removal and recovery implicitly implies 'recovery to shore for preferential recycling of their component materials'	

Table 1-1: Summary of decommissioning activities

1.3 Environmental baseline

The environmental sensitivities along the pipelines, at the installations and the surrounding area that may be affected by the proposed decommissioning works are identified. This includes the area along the pipeline routes and the area around the LOGGS platform complex.

[1] The seabed is stable near the installation so we propose to cut the piles 0.6m below seabed as this is consistent with a typically acceptable pipeline depth of burial.

[2] See Section 3 for details and locations of mattresses and which ones will be removed.

In the immediate vicinity of the Annabel manifold, the water depth averages 27m lowest astronomical tide (LAT). Around the Audrey A (WD) platform the natural seabed is smooth with insignificant bedforms and a water depth of *c.*26m LAT, with the platform lying in a shallow depression. At Audrey B (XW), the natural seabed is almost flat, lying at a depth of approximately 24.5m LAT. Water depths at the LOGGS platform complex ranged from *c*.12.5m LAT in the south-east, to *c.*28.4m LAT in the north-east.

The maximum tidal current speed in the A-Fields area during mean spring tides is between 0.51m/s and 1.02m/s (1-2 knots). Surge and wind–driven currents, caused by changes in atmospheric conditions, can be much stronger and are generally more severe during winter. The annual mean significant wave height is between 1.51m and 1.80m.

The shallow water and active current regime in the southern North Sea (SNS) produces a high energy environment and as a consequence the A-Fields seabed is characterised by sandbanks, sandwaves and megaripples. The A-Fields partly lie within the North Norfolk Sandbanks and Saturn Reef Special Area of Conservation (SAC). The majority of sandbanks in the North Norfolk area of the SNS are considered to be large-scale mobile seabed forms. They can have a wavelength between 1 and 10km, and they can achieve a height of several tens of metres.

Sandwaves are a periodic bottom waviness generated by tidal currents in shallow tidal seas. Typical wavelengths range from 100 to 800m and they can be up to between 1 and 5m high. They are not static bed forms and migration speeds can be up to tens of metres per year. Megaripples are large, sandwaves or ripple-like features having wavelengths greater than 1m or a ripple height greater than 10cm.

In general, away from anthropogenic structures, seabed sediments were found to consist predominantly of fine to medium sand, developed into megaripples, with scattered shell fragments and occasional gravel (including pebbles) and cobbles. *Sabellaria spinulosa* tube aggregations were observed at Annabel, Audrey A (WD) and Audrey B (XW) but none of these aggregations were found to represent an Annex I reef structure. The Annex I 'habitat Sandbanks which are slightly covered by sea water all of the time' was found at LOGGS. Although the Audrey platforms are within the boundary of the North Norfolk Sandbanks and Saturn Reef SAC and therefore considered to be Annex I habitat, the sediments in the area didn't exhibit the characteristics that would catergorise them as the Annex I habitat 'Sandbanks which are slightly covered by sea water all of the time' in their own right.

The SNS phytoplankton community is dominated by the dinoflagellates *Ceratium fusus*, *Ceratium furca*, and *Ceratium tripos*. The population of diatoms is also significant and includes *Chaetoceros*. In the SNS, the population of zooplankton is mainly composed of small copepods, predominantly *Parapsuedocalanus* sp, with echinoderm larvae being the second most abundant.

The benthic faunal community was generally homogenous across the A-Fields area dominated by a small number of taxa and showing low diversity. Exceptions were found at the Audrey A (WD) drill cuttings pile and in areas of deposited rock as found at the Audrey B (XW) platform. Visible fauna was sparse and included Annelida (Polychaeta), Arthropoda (*Corystes cassivelaunus, Cancer pagurus*), Bryozoa (*Flustra foliacea*), Cnidaria (*Alyconium digitatum*, Hydrozoa), Echinodermata (*Asterias rubens*, *Echinocardium* sp.), Chordata (Ascidiacea, *Gadus morhua*, *Agones cataphractus*, Callionymidae, *Limanda limanda*) and Porifera (Demospongiae).

A number of commercially important fish species are known to spawn and have nursery grounds in the area. These include mackerel, herring, cod, whiting, plaice, lemon sole, sandeel, *Nephrops* and sprat.

The Annabel Field is situated close (*c.*6km) to an area identified as herring spawning ground. Herring spawning ground potential was investigated around the Annabel template and the AB1 and AB2 WHPS. No stations were identified as gravels forming raised banks (the seabed type widely considered to be the preferred spawning substrate of herring), and all stations presented no herring spawning potential.

Seabird vulnerability to surface pollution in the vicinity of the Annabel Field, the Audrey platforms, and the LOGGS platform complex is variable throughout the year. Overall, annual vulnerability is considered moderate around the Audrey platforms and the LOGGS platform complex and very high around the Annabel Field.

Harbour porpoise, and white-beaked dolphin have been sighted in the vicinity of the A-Fields. The mean density of seals expected in the vicinity of the A-Fields is low for both harbour seals (0-1 per $25km^2$) and grey seals (5-10 per $25km^2$).

The Audrey platforms and pipelines, the majority of the Annabel pipelines and the LOGGS platform complex lie within the North Norfolk Sandbanks and Saturn Reef SAC. The Annabel subsea infrastructure and pipelines, the Audrey platforms and pipelines and the LOGGS platform complex also lie within the SNS candidate SAC (cSAC) for harbour porpoise. The nearest Special Protection Area (SPA) site is the North Norfolk Coast SPA, which is over 90km south-west of the A-Fields. The nearest Marine Conservation Zone (MCZ) to the A-Fields is the Markham's Triangle recommended MCZ which is approximately 51km north-east of the Annabel infrastructure.

1.4 Impact Assessment

The EIA process presented in this document considers the impact of the planned activities associated with the decommissioning of the Annabel and Audrey Fields. The impact was determined by considering the duration/frequency of each of the planned activities and environmental to determine the overall level of impact as either low, medium or high significance.

Unplanned (accidental) events are also considered in terms of their likelihood and the impact on the environment. This provides a risk of low, medium or high significance.

1.4.1 Energy use and atmospheric emissions

The principal energy use and generation of emissions to air will arise from fuel combustion for propulsion and power generation by the vessels associated with Annabel and Audrey decommissioning activities. These emissions will include components which have the potential to contribute to global warming, acid rainfall, dry deposition of particulates and photochemical pollution or cause impacts on local air quality. It is expected that impacts will be of low significance as they will be short term.

The energy usage from the decommissioning of the Annabel and Audrey facilities is estimated to be 221,017GJ direct (vessel use) and 281,521GJ indirect requirements (manufacture of new materials to replace those decommissioned *in situ*).

Emissions to atmosphere from the decommissioning activities are unlikely to significantly contribute to greenhouse gas emissions or global warming impacts; total direct CO_2 emissions generated by the proposed decommissioning are 16,410Te. In relation to the total CO_2 produced from domestic shipping the direct CO_2 emissions from the decommissioning of the Annabel and Audrey facilities is *c.*0.17%.

Standard mitigation measures to optimise energy usage by vessels will include operational practices and power management systems for engines, generators and any other combustion plant, and planned preventative maintenance systems for all equipment for peak operational efficiency.

In summary, due to the localised and relatively short durations of activities and with the identified control and mitigation measures in place, the overall significance of the impact of energy use and associated atmospheric emissions arising from decommissioning the

Annabel and Audrey facilities is considered to be **low**.

1.4.2 Underwater sound

The principal sources of underwater sound associated with the Annabel and Audrey decommissioning are associated with the use of vessels, surveying equipment and cutting tools.

The vessel work programme (comprising a total of 322 individual vessel days spread over a multi-year period) is of relatively short duration and represents only small increment to existing vessel traffic in the area. Cutting tools will only require to be used intermittently over this period and at point locations.

Although there are marine mammals and fish in the area around the Annabel and Audrey facilities, the level of sound that will be generated is not expected to cause physiological harm or substantive behavioural interference to either fish or mammals known to inhabit the area. The greatest potential disturbance is as a result of the use dynamic positioning by vessels. However, given that the Annabel and Audrey facilities are in an area of established oil and gas activity with high shipping activity, marine mammals are likely to be accustomed to similar sound levels and this reduces the level of impact.

Standard measures that will be applied to control sound include planned maintenance of equipment and optimisation of the work programme to minimise vessel use.

In summary, due to the localised, and short duration or intermittent nature of the activities, and with the identified control and mitigation measures in place, the overall significance of the impact of underwater sound generated during decommissioning of the Annabel and Audrey facilities is considered to be **low**.

1.4.3 Seabed disturbance

The principal sources of seabed disturbance associated with the Annabel and Audrey decommissioning concern the removal of PL576 and PL575, the removal of spools, mattresses and grout bags and cutting operations around the Annabel AB1 and AB2 WHPS, the Annabel template, the Audrey platforms and the Audrey 11a-7 WHPS, the use of anchors and anchor chains on the Heavy Lift Vessel in addition to the over-trawl assessment at the end of decommissioning. The base case for the over-trawl assessment is that it will be conducted in the 500m safety zones and over a 200m corridor along the pipeline lengths. These activities will result in the displacement of substrate and the suspension and subsequent settlement of sediment.

Standard measures to control disturbance include operational planning and equipment selection.

The species and habitats observed in the vicinity of Annabel and Audrey are relatively widespread throughout the SNS and the area anticipated to be impacted represents a very small percentage of the available habitat. Furthermore, the environment in the vicinity of the Annabel and Audrey Fields is dynamic due to the shallow water depth therefore all disturbed sediments/habitats are expected to recover rapidly though species recruitment from adjacent undisturbed areas.

In summary, due to the localised and relatively short duration of the decommissioning activities, and with the identified control and mitigation measures in place, the overall significance of the impact of seabed disturbance as a result of the decommissioning of the Annabel and Audrey facilities is considered to be **low**.

1.4.4 Discharges to sea

The principal sources of discharges to sea associated with the Annabel and Audrey decommissioning are associated with vessels and the breaking containment/lifting of sections of the pipelines.

The vessel use is of relatively short duration. Operational discharges from vessels during this time are expected to be rapidly diluted and dispersed under prevailing metocean conditions.

The production fluids will have been removed from the pipeline. The hydraulic fluid that remains within the umbilical is expected to be discharged to the marine environment (other than PL576 which will be removed with fluids inside).

The seabed and the water column are the primary receptors. Control measures include permitting of chemical discharges and strict vessel operating procedures. All of these impacts will be localised and short term given the highly dynamic environment around the Annabel and Audrey facilities.

In summary, given the localised, and short duration or intermittent nature of the activities, and with the identified control and mitigation measures in place, the overall significance of the impact of discharges and releases to sea as a result of decommissioning the Annabel and Audrey facilities is considered to be **low**.

1.4.5 Large hydrocarbon releases and oil spill response

The worst case scenario of an accidental hydrocarbon release would result from a complete loss of fuel inventory from on-site vessels or collision. In the unlikely event of such an incident the vessels will have a Shipboard Oil Pollution Emergency Plan (SOPEP) in place. Centrica will minimise the likelihood of such an event occurring by awarding the contract only to vessels that meet Centrica's Marine Standard which ensures that relevant regulatory requirements are implemented.

The environmental risk of an accidental event is determined by combining an assessment of the environmental impact of an event and the likelihood of it occurring.

Taking into account the types of sediment and receptors in the area and the mitigations and controls that will be put in place, the overall significance of the environmental impact from a major diesel release during the Annabel and Audrey decommissioning activities has been assessed as moderate. The likelihood of such an event occurring is considered unlikely with a rare combination of factors being required for an event to occur.

Given that the diesel readily evaporates, would disperse and dilute quickly and is unlikely to impact on any coastline, the significance of such an incident is considered to be **low**.

1.4.6 Waste

All wastes returned to shore will be handled and disposed of in accordance with legislation and the waste hierarchy. All regulatory and company procedures for segregation, transport, recycling or disposal, as set out in the project Waste Management Plan (WMP), will be strictly adhered to and only fully permitted facilities will be used for transfer, treatment, recycling or disposal.

In summary, with the identified control and mitigation measures in place ensuring that the majority of the materials recovered to shore will be recycled, the overall significance of the impact of waste as a result of decommissioning the Annabel and Audrey facilities is considered to be **low**.

1.4.7 Socio-economic impacts

The primary socio-economic activities that could be impacted are commercial activities, such as oil and gas operations, shipping and fishing.

Access to the area for fishing will be restricted whilst decommissioning is undertaken and this will lead to short term impacts on the fishing industry; however, the impact is considered to be low due to the short duration of operations, the relatively small scale of the activities and the existing HSE 500m safety zones.

A beneficial socio-economic impact is the short-term continuation of jobs in onshore yards and on vessels. It is expected that the overall impact will be low since the local socio-economic system is already altered owing to the presence of the oil industry itself.

An over-trawl assessment will verify that there are no remaining obstructions likely to snag fishing trawls.

In summary, due to the localised and short duration of decommissioning activities, and with the identified control and mitigation measures in place, the overall significance of the socio-economic impact from the decommissioning of the Annabel and Audrey facilities is considered to be **low**.

1.4.8 Designated conservation sites impacts

The Audrey platforms and the majority of the Annabel and Audrey pipelines lie within the North Norfolk Sandbanks and Saturn Reef SAC and the Annabel, Audrey Fields and LOGGS platform complex lie within the SNS cSAC for harbour porpoise. The impacts associated with activities at the sites (e.g. cutting, jetting, removal, anchoring) are localised. Sound associated with vessels and the activities could impact the area, however given the existing level of shipping in the area the significance of the impact is assessed as **low**.

The principal sources of seabed disturbance associated with the Annabel and Audrey decommissioning concern the removal of spools, mattresses and grout bags and cutting, the use of anchors and anchor chains on the Heavy Lift Vessel, jetting and the over-trawl assessment operations around the Annabel AB1 and AB2 WHPS, the Annabel template, the Audrey platforms and the Audrey 11-a7 WHPS. The base case for the over-trawl assessment is that it will be conducted in the 500m safety zones and over a 200m corridor along the pipeline lengths. These activities will result in the displacement of substrate and the suspension and subsequent settlement of sediment. All disturbed sediments are expected to recover rapidly though recruitment from adjacent undisturbed areas therefore the overall significance of the impact of seabed disturbance is considered to be **low**.

A large hydrocarbon release could impact the SAC and cSAC however modelling has shown the risk is relatively low and with control and mitigation measures in place the significance has also been assessed as **low**.

Given that the impacts on North Norfolk Sandbanks and Saturn Reef SAC and SNS cSAC for harbour porpoise have been assessed as **low**, the impact on the Markham's Triangle recommended Marine Conservation Zone (MCZ) which is approximately 51km north-east of the Annabel infrastructure has also been assessed as **low**.

1.4.9 Summary of control and mitigation measures

Centrica will follow routine environmental management activities for example contractor vessel audits and legal requirements to report discharges and emissions, such that the environmental impact of the decommissioning activities will be minimised. Following the EIA process, it can be concluded that activities associated with the decommissioning of the Annabel and Audrey facilities are unlikely to significantly impact the environment or other sea users, for example shipping traffic and fishing, provided that the proposed mitigation and control measures are put in place.

A summary of proposed control and mitigation measures is shown in Table 1-2.

CONTROL AND MITIGATON MEASURES
General
Lessons learnt from previous decommissioning scopes will be reviewed and implemented.
Energy use and atmospheric emissions
Prior to mobilisation, vessels will be audited to ensure that appropriate planned and preventative maintenance has been carried out and condition of both generators and engine efficiency is in line with manufacturers specifications.
Fuel use for mobilised vessels will be monitored and comply with International Convention for the prevention of Pollution from Ships (MARPOL) requirements, in particular with regard to low sulphur content.
Decommissioning activities will be planned to minimise vessel use (e.g. the vessels' work programme will be optimised to minimise vessel use).
Fuel consumption will be minimised by operational practices and power management systems for engines, generators and any other combustion plant (as required under the contract with the subcontractor).
Planned and preventative maintenance systems will be required for all vessels to ensure that all equipment is maintained at peak operating efficiency for minimum overall fuel usage (as required under the contract with the subcontractor).
Underwater sound
Machinery, tools and equipment will be in good working order and well-maintained (as will be required under the contract with the subcontractor).
The vessels' work programme will be optimisd to minimise vessel use
The number of required cuts will be minimised consistent with operational (including safety) considerations.
Seabed disturbance
All activities which may lead to seabed disturbance will be planned, managed and implemented in such a way that disturbance is minimised.
The careful planning, selection of equipment, and management and implementation of activities.
A debris survey will be undertaken at the completion of the decommissioning activities. Any debris identified as resulting from decommissioning activities will be recovered from the seabed where possible.
Optimise the area that requires an over-trawl assessment through discussion with the NFFO and the regulators.
Discharges and releases to sea
Pigging and/or flushing procedures will be followed to minimise residual contaminants within pipelines and umbilicals.
Procedures and systems for the minimisation of waste and effluent generation (maintained as required under the contract with the subcontractor).
Procedures and systems for the management of ballast and bilge water (maintained as required under the contract with the subcontractor).
Accident prevention measures will be in place in order to minimise the potential for accidental spillages of hydrocarbons or other polluting materials.
Vessels will be selected and audited to ensure that effective operational systems and onboard control measures are in place.
The vessels' work programme will be optimisd to minimise vessel use

CONTROL AND MITIGATON MEASURES
Large hydrocarbon releases and oil spill response
Comprehensive management and operational controls plan developed to minimise the likelihood of large hydrocarbon releases and to mitigate their impacts should they occur. These include the Marine Standard and the A-Fields OPEP.
All vessels undertaking decommissioning activities will have an approved SOPEP.
Waste
A WMP will be in place.
If hazardous waste is produced it will be pre-treated to reduce hazardous properties or, in some cases, render it non-hazardous prior to recycling or landfilling.
Any Naturally Occurring Radioactive Material (NORM) contaminated equipment will be handled, transported, stored, maintained or disposed of in a controlled manner.
Socio-economic impacts
The timing and location of decommissioning activities, and the location of infrastructure decommissioned *in situ*, will be advertised via the Kingfisher bulletin and via Notices to Mariners.
Necessary seabed debris surveys, seabed over-trawl assessment, depth of burial surveys and environmental surveys will be conducted.
The vessels' work programme will be optimisd to minimise vessel use.

Table 1-2: Summary of proposed control and mitigation measures

1.5 Conclusion

Overall, the EIA concludes that the potential for significant impacts as a consequence of decommissioning the Annabel and Audrey facilities is **low**. Generally, the impacts identified were assessed as localised and short term with low potential for long term or transboundary and cumulative impacts.

2. INTRODUCTION

This EIA report is a supporting document to the Decommissioning Programmes required by the Department for Business, Energy and Industrial Strategy (BEIS) for the decommissioning of the Annabel and Audrey facilities. The purpose of the EIA is to assess the environmental impacts and potential impacts (risks) associated with decommissioning and to identify control and mitigation measures to reduce the level of these impacts to 'as low as reasonably practicable'.

The Section 29 and the Pipeline Works Authorisation (PWA) documents for the Annabel Field use the term Saturn (Annabel) Field. For the purpose of this EIA, the term 'Annabel and Audrey facilities' is used herein to collectively describe the Audrey surface installations (platforms including drilling templates) and the Saturn (Annabel) and Audrey subsea installations (templates), pipelines and umbilicals as described in Section 3.

2.1 Project background and purpose

'A-Fields' is a collective term used to describe the Ann, Alison, Annabel and Audrey Fields. The A-Fields, situated on the United Kingdom Continental Shelf (UKCS) lie 112km due east of Theddlethorpe Gas Terminal (TGT), in the southern North Sea (SNS) (Figure 2-1).

The A-Fields extend over UKCS quadrants 48 and 49; the Audrey B (XW) platform is located in block 48/15a, the Audrey A (WD) platform is located in block 49/11a, the Ann subsea infrastructure located in block 49/6a, the Alison subsea infrastructure located in block 49/11a, and the Annabel subsea infrastructure is located in block 48/10a (Figure 2-1). The nearest jurisdictional boundary is the UK/NL median line with the Audrey and Annabel Fields located 67km and 66km respectively to the west.

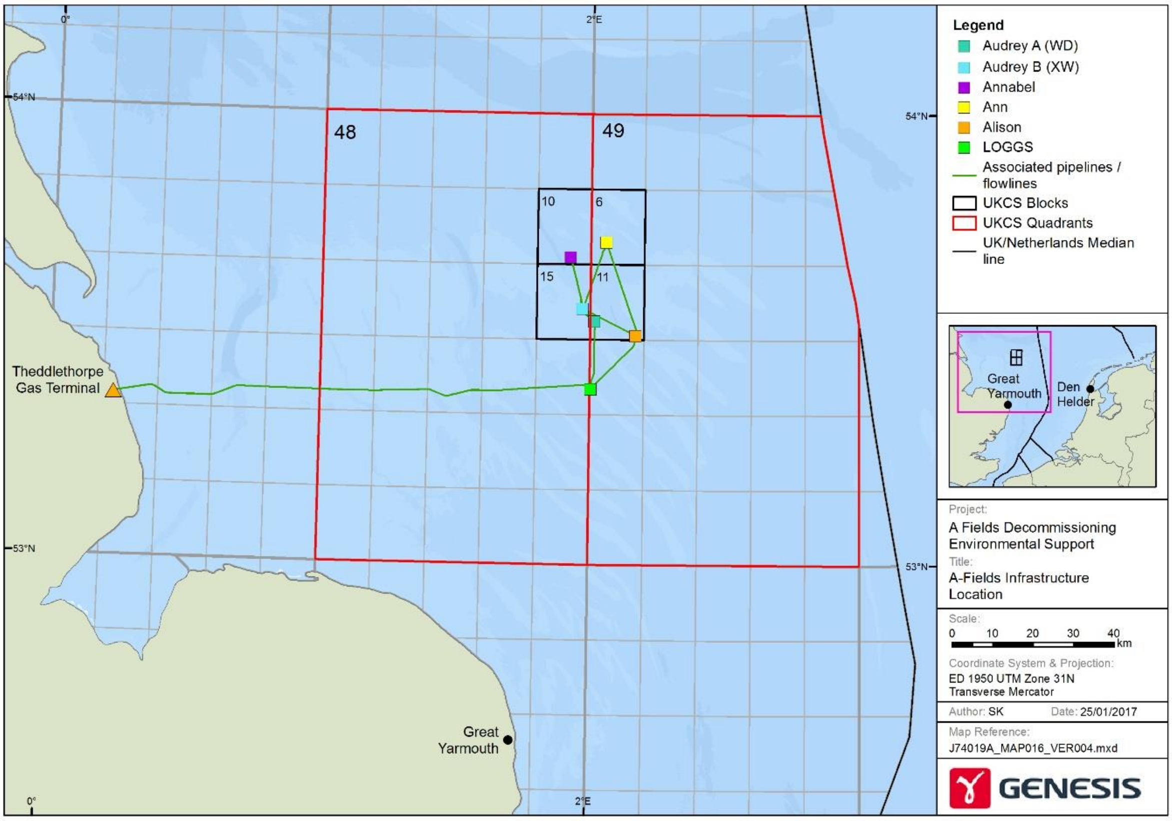

Figure 2-1: Location of the A-Fields in the southern North Sea

Gas was discovered in 1966 with exploration well 49/06-1 at the Ann Field. Progressive development over the period 1988 (when first production from the Audrey Field was achieved) to 2005 (first production from the Annabel Field) has resulted in the present complex arrangement of subsea tie-backs centred on the infrastructure hub of the Audrey Field platforms. All production from the A-Fields has now ceased. The Ensign Field, which continues to produce over the Audrey A (WD) platform, is not part of the A-Fields development (nor A-Fields decommissioning), and does not form part of this assessment.

A-Fields area infrastructure comprises two platforms, Audrey A (WD) and Audrey B (XW) supporting fourteen production topsides wells and four subsea tie-backs, Audrey 11a-7, Ann, Alison and Annabel supporting seven production wells (Figure 2-2). All production over the entire field life was by natural depletion and routed to ConocoPhillips' Lincolnshire Offshore Gas Gathering System (LOGGS) which exported gas, after treatment, to the TGT on the Lincolnshire coast (Figure 2-1). Cessation of Production (CoP) from the A-Fields was achieved on 1st May 2016.

Three EIAs have been undertaken to support the decommissioning of the A-Fields. The Ann A4 Installation Decommissioning EIA (Centrica, 2016a), the Ann and Alison Fields Decommissioning EIA (Centrica 2017c) and the platforms and subsea infrastructure included in the Annabel and Audrey Fields decommissioning scope which are discussed in Section 3.

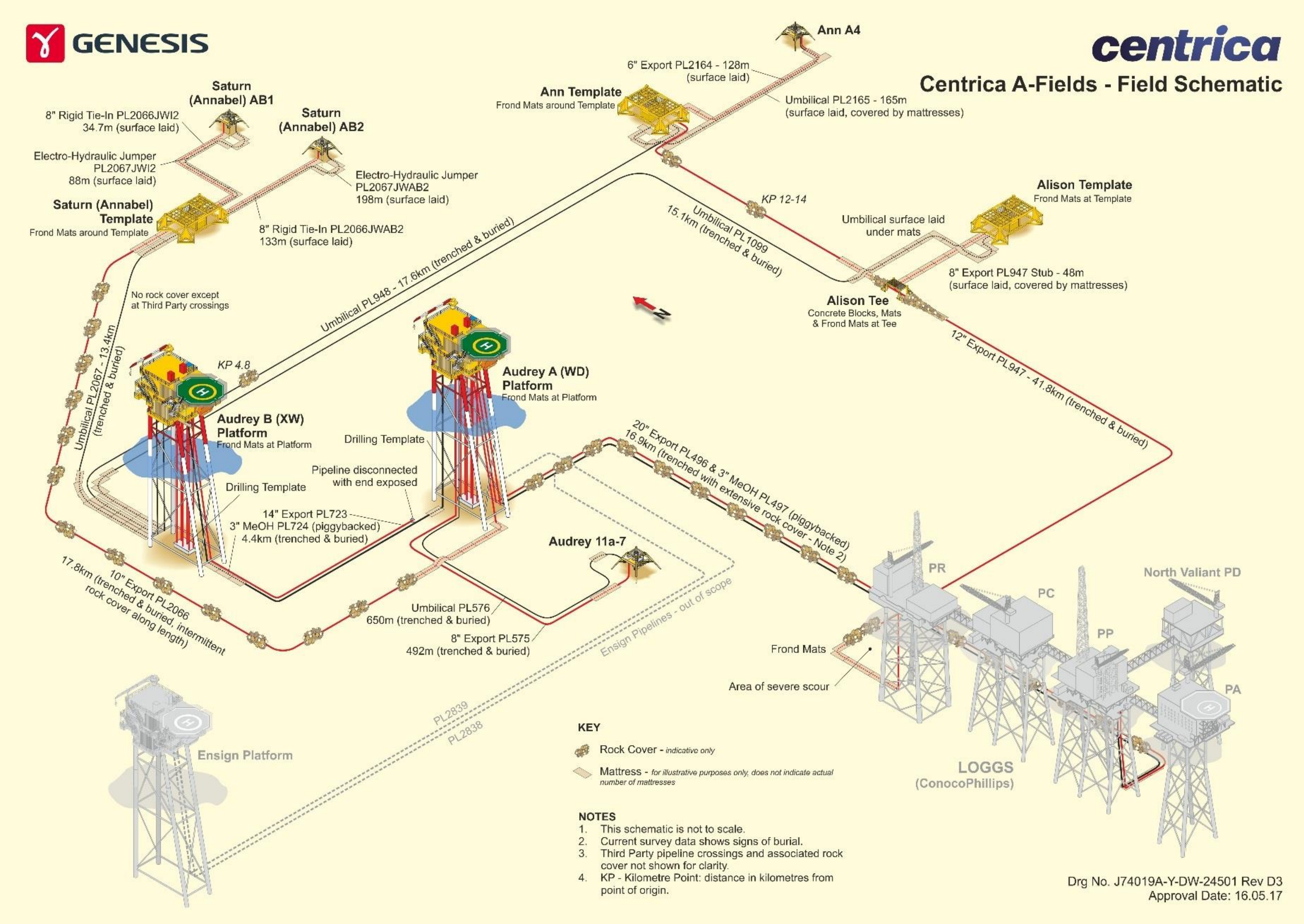

Figure 2-2: A-Fields area infrastructure

2.2 Background to the Decommissioning Programmes

Twenty-one wells (fourteen at the Audrey platforms, one at Audrey 11-a7, three at Ann, one at Alison and two at Annabel) will be abandoned in compliance with Health and Safety Executive (HSE) regulations (HSE, 1996) and with Oil and Gas UK guidelines (OGUK, 2015) and preparations need to be made to decommission the associated subsea infrastructure in accordance with the requirements of BEIS guidance (DECC, 2011b) (Section 3.2). These activities are considered to be preparatory work and do not fall within the scope of the Decommissioning Programmes. Environmental impacts, including chemical use and discharges associated with well abandonment will be assessed within the well abandonment submission.

This EIA supports four Decommissioning Programmes (which are contained in two separate documents), the Annabel Decommissioning Programmes (Centrica, 2017d) and the Audrey Decommissioning Programmes (Centrica, 2017e);

- Decommissioning of the Annabel installations;
- Decommissioning of the Annabel pipelines;
- Decommissioning of the Audrey installations (including Audrey 11a-7 WHPS); and
- Decommissioning of the Audrey pipelines.

The purpose of this EIA is to assess the potential environmental impacts and risks associated with the decommissioning of the Annabel and Audrey Fields and to identify mitigation and control measures to reduce those impacts to “as low as reasonably practicable”.

2.3 Regulatory context

The relevant UK and international legislation is outlined below.

The UK 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 (OSPAR, 1992). The OSPAR Decision 98/3 (OSPAR, 1998) sets out the UK’s international obligations on the decommissioning of offshore installations. However, pipelines and umbilicals are not included within the Decision.

The decommissioning of offshore oil and gas infrastructure (including pipelines) in the UKCS is principally governed by the Petroleum Act 1998 (as amended by the Energy Act 2008) (Petroleum Act, 1998). The Petroleum Act sets out the requirements for a formal Decommissioning Programme, which must be approved by BEIS before the owners of an offshore installation or pipeline may proceed with decommissioning.

The BEIS Guidance Notes (DECC, 2011b) on the Decommissioning of Offshore Oil and Gas Installations and Pipelines advise that any Decommissioning Programme must be supported by an EIA. The Guidance goes on to state that the EIA should include an assessment of the following:

- All potential impacts on the marine environment including exposure of biota to contaminants; other biological impacts arising from physical effects; conflicts with the conservation of species and their habitats;
- All potential impacts on other environmental compartments, including emissions to the atmosphere, leaching to groundwater, discharges to surface fresh water and impacts on the soil;
- Consumption of natural resources and energy associated with reuse and recycling;

- Interference with other legitimate uses of the sea and consequential impacts on the physical environment; and,
- Potential impacts on amenities, the activities of communities and on future uses of the environment.

The Marine and Coastal Access Act 2009 (MCAA) (MCAA, 2009) states that an EIA is required for all licence applications relating to decommissioning activities. The MCAA licence application will be made at the time of decommissioning.

Other relevant legislation includes:

- The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001;
- The Offshore Chemical Regulations 2002;
- The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005;
- The Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998 (requiring an Oil Pollution Emergency Plan (OPEP));
- The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999;
- Environmental Protection Act 1990;
- Special Waste Regulations 1996;
- Hazardous Waste (England and Wales) Regulations 2005;
- Transfrontier Shipment of Waste Regulations 2007; and
- Transfrontier Shipment of Radioactive Waste and Spent Fuel Regulations 2008.

As part of the requirements of the International Standardisation Organisation (ISO) 14001 certified Environmental Management System (EMS), Centrica has identified all applicable legal and other requirements associated with the decommissioning activities.

2.4 Stakeholder consultation

Stakeholder consultation is an important part of the decommissioning process. Informal responses received to date from stakeholders that are relevant to the EIA are shown in Table 2-1 and will be addressed as the project progresses.

STAKEHOLDER	COMMENT	RESPONSE
STATUTORY CONSULTATIONS		
National Federation of Fishermen's Organisations (NFFO)	Centrica discussed the decommissioning proposals with NFFO via teleconference 14th March 2017. Centrica also discussed the type of fishing and were advised that the predominant type of fishing in the area is demersal fishing using rock hoppers and beam trawling.	The decommissioning proposals were acceptable. One of the more major concerns is that while 'rock hoppers' can quite easily overcome obstacles such as surface laid concrete mattresses, should these be left in place, these can quite easily be caught up in beam trawlers and be dragged for several miles without being noticed, removing the protection from infrastructure decommissioned *in situ* and therefore increasing the risk of future snagging.
Joint Nature Conservation Committee (JNCC) and BEIS	Centrica discussed the decommissioning proposals with JNCC and BEIS at a meeting on 3rd May 2017. The following areas were discussed: • Pipelines; • Mattresses; • Rock dumping and anchoring; • Over trawl surveys; • Cumulative impacts; • Drill cuttings contamination; • Stabilisation features; • Habitat assessment; • Noise levels; and • Timelines.	The decommissioning proposals were acceptable. The following items were raised as issues to be taken into consideration within the EIA: • Cumulative effects are of particular interest to JNCC and it was suggested to take into account the marine aggregate industry within the EIA. • JNCC stated that rock dumping is a concern, however none is planned for the Annabel and Audrey decommissioning. • JNCC welcomed the inclusion of the over-trawl assessment within the seabed disturbance calculation. • JNCC acknowledged the suggested approach to decommissioning of drill cutting piles *in situ* to degrade naturally, which is in line with the OSPAR recommendation for the level of contamination.
ConcocoPhillips	Centrica are in constant dialogue with ConcocoPhillips in terms of decommissioning operations in the LOGGS complex area.	

Table 2-1: Summary of stakeholder comments

2.4.1 Future consultation

The formal consultation will begin with the submission of the draft Decommissioning Programmes, supported by this EIA report, to BEIS. The consultation process at this stage will include the use of the Centrica's external website to make these documents publicly available.

2.5 Business Management System including environmental management

The management of the decommissioning activities is addressed within the Centrica E&P EMS which is fully certified to the requirements of ISO 14001. The EMS itself is embedded within the Business Management System (BMS) which is a repository for all policies, standards, processes and procedures and supporting documents, is a platform that supports Centrica in managing safety, risk and compliance and in driving operational performance.

2.5.1 Environmental management

Centrica has a commitment to health, safety and security, as outlined below:

- The health, safety and security of our employees, customers and others who may be affected by our activities are a top priority. We believe that all work-related fatalities, injuries and illnesses can be prevented and we are committed to ensuring that all employees work in a safe and healthy way.
- The company's BMS, which describes those controls required to address quality, health, safety, environment (QHSE) risks, is designed to meet business needs and to adopt a consistent approach to QHSE management by satisfying the requirements of the recognised, applicable management systems standards, for environment, ISO 14001 Environmental management systems.

Centrica also has a commitment to the environment and details of this are outlined below:

- We are committed to understanding, managing and reducing the environmental impact of our activities. In particular, we are committed to playing our part in the transition to low carbon energy, while ensuring the security of present and future energy supplies. We aim to achieve this by sourcing and producing energy from cleaner sources, reducing wasted energy and developing and deploying new technology.
- We aim to reduce the carbon intensity of our power generation by developing renewable energy sources. We are also committed to leading the consumer market for low carbon energy products and services, helping customers to reduce their energy usage.
- We recognise that our operations, together with the way we deliver products and services, can have a major impact on the environment. For example, in the way we produce and use energy, manage our local environment and its biodiversity, operate our fleet of vehicles and manage the waste we create. We will work with our employees and suppliers to reduce these impacts through innovation, technology and cultural change. In addition, we will quantify, measure and communicate our environmental performance in a rigorous and clear manner.

2.5.2 Contractor management

Centrica will appoint a project management team to select and manage the operations of competent contractors. The team will ensure the decommissioning is executed safely, in accordance with Centrica Health and Safety principles and safeguard the environment in line with the environmental policy. Any change to the proposed decommissioning activities will be discussed with BEIS.

3. PROJECT DESCRIPTION

This section describes the Annabel and Audrey facilities that will be decommissioned and outlines the method that will be utilised. Please note that where the term ‘mattress’ has been used this refers to a concrete mattress unless otherwise specified.

3.1 Project scope and boundaries

This EIA supports four Decommissioning Programmes (which are contained in two separate documents), the Saturn (Annabel) Decommissioning Programme (Centrica, 2017d) and the Audrey Decommissioning Programme (Centrica, 2017e);

1. **The Annabel Installations Decommissioning Programme covers:**
    - Removal and recovery of the Annabel template;
    - Removal and recovery of the Annabel AB1 wellhead protection structure (WHPS); and
    - Removal and recovery of the Annabel AB2 WHPS.
2. **The Annabel Pipelines Decommissioning Programme covers:**
    - Decommissioning of the 10" pipeline (PL2066);
    - Decommissioning of the 8" pipe spools (PL2066JW12);
    - Decommissioning of the 8" pipe spools (PL2066JWAB2);
    - Decommissioning of the 4½" umbilical (PL2067);
    - Decommissioning of the 4½" umbilical (PL2067JW12);
    - Decommissioning of the electro-hydraulic bundle (PL20167JWAB2); and
    - Recovery of protection and stabilisation features.
3. **The Audrey Installations Decommissioning Programme covers:**
    - Complete removal and recovery of the Audrey A (WD) platform topsides and jacket;
    - Complete removal and recovery of the Audrey B (XW) platform topsides and jacket;
    - Complete removal and recovery of the Audrey A (WD) and Audrey B (XW) drilling templates;
    - Complete removal and recovery of the Audrey 11a-7 WHPS;
    - Complete removal and recovery of the top section of platform piles;
    - Complete removal and recovery of the top section of drilling template piles; and
    - Complete removal and recovery of the top section of WHPS piles; and
    - Decommissioning of the drill cuttings piles.
4. **The Audrey Pipelines Decommissioning Programme covers:**
    - Decommissioning of the 20" gas export line (PL496);
    - Decommissioning of the 3" methanol line (PL497);
    - Decommissioning of the 8" gas export line (PL575);
    - Decommissioning of the 4" umbilical (PL576);
    - Decommissioning of the 14" gas pipeline (PL723);

- Decommissioning of the 3" methanol line (PL724); and
- Recovery of protection and stabilisation features.

The installations and pipelines covered under the four Decommissioning Programmes listed above are shown in Figure 3-1 and Figure 3-2.

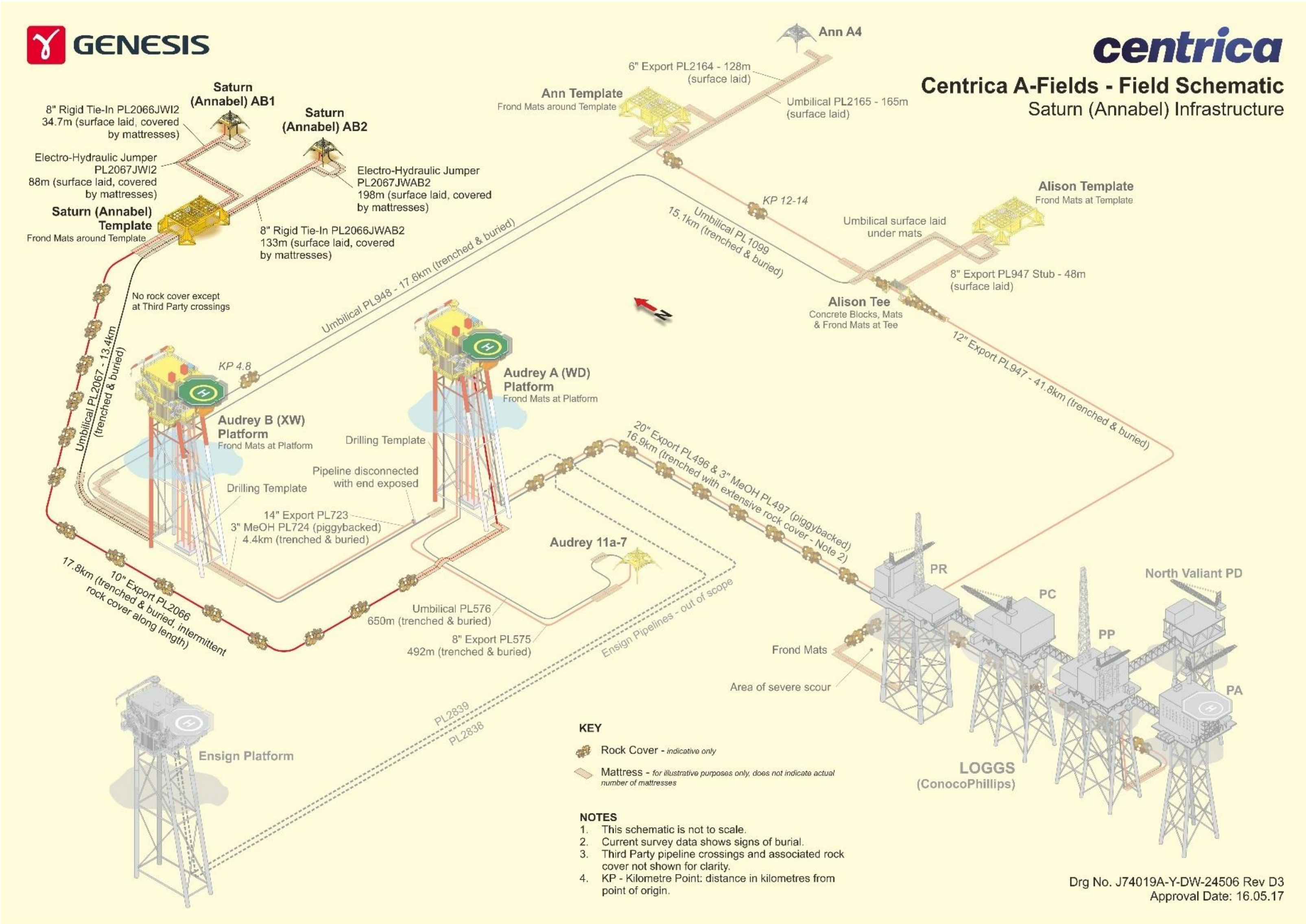

Figure 3-1: Illustration to show all infrastructure and pipelines covered under the Annabel Decommissioning Programme

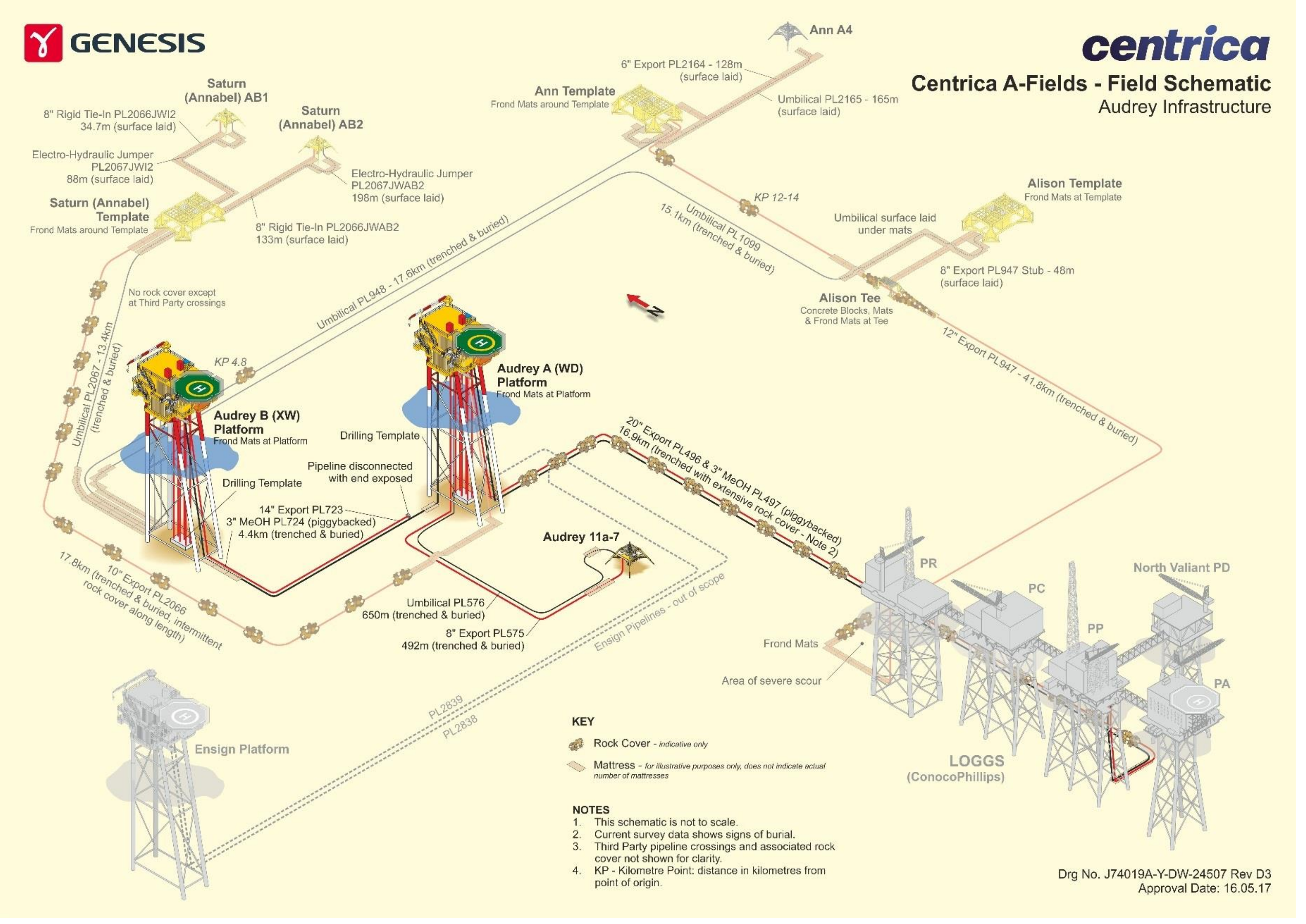

Figure 3-2: Illustration to show all infrastructure and pipelines covered under the Audrey Decommissioning Programme

3.2 Preparatory works

Although preparatory works are outside the scope of the Decommissioning Programmes, a summary is provided here in order to describe the status of the facilities prior to the commencement of the decommissioning scope.

3.2.1 Well abandonment

As required by Centrica standards, abandonment of the fourteen Audrey wells, one Audrey 11-a7 well and two Annabel wells will be undertaken in accordance with Oil and Gas UK (OGUK) Guidelines for the Abandonment of Wells (OGUK, 2015).

The well abandonment campaign is scheduled to take place during 2018. A drilling rig will be required at eight separate locations across the area. The spud cans used to stabilise the drilling rig will result in seabed disturbance (Section 6.3.3).

Chemical use and discharges associated with well abandonment will be assessed on well abandonment permit and licence submissions.

3.2.2 PL496, PL575 and PL2066 (including spool pieces at Annabel) preparation

Pipelines within the A-Fields contain produced fluids which are a mix of predominantly gas with small volumes of condensate and produced water. The pipelines will be prepared for decommissioning by removing the produced fluids. The method for the removal will be agreed with BEIS through the environmental permitting process and associated consultation.

It is likely that the produced fluids will be removed from the pipelines with the use of a combination of pigs and flushing. The exact method will be developed during detailed design.

Removal of the produced fluids from the tree spools will be carried out prior to recovery unless detailed design identifies that it is not technically possible (e.g. where dead legs occur). If this occurs, it will be presented in the environmental permits and discussed during consultation. The flushing fluids, including produced fluids and seawater, will be pushed into PL496 from where, it is currently anticipated, it will be directed into a dedicated disposal well at the North Valiant platform (Figure 3-1 and Figure 3-2).

3.2.3 PL2067, PL576 and PL724 (including jumper bundle at Annabel) preparation

The methanol (MeOH) cores of PL2067 and the MeOH pipelines PL724 and PL497 will be flushed.

The pipelines (including spool pieces), and the umbilical cores containing methanol (with the exception of those of PL576) will be flushed with, and left containing filtered seawater prior to decommissioning. Recent attempts to flush PL576 have proved unsuccessful. It is planned however to completely remove the entire length of this umbilical by the reverse installation method such that no discharge of chemical to the environment will occur.

3.3 Decommissioning – Annabel

The Annabel Field was the last of the A-Fields to be developed, achieving its first production in 2005. It is a subsea development comprising two production wells (Annabel AB1 and Annabel AB2), from which gas (and lesser quantities of other produced fluids), after being commingled at the Annabel template, were exported to the Audrey A (WD) platform. Each well has a WHPS (Figure 3-1 and Figure 3-3).

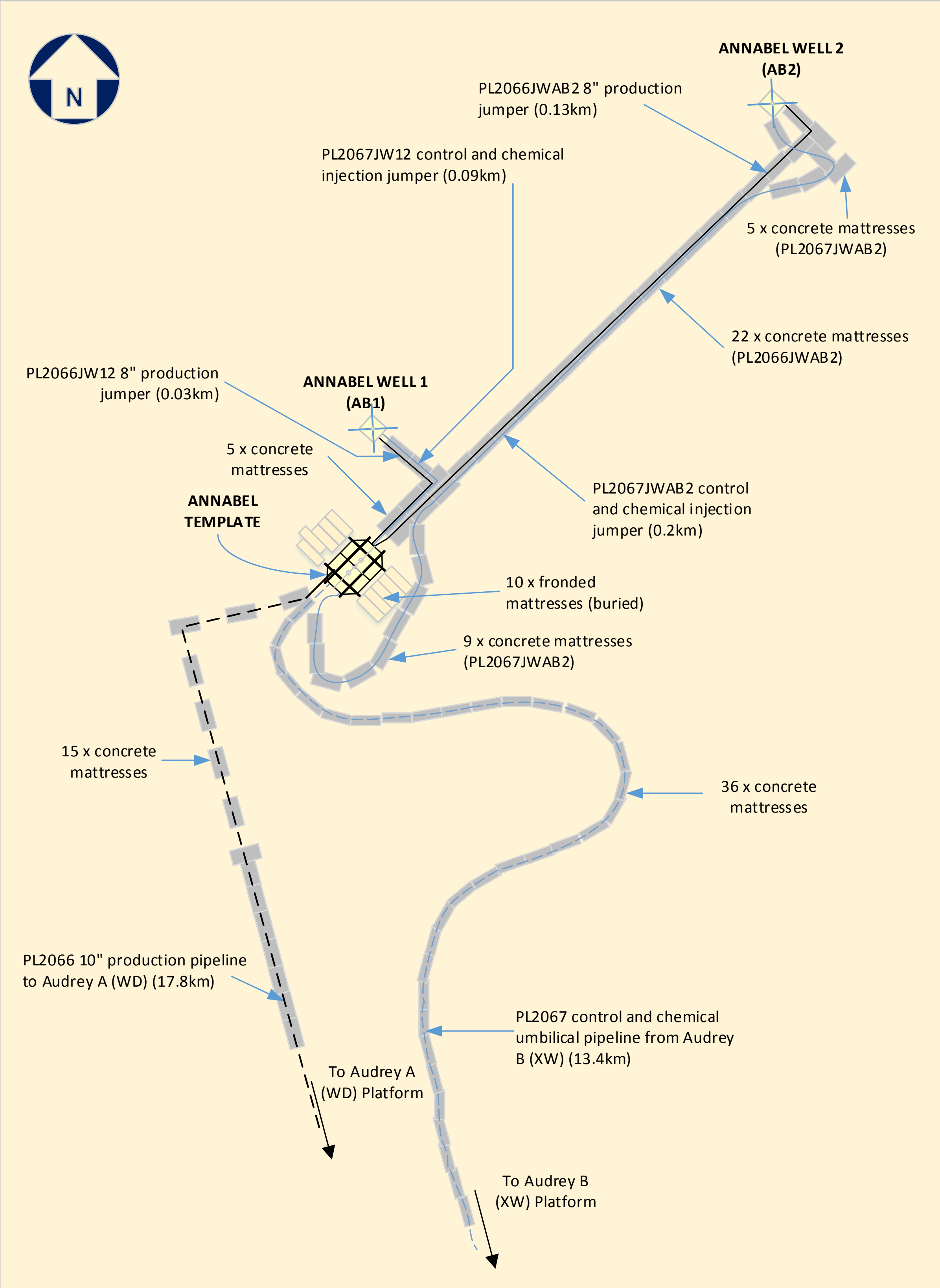

Figure 3-3: Overview of Annabel approaches

3.3.1 Annabel subsea installations

The Annabel installations are summarised in Table 3-1. The Annabel installations will be completely removed and recovered to shore.

DESCRIPTION	MASS (Te)
Annabel template	198.9
AB1 WHPS	33.7
AB2 WHPS	33.7
TOTAL MASS	**266.3**

Table 3-1: Annabel – Summary of Annabel subsea installations

3.3.2 Annabel pipelines and umbilicals

The Annabel pipelines and umbilicals are summarised in Table 3-2.

PIPELINE ID	DESCRIPTION	LENGTH (km)
PL2066	10" pipeline routed from Annabel manifold to Audrey A (WD) platform	17.8
PL2067	4½" umbilical routed from Audrey B (XW) to Annabel template	13.4
PL2066JW12	8" pipe spools routed from Annabel AB1 to the Annabel template	0.035
PL2066JWAB2	8" pipe spools routed from Annabel AB2 to the Annabel template	0.133
PL2067JW12	4½" umbilical control jumper routed from Annabel template to Annabel AB1	0.088
PL2067JWAB2	Electro-hydraulic bundle routed from Annabel template to Annabel AB2	0.198

Table 3-2: Annabel – summary of pipelines and umbilicals

3.3.2.1 10" pipeline (PL2066)

Following commingling, gas was exported via a 17.8km long, 10" pipeline (PL2066) from the Annabel template to Audrey A (WD). This pipeline is trenched and buried along its length, and protected and stabilised near its ends with concrete mattresses and other features such as grout bags.

When installed in 2006 the pipeline was trenched and buried, but along its length the pipeline is intermittently protected by deposited rock. The approaches to both the Annabel template and the Audrey A (WD) platform are protected and stabilised with concrete mattresses. Mattress cover on the approach to the Annabel template is not continuous.

Survey data obtained since the original installation suggest that the majority of PL2066 has remained relatively stable along its entire length (Figure 3-4). Relatively short lengths of PL2066 close to the Annabel manifold and close to the Audrey A (WD) platform (up to a maximum of 21m in any one location) have been exposed over the years. No free spans have been recorded.

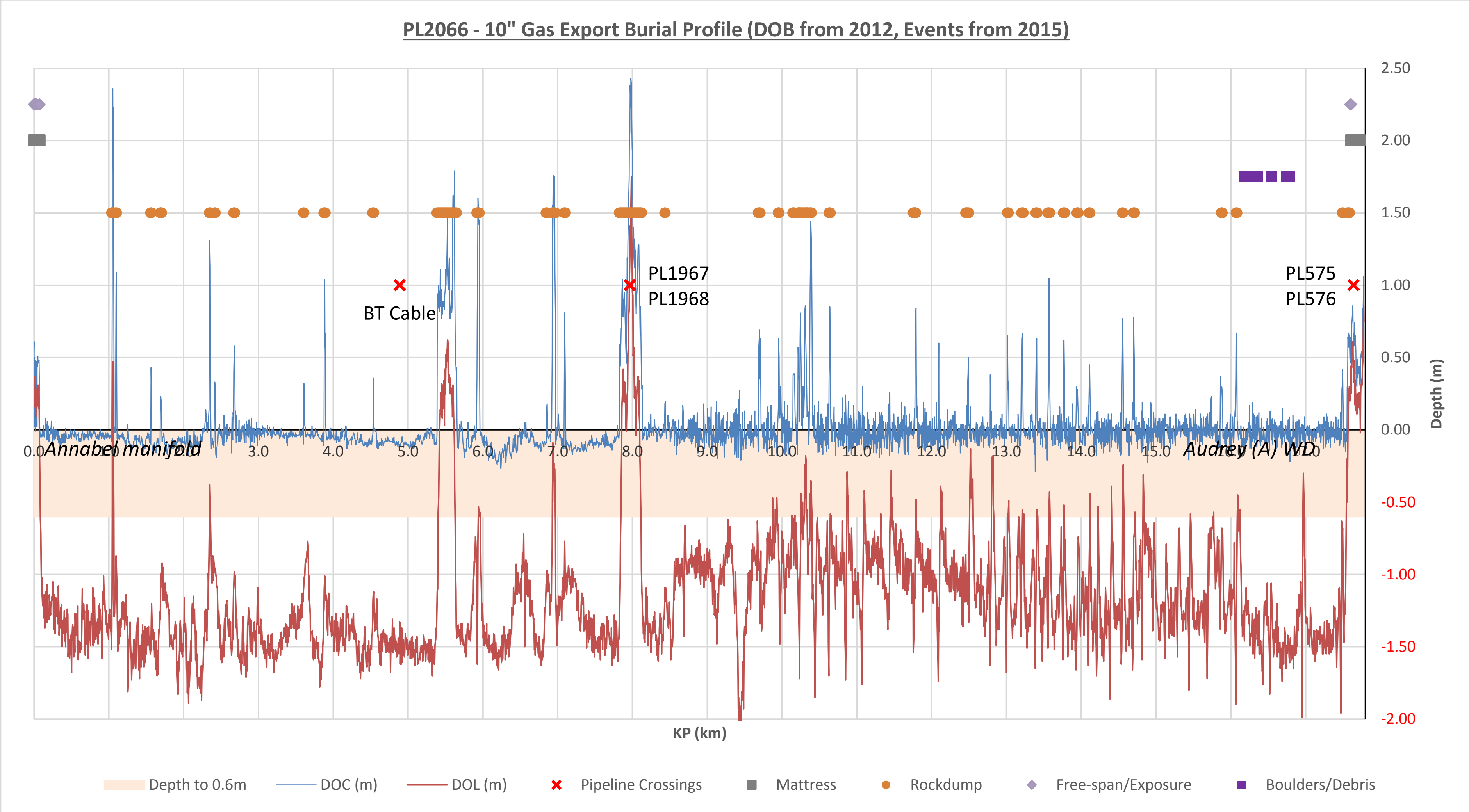

Figure 3-4: Overall burial of PL2066 (10" export line from Annabel to Audrey A (WD))

3.3.2.2 4½" umbilical (PL2067)

Power, controls and chemicals were provided from the Audrey B (XW) platform to the Annabel manifold via a 13.4km long, 4½" umbilical (PL2067). PL2067 comprises steel wire armour, 10 hydraulic hoses, two power cables and plastic fillers. (Figure 3-5).

When installed in 2006, PL2067 was trenched and buried. The third-party pipeline crossings are protected with deposited rock. The approaches to both Annabel template and the Audrey B (XW) platform are stabilised and protected with concrete mattresses. PL2067 experiences a good burial profile with the majority of the pipeline buried to a depth greater than 0.6m below the local seabed (Figure 3-6). The umbilical remains comparatively stable.

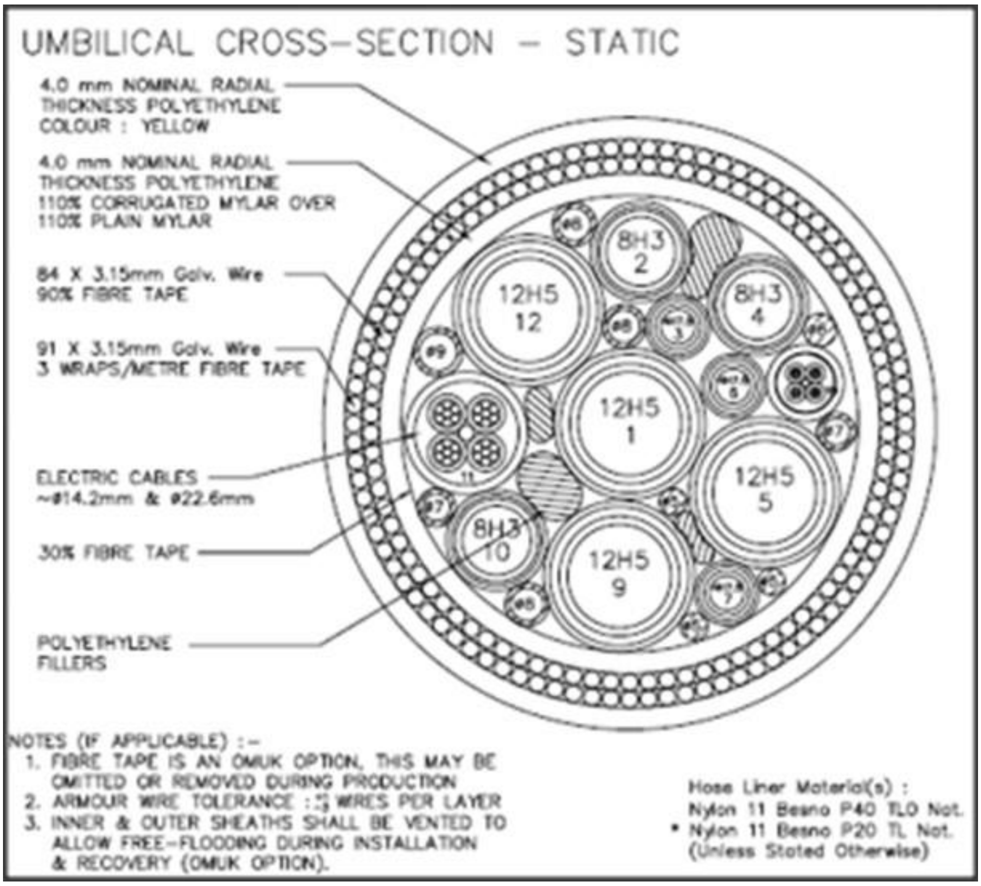

Figure 3-5: Cross-section through the Annabel 4½" umbilical (PL2067)

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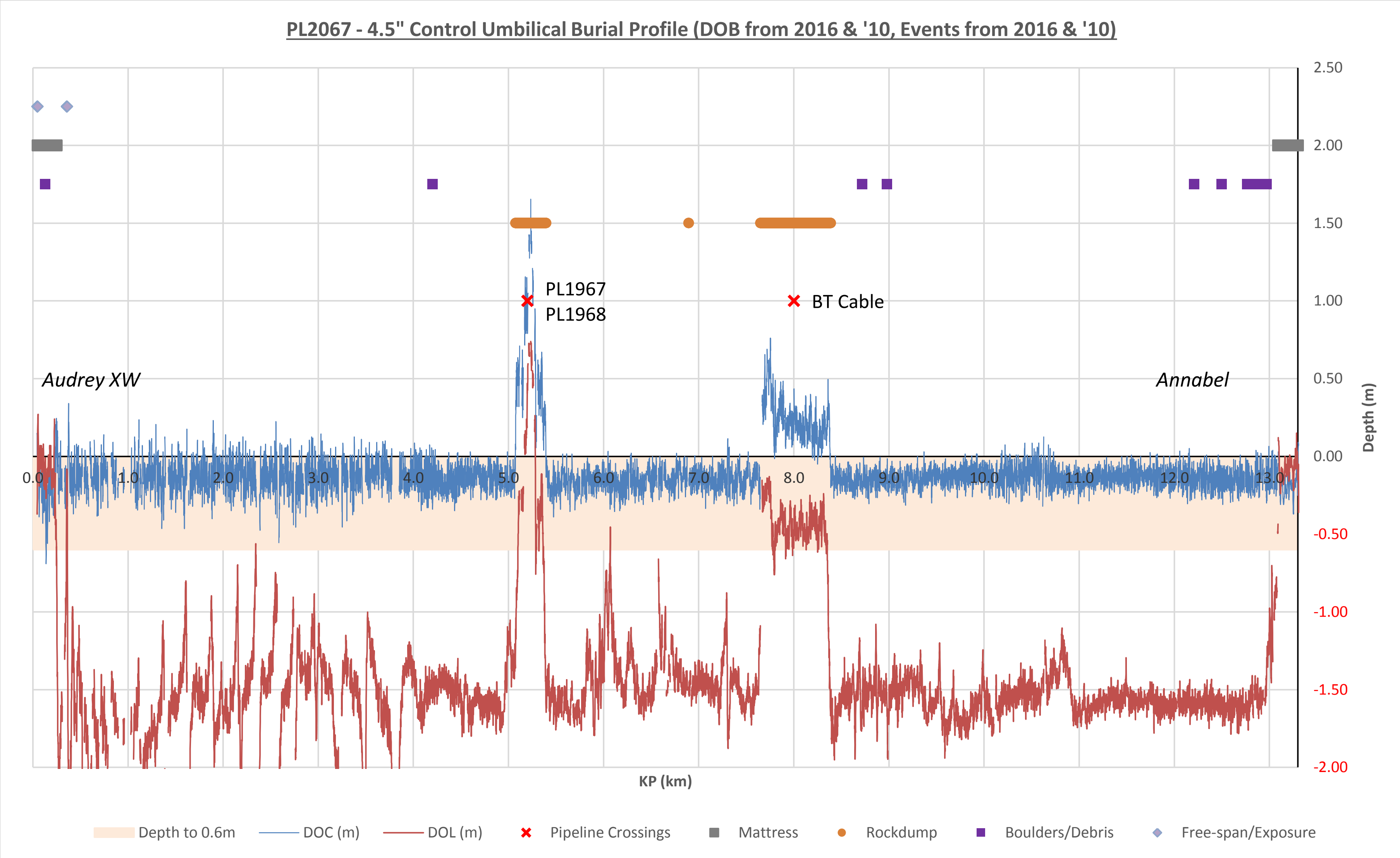


Figure 3-6: Overall burial of PL2067 (4" umbilical from Annabel to Audrey A (WD))

3.3.2.3 8" pipe spools (PL2066JW12) and (PL2066JWAB2)

Annabel AB1 and Annabel AB2 each exported gas to the Annabel template via 8" spool pieces, PL2066JW12 and PL2066JWAB2 respectively.

PL2066JW12 is a short 34.7m long, 8" pipeline, routed from Annabel AB1 to the Annabel manifold located inside the Annabel template. It comprises a number of surface laid pipe spools. PL2066JW12 is protected and stabilised using concrete mattresses.

PL2066JWAB2 is a short 8" pipeline 133m long, routed from Annabel AB2 to the Annabel manifold located inside the Annabel template. It comprises a number of surface laid pipe spools. PL2066JWAB2 is protected and stabilised using concrete mattresses.

3.3.2.4 4½" umbilical electro-hydraulic jumper (PL2067JW12) and Electro-hydraulic bundle (PL2067JWAB2)

The Annabel manifold acts as an umbilical distribution centre from which PL2067JW12 is routed to Annabel AB1 and PL2067JWAB2 is routed to Annabel AB2.

PL2067JW12 is a short 88m long, 4½" electro-hydraulic jumper routed from Annabel manifold inside the template to Annabel AB1 wellhead. PL2067JW12 is protected and stabilised using concrete mattresses.

PL2067JWAB2 is a short electro-hydraulic bundle 198m long routed from Annabel manifold inside the template to Annabel AB2 wellhead. PL2067JWAB2 is protected and stabilised using concrete mattresses.

3.3.2.5 Pipeline crossings

The pipeline crossings associated with the Annabel pipelines are shown in Table 3-3.

CROSSING No.	PIPELINE CROSSING ID	CROSSING DESCRIPTION	OPERATOR	KP (km)	OVER/ UNDER
18	Cable	NSO-1 Telecoms Cable from Weybourne to ACMI MASTER	BT	4.89	Over
19	PL1967 PL1968	20" GE line from Carrack QA to Clipper PR 4" MEG line from Clipper PR to Carrack QA	Shell	7.98	Over
20	PL575 PL576	8" GE line from Audrey 7 Well to Audrey A (WD) 4" Umbilical from Audrey A (WD) to Audrey 7 Well	Centrica	17.65	Over

Table 3-3: Summary of pipeline crossings associated with the Annabel export pipeline (PL2066). Direction of flow Annabel to Audrey A (WD)

CROSSING No.	PIPELINE CROSSING ID	CROSSING DESCRIPTION	OPERATOR	KP (km)	OVER/ UNDER
21	Cable	NSO-1 Telecoms Cable from Weybourne to ACMI MASTER	BT	8.00	Over
19	PL1967 PL1968	20" GE line from Carrack QA to Clipper PR 4" MEG line from Clipper PR to Carrack QA	Shell	5.20	Over

Table 3-4: Summary of pipeline crossings associated with the Annabel umbilical (PL2067). Direction of flow Annabel to Audrey B (XW)

3.3.3 Annabel protection and stabilisation features

The Annabel protection and stabilisation features are summarised in Table 3-5, and the Annabel pipeline protection and stabilisation features are summarised in Table 3-6, Table 3-7, and Table 3-8. Concrete mattresses and grout bags will be completely removed where both their access and condition safely allows and recovered to shore. Deposited rock and frond mattresses will be decommissioned *in situ*.

DESCRIPTION	STABILISATION FEATURES	NO.	DIMENSIONS L x W x H (m)	MASS (Te)	TOTAL MASS (Te)
Annabel template	Anti-scour frond mattresses	10	6.0 x 2.0 x 1.0	0.75	7.5
TOTAL MASS					**7.5**

Table 3-5: Annabel – Summary of Annabel installation anti-scour features

PIPELINE ID	DESCRIPTION	NO.	DIMENSIONS L x W x H (m)	MASS (Te)	TOTAL MASS (Te)
PL2066/ PL2067	Deposited rock on 20" and 4" Carrick to Clipper lines	N/A	N/A	4,800	4,800
PL2066/ PL2067	Deposited rock on BT telecoms cable	N/A	N/A	3,000	3,000
PL2066	Intermittent deposited rock	N/A	N/A	12,000	12,200
TOTAL MASS					**20,000**

Table 3-6: Annabel - Summary of deposited rock on the Annabel pipelines

PIPELINE ID	DESCRIPTION	NO.	DIMENSIONS L x W x H (m)	MASS (Te)	TOTAL MASS (Te)
PL2066	Approach from Annabel manifold, concrete mattresses	15	6.0 x 3.0 x 0.3	8.3	124.5
PL2066	Approach to Audrey A (WD), tapered edge concrete mattresses	41	6.0 x 3.0 x 0.3	8.3	369
PL2066	Concrete mattresses on fibre optic cable NSO-1	4 2	6 x 3 x 0.3 6 x 3 x 0.15	8.3 4.15	41.5
PL2066	Concrete mattresses on 20" and 4" Carrick to Clipper lines	5	Various	Various	43
PL2066	Over PL575 at pipeline crossing near Audrey A (WD)	9	Various	Various	51
PL2066JW12	Approach between Annabel AB1 and Annabel manifold, concrete mattresses	5	6.0 x 2.0 x 0.3	6	30
PL2066JWAB2 PL2067JWAB2	Approach between Annabel AB2 and Annabel manifold, concrete mattresses	36	6.0 x 3.0 x 0.3	9	324
PL2067	Approach from Audrey B (XW), concrete mattresses	30	6.0 x 2.0 x 0.3	6	189
PL2067	Approach to Annabel manifold, concrete mattresses	36	6.0 x 2.0 x 0.3	6	216
PL2067JW12	Uses same protection features as PL2066JW12	N/A	N/A	N/A	N/A
TOTAL		**183**			**1,388**

Table 3-7: Annabel - Summary of concrete mattresses on the Annabel pipelines

PIPELINE ID	DESCRIPTION	NO.	DIMENSIONS L x W x H (m)	MASS (Te)	TOTAL MASS (Te)
PL2066	Approach to Audrey A (WD), grout bags	100	0.25 x 0.45 x 0.125	0.025	2.5
PL2066	Between PL575 crossing and Audrey A (WD), gabion bags	2	1 x 1 x 1	1	2
PL2066	At Audrey A (WD), gabion bags	3	1 x 1 x 1	1	3
PL2067	Approach to Annabel template, gravel gabions	8	1 x 1 x 1	1	8
TOTAL		**113**			**15.5**

Table 3-8: Annabel - Summary of grout bags and gravel gabions on the Annabel pipelines

3.3.3.1 Concrete mattresses

An interrogation of recent survey data (May 2016) would suggest that the concrete mattresses are of the 'flexible' concrete mattress type, capable of articulating along and across pipeline being protected, rather than the 'log' type which is only flexible in one direction. These are available from several different manufacturers, including Subsea Protection Systems Ltd (1990s), Pipeshield (1999), etc.

Older concrete mattresses were manufactured using steel rope, although this material is less durable. If the mattresses have been in location for a long time its condition usually precludes using the loops for lifting and often results in the concrete mattress disintegrating as attempts at recovery are made.

The intention is to remove all the accessible[3] concrete mattresses. The recoverability of a mattress is heavily influenced by its condition. Mattresses that have become degraded are more difficult and dangerous to recover and have less scope for re-use once recovered. In this case, however, as Centrica have test lifted one of the concrete mattresses at the Ann template in January 2016, and as the mattresses are of a similar age as those at Audrey, Centrica believe that the condition of the concrete mattresses at both Annabel and Audrey is such that they can be fully recovered. Should any difficulties be encountered during recovery operations, Centrica will discuss possible solutions with BEIS.

3.3.3.2 Frond mattresses

When a pipeline or structure is placed into an area with a loose sedimentary material, under certain conditions the flow of water can cause erosion of the seabed known as 'scour'. Scour around a structure or pipeline will undermine its stability, and so is undesirable.

Frond mattresses are put in place to provide protection against scour, and in performing their action the fronds act like natural seaweed, and silt and sediment that is carried in the water column builds up within the fronds. Eventually they become buried. Given the right conditions they can be very effective.

There are two basic types of frond mattresses: the anchor retained type and the gravity-based type, but they both perform the same basic function. The anchor retained type are typically rolled out as a sheet and pegged into the seabed, whereas gravity-based types

[3] That is, not those buried under rock or under crossings

might use concrete or some other medium to hold them in place while they become buried.

There are known to be a number of frond mattresses protecting the Annabel template (Figure 3-1, Figure 3-3 and Table 3-5) although it has not been possible to determine the design details. The indications are that they have performed their function and are now quite indistinguishable from the surrounding seabed.

An example of a frond mattress is shown in Figure 3-7. Given that they are largely constructed of flexible fronds it is not believed that frond mattresses would present a snagging hazard. All frond mattresses will be decommissioned *in situ*.

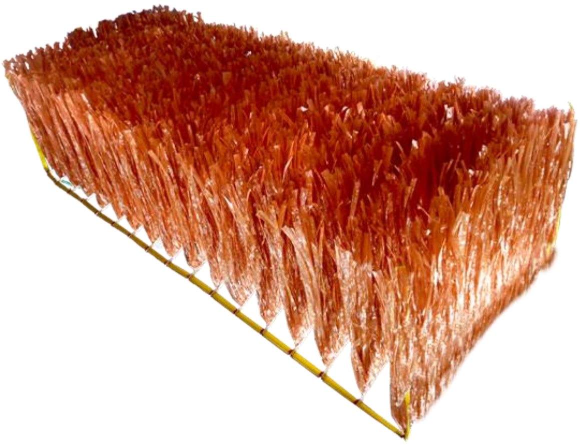


Figure 3-7: Example of a frond mattress

3.3.3.3 Grout bags and gabion bags

The grout bags and gabion bags, where both their access and condition safely allows, will be removed when decommissioning the Annabel infrastructure unless buried by deposited rock. The integrity of the bags and the feasibility of recovery will depend on the materials used.

3.4 Decommissioning – Audrey

The Audrey infrastructure is the A-Fields hub and was the first of the A-Fields development. It comprises two Normally Unattended Installations (NUI) wellhead platforms, Audrey A (WD) and Audrey B (XW) (Figure 3-8), and a single subsea production well, Audrey 11a-7 (Figure 3-9), located to the west-north-west of Audrey A (WD), within its HSE 500m safety zone (Figure 3-10). Gas and lesser quantities of other produced fluids were exported from Audrey A (WD) to the LOGGS platform complex.

Audrey B (XW) also provided power, controls and chemicals to the Ann, Alison and Annabel Fields via umbilicals PL948, PL1099, and PL2067 respectively (Figure 3-11). The intention is to completely remove and recover the Audrey platforms and the Audrey 11a-7 WHPS and to partly remove the template piles.

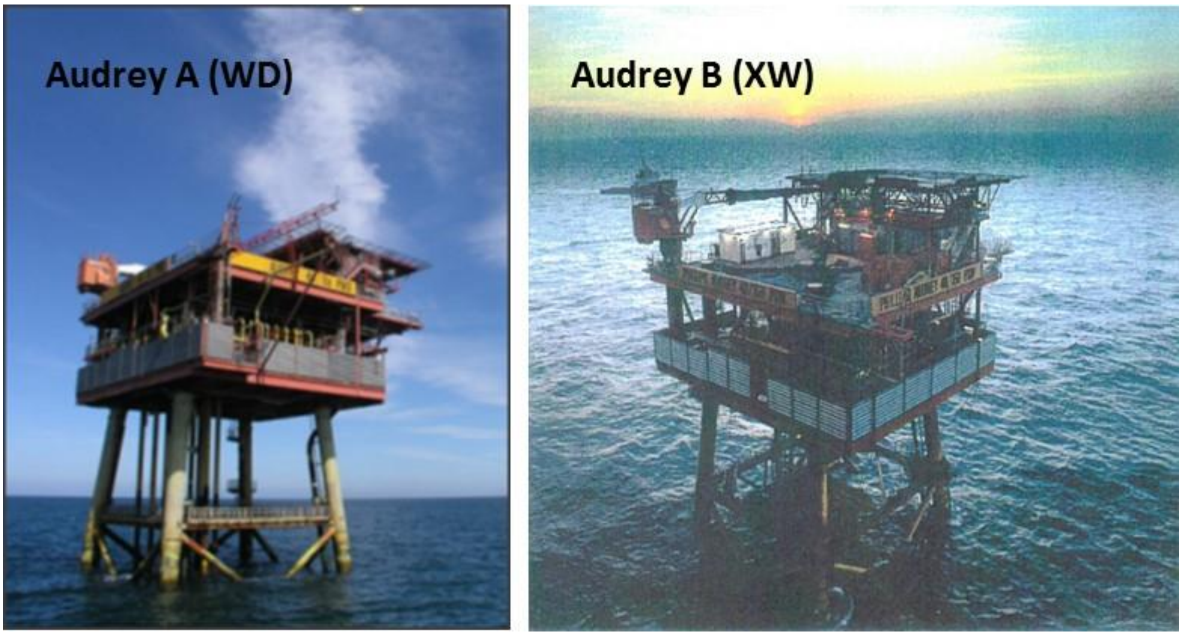


Figure 3-8:Audrey A (WD) and Audrey B (XW) platforms

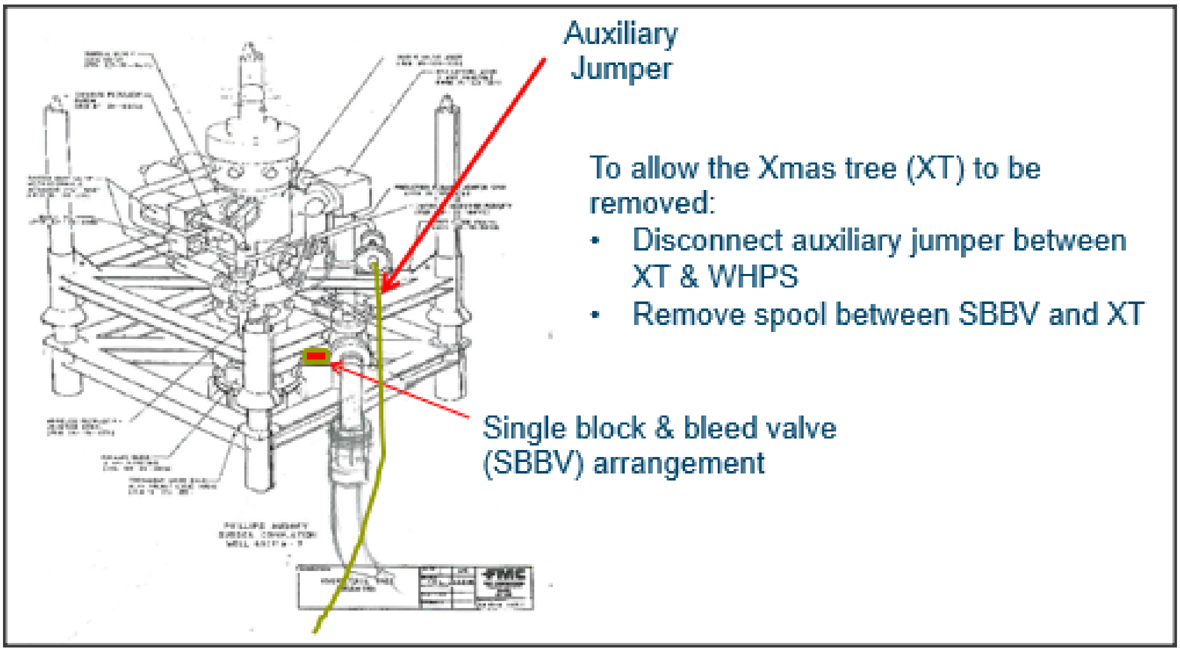


Figure 3-9: Audrey 11-a7

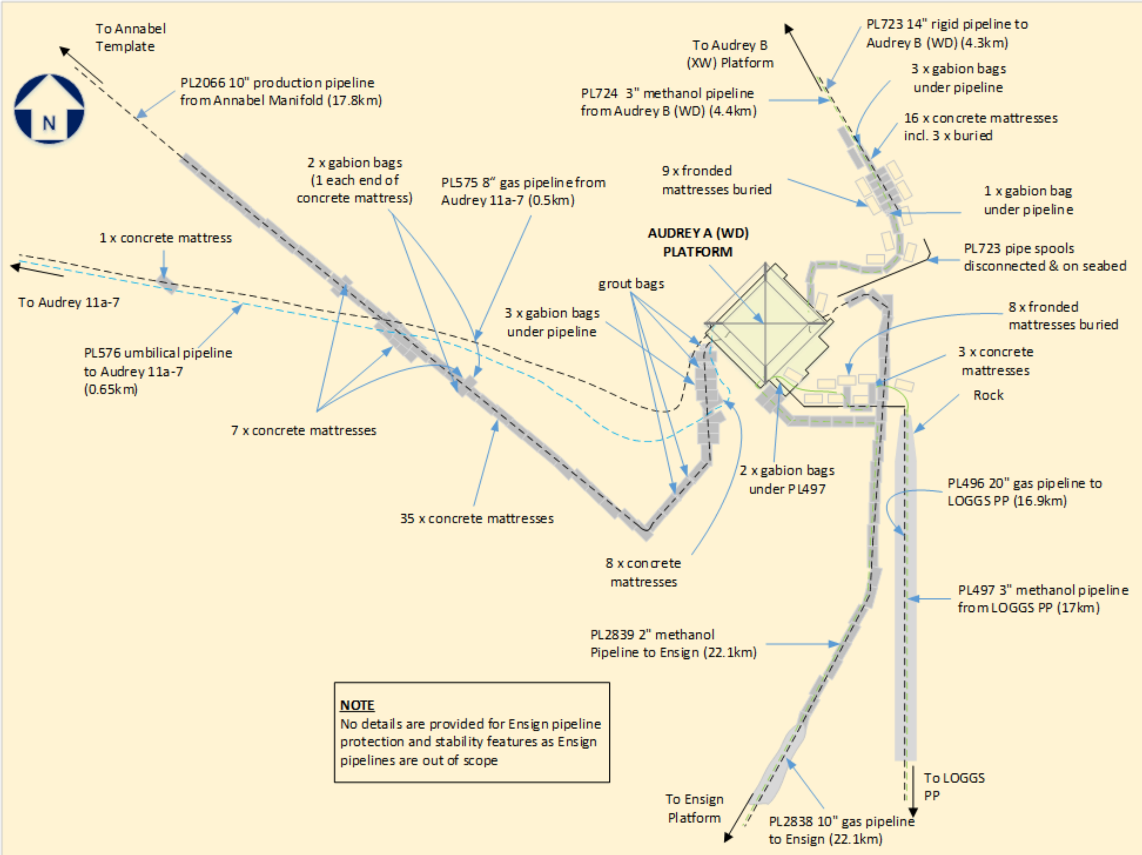


Figure 3-10: Overview of Audrey A (WD) approaches

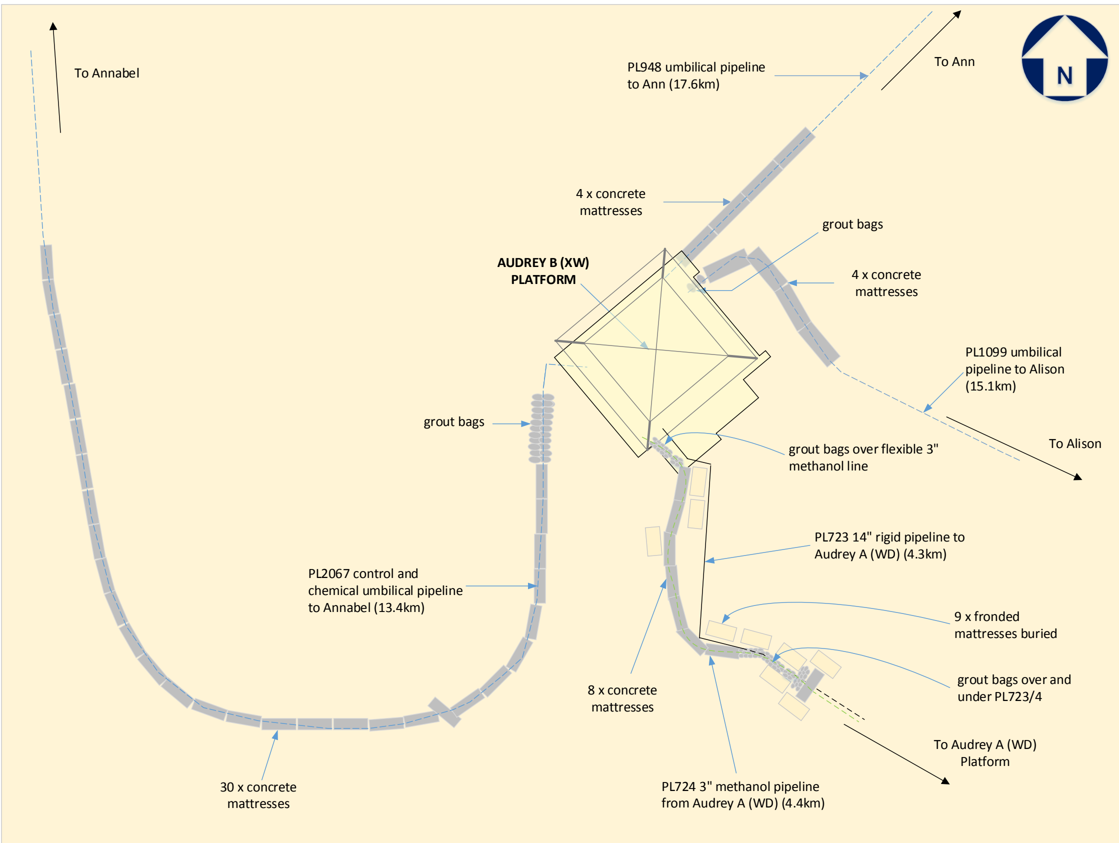


Figure 3-11: Overview of Audrey B (XW) approaches

3.4.1 Audrey platforms and subsea installations

The Audrey platforms and subsea installations are summarised in Table 3-9. The Audrey platforms, drilling templates and the Audrey 11a-7 WHPS will be completely removed and recovered to shore.

DESCRIPTION	MASS (Te)
Audrey A (WD) topsides	1,276
Jacket	1,063
Piles (incl. grout)	585
Drilling template (incl. piles)	49.5
Audrey B (XW) topsides	1,298
Jacket	865
Piles (incl. grout)	585
Drilling template (incl. piles)	49.5
Audrey 11a-7 WHPS (incl. piles)	38.3
TOTAL MASS	**5,809**

Table 3-9: Audrey – Summary of infrastructure

3.4.2 Audrey pipelines and umbilicals

A summary of the Audrey pipelines and umbilicals is given in Table 3-10.

PIPELINE ID	DESCRIPTION	LENGTH (km)
PL496	20" gas export pipeline routed from Audrey A (WD) to the LOGGS PP.	16.89
PL497	3" methanol line routed from LOGGS PP to Audrey A (WD) piggybacked onto PL946.	16.96
PL575	8" gas export pipeline routed from Audrey 11a-7 to Audrey A (WD).	0.492
PL576	4" umbilical routed from Audrey A (WD) to Audrey 11-a7.	0.650
PL723	Disused 14" gas pipeline routed from Audrey B (XW) to Audrey A (WD).	4.34
PL724	3" methanol line routed from Audrey A (WD) to Audrey B (XW) piggybacked on to PL723.	4.42

Table 3-10: Audrey – summary of pipelines and umbilicals

3.4.2.1 20" gas export pipeline (PL496) and 3" methanol line (PL497)

The commingled gas from Annabel, Ensign and Audrey Fields was exported from Audrey A (WD) to the LOGGS Production Platform (PP) via a 16.89km long, 20" pipeline (PL496) (Figure 3-1). PL496 is 20" steel pipeline coated in Coal Tar Enamel (CTE) and concrete.

The LOGGS PP provided MeOH to Audrey A (WD) via a 16.96km long, 3" pipeline (PL497) that is piggybacked onto the export pipeline (PL496), that is PL947 is connected to PL496 using clamps. It is believed that attempts to trench the pipeline during the original installation operations were not entirely successful, and that deposited rock was used to backfill the trench and stabilise the pipeline. The ends at Audrey A (WD) and LOGGS PP of each of these pipelines are also protected and stabilised with concrete mattresses.

The burial profile in Figure 3-12 was prepared using 2016 survey data. The 20" pipe spools are connected to the platform riser and the main pipeline using a hyperbaric weld. From just before the hyperbaric weld to approximately KP 0.51 the pipelines are buried under deposited rock. Quantities of deposited rock are also found between KP4.06 and KP4.12 with a break of a few metres at KP4.09, between KP4.51 and KP4.55, between KP5.97 and KP5.98, between KP8.03 and KP8.07 with a short break of a few metres at KP8.05, between KP8.09 and KP8.48 with short breaks of a few metres at KP8.19, KP8.23, KP8.32, KP8.39, KP8.43, and KP8.46. The next deposited rock was surveyed to be located at KP13.66 and KP13.68, and the final stretch is to be found between KP16.23 through to the end of the pipeline with breaks of a few m at KP16.25, KP16.36, and KP16.43, There is a larger break in the rock of 20 and 40m at KP16.52, KP16.58, KP16.63, KP16.79.

Ignoring the pipespools at the platform approaches, short exposed lengths of pipeline are found at KP 7.06 for approximately 1m, at KP7.09 for 6m, at KP7.11 for 9m, KP7.14 for 14m, KP7.16 for 21m, KP7.2 for 7m, KP8.2 for 4m, KP11.98 for 5m, KP12 for 5m, KP12.02 for 5m, and KP12.02 for 6m. Note that the infield pipeline exposures are outside the HSE 500m safety zones and will have been subject to any fishing activities in the area.

On the final LOGGS PP approach the last 10-15m of the 20" pipeline pipespools and the piggybacked flexible 3" methanol line appear to be exposed.

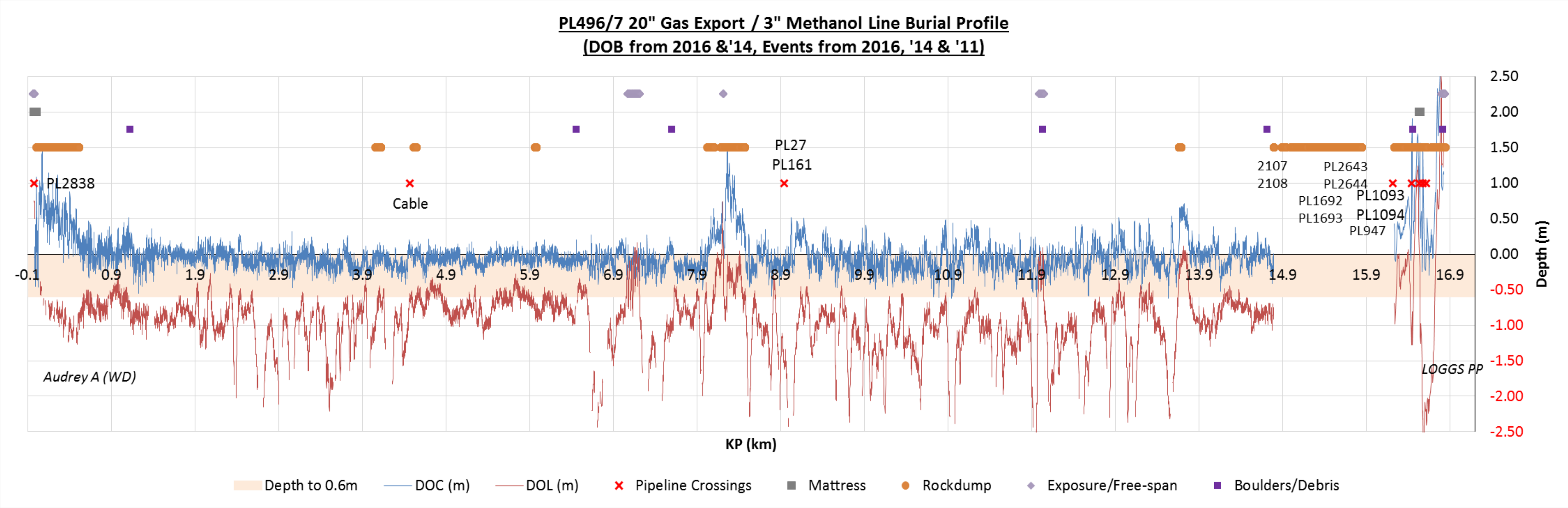


Figure 3-12: Overall burial of PL496/PL497 (Audrey A (WD) to the LOGGS platform complex)

3.4.2.2 8" gas export pipeline (PL575) and 4" umbilical (PL576)

The Audrey 11a-7 well is tied back to Audrey A (WD) via a 492m long, 8" pipeline (PL575). Audrey A (WD) supplied power, controls and chemicals to Audrey 11a-7 via a 650m long, 4" umbilical (PL576). PL575 and PL576 are laid in the same trench and buried.

The burial profile of PL575 (Figure 3-13) is somewhat erratic. The pipeline appears to be reasonably well buried for most of its length, with burial being almost 1.5m deep in three locations. However, the pipeline is exposed at the start and end as well as approximately half-way along. The burial profile has changed slightly over the years, although the pipeline does not appear to be unstable.

The burial profile of PL576 (Figure 3-14) is somewhat erratic. The umbilical appears to be reasonably well buried for most of its length, with burial of the umbilical being around 1.5m deep in three locations. However, the umbilical is exposed at the start and end as well as at two points approximately one-third and two-thirds along.

3.4.2.3 Disused 14" gas pipeline (PL723) and 3" methanol line (PL724)

Audrey B (XW) used to export gas to Audrey A (WD) via a 4.34km long, 14" pipeline (PL723) but production from Audrey B (XW) was shut in, and PL723 disconnected in 2011 to allow Ensign to tie into Audrey A (WD) and export gas to the LOGGS PP via pipeline PL496 (Figure 3-10 and Figure 3-11).

Audrey A (WD) supplied methanol to Audrey B (XW) via a 4.42km long, 3" methanol pipeline (PL724) that is piggybacked onto the disused export pipeline (PL723) (Figure 3-10 and Figure 3-11). These pipelines are trenched and buried, and protected and stabilised near their ends by mattresses.

Based on the burial profiles presented in Figure 3-15, it is believed that the pipeline is buried and remains stable.

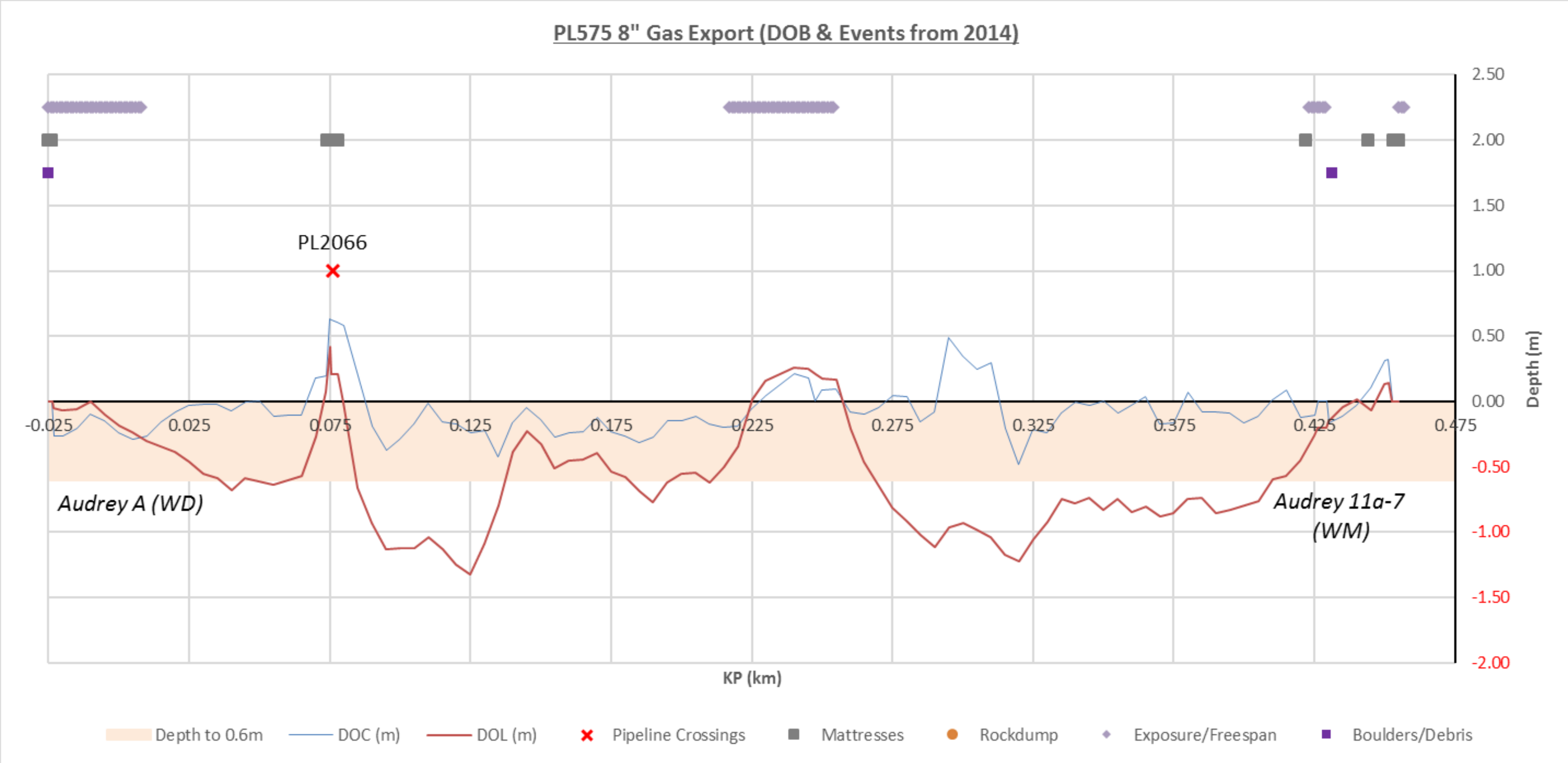


Figure 3-13: Overall burial of PL575[4] (Audrey 11a-7 gas export pipeline)

[4] In this instance the KP start at the end of the pipeline – Audrey A (WD) rather than the point of origin, Audrey 11a-7

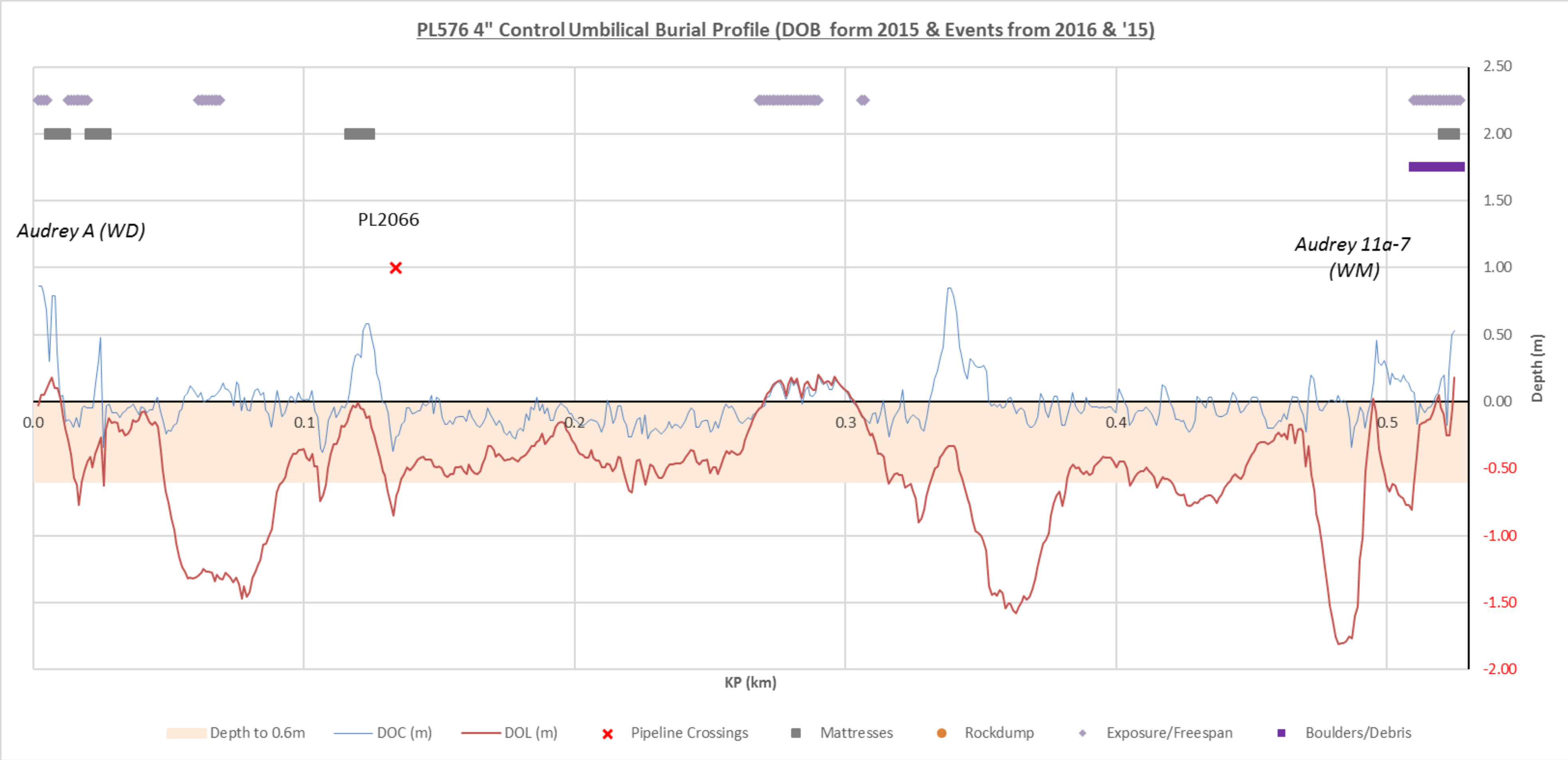


Figure 3-14: Overall burial of PL576 (Audrey A (WD) to Audrey 11a-7)[5]

[5] Although the burial chart suggests that the umbilical is approx. 520m long, the ‘as-built’ drawings indicate that the umbilical is 650m long; the difference arises because the umbilical follows a wide loop near Audrey 11a-7 and the Audrey A (WD) platform, and these are not captured on the burial survey

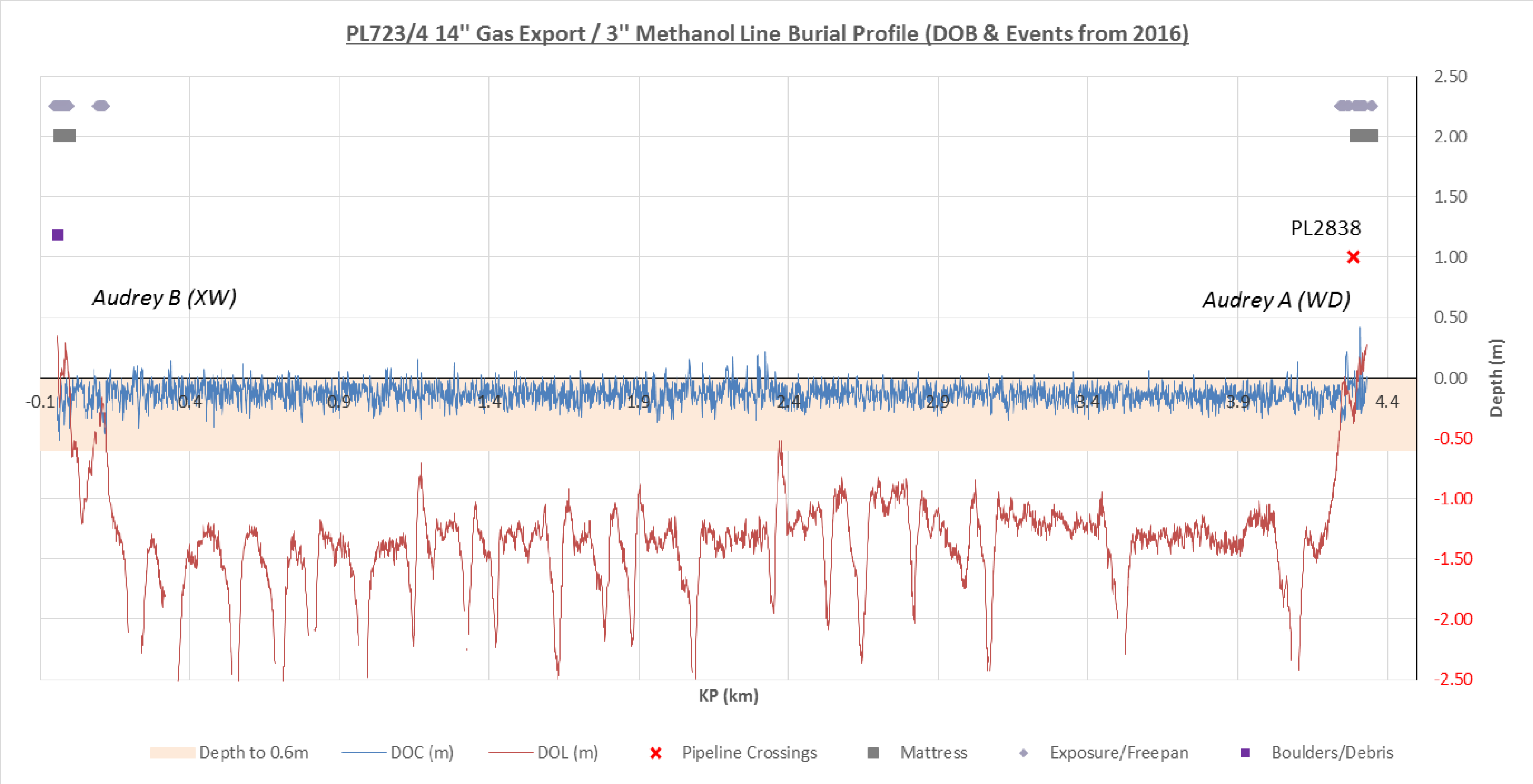


Figure 3-15: Burial profile for PL723/4 (Audrey B (XW) to Audrey A (WD))

3.4.2.4 Pipeline crossings

The following pipeline crossings associated with the Audrey pipelines have been identified and are shown in Table 3-11, Table 3-12 and Table 3-13.

CROSSING No.	PIPELINE CROSSING ID	CROSSING DESCRIPTION	OPERATOR	KP (km)	OVER/ UNDER
22	PL2838	10" GE line from Ensign NPAI to Audrey A (WD)	Centrica	*-0.02*	Under
23	Cable	Cable from Weybourne to Fano (Dead) – cable not found; no physical crossing	BT		Over
24	PL27 PL161	28" GE line from Viking AR to Mablethorpe 3" MeOH piggy back line from Viking AR to Mablethorpe	ConocoPhillips	8.95	Over
25	Cable	Cable from Mundersley to Nordeney (Dead)	Unknown		Over
26	PL2107 PL2108	14" GE from Saturn ND to LOGGS PR 3" MeOH line from LOGGS PR to Saturn ND	ConocoPhillips	16.22	Under
27	PL1692 PL1693	12" GE line from Vampire OD to LOGGS PR 3" MeOH line from LOGGS PR to Vampire OD	ConocoPhillips	16.44	Under
9	PL947	12" GE line from Ann manifold to LOGGS PR	Centrica	16.54	Under
28	PL2643 PL2644	12" GE line from Viking to LOGGS PR 3" MeOH line from LOGGS PR to Viking	ConocoPhillips	16.58	Under
29	PL1093 PL1094	18" GE line from Ganymede ZD to LOGGS PR 3" MeOH line from LOGGS PR to Ganymede ZD	ConocoPhillips	16.62	Under

Table 3-11: Summary of pipeline crossings associated with the Audrey A (WD) export pipeline (PL496) to LOGGS PP and the MeOH line (PL467) from LOGGS PP to Audrey A (WD)

CROSSING No.	PIPELINE CROSSING ID	CROSSING DESCRIPTION	OPERATOR	KP (km)	OVER/ UNDER
20	PL2066	10" GE line from Annabel template to Audrey A (WD)	Centrica	17.65	Under

Table 3-12: Summary of pipeline crossings associated with the Audrey A (WD) export line (PL575) and umbilical (PL576). Direction of flow Audrey A (WD) to Audrey 11-a7

CROSSING No.	PIPELINE CROSSING ID	CROSSING DESCRIPTION	OPERATOR	KP (km)	OVER/ UNDER
30	PL2838	10" GE line from Ensign to Audrey A (WD)	Centrica	*4.29*	Under

Table 3-13: Summary of pipeline crossings associated with the Audrey A (WD) MeOH line (PL724). Direction of flow Audrey A (WD) to Audrey B (XW)

3.4.3 Audrey protection and stabilisation features

The Audrey pipeline protection and stabilisation features are summarised in Table 3-14, Table 3-15, Table 3-16 and Table 3-17. Concrete mattresses and grout bags will be completely removed where both their access and their condition safely allows, and recovered to shore. Deposited rock and frond mattresses will be decommissioned *in situ*.

PIPELINE ID	DESCRIPTION	NO.	DIMENSIONS L x W x H (m)	MASS (Te)	TOTAL MASS (Te)
PL496/PL497	Deposited rock interspersed throughout the full length of the pipeline	N/A	N/A	69,516	69,516
TOTAL MASS					**69,516**

Table 3-14: Audrey - Summary of deposited rock on the Audrey pipelines

PIPELINE ID	DESCRIPTION	NO.	DIMENSIONS L x W x H (m)	MASS (Te)	TOTAL MASS (Te)
PL496/PL497	3 in vicinity of Audrey A (WD) 6 in vicinity of LOGGS PP 21 at pipeline crossing over PL27 & PL161	30	6 x 2 x 0.15		69.6
PL575	In vicinity of Audrey 11a-7	3	6 x 2 x 0.15		8.3
PL723/PL724	16 in vicinity of Audrey A (WD) 12 in vicinity of Audrey B (XW)	28	6 x 2 x 0.15		77.5
TOTAL		**61**			**155.4**

Table 3-15: Audrey - Summary of concrete mattresses on the Audrey pipelines

PIPELINE ID	DESCRIPTION	NO.	DIMENSIONS L x W x H (m)	MASS (Te)	TOTAL MASS (Te)
PL496/PL497	5 in vicinity of LOGGS PP	5	6 x 2 x 0.15		3.75
PL723/PL724	17 in vicinity of Audrey A (WD) 9 in vicinity of Audrey B (XW)	26	6 x 2 x 0.15		19.5
TOTAL		31			23.25

Table 3-16: Audrey – Summary of frond mattresses on the Audrey pipelines

PIPELINE ID	DESCRIPTION	NO.	DIMENSIONS L x W x H (m)	MASS (Te)	TOTAL MASS (Te)
PL723/PL724	Audrey A (WD) (Gabion bags)	4	1 x 1 x 1	1	4
PL723/PL724	Audrey B (XW) (Grout bags)	200	0.25 x 0.45 x 0.125	0.025	5
PL496/PL497	Audrey A (WD) (Gabion bags)	2	1 x 1 x 1	1	2
PL496/PL497	LOGGS PP (Gabion bags)	2	1 x 1 x 1	1	2
PL496/PL497	LOGGS PP (Grout bags)	100	0.25 x 0.45 x 0.125	0.025	2.5
TOTAL		308			15.5

Table 3-17: Audrey – Summary of pipeline grout and gabion bag deposits

3.4.3.1 Concrete mattresses

The intention is to remove all of the concrete mattresses. It is understood that the concrete mattresses are Dunlop ‘Linklok’ type but it has not been possible to confirm this. Dunlop ‘Linklok’ mattresses are made of articulated blocks that are constructed by casting concrete into hard plastic honeycombed moulds, with polypropylene rope used to link the blocks together.

The recoverability of a mattress is heavily influenced by its condition. Mattresses that have become degraded are more difficult and dangerous to recover and have less scope for re-use. However, at present it is believed that the condition of the concrete mattresses in the Audrey Field will allow recovery.

3.4.3.2 Frond mattresses

Frond mattresses are used to a lesser extent than concrete mattresses in the SNS. An example of a frond mattress is shown in Figure 3-7. There are a number of frond mattresses protecting the Audrey pipelines at the Audrey platforms (Figure 3-10, Figure 3-11 and Table 3-16) although it has not been possible to determine the design details. The indications are that they have performed their function and are now quite indistinguishable from the surrounding seabed.

The majority of their thickness is manufactured from flexible material designed to accumulate seabed sediment (Figure 3-7) and as such it is not believed that they would present a snagging hazard. Therefore, it is proposed to decommission the frond mattresses by leaving them *in situ*.

3.4.3.3 Grout bags and gabion bags

The grout bags and gabions bags, where both their access and condition safely allows, will be removed when decommissioning the Audrey infrastructure unless buried by deposited rock. The integrity of the bags and the feasibility of recovery will depend on the materials used.

3.4.4 Audrey drill cuttings piles

As identified in the pre-decommissioning survey report (Gardline Geosurvey, 2016c) one area of anthropogenic rock at Audrey A (WD) and one area of anthropogenic rock at Audrey B (WD) showed elevated levels of hydrocarbons and other contaminants associated with drill cuttings, with the area and levels of contamination being greater at Audrey A (WD) than at Audrey B (XW).

The area of disturbed seabed associated with an accumulation of drill cuttings lies immediately to the north of the Audrey A (WD) platform and occupies an area of approximately 110m north-west to south-east by 15-50m south-west to north-east. The drill cuttings pile at Audrey A (WD) covers an area of 3,270m^2, but is very thin, as evidenced by the surface expression of the underlying sand megaripples visible on the geophysical data. As such, its edges are very diffuse, so an estimation of the area difficult. The thickness is also hard to estimate, but is thought to be in the region of 10cm to 20cm, which would give an approximate volume of 500m^3 (Figure 3-16).

Figure 3-16: Audrey A (WD) drill cuttings pile

3.5 Comparative Assessment

A Comparative Assessment (CA) (Centrica, 2017b) of the pipeline decommissioning options is a key supporting document of the Decommissioning Programmes submitted to the BEIS. The options were assessed using the BEIS Decommissioning Guidance Notes (DECC, 2011a) and Centrica Comparative Assessment guidelines (Centrica Energy, 2014). During the assessment process, evaluations were made principally on a qualitative basis using Centrica's established corporate risk assessment tables but also combined with deterministic values from the cost which were normalised to provide a consistent measure against all CA evaluation criteria of:

- Safety;
- Environmental;
- Technical;
- Societal; and
- Cost.

The CA focussed on the decommissioning options for the 20" export pipeline Audrey A (WD) to LOGGS (PL496); the 3" MeOH line (PL497), the 8" gas export pipeline routed from Audrey 11a-7 to Audrey A (WD) (PL575), the 4" umbilical routed from Audrey A (WD) to Audrey 11-a7 (PL576), the 14" disused export line from Audrey A (WD) to Audrey B (XW) (PL723), the 3" MeOH line (PL724), the 10" export line from Audrey A (WD) to Annabel (PL2066), the 4½" umbilical (PL2067), the Annabel spool pieces (PL2066JW12 and PL2066JWAB2), the umbilical (PL2067JWAB2) and jumper (PL2067JW12) and the drill cuttings pile as summarised in Table 3-10 and Table 3-2. The CA also considered the protection and stabilisation features as discussed in Sections 3.4.3 and 3.3.3.

3.5.1 Decommissioning options

The options detailed in this section are those that have been included in the CA process. The pipelines are separate and are therefore considered individually. Therefore, the decommissioning options are considered independently for each pipeline.

There is an implicit assumption that options for re-use of the pipelines have been exhausted prior to the facilities moving into the decommissioning phase and associated CA; therefore, this option has been excluded.

In most instances three options are considered for decommissioning the pipelines, although depending on the pipeline being assessed the number of options may reduce to two, because there is little to differentiate at least two of the three options:

- **Complete removal** – This involves the complete removal of the pipelines by whatever means would be most practicable and acceptable from a technical perspective. In the event a pipeline is crossed over by a third-party pipeline, the pipeline would be cut either side of the third-party crossing;
- **Partial removal** – This will either involve removing poorly buried or potentially unstable sections of pipelines or doing what other remedial work we believe would be necessary to make the pipeline safe for leaving the remainder *in situ*;
- **Leave *in situ* –** This involves leaving the pipeline *in situ* with no remedial works but possibly verifying the stability of the pipeline via future surveys

By implication, both options would involve removing short ends exposed on the sea bed as well as the pipelines in the trench transition areas not covered with rock, so these elements are not considered as differentiators in the CA process. Both options include removal of features such as spool pieces, mattresses and grout bags in accordance with mandatory requirements.

Details of the pipeline decommissioning options for PL496, PL497, PL723, PL724, PL2066, PL2067, PL575 and PL576 are shown in Table 3-18 to Table 3-23. The majority of the activities detailed in the tables are expected to be undertaken with a dive support vessel (DSV), except the complete removal of the buried pipelines, which would be undertaken by DSV and a pipelay vessel.

PL2066 ITEM	OPTION 1 COMPLETE REMOVAL	OPTION 2 LEAVE *IN SITU*
10" pipeline spool pieces between Annabel template and pipeline flange, 40m long, 50m of pipeline surface laid and 50m of pipeline to transition depth. Total 40m pipespools and 100m pipeline.	Remove. *Disconnect or cut at manifold flange and cut at pipeline flange using remotely operated cutting equipment and lift pipe to DSV. Remove remainder of pipe in 20-30m long sections (i.e. repeat 5 or 6 times). Return pipe to shore for processing.*	Remove. *As option 1.*
10" pipeline, 17.453km as length of pipeline approaches is excluded.	Remove. *Uncover the buried pipeline ahead of removal operations using mass flow excavator; recover pipelines by spooling onto to a suitable vessel such as a pipelay vessel. The vessel used would be dependent on cost, but essentially recovery works would be supported by ROVSV. A typical vessel might be able hold up to 15km of pipe at one go so would potentially need up to one additional trip to port to offload the spooled pipeline. Return pipe to shore for cutting into transportable lengths and processing.*	Leave entire pipeline *in situ* with no remedial works required.
10" flowline, 50m from transition depth, 131m surface laid connected to pipeline flange. Pipeline spool pieces between pipeline flange and Audrey A (WD) platform riser flange, 70m long. Total 70m pipespools and 181m of flowline.	Remove. *Disconnect or cut at riser flange and cut at pipeline flange using remotely operated cutting equipment and lift pipe to DSV. Remove remainder of pipe in 20-30m long sections (i.e. repeat 8-10 times). Return pipe to shore for processing.*	Remove. *As option 1.*

Table 3-18: Options for decommissioning PL2066

PL2067 ITEM	OPTION 1 COMPLETE REMOVAL	OPTION 2 LEAVE *IN SITU*
Umbilical end adjacent to Audrey B (XW) to transition depth, 42m from bottom of J-tube to TUTU 140m long on seabed, and 15m to transition depth. Total length to be removed approx. 197m	Remove. *Disconnect from TUTU on platform topsides and connect rigging to subsea end excavated at transition depth. This may also involve local water jetting. Pull section out from bottom of J-tube to deck of Dive Support Vessel or Construction Support Vessel using winch. Cut into manageable lengths using remotely operated cutting equipment. Return to shore for processing.*	*Complete removal, as option 1*
Buried umbilical from transition depth at Audrey B (XW) to start of transition on approach to Annabel manifold, approx.12.95km.	Remove. *Pull umbilical pipeline out through covered trench and onto a reel mounted on a vessel, probably a DSV. Return to shore for cutting into manageable lengths and processing.*	Leave *in situ*. No work
Transition length 15m long together with surface laid umbilical connected to SUTU Annabel manifold, 235m long. Total length to be removed approx. 250m.	Remove. *Remove concrete mattresses to expose the surface laid umbilical pipeline and excavate to transition depth. This may involve local water jetting. Cut into manageable lengths using remotely operated cutting equipment. Return to shore for processing.*	*Complete removal, as option 1*

Table 3-19: Options for decommissioning PL2067

ID[6]	PL496/7 ITEM	OPTION 1 COMPLETE REMOVAL	OPTION 2 PARTIAL REMOVAL	OPTION 3 LEAVE *IN SITU*
1	20" pipeline pipe spools (37.3m long), 3" methanol pipe spools (62m long) connected to the base of their respective risers c/w length to trench depth (100m each) at the Audrey A (WD) platform. Total to be removed approx. 137.3m (PL496) & 162m (PL497) at Audrey A (WD).	Remove. *Disconnect or cut at base of riser at Audrey A (WD) and cut as the pipelines enters the existing rock. Completely remove 20" pipeline spools using cut and lift technique and 3" flexible methanol pipe spool using remotely operated cutting equipment and lift pipe to DSV. Return pipe to shore for processing.*	Remove. *As option 1.*	Remove. *As option 1.*
2	20" pipeline and piggybacked 3" methanol pipeline, both approx.16.6km long (excluding approaches at each end).	Remove. *Uncover the buried pipeline ahead of removal operations using mass flow excavator; recover pipelines. This would mean displacing the sediment and deposited rock along the pipeline and recovering the pipeline in short 20-30m long sections using the 'cut and lift' method. Return pipe to shore for cutting into transportable lengths and processing.*	Remove. *Locate exposure sections at KP 7.06 (approx. 1m), KP7.09 (6m), KP7.11 (9m), KP7.14 (14m), KP7.16 (21m), KP7.2 (7m), KP8.2 (4m), KP11.98 (5m), KP12 (5m), KP12.02 (5m), and KP12.02 (6m). Expose end extremities using mass flow excavator or by local water jetting. Cut using remotely operated cutting equipment, and connect to winch for recovering to deck of vessel. Recover to deck of DSV and return to shore for processing. Leave remainder of pipeline in situ.*	Leave entire pipeline *in situ* with no remedial work required.
3	20" pipeline pipe spools (23m long) and 3" methanol pipe spools (50m long) c/w length to transition depth (70m each) at LOGGS PP. Total to be removed approx. 93m (PL496) & 120m (PL497).	Remove. *Disconnect or cut at base of riser at LOGGS PP and cut pipe spool as it enters the existing rock. Completely remove 20" pipeline spools using cut and lift technique and 3" flexible methanol pipe spool using remotely operated cutting equipment and lift pipe to DSV. Return pipe to shore for processing.*	Remove. *As option 1.*	Remove. *As option 1.*

Table 3-20: Options for decommissioning PL496/7

[6] Items 1 & 3 are included for completeness, although the approach will be the same for all decommissioning options being considered

ID[7]	PL575 ITEM	OPTION 1 COMPLETE REMOVAL	OPTION 2 PARTIAL REMOVAL	OPTION 3 LEAVE *IN SITU*
1	8" pipeline pipe spools connected to the Audrey 11a-7 manifold (29.5m long) and from pipe spool end down to trench depth (40m). Total to be removed approx. 69.5m, the first 39m of which lies on the seabed.	Remove. *Remove concrete mattress to expose the surface laid pipeline. Disconnect or cut at Audrey 11a-7 manifold. Completely remove 8" pipeline spools using 'cut and lift' technique using remotely operated cutting equipment and lift pipe to DSV. Return pipe to shore for processing.*	Remove. *As option 1.*	Remove. *As option 1.*
2	8" pipeline, approx. 433m long excluding pipe spools.	Remove. *Uncover the buried pipeline ahead of removal operations using mass flow excavator; and recover pipelines using the 'cut and lift' method using a vessel such as a DSV or CSV. The vessel used would be dependent on cost, but essentially recovery works would be supported by ROVSV. Return pipe to shore for cutting into transportable lengths and processing.*	Remove. *Locate exposures at approximately KP0.12 (approx.1m), KP0.27 (30m) and KP 0.49 (1m) Expose end extremities using mass flow excavator or by local water jetting. Cut using remotely operated cutting equipment, and connect to winch for recovering to deck of vessel. Recover to deck of DSV and return to shore for processing.*	Leave entire pipeline *in situ* with no remedial work required.
3	8" pipeline from trench depth to pipespools (70m), pipe spools to riser connection (29.3m) at Audrey A (WD) platform. Total to be removed approx. 99.3m, the last 39m of which lies on the seabed.	Remove. *Disconnect or cut at base of riser at Audrey A (WD) platform. Completely remove 8" pipeline spools using cut and lift technique using remotely operated cutting equipment and lift pipe to DSV. Return pipe to shore for processing.*	Remove. *As option 1.*	Remove. *As option 1.*

Table 3-21: Options for decommissioning PL575

[7] Items 1 & 3 are included for completeness, although the approach will be the same for all decommissioning options being considered

ID[8]	PL576 ITEM	OPTION 1 COMPLETE REMOVAL	OPTION 2 PARTIAL REMOVAL	OPTION 3 LEAVE *IN SITU*
1	Umbilical end adjacent to Audrey A (WD). Unburied length on seabed approx. 80m long. c/w length to trench depth approx. 40m. Total length approx. 120m.	Remove. *Disconnect from TUTU on platform topsides and connect rigging to subsea end excavated at transition depth. This may also involve local water jetting. Pull section out from bottom of J-tube to deck of Dive Support Vessel or Construction Support Vessel using winch. Cut into manageable lengths using remotely operated cutting equipment. Return to shore for processing.*	Remove*. As option 1.*	Remove*. As option 1.*
2	Partially but mostly buried umbilical pipeline, approx. 365m long if length of umbilical ends are excluded.	Remove. *Recover the buried umbilical in its entirety (that is, including the ends) by pulling up through the seabed; recover by spooling onto to a suitable vessel such as a pipelay vessel, DSV or CSV. The vessel used would be dependent on cost, but essentially recovery works would be supported by ROVSV. Return umbilical to shore for cutting into transportable lengths and processing.*	Remove. *Locate exposures at approximately KP0.12 (1m), KP0.27 (30m) and KP 0.49 (1m) Expose end extremities using mass flow excavator or by local water jetting. Cut using remotely operated cutting equipment, and connect to winch for recovering to deck of vessel. Recover to deck of DSV and return to shore for processing.*	Leave entire pipeline *in situ* with no remedial work required.
3	SUTU and umbilical end at Audrey 11a-7 manifold. Unburied length on seabed approx. 125m, c/w length to trench depth approx. 40m. Total length approx. 165m.	Remove. *Remove concrete mattress to expose the surface laid umbilical and excavate to transition depth. This may involve local water jetting. Cut into manageable lengths using remotely operated cutting equipment. Return to shore for processing.*	Remove*. As option 1.*	Remove*. As option 1.*

Table 3-22: Options for decommissioning PL576

[8] Items 1 & 3 are included for completeness, although the approach will be the same for all decommissioning options being considered

ID[9]	PL723/4 ITEM	OPTION 1 COMPLETE REMOVAL	OPTION 3 LEAVE *IN SITU*
1	14" pipeline pipe spools (45.1m long) and 3" methanol pipeline pipe spools (62m) connected to the base of their respective risers at the Audrey B (XW) platform c/w length to trench depth, 120m for each pipeline50m of which is untrenched. Total to be removed approx.165m (PL723) and 182m (PL724).	Remove. *Remove concrete mattresses and any grout bags. Disconnect or cut at base of riser at Audrey B (XW) and cut pipelines at trench depth at end of transition. Completely remove 14" pipeline spools 3" flexible methanol pipe spool using remotely operated cutting equipment and lift pipe to DSV. Return pipe to shore for processing.*	Remove*. As option 1.*
2	14" pipeline (4.3km long) and piggybacked 3" methanol pipeline (4.2km long, as length of pipeline approaches is excluded).	Remove. *Uncover the buried pipelines ahead of removal operations using mass flow excavator; recover pipelines. This would mean displacing the sediment along the pipelines and recovering the pipelines in short 20-30m long sections using the 'cut and lift' method. Return pipe to shore for cutting into transportable lengths and processing.*	Leave entire pipeline *in situ* with no remedial work required.
3	14" pipeline pipe spools (0m[10] long) and 3" methanol pipe spools (68m long) at Audrey A (WD) c/w length to transition depth, 120m for each pipeline. Total to be removed approx. 188m (PL723) and 120m (PL724).	Remove. *Remove any concrete mattresses and grout bags should they be present. Disconnect or cut at base of riser at Audrey A (WD). Completely remove 14" pipeline spools lying on seabed adjacent to original pipeline route and 3" methanol pipe spools that are still connected using remotely operated cutting equipment and lift pipe to DSV. Return pipe to shore for processing.*	Remove*. As option 1.*

Table 3-23: Options for decommissioning PL723/4

[9] Items 1 & 3 are included for completeness, although the approach will be the same for all decommissioning options being considered

[10] The pipespools @ Audrey A (WD) have already been removed to accommodate Ensign gas export pipeline. The Ensign pipelines PL2838 and PL2839 will need to be disconnected before Audrey A (WD) platform can be removed

3.5.2 Conclusion of PL2066 CA

Pipeline PL2066 is trenched and buried with no exposures reported outside of the approaches throughout the pipeline's survey history. The most recent survey data indicate that most of the umbilical is buried to more than 0.6m below seabed.

Two decommissioning options were compared for this pipeline – complete removal, and leave *in situ*. The leave *in situ* solution would involve leaving the pipeline 'as is' and monitor its burial over the foreseeable future.

Complete removal would involve exposing the pipeline using a mass flow excavator and then re-reeling the pipeline back onto a pipe lay vessel. The pipeline would need to be removed from the backfill and large quantities of rock that were deposited at the time of installation. Depending on the capacity of the pipeline reel, recovery of the pipeline may involve at least one additional trip back to shore to offload the recovered pipe. Once onshore, approximately 17.8km of pipe would need to be retrieved from the pipe reel, cut into manageable lengths and recycled.

Complete removal option would incur higher cost, unplanned risk and greater short-term impacts on the environment. Offshore there would be an increased risk to safety of personnel and planned environmental impacts associated with transferring and disposing of any recovered material onshore.

By completely removing the pipeline the risk of snagging is removed in perpetuity and therefore the complete removal option results in lower residual risks to mariners and other users of the sea. However, residual snagging hazards for the leave *in situ* option can also be considered low on the basis that the pipelines are buried.

The leave *in situ* option was found to be materially better for safety, environment, technical and cost considerations than complete removal. Although we think that residual snagging risks associated with the leave *in situ* option are likely to remain low, but legacy surveys will be required to verify this.

In conclusion, based on the comparative assessment 'leave *in situ*' is the recommended option for decommissioning the pipeline. On this basis, most of the pipeline will be left *in situ* underneath existing burial cover, but future inspections will be planned as appropriate over the near future to ensure that that pipeline does not pose a risk to other users of the sea.

3.5.3 Conclusion of PL2067 CA

Pipeline PL2067 is approximately 13.4km long and trenched and buried. The most recent survey data indicate that the majority of the umbilical is buried to more than 0.6m below seabed.

The assessment found the risks and impacts associated with the decommissioning options to be broadly acceptable for most impacts and risks except that in the complete removal option the short-term impact of decommissioning operations on SAC rises to 'tolerable' and non-preferred compared to other options.

Small differences are found between the safety assessment with more work required offshore and onshore for the complete removal than leave *in situ* and consequently higher safety risk. Conversely there would be lower safety risks to mariners arising from complete removal than for either partial removal or leave *in situ* because the pipeline would no longer be present as a potential snag hazard. However, our assessment concluded that even with the umbilical remaining *in situ* the snagging risk posed to fishermen and other users of the sea would remain low on the basis that the umbilical would remain buried.

In conclusion, based on the comparative assessment 'leave *in situ*' is the recommended option for decommissioning the pipeline. On this basis, most of the pipeline will be left *in situ* underneath existing burial cover, but future inspections will be planned as appropriate over the near future to ensure that that pipeline does not pose a risk to other users of the sea.

3.5.4 Conclusion of PL2066JW12/PL2066JWAB2 CA

PL2066JW12 is a short pipeline 34.7m long routed from Annabel AB1 to Annabel manifold located inside the Annabel template. It comprises a number of surface laid pipe spools. The pipeline is protected and stabilised using concrete mattresses. As it is surface laid, Centrica propose to fully remove this pipeline and associated stabilisation features.

PL2066JWAB2 is a short pipeline 133m long routed from Annabel AB2 to Annabel manifold located inside the Annabel template. It comprises a number of surface laid pipe spools. The pipeline is protected and stabilised using concrete mattresses. As it is surface laid, Centrica propose to fully remove this pipeline and associated stabilisation features.

3.5.5 Conclusion of PL2067JW12/PL2067JWAB2 CA

PL2067JW12 is a short electro-hydraulic jumper 88m long routed from Annabel manifold inside the template to Annabel AB1 wellhead. The pipeline is protected and stabilised using concrete mattresses. As it is surface laid, Centrica propose to fully remove this pipeline and associated stabilisation features.

PL2067JWAB2 is a short electro-hydraulic jumper 198m long routed from Annabel manifold inside the template to Annabel AB1 wellhead. The pipeline is protected and stabilised using concrete mattresses. As it is surface laid, Centrica propose to fully remove this pipeline and associated stabilisation features.

3.5.6 Conclusion of PL496/7 CA

PL496/7 is a 20” concrete coated pipeline piggybacked with a 3” methanol pipeline buried under rock for much of its length, with some short pipeline lengths exposed along the way. These exposures are outside of the current Audrey and LOGGS 500m safety zones and will already have been exposed to fishing activity in the area.

Three decommissioning options were compared for this pipeline – complete removal, partial removal and leave *in situ*. Partial removal would involve a few exposed lengths of pipeline being removed. The leave *in situ* solution could involve leaving the pipeline ‘as is’ and monitor its burial over the foreseeable future.

Complete removal would involve exposing the pipeline from under rock using a mass flow excavator and then recovering the 20” pipeline and piggybacked 3” methanol pipelines onto a suitable vessel by cutting into manageable sections and lifting. Recovery of 16.9km of pipeline – not including the length of the 3” piggybacked pipeline - would likely involve several trips back to shore to offload the recovered pipe. Once onshore, the recovered pipe would need to be retrieved from the vessel, cut into manageable lengths and recycled.

Complete removal option would incur highest cost, unplanned impacts and greater short-term impacts on the environment. Offshore there would be an increased risk to safety of personnel and planned environmental impacts associated with transferring and disposing of any recovered material to the vessel and to shore.

By completely removing the pipeline the risk of snagging is removed in perpetuity and therefore the complete removal option results in lower residual risks to mariners and other users of the sea. However, residual snagging hazards for the partial removal and leave *in situ* options can also be considered low on the basis that the pipelines are buried and stable once the exposed ends have been removed.

Although the pipeline has exposed sections of pipe along its length, the assessment found that these was little to differentiate the partial removal and leave *in situ* options, but both were found preferable to complete removal. Both options were found to be materially better for safety, environment, technical and cost considerations.

Residual snagging risks associated with the partial removal and leave *in situ* options are likely to remain low, but legacy surveys will be required in order to verify this.

Finally, there is an order of magnitude in the incremental difference in cost for complete removal versus partial removal or leave *in situ*.

In conclusion, based on the comparative assessment 'leave *in situ*' is the recommended option for decommissioning the pipeline. On this basis, the pipeline will be left *in situ* underneath existing burial cover, but future inspections will be planned as appropriate to ensure that that pipeline does not pose a risk to other users of the sea.

3.5.7 Conclusion of PL575 CA

PL575 is an 8" pipeline approximately 492m, long partly buried, and contained entirely within the Audrey A (WD) 500m safety zone. Most recent survey data indicates that there is a short exposure about mid-way along the pipeline and there are a couple of other locations where the pipeline could easily become exposed in future.

Otherwise given the short length of the pipeline the assessment found the risks and impacts associated with the decommissioning options to be broadly acceptable for all impacts.

Small differences are found between the safety assessment with more work required offshore and onshore for the complete removal than leave *in situ* and consequently slightly higher safety risk. Conversely there would be lower safety risks to mariners arising from complete removal than for leave *in situ* because the pipeline would no longer be present as a potential snag hazard. However, our assessment concluded that with the pipeline remaining there would remain a real possibility of the exposed section of pipeline being snagged because the area has not been exposed to fishing activity since the existence of the 500m safety zone.

Finally, there is a difference in cost for complete removal versus leave *in situ* but in overall terms we believe that the increase is small.

In conclusion, given the short length of pipeline and based on the comparative assessment complete removal is the recommended option for decommissioning the pipeline. This will remove the need for pipeline inspections in future and remove potential snagging hazards in perpetuity.

3.5.8 Conclusion of PL576 CA

PL576 is a power, control and chemical umbilical line approximately 650m long, partly buried, and contained entirely within the Audrey A (WD) 500m safety zone. Most recent survey data indicates that there is a short exposure about mid-way along the pipeline and there are a couple of other locations where the pipeline could easily become exposed in future.

Otherwise given the short length of the umbilical the assessment found the risks and impacts associated with the decommissioning options to be broadly acceptable for all impacts.

Small differences are found between the safety assessment with more work required offshore and onshore for the complete removal than leave *in situ* and consequently slightly higher safety risk. Conversely there would be lower safety risks to mariners arising from complete removal than for leave *in situ* because the pipeline would no longer be present as a potential snag hazard. However, our assessment concluded that with the pipeline remaining there would remain a real possibility of the exposed section of pipeline being snagged because the area has not been exposed to fishing activity since the existence of the 500m safety zone.

Finally, there is a difference in cost for complete removal versus leave *in situ* but in overall terms we believe that the increase is small.

In conclusion, given the short length of pipeline and based on the comparative assessment complete removal is the recommended option for decommissioning the pipeline. This will remove the need for pipeline inspections in future and remove potential snagging hazards in perpetuity.

3.5.9 Conclusion of PL723/4 CA

Pipeline PL723/4 is a 14” pipeline piggybacked with a 3” methanol line trenched and buried with survey data indicating no exposures outside of the approaches. The most recent survey data indicate that the majority of the umbilical is buried to more than 0.6m below seabed.

Two decommissioning options were compared for this pipeline – complete removal and leave *in situ*. The leave *in situ* solution could involve leaving the pipeline ‘as is’ and monitor its burial over the foreseeable future.

Complete removal would involve exposing the pipeline from under rock using a mass flow excavator and then recovering the 14” pipeline and piggybacked 3” methanol pipelines onto a suitable vessel by cutting into manageable sections and lifting. Recovery of 4.4km of pipeline – not including the length of the 3” piggybacked pipeline - would likely involve several trips back to shore to offload the recovered pipe. Once onshore, the recovered pipe would need to be retrieved from the vessel, cut into manageable lengths and recycled.

Complete removal option would incur highest cost, unplanned impacts and greater short-term impacts on the environment. Offshore there would be an increased risk to safety of personnel and planned environmental impacts associated with transferring and disposing of any recovered material to the vessel and to shore.

By completely removing the pipeline the risk of snagging is removed in perpetuity and therefore the complete removal option results in lower residual risks to mariners and other users of the sea. However, residual snagging hazards for the leave *in situ* option can also be considered low on the basis that the pipelines are buried and stable once the exposed ends have been removed.

Although the pipeline has exposed sections of pipe along its length, the assessment found that there was little to differentiate the partial removal and leave *in situ* options, but both were found preferable to complete removal. Both options were found to be materially better for safety, environment, technical and cost considerations.

Residual snagging risks associated with the partial removal and leave *in situ* options are likely to remain low, but legacy surveys will be required in order to verify this.

Finally, there is an order of magnitude in the incremental difference in cost for complete removal versus partial removal or leave *in situ*.

In conclusion, based on the comparative assessment ‘leave *in situ*’ is the recommended option for decommissioning the pipeline. On this basis, the pipeline will be left *in situ* underneath existing burial cover, but future inspections will be planned as appropriate to ensure that that pipeline does not pose a risk to other users of the sea.

3.5.10 Conclusion of drill cuttings piles CA

As identified in the pre-decommissioning survey report (Gardline Geosurvey, 2016c), one area of anthropogenic rock at Audrey A (WD) and one area of anthropogenic rock at Audrey B (WD) showed elevated levels of hydrocarbons and other contaminants associated with drill cuttings, with the area and levels of contamination being greater at Audrey A (WD) than at Audrey B (XW).

OSPAR Recommendation 2006/5 (OSPAR, 2006) gives recommendations for how to deal with drill cuttings, and the recommendations are divided into two stages. Stage 1 involves initial screening of all cuttings piles while stage 2 is enacted for cases where either the rate of oil loss or the persistence is above the recommended thresholds.

Where organic phase drilling fluids were used, and discharged or other discharges have contaminated the cuttings pile the rate of oil loss and the persistence over the area of seabed contaminated are assessed. The rate of oil loss is assessed on the basis of the quantity of oil lost from the cuttings pile to the water column over time in tonnes per year (tonnes/year). The persistence is assessed on the basis of the area of the seabed where the concentration of oil remains above 50mg/kg and the duration that this contamination level remains. The unit used should be square kilometre years (km^2years).

The results of this process are compared against the following two criteria:

1) Rate of oil loss to water column: 10 tonnes/year;
2) Persistence over the area of seabed contaminated: 500 square kilometre years (km^2yrs).

Where both the rate and persistence are below the thresholds and no other discharges have contaminated the cuttings pile, no further action is necessary and the cuttings pile may be left *in situ* to degrade naturally.

The survey showed the area of drill cuttings at Audrey A (WD) to cover 3,270m^2 which is 0.00327km^2 and is a thin layer with diffuse edges. The depth of the cuttings pile is estimated to be in the region of 10cm to 20cm, thinning at the edges. Therefore, the worst case total volume would be in the region of 500m^3 to 654m^3.

Assessing the cuttings pile for the first criterion, analysis of one of the samples showed a maximum total hydrocarbon content of 16,920µg/g while other samples in the region indicated values of 215µg/g. Adopting a conservative approach, assuming the whole cuttings pile is at the highest total hydrocarbon content, the total volume of hydrocarbons within the pile would be 22 tonnes assuming a specific gravity of 2 for the sediment. Using the average total hydrocarbon content (5,784µg/g) results from all stations sampled on the cuttings pile, the total volume of hydrocarbon within the pile would be 7.5 tonnes. On this basis, we believe that the rate of oil loss to water column will be less than 10 tonnes/year.

The second criterion is a measure of recovery of the area contaminated where 500km^2years is the threshold. Although the hydrocarbon content in the samples was elevated, the area of contaminated is small, using a very conservative approach a maximum of 0.00327km^2. Given the very large difference in the area impacted and the threshold area it can be concluded that the second criteria will not be exceeded.

In summary, the survey data and sample analysis shows the drill cutting contamination to be below the OSPAR thresholds. In accordance with OSPAR Recommendation 2006/5 (OSPAR, 2006) if survey data and sampling analysis from areas contaminated with drill cuttings shows the area and contamination level to below the two criteria for oil loss and area of the seabed leaving *in situ* for natural degradation is the best environmental strategy.

3.6 Summary of the Annabel and Audrey infrastructure to be removed

The Annabel and Audrey infrastructure to be removed from the seabed is detailed in Table Table 3-24 and illustrated in Figure 3-17 (Annabel) and Figure 3-18 (Audrey).

ITEM	METHOD
Annabel template	Complete removal and recovery to shore.
Annabel AB1 and AB2 WHPS	Complete removal and recovery to shore.
Audrey A (WD) and Audrey B (XW) platform and piles	Complete removal and recovery to shore. The platform piles will be cut to 3m below the seabed and removed.
Audrey A (WD) and Audrey B (XW) drilling templates and piles	Complete removal and recovery to shore. The template piles will be cut to 3m below the seabed and removed.
Audrey 11-a7 WHPS	Complete removal and recovery to shore. The WHPS piles will be cut to 0.6m below the seabed and removed. [11]
PL2066; PL2067	Removal of those sections that are not sufficiently buried. *In situ* decommissioning of those sections under sufficient and stable existing burial cover.
PL2066JW12; PL2066JWAB2; PL2067JW12; PL2067JWAB2	Complete removal and recovery.
PL496; PL497	Removal of those sections that are not sufficiently buried. *In situ* decommissioning of those sections under sufficient and stable existing burial cover.
PL575; PL576	Complete removal and recovery.
PL723; PL724	Removal of those sections that are not sufficiently buried. *In situ* decommissioning of those sections under sufficient and stable existing burial cover.
Deposited rock	Decommission *in situ.*
Concrete mattresses and grout bags	Complete removal.
Frond mattresses	Decommission *in situ.*
Audrey A (WD) and Audrey B (XW) drill cuttings piles	Decommission *in situ* for natural degradation.
Note: complete recovery implicitly implies 'recovery to shore for preferential recycling of their component materials'	

Table 3-24: Summary of Annabel and Audrey decommissioning activities

[11] The seabed is stable near the installation so we propose to cut the piles 0.6m below seabed as this is consistent with a typically acceptable pipeline depth of burial.

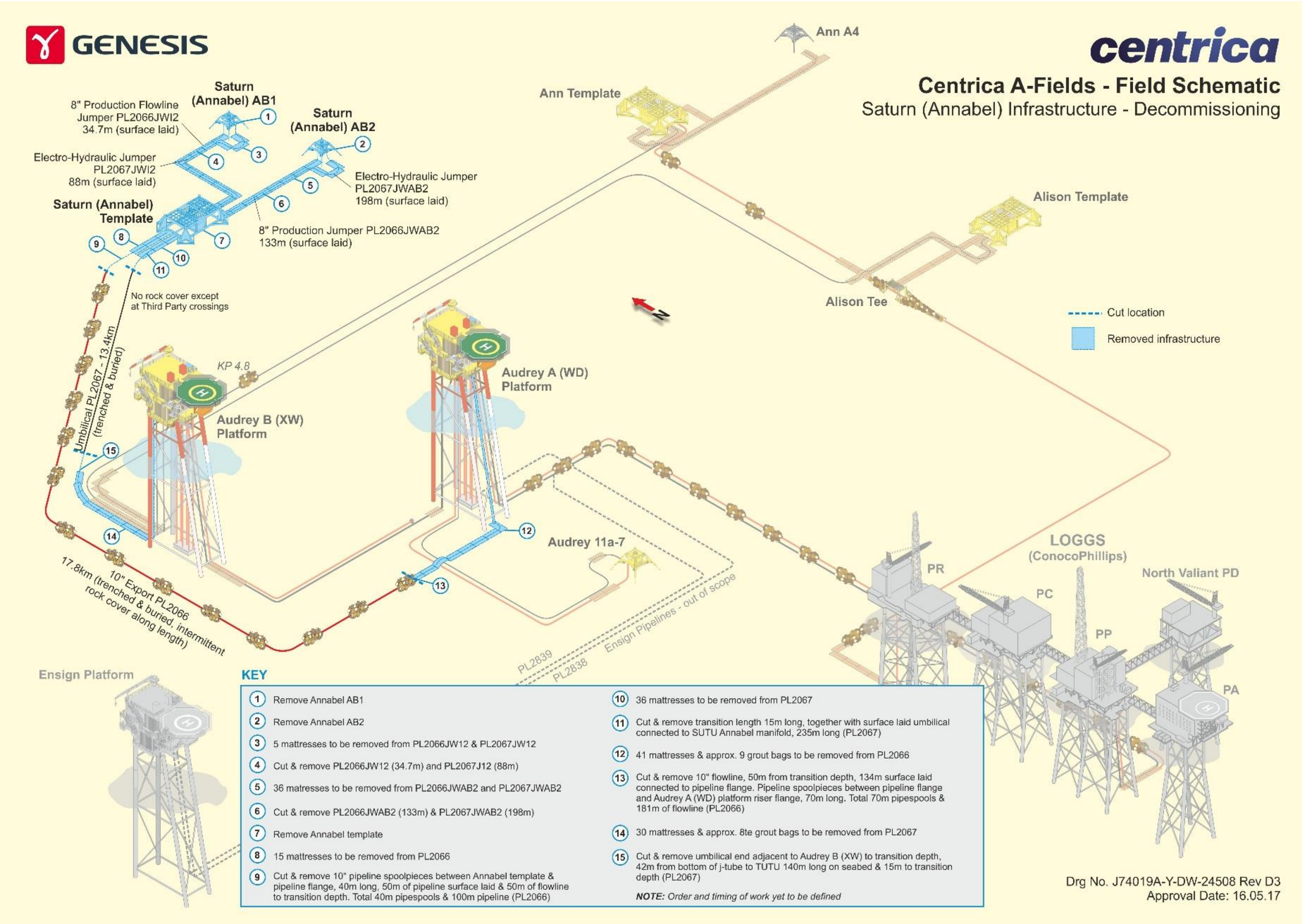


Figure 3-17: Annabel infrastructure to be removed from the seabed

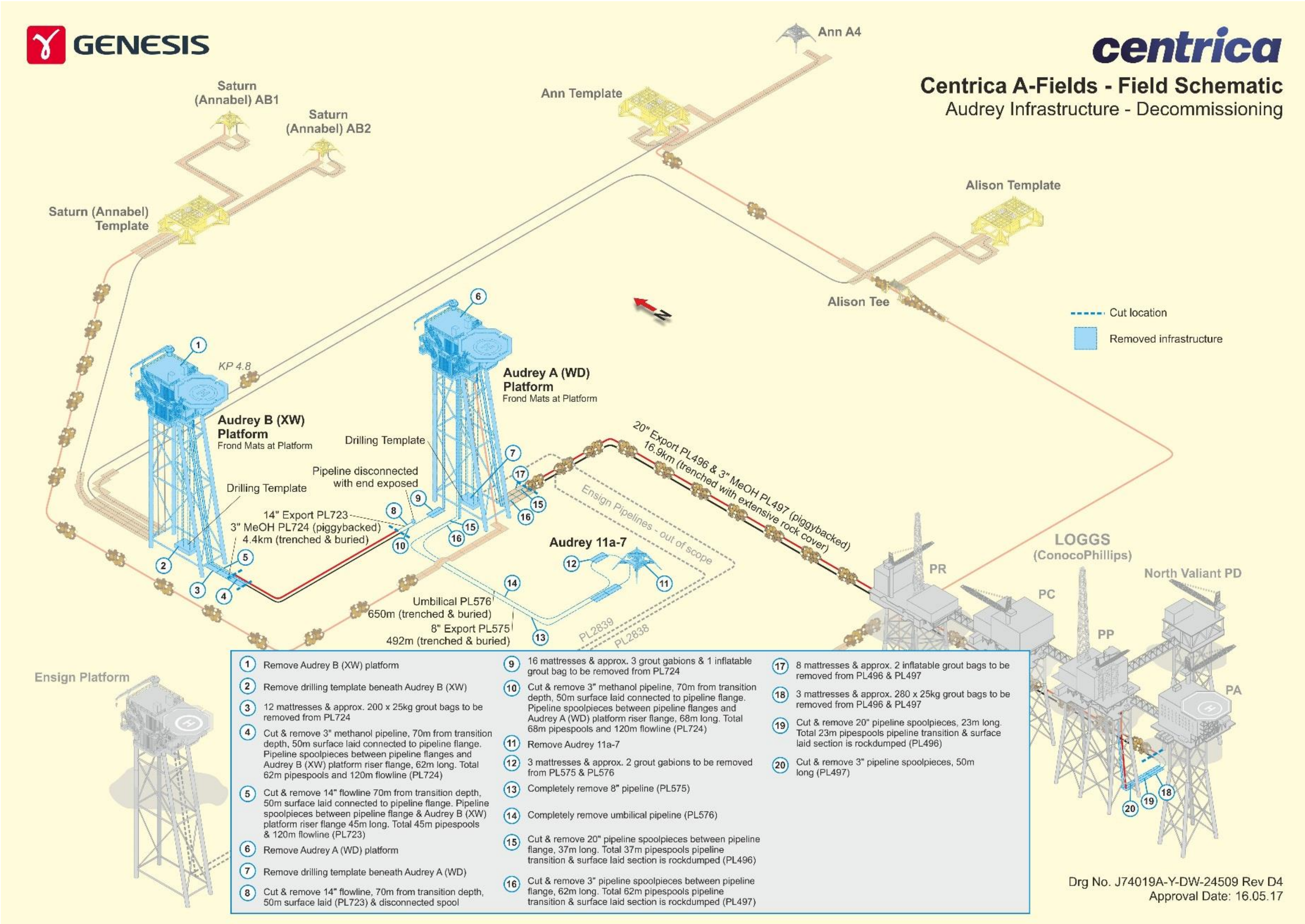


Figure 3-18: Audrey infrastructure to be removed from the seabed

3.7 Summary of principal planned decommissioning activities

3.7.1 Offshore

The following specific decommissioning activities are currently anticipated. Each, in conjunction with the chosen offshore contractor, will be confirmed during the projects detailed design and execution process.

3.7.1.1 General (in support of all execution decommissioning activities)

- Use of vessels for the deployment of specialist subsea tools; the lifting (removal) from the seabed, and the transport (recovery) to shore, of infrastructure and materials; and for surveying; and
- Positioning of vessels e.g. use of dynamic positioning (DSV) or anchor systems (heavy lift vessel).

3.7.1.2 Removal and recovery of installations

Subsea installations (the Annabel template, and the Annabel AB1, Annabel AB2 and Audrey 11a-7 WHPSs) will be completely removed from the seabed using specialist tools and lifting apparatus deployed from a surface vessel, and recovered to shore. The template and WHPSs will, following reconditioning, preferentially be re-used in accordance with the waste hierarchy. To facilitate removal, the top sections of the Audrey 11a-7 WHPS's foundation piles will require to be removed to a depth of 0.6m below the seabed[12] and, in not being suitable for re-use, will have their component material (steel) recycled. If re-use of an installation is not possible, following onshore disassembly, its component materials (predominantly steel) will, where possible, be recycled. Non-recyclable materials will, as a last resort, be disposed of to landfill.

Surface installations (the Audrey platforms including drilling templates) will be completely removed from the seabed using specialist tools and lifting apparatus deployed from a surface vessel, and recovered to shore. To facilitate their removal, the top section of the platforms jackets' and drilling templates' foundation piles will be removed to a depth of 3m below the seabed. The majority of the component materials of the platforms and templates comprise steel and, following disassembly, these, along with the piles (wholly comprised of steel) will be recycled in accordance with the waste hierarchy. Non-recyclable materials, as a last resort, will be disposed of to landfill.

In summary:

- Preparatory mechanical disconnection (using an unbolting or cutting tool) of any pipelines or umbilicals from the subsea or surface installation;
- Mechanical cutting of any installation piles and pile sleeves internally (within the pile) to disconnect them from the seabed;
- Lifting of the installation, either whole or in parts, by and to, a surface vessel; and
- Local (as required) excavation of sediment or clearance of marine growth to permit access to the installation's surfaces for the attachment of lifting loops or slings, or to permit access to existing lifting loops, bolt heads etc.

[12] The seabed is stable near the installation so we propose to cut the piles 0.6m below seabed as this is consistent with a typically acceptable pipeline depth of burial.

3.7.1.3 Complete removal and recovery of protection and stabilisation features

Where both their access and condition safely allows, pipeline (including spool pieces) and umbilical protection and stabilisation features including concrete mattresses and grout bags, but excluding frond mattresses and deposited rock, will be completely removed from the seabed using specialist tools and lifting apparatus deployed from a surface vessel, and recovered to shore for preferential re-use in accordance with the waste hierarchy. If re-use is not possible, following onshore disassembly, their component materials (concrete, steel, and plastic) will preferentially be recycled. Non-recyclable materials, as a last resort, will be disposed of to landfill.

Deposited rock and frond mattresses will be decommissioned *in situ,* on or within the seabed.

In summary:

- Lifting of features by, and to, a surface vessel either individually and directly, or in batches following their temporary seabed placement within a basket; and
- Local (as required) excavation of sediment or clearance of marine growth for general de-burying of features, and to permit access to the feature's surfaces for the attachment of lifting loops or slings, or to permit access to the installation's existing lifting loops etc.

3.7.1.4 Decommissioning of cuttings piles

The cuttings pile at Audrey A (WD) and the cuttings pile at Audrey B (XW) will be decommissioned *in situ.*

3.7.1.5 Removal and recovery of pipelines (including spool pieces)

The Annabel spool piece pipeline sections (PL2066JW12 and PL2066JWAB2) are surface laid and will be completely removed from the seabed using specialist tools and lifting apparatus deployed from a surface vessel. The spool pieces will be mechanically disconnected into manageable lengths either by unbolting at existing flange connections, or by cutting at required locations, and recovered to shore.

The Audrey 11a-7 pipeline (PL575) is trenched and buried and will be completely removed from the seabed using specialist tools and lifting apparatus deployed from a surface vessel. The pipeline will be cut at required locations, and recovered to shore.

Those sections of the Annabel pipeline (PL2066), the Audrey B (XW) to Audrey A (WD) pipeline (PL723) and associated methanol line (PL724), and the Audrey A (WD) to LOGGS pipeline (PL496) that make the transition from full burial to the seabed surface, that rest on the seabed, or which have a 'not stable' burial status will be removed (the remaining sections of these pipelines will be decommissioned *in situ*). Two basic removal methods are being considered: 'cut and lift' and 'reverse installation'.

Cut and lift

The sections requiring removal will be mechanically disconnected into manageable lengths using either an unbolting tool (at existing flange connections) or a cutting tool (at designated locations) deployed from a surface vessel. These sections will then be removed from on or within the seabed using specialist lifting apparatus deployed by the same vessel, and recovered to shore.

Reverse installation

Each end of the section requiring removal will be mechanically disconnected either by unbolting at existing flange connections, or by cutting at the designated location using specialist tools deployed from a surface vessel. The vessel, after attaching a line to one end, will then winch and reel the section to the surface as a continuous length while simultaneously moving forward over the seabed at the same rate as which the pipeline is being retrieved. The spooled pipeline will then be recovered to shore by the surface vessel.

Following onshore disassembly, the component materials (steel, concrete, and plastic) of all recovered pipelines (including spool pieces) will, where possible, be recycled in accordance with the waste hierarchy. Non-recyclable materials, as a last resort, will be disposed of to landfill.

Access to spool piece flange connections (for unbolting) or to the pipeline or spool piece circumference (for external cutting) may require the deployment of water jetting or suction tools to locally excavate (displace) sediment, or to locally remove marine growth. The excavations containing the cut ends of the sections that will be subject to *in situ* decommissioning will be left to naturally back fill with sediment.

In summary:

- Local (as required) excavation of sediment at required cut locations to permit access to the pipeline or spool piece circumference for the unbolting or cutting tool;
- Local (as required) excavation of sediment along sections of pipeline (de-burial) in preparation for lifting;
- Mechanical disconnection (using an unbolting or cutting tool);
- Cut and lift: Lifting of cut lengths of pipeline or spool piece from on, or within, the seabed by, and to a surface vessel either individually and directly, or in batches following their temporary seabed placement within a basket; and
- Reverse installation: Lifting of sections of pipeline from on, or within, the seabed by, and to a surface vessel as a continuous length.

3.7.1.6 Removal and recovery of umbilicals (including jumpers and bundles)

The Annabel umbilical jumper (PL2067JW12) and umbilical bundle (PL2067JWAB2) are surface laid and will be removed from the seabed using specialist tools and lifting apparatus deployed from a surface vessel. The umbilical jumper and the umbilical bundle will be mechanically disconnected into manageable lengths either by unbolting at existing flange connections, or by cutting at designated locations, and recovered to shore.

The Audrey 11a-7 umbilical (PL576) is trenched and buried and will be completely removed from the seabed using specialist tools and lifting apparatus deployed from a surface vessel. It will be removed in a similar manner as that described below for the Annabel umbilical (without however being cut), and recovered to shore.

Those sections of the Annabel umbilical (PL2067) that make the transition from full burial to the seabed surface, and those that rest on the seabed will be removed (the remaining sections of the umbilical will be decommissioned *in situ*). Two basic removal methods are being considered: ‘cut and lift’ and ‘reverse installation’.

Cut and lift

The sections requiring removal will be cut into manageable lengths using a specialist tool and removed from on, or within, the seabed using specialist lifting apparatus (each tool being deployed from a surface vessel) and recovered to shore.

Reverse installation

Each end of the section requiring removal will be cut using a specialist tool deployed from a surface vessel. The vessel, after attaching a line to one end, will then winch and reel the section to the surface as a continuous length while simultaneously moving forward over the seabed at the same rate as which the pipeline is being retrieved. The spooled pipeline will be recovered to shore by the surface vessel.

Following onshore disassembly, the component materials (predominantly steel and plastic) of all recovered umbilicals (including jumpers and bundles) will, where possible, be recycled in accordance with the waste hierarchy. Non-recyclable materials, as a last resort, will be disposed of to landfill.

Access to the circumference of the umbilicals (including jumpers and bundles) for disconnection may require the deployment of water jetting or suction tools from the vessel to locally excavate (displace) sediment, or to locally remove marine growth. The excavations containing the cut ends of the sections that will be subject to *in situ* decommissioning will be left to naturally back fill with sediment.

In summary:

- Local (as required) excavation of sediment at required cut locations to permit access to the umbilical and umbilical jumper/bundle circumference for the unbolting or cutting tool;
- Local (as required) excavation of sediment along sections of the umbilical (de-burial) in preparation for lifting;
- Mechanical disconnection (using an unbolting or cutting tool);
- Cut and lift: Lifting of cut lengths of umbilical or umbilical jumper/bundle from on, or within, the seabed by, and to a surface vessel either individually and directly, or in batches following their temporary seabed placement within a basket; and
- Reverse installation: Lifting of sections of umbilical from on, or within, the seabed by, and to a surface vessel as a continuous length

3.7.1.7 Surveys

The following types of survey will require to be undertaken:

- Visual debris survey using the DSV or CSV;
- Seabed ‘over-trawl’ assessment using a fishing vessel; and
- Depth of burial, and
- Seabed environmental surveys using a survey vessel.

3.7.2 Onshore

3.7.2.1 Processing and management of recovered materials; use of services

- The onshore transport and light processing (cleaning, cutting, crushing etc. but excluding recycling) of recovered materials at a shore base by a variety of plant and equipment in preparation for their preferential re-use, recycling, or as a last resort, disposal to landfill; and
- Use of miscellaneous services.

3.8 Vessel use

Offshore decommissioning activities will take place in four principal geographical areas, and under two principal operational modes, namely:

- At, and in the vicinity of, Annabel Field, the Audrey platforms, Audrey 11-a7 WHPS and the LOGGS platform complex; vessel supported subsea operations predominantly in relation to removal and recovery of the pipeline (including spool pieces) and umbilical sections, concrete mattresses and grout bags; and

- Along the length of the Audrey A (WD) gas export line (PL496), the Annabel gas export line (PL2066), the Audrey 11-a7 export line (PL575) and the Audrey A (WD) to Audrey B (XW) export line (PL723) – vessel operations predominantly in relation to surveying and monitoring.

A range of specialist and support vessel types (e.g. DSV, Construction Support Vessel (CSV), survey vessel) will be required at various times, and for various durations, to undertake particular component activities of the offshore decommissioning programme. The fuel consumption rate of the generic vessel types required to execute the work programme are understood which, in conjunction with the anticipated vessel schedule, has allowed fuel consumption to be calculated (Table 3-25).

The Institute of Petroleum (IoP, now the Energy Institute) Guidleines for calculating estimates of energy use and emissions for decommissioning have been used to inform this assessment (IoP, 2000). Estimates of fuel use are based on IoP Guidelines. The durations given allow for transit to and from the site as well as the operations. The vessel durations given are worst case estimates.

VESSEL				FUEL USAGE (Te)		
TYPE	DURATION (Days)					
	Annabel	Audrey	Total	Annabel	Audrey	Total
Heavy Lift Vessel (HLV)	0	55	55	0	1,375	1,375
DSV, CSV	104	98	202	1,456	1,372	2,828
Burial Survey Vessel	12	8	20	258	172	430
Environmental Survey Vessel	8	10	18	172	215	387
Fishing Vessel	11	16	27	44	64	108
TOTAL			**322**			**5,128**

Table 3-25: Vessel requirements for the Annabel and Audrey decommissioning scope including legacy surveys

3.8.1 Surveys

When all infrastructure and materials have either been removed or decommissioned *in situ*, a series of surveys will be undertaken.

The DSV or CSV will undertake a seabed debris survey. When any identified debris has been removed, a seabed 'over-trawlability' assessment using a fishing vessel will be undertaken. When this assessment has been completed to its satisfaction, the NFFO will issue a Clear Seabed Certificate. Pipeline and umbilical burial status, and environmental surveys will also be undertaken using a survey vessel. The results of these surveys will inform both the project Close-out report and the requirements for future 'legacy' burial status and environmental monitoring.

While the exact timing and extent of required 'legacy' monitoring will be agreed with the BEIS for the purpose of this EIA two such rounds have been assumed. The estimates of survey vessel days used in Table 3-25 are based upon this requirement and allow for both vessel mobilisation and demobilisation. It should be noted however that legacy monitoring of decommissioned Annabel and Audrey Field infrastructure will be undertaken in combination with other Centrica surveying requirements at the time in the SNS and that actual required vessel days are likely to be lower.

3.9 Management of waste and recovered materials

Recovered materials will be returned to a shore base for initial laydown.

All sites and waste carriers will have appropriate environmental and other operating licences in order to carry out this work and will be closely managed within contractor assurance processes.

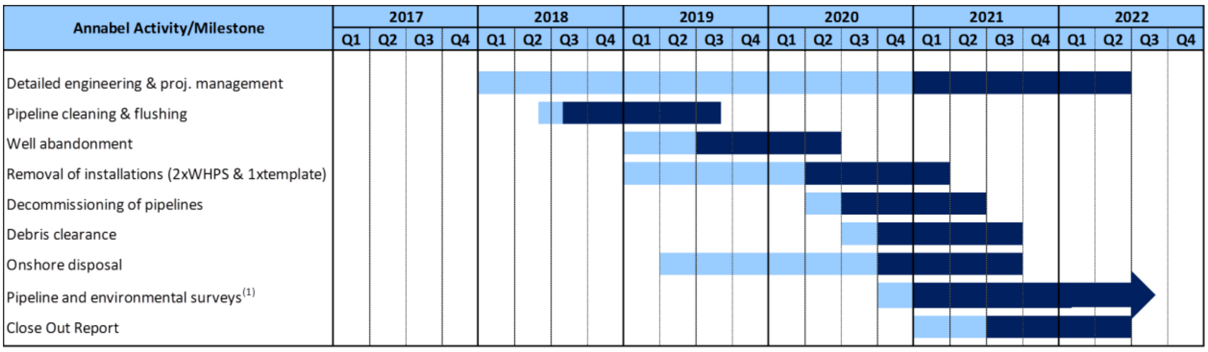
Non-hazardous material includes scrap metals (steel, aluminium and copper), concrete and plastics that are not cross-contaminated with hazardous material. Hazardous materials will include oil contaminated materials and chemicals. A small amount of asbestos may be on the Audrey topsides.

Many types of hazardous waste generated during decommissioning are routinely generated during production and maintenance of offshore installations. However, the decommissioning process may generate significantly greater quantities of both non-hazardous and hazardous waste when compared to routine operations and as such requires appropriate management.

Pipework that has been exposed to produced fluids may be contaminated by Naturally Occurring Radioactive Material (NORM). Centrica holds a permit issued by the Environment Agency allowing it to accumulate and dispose of radioactive waste containing NORM in the form of solid waste arising from the production of oil and gas at its Annabel and Audrey Fields. The permit limits the amount of solid radioactive waste that can be held on site at any one time, and requires solid wastes to be disposed of within certain time limits by transfer to operators who are themselves permitted to receive and dispose of these wastes.

3.10 Decommissioning schedule

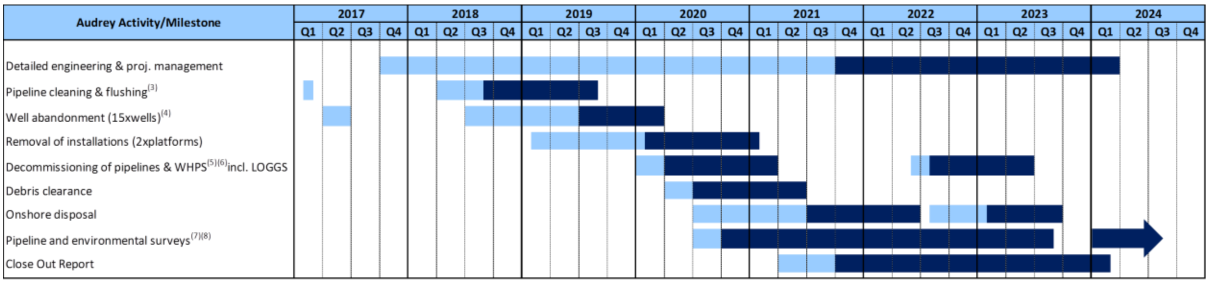
The proposed schedule for the Annabel and Audrey Fields decommissioning is shown in Table 3-26 and Table 3-27. The proposed schedule for the other A-Fields decommissioning (Ann and Alison Fields) which are not considered within this EIA are shown in Table 3-28 for reference and in order that cumulative environmental impacts of the decommissioning of the Annabel and Audrey Fields may be considered.



Notes / Key

1. Earliest potential activity
2. Activity window to allow commercial flexibility associated with well abandonment, installation and pipeline decommissioning activities
3. First Decommissioning survey and environmental survey; timing of any future surveys to be agreed with BEIS
4. Decommissioning of pipelines will be subject to Comparative Assessment

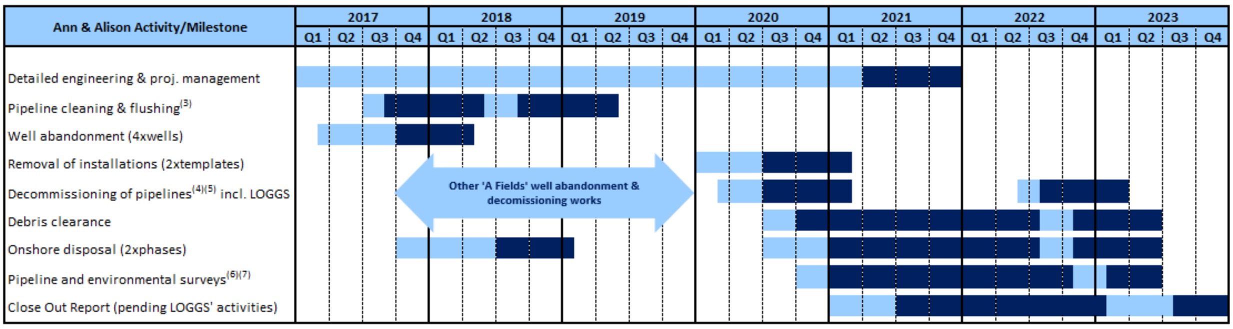
Table 3-26: Proposed Annabel Field decommissioning schedule



Notes / Key

1. Earliest potential activity
2. Activity window to allow commercial flexibility associated with well abandonment, installation and pipeline decommissioning activities
3. Audrey 11a-7 pipeline flushing in 2017 campaign, remaining pipelines in second campaign
4. Audrey 11a-7 subsea well in 2017 campaign, platform wells in second campaign
5. Decommissioning of pipelines subject to Comparative Assessment and in same subsea campaign as removal of WHPS
6. There may be an opportunity to decommission the pipeline ends at LOGGS concurrently with other decommissioning works, subject to agreement
7. Post decommissioning survey and environmental survey; timing of any future surveys to be agreed with BEIS
8. Timing and any synergistic opportunities to be explored for post-decomissioning survey at LOGGS if completion of activities as a whole are delayed

Table 3-27: Proposed Audrey Field decommissioning schedule



Notes / Key

1. Earliest potential activity
2. Activity window to allow commercial flexibility associated with well abandonment, installation and pipeline decommissioning activities
3. Pipeline PL947 flushing in 2017 campaign, pipeline PL948 and PL1099 flushing in 2018 campaign
4. Decommissioning of pipelines subject to Comparative Assessment
5. There may be an opportunity to decommission the pipeline ends at LOGGS concurrently with other decommissioning works, subject to agreement
6. Post decommissioning survey and environmental survey; timing of any future surveys to be agreed with BEIS
7. Timing and any synergistic opportunities to be explored for post-decomissioning survey at LOGGS

Table 3-28: Proposed Ann and Alison Fields decommissioning schedule

4. ENVIRONMENTAL BASELINE

This section provides an overview of the key environmental features in the vicinity of the Annabel and Audrey infrastructure. The sensitivities in the location and the surrounding area that may be affected by the proposed decommissioning works are identified which the includes the area along the pipeline routes and the area around the LOGGS platform complex. The information will be used to assess the level of impact that the aspects (activities with the potential to impact the environment) have on the environment.

4.1 Environmental surveys

A number of surveys have been undertaken in the vicinity of the Annabel and Audrey infrastructure and the wider A-Fields area prior to decommissioning. These surveys, which are detailed in Table 4-1 inform the environmental baseline and the impact assessment.

Geophysical data were acquired across the Audrey A (WD), Audrey B (XW), Annabel and LOGGS survey areas utilising Side Scan Sonar (SSS), Single Beam Echo Sounder (SBES) and Multibeam Echo Sounder (MBES) to accurately confirm water depths and seabed material, and to locate and identify any environmental habitats, seabed features or debris.

Seabed sampling was conducted with a double van Veen grab (2 x 0.1m^2). Four samples were acquired from two deployments at each station; one sample was retained for physico-chemical sub-sampling and three samples retained and screened through a 0.5mm mesh size sieve to provide benthic macrofaunal samples.

Figure 4-1 shows the extent of the pre-decommissioning survey coverage within the A-Fields areas. The results and the location of sampling locations are discussed in more detail in the relevant sections.

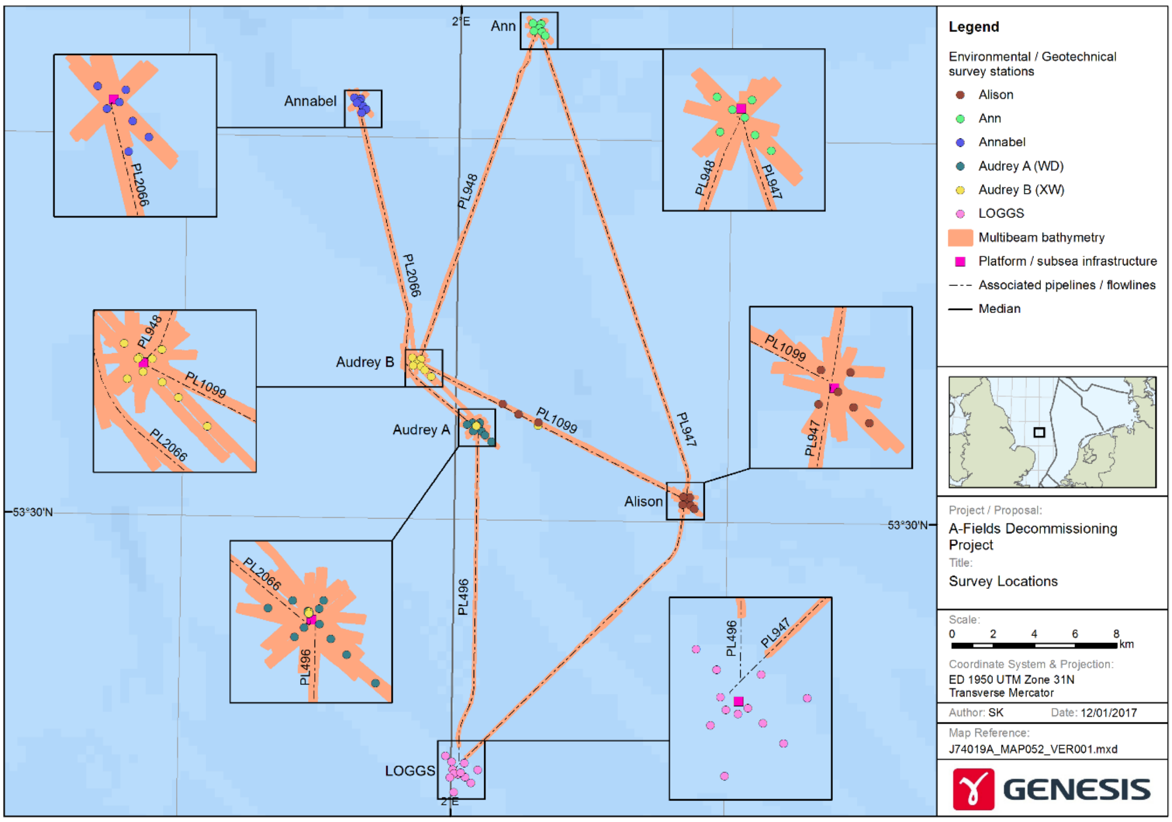


Figure 4-1: Pre-decommissioning survey coverage of the A-Fields

TITLE	SURVEY COMPONENTS	REFERENCE
Ann Pre-decommissioning Survey	Geophysical seabed survey at Ann and pipeline/umbilical status and seabed surveys along PL947, PL948, PL2164 and PL2165 including mattressing status assessments (with remotely operated vehicle (ROV) visuals). Habitat assessment and environmental baseline site survey at Ann.	Gardline Geosurvey Ltd, (2016a)
Alison Pre-decommissioning Survey	Geophysical seabed survey at Alison and pipeline/umbilical status and seabed surveys along PL1099 and the tie in line to Tee including mattressing status assessments (with ROV visuals). Habitat assessment and environmental baseline site survey at Alison and along PL1099 (KP4.3 – KP6.8).	Gardline Geosurvey Ltd, (2016b)
Audrey A (WD) to Audrey B (XW) Pre-decommissioning Survey	Geophysical seabed survey at Audrey A (WD) and Audrey B (XW) and pipeline/umbilical status and seabed surveys along PL496, PL497, PL575, PL576, PL723 and PL724 including mattressing status assessments (with ROV visuals). Habitats assessment and environmental baseline at Audrey A (WD) and Audrey B (XW). Drill cuttings pile survey.	Gardline Geosurvey Ltd, (2016c)
Annabel Pre-decommissioning Survey	Geophysical seabed survey at Annabel and pipeline/umbilical status and seabed surveys along PL2066 and PL2067 including mattressing status assessments (with ROV visuals). Habitat assessment, environmental baseline and herring spawning ground assessment at Annabel.	Gardline Geosurvey Ltd, (2016d)
SNS Decommissioning Survey LOGGS Hub, Mimas MN, Ganymede ZD, South Valiant TD and Europa EZ Habitat Assessment Report	Geophysical data were acquired across all five areas (LOGGS Hub, Mimas MN, Ganymede ZD, South Valiant TD and Europa EZ platforms) utilising SSS and (MBES to accurately confirm water depths and seabed material and to locate and identify any environmental habitats, seabed features or debris.	Gardline Environmental Limited (2015a),
SNS Decommissioning Survey LOGGS Gas Fields (LOGGS Hub, Mimas MN, Ganymede ZD, South Valiant TD and Europa EZ) Pre-decommissioning Survey Report	The objective was to obtain baseline physico-chemical and faunal data around the LOGGS Hub, Mimas MN and Ganymede ZD installations, prior to decommissioning. No environmental sampling or imagery work was undertaken in the South Valiant TD or Europa EZ survey areas. Geophysical data were acquired across all five areas utilising SSS, single bean echo sounder (SBES) and MBES to accurately confirm water depth and seabed material, and to locate and identify any environmental habitats, seabed features or debris.	Gardline Environmental Limited, (2015b)

Table 4-1: Pre-decommissioning surveys in the vicinity of the A-Fields

Annabel

Six environmental stations (ENV14 to ENV19) were pre-selected by Centrica, arranged in an approximate cruciform pattern, offset at various distances from the Annabel template, up-current, down-current and cross-current relative to the primary tidal current direction. After review of the geophysical data an additional station (Station ENV48) was selected to investigate an area of higher reflectivity in SSS data as part of the herring spawning ground assessment (Figure 4-2) (Gardline Geosurvey Ltd, 2016d).

Audrey A (WD) platform and Audrey 11a-7 WHPS

13 environmental stations ENV20 to ENV32 were pre-selected by Centrica. Of the selected stations, Stations ENV20, ENV21, ENV22 were situated on a suspected drill cuttings pile (Figure 4-3) (Gardline Geosurvey Ltd, 2016c).

Audrey B (XW) platform

11 environmental stations ENV33 to ENV43 were pre-selected by Centrica with ENV33, ENV34 and ENV35 situated on a suspected drill cuttings pile (Figure 4-4). These station locations were amended after review of geophysical survey data notably with the replacement of Station ENV35 which was selected too close to the Audrey B (XW) platform (59m north-north-west) and was cancelled in the field, and another Station ENV47 was selected slightly further afield (73m north-west of Audrey B (XW)) (Figure 4-4) (Gardline Geosurvey Ltd, 2016c).

The LOGGS platform complex

Geophysical data were acquired utilising SBES and SSS. These data covered an area of 2km x 2km at each installation surveyed (Gardline Environmental Limited, 2015a). A total of 11 environmental stations were sampled around the LOGGS platform complex (Figure 4-5).

4.2 Metocean conditions

In order to design, operate and decommission offshore installations in a safe and efficient manner, it is essential to have a good understanding of the metocean (meteorological and oceanographic) conditions to which the installation may be exposed. Sediment type, currents, tides and circulation patterns all influence the type and distribution of marine life in an area. Metocean conditions also influence the behaviour of emissions and discharges (including spills) from offshore facilities. For example, the speed and direction of water currents have a direct effect on the transport, dispersion and ultimate fate of any discharges from an installation while sediment type can influence the levels of contaminants that may be retained in an area.

4.2.1 Bathymetry

Annabel

The natural seabed within the survey area at Annabel is almost flat with water depths ranging from 27.5m LAT in the north-north-east (175m north-north-east of Annabel) to 27.0m LAT in the south-east Figure 4-2). In the immediate vicinity of the Annabel manifold, the water depth averages 27.0m LAT.

Audrey A (WD) platform and Audrey 11a-7 WHPS

At Audrey A (WD), the natural seabed is smooth with insignificant bedforms and a depth of *c.*26m LAT, with the platform lying in a shallow depression (Figure 4-3). Bedforms increase in size and frequency towards the north-west where low sandwaves and megaripples are present and water depth reach a minimum of 22.4m LAT on the crest of a sand wave, which has a south-east facing lee slope indicating a net south-easterly sediment transport direction (Gardline Geosurvey Ltd, 2016c).

Audrey B (XW) platform

The Audrey B (XW) platform lies at the end of the Swarte Bank (Figure 4-28) one of the sandbanks in the North Norfolk Sandbanks and Saturn Reef SAC (Section 4.5.1.1). At Audrey B (XW), the natural seabed is almost flat, lying at a depth of *c.*24.5m LAT. The platform lies in a trough, midway between two large south-west, north-east trending sandwaves with south-east facing lee slopes (Figure 4-4). The sandwave crests lie at water depths of 21-22m, standing 1.5-2m above the local seabed level. Between the major sandwaves, the seabed shows numerous megaripples. These are less than 0.5m high and are particularly insignificant in the immediate area of Audrey B (XW) (Gardline Geosurvey Ltd, 2016c).

The LOGGS platform complex

The LOGGS platform complex lies at the end of Broken Bank (Figure 4-28) another of the sandbanks in the North Norfolk Sandbanks and Saturn Reef SAC (Section 4.5.1.1). Depths at the LOGGS platform complex surveyed in 2015 ranged from *c*.12.5m LAT in the south-east, to *c.*28.4m LAT in the north-east (Figure 4-5). In the central and western regions of the surveyed area, the seabed was characterised by north-east to south-west orientated sandwaves with a maximum height of 7.6m and an average wavelength of *c*.175m (Gardline Environmental Limited, 2015a).

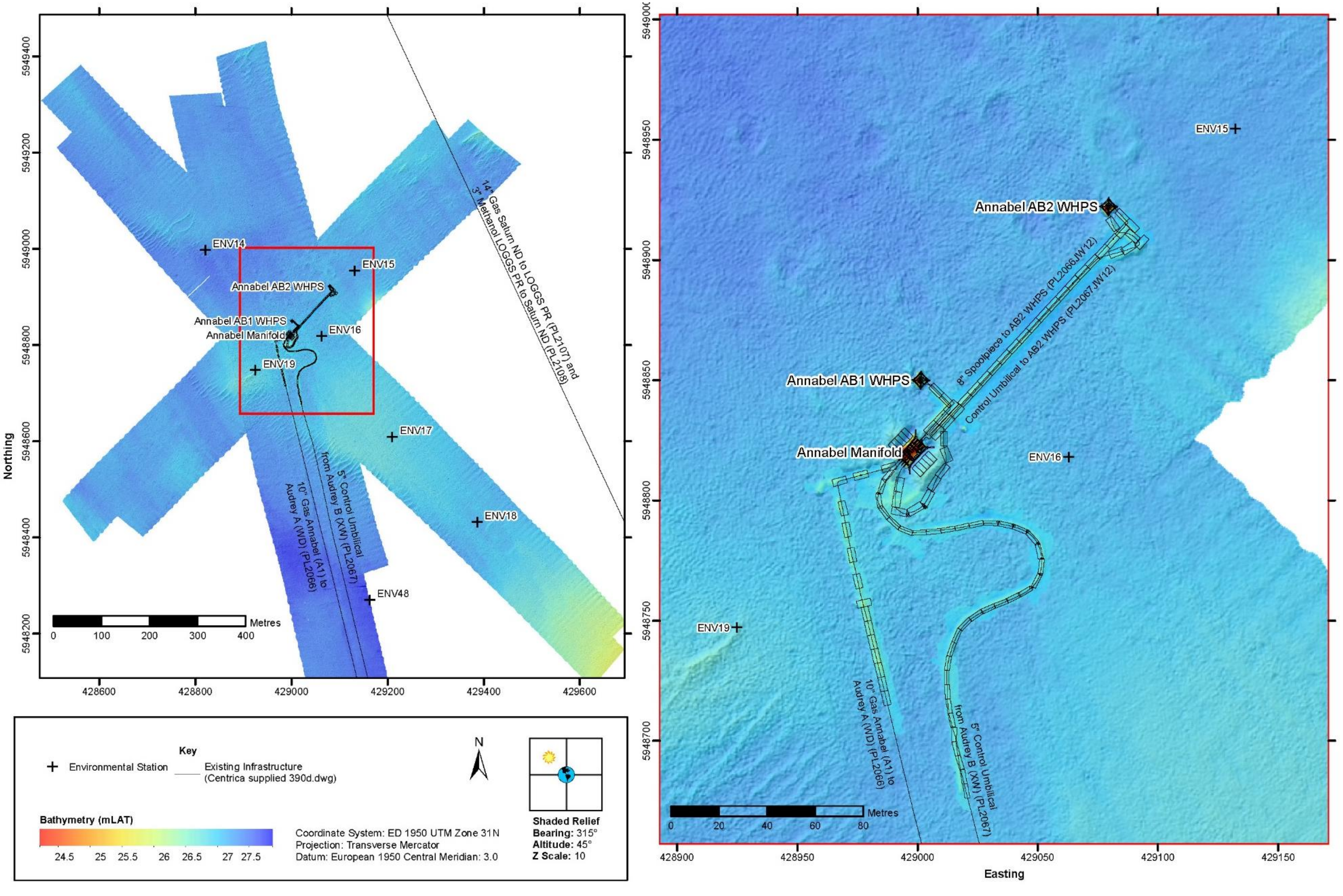


Figure 4-2: Colour shaded relief of bathymetry at the Annabel Field. Environmental sampling locations are also shown

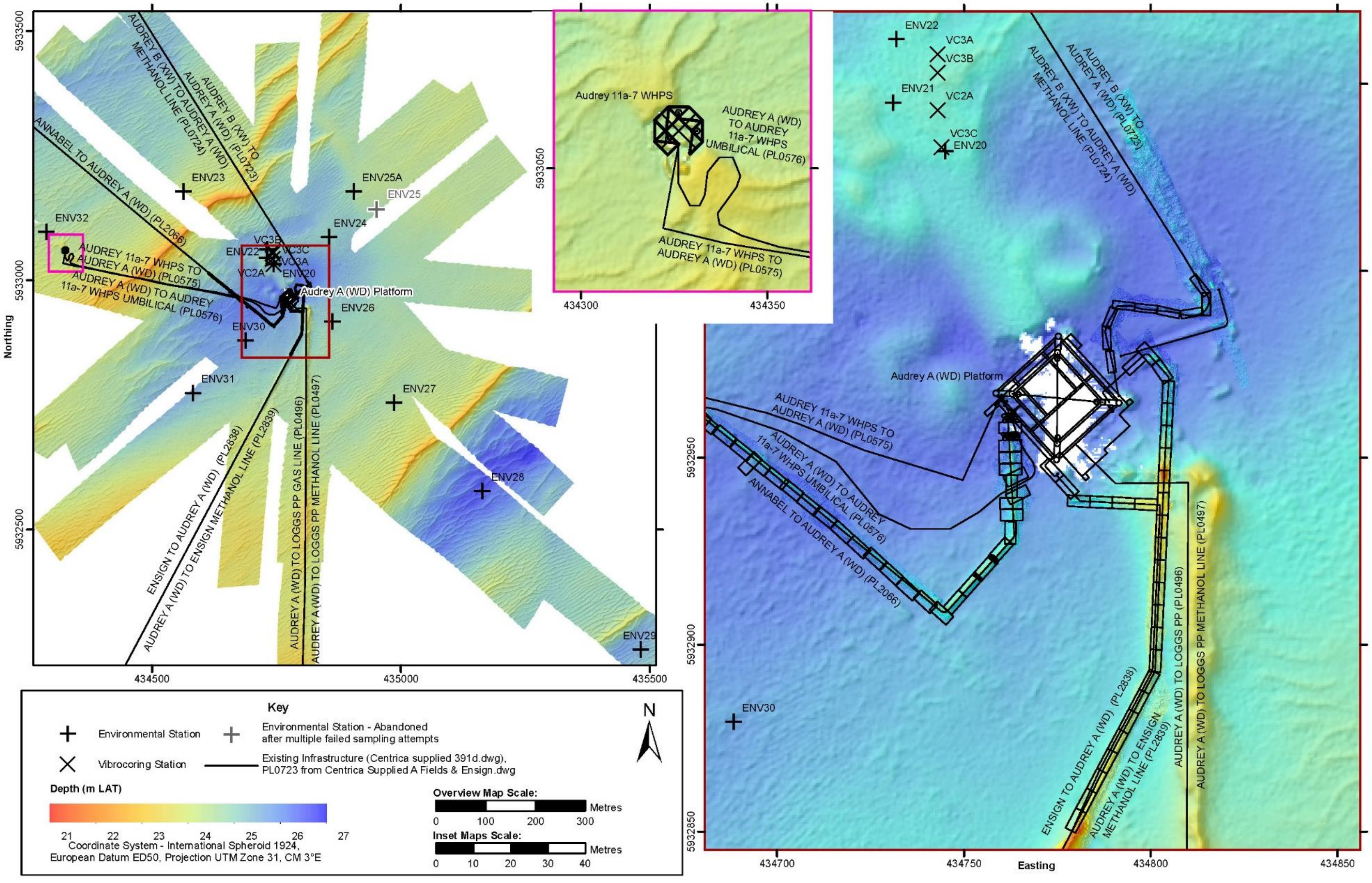


Figure 4-3: Colour shaded relief of bathymetry at the Audrey A (WD) platform and Audrey 11-a7 WHPS. Environmental sampling locations are also shown

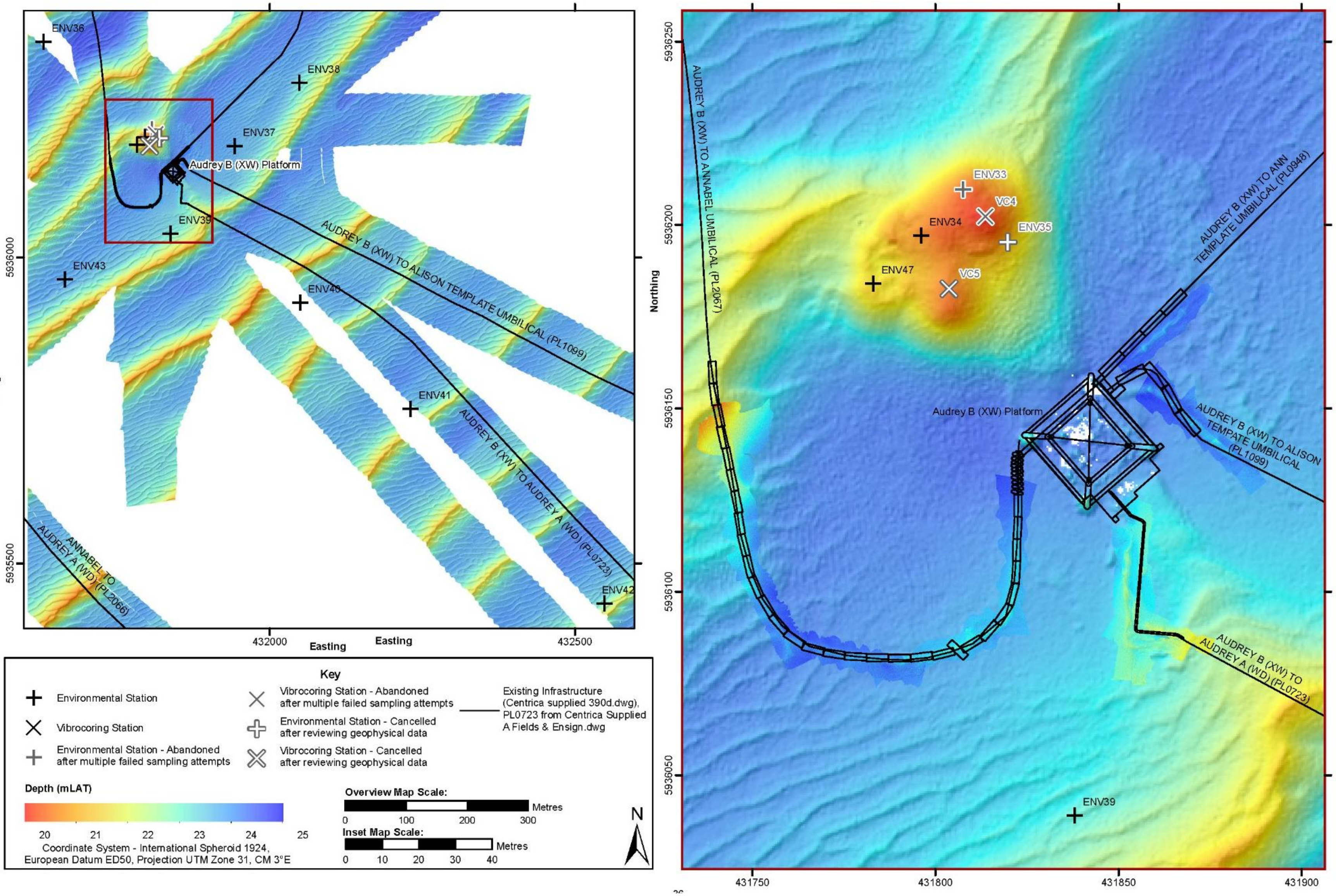


Figure 4-4: Colour shaded relief of bathymetry at the Audrey B (XW) platform. Environmental sampling locations are also shown.

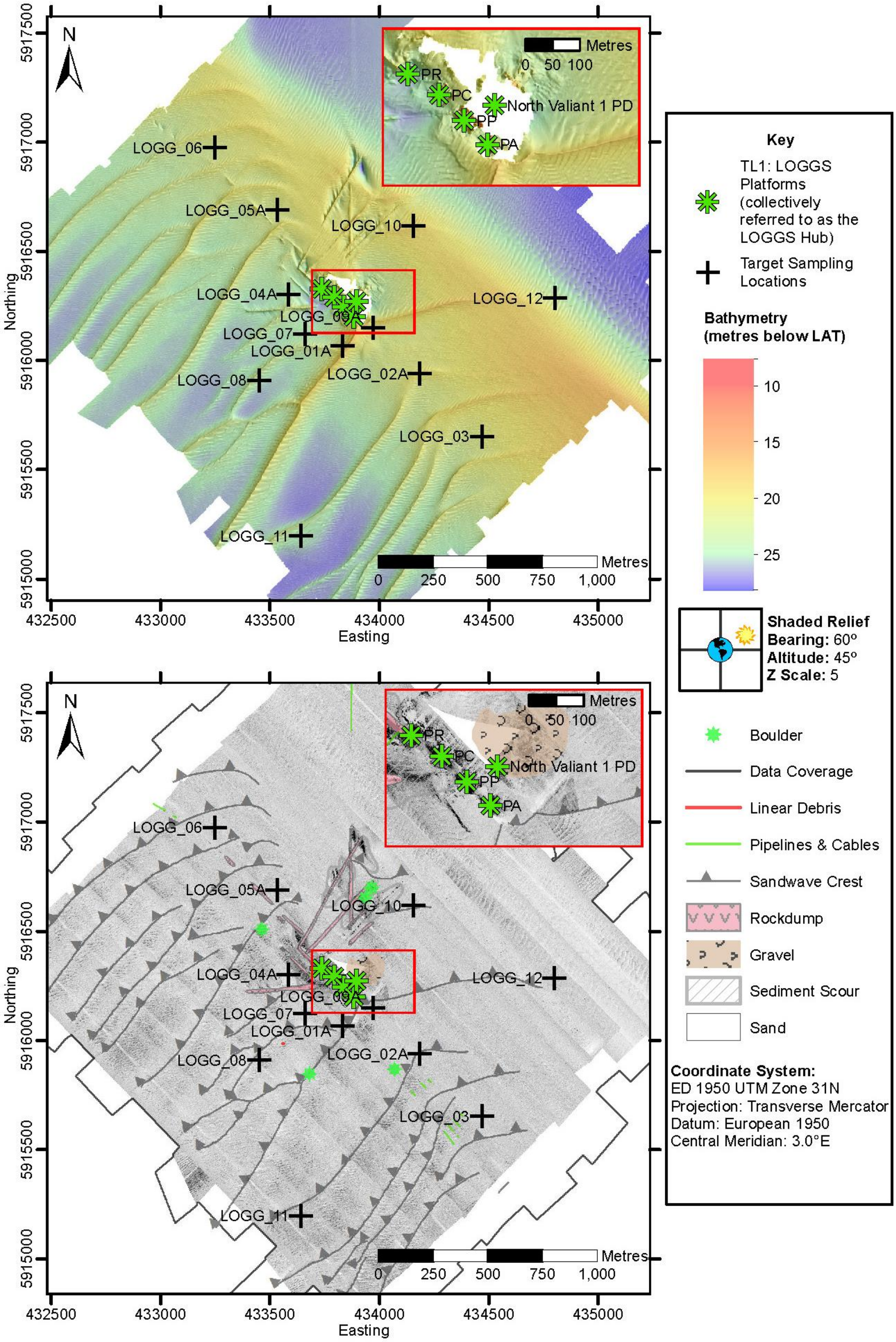


Figure 4-5: Colour shaded relief of bathymetry and seabed features at the LOGGS gathering station. Environmental sampling locations are also shown. (Gardline, 2015)

centrica

4.2.2 Hydrology

Water circulation in the North Sea is anticlockwise, with the main inflow occurring along the western slopes of the Norwegian Trench. Minor inflows from the English Channel and the Baltic Sea supplement this flow, as shown in Figure 4-6. Frontal zones, marking boundaries between water masses including tidally mixed and stratified (layered) water are numerous in the North Sea. The water column of the SNS remains mixed throughout the year while to the north it becomes layered (stratified) in summer (DTI, 2002).

The maximum tidal current speed in the A-Fields area during mean spring tides is between 0.51m/s and 1.02m/s (1-2 knots) (BODC, 1998). Surge and wind–driven currents, caused by changes in atmospheric conditions, can be much stronger and are generally more severe during winter. The annual mean significant wave height is between 1.51m and 1.80m (Scottish Government National Marine Plan Interactive (NMPI), 2016).

During storms, the re-suspension and vertical dispersion of bottom sediments due to waves and currents affects most of the North Sea. The storm surge elevation in the A-Fields area is *c.*1.75-2m with a return period of 50 years (BODC, 1998).

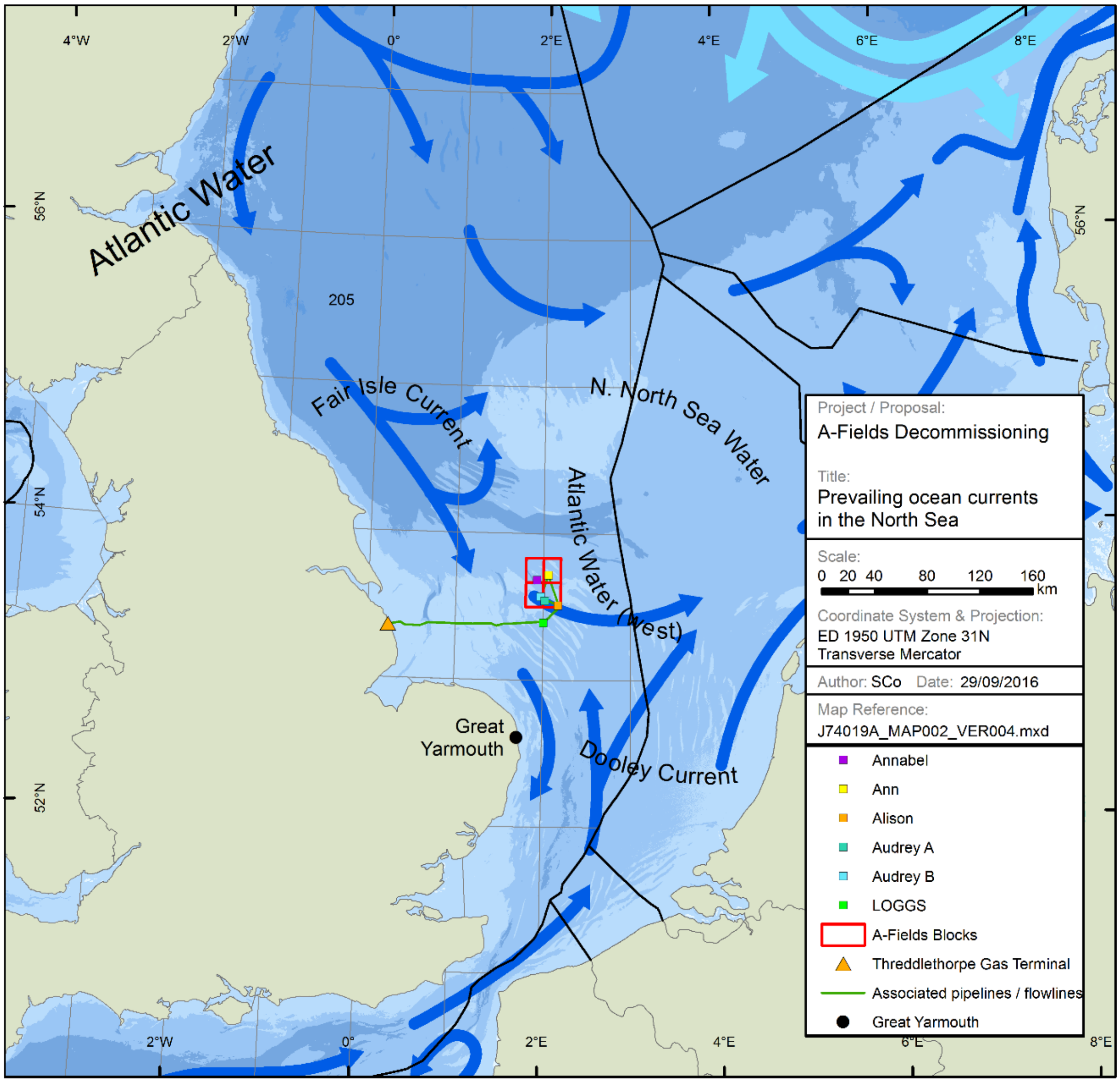


Figure 4-6: General water circulation of the SNS

4.2.3 Meteorology

Wind speed and direction directly influence the transport and dispersion of atmospheric emissions from an installation. These factors are also important for the dispersion of water borne emissions, including oil, by affecting the movement, direction and break up of substances on the sea surface.

Winds in the SNS can occur from all directions, with speeds generally representing moderate to strong breezes (6-13m/s) (DTI, 2001).

4.2.4 Temperature and salinity

There is little difference between water temperatures on the sea surface and sea bottom in this shallow water area. Annual mean temperatures are between 10-11°C for both surface and seabed temperatures (NMPI, 2016).

Fluctuations in salinity are largely caused by the addition or removal of freshwater to/from seawater through natural processes such as rainfall and evaporation. The salinity of seawater around an installation has a direct influence on the initial dilution of aqueous effluents such that the solubility of effluents increases as the salinity decreases. Salinity in the area shows little seasonal variation, with water salinities reported as *c.*34.5‰ throughout the year (NMPI, 2016).

4.3 The seabed

The nature of seabed sediments is an important factor in providing information to help assess the potential for re-suspension and transport of sediments. It is also a determining factor in the flora and fauna present and for their suitability as spawning and nursery grounds.

Sediment erosion and transport in the SNS is driven by the strength and direction of tides and currents, and is influenced by the susceptibility of the source rock type to erosion (BGS, 2002). The shallow water and active current regime in the SNS produces a high energy environment which results in a relatively thin sediment layer. Sands and gravelly sands are the principal component in nearshore areas, with finer sediments becoming dominant as the water deepens further offshore (Wallingford, 2002).

The A-Fields partly lie within the North Norfolk Sandbanks and Saturn Reef Special Area of Conservation, details of which can be found in Section 4.5. The formation of the different sedimentary features depends on current strength and sand availability (Belderson *et al.*, 1982). With increasing currents, the following series of bedforms is observed: megaripples, sandwaves, sand banks, sand ribbons and finally sand streams. If the sand supply decreases, sand banks will be cannibalised to form sand ribbons and sand streams, sand patches replace fields of megaripples and the other types of bedforms will appear less frequently (Figure 4-7).

Below is a definition of sand banks, sandwaves and megaripples which are a feature of the A-Fields area.

4.3.1 Sandbanks

The majority of sandbanks in the North Norfolk area of the SNS are considered to be large-scale mobile seabed forms in dynamic equilibrium with the environment. They can have a wavelength between 1 and 10km, and they can achieve a height of several tens of metres (van der Veen and Hulscher, 2009). Sandbanks are found widely on shallow continental shelves where there is an abundance of sand and where currents exceed a certain speed (Kenyon and Cooper, 2005) (Figure 4-7). This speed is much more than is needed to move seabed sediment and sand banks arise from an inherent instability of a seabed subject to tidal flow and mass transport. They can go from being active to a dying state, stranded in weak currents as the sea level rises.

4.3.2 Sandwaves

Sandwaves are a periodic bottom waviness generated by tidal currents in shallow tidal seas. Typical wavelengths range from 100 to 800m and they can be up to between 1 and 5m high (Figure 4-7). The crests are almost orthogonal to the direction of tide propagation. They are not static bed forms and migration speeds can be up to tens of metres per year.

When local tidal flows interact with a bottom waviness it generates a steady streaming in the form of recirculating cells. When the steady velocity drags the sediment from the troughs towards the crests of the waviness, sandwaves tend to appear. They can be complex to model, and subtle changes to the environment can change the dynamics of the local interaction between the tidal flows and the seabed.

4.3.3 Megaripples

Large, sandwaves or ripple-like features having wavelengths greater than 1m or a ripple height greater than 10cm, megaripples are formed in a subaqueous environment, and they are also known as subaqueous dunes. They may be superimposed with smaller bedforms (Bates and Jackson 1984).

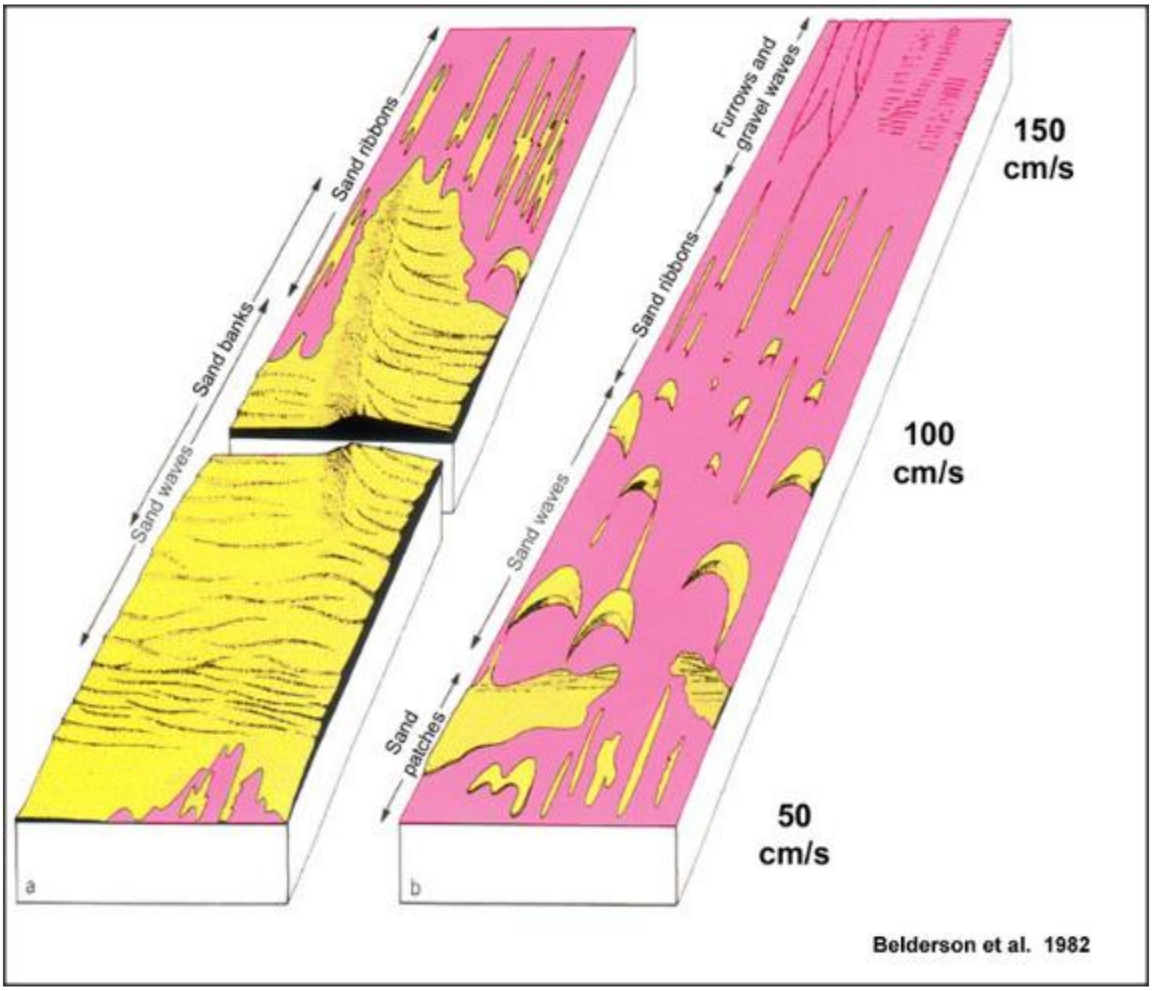


Figure 4-7: Sandwaves and sandbanks

4.3.4 Sediment characteristics

Annabel

All stations within the Annabel manifold, AB1 WHPS and AB2 WHPS survey area were characterised by fine to medium sand with varying amounts of gravel. As such, stations were very poorly to moderately well sorted, with unimodal sediment grain size distributions at Stations ENV14 and ENV19 (medium sand), bimodal distributions at Stations ENV17 and ENV18 (granule and medium sand), and trimodal distributions at Stations ENV15 and ENV16 (pebble, granule and medium sand).

The proportion of fine material (<63µm, silts and clays) was low (<2%) at all stations sampled, while percentages of gravel (≥2mm) ranged from 4.5% at Station ENV14 to 68% at Station ENV16. Gravel proportions were <10% at Stations ENV14 and ENV19. This variable proportion of gravel sized material resulted in modified Folk classifications ranging from slightly gravelly sand at Station ENV14, and gravelly sand at Stations ENV15 and ENV19, to sandy gravel at Stations ENV16, ENV17 and ENV18.

Audrey A (WD) platform and Audrey 11a-7 WHPS

All stations within the Audrey A (WD) and Audrey 11a-7 WHPS area were characterised by a grain size distribution centred on fine to medium sand under the Wentworth classification (Wentworth, 1992). Stations furthest (≥*c.*250m) from the platform, located in areas of megaripples and sandwaves (ENV23, ENV25A, ENV27 to ENV29 and ENV32) were characterised by a lack of fine material (<63µm, silts and clays), consistent with the currents associated with this type of bedform. These stations did, however, exhibit a variable gravel content, ranging from 0.6% at Station ENV32 to 19% at Station ENV23, leading to well sorted to poorly sorted sediment, respectively and a modified Folk classification of gravelly sand to sand.

Closer to the platform the megaripples and sandwaves were absent. Stations located in this area (ENV20 to ENV22, ENV24, ENV26, ENV30 and ENV31) recorded a fine fraction accounting for between 0.8% and 30% at Stations ENV30 and ENV22, respectively and gravel content ranging from 1.6% to 40% at Stations ENV30 and ENV26, respectively. Modified Folk classifications (Folk, 1954) varied from slightly gravelly sand (ENV30), gravelly sand (ENV20, ENV21, ENV31), gravelly muddy sand (ENV22 and ENV24) and sandy gravel (ENV26). The fines and gravel at these stations closer to the platform is not necessarily indicative of the presence of fine drilling muds and coarse drill cuttings. More likely they reflect the natural geology of the area, albeit exposed by the anthropogenically influenced current regime around the platform.

Audrey B (XW) platform

Sediments were generally homogeneous across the Audrey B (XW) survey area, where fines were mostly absent or in negligible (<1%) proportions, while gravel varied between 0.2% at Station ENV42 and 17% at Station ENV37. All stations, were therefore classified as sand, slightly gravelly sand or gravelly sand under the modified Folk (1954) classification (Gardline Geosurvey Limited, 2016c).

Seabed imagery supported the geophysical data interpretation, confirming the seabed sediments at Audrey B (XW) as sand with shell fragments and occasional gravel, pebbles and cobbles. Areas of abundant cobbles and boulders were visible at the transect Station ENV33 (covering Stations ENV33, ENV34 and ENV35) (Figure 4-4), which could correspond to a low resemblance stony reef, as listed under Annex I of the Habitats Directive as implemented by the Offshore Marine Conservation (Natural Habitats, &c.) Regulations (Gardline Geosurvey Limited, 2016c).

The LOGGS platform complex

Particle Size Analysis (PSA) generally supported the observations made at the time of sampling. Sediments across the LOGGS hub survey area were largely uniform with the mean particle diameter varying from 250µm at Station LOGG_06 to 362µm at Station LOGG_08.

All stations were dominated by sand (≥63µm to <2mm), which accounted for ≥98.9% at all stations. There was no fine material (<63µm) at any of the sampled LOGGS stations, and the proportions of gravel (≥2mm) were negligible, reaching a maximum recorded value of 1.1% at LOGG_07. For this reason, all stations were characterised as sand under the modified Folk classification, with the exception of Station LOGG_07, classified as slightly gravelly sand due to a proportion of gravel >1% (Gardline Environmental Limited, 2015b).

4.3.5 Seabed chemistry

4.3.5.1 Hydrocarbon concentrations

It has been previously shown that benthic macrofauna suffer adverse effects when Total Hydrocarbon Content (THC) is in excess of 50µg g^{-1} (UKOOA, 2002; Kjeilen-Eilertsen *et al*., 2004; UKOOA, 2005) and as such this value represents the threshold above which hydrocarbons are expected to have a 'significant environmental impact' (SEI). Following a review of studies on the effect of macrobenthos from hydrocarbon contamination, Gerrard *et al.,* (1999) identified a range of threshold values for ecological effects in the North Sea noting a change in community composition to be possible at THC concentrations from anywhere between 0.8µg g^{-1} and 10µg g^{-1}, reduced faunal diversity from anywhere between 3µg g^{-1} and 109µg g^{-1} and that a prevalence of opportunistic species would not be expected until anywhere between 31µg g^{-1} and 291µg g^{-1}. To put these values in to a wider regional context, UKOOA (2001) reported a mean THC of 4.3µg g^{-1} (measured by Gas Chromatography (GC)) for stations over 5km from existing infrastructure in the SNS between 1975 and 1995.

Annabel

Concentrations of THCs were low and ranged from 1.8µg g^{-1} at Station ENV19 in sandy sediments perpendicular to the primary tidal current to a maximum of 7.9µg g^{-1} at Station ENV16 (Figure 4-2), the closest station, 65m down-current of the Annabel manifold, AB1 WHPS and AB2 WHPS. There was a clear trend of decreasing THC and n-alkane concentrations with increasing distance down-current of the Annabel manifold, AB1 WHPS and AB2 WHPS, indicating a point source of low-level hydrocarbons within the survey area.

GC across all stations revealed low level HMW UCM, with a predominance of odd over even numbered n-alkanes. This pattern suggested that the majority of sediment hydrocarbons in the Annabel survey area were a low level mixture of biogenic material from terrestrial plant sources and highly weathered petrogenic material, typical of areas of historical oil and gas exploration such as the North Sea.

PAH distribution at all stations indicated a mixed input of petrogenic compounds likely derived from anthropogenic activities such as shipping and oil and gas exploration, and pyrogenic hydrocarbons from inputs such as atmospheric fallout and river discharges. At each station, the United States Environmental Protection Agency (US EPA) PAH concentrations were below their respective AETs and ERLs, indicating that these concentrations would not be expected to have an ecotoxicological effect on the fauna.

Audrey A (WD) platform and Audrey 11a-7 WHPS

THC concentrations across the majority of stations ranged from 2.3µg g-1 at Station ENV32 to 21.3µg g^{-1} at Station ENV24, with the exception of Stations ENV20, ENV21 and ENV22, which were located on the drill cuttings pile (Figure 4-3) and presented higher concentrations of 16,920µg g^{-1}, 216µg g^{-1} and 217µg g^{-1}, respectively. The average THC value across the Audrey A (WD) area was 1,342µg g^{-1} (Table 4-2).

Stations ≤300m north-east and south-east and ≤122m north-west and south-west presented THC concentrations above the 95th percentile threshold value of 11.4µg g^{-1} for stations over 5km from infrastructure in the SNS (UKOOA, 2001), indicating that they were not representative of background SNS THC levels. However, they were all, with the exception of Station ENV20, representative of levels expected ≤500m from active platforms in the SNS (UKOOA, 2001), indicating a localised influence of drill cuttings release and oil and gas exploration across the survey area.

The higher concentrations at Stations ENV20, ENV21 and ENV22 were comparable or significantly higher (Station ENV20) than the threshold of 291.4 µg g^{-1} at which a notable increase in the dominance of opportunistic species can occur (Mair *et al.*, 1987). Additionally, concentrations of total n-alkanes at the drill cuttings pile (Stations ENV20, ENV21, ENV22), up to 250m north-east (ENV25A), and up to 300m south-east (ENV27) were above the UKOOA (2001) 95th percentile concentration of 0.780µg g^{-1}, indicating that the concentrations at these stations were not representative of 95% of stations over 5km from infrastructure in the SNS. This pattern was in line with a dissemination of hydrocarbon contaminated drill cuttings in the wider area around the pile and particularly toward the south-south-west along the main current axis.

GC across Stations ENV24 to ENV32 revealed a low-level, high molecular weight (HMW) unresolved complex mixture (UCM) with a pattern of odd over even-numbered n-alkanes. This pattern suggested that the majority of sediment hydrocarbons at these stations were a low level mixture of biogenic material from terrestrial plant sources and highly weathered petrogenic material, typical of areas of historical oil and gas exploration such as the North Sea.

Total polycyclic aromatic hydrocarbons (PAHs) concentrations were ≤0.742µg g^{-1}, with an average of 0.708µg g^{-1} with the exception of Station ENV20, where 6.625µg g^{-1} was recorded. Station ENV20 was also the only station to record a concentration of naphthalenes, phenanthrenes, dibenzothiophenes (NPD) above the ‘Apparent Effect Threshold’ concentration (AET; Buchman, 2008), indicating that it could present a potential Ecotoxicological impact on the fauna. Additionally, once normalised to 1% Total Organic Compounds (TOC), the concentration of total PAHs at Station ENV20, concentrations of NPD PAHs at Stations ENV20, ENV21, ENV22 (≤105m north-west), ENV24 and ENV25A (≤250m north-east) and concentrations of HMW PAHs at Station ENV24 (146m north-east) were above their respective ‘Effect Range Low’ (ERL) concentrations (Long *et al*., 1995), indicating they were likely to be associated with toxicity in the sediments.

Audrey B (XW) platform

With the exception of Station ENV47, THC concentrations across the survey area were ≤6.3µg g^{-1} with an average THC of 5.0µg g^{-1} (Table 4-2) and were below the threshold value of 4.3µg g^{-1} for stations over 5km from infrastructure in the SNS. Station ENV47, which was located on the area interpreted as deposited rock presented a THC concentration of 17.9µg g^{-1}. The highest THC concentrations were recorded at the stations closest to the Audrey B (XW) Platform, ≤*c.*100m south east and north west, and therefore could reflect low level dispersion of contamination in the vicinity of the platform and particularly on the deposited rock. All THC concentrations were below the SEI threshold and below the minimum threshold value considered for any opportunistic species to be prevalent. Therefore, whilst the THC concentration at Station ENV47 could not be considered as representative of background conditions in the SNS, this concentration was not expected to impact the faunal community.

GC at all stations showed a low-level, HMW UCM with a pattern of odd over even-numbered n-alkanes. This pattern suggested that the majority of sediment hydrocarbons were a low level mixture of biogenic material from terrestrial plant sources and highly weathered petrogenic material, typical of areas of historical oil and gas exploration such as the North Sea.

Total PAHs and NPD PAH concentrations were below their respective AETs at all stations indicating these concentrations were not thought to present a potential ecotoxicological impact on the macrofauna. The concentration of NPD PAH at Station ENV40 was, however, above its ERL, indicating that it could potentially be associated with toxicity in the sediments. Overall, PAH distribution at most stations presented <50% of petrogenic NPD compounds likely derived from anthropogenic activities such as shipping and oil and gas exploration, and were dominated by pyrogenic HMW compounds from inputs such as atmospheric fallout and river discharges.

The LOGGS platform complex

THC concentrations were low and ranged from 0.5µg g^{-1} to 2.6µg g^{-1} with an average THC of 1.4µg g^{-1} (Table 4-2). This range of concentrations is well below the SEI threshold and well below the UKOOA (2001) regional background level.

The UCM accounted for 83% to 100% of the THC at all stations within the LOGGS platform complex indicating that the majority of hydrocarbons were well weathered at all stations (Gardline Environmental Limited, 2015b).

SURVEY	THC	UCM	nC_{10-20}	nC_{21-37}	nC_{10-37}	CPI[1]	Pristane (Pr)	Phytane (Ph)	Pr/Ph Ratio	NPD[2]	Total PAH	NPD[3]/ 4-6 Ring
Ann[3]	0.9	0.8	0.036	0.062	0.098	2.6	0.008	NC	3.2	0.010	0.022	1.0
Alison Template[4]	1.7	1.4	0.115	0.204	0.319	1.5	0.035	0.011	3.2	0.078	0.145	1.2
Audrey A (WD)[5]	1,342[8]	1,330.4	7.231	1.110	8.341	1.8	3.757	0.076	12.4	0.592	0.708	2.5
Audrey B (XW)[5]	5.0	4.8	0.075	0.086	0.161	1.8	0.020	NC	NC	NC	0.040	NC
Annabel[6]	5.0	4.5	0.173	0.318	0.491	1.6	0.035	0.008	4.9	0.074	0.127	0.9
LOGGS[7]	1.4	1.3	0.053	0.069	0.122	1.5	0.017	0.004	3.0	NC	NC	NC

Unless indicated, concentrations expressed as mean µg g^{-1} dry sediment

NC - Not calculated due to one or more values below the LOD.

[1] Calculated using $2(nC_{27} + nC_{29})/nC_{26} + 2(nC_{28}) + nC_{30}$.

[2] Naphthalenes, phenanthrenes and dibenzothiophenes (total).

[3] Gardline Geosurvey Limited (2016a)

[4] Gardline Geosurvey Limited (2016b)

[5] Gardline Geosurvey Limited (2016c)

[6] Gardline Geosurvey Limited (2016d)

[7] Gardline Environmental Limited, (2015b)

[8] THC is high for Audrey A (WD) due to samples having been taken from an area of drill cuttings

Table 4-2: Summary of sediment hydrocarbon analyses across the A-Fields. Average values are presented

4.3.5.2 Metal concentrations

Concentrations of arsenic (As), cadmium (Cd), chromium (Cr), nickel (Ni), lead (Pb), selenium (Se), tin (Sn), vanadium (V) and zinc (Zn) were all determined by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) following 50% nitric acid extraction. Concentrations of aluminium (Al), barium (Ba), iron (Fe), lithium (Li), magnesium (Mg) and strontium (Sr) were determined by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) following the same extraction technique.

Where available, metals data were compared to OSPAR (2005) background concentrations (BC) and background assessment criteria (BACs, and where these were not available, to OSPAR background/reference concentrations (BRCs) (OSPAR, 1997).

Annabel

There were no correlations between Ba and sediment characteristics, hydrocarbon concentrations or other metals. However, Station ENV18, located 550m south-east of the Annabel template, together with Station ENV16, located 65m east of the template, recorded some of the highest concentrations of several other metals across the survey area (Al, Cr, Cu, Fe, Li, Ni, Sr and Zn). This apparent halo of distribution, focussed near the template and then at a distance of 550m south-east may be related to the anthropogenic changes to the current regime immediately around the template influencing the transport and settlement of some metals. It is a phenomenon also observed around Audrey A (WD) (see below)) and reported by UKOOA (2001) in the SNS, whereby in the latter mean concentrations of Cr, Ni, V and Fe were higher at stations 500-1000m from an installation, compared with stations <500m.

There was also a clear trend associated with natural sediment variability, with Stations ENV16, ENV17 and ENV18, consistently presenting higher metal concentrations than the remaining stations, corresponding with the less sandy conditions at these stations. The trend was most apparent with Al, Li, Mn and Ni where the concentrations were ≥2.0-fold higher at these stations. While these relatively higher concentrations could relate to the fine fraction, which was absent from the other stations, it could also represent metals extracted from the sediment gravel matrix, during the acid digest process, slightly skewing the results of the overall metals concentrations at these locations.

Audrey A (WD) platform and Audrey 11a-7 WHPS

Across the Audrey A (WD) and Audrey 11a-7 WHPS survey area, Ba concentrations were ≤128.0μg g^{-1} with the exception of Stations ENV20, ENV21, ENV22 on the drill cuttings pile and ENV28 (550m south-east of the platform) where concentrations of Ba varied between 414.0μg g^{-1} (Station ENV28) to 11,000μg g^{-1} (Station ENV20). These higher concentrations were linked to the use of Ba enriched drilling fluids within the survey area.

This apparent halo of distribution, focussed on the drill cuttings pile and then at a distance of 550m south-east of the platform may be related to the anthropogenic changes to the current regime immediately around the platform influencing the transport and settlement of some metals.

As with Ba, Station ENV20 situated at the drill cuttings pile recorded the highest concentrations of most other metals. The exceptions included, As and V, which were recorded in highest concentration at Station ENV25, located *c* .250m north-east of the platform, closely followed by Station ENV26, located *c.*100m south-east of the platform, where Cd, Fe, Mn and Zn were also recorded at their highest concentrations. This distribution of metals focussed on the cuttings pile and nearby stations reflect the less sandy and more variable sediments evident in the seabed video imagery, camera stills photography, grab samples or PSA results at these stations. It could also represent metals extracted from the sediment gravel matrix, during the acid digest process, slightly skewing the results of the overall metals concentrations at these locations. Metals such as Cr, Pb and

Zn are also known constituents of drilling muds (Neff, 2005), and therefore drilling fluids should also be considered the source of these higher metal concentrations at Station ENV20, associated with the drill cuttings pile and also potential residual discharges down-current at Station ENV26 derived from historical activity at Audrey A (WD).

Audrey B (XW) platform

Concentrations of Ba across the Audrey B (XW) platform survey area were ≤56.3µg g^{-1}. The average Ba concentration of 25.8µg g^{-1} was lower than results at Audrey A (WD) and the Alison manifold, however, were generally higher and more variable than those of the LOGGS and Ann surveys (Table 4-3). Ba concentrations were positively correlated with the percentages of gravel across the survey area, and also correlated to the distance to the closest existing well from each station. These correlations showed that although Ba was linked to natural variations of sediment size, concentrations were also linked to the existing infrastructure and drill cuttings pile in the area.

A subtle halo effect (as described above) was apparent around Audrey B (XW), with highest concentrations of metals focussed on the drill cuttings pile (ENV34 and ENV47) or nearby perpendicular to the main current (ENV37) and then at a distance of *c.*300m or 1,000m south-east of the platform (ENV40 or ENV42). This distribution of metals also reflects the less sandy and more variable sediments evident in the seabed video imagery, camera stills photography, grab samples or PSA results at most of these stations.

All detectable concentrations of As, Cd (one detectable concentration), Cr, Cu, Hg, Ni, Pb and Zn were above their respective BCs, with averages of all these metals bar Cd and Hg, also above their respective BACs (Table 4-3).

All detectable concentrations of Li (two stations) and V were also above the upper limit of their respective BRC ranges. These patterns indicated that most metals within the survey area presented concentrations above background, and above concentrations expected in areas where certain activities such as oil and gas exploration would not be present. This was an expected outcome of this comparison as the area has been shown to be heavily industrialised, notably due to oil and gas exploration.

The LOGGS platform complex

Concentrations of Ba within the LOGGS platform complex varied between 8.7µg g^{-1} and 33.4µg g^{-1} with most stations <20µg g^{-1} (Table 4-3). Concentrations of Ba were correlated to the depth across the survey area indication a distribution of Ba in sediments consistent with natural variation (Gardline Environmental Limited, 2015b).

All concentrations of As, Cr, Cu, Ni, Pb and Zn were above their respective BCs, with all averages also above their respective BACs. All concentrations of Fe and V were also above the upper limit of their respective BRC ranges.

These patterns indicated that most metals within the survey area presented concentrations above background, and above concentrations expected in areas where certain activities such as oil and gas exploration are not present. This was an expected outcome of this comparison, given the area has been shown to be heavily industrialised, notably due to gas exploration (Gardline Environmental Limited, 2015b).

centrica

SURVEY	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Li	Mn	Ni	Pb	Se	Sn	Sr	V	Zn
Ann[1]	1,056	5.8	18.8	NC	6.9	1.8	4,775	NC	NC	121.3	3.7	4.1	NC	NC	13.0	14.4	11.3
Alison Template[2]	5,040	10.4	80.5	NC	14.9	8.0	16,604	NC	10.4	365.8	17.5	7.3	NC	NC	80.1	28.8	32.5
Audrey A (WD)[3]	1,464	9.6	1,095	NC	7.4	4.7	10,032	NC	NC	218	6.6	4.9	NC	NC	41.4	14.9	17.8
Audrey B (XW)[3]	1,103	14.4	25.8	NC	11.5	2.7	6,692	NC	NC	356	5.3	3.8	NC	NC	42.3	57.0	12.1
Annabel[4]	3,403	28.9	80.5	NC	13.2	6.1	17,182	NC	5.6	753	14.9	8.5	NC	NC	65.4	39.6	29.6
LOGGS[5]	741	8.5	13.7	NC	6.6	3.2	6,118	NC	NC	65.4	4.2	3.0	NC	NC	23.7	14.5	8.1

Concentrations expressed as mean µg g^{-1} dry weight sediment.
Unless specified, concentrations determined following 50% nitric acid sediment digestion.
NC - Not calculated due to one or more values below the LOD.
[1] Gardline Geosurvey Limited (2016a)
[2] Gardline Geosuvey Limited (2016b)
[3] Gardline Geosurvey Limited (2016c)
[4] Gardline Geosurvey Limited (2016d)
[5] Gardline Environmental Limited (2015a)

Table 4-3: Summary of average sediment metal concentrations

4.3.6 Seabed characteristics

Annabel

Interpretation of the environmental data in the immediate vicinity of Annabel shows the Annabel infrastructure to lie within a north-west / south-east trending strip of sand and gravel. To the south, north and east the seabed is sandier leading to the development of low megaripples. This sand is probably thin, as scattered boulders are visible within the sand outcrop (Figure 4-8).

Between Annabel and AB1 and AB2 WHPS the pipelines and umbilicals lie on a gravel and sand seabed with some evidence of slight sand accumulation on the south side of the wellheads and their mattresses.

The pipelines and umbilicals at Annabel lie beneath mattressing, which forms low linear mounds 20-30cm high and 2-3m wide draped over the underlying pipe or umbilical.

Several spudcan depressions are present to the north and north-east of Annabel. They form insignificant depressions approximately 0.2m deep, varying from 11m to 21.5m in diameter (Figure 4-8).

PL2066

The 10" pipeline PL2066 is almost entirely buried along its length with only very brief exposures along the route and at the two ends. The seabed falls from a depth of approximately 27m LAT at Annabel to a maximum depth of 36.5m Lowest Astronomical Tide (LAT) between KP2.4 and KP3.4 in a broad shallow channel. From KP3.4 to KP9.0, PL2066 crosses an undulating seabed rising from 36m LAT to 32m LAT with rare sandwaves up to 6m high. From KP9.0 it ascends to a plateau lying at 24m LAT that continues to KP16.0 from where the seabed falls to 26m LAT at Audrey A (WD) (Figure 4-9). This part of the route crosses a densely populated sandwave field, with sandwaves initially being up to 5.5m high around KP10.0 falling to approximately 2m at KP16.0. From KP16.0 the sandwaves have a wavelength of about 500m and stand up to 5m above the local seabed level.

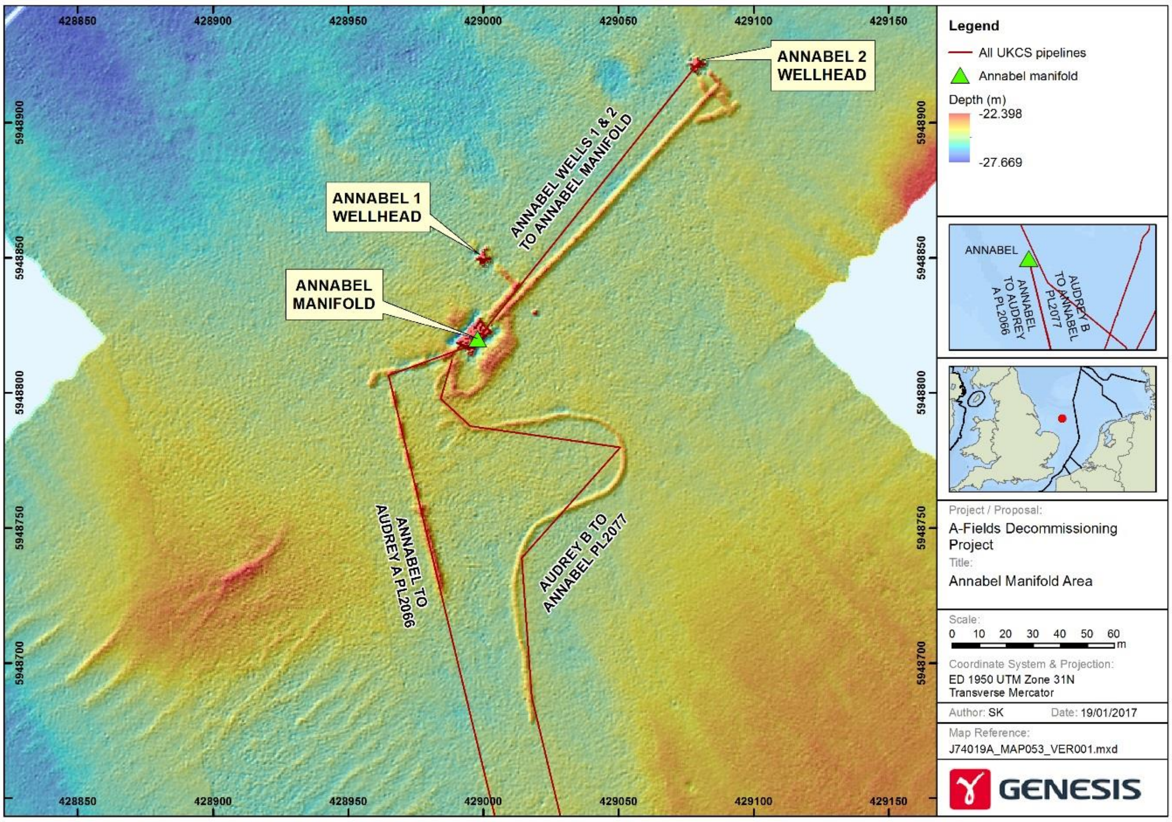


Figure 4-8: Annabel template

PL2067

The 4½" umbilical PL2067 is predominantly buried along its entire length with seven examples of exposed umbilical being identified away from the exit and entry points at Audrey B (XW) and Annabel and with two larger areas of “crowning” (umbilical just detectable at the seabed) totalling approximately 500m. The exposures are all ≤5m long with most of them occurring in the sandwave area between KP1.627 and KP3.743. There is a short length of very shallow remnant trenching visible between KP7.398 and KP7.648.

PL2067 exits Audrey B (XW) at the platform’s western corner, initially heading south on a relatively smooth seabed before swinging in a broad arc to the north (Figure 4-11). The umbilical enters a megaripple and sandwave field 80m west of the platform at KP0.181. The bedforms slowly increase in amplitude from 2m reaching 6m at KP2.91 before dying out by KP3.81. From KP0.181 to KP2.75 the sandwaves are typically 3-3.5m high with a wavelength of about 250m and rest on a level seabed lying at about 24m LAT. From KP2.75 the seabed falls gently reaching a depth of 32m LAT at KP4.1. The seabed continues to gently fall to the north at less than 0.1° until reaching the greatest depth encountered of 36.5m LAT in a shallow channel between KP9.75 and KP10.5. From KP10.5, PL2067 ascends a smooth sandy, later megarippled slope of approximately 0.2° to the Annabel template, which lies at a depth of 27.0m LAT.

Audrey A (WD) platform and Audrey 11a-7 WHPS

The natural sand and gravel seabed in the vicinity of Audrey A (WD) is almost flat, lying at a depth of approximately 26m LAT, with the platform lying in a broad shallow depression (Figure 4-9). To the south, the terrain gently shoals to 25.0m LAT, whilst to the extreme north-west corner of the area it rises to 22.4m LAT on the crest of a sandwave. In the vicinity of the platform, away from anthropogenic features the seabed is smooth with only insignificant bedforms. Bedforms, however, increase in size and frequency towards the north-west sandwave, where low megaripples are present (Figure 4-9). The “regional” bathymetric contours and bedforms trend north-east/south-west with the large sandwave having a south-east facing lee slope.

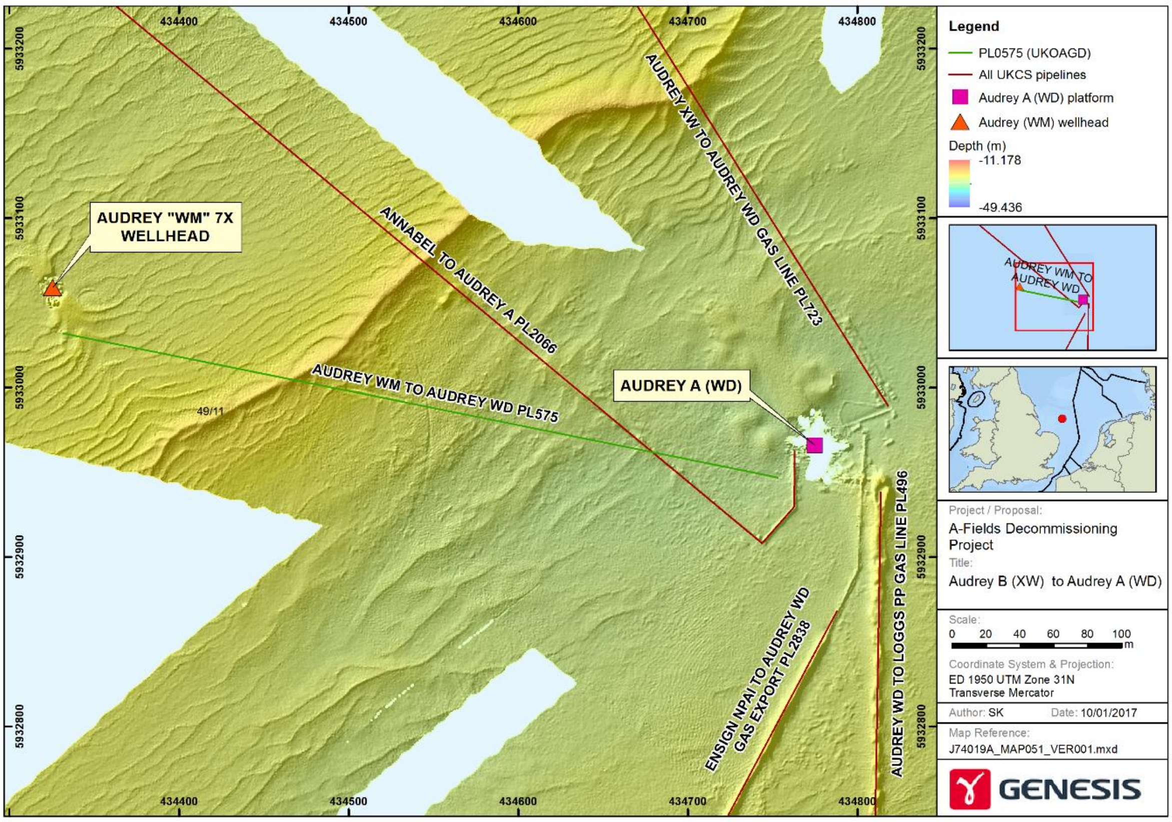


Figure 4-9: Audrey A (WD) and Audrey 11a-7

There is an area of disturbed seabed associated with an accumulation of drill cuttings lying immediately to the north of the platform and occupying an area of approximately 110m north-west/south-east by 15-50m south-west/north-east (Section 3.4.4).

PL496

Much of the 20" gas export line PL496, between Audrey A (WD) and LOGGS lies within megaripple and low sandwave fields with deposited rock over the pipeline appearing between the bedforms. In the occasional areas without bedforms, there is frequently only the very faintest impression of the deposited rock mound. Although the deposited rock is not continuous, examples of exposed pipe are very sparse and appear to be limited to areas of low megaripples with apparently only the shoulder of the pipe exposed. There are eight exposures totalling 56m between KP7.070 and KP7.213 and five exposures totalling 37m between KP11.993 to KP12.064.

In the vicinity of Audrey A (WD), the seabed lies at a depth of approximately 26m LAT. From here, PL496 ascends a very gentle slope, crossing a minor sandwave field (with sandwaves up to 3.5m high) and water depths reaching a minimum of 20.0m LAT at KP4.0. South of the shoal, the seabed initially megarippled, becomes smooth, falling to 24.0m LAT at KP6.613. From this point, a megaripple and sparsely populated sandwave field continues to KP14.293. The sandwaves in this part of PL496 are typically 1m to 2m high but with large relatively isolated examples standing up to 6m above the local seabed level, *i.e.,* at KP11.960. From KP14.293 to the end of coverage at KP15.659 the seabed consists of a smooth gently undulating surface with *Sabellaria* sp. mounds being present astride PL496 from KP14.293 to KP15.031 (see Section 4.3.7).

PL497

The 3" methanol line PL497 is piggybacked onto PL496. There is no evidence from the swathe data to question the integrity of the piggybacking.

PL723 and PL724

PL723 and its companion PL724 run between Audrey B (XW) and Audrey A (WD). PL723 and PL724 exit Audrey B (XW) close to the platform's southern corner (Figure 4-11). The pipelines are not piggybacked together at this point and are briefly exposed. The pipelines head south initially crossing seabed at 24m LAT, approximately 4m apart before turning east approximately 40m from the platform and becoming briefly rock dumped and then buried at KP0.006.

PL724 (the western pipeline) is largely protected by mattressing whilst the abandoned PL723 lies mostly fully exposed on the seabed with necking at joints and spalled weight coat on the spool being evident. The union of the two pipelines is not seen, but the piggybacked lines continue south-east through a megaripple and sandwave field to KP3.606. Within this sandwave field there is a 5.2m exposure of a pipeline between KP0.113 and KP0.118 (Figure 4-13) and another 4.1m length of exposure starting at KP3.864. Individual sandwaves up to this point are up to 3.0m high but more typically average 2m to 2.5m. The sandwaves in this area stand on a gently undulating seabed surface lying at 24m to 26m LAT. Between KP3.540 and KP4.000 the seabed is covered with low megaripples. Between KP4.000 and KP4.165 there is a complex sandwave standing 2m above local seabed. From this southernmost sandwave, the gently undulating terrain falls towards Audrey A (WD), which lies on a relatively smooth seabed at a depth of approximately 26.5m LAT (Figure 4-9).

Figure 4-10: Exposed pipeline between KP0.113

Audrey B (XW) platform

The Audrey B (XW) platform lies in the trough, midway between (i.e. about 80m from), two large south-west, north-east trending sandwaves with a further sand wave lying another 80m to the north (Figure 4-11). The sand wave crests lie at water depths of 21-22m LAT, standing 1.5-2m above the local seabed level, with south-east facing lee slopes indicating a net south-easterly sediment transport direction.

The seabed at Audrey B (XW) is dominated by an anthropogenic rock mound approximately 60m in diameter with its centre lying approximately 70m north west of Audrey B (XW) (Figure 4-4 and Figure 4-11). The mound presents a minimum depth of 19.8m LAT, a maximum height of about 3.5m above the local seabed level and a volume of about 4,800m³

(Figure 4-4 and Figure 4-11) (Gardline Geosurvey Ltd, 2016c).

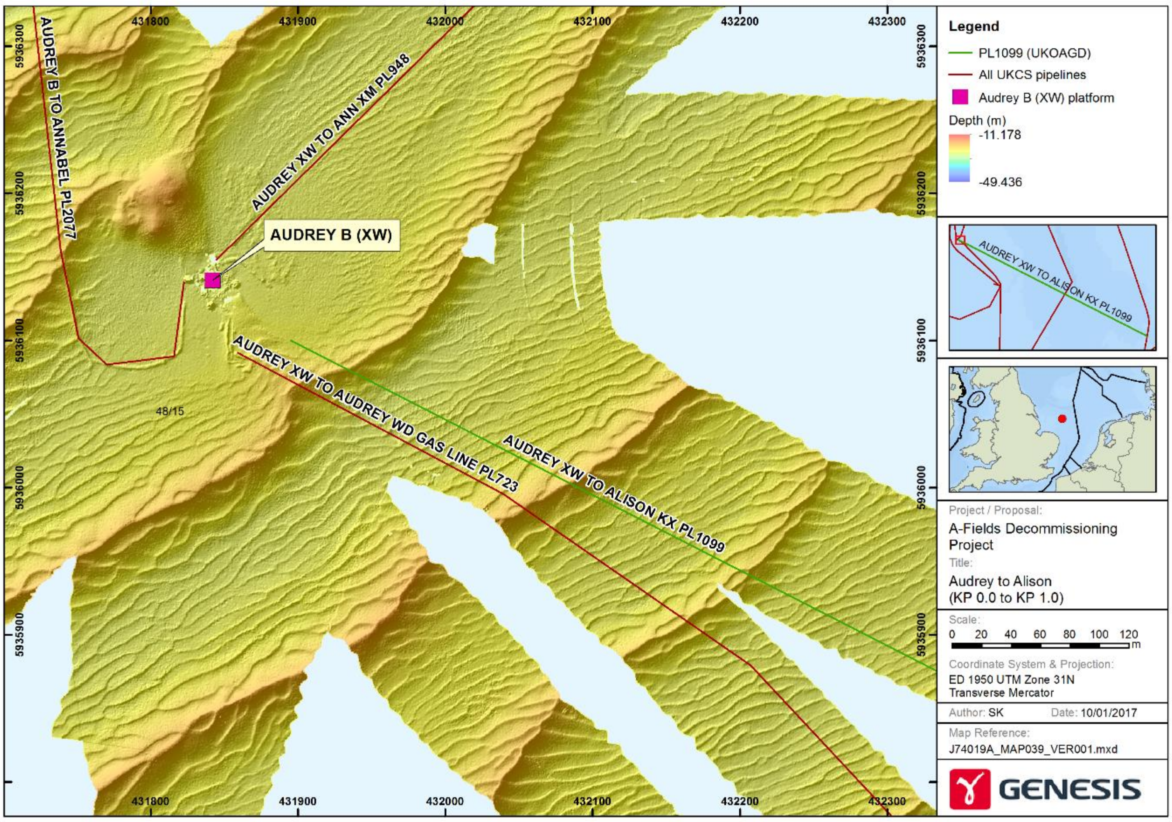


Figure 4-11: Audrey B (XW)

The LOGGS platform complex

In the central and western regions of the LOGGS platform complex survey area, the seabed was characterised by north-east to south-west orientated sandwaves with a maximum height of 7.6m and an average wavelength of *c.*175m (Figure 4-5). A north-west to south-east orientated bathymetric ridge was observed trending through the central region of the survey area. There was a significant area of seabed scour to the north and south of the Saturn ND to LOGGS PR 14" Gas Line PL2107 (Figure 4-5). The scour was situated 550m to the north of the LOGGS PR platform and was approximately 7m deep.

Interpretation of the SSS data identified occasional isolated boulders/debris contacts up to 1.7m high across the survey areas at the LOGGS platform complex. It is possible that the majority of these contacts represent accumulations of isolated deposited rock. Environmental camera imagery revealed the seabed predominantly comprised sand with shells and shell fragments. Ripples were observed on the cameral imagery supporting the evidence of a mobile sandy seabed (Gardline Environmental Limited, 2015a).

4.3.7 Seabed habitats

Annabel

Seabed imagery supported the geophysical data interpretation confirming the seabed sediments within the Annabel manifold, AB1 WHPS and AB2 WHPS survey area were predominantly rippled sand with gravel, pebbles and occasional cobbles. Gravel patches with a greater abundance of cobbles were visible at Stations ENV16 to ENV18 and ENV48, but were otherwise dominated by sands.

Although *Sabellaria* sp. has previously been identified in the vicinity of the Annabel manifold, AB1 WHPS and AB2 WHPS (Centrica, 2016b), no *Sabellaria* sp. were present in the seabed video imagery or camera photography or notable in the samples obtained from any of the stations investigated during the current survey.

Despite being previously identified by Centre for Environment, Fisheries and Aquaculture Science (CEFAS)/BEIS as a potential herring spawning habitat (Centrica, 2016) the Annabel manifold, AB1 WHPS and AB2 WHPS survey area presented no potential for herring spawning during the current survey (see Section 4.4.3.1).

There was no other evidence in the imagery of any habitats listed under Annex I of the Habitats Directive (1992), or habitat/species Features of Conservation Importance (FOCI) and broadscale habitats, defined in relation to the MCZ or priority habitats or species in England, listed under Section 41 of the NERC Act (2006) or species or habitats on the OSPAR (2016) list of threatened and/or declining species and habitats; and no evidence of species on the IUCN Global Red List of threatened species (IUCN, 2016).

Fauna that occurred across the Annabel manifold, AB1 WHPS and AB2 WHPS stations included Annelida (Polychaeta tubes), Arthropoda (*Cancer pagurus*, *Pagurus* sp.), Echinodermata (*Asterias rubens,* Ophiuroidea), Chordata (*Agonus cataphractus*, *Pleuronectes platessa*, possible *Hyperoplus lanceolatus*, Gadidae, Gobiidae), Cnidaria (Actiniaria, *Alcyonium digitatum*, Hexacorallia), Mollusca (*Flabellina browni*), Bryozoa (*Alcyonidium diaphanum*, *Flustra foliacea*, *Pentapora* cf. *foliacea)*, Cnidaria (Hydrozoa) and a possible Ctenophora. Benthic fauna density was generally sparse, particularly in the areas dominated by sand, which is expected in similar habitats lacking hard substrate in the North Sea. Abundance and diversity was generally higher in areas of coarser sediments, *i.e*. cobbles. This was associated to the presence of harder substrate allowing for the settlement of epifaunal organisms such as Hydrozoa and providing shelter for organisms. Seabed photographs taken in the Annabel survey area are shown in Figure 4-12 and Figure 4-13.

Fix: 6175 **E:** 428848 **N:** 5948966 **Depth:** 27m **Laser Scale:** 10cm

Fix: 6181 **E:** 428865 **N:** 5948951 **Depth:** 27m **Laser Scale:** 10cm

Station: ENV14
Sediment Description:
Fix6175: Rippled sand with gravel and occasional cobbles

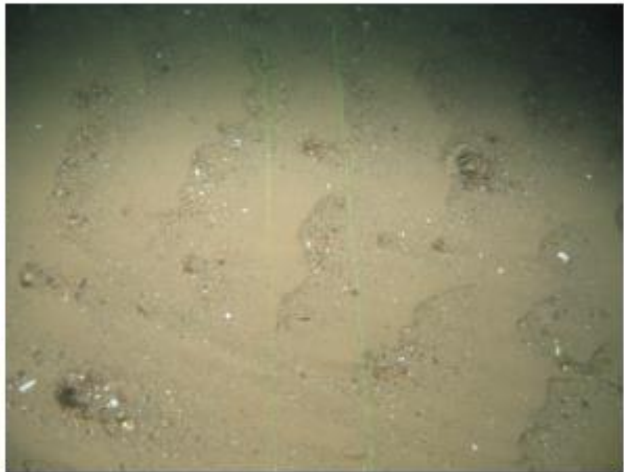
Fix6181: Rippled sand with gravel and cobbles

Fauna Description:
Fix6175: Cnidaria (Hydrozoa sp. A, Hydroid turf), Echinodermata (possible Ophiuroidea)

Fix6181: Arthropoda (*Cancer pagurus*), Echinodermata (*Asterias rubens*), Cnidaria (*Alcyonium digitatum*, Hydrozoa sp. A, Hydrozoa sp. B, Hydrozoa sp. C, Hydroid Turf), Bryozoa (*Flustra foliacea*, *Alcyonidium diaphanum*, *Pentapora* cf. *foliacea*)

Figure 4-12: Seabed photographs from station ENV14 at Annabel (location shown in Figure 4-2)

Fix: 6216 **E:** 429209 **N:** 5948611 **Depth:** 27m **Laser Scale:** 10cm



Fix: 6223 **E:** 429241 **N:** 5948588 **Depth:** 27m **Laser Scale:** 10cm

Station: ENV17
Sediment Description:
Fix6216: Rippled sand with gravel and occasional cobbles

Fix6223: Rippled sand with gravel

Fauna Description:
Fix6216: Echinodermata (*Asterias rubens*), Bryozoa (*Alcyonidium diaphanum*), Cnidaria (Hydroid turf)

Fix6223: Annelida (Polychaeta tube), Bryozoa (*Flustra foliacea*), Cnidaria (Hydrozoa sp. A)

Figure 4-13: Seabed photographs from station ENV17 at Annabel (location shown in Figure 4-2)

Audrey A (WD) platform and Audrey 11a-7 WHPS

All 13 stations selected for investigation were successfully ground-truthed with the digital camera system. Geophysical data presented generally lower reflectivity interpreted as predominantly rippled sand throughout the survey area, with an area of higher reflectivity interpreted as occasional gravel, pebbles and cobbles at Stations ENV20, ENV21 and ENV22, thought to represent anthropogenic rock. Seabed imagery supported the geophysical data confirming the seabed sediments within the Audrey A (WD) survey area were predominantly rippled sand with scattered shell fragments and occasional gravel, pebbles, cobbles and boulders (Figure 4-14).

At Stations ENV21 (transect covering Stations ENV20, ENV21 and ENV22), ENV24, ENV25, ENV26, ENV31 and ENV32, *Sabellaria* sp. tubes were observed in a number of photographs (Figure 4-14 and Figure 4-15).

Sabellaria sp. reefs are listed under Annex I of the Habitats Directive (1992), as implemented by the Offshore Marine Conservation (Natural Habitats, &c.) Regulations (2007 (as amended)). The distinction between what is, or is not a *Sabellaria spinulosa* ‘reef’ is imprecise. To try to make the process of ‘reef definition’ more transparent and reproducible, Hendrick and Foster-Smith (2006) produced a scoring system based on a series of physical, biological and temporal characteristics of reef features.

- Physical characteristics: elevation, sediment consolidation, spatial extent, patchiness;
- Biological characteristics: *Sabellaria sp.* density, biodiversity, biotope and community structure; and
- Temporal characteristics: longevity and stability.

Upon acquisition of seabed imagery, and should *Sabellaria* sp. be identified, the Hendrick and Foster-Smith (2006) scoring system can be applied in an attempt to define the ‘reefiness’ of the areas or colonies identified within the surveyed area. The scoring criteria that can be used are:

- Spatial Extent – Area (from the geophysical data) of interpreted extent of colonies;
- Patchiness – Percentage cover (from video/stills footage); and
- Elevation – Average height of tubes within colony(ies) (from video/stills footage) as well as elevation of overall reef-like features relative to surrounding seabed (from MBES data).

Whilst mainly subjective, the results can allow a basic understanding of the *Sabellaria* sp. colony composition of each area to be made, and a measure of its ‘reefiness’ to be arrived at.

Image analysis revealed *Sabellaria* sp. to be present at all stations with the exception of ENV23 in the Audrey A (WD) survey area (Figure 4-17). Aggregations were observed in greatest abundance and height where the seabed presented occasional to abundant cobbles and boulders. The Hendrick and Foster-Smith (2006) scoring system was applied in an attempt to define the ‘reefiness’ of the area or of colonies identified within the survey area (Gubbay, 2007). Results showed the patchiness and low elevation of the clusters of *Sabellaria* sp. not to represent a biogenic reef structure at any of the stations where this species occurred. (Section 4.5.1.1).

Other fauna observed across the Audrey A (WD) stations included Annelida (Echiura, Errantia, Polychaeta, *S. spinulosa*, Serpulidae), Arthropoda (Brachyura, *Cancer pagurus*, Cirripedia, Paguridae), Bryozoa (*Alcyonidium diaphanum*, *Flustra foliacea*), (e.g. Figure 4-16) Cnidaria (*Alcyonium digitatum*, Actiniaria including *Metridium senile*, Hydrozoa including *Tubularia indivisa*), Echinodermata (Asteroidea including *Asterias rubens*, *Echinocardium* sp., Asteroidea, Ophiuroidea), Mollusca (Bivalvia), Chordata (Ascidiacea, *Agonus cataphractus*, Ammodytidae, Callionymidae, *Eutrigla gurnardus*, *Limanda limanda*) Porifera (Demospongiae) and Sipuncula. Benthic fauna density was generally sparse, which is expected in similar habitats lacking hard substrate in the North Sea (e.g. Figure 4-16). Abundance and diversity were generally higher at Stations ENV20, ENV21 and ENV22 (covered in one transect). This was associated to the presence of harder substrate allowing for the settlement of epifaunal organisms such as Bryozoa, Hydrozoa and Porifera and providing shelter for organisms. Possible anthropogenic debris items (resembling cables) were observed at the transect Station ENV21 (e.g. Figure 4-14).

Fix: 3391 **E:** 434724 **N:** 5933057 **Depth:** 25.1

Fix: 3399 **E:** 434726 **N:** 5933050 **Depth:** 25.2

Station: CAM20, CAM21 & CAM22 Transect
Sediment Description:
Fix3391: Sand ripples with gravel, pebbles and shell fragments.

Fix3399: Sand ripples with cobbles pebbles, shell fragments and gravel.

Fauna Description:
Fix3391: Chordata (*Limanda limanda*)

Fix3399: Annelida (*S. spinulosa*), Echinodermata (Asteroidea) Porifera (Demospongiae)

Fix: 3448 **E:** 434714 **N:** 5933049 **Depth:** 25.2

Fix: 3454 **E:** 434708 **N:** 5933050 **Depth:** 25.4

Station: CAM20, CAM21 & CAM22 Transect
Sediment Description:
Fix3448: Sand with shell fragments.

Fix3454: Sand ripples with shell fragments and gravel. Anthropogenic debris present.

Fauna Description:
Fix3448: Annelida (*S. spinulosa*)

Fix3454: No Visible Fauna

Figure 4-14: Seabed photographs from stations ENV20, 21 and 22 at Audrey A (WD) (location shown in Figure 4-3)

Fix: 3475 E: 434980 N: 5933126 Depth: 24.4

Fix: 3491 E: 434955 N: 5933144 Depth: 24.4

Station: CAM25
Sediment Description:
Fix3475: Sand ripples with shell fragments, gravel and cobbles.

Fix3491: Sand ripples with shell fragments and gravel. Cobbles and boulders also present.

Fauna Description:
Fix3475: Annelida (*S. spinulosa*)

Fix3491: Echinodermata (Asteroidea), Cnidaria (*Alcyonium digitatum, Tubularia indivisa*), Porifera (Demospongiae)

Figure 4-15: Seabed photographs from station ENV25 at Audrey A (WD) (location shown in Figure 4-3)

Fix: 3342 E: 434672 N: 5932894 Depth: 25.9

Fix: 3343 E: 434667 N: 5932892 Depth: 25.9

Station: CAM30
Sediment Description:
Fix3342: Sand ripples with shell fragments, gravel and pebbles.

Fix3343: Sand ripples with shell fragments and gravel.

Fauna Description:
Fix3342: Bryozoa, Hydrozoa

Fix3343: No Visible Fauna

Figure 4-16: Seabed photographs from station ENV30 at Audrey A (WD) (location shown in Figure 4-3)

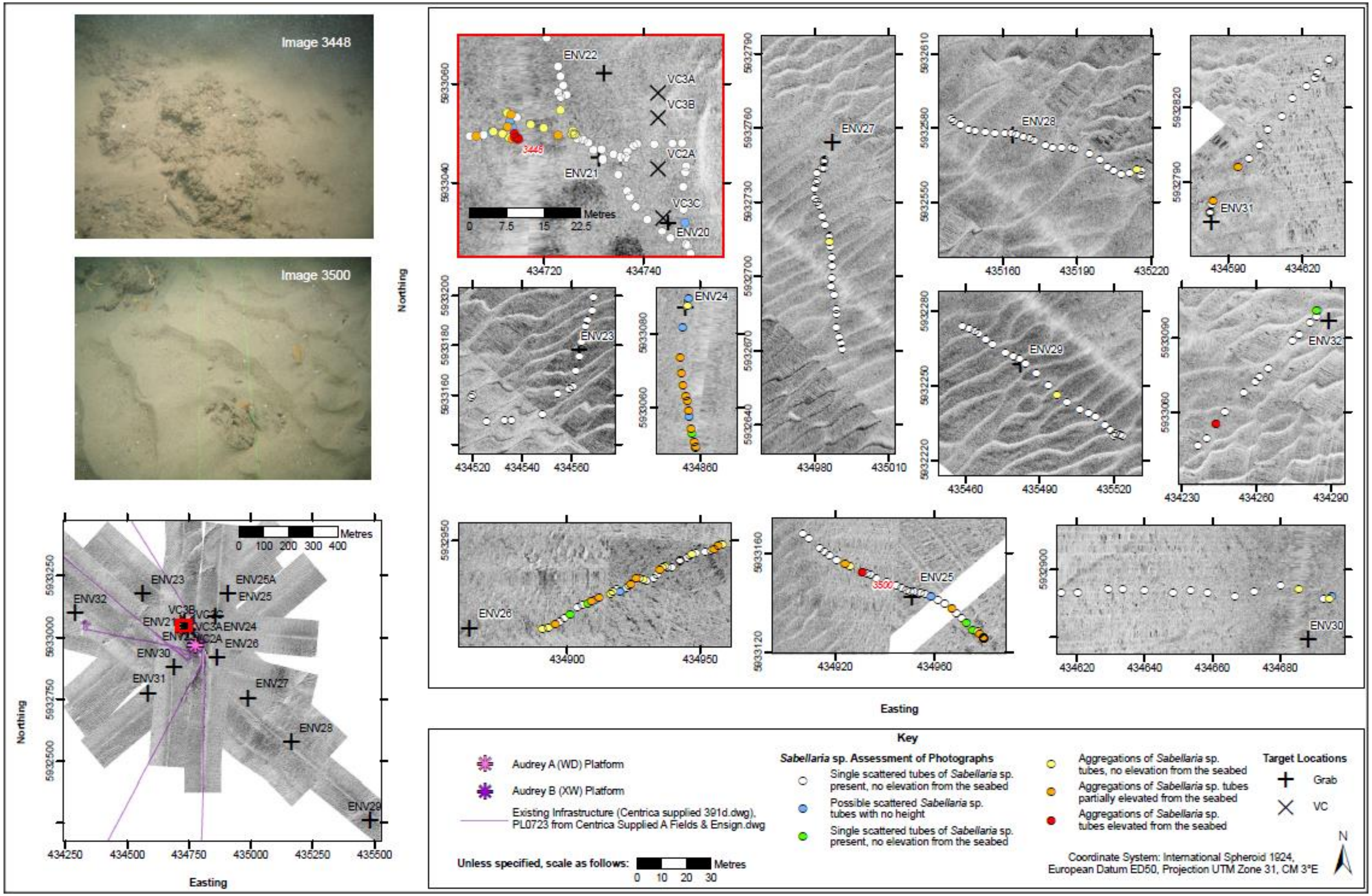


Figure 4-17: *Sabellaria spinulosa* assessment at Audrey A (WD)

Audrey B (XW) platform

All 11 stations selected for investigation were successfully ground-truthed with the digital camera system. Geophysical data showed generally lower sonar reflectivity interpreted as predominantly sand. Seabed imagery supported the geophysical data interpretation, confirming the seabed sediments as sand with shell fragments and occasional gravel, pebbles and cobbles. Areas of abundant cobbles and boulders were visible at the transect Station ENV33 (covering Stations ENV33, ENV34 and ENV35), which could correspond to a low resemblance stony reef, as listed under Annex I of the Habitats Directive (1992), as implemented by the Offshore Marine Conservation (Natural Habitats, &c.) Regulations (2007 (as amended)).

Overall, the composition of Stations ENV33, ENV34 and ENV35 was indicative of having no resemblance to a ‘stony reef’ as defined by Irving (2009) although it should be noted that some images at these stations were classified as low resemblance ‘stony reef’. Additionally, no potential ‘stony reef’ features were interpreted from the acoustic (SSS and MBES) data.

Sabellaria sp. reefs are listed under Annex I of the Habitats Directive (1992), as implemented by the Offshore Marine Conservation (Natural Habitats, &c.) Regulations (2007 (as amended)). *Sabellaria spinulosa* tubes were observed in a number of photographs at the transect Station ENV33. The Hendrick and Foster-Smith (2006) scoring system was applied in an attempt to define the ‘reefiness’ of the area or colonies identified within the survey area (Gubbay, 2007). Aggregations were observed in greatest abundance and height where the seabed presented occasional to abundant cobbles and boulders. No *Sabellaria sp.* aggregations were observed where sediments did not comprise coarse material (cobbles and boulders).

Sabellaria sp. individuals only occurred at the transect across Station ENV33 (covering ENV33, ENV34 and ENV35 locations) in the Audrey B (XW) survey area (Figure 4-20). At the transect across Station ENV33, most of the *Sabellaria* sp. occurred as partially raised aggregations. *Sabellaria* sp. also occurred as aggregations rising off the seabed, most similar to a reef. Taking into account the patchiness of the *Sabellaria* sp. aggregations observed and their variable elevation, these aggregations of *Sabellaria* sp. exhibited low 'reefiness' as described by Gubbay (2007) and this station cannot be considered as a *Sabellaria* sp. reef.

Other fauna observed across the stations included Annelida (Echiura, Polychaeta including *Lanice conchilega*, *S. spinulosa*, Serpulidae), Arthropoda (Brachyura, *Cancer pagurus*, Cirripedia, *Necora puber*, Paguridae), Bryozoa (*A. diaphanum*, *F. foliacea*), Cnidaria (*A. digitatum*, Actiniaria including *M. senile*, Hexacorallia, Hydrozoa including *Hydractinia echinata* and *Tubularia indivisa*), Echinodermata (*A. rubens*, Ophiuroidea), Chordata (Ascidiacea, *Agonus cataphractus*, Callionymidae, *Limanda limanda*), Porifera (Demospongiae) and Sipuncula. Similar to the Audrey A (WD) area, benthic fauna was generally sparse with higher densities associated with the occasional presence of gravel, pebbles and cobbles.

Station: CAM42
Sediment Description:
Fix4306: Sand ripples with shell fragments and gravel.

Fix4312: Sand ripples with shell fragments and gravel.

Fauna Description:
Fix4306: Echinodermata (Ophiuroidea)

Fix4312: No Visible Fauna

Figure 4-18: Seabed photographs from station ENV42 at Audrey B (XW) (location shown in Figure 4-4)

Station: CAM43
Sediment Description:
Fix4387: Sand ripples with shell fragments and gravel.

Fix4404: Sand ripples with shell fragments and gravel.

Fauna Description:
Fix4387: Echinodermata (Asteroidea)

Fix4404: No Visible Fauna

Figure 4-19: Seabed photographs from station ENV43 at Audrey B (XW) (location shown in Figure 4-4

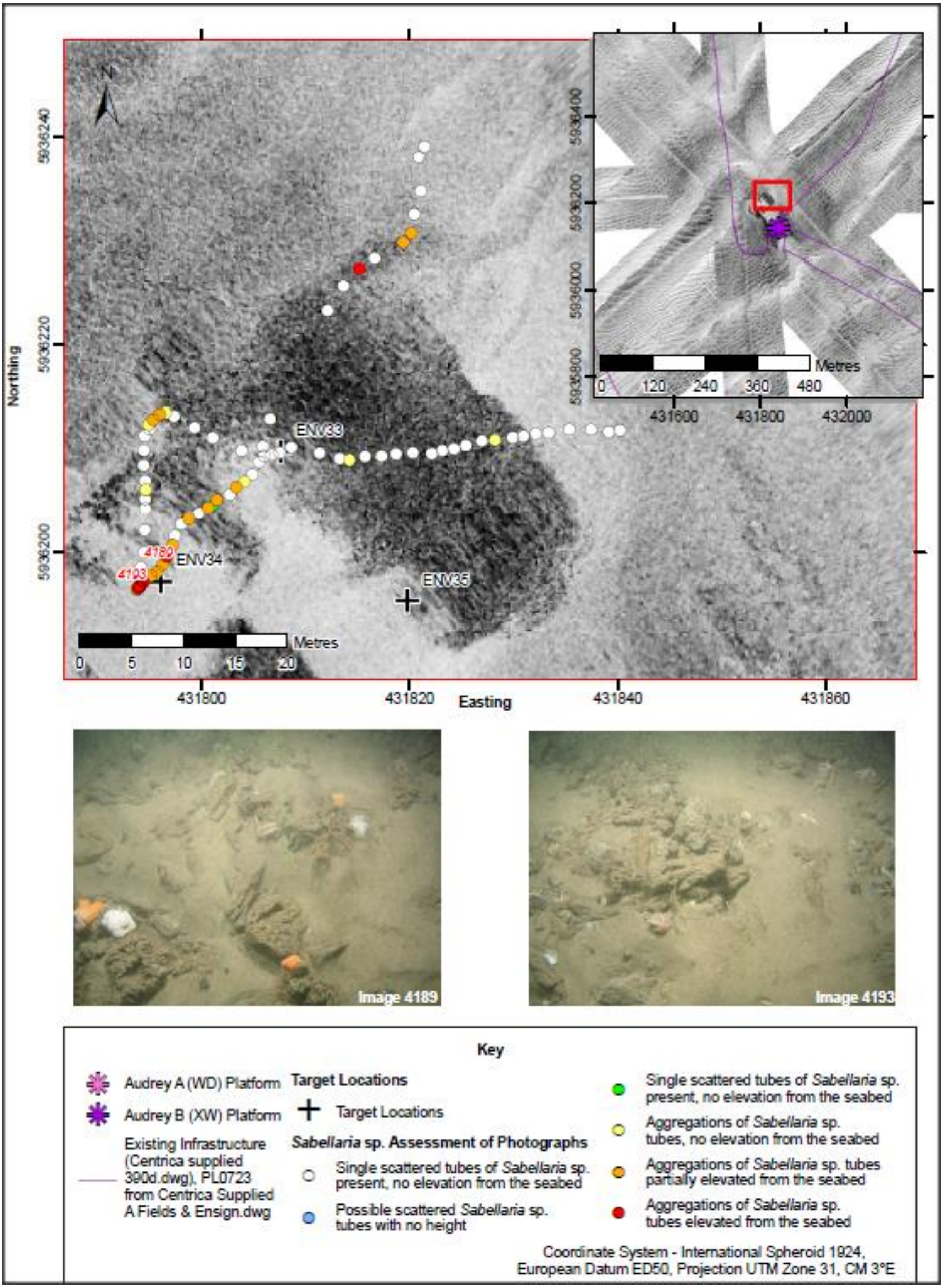


Figure 4-20: *Sabellaria* sp. assessment at Stations ENV33, ENV34 and ENV35 – Audrey B (XW)

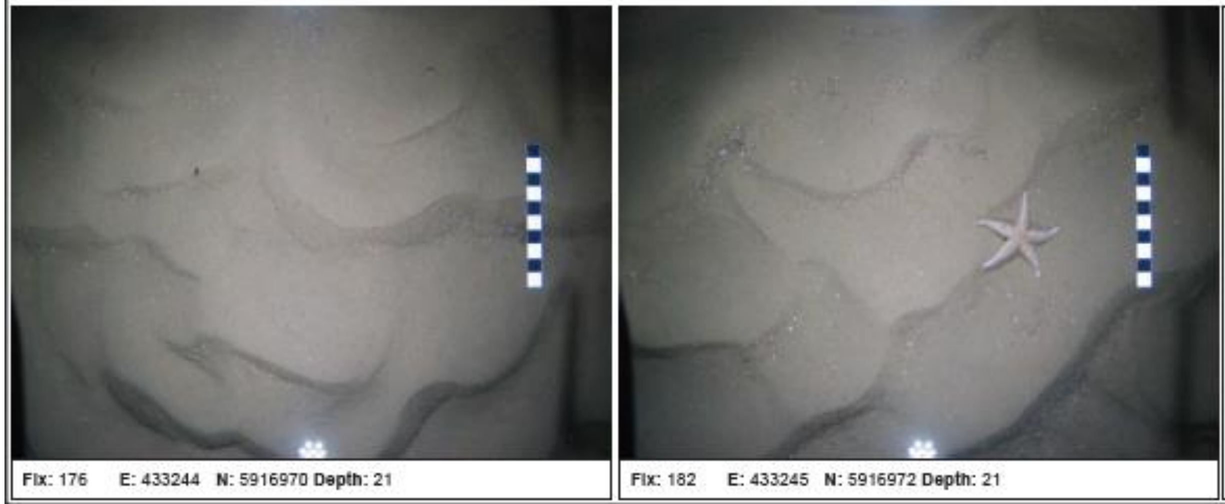
The LOGGS platform complex

The LOGGS survey area was found to be relatively homogeneous consisting of fine to coarse sand with shell fragments (Figure 4-21 and Figure 4-22).

The LOGGS survey area showed similarity to the Annex I habitat ‘Sandbanks which are slightly covered by sea water all of the time’. A north-west to south-east orientated bathymetric ridge was observed trending through the central region of the survey area which corresponds to Broken Bank, over the top of which water depths were generally less than 20m. This bathymetric feature, the sandy nature of the sediments and the EUNIS classification of the infralittoral fine sand are all consistent with the Annex I habitat ‘Sandbanks which are slightly covered by sea water all of the time’ (Gardline Environmental Limited, 2015b).

Visible fauna included: Arthropoda (Paguroidea), Chordata (Pleuronectiformes), Echinodermata (*Asterius rubens*, *Astropecten irregularis*, Ophiuroidea), Cnidaria (possible *Alcyonium digitatum*).

There was no indication of species or habitats on the OSPAR (2016) list of threatened and/or declining species and habitats or any species on the IUCN Global Red List of threatened species (IUCN, 2016).



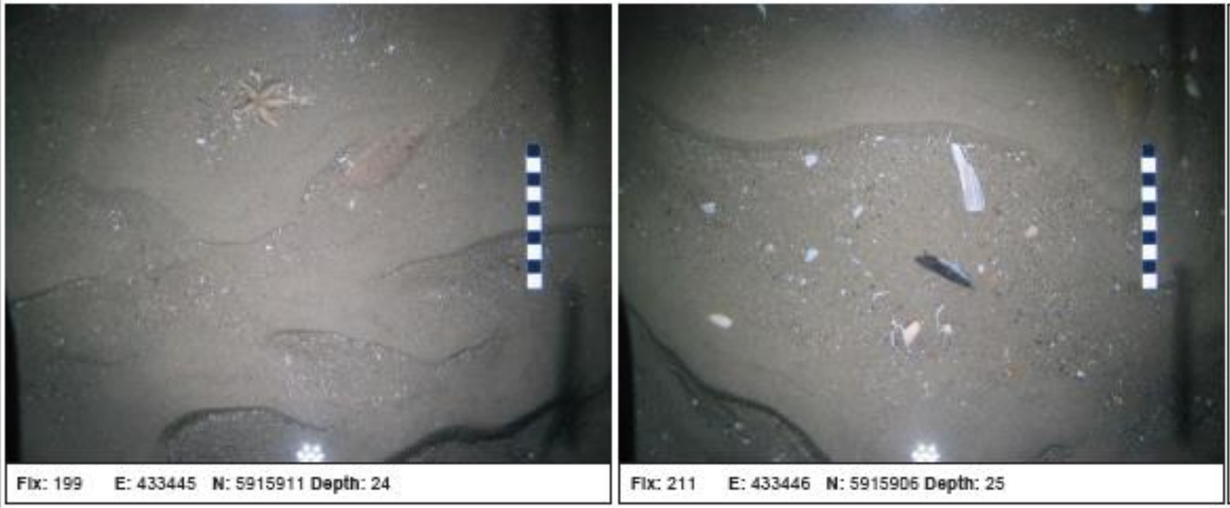
Station: LOGG_06
Sediment Description:
Fix176: Rippled sand with occasional shell fragments/hash

Fix182: Rippled sand with shell fragments/hash

Fauna Description:
Fix176: None Visible

Fix182: Echinodermata (Possible *Asterias rubens*)

Figure 4-21: Seabed photograph from station ENV06 at LOGGS (location shown in Figure 4-5)



Station: LOGG_08
Sediment Description:
Fix199: Rippled sand with shell fragments/hash

Fix211: Rippled sand with shell fragments and ocassional gravel

Fauna Description:
Fix199: Chordata (Possible *Buglossidium luteum*), Echinodermata (Possible *Asterias rubens*)

Fix211: Chordata (Possible *Buglossidium luteum*)

Figure 4-22: Seabed photograph from station ENV08 at LOGGS (location shown in Figure 4-5)

4.4 Marine flora and fauna

Typical of a shallow region in a temperate climatic zone, the North Sea is a complex and productive ecosystem which supports important fish, seabird and marine mammal populations. Pelagic and benthic communities are interlinked in tightly coupled food webs which, together with the abiotic environment, make up marine ecosystems. The flora and fauna that interact to make up the North Sea ecosystem are discussed below.

4.4.1 Plankton

Within the North Sea, planktonic assemblages are influenced mainly by vertical mixing and the availability of light and nutrients for growth (Striebel *et al*., 2010). During the winter months the rate of phytoplankton production decreases and increased concentrations of key nutrients i.e. phosphorus, ammonia, nitrogen and silicate, can be recorded as these are no longer used up during the production of phytoplankton. However, during the spring months, the rate of primary production increases significantly, coupled with a reduction in the available nutrients, which is subsequently followed in August by a smaller peak in abundance of phytoplankton (Johns and Reid, 2001). These large phytoplankton blooms which occur in the North Sea during the spring and autumn support the majority of marine food chains in the area.

The SNS is characterised by shallow, well-mixed waters, which undergo large seasonal temperature variations (JNCC 2004). The region is largely enclosed by land and, as a result, the environment here is dynamic with considerable tidal mixing and nutrient-rich run-offs from the land (eutrophication). Under these conditions, there is relatively little stratification throughout the year and constant replenishment of nutrients, so opportunistic organisms such as diatoms are particularly successful (Margalef 1973, cited in Leterme *et al.*, 2006); diatoms comprise a greater proportion of the phytoplankton community than dinoflagellates from November to May, when mixing is at its greatest (McQuatters-Gollop *et al.,* 2007). The phytoplankton community is dominated by the dinoflagellate genus *Ceratium* (*C. fusus*, *C. furca*, *C. lineatum*), along with higher numbers of the diatom, *Chaetoceros* than are typically found in the Northern North Sea (NNS). Harmful algal blooms (HABs) caused by *Noctiluca* sp. are often observed in the region.

The zooplankton community comprises *Calanus helgolandicus* and *C. finmarchicus* as well as *Paracalanus* sp., *Pseudocalanus* sp., *Acartia* sp., *Temora* sp. and cladocerans such as *Evadne* sp. There has been a marked decrease in copepod abundance in the SNS in recent years (Edwards *et al*. 2013), possibly linked to the North Atlantic Oscillation (NAO) index, which has a significant impact in the SNS, where the interface between the atmosphere and the sea is most pronounced (Harris *et al*. 2013)

4.4.2 Benthos

Bacteria, plants and animals living on or within the seabed sediments are collectively referred to as benthos. Species living on top of the sea floor may be sessile (e.g. seaweeds) or freely moving (e.g. starfish) and collectively are referred to as epibenthic organisms. Animals living within the sediment (e.g. clams, tubeworms and burrowing crabs) are termed infaunal species. Semi-infaunal animals, including sea pens and some bivalves, lie partially buried in the seabed.

The structure and distribution of North Sea benthic communities can be explained by the environmental parameters including temperature, salinity, tidal/wave-induced seabed stress, stratification, depth, and sediment type. Their relative importance varies spatially, and many are inter-correlated (Rees *et al*., 2007).

Annabel

The macrofaunal community structure was slightly heterogeneous, with lower faunal density and species richness at Stations ENV14, ENV15 and ENV19, associated with sandier, more mobile conditions (Figure 4-2). These stations were dominated by the polychaete *Ophelia borealis*, where it accounted for >30% of the adult community, together with a higher relative contribution from juveniles. In contrast the slightly more diverse community at Stations ENV16, ENV17 and ENV18 was attributed to the more stable and mixed sediment type present. This was in line with the seabed video imagery and camera photography observations, which revealed greater faunal density and species richness at these locations.

The macrofaunal faunal community at these stations was characterised by a wider variety of taxa and distinct largely due to higher abundances of *Echinocyamus pusillus,* Nemertea, *Grania*, *Timoclea ovata* and *Aonides paucibranchiata* and the presence of *Caecum glabrum* and *Rullierinereis ancornunezi, Pholoe baltica*, *Pisione remota*, *Notomastus latericeus, Mediomastus fragilis* and *Glycera lapidum.* Overall, the macrofaunal community was generally representative of the wider area and showed no evidence of anthropogenic disturbance related to historic drilling activity within the Annabel manifold, AB1 WHPS and AB2 WHPS survey area.

Overall, the results of the physico-chemical and macrofauna analyses did not indicate an effect of anthropogenic activities on the faunal community. Levels of contaminants were generally representative of the background levels for the wider area of the SNS. Variations in the macrofaunal community corresponded with natural variation in the sediment composition.

Audrey A (WD) platform and Audrey 11a-7 WHPS

The Polychaeta group dominated the macrofaunal community both in terms of individuals and taxa across the samples. Overall, Polychaeta represented 66% of all individuals and 47% of all taxa in the full data set, while Crustacea represented 17% of individuals and 28% of taxa (Table 4-4).

The benthic faunal community was slightly heterogeneous across the survey area, generally typical of the sandy sediments of the SNS, dominated by the polychaetes *Spiophanes bombyx* most notably on the drill cuttings pile and *Ophelia borealis* particularly at stations ≥150m from the platform as well as the crustacean *Bathyporeia elegans,* which increased its dominance ≥500m from the platform. These three taxa together accounted for 37% of the 4,378 individuals across the 25 samples obtained in the survey area. In terms of taxonomic groups, the macrofaunal community was dominated by Polychaeta both in terms of individuals and taxa, which was representative of the wider area of the SNS. Approximately 8% of individuals and 14% of taxa were juvenile. Univariate statistics indicated some heterogeneity in the community structures across the samples. Samples ENV20, ENV21, ENV22, all situated at the Audrey A (WD) drill cuttings pile (Figure 4-3), generally presented the lowest faunal density and species richness across the survey area including the absence or lower abundances of the survey wide top ten taxa, possibly indicating an impact from drilling related contamination. Multivariate analyses confirmed the clear dissimilarities in the macrofaunal composition based on distance from the Audrey A (WD) Platform/drill cuttings pile described above, with the samples from the drill cuttings pile (ENV20 to ENV22) identified as the most dissimilar to the remaining samples.

This pattern was compared to the physico-chemical data set, which resulted in a 74% correlation between the faunal pattern and percentages of sand and concentrations of hydrocarbons across the survey area. It was concluded that the macrofaunal community in the Audrey A (WD) Platform and Audrey 11a-7 WHPS survey area was influenced by variations of sediment size, which may be linked to the presence of drill cuttings, as well as the anthropogenic input of hydrocarbon contaminated drill cuttings in the survey area.

Audrey B (XW) platform

The benthic faunal community was slightly heterogeneous across the survey area, generally typical of the sandy sediments of the SNS, dominated by the polychaetes *Ophelia borealis* most notably at stations *c.*100m from the Audrey B (XW) platform (Stations ENV37 and ENV39), *Spiophanes bombyx* and the crustacean *Bathyporeia elegans* particularly at stations *c.*300m north-west and south-east to 550m south-east of the platform (Stations ENV36, ENV40 and ENV41) and *Spio goniocephala* most notably at 1,000m south-east (Station ENV42) or perpendicular to the dominant current at *c.*250m north-east (Station ENV38). These three taxa together accounted for 42% of the 2,148 individuals across the 18 samples obtained in the survey area (Table 4-4).

In terms of taxonomic groups, the macrofaunal community was dominated by Polychaeta both in terms of individuals and taxa, which was found representative of the wider area of the SNS. Approximately 11% of individuals and 14% of taxa were juvenile, and these were also predominantly polychaetes, therefore having an insignificant influence on the overall faunal community structure.

Univariate statistics indicated some heterogeneity in the community structures across the samples. Interestingly, the samples from the deposited rock/drill cuttings pile presented the greatest species richness and diversity values, albeit with the absence or lower abundances of the survey wide top ten taxa. This shift in community structure, including the tube dwelling amphipod *Jassa* and the Polychaeta *Phyllodoce maculata*, which were unique to these two stations is consistent with the relatively stable substrate at this location. The remaining stations were more sparsely populated and less diverse, as would be expected for the mobile sandy conditions across the rest of the survey area.

Multivariate analyses confirmed the clear dissimilarities in the macrofaunal composition based on distance from the Audrey B (XW) Platform, described above, with the samples from the deposited rock/drill cuttings pile (ENV34 and ENV47) identified as the most dissimilar to the remaining samples. This pattern was compared to the physico-chemical data set, which resulted in an 82% correlation between the faunal pattern and concentrations of TOC, THC, As and Pb. It was therefore concluded that the macrofaunal community in the Audrey B (XW) Platform survey area was influenced by variations in sediment characteristics and concentrations of contaminants that can all be related to the presence of drill cuttings and coarse sediments.

The LOGGS platform complex

At the LOGGS platform complex 12 faunal samples were collected from 12 sampling stations. A total of 1,339 individuals representing 83 taxa were recorded across the 12 stations. Juveniles accounted for 420 individuals from 26 taxa representing 31% of total individuals and of the total taxa (Table 4-4).

Amphipoda represented 87% of all juvenile Crustacea with 95% of those distributed across the genera *Urothoe* and *Bathyporeia*. Adult Crustacea, were dominated by Cumacea, which represented 49% of all adult Crustacea, 86% of which belonged to a single species, *Monopseudocuma gilsoni*.

Polychaeta was the second most abundant major taxonomic group in both full and adult data sets, representing 25% of all individuals and 29% of adults, which corresponded to 36% of all taxa and 39% of adult taxa. The taxonomic groups Mollusca, Echinodermata and “Others” each represented ≤5% of all individuals and a lower proportion of adults (≤2%). Mollusca, Echinodermata and “Others” comprised 8%, 6% and 6% of all taxa, respectively and 7%, 4% and 7% of adult taxa, respectively. Only two Echinodermata individuals were adults, all other 63 individuals (97%) were juveniles, dominated by Ophiuroidea and Spatangoida juveniles (73% and 22% of all Echinodermata juveniles, respectively).

GROUP	AUDREY A (WD) PLATFORM		AUDREY B (XW) PLATFORM		ANNABEL		The LOGGS platform complex	
	PROPORTION CONTRIBUTION (%)		PROPORTION CONTRIBUTION (%)		PROPORTION CONTRIBUTION (%)		PROPORTION CONTRIBUTION (%)	
	INDIVIDUALS (n=4,378)	TAXA (n=177)	INDIVIDUALS (n=2,148)	TAXA (n=103)	INDIVIDUALS (n=1,603)	TAXA (n=139)	INDIVIDUALS (n=1,339)	TAXA (n=83)
Polychaeta	65.6	68.4	68.4	42.7	44.4	46.8	24.8	36.1
Crustacea	16.8	21.1	21.1	31.1	7.7	26.6	67.7	43.4
Mollusca	4.1	2.9	2.9	15.5	13.0	15.8	1.7	8.4
Echinodermata	3.3	0.4	0.4	4.9	25.1	4.3	4.9	6.0
Others	10.2	7.2	7.2	5.8	9.8	6.5	1.0	6.0

Table 4-4: Contribution of taxonomic groups to the macrofaunal community (full data set)

4.4.3 Fish populations

Fish occupying areas in close proximity to offshore oil and gas activities could be exposed to aqueous discharges and may accumulate hydrocarbons and other contaminating chemicals in their body tissues.

Fish communities comprise species that have complex interactions with one another and the natural environment. They consume a wide range of benthic invertebrates and/or act as predators at higher trophic levels, while themselves being a source of prey for larger animals.

At present, more than 330 fish species are thought to inhabit the shelf seas of the UKCS (Pinnegar *et al*, 2010). Finfish species can broadly be divided into pelagic and demersal species. Pelagic species e.g. herring, mackerel, blue whiting and sprat are found in mid-water and typically make extensive seasonal movements or migrations. Demersal species e.g. cod, haddock, sandeels, sole and whiting live on or near the seabed and, similar to pelagic species, many are known to passively move (e.g. drifting eggs and larvae) and/or actively migrate (e.g. juveniles and adults) between areas during their lifecycle.

The most vulnerable stages of the life cycle of fish to general disturbances, such as disruption to sediments and oil pollution, are the egg and larval stages. Hence, recognition of spawning and nursery grounds within a project area is important. Table 4-5 shows approximate spawning times of some of the commercial fish species occurring in the region of the A-Fields and identifies some species known to use the area as a nursery ground (Coull *et al*., 1998; Ellis *et al*., 2012).

SPECIES	J	F	M	A	M	J	J	A	S	O	N	D	NURSERY
Mackerel					■	■	■	■					▒
Herring								■	■	■			▒
Cod	■	■	■	■									▒
Whiting		■	■	■	■	■							▒
Plaice	■	■	■									■	▒
Lemon Sole				■	■	■	■	■	■				▒
Sandeel	■	■									■	■	▒
Nephrops	■	■	■	■	■	■	■	■	■	■	■	■	▒
Sprat					■	■	■	■					▒
KEY	■ SPAWNING PERIODS							▒ NURSERY GROUNDS PRESENT					

Table 4-5: Spawning periods and nursery grounds in the vicinity of the A-Fields

Spawning and nursery areas cannot be defined with absolute accuracy and are found to shift over time. Recognised spawning and nursery grounds of some commercially important species occurring within the area are shown in Figure 4-23 (Coull *et al*, 1998; Ellis *et al*., 2012). It can be seen from Figure 4-23 that there is the potential for the Annabel Field decommissioning to impact possible herring spawning grounds. This is discussed in detail below in Section 4.4.3.1

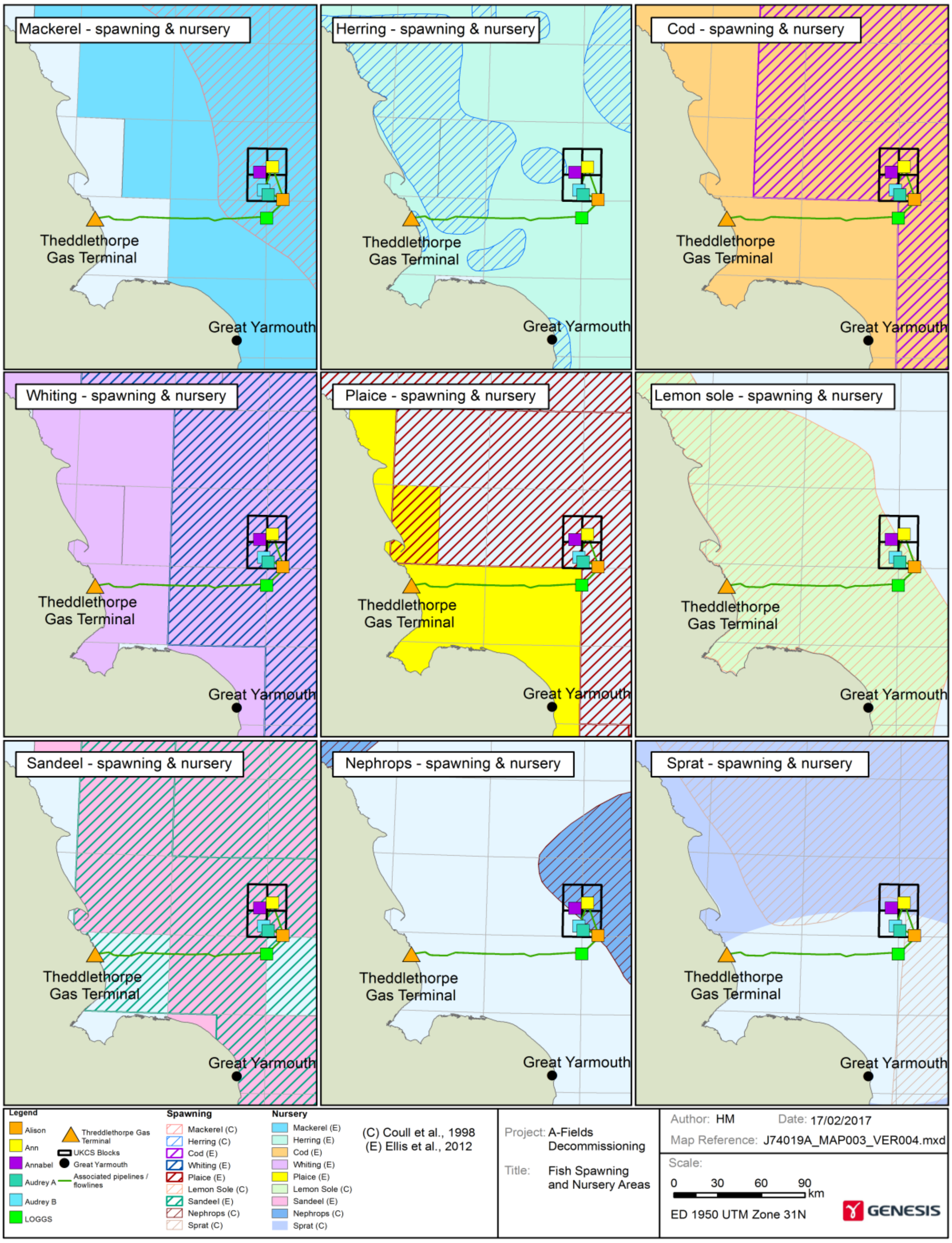


Figure 4-23: Spawning and nursery grounds in the vicinity of the A-Fields

4.4.3.1 Herring spawning grounds

Determination of spawning potential for a specific area of seabed has been based on guidelines provided by Cefas (2001), and a variety of measured and inferred sedimentological and hydrodynamic characteristics.

In order to be considered suitable for herring spawning the sediment must be composed of well sorted (≤0.5 sorting coefficient), coarse sand or fine gravel with little (<2%) or no fine material (<63µm, silt and clay). In addition, the area must be exposed to the main flow of water in order to ensure maximum oxygenation of the sediment and hence the lower layers of herring eggs; the area should be elevated with respect to the surrounding seabed. Based on these criteria, the herring spawning potential of each sample station is graded from none to high as shown in Table 4-6.

HERRING SPAWNING GROUND POTENTIAL	
High	Meets all of the criteria. Significant herring spawning potential.
Moderate	Meets most of the criteria. Some herring spawning potential.
Low	Meets few of the criteria. Insignificant herring spawning potential.
None	Meets none of the criteria. No herring spawning potential.

Table 4-6: Herring spawning ground potential criteria

The Annabel Field is situated close (*c.*6km) to an area identified as herring spawning ground. Herring spawning ground potential was investigated around the Annabel template and the AB1 and AB2 WHPS.

The herring spawning potential at each station, based on these criteria along with factors important in determining this, are displayed in Table 4-7. The site lies in UKCS block 48/10a, and is situated approximately 6km east of the nearest zone of spawning, as identified by (Coull *et al.*, 1998, Figure 4-23). Other spawning areas lie 41km to the north-east and 55km to the south-west, all of which are reported to support herring spawning between August and October (Figure 4-23 and Table 4-5). This area experiences a predominant current direction of north-west to south-east, as supported by the orientation of megaripples occurring in bathymetry and sonar data across the survey area. The tidal currents are reported to be up to 1.9 knots in this area (Du Port and Buttress, 2012), which falls within the preferred range of between 1.5 knots and 3.0 knots for herring to spawn (Reid *et al.*, 1999).

The water depth across the Annabel manifold, AB1 WHPS and AB2 WHPS survey area was approximately 24.2m to 27.9m, which lies within the suitable range for herring spawning (Reid *et al.*, 1999). Results of the particle size analysis revealed all stations were composed of moderate to very poorly sorted slightly gravelly sand to sandy gravel, with a low (≤1.9%) proportion of fine material (<63µm, silt and clay), and with coarse material (gravel, >2mm) representing from 4.5% to 67.7% of the samples. All stations showed low fines content, however, no station presented well sorted sediments and gravel content was quite variable. Therefore, no stations were identified as gravels forming raised banks; the seabed type widely considered to be the preferred spawning substrate of herring (Drapeau, 1973), and all stations presented no potential (Table 4-7).

STATIONS	STATION DESIGNATION[1]	% COARSE SAND TO GRANULE /SORTING COEFFICIENT[2]	WELL SORTED SEDIMENT (<0.5)	SEDIMENT DESCRIPTION[3]	% FINE MATERIAL (% <63µM)	EXPOSED TO THE MAIN FLOW OF WATER	HERRING SPAWNING POTENTIAL
ENV14	250m NW	27.56	Moderate (0.9)	Slightly gravelly sand (m)	0.0	Edge of area of sandwaves	None
ENV15	190m NE	11.18	Poor (1.9)	Gravelly (g) sand (m)	0.0	Featureless	None
ENV16	65m E	15.15	Very poor (2.3)	Sandy (m), gravel (p, g)	1.1	Featureless	None
ENV17	300m SE	24.66	Poor (1.9)	Sandy (m) gravel (g)	1.9	Featureless	None
ENV18	550m SE	22.01	Poor (2)	Sandy (m) gravel (g)	1.1	Featureless	None
ENV19	104m SW	30.30	Moderate (0.9)	Gravelly sand (m)	0.0	Edge of area of sandwaves	None
ENV48	560m SE	N/A	N/A	Sandy gravel*	N/A	Featureless	None

[1]Distance and direction from the Annabel template location.
[2]This index combines both the percentage coarse sand to granule sized material, and the sorting coefficient. High values (*c* 200) result from the sediment being both coarse and well sorted.
[3]Mode grain size is indicated in brackets; m= medium sand; g= granule; p=pebble.
*Sediment Description for Station ENV48 was approximated from seabed video imagery and camera photography.
N/A Not available

Table 4-7: Summary of herring spawning potential. Station locations are shown in Figure 4-2

4.4.4 Marine mammals

Marine mammals include cetaceans (whales, dolphins and porpoises), pinnipeds (seals) and mustelids (otters), all of which are susceptible to anthropogenic stresses.

4.4.4.1 Cetaceans

Sightings of numerous species of cetacean have been recorded on the European continental shelf. However, in many instances within the North Sea, recorded sightings are associated with single individuals (Reid *et al*, 2003). All cetacean species occurring in UK waters are afforded European Protected Species (EPS) status (Section 4.5.5).

As with most species, an optimal survey design for monitoring population sizes of cetaceans would involve surveying the species across its entire distribution at any one time. The impracticality of such a task, combined with difficulties of species identification, has made it difficult to confidently assess cetacean population sizes. The Joint Nature Conservation Committee (JNCC) has compiled an atlas of cetacean distribution in north-west European waters (Reid *et al*., 2003) which gives an indication of the types of cetaceans and times of the year that they are likely to frequent areas of the North Sea.

Harbour porpoise, and white-beaked dolphin have been sighted in the vicinity of the A-Fields as shown in Table 4-8 and Figure 4-24 (Reid *et al*, 2003).

SPECIES	J	F	M	A	M	J	J	A	S	O	N	D
Harbour Porpoise												
White-beaked dolphin												
	Species sighted						Species not sighted					

Table 4-8: Cetaceans sighted in the vicinity of the A-Fields (Reid *et al*, 2003)

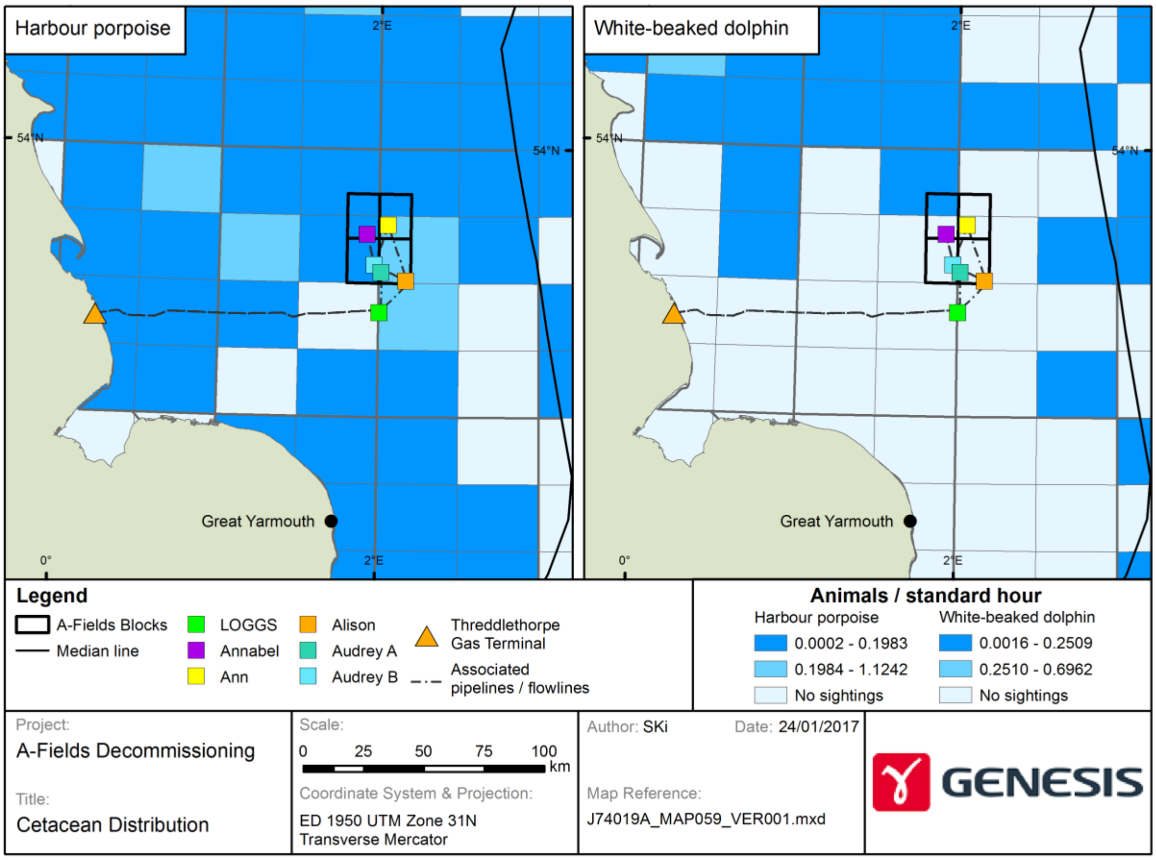


Figure 4-24: Sightings of harbour porpoise and white beaked dolphins in the vicinity of the A-Fields (Reid *et al*., 2003)

The Habitats Directive lists those habitats and species (Annex I and II respectively) whose conservation requires the designation of special areas of interest. Harbour porpoise are listed under Annex II of the Habitats Directive (see Section 4.5.5). Candidate SACs (cSACs) have been identified for harbour porpoise in UKCS waters and are currently under public consultation (JNCC, 2016a). The A-Fields are located in one of these identified areas and is discussed further in Section 4.5.

4.4.4.2 Pinnipeds

Two species of seal reside in UK coastal waters; the grey seal (*Halichoerus grypus*) and the common seal (*Phoca vitulina*).

Both species will feed in both inshore and offshore waters depending on the distribution of their prey, which changes both seasonally and yearly. Both species tend to be concentrated close to shore, particularly during the pupping (October and November for grey seals and June and July for common seals) and moulting (generally January to April for grey seals and August and September for the common seal) seasons. Seal tracking studies from the Moray Firth have indicated that the foraging movements of common seals are generally restricted to within a 40 to 50km range of their haul-out sites (Special Committee on Seals (SCOS, 2012).

The movements of grey seals can involve larger distances than those of the common seal, and trips of several hundred kilometres from one haul-out to another have been recorded (Jones *et al.*, 2013). Figure 4-25 shows that the mean density of seals expected in the vicinity of the A-Fields is low for both harbour seals (0-1 per 25km^2) and grey seals (5-10 per 25km^2) (Jones *et al.*, 2013). As such it is possible that seals may pass through the area around the A-Fields, but they are unlikely to spend significant periods there, particularly during the pupping and moulting seasons when they will spend more time ashore.

It should be noted that grey seals and harbour seals are both listed under Annex II of the Habitats Directive (Section 4.5.5).

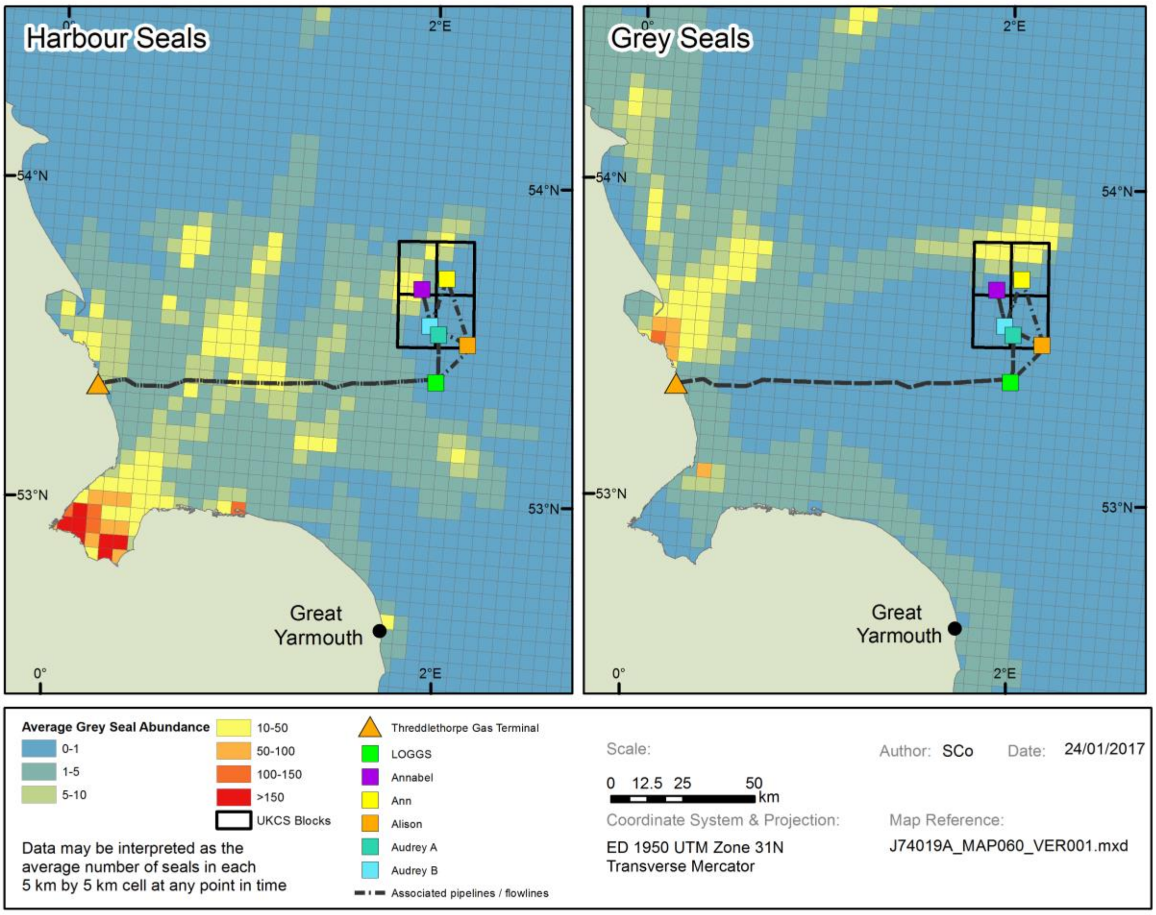


Figure 4-25: Average seal abundance in the vicinity of the A-Fields

4.4.5 Seabirds

Seabirds are generally not at risk from routine offshore operations. However, they may be vulnerable to pollution from less regular activities, for example from accidental hydrocarbon releases.

The Seabird Oil Sensitivity Index (SOSI) is a tool which aids planning and emergency decision making with regards to oil pollution. It identifies areas at sea where seabirds are likely to be most sensitive to oil pollution. It is based on seabird survey data collected from 1995 to 2015, from a wide survey area extending beyond the UK Continental Shelf using boat-based, visual aerial, and digital video aerial survey techniques.

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

- Habitat flexibility (a species ability to locate to alternative feeding sites);
- Adult survival rate;
- Potential annual productivity; and
- The proportion of the biogeographical population in the UK

were classified following the methods developed by Certain *et al*., (2015).

The combined seabird data and species sensitivity index values are subsequently summed at each location to create a single measure of seabird sensitivity to oil pollution. This is presented as a series of fine scale density maps for each month that show the median, minimum and maximum seabird sensitivity to oil pollution, and an indication of data confidence. The index is independent of where oil pollution is most likely to occur; rather, it indicates where the highest seabird sensitivities might lie if there were to be a pollution incident. The mean sensitivity SOSI data for the area surrounding the A-Fields is shown in Figure 4-26. Where data is available, sensitivity is seen to be extremely high, except in August when sensitivity is considered to be medium. Data is not available for the A-Fields blocks in January, March, April, May, June, October and December.

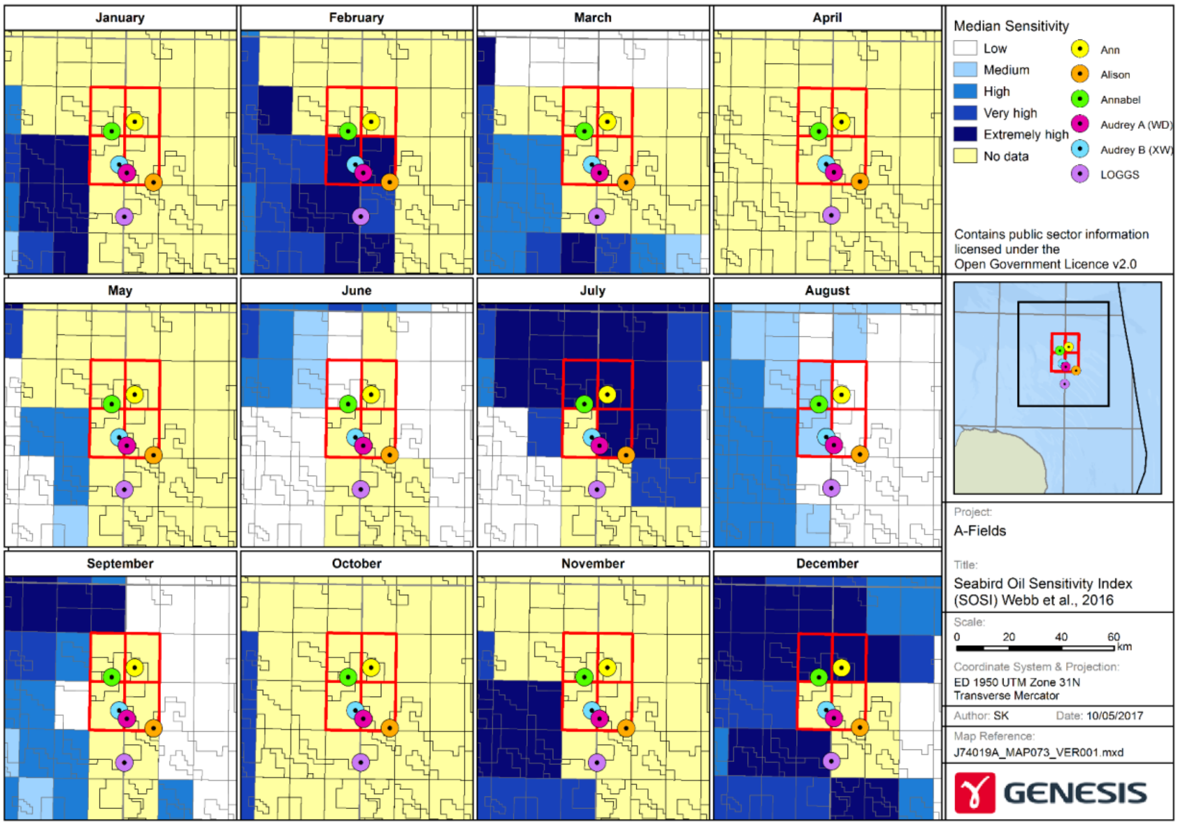


Figure 4-26: Median seabird oil sensitivity index in the vicinity of the A-Fields (Webb *et al.*, 2016)

In order to reduce the extent of the coverage gaps in Figure 4-26, guidance from JNCC (JNCC, 2017) has been followed. By following the JNCC guidance, the data gaps are reduced. The revised SOSI for the A-Fields area is shown in

Block	J	F	M	A	M	J	J	A	S	O	N	D
48/4	*	*		*	*					*	*	
48/5	*	*		*	*					*	*	
49/1	*	*		*						*	*	
49/2	*	*		*	*					*	*	
48/9	*	**	**		*					*	*	
48/10 **(Annabel)**	*	**	**		*				*		*	
49/6 **(Ann)**	*	**							*		*	
49/7	*	**			*					*	*	
48/14				*		*				*		
48/15 **(Audrey B)**	*		*		**	**	*		*		**	**
49/11 **(Audrey A, Alison)**	*		*			*			*			**
49/12		**			*					*		
48/19				*						*		
48/20 **(LOGGS)**	*		*		**	**	*		*		*	
49/16 **(LOGGS)**	*		*				*		*			**
49/17		**	**			*				*		**
48/24				*			*			*		
48/25	*			*	**	**	*		*	*		
49/21	*			*			*		*	**	*	
49/22	*	*		*			*			*	*	

KEY	Extremely High	Very High	High	Medium	Low	No data

** data gap filled using data from the same block in adjacent months (JNCC, 2017)*

*** data gap filled using data from adjacent blocks within the same month (JNCC, 2017)*

Table 4-9. Using the JNCC guidance the areas with no data have been reduced. In general, sensitivity is extremely high from November to February in the A-Fields blocks. From March to October, sensitivity is generally high to low with the exception of July where sensitivity is extremely high.

Block	J	F	M	A	M	J	J	A	S	O	N	D
48/4	*	*		*	*					*	*	
48/5	*	*		*	*					*	*	
49/1	*	*		*						*	*	
49/2	*	*		*	*					*	*	
48/9	*	**	**		*					*	*	
48/10 **(Annabel)**	*	**	**		*				*		*	
49/6 **(Ann)**	*	**							*		*	
49/7	*	**			*					*	*	
48/14				*		*				*		
48/15 **(Audrey B)**	*		*		**	**	*		*		**	**
49/11 **(Audrey A, Alison)**	*		*			*			*			**
49/12		**			*					*		
48/19				*						*		
48/20 **(LOGGS)**	*		*		**	**	*		*		*	
49/16 **(LOGGS)**	*		*				*		*			**
49/17		**	**			*				*		**
48/24				*			*			*		
48/25	*			*	**	**	*		*	*		
49/21	*			*			*		*	**	*	
49/22	*	*		*			*			*	*	
KEY	Extremely High		Very High		High		Medium		Low		No data	
** data gap filled using data from the same block in adjacent months (JNCC, 2017)*												
*** data gap filled using data from adjacent blocks within the same month (JNCC, 2017)*												

Table 4-9: Revised median seabird oil sensitivity index using JNCC guidelines to fill on data gaps (JNCC, 2017)

4.5 Habitats and species of conservation concern

The EU Habitats Directive (92/43/EEC) and the EU Birds Directive (79/409/EEC) are the main driving forces for safeguarding biodiversity in Europe.

Through the establishment of a network of protected sites these directives provide for the protection of animal and plant species of European importance and the habitats that support them.

The EU Habitats Directive 92/43/EEC and the EU Birds Directive 79/409/EEC have been enacted in the UK by the following legislation:

- The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) transpose the Habitats and Birds Directives into UK law. They apply to land and to territorial waters out to 12nm from the coast and have been subsequently amended several times;
- The Conservation of Habitats and Species Regulations 2010: The Conservation of Habitats and Species Regulations 2010 consolidate all the various amendments made to the Conservation (Natural Habitats, &c.) Regulations 1994 in respect of England and Wales. In Scotland, the Habitats and Birds Directives are transposed through a combination of the Habitats Regulations 2010 (in relation to reserved matters) and the 1994 Regulations;
- The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended 2009 and 2010): These regulations are the principal means by which the Birds and Habitats Directives are transposed in the UK offshore marine area (i.e. outside the 12nm territorial limit) and in English and Welsh territorial waters; and

- The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended 2007): These regulations apply the Habitats Directive and the Wild Birds Directive in relation to oil and gas plans or projects wholly or partly on the United Kingdom Continental Shelf and adjacent waters outside territorial waters (i.e. outside the 12nm territorial zone).

The Habitats Directive lists those habitats and species (Annex I and II respectively) whose conservation requires the designation of special areas of interest. These habitats and species are to be protected by the creation of a series of Special Areas of Conservation (SACs), and by various other safeguard measures such as Sites of Community Importance (SCIs) for particular species. SACs are sites that have been adopted by the European Commission (EC) and formally designated by the government of the country where the site lies and SCIs are sites that have been adopted by the EC but not yet formally designated by the government of the relevant country.

The Birds Directive requires member states to nominate sites as Special Protection Areas (SPAs). Together with adopted SACs, the SPA network form the 'Natura 2000' network of protected areas in the European Union. Figure 4-27 shows the location of the Audrey platforms and the Annabel Field in relation to protected areas.

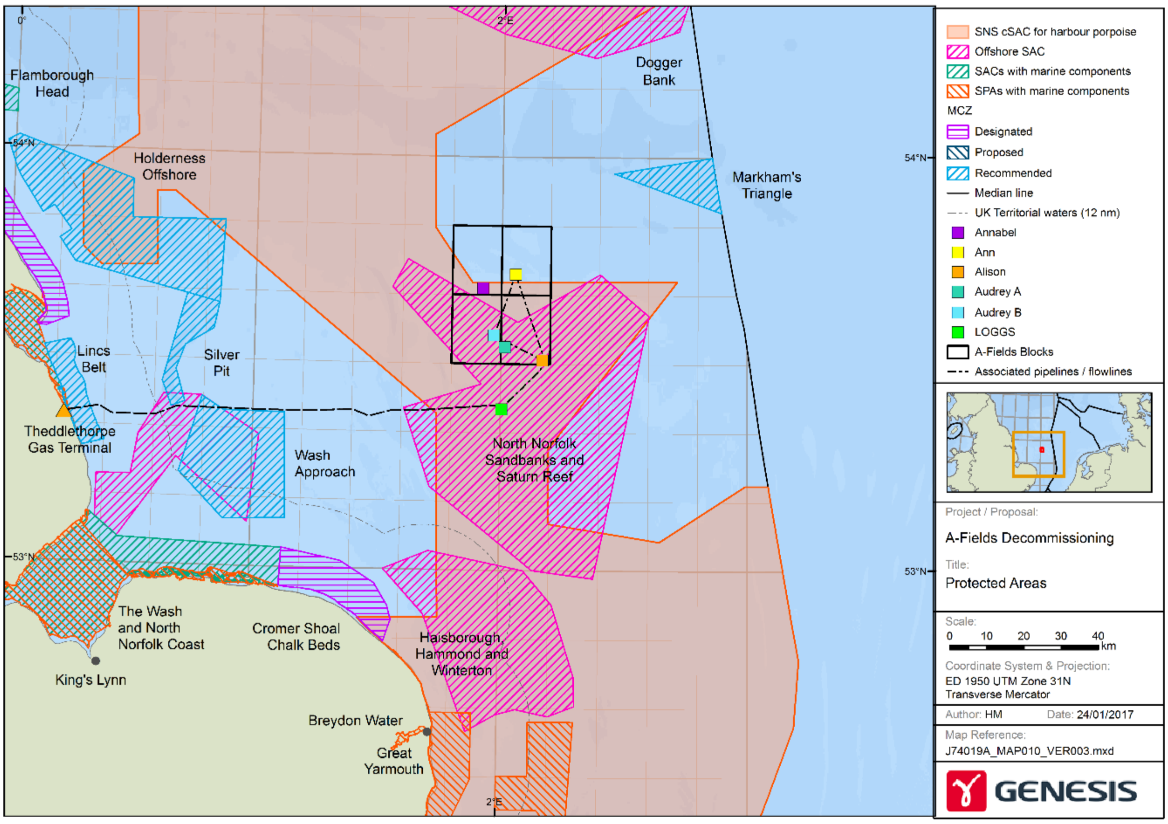


Figure 4-27: SACs/SCIs, cSACs, SPAs and Natura 2000 sites in the region of the Audrey platforms and the Annabel Field

4.5.1 Special areas of conservation / sites of community importance

There are currently 99 SACs with marine components, covering 7.6% of the UK marine area. Of these, 83 SACs are found within inshore waters, 16 are located in offshore waters and there are four sites which are within both inshore and offshore waters. In addition, five cSACs for the Annex II species harbour porpoise (*Phocoena phocoena*) have been identified, including one in the SNS which coincides with the majority of the A-Fields area.

4.5.1.1 North Norfolk Sandbanks and Saturn Reef SAC

Annablel is 3.5km north of the North Norfolk Sandbanks and Saturn Reef SAC and the Audrey platforms lie within it (Figure 4-28). It covers which covers an area of 3,603km^2. This comprises a series of ten main sandbanks and associated fragmented smaller banks formed as a result of tidal processes (Section 4.3.7) and areas of *Sabellaria* sp. biogenic reef.

The Conservation Objectives for North Norfolk Sandbanks and Saturn Reef SAC sandbanks which are slightly covered by seawater all the time, and reef, are:

Subject to natural change, restore the sandbanks which are slightly covered by seawater all the time and reefs to favourable condition, such that the:

- *The natural environmental quality, natural environmental processes and extent are maintained; and*
- *The physical structure, diversity, community structure and typical species, representative of sandbanks which are slightly covered by seawater all the time and reefs in the Southern North Sea are restored* (JNCC, 2012)*.*

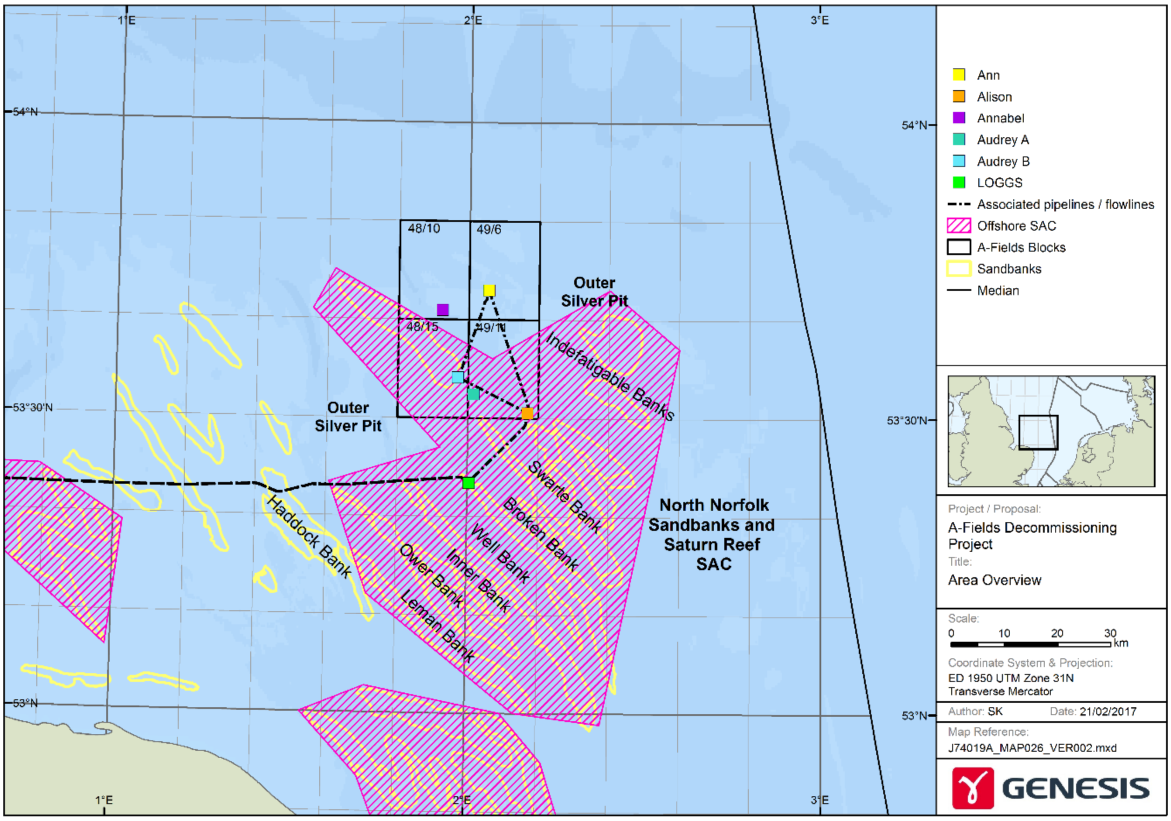


Figure 4-28: North Norfolk Sandbanks and Saturn Reef SAC

Sandbanks

The North Norfolk Sandbanks extend from about 40km off the north-east coast of Norfolk out to *c.*110km. The banks are the most extensive example of offshore linear ridge sandbank types in UK waters and the outer banks are the best example of open sea, tidal sandbanks in a moderate current strength in UK waters (Graham *et al*., 2001).

The sand banks are subject to a range of current strengths which are strongest on the banks closest to shore and which reduce offshore (Collins *et al*., 1995). The outer banks are the best example of open sea, tidal sandbanks in a moderate current strength in UK waters. Sandwaves are present, being best developed on the inner banks; the outer banks having small or no sandwaves associated with them (Collins *et al*., 1995).

The sand banks have a north-west to south-east orientation and are thought to be progressively, though very slowly, elongating in a north-easterly direction (perpendicular to their long axes) (Cooper *et al*., 2008). The summits of the banks are in water shallower than 20m below Chart Datum, and the flanks of the banks extend into waters up to 40m deep.

A sandbank by definition lies under no more than 20m of water however, the extent of the Annex I sandbank habitat in the North Norfolk Sandbanks and Saturn Reef area was determined including flanks and troughs of these banks which are also part of the sandbank feature but extend into deeper waters (JNCC, 2010b).

***Sabellaria spinulosa* reefs**

The Saturn *Sabellaria* sp. reef consists of thousands of fragile sand-tubes made by polychaetes which have consolidated together to create a solid structure rising above the seabed. Reef habitats such as those formed by *Sabellaria* sp. are listed within Annex I of the Habitats Directive. Although *Sabellaria* sp. is found widely distributed in UK waters, significant elevated reef structures are rare (JNCC, 2010b). *Sabellaria* sp. reef structures can be temporary and unstable but it is generally accepted that broad areas which support reef production typically remain so until hydrographic conditions change (Jones *et al*., 2000).

Stony reef

Reefs are one of the habitats of conservation significance listed under Annex I of the Habitats Directive for protection within SACs. Rocky reefs (bedrock and stony reefs) can be extremely variable, both in structure and in the communities they support. A wide range of topographical reef forms meet the European definition of this habitat type, including vertical rock walls, horizontal ledges, sloping or flat bed rock, broken rock, boulder fields, and aggregations of cobbles (McLeod *et al.*, 2005). In terms of its intended composition, a deposited rock would meet these criteria, hence why an assessment against the stony reef criteria is appropriate.

Stony reefs can comprise areas of boulders or cobbles that stand proud from the seafloor and can provide a suitable substratum for the attachment of benthic communities of algae and marine fauna. Boulders and cobbles are generally considered to be greater than 64mm in diameter; and a feature of a stony reef must be that it is topographically distinct from the surrounding seafloor. A multi-criteria scoring system is used to assess the characteristics of a potential stony reef. Each characteristic can be scored as low, medium or high, with spatial extent (m^2), substrate composition (% cover) and elevation as the primary characteristics, as defined by Irving (2009).

Table 4-10 summaries the presence of Annex I habitat in the vicinity of the Annabel and Audrey decommissioning activities.

AREA	ANNEX I HABITAT		
	'Sandbanks which are slightly covered by seawater all of the time'	*Sabellaria* reef'	Rocky reefs (bedrock and stony reefs)
Annabel	✗	✗	✗
Audrey A (WD) platform	✓*	✗	✗
Audrey B (XW) platform	✓*	✗	✗
The LOGGS platform complex	✓	✗	✗
*Audrey A (WD) and Audrey B (XW) are both situated within the North Norfolk Sandbanks and Saturn Reef SAC. Despite the pre-decommissioning surveys not classifying the habitat as Annex I (Section 4.3.7 and Gardline Geosurvey Ltd, 2016c) it is classified as an Annex I habitat in this table.			

Table 4-10: Presence of Annex I habitat within the vicinity Annabel and Audrey

4.5.1.2 Harbour porpoise cSAC

The Annabel subsea infrastructure and the Audrey platforms lie within one of a number of cSACs which have been identified for harbour porpoise in UKCS waters, which are currently under public consultation (JNCC, 2016a).

The cSAC is a single feature site, proposed to be designated solely for the purpose of aiding the management of harbour porpoise populations throughout UK waters, in accordance with EU legislation. The Conservation Objectives for the site are:

To avoid deterioration of the habitats of the harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to maintaining Favourable Conservation Status for the UK harbour porpoise. The aim is to achieve this by ensuring that:

- *The species is a viable component of the site (e.g. they are able to survive and live successfully within the site);*
- *There is no significant disturbance of the species; and*
- *The supporting habitats and processes relevant to harbour porpoises and their prey are maintained* (JNCC, 2016a).

As harbour porpoise are highly mobile species, the areas proposed are large. The SNS cSAC covers 36,958km^2, extending down the North Sea from the River Tyne south to the Thames and includes habitats such as sandbanks and gravel beds (Figure 4-29). The water depths within the site range between 10 and 75m.

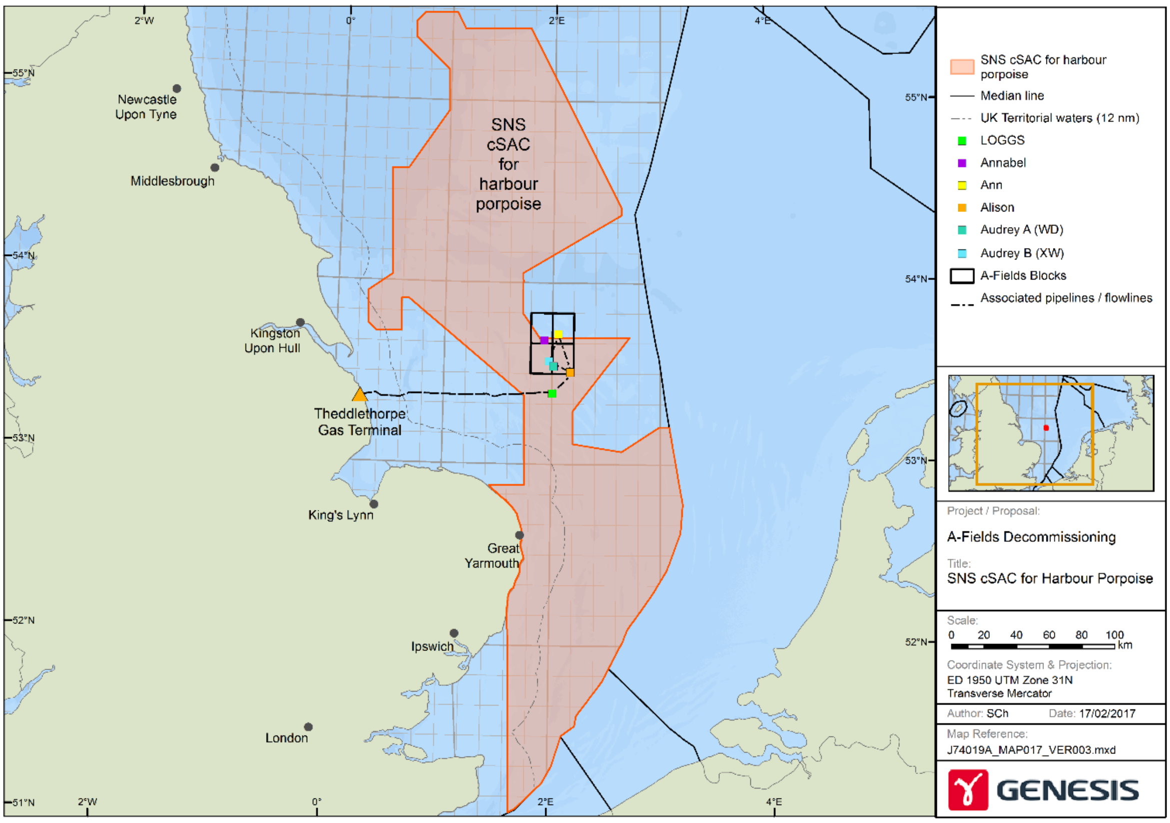


Figure 4-29: SNS cSAC for harbour porpoise

Tagging studies undertaken in Denmark indicate that harbour porpoises range widely in the North Sea, with individuals tagged in the Skagerrak occurring off the east coasts of Scotland and England (Sveegaard *et al.*, 2011). Harbour porpoise densities vary seasonally and across the SNS cSAC. In the central and northern area of the cSAC, the highest densities occur during the summer period with modelled harbour porpoise densities greater than

3.0/km^2 occurring widely across the SNS (Figure 4-30). During the winter period the distribution of harbour porpoise in the SNS changes with reduced densities over the central and northern area but an increase in densities in nearshore waters and the southern part of the cSAC (Figure 4-30) (Heinänen and Skov, 2015).

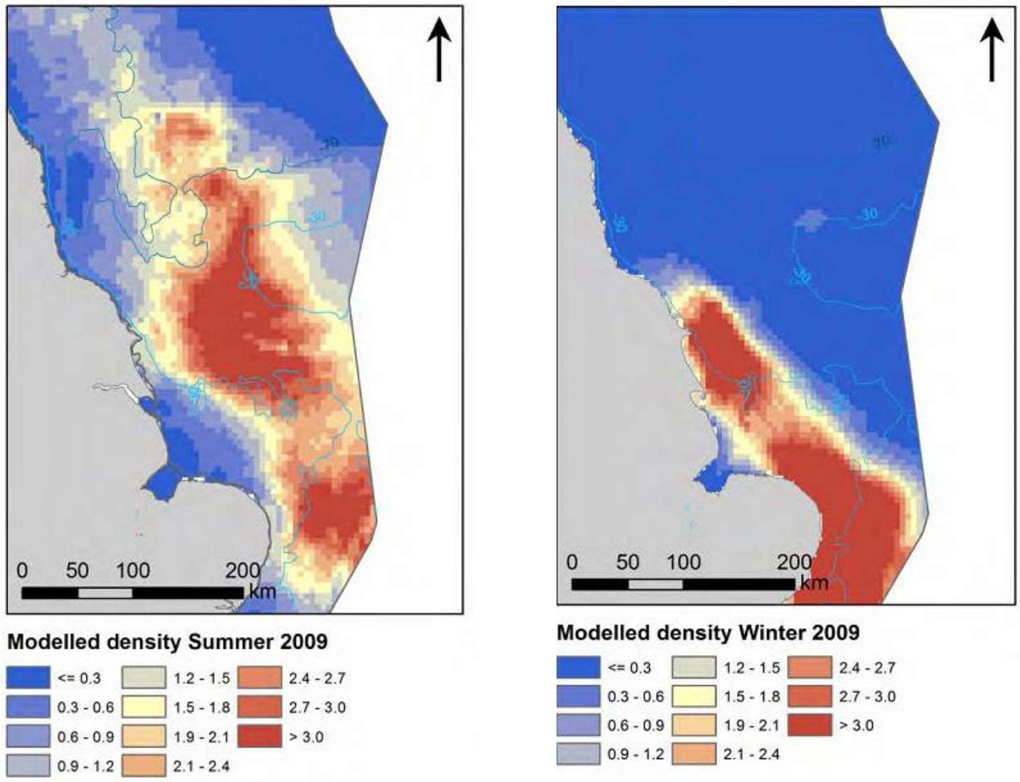


Figure 4-30: Estimated densities (no/km^2) of harbour porpoise in the SNS

4.5.2 Special Protection Areas

SPAs are strictly protected sites classified in accordance with Article 4 of the EC Birds Directive. They are classified for rare and vulnerable birds (as listed on Annex I of the Directive), and for regularly occurring migratory species. There are a total of 270 SPAs designated in the UK. The nearest protected site is the North Norfolk Coast SPA, which is over 90km south-west of the blocks (Figure 4-27). The proposed decommissioning activities are therefore not expected to impact on any SPAs.

4.5.3 Marine Conservation Zones

Under the MCAA (2009) the Marine Conservation Zone (MCZ) project (led by the JNCC and Natural England) was set up in 2008 to identify MCZs in English, Welsh and Northern Irish offshore waters. MCZs aim to protect a range of nationally important marine wildlife, habitats, geology and geomorphology. In November 2013, 27 MCZs were designated. In January 2016, a further 23 sites were designated following the Tranche Two consultation. It is expected that there will be a third tranche of designations in the future (candidate MCZs).

The nearest MCZ to the A-Fields is the Markham's Triangle recommended MCZ (Figure 4-27) which is approximately 51km north-east of the Annabel infrastructure and designated for broad scale habitat features such as subtidal sand and subtidal coarse sediments. The next closest MCZ is the Wash Approach recommended MCZ which is approximately 60km from the Audrey B (XW) platform (Figure 4-27).

4.5.4 East Inshore and East Offshore Marine plan

The East Inshore and East Offshore Marine Plans are the first plans produced for English seas, and entered into force in April 2014 (Figure 4-31).

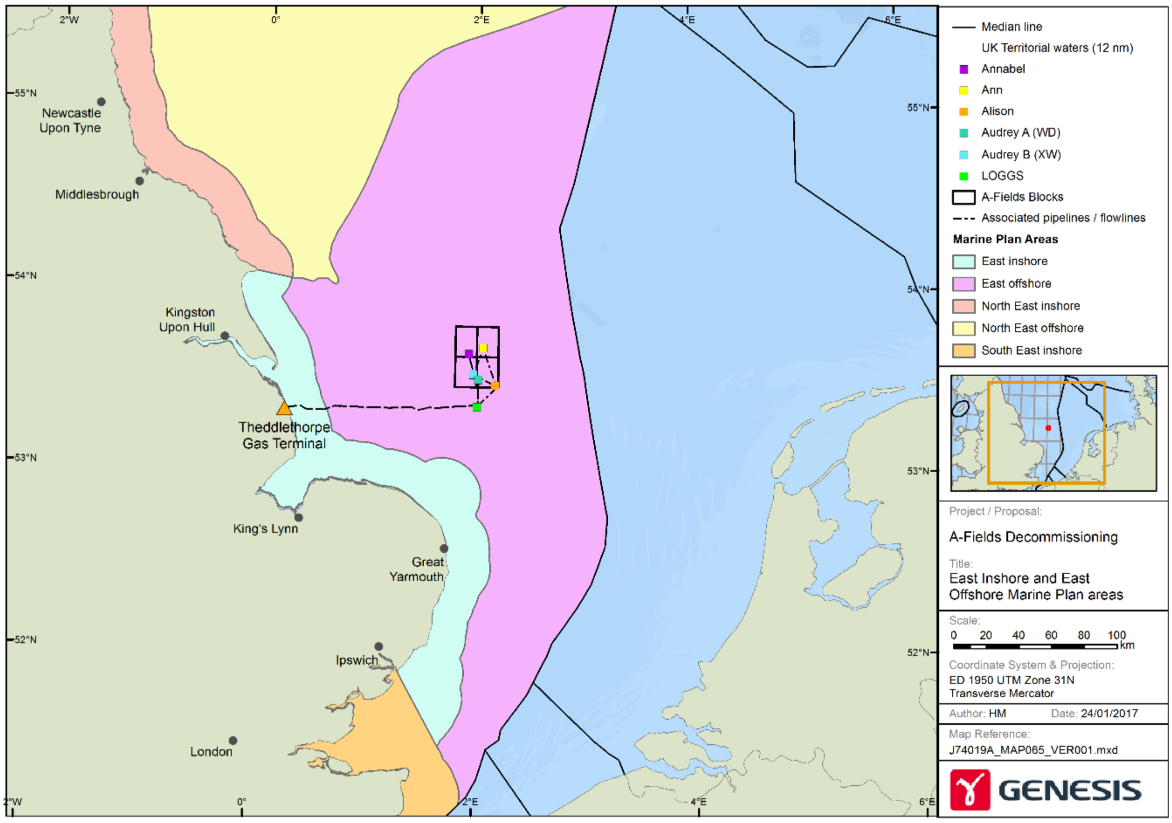


Figure 4-31: East Inshore and East Offshore Marine Plan areas and bordering nations

The aim of marine plans is to help ensure the sustainable development of the marine area through informing and guiding regulation, management, use and protection of the marine plan areas. The Plan sets out 11 objectives (listed in Table 4-11) that need to be met in order to deliver the vision for East Marine Plan Areas in 2034. The objectives are supported by cross-sectorial and sector specific policies. The purpose of the policies is to provide direction or guidance on how decisions should be made to ensure the plan objectives are met. The Plan's policies in general apply to new, rather than existing, developments, uses and management measures. However, they may also apply in the review of existing activities or measures (MMO, 2014).

OBJECTIVE	DETAILS
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.
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.
3	To realise sustainably the potential of renewable energy, particularly offshore wind farms, which is likely to be the most significant transformational economic activity over the next 20 years in the East marine plan areas, helping to achieve the United Kingdom's energy security and carbon reduction objectives.
4	To reduce deprivation and support vibrant, sustainable communities through improving health and social well-being.
5	To conserve heritage assets, nationally protected landscapes and ensure that decisions consider the seascape of the local area.
6	To have a healthy, resilient and adaptable marine ecosystem in the East marine plan areas.
7	To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East marine plan areas.
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.
9	To facilitate action on climate change adaptation and mitigation in the East marine plan areas.
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.
11	To continue to develop the marine evidence base to support implementation, monitoring and review of the East marine plans

Table 4-11: Objectives for the East Inshore and East Offshore Marine Plans (MMO, 2014)

The proposed operations have been assessed against the marine plan objectives and cross-sectorial and sectorial policies. In summary, the proposed activity does not contradict any of the marine plan objectives and policies.

4.5.5 Species of conservation concern

The designation of fish species requiring special protection in UK waters is receiving increasing attention with particular consideration being paid to large slow growing species such as sharks and rays. A number of international laws, conventions and regulations as well as national legislative Acts have been implemented which provide for the protection of these species. They include:

- The UK Biodiversity Action Plan (BAP) priority fish species (JNCC, 2016b);
- The OSPAR List of Threatened and/or Declining Species & Habitats (OSPAR, 2016);
- The IUCN (International Union for Conservation of Nature) Red List of Threatened Species (IUCN, 2016);
- The Wildlife and Countryside Act 1981 (which consolidates and amends existing national legislation to implement the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and the Birds Directive in Great Britain) (JNCC, 2016c). The Wildlife and Countryside Act makes it an offence to intentionally kill, injure, possess or trade any animal listed in Schedule 5 and to interfere with places used by such animals for shelter or protection; and

- The EC Habitats Directive (transposed into UK law through the Conservation of Habitats and Species Regulations 2010 in England and Wales and also the 1994 Regulations in Scotland).

Those species of fish that could potentially occur in the vicinity of the A-Fields (Fishbase, 2016) and are listed under the protection measures discussed above are shown in Table 4-12. It should be noted however that only Atlantic cod (*G. morhua*) were observed in the vicinity of the A-Fields during the pre-decommissioning surveys undertaken in 2016.

SPECIES	UK BAP	OSPAR	IUCN	BERN CONVENTION	HABITATS REGULATIONS
Allis shad *(A. alosa)*	✓	✓	Least Concern	✓	×
Twaite shad (*A. fallax*)	✓	×	Least Concern	✓	×
Angel shark *(S. squatina)*	✓	✓	Critically Endangered	✓[1]	×
Atlantic salmon (*S. salar*)	✓	✓	Least Concern	✓[2]	×
Atlantic cod *(G. morhua)*	×	✓	Vulnerable	×	×
Common skate (*D. batis*)	✓	✓	Critically Endangered	×	×
Basking shark (*C. maximus*)	✓	×	Vulnerable	✓	×
Porbeagle shark (*L. nasus*)	✓	✓	Vulnerable	✓	×
[1] = Applies in the Mediterranean only. [2] = Does not apply in sea waters.					

Table 4-12: Designation of fish species occurring in the vicinity of the proposed project

In addition, four marine mammal species listed under Annex II of the Habitats Directive occur in relatively large numbers in UK offshore waters:

- Grey seal (*Halichorerus grypus*);
- Harbour seal (*Phoca vitulina*);
- Bottlenose dolphin (*Tursiops truncatus*); and
- Harbour porpoise (*Phocoena phocoena*).

The bottlenose dolphin and harbour porpoise, like all the cetacean species found in UK waters, also have EPS status, along with several other marine mammals found in UK waters. Developers must therefore consider the requirement to apply for the necessary licences if there is a risk of causing any potential disturbance / injury to EPS.

4.6 Socio-economic

As part of the assessment it is necessary to consider the impact of decommissioning operations and endpoints on other users of the environment.

4.6.1 Fishing activity

The International Council for the Exploration of the Sea (ICES) is the primary source of scientific advice to the governments and international regulatory bodies that manage the North Atlantic Ocean and adjacent seas. For management purposes ICES collates fisheries information for area units termed ICES rectangles measuring 30nm by 30nm. Each ICES rectangle covers approximately one half of one quadrant i.e. 15 licence blocks. The importance of an area to the fishing industry is assessed by measuring the fishing effort which may be defined as the number of days (time) x fleet capacity (tonnage and engine power). Due to the requirement by UK fishermen to report catch information such as total landings (includes species type and tonnage of each), and location of hauls and catch method (type of gear/duration of fishing), it is possible to get an indication of the value of an area (ICES rectangle) to the UK fishing industry. It should be noted, however, that fishing activity may not be uniformly distributed over the whole area of the ICES rectangle. The A-Fields infrastructure is located in ICES rectangle 36F2.

4.6.2 Fishing effort

The UK fishing effort within 36F2 varies throughout the year and averages 109 days per annum (2012–2015) (Scottish Government, 2016). Approximately 0.07% of total UK landings between 2012 and 2015 were taken from the area (Table 4-13).

Year	Total Fishing Effort by UK Fishing Fleet (days)		
	UK Total	36F2	36F2 as % UK Total
2012	185,200	76	0.04
2013	183,400	147	0.08
2014	129,850	108	0.08
2015	124,850	107	0.09
Average over 2012 - 2015		109	0.07
Note these data are based on reported landings from ICES rectangles within which more than five UK vessels measuring over 10m were active. In those ICES rectangles where < 5 vessels were active the information is considered disclosive and is therefore not available.			

Table 4-13: Fishing effort by UK fishing fleet in ICES rectangle 36F2 and UK total (Scottish Government, 2016)

4.6.3 Fish landings

The quantity of landings by UK vessels in ICES rectangle 36F2 is shown Table 4-14. The data suggest that ICES rectangle 36F2 is of relatively low value to the UK fishing industry.

Year	Total Landings by UK Fishing Fleet (Te)		
	UK Total	36F2	36F2 as % UK Total
2012	678,980	962	0.14
2013	640,930	448	0.07
2014	604,180	235	0.04
2015	547,070	292	0.05
Note these data are based on reported landings from ICES rectangles within which more than five UK vessels measuring over 10m were active. In those ICES rectangles where < 5 vessels were active the information is considered disclosive and is therefore not available.			

Table 4-14: Total landings by UK fishing fleet in ICES rectangle 36F2 and UK total (Scottish Government, 2016)

The mass of fish landings from the area by species type is shown in Figure 4-32. The area is targeted primarily for demersal species.

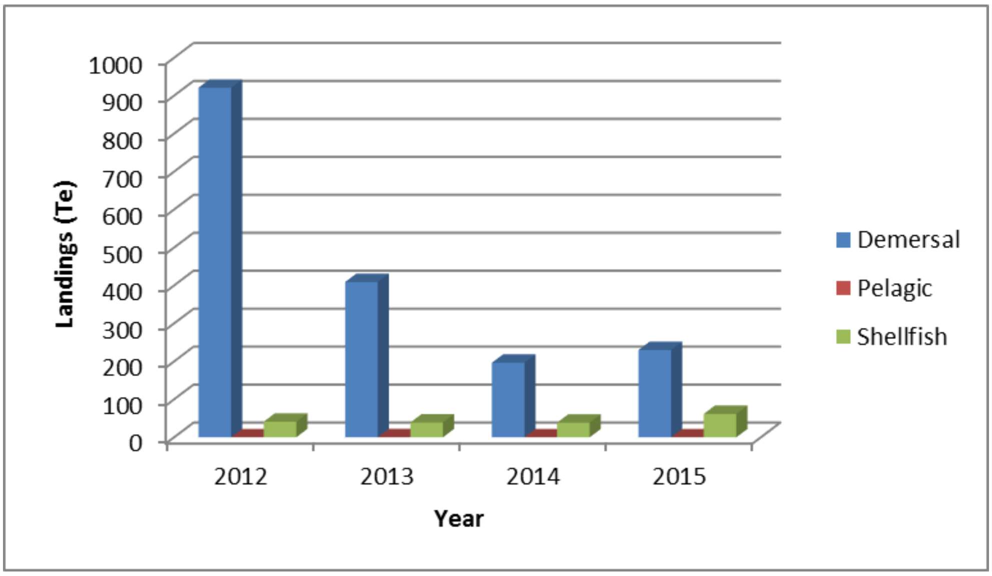


Figure 4-32: Live catches within ICES rectangle 36F2 by species type

The value of landings of different fish types (demersal, pelagic or shellfish) from ICES rectangle 36F2 in 2015 is shown in Table 4-15. The total value of landings from ICES rectangle in 2015 was £562,101 with the majority of this (£417,493) comprising demersal species. These landings equate to approximately 0.20% of the total reported landings of demersal species types at UK ports in 2015, suggesting the area is of relatively low importance to the UK demersal fishing industry.

ICES Rectangle 36F2	Demersal	Pelagic	Shellfish	Total
Value of landings (£)	417,493	1	144,607	562,101
UK Annual Total (£)	205,126,339	173,299,527	195,493,099	573,918,965
% UK Total	0.20	0.00	0.07	0.10

Table 4-15: Relative value of landings from ICES Block 36F2 to total UK catches in 2015

UK vessels ≥15m in length have Vessel Monitoring Systems (VMS) on board that allow environmental and fisheries regulatory organisations to monitor the position, time at a position, course and speed of fishing vessels. VMS data for all UK registered commercial fishing vessels ≥15m length for the period 2007-2013 have been combined with landings information to develop GIS layers describing the spatial patterns of landings of the UK offshore fleet from within the UK Fishing limits (200nm) (Kafas *et al*., 2012). Figure 4-33 shows the fishing intensity by the monitored fishing vessels. The data shows that fishing intensity is low in the A-Fields area.

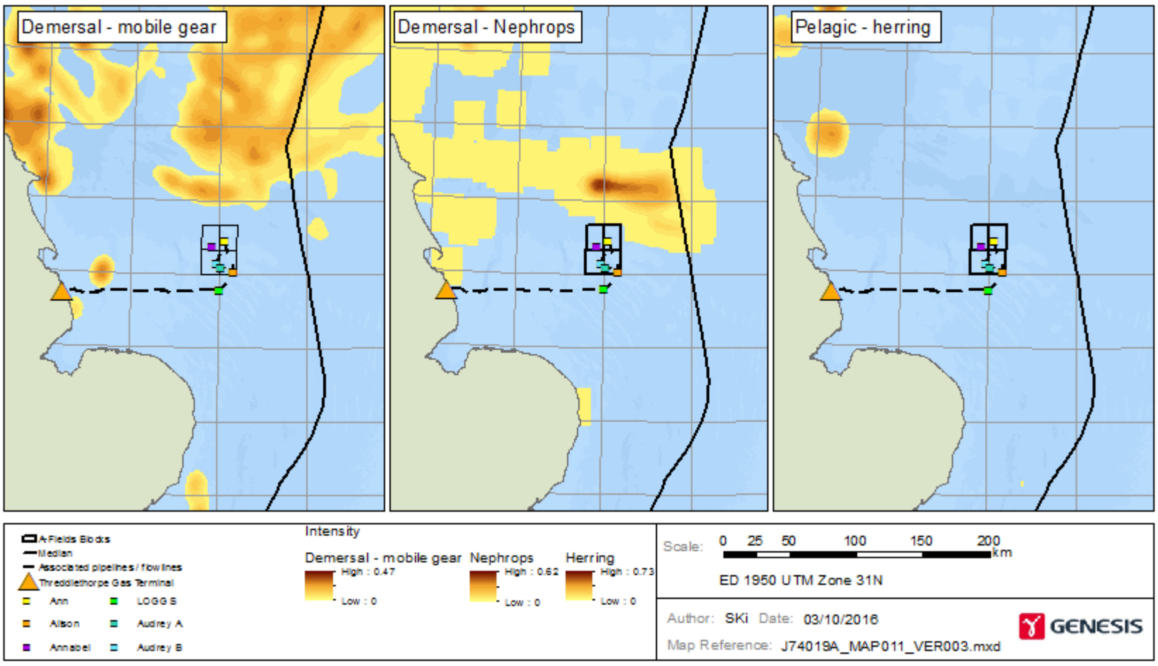


Figure 4-33: VMS data combined from 2009 – 2013 showing the fishing intensity by fishing vessels >15m in length in the North Sea using demersal mobile gears, *Nephrops* mobile gears and pelagic herring gears (Kafas *et al*., 2012)

4.6.4 Shipping

The density of shipping traffic within the SNS is high, due to the presence of a number of large international ports within the region. There are 33 shipping routes utilised by an estimated 3,426 ships per year passing within 10nm of the Audrey platforms. This corresponds to an average of 9-10 vessels per day (Anatec, 2015).

Shipping activities in the North Sea are categorised by the Oil and Gas Authority (OGA, 2016) to have either: very low; low; moderate; high; or very high shipping density. Figure 4-34 provides an assessment of the level of shipping activity within the area of the A-Fields. Shipping in block 48/15 in which the Audrey B (XW) platform is situated is considered moderate whilst shipping in blocks 49/11, 48/10, 48/20 which contain the Audrey A (WD) platform, the Annabel Field infrastructure and the LOGGS platform complex respectively are considered high.

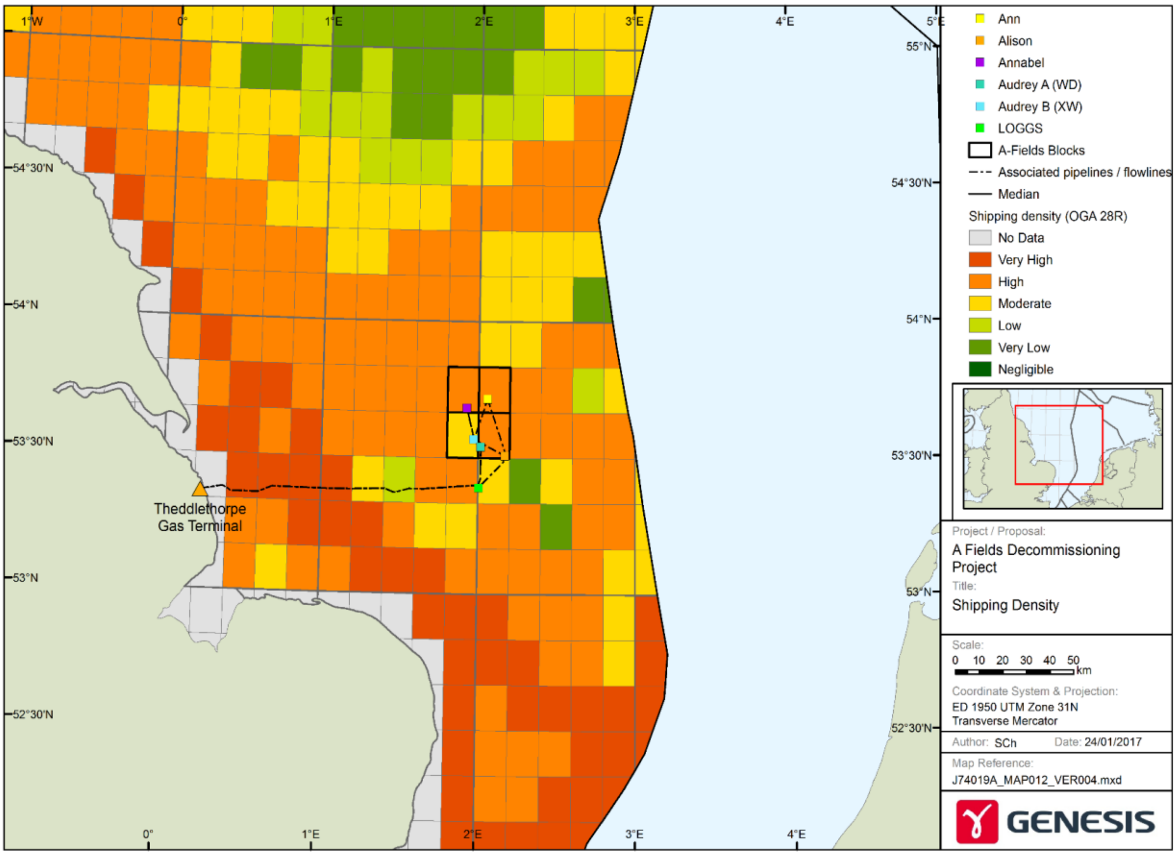


Figure 4-34: Shipping density in the vicinity of the A-Fields as categorised by the OGA (2016)

4.6.5 Existing oil and gas activity

The SNS gas basin in which the A-Fields are located is a region well developed by the oil and gas industry. Figure 4-35 shows surface oil and gas installations in the vicinity of the A-Fields (note it also shows the Ann, Alison and Annabel subsurface installations). There are 140 surface installations in the region of the A-Fields. Of the 140 surface installations, Leman BH (Shell) and ST-1 (Centrica) currently have decommissioning plans submitted to BEIS. The decommissioning plans for the Thames Complex (Perenco), Horne & Wren (Tullow) and Viking Platforms (ConocoPhillips) have been approved (Figure 4-35) (BEIS, 2017a).

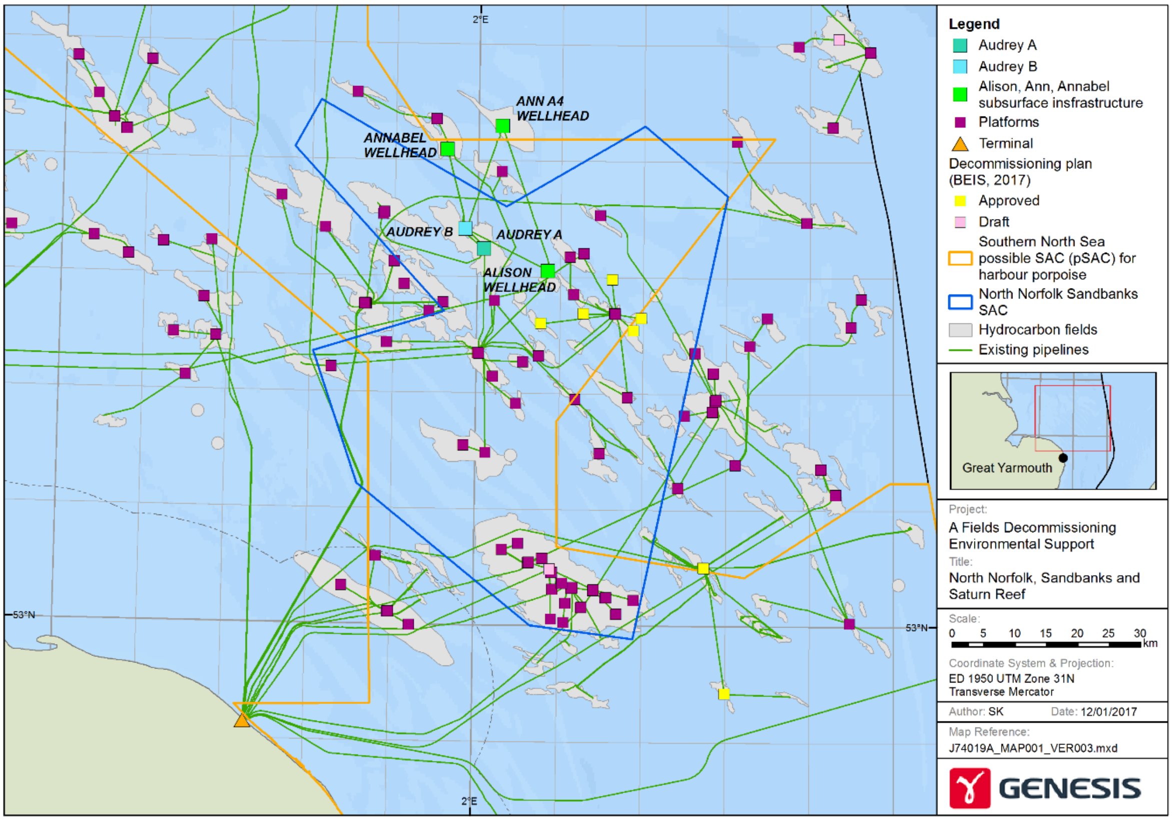


Figure 4-35: Oil and gas surface infrastructure within the vicinity of the A-Fields

4.6.6 Offshore renewable energy activity

There are a number of wind farm areas at different stages of the consenting process within the vicinity of the A-Fields (Figure 4-36). The closest operational wind farm to the Annabel and Audrey infrastructure is Sheringham Shoal, 72km to the south-west of the Audrey B (XW) platform. The nearest wind farm under construction is Dudgeon, 50km to the south-west. The Heron West, Njord and Heron East consented blocks are being developed by Dong Energy as the Hornsea Project One at a distance of approximately 17km north of Annabel at the closest point. Onshore construction of the project commenced in 2016 with offshore construction due to begin in 2018. The proposed cable route for the Dong Energy Hornsea Project Three (area Z4 Project Three in Figure 4-36) passes through the A-Fields area. Construction for this project is currently expected to occur between 2022 and 2025.

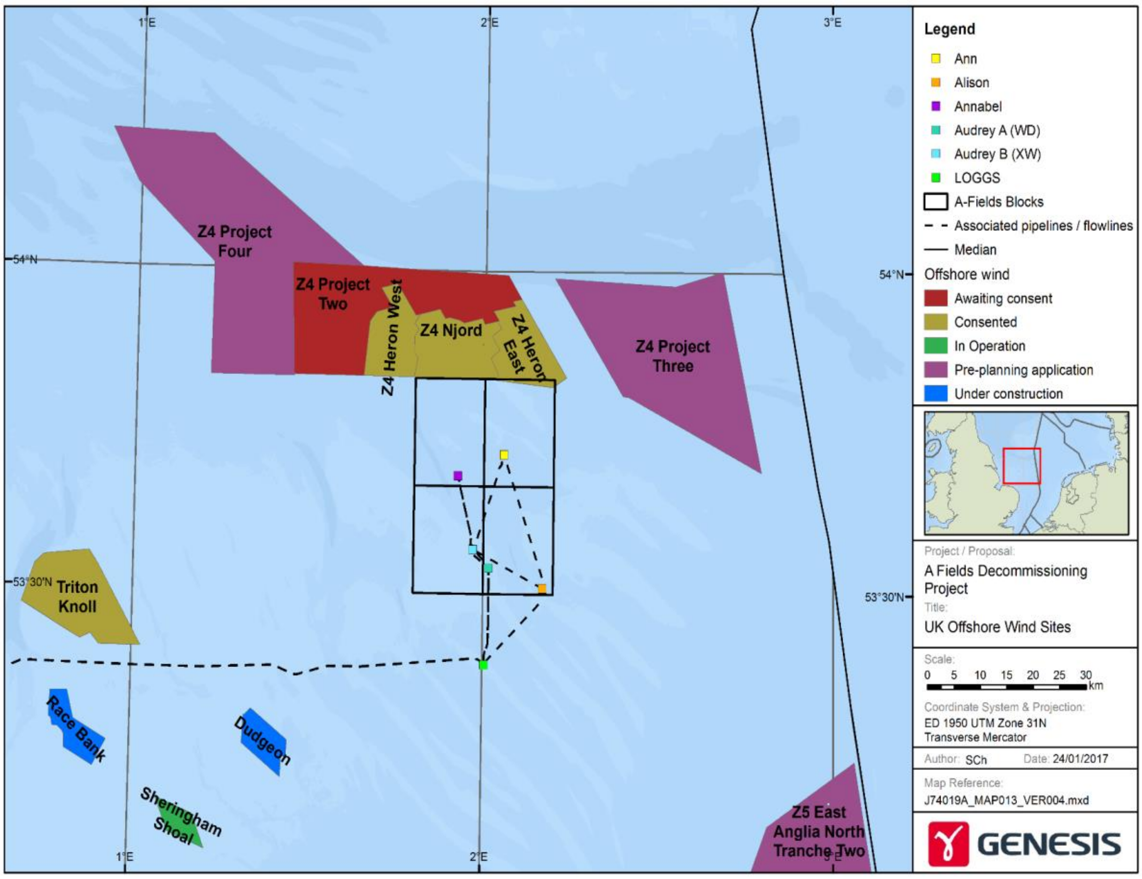


Figure 4-36: Location of wind farm projects in the vicinity of the A-Fields (NMPI, 2016)

4.6.7 Military exercises

There are no military exercise areas within the proximity of the A-Fields.

4.6.8 Other offshore activity

There are two disused telecommunications cables within the vicinity of the A-Fields (Figure 4-37). Approximately 4.2km to the north of Annabel is an area available as an aggregates option and an aggregates application in place in the same area (Figure 4-38). Tender rounds offer interested parties the opportunity to bid for rights to prospect the seabed in some or all regions under Crown Estate mineral management and to obtain an option for a production agreement to extract marine aggregate (subject to the terms of a marine licence) (Crown Estate, 2016).

Tender applications are assessed on a number of factors and successful bidders are granted a prospecting licence to undertake further investigations, in conjunction with a time-limited option to obtain a marine licence from the regulator.

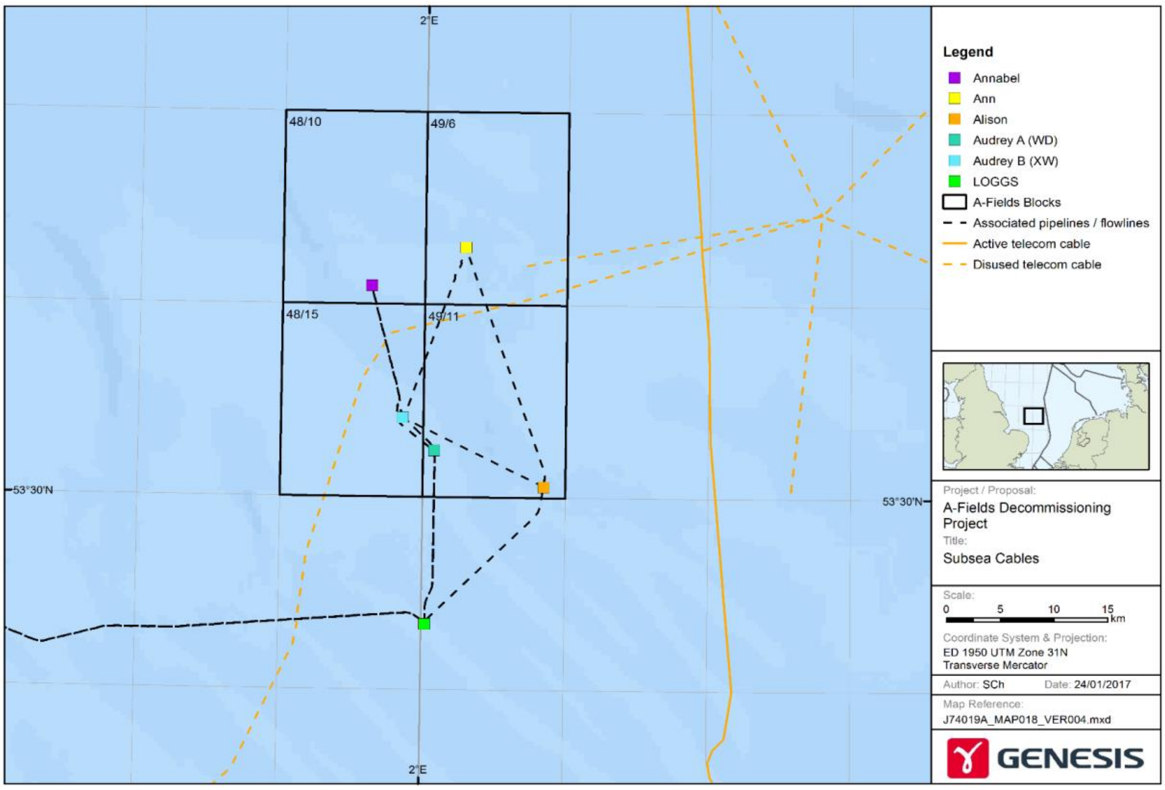


Figure 4-37: Subsea telecommunication cables within the area (NMPI, 2016)

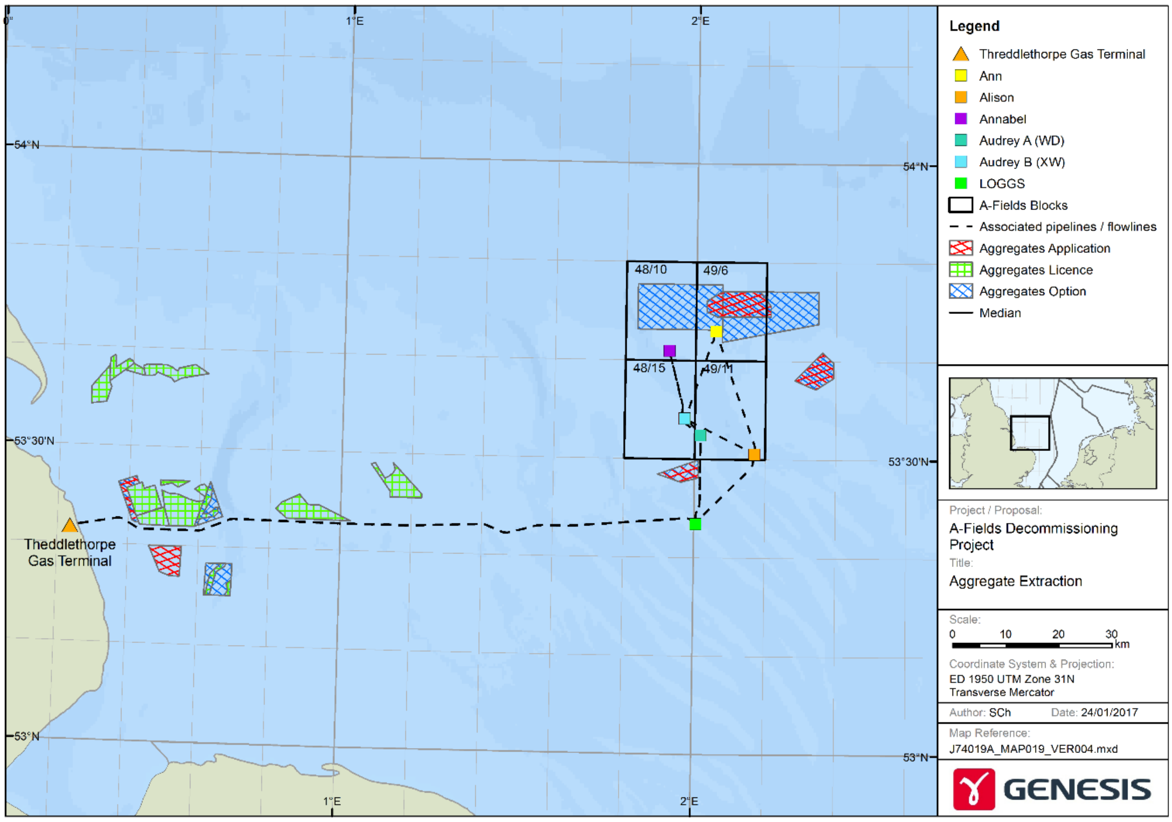


Figure 4-38: Aggregate extraction within the area (Crown Estate, 2016)

5. ENVIRONMENTAL IMPACT ASSESSMENT METHOD

This section applies the EIA process to each of the decommissioning activities in order to determine the significance of the environmental and social impacts.

5.1 Overview

The EIA process identifies the potential environmental and social impacts of a project from both planned and unplanned activities, and aims to prevent, reduce and offset any adverse impacts identified. Planned activities and unplanned events (aspects) likely to affect the environment or other users of the area are first identified, then assessed to define the level of potential impact they may cause. Where necessary, project specific control and/or mitigation measures in addition to the industry standard, legislative and prescriptive controls and mitigation measures are identified in order to reduce any impacts to 'as low as reasonably practicable' in line with the philosophy of the Centrica Environmental Policy.

The environmental impact of planned and unplanned activities were assessed separately using specific matrices for each. The approach is described in detail in the following sections.

5.2 Definitions

The most important consideration in any assessment is whether the impacts have been identified, are understood and that suitable controls and mitigation measures have been documented and will be implemented such that the impacts will be managed to as low as reasonably practicable in line with the philosophy of the Centrica Group Environmental Policy (Centrica Energy, 2015a).

Definitions of the key terms used in the EIA method are shown in Table 5-1.

Aspect (ISO 14001:2004)	Element of an organisations activities, products or services that can interact with the environment.
Impact (ISO 14001:2004)	Any change to the environment wholly or partially resulting from an organisations environmental aspects.
Inherent Control and Mitigation Measures	• Standard controls for the activity within the region; • Administrative or Procedural Controls; and • Engineering or Physical Controls.
Additional or supplementary Control and Mitigation Measures	• Project Specific; and • Centrica E&P Best Practice.
In combination effect	Effects on the environment which are caused by the combined results of past, current and future activities.

Table 5-1: Definition of key terms

5.3 Planned activities

5.3.1 Significance of planned event impacts

The matrices shown in Table 5-2 and Table 5-3 are used for assessment of the significance of impacts from planned events by combining the extent of the aspect to the different receptor types and the duration the different receptor types will take to recover. It is considered that a receptor has recovered when approximately 80% of the damage has been rectified.

When combined these are plotted onto the matrix, the position on the matrix indicates the level of significance of the impact. It also allows for the identification of beneficial effects. The level is presented in two ways, numerically and graphically with colours. The higher the number the greater the level of significance. Likewise, the colours are graduated from pale blue to dark blue, with dark blue representing a higher level of significance, the level of significance is graduated from the bottom left corner up to the top right.

All practicable mitigation and control measures should be applied to drive the level of significance to the bottom left corner. The level of significance which is acceptable should be decided on an impact by impact basis, dependent on project factors such as alternatives, receiving environment and in combination effects, nevertheless all potential impacts should be "as low as reasonably practicable".

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Extent	Land and air		Benefit	Duration of harmful effect (habitat or species *c.*80% of damage rectified)				
				within 1 month	within 1 year	≤3 years	>3 years or >2 growing seasons for agricultural land	>20 years
Habitats / Species	**Air and Soil or sediment**		+1	1	2	3	4	5
• >50% of site area, associated linear feature or population of designated land/water sites (nationally important) • >25% of site area, associated linear feature or population of a designated land/water sites (internationally important) • >100ha or >50% of land of other designated land • >20ha or >50% of habitat of scarce habitat • Widespread habitat - non-designated land - contamination of >100ha of land, preventing growing of crops, grazing of domestic animals or renders the area inaccessible to the public because of possible skin contact with dangerous substances. Alternatively, contamination of 10ha or more of vacant land. • Widespread habitat - non-designated water - contamination of aquatic habitat which prevents fishing or aquaculture or renders is inaccessible to the public. Loss of >10% of animal or >50% of plant ground cover of a particular species (Note - these criteria apply nationally) • Marine >20ha littoral or sub-littoral zone, >100ha of open sea benthic community, >1,000 dead sea birds (>5,000 gulls), >50 dead/significantly impaired sea mammals	**Air** – increase in contaminants to the atmosphere such that the relevant thresholds (e.g. Air Quality Limits) are exceeded. **Soil or sediment (**i.e. as receptor rather than purely a pathway) - contamination of >100ha of land, as per widespread habitat; contamination rendering the soil immediately hazardous to humans (e.g. skin contact) or the living environment, but remediation available (but difficult).	5	-	5	10	15	20	25
• >0.5ha or 10-50% of site area, associated linear feature or population of designated land/water sites (nationally important) • >0.5ha or 5-25% of site area or 5-25% of associated linear feature or population of designated land/water sites (internationally important) • 10-100ha or 10-50% of land of other designated Land • 2-20ha or 10-50% of scarce habitat • Widespread habitat - non-designated land - contamination of 10-100ha of land, preventing growing of crops, grazing of domestic animals or renders the area inaccessible to the public because of possible skin contact with dangerous substances. Alternatively, contamination of 10ha or more of vacant land. • Widespread habitat - non-designated water - contamination of aquatic habitat which prevents fishing or aquaculture or renders is inaccessible to the public. • Particular species (note - these criteria apply nationally) - Loss of 1-10% of animal or 5-50% of plant ground cover. • Marine - 2-20ha littoral or sublittoral zone, 100-1000ha of open sea benthic community, 100-1000 dead sea birds (500-5000 gulls), 5-50 dead/significantly impaired sea mammals	**Air** – increase in contaminants to the atmosphere such that the relevant thresholds (e.g. Air Quality Limits) are exceeded. **Soil or sediment** (i.e. as receptor rather than purely a pathway) - contamination not leading to environmental damage (as per Environmental Liability Directive), or not significantly affecting overlying water quality or exceeding contaminated land thresholds.	4	-	4	8	12	16	20
• <0.5ha or <10% of designated land/water sites (nationally important) • <0.5ha or <5% (<5% linear feature/population) of designated land/water sites (internationally important) • <10ha or <10% of other designated land • <2ha or <10% of scarce habitat • <10ha of widespread habitat - non-designated Land • Widespread habitat - non-designated water - contamination of aquatic habitat such that fishing or aquaculture is not inaccessible to the public. • Particular species - Loss of <1% of animal or <5% of plant ground cover in a habitat. • Marine- <2ha littoral or sublittoral zone, <100ha of open sea benthic community, <100 dead sea birds (<500 gulls), <5 dead/significantly impaired sea mammals	**Air** – increase in contaminants to the atmosphere such that they are above background, but below thresholds. **Soil or sediment** (i.e. as receptor rather than purely a pathway) - contamination of 10-100ha of land etc.as per widespread habitat; contamination sufficient to be deemed environmental damage (Environmental Liability Directive) or in alignment with contaminated land legislation.	3	-	3	6	9	12	15
Environment - Change is within scope of existing variability but potentially detectable or all within the site boundary / HSE 500m zone (78.5 ha).		2	-	2	4	6	8	10
Environment - Effects are unlikely to be noticed or detectable.		1	-	1	2	3	4	5

Table 5-2: Environmental Impact Matrix – Habitats / Species, Air and Soil or Sediment

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Extent			Benefit	Duration of harmful effect				
Surface water (any harm of drinking water source or ground water would be cat 4 or above)				Immediate	within 1 month	≤1 years	>1 year	>10 years
Reinstatement of Built Environment - Can be repaired…				…immediately	…in <1 year	…in <3 years	… in >3 years	Cannot be rebuilt
Recovery for Societal - Decrease in the availability or quality of a resource				Access immediately after operations have been completed	Short term decrease	Medium term decrease Short or medium term loss	Medium to long term decrease & Medium term substantial or long term minor loss	Long term decrease Substantial loss (e.g. long term loss of fishing grounds).
Water	**Built Environment and Societal**		+1	1	2	3	4	5
• Source of public or private drinking water (groundwater or surface water) >1 x 107 person-hours interruption of drinking water (a town of ~100,000 people losing supply for month) or 10-100ha for groundwater protection zones (e.g. SPZ) drinking water standards breached • >100ha groundwater body (non- drinking water source) • Fresh and estuarine water habitats - The effect causes the water quality to exceed a water quality guideline or water quality objectives, or for the WFD chemical or ecological status lowered by one class for >10km of watercourse or >20ha or >50% area of estuaries or ponds or present an increased risk to ground water (as above). • Where the groundwater is a pathway for another receptor assess against relevant criteria for the receptor.	**Built Environment -** Complete destruction of an area of built importance or nationally registered building **Societal -** A large population with high dependence on the impacted resource affected. Substantial loss of private users or public finance. e.g. highly productive fishing grounds	5	-	5	10	15	20	25
• Source of public or private drinking Water (groundwater or surface water) interruption of drinking water supplied from a ground or surface source (where persons affected x duration in hours [at least 2] > 1,000) or 1-10ha of ground water protection zones where drinking water standards are breached • Groundwater body (non- drinking water source) - 1-100ha of groundwater body where the WFD status has been lowered or the water quality has exceeded a water quality guideline • Fresh and estuarine water habitats – The effect causes the water quality to exceed a water quality guideline or a water quality objective, or for the WFD chemical or ecological status lowered by one class for 2-10km of watercourse or 2-20ha or 10-50% area of estuaries or, ponds or present an increased risk to ground water (as above). • Where the groundwater is a pathway for another receptor assess against relevant criteria for the receptor.	**Built Environment -** Damage to an area of built importance or nationally registered building such that there would be a loss of integrity, leading to de-registering / categorisation with a requirement for remedial / restorative work to be undertaken. **Societal -** A moderate population with high dependence on the impacted resource affected. Moderate loss of private users or public finance (e.g. medium term loss of fishing grounds).	4	-	4	8	12	16	20
• Interruption of drinking water supply <1000 person-hours or <1ha of ground water protection zones, e.g. SPZ, for public or private drinking water (groundwater or surface water) • <1ha of groundwater body (non- drinking water source) • Groundwater not a pathway to another receptor. • Fresh and estuarine water habitats – The effect does not cause the water quality to exceed a water quality guideline or a water quality objective, or for the Water Framework Directive (WFD) chemical or ecological status to be lowered for more than 2km of watercourse or 2ha or 10-% area of estuaries or ponds or, present an increased risk to groundwater (as above).	**Built Environment -** Damage to an area of built importance or nationally registered building with a requirement for remedial / restorative work to be undertaken. **Societal -** A small population with some dependence on the impacted resource affected. Minor loss to private users or public finances (e.g. short term loss of fishing grounds).	3	-	3	6	9	12	15
Change is within scope of existing variability but potentially detectable or all within the site boundary / HSE 500m zone.	**Built Environment -** Damage to an area of built importance or nationally registered building with a requirement for remedial / restorative work to be undertaken. **Societal -** A small population with some dependence on the impacted resource affected. Negligible loss to private users or public finances.	2	-	2	4	6	8	10
Effects are unlikely to be noticed or detectable.	**Built Environment -** Damage to an area of built importance or nationally registered building with no requirement for remedial / restorative work to be undertaken. **Societal -** Short term decrease in the availability or quality of a resource affecting a few individual with low dependency on the impacted resource.	1	-	1	2	3	4	5

Table 5-3: Environmental Impact Matrix – Water, Built Environment and Societal

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5.4 Unplanned events

The Centrica risk assessment matrix for assessing the risk and severity of impact from unplanned events considers the likelihood of an event occurring (rather than its duration and frequency as is the case for a planned event) and its consequence to determine the risk.

5.4.1 Risk of impact from unplanned events

The significance of the impact translates across onto the severity when assessing the level of risk, where the level of risk is the combination of the probability (or likelihood) of an event happening which could have a certain significance of impact or severity (Centrica Energy, 2011). The translation for the impact matrix to the severity is as shown below in Table 5-4.

SIGNIFICANCE OF IMPACT (FROM THE IMPACT MATRIX)	SEVERITY SCALE (FROM THE RISK MATRIX)	ENVIRONMENTAL DESCRIPTION (FROM THE RISK MATRIX)
20-25	Catastrophic	Catastrophic effect on the regional environment resulting in > 10yrs remediation and monitoring over an extensive area
15-16	Major	Major effect on the regional environment resulting in > 5yrs remediation and monitoring over a wide area
10-12	Severe	Severe effect on the local environment resulting in a requirement for some remediation and monitoring
5-9	Moderate	Limited effect on the local environment requiring some monitoring but no remediation
1-4	Minor	Insignificant effect on local environment with no remediation or monitoring required

Table 5-4: Significance of impact translated into risk severity scale

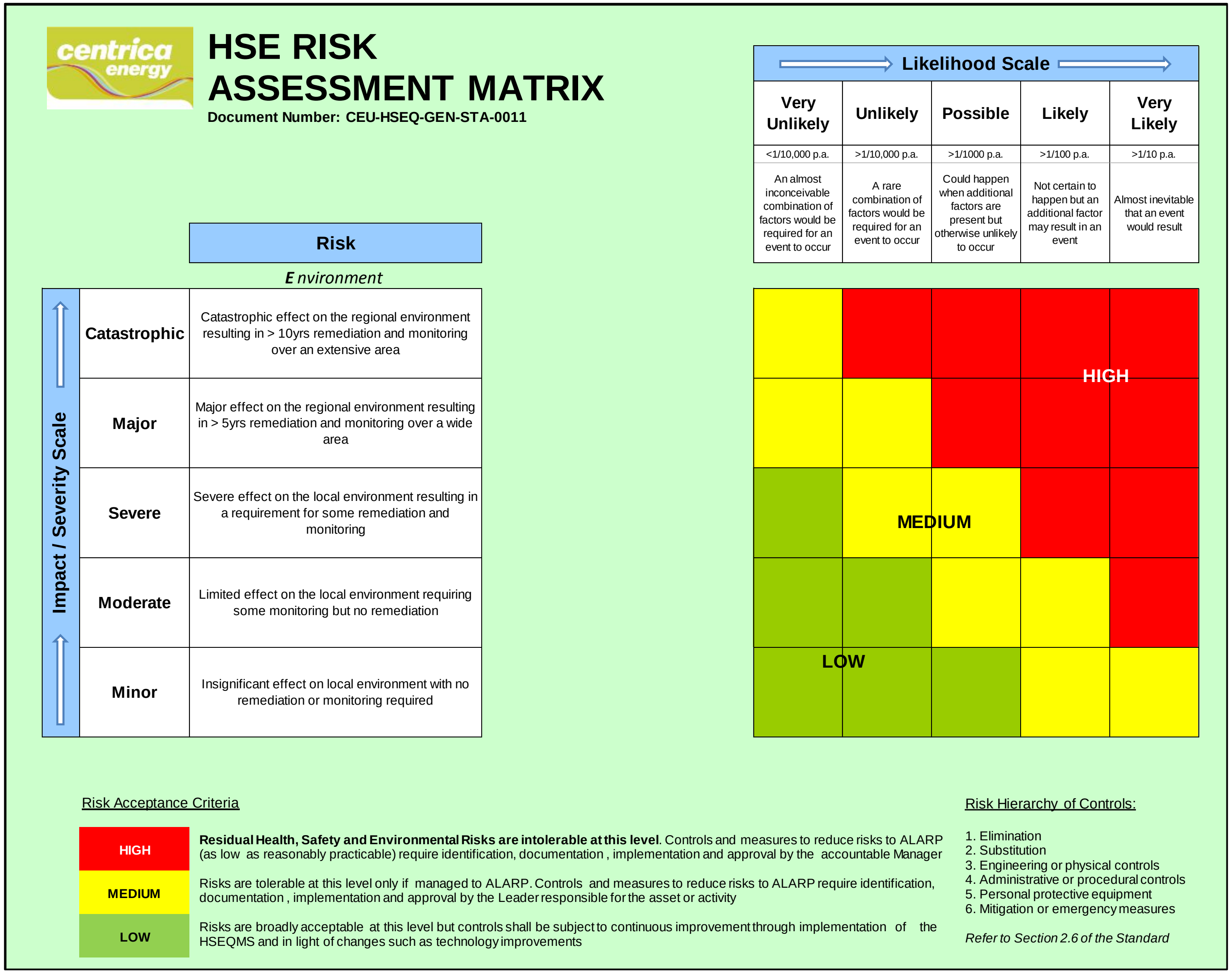

Figure 5-1: Centrica Health, Safety and Environment risk assessment matrix (Centrica Energy, 2011)

5.5 Assessment of potential impacts and control measures

Using the information provided in Sections 3 and 4 and the criteria set out in Section 5, an Environmental Assessment and Management Workshop was held to identify the environmental aspects and assess their potential environmental impact and risk. The output table from this process is shown in Appendix A.

The environmental aspects which were either: subject to regulatory control, or were found to pose a moderate or high risk to the environment, or were recognised during the consultation phase as areas of public concern, were further assessed and are described in Section 6.

6. ENVIRONMENTAL IMPACT ASSESSMENT

In this section, the environmental impacts, and potential environmental impacts (risks), have been identified and the control and mitigation measures designed to minimise these impacts to as low as reasonably practicable have been detailed.

An Environmental Assessment and Management Workshop was held on the 21st June 2016 which identified the aspects and assessed the environmental impact and risk associated with the following:

- Energy use and atmospheric emissions;
- Underwater sound;
- Seabed disturbance;
- Discharges and releases to sea;
- Large hydrocarbon releases and oil spill response;
- Waste; and
- Socio-economic impacts.

This section applies the EIA process to each of the decommissioning activities in order to determine the significance of the environmental and social impacts.

6.1 Energy use and atmospheric emissions

This section identifies the various offshore and onshore based energy requirements connected with the decommissioning activities. The quantity of the associated atmospheric emissions is estimated and the impact assessed.

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

6.1.1 Sources

The principal planned activities, including their location and estimated duration, are described in Section 3. Of these, the use of specialist and support vessels has been identified as the only offshore activity that will have a substantive direct energy requirement, and therefore the only activity to warrant additional assessment.

The onshore transport and light processing (e.g. cleaning, cutting and crushing, but excluding recycling) of recovered materials, (primarily steel) will require the use of a variety of vehicles, plant and equipment at a shore base. Onshore transportation of recovered materials for reuse, processing, recycling or disposal to landfill is unlikely to be conducted on a scale that would lead to substantive additional emissions when considered in the wider context of general onshore transportation activities and is therefore excluded from this assessment.

The Institute of Petroleum (IoP, now the Energy Institute) Guidleines for calculating estimates of energy use and emissions for decommissioning have been used to inform this assessment (IoP, 2000). They advise that:

- A materials inventory for each structure to be decommissioned must be created;
- All decommissioning activities with the Decommissioning Programmes should be identified; and,
- A calculation of direct and indirect energy use and the associated atmospheric emissions from the activities should be undertaken using suitable conversion factors.

The decommissioning activities' direct and indirect energy requirements will result in the emission of a range of gaseous combustion products, primarily carbon dioxide (CO_2) but including nitrogen oxides (NO_x), nitrous oxide (N_2O), sulphur dioxide (SO_2), carbon monoxide (CO), methane (CH_4) and volatile organic compounds (VOC).

Under the IoP guidance, the significant indirect energy use associated with the following activities has been accounted for:

- Onshore recycling: the energy that would be indirectly used in recycling recovered materials; and
- Offshore *in situ* decommissioning: the replacement energy that would be indirectly required in the manufacture of 'lost' materials.

6.1.1.1 Offshore

Vessels

Energy (fuel) is required by vessels to provide propulsion, dynamic positioning and ancillary services (e.g. electrical power) will account for a significant proportion of the decommissioning activities' atmospheric emissions.

While contracts securing the services of named vessels have not yet been established, the performance characteristics (including the fuel consumption) of the required generic vessel types are well understood. This has allowed, in conjunction with a consideration of the vessels' work programme, estimates of atmospheric emissions to be made (Table 6-1).

SOURCE	FUEL USE (Te)	ENERGY USE (GJ)	EMISSIONS FROM FUEL USE (Te)						
			CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC
Total vessels	5,128	221,017	16,410	305	1.1	10	81	0.9	10
UK shipping emissions 2014 (CCC, 2016)			9,900,000						
Total vessel emissions as % of 2014 UK shipping emissions			0.17						

Table 6-1: Fuel and Energy use and emissions associated with vessel use

6.1.1.2 Onshore

Recycling

An estimate of the indirect energy that would be required to recycle the recovered steel has been undertaken (Table 6-2). It should be noted that the atmospheric emissions resulting from this energy use would occur at a location (or locations) remote from the Annabel and Audrey facilities. It is anticipated that reuse or recycling of recovered metals other than steel will not be undertaken on a scale that will lead to significant emissions, so they are not considered further. For example, recovered concrete (e.g. from mattresses) may be crushed for reuse, an activity considered to have a relatively low energy demand.

Manufacture

An estimate of the indirect, replacement energy that would be required to manufacture a quantity of steel equivalent to that contained within the pipeline and umbilical sections that will be decommissioned *in situ* has been undertaken (Table 6-2).

INFRASTRUCTURE	STEEL (Te)	ENERGY USE (GJ)	CO_2 (Te)
Emissions associated with recycling of recovered steel			
Annabel installation	305	2,748	293
Annabel pipelines	71	642	69
Audrey installations	4,672	42,047	4,485
Audrey pipelines	471	4,242	453
Steel recycling total	**5,519**	**49,679**	**5,300**
Emissions associated with manufacture of 'lost' steel			
Annabel installation	0	0	0
Annabel pipelines	2,432	60,801	4,594
Audrey installations	645	16,122	1,218
Audrey pipelines	6,197	154,920	11,706
Steel replacement total	**9,274**	**231,843**	**17,518**
Overall steel total	**14,794**	**281,521**	**22,817**

Table 6-2: Energy use and emissions from recycling and manufacture of steel

A summary of direct and indirect energy use and associated atmospheric emissions is shown in Table 6-3.

SOURCE	ENERGY USE (GJ)	ENERGY USE (%)	CO_2 (Te)	CO_2 (%)
Recycling and manufacture of steel	281,521	56	22,817	58
Vessel use	221,017	44	16,410	42
Total	**502,538**	**100**	**39,227**	**100**

Table 6-3: Summary of energy use and atmospheric emissions

6.1.2 Impacts and receptors

6.1.2.1 Offshore

The direct energy consumption accounts for approximately 44% of the total energy. consumption and 42% of the associated atmospheric emissions resulting from, or attributable to, the decommissioning activities

The impact of NO_x, SO_2 and VOC in the atmosphere is the formation of photochemical pollution in the presence of sunlight, comprising mainly low level ozone, but by-products may include nitric acid, sulphuric acid and nitrate-based particulate. The formation of acid and particulate contributes to acid rainfall and the dry deposition of particulate. If such deposition occurs at sea, it is possible that the substances will dissolve in sea water. The ultimate fate of emitted pollutants can often be difficult to predict owing to the dependence on metocean conditions (especially wind), which may be highly variable and lead to wide variations in pollutant fate over short timescales.

The activities will be of localised extent, of relatively short duration, and take place a significant distance (*c*.85km) from the nearest coastline. In general, prevailing metocean conditions would be expected to lead to the rapid dispersion and dilution of the associated atmospheric emissions resulting in localised and short term impacts only to air and water quality. The significance of these impacts has therefore been assessed as **low**.

The facilities are located in an area known to support fish spawning and nursery grounds; there is also the potential for marine mammals and seabirds to be present throughout the year (Section 4). Given the low impact on air and water quality assessed above, the significance of the impact of atmospheric emissions on biological receptors has also been assessed as **low**.

CO_2, as a greenhouse gas, contributes to global warming. The total estimated direct CO_2 emissions produced as a result of the decommissioning activities in relation to the total CO_2 produced annually by shipping vessels in the UK is 0.17%. On this basis, the significance of the impact of CO_2 emissions has been assessed as **low**.

6.1.2.2 Onshore

Power or heat generation for primary or secondary smelting, and the associated emissions, is permitted under the Environmental Permitting regime (England) and the Pollution Prevention and Control regime (Scotland). The impact of emissions will have had to have been assessed as 'acceptable' for these permits to have been approved.

The indirect energy required for replacement of 'lost' steel and for recycling of recovered steel has been estimated as approximately 56% of total energy use for the decommissioning activities. This energy use equates to the emission of 22,817Te of CO_2 which is 0.18% of the total emission of CO_2 equivalent (CO_2e) from industry in the UK in 2015 (13Mte CO_2e) (BEIS, 2017b). On this basis, the significance of the impact of CO_2 emissions has been assessed as **low**.

6.1.3 Transboundary and cumulative impacts

The Annabel and Audrey facilities are located approximately 55km west of the UK/NL median line. The transboundary impacts of the direct atmospheric emissions arising from the decommissioning activities has been assessed to be of **low** significance owing to the distance from the median line and the anticipated rapid dispersion and dilution of emissions that will occur under prevailing metocean conditions.

In comparison with current levels of shipping traffic present in the vicinity of the A-Fields (approximately 9.4 vessels per day within 10nm (Anatec, 2015)) direct emissions from the decommissioning activities represent a very small increment only. The significance of cumulative impacts on receptors from atmospheric emissions resulting from the decommissioning activities has therefore been assessed as **low**.

6.1.4 Control and mitigation measures

In accordance with Centrica's standard environmental management of vessels, the following measures will be adopted to optimise energy consumption and reduce the impacts from atmospheric emissions to 'as low as reasonably practicable':

- Prior to mobilisation, vessels will be audited to ensure that appropriate planned and preventative maintenance has been carried out and condition of both generators and engine efficiency is in line with manufacturers specifications.;
- Fuel use for mobilised vessels will be monitored and comply with MARPOL (MARPOL, 1973) requirements, in particular with regard to low sulphur content;
- Decommissioning activities will be planned to minimise vessel use (e.g. optimisation of vessel work programmes);

- Fuel consumption will be minimised by operational practices and power management systems for engines, generators and any other combustion plant (as required under the contract with the subcontractor); and
- Planned and preventative maintenance systems will be required for all vessels to ensure that all equipment is maintained at peak operating efficiency for minimum overall fuel usage (as required under the contract with the subcontractor).

6.1.5 Conclusion

The principal direct energy requirement and source of atmospheric emissions associated with Annabel and Audrey facilities decommissioning activities concerns the fuel combusted by vessels for power generation. The indirect energy requirements and atmospheric emissions attributable to materials replacement and materials recycling have also been considered. The direct atmospheric emissions associated with decommissioning activities have the potential to impact upon both local and regional air quality, and to contribute to global warming. The prevailing metocean conditions are however expected to rapidly disperse and dilute airborne contaminants. The direct CO_2 emissions generated by the decommissioning represent approximately 0.17% of the total CO_2 produced by shipping on the UKCS.

Standard mitigation measures to optimise energy usage by vessels will include operational practices and power management systems for engines, generators and any other combustion plant and planned preventative maintenance systems for all equipment for achieving peak operational efficiency.

In summary, due to the localised and relatively short duration of activities, and with the identified control and mitigation measures in place, the overall significance of the impact of energy use and associated atmospheric emissions arising from the decommissioning of the Annabel and Audrey facilities is considered to be **low**.

6.2 Underwater sound

This section identifies and assesses the impact of surface, and subsea underwater sound resulting from the decommissioning activities.

Following the adoption of appropriate control and mitigation measures, residual effects and impacts are assessed with regard to the sensitivity and abundance of known receptors.

6.2.1 Sources

The principal planned decommissioning activities, including their location and estimated duration, are described in Section 3. Of these, the use of vessels and excavation and cutting tools, and the use of acoustic surveying equipment have been identified as having the potential to generate sound at levels warranting additional assessment.

Ambient sound in the undersea environment is generated by natural (e.g. wind, waves, tectonic activity, rain and marine organisms) and human (e.g. background shipping traffic and offshore construction) sources (e.g. Hildebrand, 2009; Richardson *et al*., 1995). Shipping is a key contributor to ambient sound in the frequency range 10Hz to 1kHz (Wenz, 1962).

The characteristics of the sound produced, in terms of strength or intensity and range of frequencies, vary with the type of activity and vessel type. Sound levels in the marine environment diminish with distance from the source. Details of the specific sound sources identified are discussed in this section.

6.2.1.1 Vessels

The primary sources of sound from vessels are propellers, propulsion and other machinery (Ross, 1976 and Wales *et al*., 2002). In general, vessel sound is continuous and results from narrowband tonal sounds at specific frequencies and broadband sounds.

Acoustic broadband source levels typically increase with increasing vessel size, with smaller vessels (< 50m) having a source root mean square (rms) sound pressure level (SPL) of 160-175dB re 1µPa at 1m, medium size vessels (50-100m) 165-180dB re 1µPa at 1m and large vessels (> 100m) 180-190dB re 1µPa at 1m (Richardson *et al*., 1995). However, sound levels depend on the operating status of the vessel and can vary considerably in time. Acoustic energy is strongest at frequencies below 1kHz.

Some of the vessels used for the proposed activities will use dynamic positioning systems to maintain and adjust their position when working. Sound levels can be louder during use of dynamic positioning, which requires the operation of thrusters to control a vessel's location.

6.2.1.2 Excavation and cutting tools

Any localised excavation will involve the use of tools such as water-jetting and suction equipment. Cutting of underwater structures will be achieved through mechanical methods. Mechanical methods, such as hydraulic shears, use hard cutting surfaces that produce a sawing or machining action.

There is very little information available on underwater sound generated by tools used for underwater cutting operations. Anthony *et al*., (2009) present a review of published underwater sound measurements for various types of diver-operated tools. Several of these are underwater cutting tools, including a high-pressure water jet lance, chainsaw, grinder and oxy-arc cutter. Reported source sound pressure levels were 148-170.5dB re 1µPa (it was not indicated whether these are rms or zero-peak). It is possible that larger, ROV operated cutting tools could generate higher intensity sound levels but no published data are available.

6.2.1.3 Acoustic surveying equipment

Seabed surveys carried out as part of decommissioning will typically employ acoustic surveying equipment such as SSS and echo sounders to generate images of the seabed. Airguns are not expected to be used.

6.2.2 Impacts and receptors

6.2.2.1 Fish

Fish species (as described in Section 4) differ in their hearing capabilities depending on the presence of a swimbladder, which acts as a pressure receiver, and whether the swimbladder is connected to the otolith hearing system, which further increases hearing sensitivity (McCauley, 1994; Popper *et al*., 2014). Most fish can hear within the range 100Hz to 1kHz, with some able to detect lower frequencies. Fish with a connection between the swimbladder and otolith system may detect frequencies of several thousand Hz. Elasmobranchs do not have a swim bladder and therefore have less sensitive hearing (Popper *et al*., 2006).

Fish are mobile animals that would be expected to be able to move away from a sound source that had the potential to cause them harm. If fish are disturbed by a sound, evidence suggests they will return to an area once it has ceased (Slabbekoorn *et al*., 2010).

Fish exhibit avoidance reactions to vessels and it is likely that radiated underwater sound is the cue. For example, sound from research vessels has the potential to bias fish abundance surveys by causing fish to move away (de Robertis, 2013; Mitson, 2003). Reactions include diving, horizontal movement and changes in tilt angle (de Robertis, 2013).

There is no published information on the response of fish to sound generated by underwater cutting. However, reported source levels are relatively low compared with those generated by vessels and cutting operations are expected to be of short duration.

Very little information is available on the potential effects of SSS and echo sounders on fish (Popper, 2009; ICES, 2005). Experiments exposing caged fish of various species to mid-frequency (2.8-3.5kHz) sonar at a received SPL of 210dB re 1µPa rms found evidence of temporary hearing damage in fish with hearing sensitivity in the frequency range generated by the source but not those with lower frequency hearing. Hearing damage recovered within 24 hours and no evidence of pathology or mortality was found (Halvorsen *et al.,* 2012).

Unpublished work by the Norwegian Defence Research Establishment (Jorgensen *et al.,* 2005; presented in Kvadsheim *et al.,* 2005) exposed larval and juvenile fish to simulated sonar signals at 1.5kHz, 4kHz and 6.5kHz to investigate potential effects on survival, development and behaviour. The fish species used were herring (*Clupea harengus*), Atlantic cod (*Gadus morhua*), saithe (*Pollachius virens*) and spotted wolfish (*Anarhichas minor*). Received sound levels ranged from 150 to 189dB re 1µPa. The only effects on fish behaviour were some startle or panic movements by herring for sounds at 1.5kHz. There were no long-term effects on behaviour, growth or survival. There was no damage to internal organs and no mortality apart from in two groups of herring (out of over 40 tests) at received sound levels of 189dB, for which there was a post-exposure mortality of 20 to 30%. Herring can detect higher frequencies than are detected by the other species in the study.

The level of sound generated by the decommissioning activities is considered highly unlikely to result in physiological damage to fish. Given the relatively high shipping activity in the vicinity of the A-Fields, fish behaviour would be expected to be habituated to general vessel sound and cutting sound is expected to be low compared to this. Sound generated by vessel thrusters when starting is still likely however to elicit a startle response in fish in the immediate vicinity.

Given the above, and the localised extent and short duration or intermittent nature of the activities, the significance of the impact of vessel sound upon fish has been assessed as **low**.

6.2.2.2 Marine mammals

Sound is important for marine mammals for navigation, communication and prey detection (e.g. Southall *et al*., 2007; Richardson *et al*., 1995). The introduction of anthropogenic underwater sound, therefore, has the potential to impact on marine mammals if it interferes with the ability of an animal to use and receive sound (e.g. OSPAR, 2009). The potential impact of sound on an animal depends on many factors including the level and characteristics of the sound, hearing sensitivity of the species and behaviour of the species.

Vessel sound can mask communication calls between cetaceans, reducing their communication range (Jensen *et al*., 2009). Exposure to low frequency ship sound may be associated with chronic stress in whales. Rolland *et al*., (2012) reported a decrease in baseline levels of stress-related faecal hormones concurrent with a 6dB reduction in underwater sound along the shipping lane in the Bay of Fundy, Canada in 2001.

Marine mammals potentially in the area are harbour porpoise, white-beaked dolphin, grey seals and harbour seals (Section 4.4.4).

The peak sound levels and frequency spectra generated by the various sources of underwater sound are not deemed capable of causing any physical injury to acoustically sensitive species, such as marine mammals. It is possible, however, that some sound induced disturbance to marine species may occur. For example, underwater sound levels may cause marine mammals to move away from the local area during the period of activity such as vessel use or use of cutting tools.

There is no published information regarding the response of marine mammals to sound generated by underwater cutting. However, reported source levels are relatively low compared with those generated by vessels and cutting operations are expected to be of short duration.

The impact of acoustic survey equipment sound on marine mammals depends on frequency, pulse characteristics (e.g. duration, repetition rate and intermittency), source and received levels, directivity, beam width and receptor species. A review of the impact of acoustic surveying techniques on marine fauna in the Antarctic concluded that acoustic instruments such as SSS and many echo sounders are of sufficiently low power and high frequency as to pose only a minor risk to the environment. This concurs with a review by Richardson *et al*. (1995), which found most evidence for a behavioural response to sonar operating at frequencies around 3kHz to 13kHz and no obvious response to pingers, echo sounders and other pulsed sound at higher frequencies unless the received levels were very high. Behavioural responses included avoidance and changes in swimming behaviour and vocalisation.

For echo sounders operating in shallow water depths such as at Annabel (*c.*27m), Audrey A (WD) (c.22.4-26m) and Audrey B (XW) (c.24.5m), the high-end of frequencies outside the hearing range of marine species are used, which attenuate rapidly, also operating power is lower than in deeper water (JNCC, 2010a). Under these conditions JNCC considers that injury or disturbance would be unlikely. Similarly, JNCC considers the risk of injury or disturbance from SSS to be negligible because of the high frequencies that are outside the hearing range of marine mammals and attenuate rapidly and the short duration of this type of survey.

Given the above, and the localised extent and short duration or intermittent nature of the activities, the significance of the impact of underwater sound to marine mammals has been assessed as **low**.

SNS SAC for harbour porpoise

Harbour porpoise are one of the most common species of cetaceans in the SNS and as described in Section 4.4.4, the decommissioning activities will be undertaken within the SNS SAC for harbour porpoise (Figure 4-29). The conservation objectives for the harbour porpoise SAC aim to maintain or restore in the long term the attributes listed in Section 4.5.1.2 (JNCC, 2016a).

Decommissioning activities must minimise any impact which could threaten these objectives. There should be no significant disturbance to, and no deterioration of, the qualifying species or the habitats upon which they rely. The Draft Conservation Objectives and Advice on Activities document assessed the current level of impact risk (based on sensitivity and exposure to certain activities) and identifies anthropogenic sound as having a medium level of risk meaning that there is some scope for harbour porpoise to be impacted by sound (JNCC, 2016a).

The total area of the SAC for harbour porpoise is 36,958km^2. The area of the SAC that is anticipated to be impacted by the sound associated with vessels, acoustic surveying equipment, and by sound associated with excavation and cutting tool use, is anticipated to be very small. The A-Fields are located within an extensive, mature hydrocarbon basin with emissions from routine production, maintenance and support operations (including vessel use) all contributing to a broad and active ‘soundscape’; high levels of general shipping activity are additionally present (Section 4.6.4). It is considered likely therefore that marine mammals, including harbour porpoise, in the area will already have been exposed to similar types and levels of sound that will be generated by the decommissioning activities. The reported response of animals to received sound has been found to wane with repeated exposure in some studies (Southall *et al*., 2007) and it is anticipated that any harbour porpoise or other marine mammals will avoid areas in close proximity to vessel activities (Verboom and Kastelein, 2005).

Given the above, and that only a very small proportion of the SAC will be affected by activities, the significance of the impact to it from underwater sound has also been assessed as **low** with no detrimental impact to the conservation objectives of the site being anticipated.

6.2.3 Transboundary and cumulative impacts

The A-Fields are located approximately 55km west of the UK/NL median line. The transboundary impact from underwater sound arising from the decommissioning activities has been assessed to be of **low** significance given this distance and the attenuation of sound that will occur.

The A-Fields are part of the highly developed SNS hydrocarbon basis which currently has 140 surface installations, 10 of which have either submitted decommissioning plans or had them approved (BEIS, 2017a) (Section 4.6.5). The nearest platform to Annabel infrastructure is the Saturn ND platform (5.0km) and the nearest platform to Audrey infrastructure is the Tethys platform (10.7km).

Approximately 4.2km to the north of Annabel is an area available as an aggregates extraction option and an aggregates application is in place in the same area. At the time of writing, the timescales for this application are unknown and therefore the potential for cumulative impacts are unknown.

The SNS SAC for harbour porpoise covers an area of 36,958km^2. The impact of sound generated by the decommissioning activities has been assessed as of low significance with no detrimental impact to the conservation objectives of the site being anticipated.

The underwater sound generated from vessels and in the use of underwater excavation and cutting tools are expected to be localised and of relatively short duration. Hence, no substantive cumulative impacts are anticipated.

6.2.4 Control and mitigation measures

The following measures will be adopted to ensure that sound levels, and their effects upon potential receptors, are minimised to 'as low as reasonably practicable':

- Machinery, tools and equipment will be in good working order and well-maintained (as required under the contract with the subcontractor);
- The vessels work programme will be carefully planned to optimise use; and
- The number of required pipeline cuts will be minimised consistent with operational (including safety) considerations.

6.2.5 Conclusion

The principal sources of underwater sound associated with the Annabel and Audrey facilities' decommissioning activities concern the use of vessels, and the use of excavation and cutting tools.

The vessels' work programme comprises a total of approximately 322 individual vessel days spread over a multi-year period. This is of relatively short duration and represents only a small increment to existing vessel traffic in the area. Cutting tools will only require to be used intermittently over this period and then at point locations.

The level of sound that will be generated is not expected to cause physiological harm or substantive behavioural interference to either fish or mammals known to inhabit the area.

Standard measures that will be applied to control sound include planned maintenance of equipment and optimisation of the work programme to minimise vessel use.

In summary, due to the localised, and short duration or intermittent nature of the activities, and with the identified control and mitigation measures in place, the overall significance of the impact of underwater sound generated during decommissioning of the Annabel and Audrey facilities is considered to be **low**.

6.3 Seabed disturbance

This section identifies and assesses the impact of the various sources of planned seabed disturbance resulting from the decommissioning activities. It also considers potential sources of unplanned (accidental) seabed disturbance.

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

6.3.1 Sources

The principal planned decommissioning activities, including their location and estimated duration, are described in Section 3. Of these, the excavation of sediments, the lifting (removal) of infrastructure and materials, the temporary placement of objects on the seabed, the over-trawl assessment and the use and positioning of vessels have been identified as warranting further assessment in terms of their potential to disturb the seabed.

6.3.1.1 Temporary disturbance

Temporary disturbance from decommissioning activities can result in direct physical injury to benthic species and also resuspension of sediment, resulting in increases in suspended solid concentrations in the water column and on the seabed with the potential to change its physico-chemical characteristics.

Excavation

The degree of seabed disturbance will be related to the required number of pipeline and umbilical disconnections and the extent to which each location is initially buried with sediment; and, the length of pipeline and umbilical sections being removed. Sediment may also require to be excavated in order to install or locate the lifting points of the installations, protection and stabilisation features being removed and to permit access to pipelines or umbilicals for disconnection, and for protection and stabilisation features for removal. Marine growth may also be required to be cleared at disconnection and lifting points. The anticipated low volumes of material are considered not to warrant further assessment.

Lifting (removal) of infrastructure and materials

The degree of seabed disturbance will be related to the length and diameter of the pipeline or umbilical section being removed, the size (‘footprint’) of the protection and stabilisation features being removed, the size (‘footprint’) of the installations being removed and the extent to which they are buried by sediment prior to lifting.

Temporary seabed placement

Material and equipment may be temporarily placed on the seabed to to allow the completion of the workscope. The degree of seabed disturbance caused will be related to the exact proceudres developed.

Debris survey and over-trawl assessment

Upon completion of decommissioning operations, appropriate surveys will be taken to identify and recover any debris located on the seabed which has arisen from the decommissioning operation or from past oil and gas activity.

The area to be covered includes a radius of 500m from the location of an installation and up to 100m either side of a decommissioned pipeline over its whole length.

An over-trawl assessment to confirm that the area is clear will then be carried out. In the SNS, the verification of a clear seabed might typically involve using ‘rock hopper’ fishing gear with scraper chains to determine if there remain any snagging hazards. Assuming the area is free of snagging hazards, a Clear Seabed Certificate is issued. These over-trawl assessments are carried out to make sure the seabed is safe for normal fishing.

Vessels

The HLV has yet to be selected but as a worst case, it is assumed that 12 anchors will be used to hold the HLV on location and these will be connected via anchor lines measuring *c.*1.5km each in length. It is assumed that *c.*500m of each anchor line will be in contact with the seabed impacting on a corridor of maximum width of *c.*10m. For the purposes of this EIA, it is assumed that the anchors would be *c.*2m (L) x 2m (W). An example of the worst case anchor pattern at Audrey A (WD) and Audrey B (XW) are shown in Figure 6-1 and Figure 6-2 respectively. The HLV will be required in four separate locations (for each of the topside and each jacket).

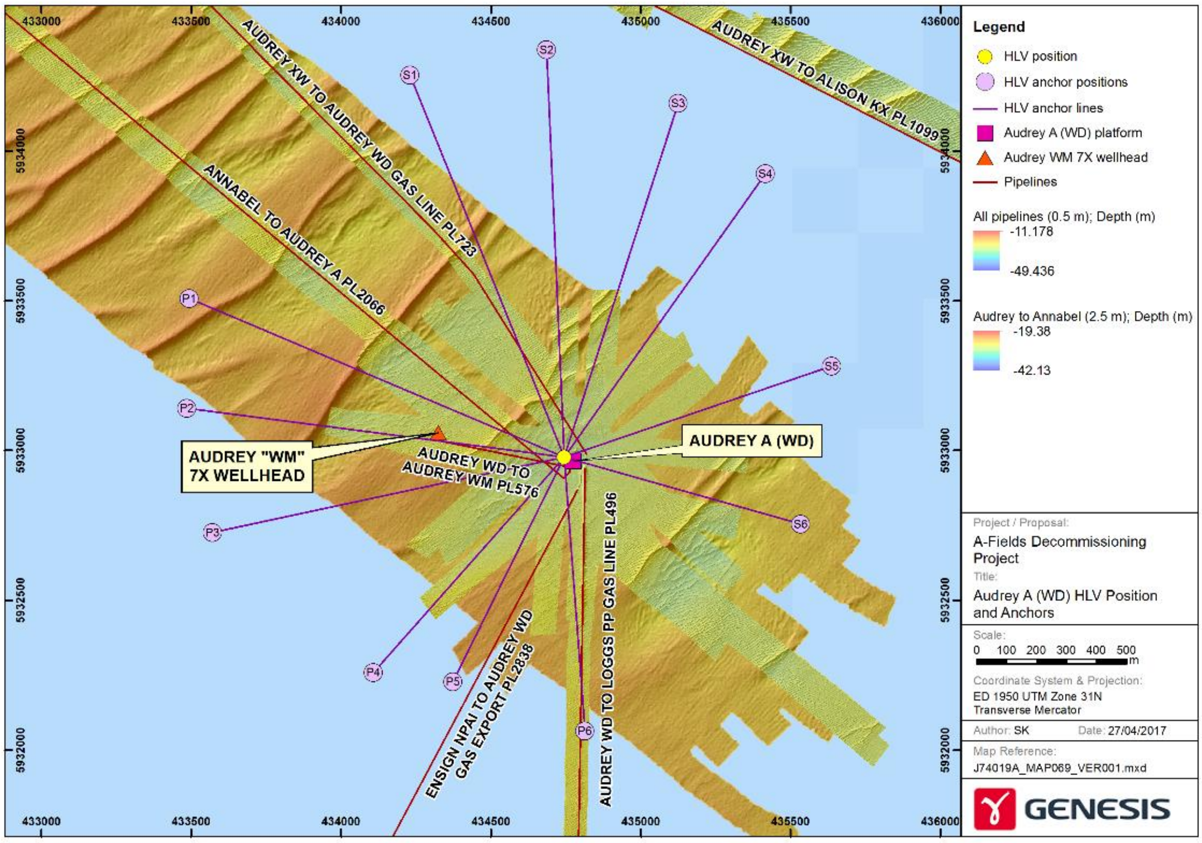

Figure 6-1 Worst case anchor pattern at Audrey A (WD)

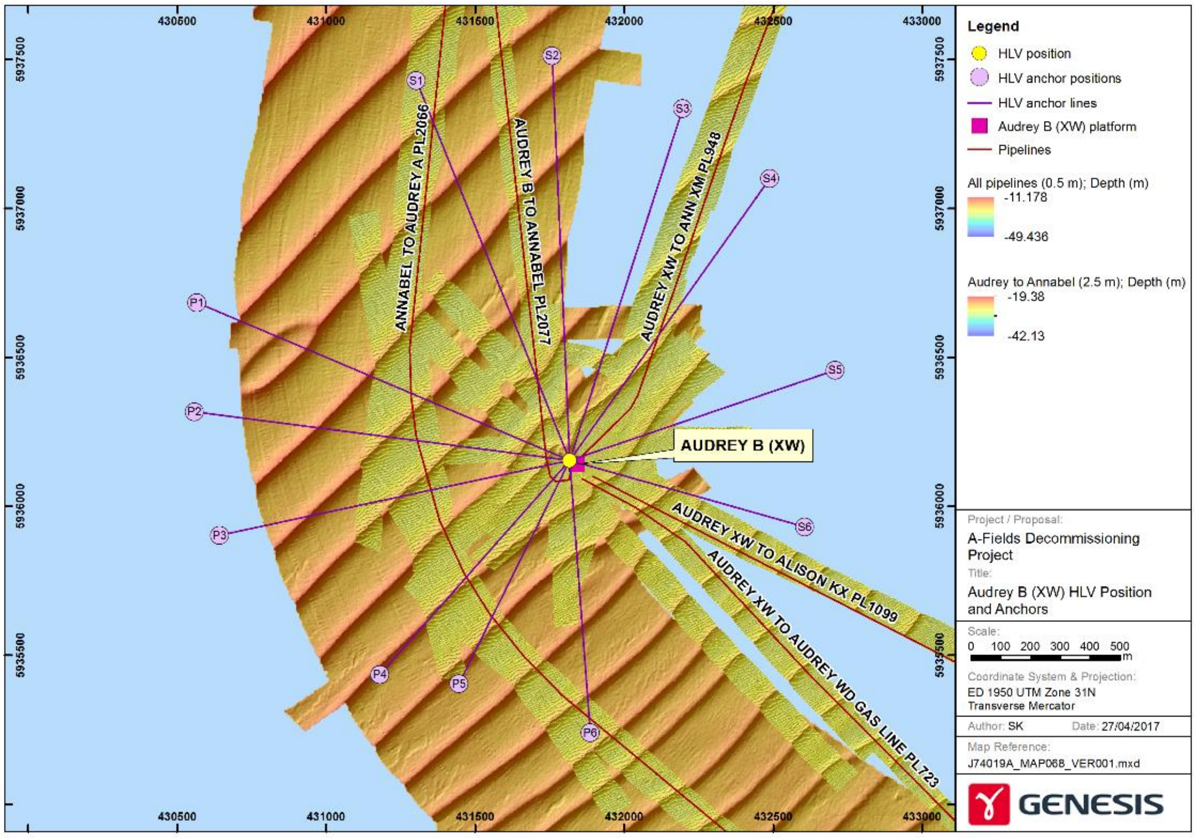

Figure 6-2 Worst case anchor pattern at Audrey B (XW)

The wash from vessel propulsion and dynamic positioning activities have the potential to disturb the seabed depending upon vessel draught, vessel operating mode and the water depth. However, given the prevailing currents in the vicinity of the A-Fields and the dynamic nature of the seabed, it is anticipated that certain sediment sizes would routinely be mobilised and it can therefore be expected that the local fauna would be habituated to this environment and would not be affected to any significant degree and would recover quickly. As such, the impact of vessel propulsion and dynamic positioning systems on seabed disturbance is not considered further.

Unplanned activities and events

During all lifting activities there is the potential for materials and equipment to be accidentally dropped as a consequence of procedural failure, or mechanical failure of lifting apparatus. The degree of disturbance will be related to the size of the dropped object's 'footprint'.

Summary

The principal sources of temporary seabed disturbance, with corresponding estimates of area, are itemised in Table 6-4 where the total estimated area of seabed disturbance is calculated to be 11.6753km^2 which is dominated by the over-trawl assessment. To put this into context, a UKCS licence block covers approximately 200km^2, and the North Norfolk Sandbanks and Saturn Reef SAC occupies 3,603km^2. The area impacted is therefore considered very small.

The estimate of seabed disturbance given in Table 6-4 does not include an allowance for the excavation of sediment, or the temporary placement of equiment on the seabed. The area will be small and within the area already impacted by the removal activities. The impact from the latter will be the subject of a Marine Licence application prior to project execution.

SOURCE OF SEABED DISTURBANCE	ASSUMPTIONS MADE	AREA IMPACTED (km^2)
Removal of pipelines (including spool pieces) and umbilicals: Ends of PL2066, PL2067, PL496, PL497, PL723 and PL724. Full recovery of PL2066JW12, PL2066JWAB2, PL2067JW12, PL2067JWAB2, PL575 and PL576	Total length of pipelines, umbilicals and spool pieces ends** to be recovered is approximately 15.10km. The area of seabed disturbance was assumed to be a corridor width of 10m, allowing for sediment to be moved from its current location over the partially buried infrastructure to either side.	0.151
Deployment of HLV anchors and chains	Based on 12 anchors and four HLV positions. Assumes the area of disturbance when positioning the anchors is 10m x 10m and a minimum length of 500m of each anchor chain impacts on the seabed across a corridor width of 10m.	0.2448
Removal of installations: Annabel template, Annabel AB1 and AB2 WHPS, Audrey 11a-7 WHPS, Audrey A (WD) and Audrey B (XW) jackets	Additional 1m added on all sides to allow for disturbance beyond exact dimension of each structure. Total area of structures = $0.00134km^2$.	0.0015
Removal of concrete mattresses	The area of disturbance associated with the removal of the 206 concrete mattresses (each 6m x 3m) was calculated based on an assumed additional length of disturbance of 1m on each side of the mattresses.	0.0098
Removal of grout bags	Recovery of approximately 211 grout bags of varying size. An additional impacted area of 1m on either side of the grout bag area.	0.0013
Over-trawl assessment	A conservative assumption has been made for the assessment to cover a 200m corridor along all pipeline lengths and the three HSE 500m safety zones.	11.2669
Total area impacted		**11.6753**
* The concrete mattresses are positioned over the pipeline and umbilical and, by considering them separately, the areas calculated above include some double counting. Likewise, grout bags may have been placed on top of each other. ** Ends are defined as sections of pipeline (including spool pieces) or umbilical that make the transition from full burial to the seabed surface, and those that rest on the seabed.		

Table 6-4: Estimate of area of temporary seabed disturbance

6.3.1.2 Permanent disturbance

The *in situ* decommissioning of pipelines and umbilicals, including any associated protection or stabilisation features, can be considered to cause permanent disturbance to the seabed. The degree of disturbance will be related to the length and diameter of the pipeline or umbilical section being decommissioned and the burial status.

An estimate of the seabed area potentially affected by permanent impacts is presented in Table 6-5. It shows that the estimated total area impacted is $0.0810km^2$. To put this into context, a licence block is approximately $200km^2$ and the North Norfolk Sandbanks and Saturn Reef SAC is $3,603km^2$. The area impacted is therefore considered small.

SOURCE OF DISTURBANCE	ASSUMPTIONS MADE	AREA IMPACTED (km^2)
Existing deposited rock	10Te rock per 1m of pipeline and a 7m corridor width along the pipeline.	0.0627
Pipelines and umbilicals decommissioned *in situ*	PL2066, Pl2067, PL496, PL497, PL723 and PL724. Area is calculated based on the length and diameter of pipelines and umbilicals decommissioned *in situ*.	0.0010
Protection / stabilisation features decommissioned *in situ*	41 frond mattresses, 27 concrete mattresses and 102 grout bags. Area is calculated based on the dimensions of the protection and stabilisation features decommissioned *in situ*.	0.0173
Total area impacted		**0.0810**

Table 6-5: Estimate of permanent impacted seabed area

6.3.2 Impacts and receptors

6.3.2.1 Temporary disturbance

A total of 11.6753km^2 of seabed has been calculated to be temporarily disturbed as a result of the removal activities and over-trawl assessment. These activities may result in the direct physical injury of benthic species. Disturbance of seabed sediment will also lead to increases in suspended solid concentrations in the surrounding waters. However, suspended materials will be rapidly dispersed and diluted by prevailing hydrodynamic conditions before settling back to the seabed and the disturbance will therefore be short term. Whilst some redistribution of material is to be expected, the impact of this will depend on the sediment characteristics in the area.

Indirect impacts

The seabed surveys showed mixed results in terms of sediment characteristics across the different sites. Sediments within the Annabel and Audrey A (WD) locality ranged from very poorly sorted to well sorted while the Audrey B (XW) and LOGGS sediments were generally homogenous. Concentrations of contaminants across the A-Fields survey area were generally low for THC with the exception of samples taken at cuttings piles within the Audrey A (WD) area. Six stations sampled (five at Audrey A (WD) and one at Audrey B (XW)) showed concentrations of NPD PAHs above their respective ERL concentrations indicating that they were likely to be associated with toxicity in the sediments. However, the mobile nature of the seabed within the North Norfolk Sandbanks and Saturn Reef SAC is likely to result in turbidity, reducing the impact of sediment re-suspension from the decommissioning activities. Long term impacts are therefore not anticipated and the significance of the risk of habitat modification (due to the homogenous nature of the sediment) has been assessed as **low**.

Localised disturbance of the ecosystem at the seabed may occur, leading to some degree of community change. It is known that some bottom-dwelling marine organisms are particularly vulnerable to natural or man-made activities which cause disturbances of the seabed, such as deposition of sedimentary material. The majority of offshore benthic species are recruited from the plankton, and usually recover rapidly once disturbance from the decommissioning activities cease.

It is also possible that bottom-dwelling organisms may be smothered by settlement of suspended solids, however rapid dispersion and dilution by prevailing hydrodynamic conditions before the material settles back to the seabed will prevent the development of substantial accumulations of re-settled materials far from the disturbance. The risk of smothering is therefore considered to be in line with the normal re-distribution of seabed sediment which occurs as a result of natural hydrodynamic conditions and is an inherent component of the ecosystem.

Direct impacts

Lifting of materials is likely to damage/destroy any sensitive surface species settled on the sediment. It is unlikely however to affect mobile species, either on, or under the surface of the sediment, which are likely to move away from the disturbance.

The intentional or unintentional temporary placement of objects on the seabed will result in the effected substrate being no longer available for colonisation by either surface dwelling or burrowing species.

There may be the potential for sub-lethal impacts on benthic and epibenthic fauna as a consequence of physical abrasion from excavation works. Careful management and planning of activities to minimise affected areas will reduce the potential for physical abrasion but it is impossible to eliminate the risk entirely and some impacts on populations may occur. Since the disturbance will be short term and given the strong currents in the SNS, it is expected that any impacts on the populations and the wider ecosystem will be minimal and that rapid and complete recovery of the localised seabed community will occur once activities cease.

Sabellaria sp. tube aggregations were observed at Audrey A (WD), Audrey B (XW) and Annabel. The aggregations of Sabellaria sp. exhibited low 'Reefiness' as described by Gubbay (2007) and therefore none of these aggregations were found to represent an Annex I reef structure.

Given that the area of seabed/infrastructure that will be affected by excavation, lifting of materials, or temporary placement of objects represents only a very small proportion of biotopes available in the SNS, that the *Sabellaria* sp. present do not represent Annex I habitat and that recolonization of affected substrate is expected to occur rapidly via recruitment of individuals from adjacent undisturbed areas, the significance of these impact has been assessed as **low**.

Fish spawning and nursery grounds

As discussed previously a number of species of fish are known to spawn within the vicinity of Annabel and Audrey with others using it as a nursery area in the period immediately following spawning. Smothering of these areas, particularly during spawning is likely to affect the spawning success which could have wider impacts to the population as a whole.

Ideally, the decommissioning activities would be undertaken outside of the spawning period to ensure there is no impact. However, the overlap of spawning periods throughout the year would make this impossible. Given the above, longer term habitat modification is not anticipated and the significance of the impact has been assessed as **low**.

6.3.2.2 Permanent disturbance

The *in situ* decommissioning of infrastructure can lead to long term impacts to the seabed and its habitat, especially modifications to seabed dynamics (and morphology) and changes to the benthic fauna.

There is no additional deposited rock required for the decommissioning of the Annabel and Audrey infrastructure. As such, there is no additional permanent loss of habitat expected and this is not considered further.

Seabed Dynamics

Decommissioning of *c*.72km of pipeline *in situ* and 89,500Te of deposited rock in the area of the North Norfolk Sandbanks (a large proportion of which is on PL723 and PL724 and is within a trench) could potentially change the seabed dynamics. The total area of pipelines and stabilisation materials is 0.081km^2 which is 0.002% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC.

An assessment was undertaken to determine the impact of the Scroby Sands offshore windfarm (located 2.3km offshore of Great Yarmouth) on sandbank morphology (Cefas, 2006). The study found no evidence of any changes to sandbank morphology as a result of the 30, 4.2m diameter monopile foundations driven up to 30m into the seabed. This suggests that the decommissioning of the Annabel and Audrey pipelines and associated rock protection *in situ* is unlikely to have an impact on the sandbank morphology and dynamics.

Change to Fauna

Under the Annabel and Audrey Decommissioning Programme, a total of *c*.72km of pipeline are proposed to be decommissioned *in situ.* The pipeline will corrode and degrade over time and as such there is a possibility that any constinuents on the within the pipeline will be released to the water column. This could impact benthic species if these constinuents become bioavailable. Any such release would be very gradual and any impact would be highly localised (OGUK, 2013).

6.3.3 Transboundary and cumulative impacts

The A-Fields are located approximately 55km west of the UK/NL median line. Given this distance and the localised nature of the impacts resulting from the seabed disturbances, no substantive transboundary impacts are anticipated.

The cumulative area of seabed disturbed due to currently planned decommissioning activities within the North Norfolk Sandbanks and Saturn Reef SAC is shown in Table 6-6.

LOCATION	AREA IMPACTED (km^2)		
	TEMPORARY	PERMANENT	
	Total[2]	Total	Deposited Rock
A-Fields well abandonment	0.0029	0	0
Ann and Alison	15.3924	0.0252	0.0111
Annabel and Audrey	11.6753	0.0810	0.0627
Viking and LOGGS	0.0144	0.6208	0.0754
Leman BH	0.4058	0	0
Dong Energy Hornsea Project Three	10.38[1]	-	-
Total	**37.8673**	**0.7270**	**0.1492**

[1] Note that not all of this area of seabed disturbance occurs within the North Norfolk Sandbanks and Saturn Reef SAC.

[2] Note that only the A-Fields temporary values include the over-trawl assessment impacts.

Table 6-6: Cumulative Impacts within North Norfolk Sandbanks and Saturn Reef SAC

The total cumulative area of seabed identified which may experience temporary impacts is 37.8673km^2 which comprises 1.05% of the North Norfolk Sandbanks and Saturn Reef SAC. The majority of the area impacted is attributed to the over-trawl assessment which is an impact equivalent to fishing activities that are currently undertaken in the area. The timing of these impacts are unlikely overlap and they will not occur in close proximity. Due to the short duration and localised nature of the activities from temporary seabed disturbance, significant cumulative impacts are not anticipated.

Approximately 4.2km to the north of Annabel is an area available as an aggregates extraction option and an aggregates application is in place in the same area. At the time of writing, the timescales for this application are unknown and therefore the potential for cumulative impacts are unknown.

The area of infrastructure and protection and stabilisation features, including deposited rock, decommissioned *in situ* from the A-Fields and other projects in the surrounding area are shown in Table 6-6. The total area equates to 0.020% of the area of the North Norfolk Sandbanks and Saturn Reef SAC. As discussed in Section 6.3.2, there is currently no evidence from survey analysis to suggest that changes to the sandbank morphology and dynamics are likely to occur.

6.3.4 Control and mitigation measures

The following measures will be adopted to ensure that seabed disturbance and its impacts are minimised to 'as low as reasonably practicable':

- All activities which may lead to seabed disturbance will be planned, managed and implemented in such a way that disturbance is minimised;
- The careful planning, selection of equipment, and management and implementation of activities;
- A debris survey will be undertaken at the completion of the decommissioning activities. Any debris identified as resulting from decommissioning activities will be recovered from the seabed where possible; and
- Optimise the area that requires an over-trawl assessment through discussion with the NFFO and the regulators.

6.3.5 Conclusion

The principal sources of seabed disturbance associated with the Annabel and Audrey facilities' decommissioning activities concern the over-trawl assessment at the end of decommissioning, positioning of HLV anchors and chains and excavation of sediments and the lifting of materials from the seabed during their recovery. These activities will result in the displacement of substrate and the suspension and subsequent settlement of sediment.

Excavation and lifting operations will be undertaken at the pipeline and umbilical ends, for the piles at the Audrey drilling templates, Audrey 11a-7 WHPS and the Audrey platforms.

Standard measures to control disturbance include operational planning and equipment selection.

The species and habitats observed in the vicinity of Annabel and Audrey facilities are relatively widespread throughout the SNS and the area anticipated to be impacted represents a very small percentage of the available habitat. Furthermore, the environment in the vicinity of the Annabel and Audrey Fields is dynamic due to the shallow water depth therefore all disturbed sediments/habitats are expected to recover rapidly, through species recruitment from adjacent undisturbed areas.

Based on as laid bathymetry data for the A-Fields infrastructure there is no evidence of long-term detrimental impact to the North Norfolk Sandbanks and Saturn Reef SAC feature due to the presence of pipelines and stabilisation features. As such, the significance of the impacts of decommissioning pipelines and deposited rock *in situ* has been assessed as **low**.

In summary, due to the localised and relatively short duration of the decommissioning activities, and with the identified control and mitigation measures in place, the overall significance of the impact of seabed disturbance as a result of the decommissioning of the Annabel and Audrey facilities has been assessed as **low**.

6.4 Discharges and releases to sea

This section identifies the various sources, and assesses the impact, of planned discharges to the marine environment that will result from the decommissioning activities. It also considers (with the exception of large hydrocarbon releases which are addressed in Section 6.5) the potential for, and the effects of, unplanned releases ('spills') to the marine environment.

Following the adoption of appropriate control and mitigation measures, residual effects and impacts (and the risk of such) are assessed in the context of the sensitivity of, and the assimilative capacity of, the receiving environment.

6.4.1 Sources and potential sources

The principal planned decommissioning activities, including their location and estimated duration, are described in Section 3. Of these, the use of vessels and cutting and removal activities have been identified as warranting further assessment in terms of the potential impact of their discharges and releases.

6.4.1.1 Surface discharges and releases

Vessels

- Planned (operational) discharges (ballast water, bilge water, general shipboard drainage, treated sewage and grey water from accommodation and amenities); and
- Unplanned (accidental) releases of small volumes of hydrocarbons or chemicals.

6.4.1.2 Seabed and water column discharges

Cutting and removal

- Planned discharge (post-cleaning), upon breaking containment of pipelines (including spool pieces), and umbilicals of residual concentrations of chemicals, hydrocarbons and solids at the seabed, and through the water column during recovery.

6.4.2 Impacts and receptors

The discharges and releases have the potential to impact the marine environment (plankton, benthos and fish, etc.) in the immediate vicinity of the discharge point. Bioaccumulation in the food chain may occur.

6.4.2.1 Vessels

Planned operational discharges to sea from vessels will be subject to on-board control measures designed to secure compliance with the requirements of MARPOL (1973).

Decommissioning activities will comprise approximately 322 vessel days spread over a multi-year period (Table 3-25, Table 3-26 and Table 3-27). During this time discharges will be controlled and minimised using operating procedures and systems for optimum performance, including planned preventative maintenance systems for peak operating efficiency of on-board systems for the management of drainage, effluent, ballast water and bilge water.

It is possible that technical problems may lead to unplanned small volume releases of diesel or other hydrocarbons (e.g. through the drainage system). The likelihood of such releases is considered very low.

Although water quality will be reduced at the immediate time and location of discharge, the effects of planned vessel discharges and any small volume unplanned releases will be minimised due to the expected rapid dilution and dispersal of contaminants under ambient metocean conditions. It is considered unlikely that impacts beyond those associated with normal shipping activities will occur. The significance of the impacts from these discharges and releases has therefore been assessed as **low**.

6.4.2.2 Cutting and removal

Discharge of remaining chemicals

The pipelines (including spool pieces), and the umbilical cores containing methanol (with the exception of those of PL576) will be flushed with, and left containing filtered seawater prior to decommissioning. Recent attempts to flush PL576 have proved unsuccessful. It is planned however to completely remove the entire length of this umbilical by the reverse installation method such that no discharge of chemical to the environment will occur.

Upon cutting of sections of pipeline and umbilical, their contents (including any remaining chemicals) will begin to be discharged, initially at the seabed. Upon lifting of cut pipeline and umbilical sections, further and complete discharge of the contents is expected to occur through the water column *en route* to surface.

The umbilical cores containing hydraulic fluid will not be flushed prior to decommissioning. Hydraulic fluids selected are water-soluble chemicals with low environmental toxicity and are permitted for use and discharge under the Offshore Chemicals Regulations 2002 (OCR). A detailed, specific chemical assessment of the impact of the discharge will be included in the environmental permits submitted prior to the execution of the work under the OCR.

The contents of the pipeline and umbilical sections being decommissioned in situ will eventually be lost to the surrounding sediment over time as the materials from which the pipelines and umbilicals are constructed gradually deteriorate, and the containment they provide fails. Should the contents migrate through the sediment to the seabed, the prevailing hydrodynamic conditions would be expected to lead to its rapid dilution and dispersion, with any impacts being localised and short term. The significance of the impact has therefore been assessed as **low**.

Discharge of residual hydrocarbons

All production pipelines (including spool pieces) will be pigged and flushed with, and left containing, filtered seawater prior to decommissioning. The pipeline contents may contain very low concentrations of residual hydrocarbons that were not able to be cleaned.

Upon cutting of sections of pipeline their contents (including any residual hydrocarbons) will begin to be discharged at the seabed. Upon lifting of the cut sections, further and complete discharge of the contents is expected to occur through the water column *en route* to surface.

Hydrocarbon discharges will be permitted under the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended) (OPPC).

The contents of the production pipeline sections being decommissioned *in situ* will eventually be lost to the surrounding sediment over time as the materials from which the pipeline is constructed gradually deteriorate, and the containment it provides fails. Should the contents migrate through the sediment to the seabed the prevailing hydrodynamic conditions would be expected to lead to its rapid dilution and dispersion, with any impacts being localised and short term. The significance of the impact has therefore been assessed as **low**.

6.4.3 Transboundary and cumulative impacts

The A-Fields are located approximately 55km west of the UK/NL median line. Given this distance, and the localised and short duration of the discharges and potential releases to the marine environment associated with the decommissioning activities, no substantive transboundary impacts are anticipated.

Cumulative impacts resulting from discharges to sea are considered unlikely as the impacts are expected to be localised and short-term with rapid dispersion, dilution and degradation.

6.4.4 Control and mitigation measures

All operational activities will be undertaken in compliance with regulations (particularly Radioactive Substances Act, Environmental Permitting Regulations, OPPC, OCR and MARPOL and all its annexes).

The following measures will be adopted to ensure that discharges to sea and its impacts are minimised 'to as low as reasonably practicable':

- Pigging and/or flushing procedures will be followed to minimise residual contaminants within pipelines and umbilicals;
- Procedures and systems for the minimisation of waste and effluent generation from vessels (maintained as required under the contract with the subcontractor);
- Procedures and systems for the management of ballast and bilge water from vessels (maintained as required under the contract with the subcontractor);
- Accident prevention measures will be in place on vessels in order to minimise the potential for accidental spillages of hydrocarbons or other polluting materials;
- Vessels will be selected and audited to ensure that effective operational systems and onboard control measures are in place; and
- Vessels' work programmes will be optimised to minimise use.

6.4.5 Conclusion

The principal sources of discharges and releases to sea associated with the Annabel and Audrey decommissioning activities concern vessels and the breaking containment/lifting of sections of pipeline and umbilical.

The vessels' work programme comprises a total of approximately 322 individual vessel days spread over a multi-year period. Discharges from vessels during this time are expected to be rapidly diluted and dispersed under prevailing metocean conditions.

The pipelines, and the umbilical cores containing methanol (with the exception of those of PL576) will be flushed with, and left containing filtered seawater prior to decommissioning. Recent attempts to flush PL576 have proved unsuccessful. It is planned to completely remove the entire length of this umbilical by the reverse installation method such that no discharge of chemical to the environment will occur.

The hydraulic fluid has previously been permitted for use and discharge during production operations at this location. The volume will be small and being water soluble, the discharge is expected to undergo rapid dispersion and dilution under the prevailing hydrodynamic conditions.

The contents of the production pipeline sections being decommissioned *in situ* will eventually be lost to the surrounding sediment over time. Should the contents migrate through the sediment to the seabed the prevailing hydrodynamic conditions would be expected to lead to its rapid dilution and dispersion, with any impacts being localised and short term.

In summary, given the localised, and short duration or intermittent nature of the activities, and with the identified control and mitigation measures in place, the overall significance of the impact of discharges and releases to sea as a result of decommissioning the Annabel and Audrey facilities is considered to be **low**.

6.5 Large hydrocarbon releases and oil spill response

This section identifies the potential sources of, and assesses the impact of, large unplanned releases ('spills') to the marine environment in connection with the decommissioning activities.

Following the adoption of appropriate prevention and response measures, the overall risk of impact presented by identified release scenarios is assessed in terms of probability of occurrence, and the consequences given the sensitivity of, and the assimilative capacity of, the receiving environment.

6.5.1 Potential sources

The principal planned decommissioning activities, including their location and estimated duration are described in Section 3. Of these, the use of vessels and the potential for an unplanned (accidental) large volume release of diesel to sea has been identified as the only activity warranting further assessment in terms of the potential impact on the environment.

6.5.1.1 Unplanned releases to the sea

Vessels

Large unplanned large volume releases of diesel to sea from vessels could occur as a result of:

- Loss of structural integrity of storage tanks following a collision with another vessel or fixed facility; and
- Loss of structural integrity of storage tanks following corrosion or mechanical failure.

The worst case in terms of volume and rate of release would be the immediate total loss of diesel inventory to sea as a consequence of collision or mechanical failure. This eventuality is considered to be highly unlikely owing to procedural (vessels' management systems) and operational controls that will be applied.

Oil spill fate and trajectory modelling

Oil Spill Contingency and Response model (OSCAR) modelling was carried out to support the OPEP (Centrica Energy, 2015b). This included modelling an instantaneous release of 3,550m^3 of diesel from the location of the A-Fields (specifically at the Annabel wellhead). This is inherently conservative in terms of impact assessment, since the expected maximum diesel release from the types of vessel required for the Annabel and Audrey decommissioning work is less than 1,400m^3 and accidents involving multiple vessels are considered to be highly improbable.

Stochastic modelling (taking into account prevailing weather conditions to determine a probability of surface oiling) was undertaken using:

- Representative wind data from the European Centre for Medium-Range Weather Forecasts (2008 – 2014); and
- Representative current data from (2008 to 2014).

For the selected worst cases, in excess of 100 simulations were undertaken using a wind-time series which started on a randomly generated date within the seasonal period covered. This approach allows a sufficient number of simulations to adequately model the variability in the wind speed and direction in the area identified within the simulation.

Running multiple release simulations during a single season should provide a reliable prediction of the oil pathways and oiling probabilities for a release starting during that season and extending into subsequent seasons.

6.5.2 Impacts and Receptors

The probability of surface oiling is modelled to be 40-50% in the direct vicinity of the discharge point (Figure 6-3). The area of water with a high probability (>40%) of surface oiling is relatively small (0.49km^2). The majority of diesel released is likely to rapidly evaporate and a significant proportion will biodegrade.

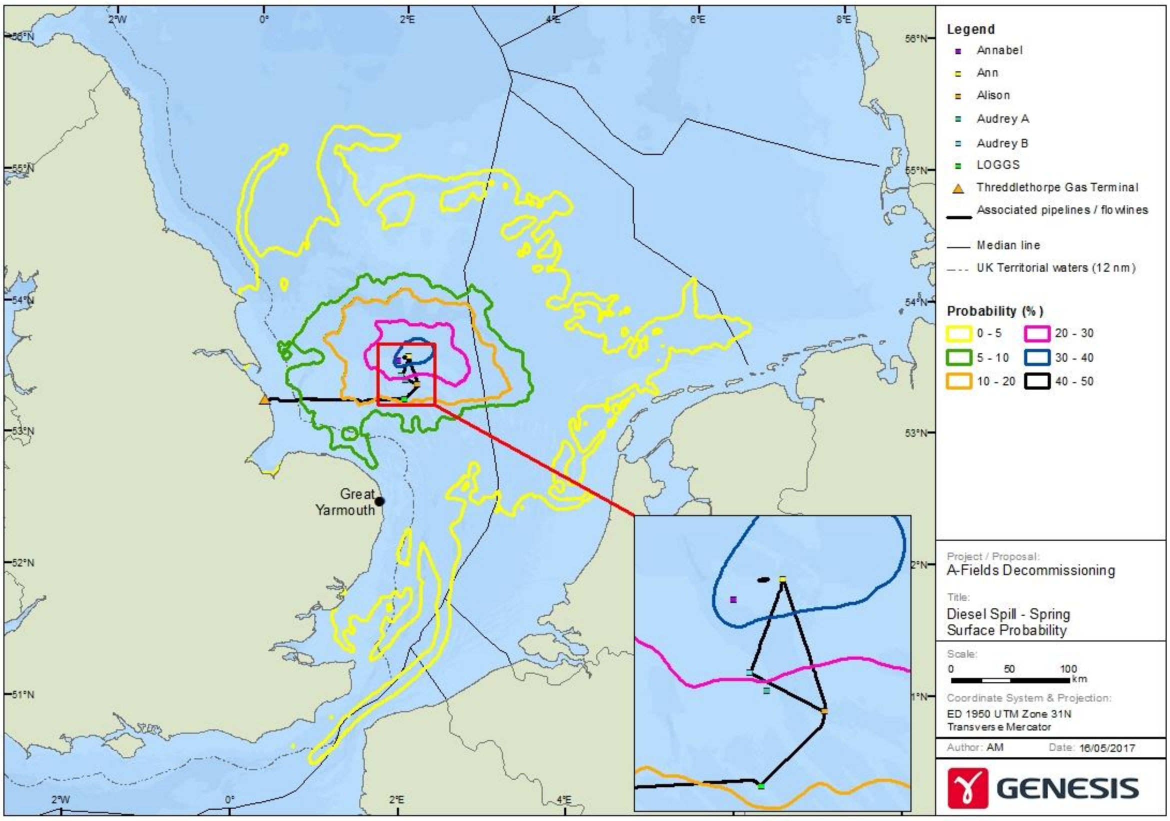

Figure 6-3: Probability of surface oiling due to a large diesel release

The maximum probability for shoreline oiling up to 20 days after release is modelled to be 10-20% in the area of Yorkshire and the Humber between March and May. The maximum mass of accumulated onshore oil from the 100+ simulations modelled was 1,392m^3. The majority of the locations and seasons modelled show either no shoreline oiling or a maximum probability of shoreline oiling of 5%.

Diesel has very high levels of light hydrocarbons and therefore evaporates quickly on release. The low asphaltene content prevents emulsification reducing its persistence in the environment. The Transocean Winner semi-submersible rig ran aground near the Isle of Lewis, Scotland on 8th August 2016 resulting in the discharge of up to 53m^3 of diesel near the coast. Investigation of the environmental impact is ongoing but an interim report by Marine Scotland has been published (Marine Scotland, 2016). Initial sampling in the days following the incident showed no discernible increase in petrogenic contamination in mussels or salmon with respect to typical farmed concentrations from a clean site. Additionally, a survey undertaken by the Royal Society for the Protection of Birds (RSPB) found no evidence of oiled birds.

The loss of the entire diesel inventory is considered highly unlikely (a rare combination of factors would be required for an event to occur) as no such incident has occurred in the UK oil and gas industry.

6.5.2.1 Plankton

The planktonic community is composed of a range of microscopic plants (phytoplankton) and animals (zooplankton) that drift with the oceanic currents. As oil can float on the water's surface and disperse within the ocean as it weathers, plankton are exposed to both floating oil slicks and to small dissolved droplets of oil in the water column (Cormack, 1999; Almeda *et al*., 2013).

Changes in the patterns of distribution and abundance of phytoplankton can have a significant impact on the entire ecosystem (Ozhan *et al*., 2014). Both oil and oil biodegradation can cause problems for phytoplankton in the immediate vicinity of a spill. Oil slicks can inhibit air-sea gas exchange and reduce sunlight penetration into the water, both essential to photosynthesis and phytoplankton growth (González *et al*., 2009). The PAHs in the oil also affect phytoplankton growth, with responses ranging from stimulation at low concentrations of oil (1mg/l i.e. 1,000ppb) to inhibition at higher concentrations (100mg/l i.e. 100,000ppb; Harrison *et al*., 1986).

Zooplankton at the air-sea interface are thought to be particularly sensitive to oil spills due to their proximity to high concentrations of dissolved oil and to the additional toxicity of photo-degraded hydrocarbon products at this boundary (Bellas *et al*., 2013). Following an oil spill zooplankton may suffer from loss of food in addition to the direct exposure of oil toxicity resulting in death from direct oiling as well as impaired feeding, growth, development, and reproduction (Blackburn *et al*., 2014 and references therein).

The limited swimming ability of the free-floating early life stages (meroplankton, i.e. eggs and larvae) of invertebrates such as sea urchins, molluscs and crustaceans renders them unable to escape oil-polluted waters. These early life stages are more sensitive to pollutants than adults and their survival is critical to the long-term health of the adult populations (Blackburn *et al*., 2014 and references therein).

Given the abundance and widespread distribution of plankton populations, and the high rates of evaporation that would be expected under the prevailing metocean conditions, the significance of the impact, given its very unlikely probability of occurrence, from a complete loss of diesel inventory has been assessed as moderate. The significance of the risk of this impact has been assessed as **low**.

6.5.2.2 Benthos

Oil that becomes emulsified or dissolves in the water column can attach to suspended particles and sink to the bottom thus becoming more bioavailable to benthic species (Meador, 2003). As stated, the low asphaltene content of diesel prevents emulsification reducing its persistence in the environment and therefore the proportion entering the water column is anticipated to be low.

In response to oil exposure, benthic animals can either move, tolerate the pollutant (with associated impacts on the overall health and fitness), or die (Gray *et al*., 1988; Lee and Page, 1997). The response to oil by benthic species differs depending on their life history and feeding behaviour as well as the ability to metabolise toxins, especially PAH compounds.

There is little documented evidence on the impact of a diesel spill of the scale which could potentially occur at the Ann and Alison. However, significant negative impacts from larger scale oil spills have been observed on amphipods such as population suppression (Jewett and Dean, 1997; Dauvin, 1982). Amphipods are possibly especially sensitive to the effects of local pollution because of their low dispersal rate, limited mobility and lack of a planktonic larval stage. Marine amphipods e.g. *Bathyporeia* sp, *Nototrophis* sp. *Liljeborgia* sp. and *Urothoe* sp. were identified during the surveys carried out at the in the vicinity of the A-Fields (Section 4.4.2).

A diesel spill in the region could impact on molluscs found in the area for example the bivalves *Spisula elliptica*, *Phaxas pellucidus*, *Mactra stultorum*, *Gari* sp., and *Abra* sp. (see Section 4.4.2). Filter feeders tend to have a limited capacity to metabolize hydrocarbons such that toxic PAH compounds have been shown to accumulate in filter feeders (Blackburn *et al*., 2014 and references therein; Menon and Menon, 1999).

Polychaetes were the most abundant taxonomic group amongst the benthic species sampled in the vicinity of the A-Fields (Section 4.4.2). The responses of polychaete populations to oil spills are complex and varied and are thought to differ depending on their different feeding strategies and trophic relationships in benthic environments. Some species decrease in abundance after an oil spill whilst others may be the first colonisers in the aftermath of oil spill die-offs (Blackburn *et al*., 2014 and references therein). Some polychaetes contribute to biodegradation of oil in sediments whilst some have different abilities to metabolize contaminants (Bauer *et al*., 1988; Driscoll and McElroy, 1997).

The different response of polychaetes to oil pollution is likely a consequence of their different feeding strategies and trophic relationships in benthic environments. *Capitella capitata* has been found to be amongst the first colonisers in the aftermath of a spill. This species thrives in the absence of competition and is a non-selective deposit feeder consuming detritus and algae and benefitting from organic pollution.

Given the low persistence of diesel in the marine environment and the low volumes of diesel entering the water column, the significance of the impact to benthos from a complete loss of diesel inventory has been assessed as moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **low**.

6.5.2.3 Fish

Exposure of fish to contaminants can occur either through uptake of dissolved fractions across the gills or skin or direct digestion of the pollutant. Fish spending the majority of their life-cycle in the water column are likely to receive the highest exposure to contaminants that remain in solution though some will also accumulate sediment bound contaminants indirectly through their diet (i.e. digestion of animals that have accumulated the contaminants in their tissues). Fish associated with the seabed (e.g. flatfish) are more exposed to particle bound contaminants with the main exposure route being either directly through ingestion of contaminated sediments or through their diet. Seabed dwelling organisms can also absorb contaminants through the surface membranes as a result of contact with interstitial water. Once the oil disappears from the water column fish generally lose their oil content very quickly. This rapid loss of oil from fish tissue is linked to the fact that fish will metabolise accumulated hydrocarbons very rapidly (Krahn *et al*. 1993).

Given the anticipated rapid rate of evaporation, the wide distribution of fish in the SNS and the evidence for rapid recovery of fish following hydrocarbon releases, the significance of the impact from a complete loss of diesel inventory has been assessed to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **low**.

6.5.2.4 Marine Mammals

Marine mammals may be exposed to oil either internally (swallowing contaminated water, consuming prey containing oil based chemicals, or inhaling of volatile oil related compounds) or externally (swimming in oil or oil on skin and body).

The effects of oil on marine mammals are dependent upon species but may include:

- Hypothermia due to conductance changes in skin;
- Toxic effects and secondary organ dysfunction due to ingestion of oil, congested lungs;

- Damaged airways;
- Interstitial emphysema due to inhalation of oil droplets and vapour;
- Gastrointestinal ulceration and haemorrhaging due to ingestion of oil during grooming and feeding;
- Eye and skin lesions from continuous exposure to oil;
- Decreased body mass due to restricted diet; and
- Stress due to oil exposure and behavioural changes.

Cetaceans known to inhabit the Annabel and Audrey area are harbour porpoise and white-beaked dolphins (see Section 4.4.4). Harbour porpoise have been observed during May to September in relatively low abundance (0.0002 – 1.12 animals per hour). White-beaked dolphins have been observed in January and December in relatively low abundance (0.0012 – 0.25 animals per hour).

Pinnipeds known to inhabit the Annabel and Audrey area are grey seals and common seals. Figure 4-25 shows that the mean density of seals expected in the vicinity of the A-Fields is low for both harbour seals (0-1 per 25km^2) and grey seals (5-10 per 25km^2).

There is little documented evidence of cetaceans being affected by oil spills. Smultea and Wursig (1995) found that bottlenose dolphins apparently did not detect sheen oil and that although they detected slick oil, they did not avoid traveling through it. Evans (1982) observed that gray whales *Eschrichtius robustus* typically swam through oil seeps off California. Lack of an olfactory system likely contributes to the difficulty cetaceans have in detecting oil. Waves and darkness can reduce their visual ability at the surface and it is possible that individuals could resurface within a fresh slick and find it difficult to locate oil-free water (Matkin *et al*., 2008).

Cetaceans can be susceptible to inhaling oil and oil vapour. This is most likely to occur when they surface to breathe. Inhaling oil and oil vapour may lead to damaging of the airways, lung ailments, mucous membrane damage or even death. A stressed or panicking dolphin tends to move faster, breathe more rapidly and therefore surface more frequently into oil and increase exposure.

Cetaceans have mostly smooth skins with limited areas of pelage (hair covered skin) or rough surfaces. Oil tends to adhere to rough surfaces, hair or calluses of animals, so contact with oil by cetaceans may cause only minor oil adherence.

Figure 6-4 and Figure 6-5 show the surface oiling probability and the abundance of harbour and grey seals respectively. Seals are very vulnerable to oil pollution because they spend much of their time near the surface and regularly haul out on beaches. Seals have been seen swimming in oil slicks during a number of documented spills (Geraci and St Aubins, 1990). Most pinnipeds scratch themselves vigorously with their flippers but do not lick or groom themselves so are less likely to ingest oil from skin surfaces. However, a pinniped mother trying to clean an oiled pup may ingest oil. The risk of oiling increases for pinniped pups. They spend much of their time in rocky shore areas and tidal pools where spilt oil can accumulate. Recent evidence suggests that pinniped pups are very vulnerable during oil spills because the mother/pup bond is affected by the odour and pinnipeds use smells to identify their young. If the mother cannot identify its pup by smell in the large colony, it may not feed it and this leads to abandonment and starvation.

Given the relatively small area of water of 0.49km^2 with a high probability (>40%) of surface oiling and the rapid evaporation expected, the significance of the environmental impact of a diesel inventory loss on marine mammals has been assessed to be moderate. The significance of the risk of this impact has been assessed as **low**.

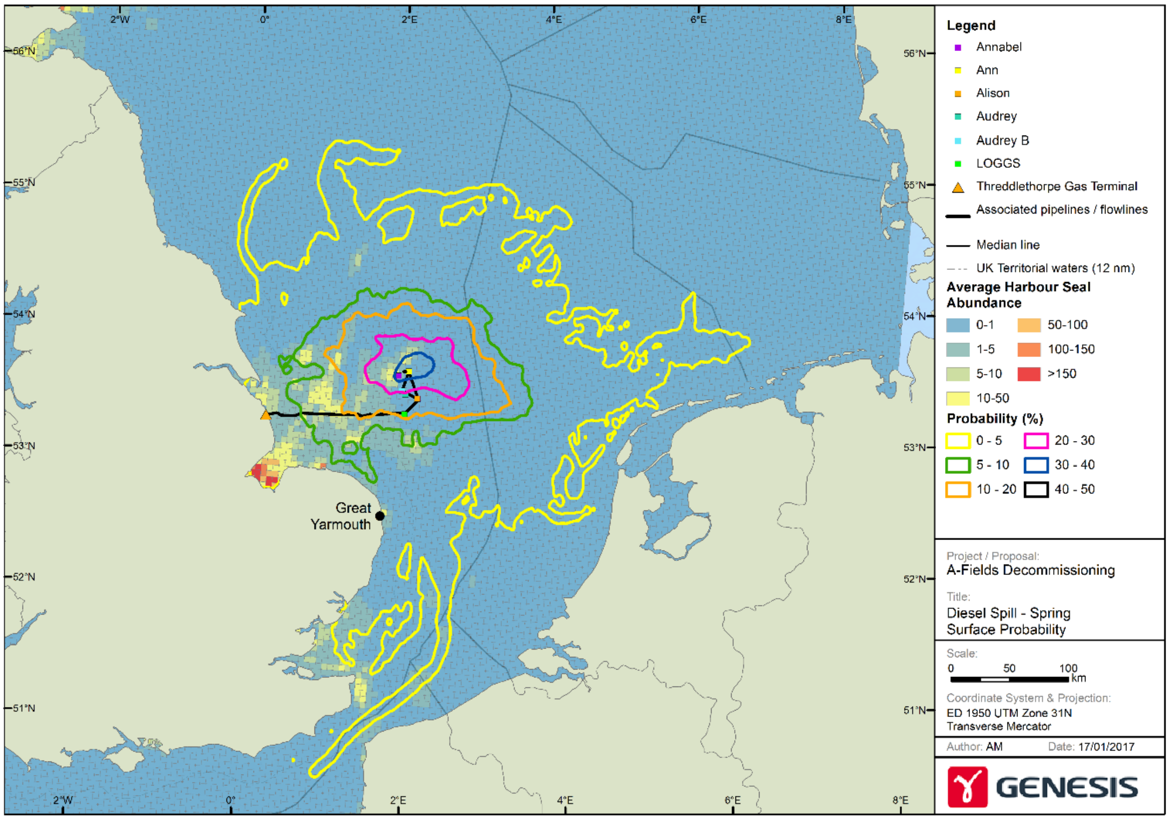

Figure 6-4: Probability of surface oiling and harbour seal abundance

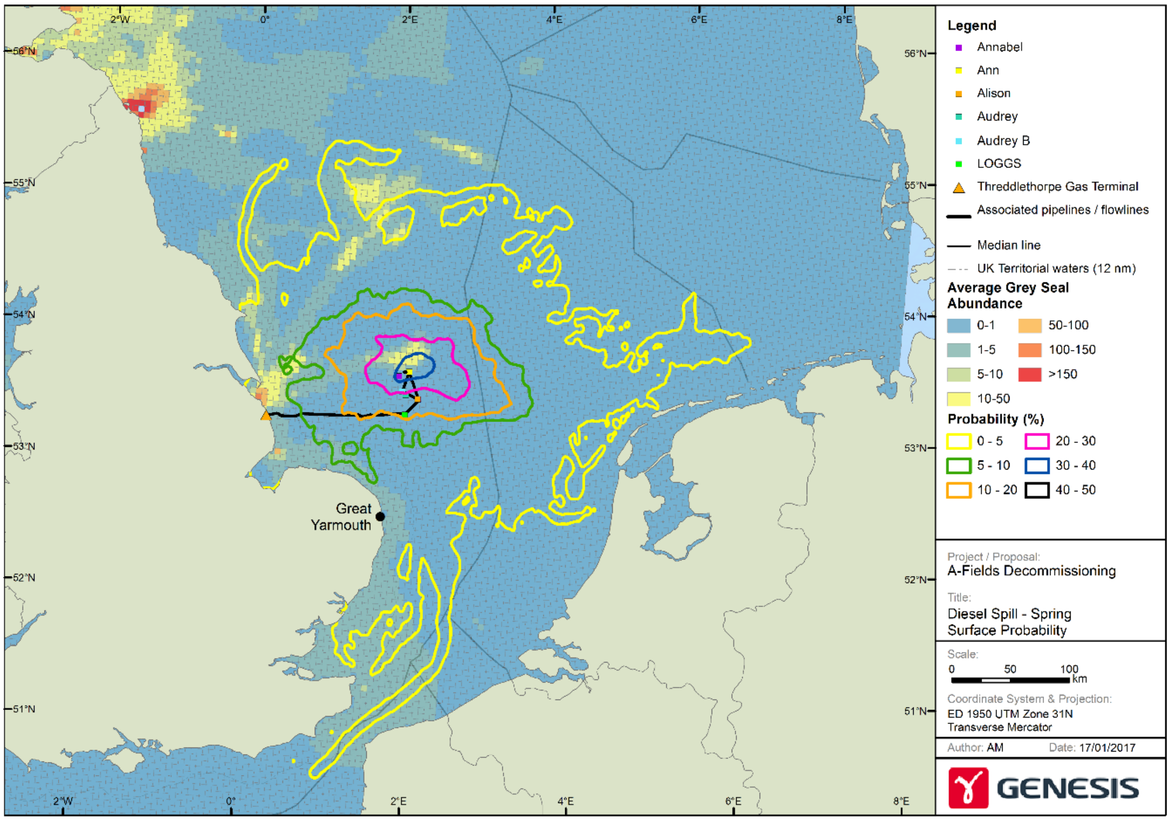

Figure 6-5: Probability of surface oiling and grey seal abundance

6.5.2.5 Seabirds

In general, seabird sensitivity to oil pollution is considered to be extremely high at Annabel from November to January and in July. For the rest of the year it ranges from moderate to low. At Audrey A (WD), Audrey B (XW) and the LOGGS platform complex, seabird sensitivity is extremely high from November to March and in June and July. For the rest of the year seabird sensitivity is generally low (Section 4.4.5).

Birds are vulnerable to oiling from surface oil pollution, which can cause direct toxicity through ingestion and hypothermia as a result of a bird's inability to waterproof their feathers. Oil pollution can also impact birds indirectly through contamination of their prey. Seabird species vary greatly in their responses and vulnerability to surface pollution, therefore in assessing their vulnerability it is important to consider species-specific aspects of their feeding, breeding and population ecology (White *et al*, 2001).

Species that spend a greater proportion of their time on the sea surface are considered to be more at risk from the effects of surface pollution; for example, puffins are more likely to be affected than the highly aerial petrels. Species that are wholly dependent on the marine environment for feeding and resting are considered more vulnerable to the effects of surface pollution than species that use offshore areas only seasonally or move offshore only to rest or roost. Additionally, the potential reproductive rate of a species will influence the time taken for a population to recover following a decline. Other factors such as mortality and migration rates, species abundance and conservation status (e.g. globally threatened) also determine the effects of an oil spill on seabird populations.

The area of water with a high probability (>40%) of surface oiling is relatively small ($0.49km^2$). A full release of diesel inventory ($1,400m^3$) is considered highly unlikely however, if it did occur, rapid evaporation of diesel expected.

Given that the area of a potential spill coincides with areas of extremely high seabird sensitivity, the significance of the environmental impact of a diesel inventory loss on seabirds has been assessed as severe. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **medium**.

6.5.2.6 Coastal Protected Areas

As discussed in Section 4.5 there are a number of protected areas along the UK coast. A number of these could be impacted following an accidental release scenario.

The probability of diesel beaching close to SPAs with marine components is shown in Figure 6-6. The graphic highlights that the probability of diesel beaching around the Humber Estuary, The Wash, Deben Estuary, Foulness, The Swale and the Outer Thames Estuary SPAs is less than 10% with the model predicting that the probability is actually likely to be less than 5 %.

Given the low probability of shoreline beaching, the significance of the impact of a diesel inventory loss on coastal protected areas has been assessed to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **low**.

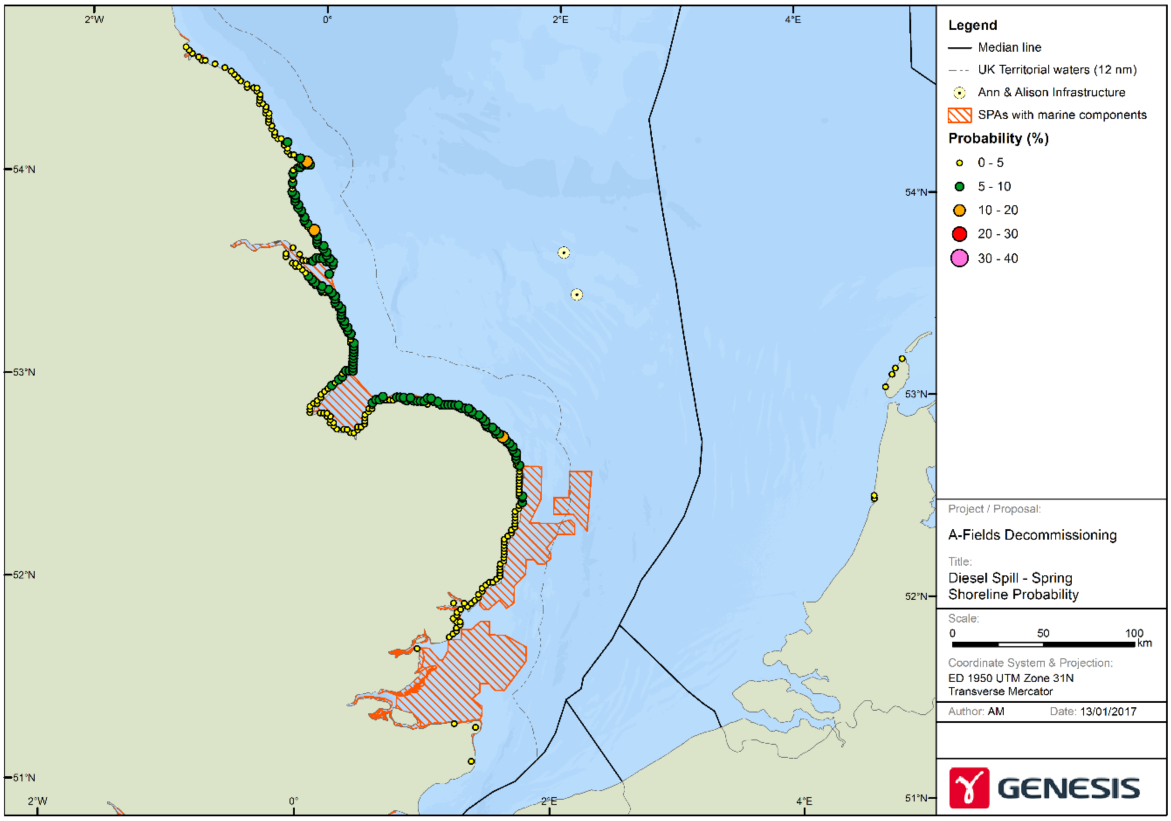

Figure 6-6: Probability of surface oiling and interaction with SPAs with marine components

6.5.2.7 Offshore Protected Areas

A number of offshore protected areas could potentially be affected by accidental hydrocarbon releases in the vicinity of the A-Fields. The nearest offshore SACs are:

- North Norfolk Sandbank and Saturn Reef SAC – 3km from Annabel; Audrey is within the SAC
    - Designated for the protection of sandbanks slightly covered by seawater all the time and reefs.
- SNS cSAC for harbour porpoise – Annabel and Audrey are within the cSAC
    - Designated for the protection of harbour porpoise.
- Markham's Triangle MCZ - 46km from Annabel; 54km from Audrey
    - Designated for the protection of sandbanks slightly covered by seawater all the time

Figure 6-7 shows the probability of surface oiling and the interaction with offshore protected areas. As discussed, diesel has very high levels of light hydrocarbons and therefore evaporates quickly on release and the low asphaltene content prevents emulsification reducing its persistence in the environment although some portion of the diesel will enter the water column. The impact of a diesel inventory loss on the sandbanks and reefs is therefore expected to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **low.**

As previously discussed, cetaceans such as harbour porpoise can be susceptible to inhaling oil and oil vapour, principally when they surface to breathe. Inhaling oil and oil vapour may lead to damaging of the airways, lung ailments, mucous membrane damage or even death. The modelled area of overlap of surface oiling with the SNS cSAC for harbour porpoise with a high probability (>40%) is very small with respect to the total cSAC area of 36,958km^2. The significance of the environmental impact of a diesel inventory loss on offshore protected areas has therefore been assessed to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **low**.

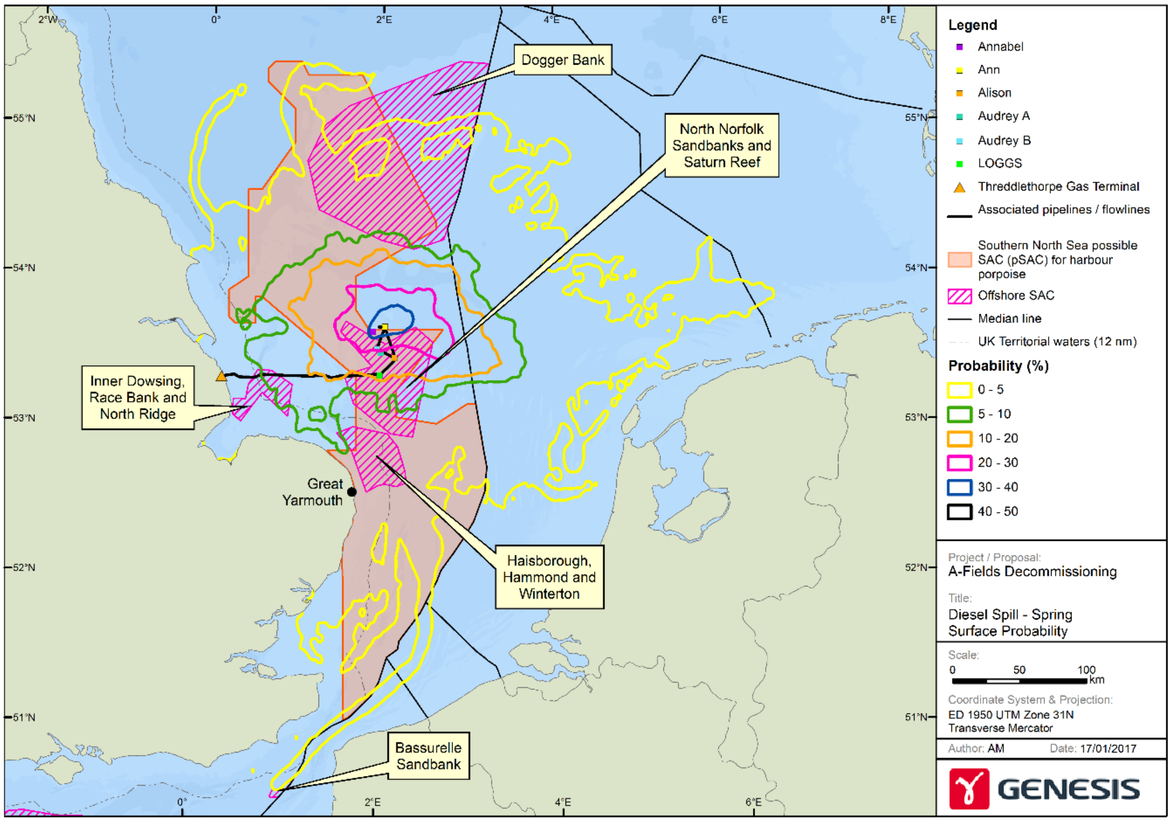

Figure 6-7: Probability of surface oiling and interaction with offshore protected areas

6.5.3 Transboundary and cumulative impacts

The A-Fields are located approximately 55km west of the UK/NL median line. The modelling shows that there is a low probability (0-5%) of surface oiling occurring in Dutch and German waters. Less than 20% of the model runs predict surface oiling beyond the UK/NL median line. The significance of transboundary impacts are therefore assessed to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, has been assessed as **low**.

6.5.4 Control and mitigation measures

Centrica has developed comprehensive procedural (vessels' management systems) and operational controls to minimise the likelihood of large hydrocarbon releases and to mitigate their impacts should they occur. These include the Marine Standard and the A-Fields OPEP (Centrica, 2015). In addition, all vessels undertaking decommissioning activities will have an approved SOPEP developed within the requirements of Regulation 37 of MARPOL Annex 1 (MARPOL, 1973).

These control measures are considered to be effective in reducing and minimising the risk of release during the decommissioning activities to 'as low as reasonably practicable'.

6.5.5 Conclusions

The sole source of a potential unplanned large volume release of diesel to sea is associated with loss of containment from a vessel. The worst case in terms of volume and rate of release would be the immediate total loss of diesel inventory to sea as a consequence of collision or mechanical failure. This eventuality is considered to be highly unlikely owing to the procedural (vessels' management systems) and operational controls that will be applied.

Diesel has very high levels of light hydrocarbons and therefore evaporates quickly on release. The low asphaltene content prevents emulsification reducing its persistence in the environment.

The modelling of diesel surface oiling probability has shown that the area of high probability (>40%) is low with respect to sensitive species and habitats.

In summary, given the low likelihood of such a release and the rapid evaporation rate of diesel, low environmental persistence, and with the identified control and mitigation measures in place, the significance of impact from a large unplanned release of diesel to sea as a result of decommissioning the Annabel and Audrey Fields is considered to be moderate. The significance of the risk of this impact, given its very unlikely probability of occurrence, is considered to be **low**.

6.6 Waste

This section identifies and assesses the impact of the management of waste likely to be generated as a result of the decommissioning activities.

Following the adoption of appropriate control and mitigation measures, residual effects and impacts are assessed with regard to the sensitivity of known receptors in the receiving environment. The volume of waste produced and disposed to landfill will be minimised.

6.6.1 Regulatory requirements

The Revised Waste Framework Directive (Council Directive 2008/98/EC) was adopted in December 2008 with European Union (EU) Member States being required to implement revisions by December 2010. The overriding aim is to ensure that waste management is carried out without endangering human health and without harming the environment. Article 4 also states that the waste hierarchy shall be applied as a priority order in waste prevention and management legislation and policy.

The Waste (England and Wales) (Amendment) Regulations 2012 outlines the requirement for collection, transport, recovery and disposal of waste. It sets out the principles of the waste hierarchy which should be considered when treating and handling waste. In addition, the DECC Guidance Notes (DECC, 2011b) under the Petroleum Act 1998 require all decommissioning decisions to be made in line with the waste hierarchy.

Whether a material or substance is determined as a 'waste' is determined under EU law. The EU Waste Framework Directive defines waste as:

"*any substance or object which the holder discards or intends or is required to discard*".

Materials disposed of onshore must comply with the relevant health and safety, pollution prevention, waste requirements and relevant sections of the Environmental Protection Act 1990. The waste management assessment should be based on the worst case and follow the hierarchy shown in Figure 6-8, in line with relevant legislation, permits and consents.

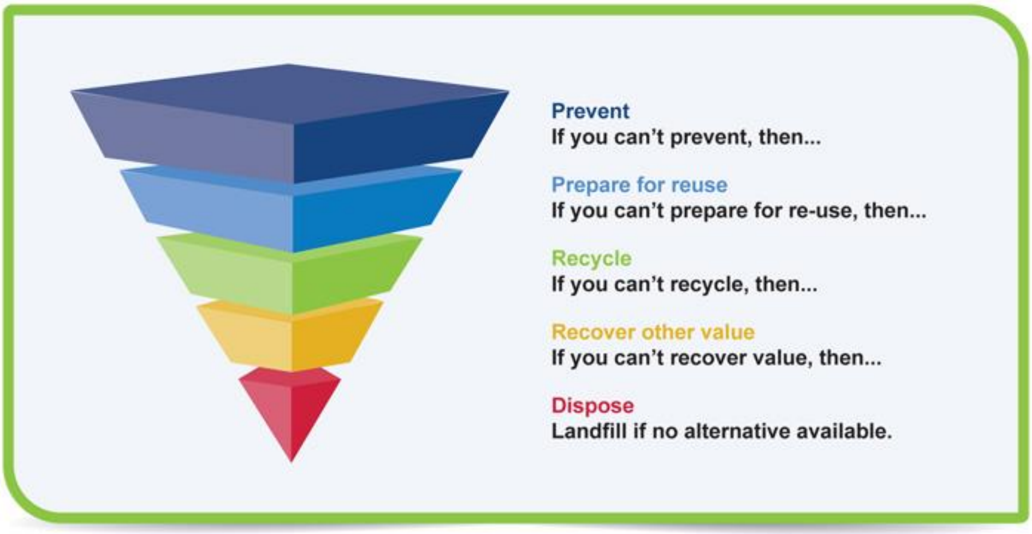

Figure 6-8: Waste hierarchy

Management of radioactive materials is governed under:

- Radioactive Substances Act 1993; and
- Transfrontier Shipment of Radioactive Waste and Spent Fuel Regulations 2008.

The handling and disposal of radioactive waste requires additional authorisation.

Onward transportation of waste or recycled materials must also be in compliance with applicable legislation, such as the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009, a highly prescriptive regulation governing the carriage of dangerous goods by road.

6.6.2 Sources

The decommissioning activities will generate hazardous and non-hazardous waste that will need to be managed to ensure appropriate disposal and minimise waste to landfill.

Non-hazardous materials, which include metals (steel, aluminium), plastics and concrete will be kept separately from any potentially hazardous substances (mainly chemicals).

Infrastructure and materials will be recovered to shore and transferred to a waste management facility, which will have all necessary approvals and licences in place and possess the capability to reuse or recycle the majority of recovered material.

The minimisation of waste arising from the decommissioning will be of particular significance at the planning stage, where opportunities for reuse will be considered initially prior to any other recycling or disposal route selection.

The inventory of Annabel and Audrey materials and the reuse, recycling and disposal aspirations of material recovered to shore are presented in Table 6-7 and Table 6-8 and include mattresses and grout bags.

INVENTORY (EXCLUDES ROCK)	TOTAL INVENTORY (Te)	PLANNED TO SHORE (Te)	PLANNED TO BE DECOMMISSIONED *IN SITU* (Te)
Installations	5,759	5,093	667
Pipelines	14,876	2,021	12,855
Total	**20,635**	**7,114**	**13,522**

Table 6-7: Inventory disposition

INVENTORY	RECYCLE	DISPOSAL
Installations	4,837.9	264.6
Pipelines	1,920.0	101.1

Table 6-8: Anticipated recycling and disposal for material recovered to shore

The planned tonnage recovered and returned to shore includes topsides, jackets, pipeline spool pieces, sections of pipeline, sections of umbilical, mattresses, grout bags, WHPSs, sections of piles, templates and manifolds.

6.6.2.1 Marine growth

The Audrey jackets will have accumulated a coating of marine growth or marine fouling after being on location for almost 30 years. An estimate of the quantity of marine growth is required to inform the EIA, in addition to the engineering contractors (for the potential weight to be lifted/transported) and the decommissioning yards (for the quantity of growth to be processed and disposed).

Between 2011 and 2013, OGUK commissioned a series of reports to identify management techniques currently applicable to marine growth in the UK and Norway which included a review of marine growth estimates versus quantities processed by decommissioning yards. The 'worst case' estimate (by wet weight) of marine growth quoted is 10% of the jacket weight for the Miller platform which is located in the Central North Sea in water depths of 103m (BP, 2010).

According to Tvedten (referenced in BMT Cordah, 2011) the water content of marine growth is typically 70-90% of its total weight. The marine growth will start to dry out as soon as it is lifted out of the sea and therefore the weight of material to be disposed of onshore will depend largely on how much drying out takes place during transportation. Factors will therefore include:

- Wet tow versus transportation on a cargo barge on a crane hook in air; and
- Prevailing weather conditions at the time e.g. temperature, wind, humidity.

A report by BMT Cordah (2011) quotes seven examples of SNS jackets which each had *c.*7Te of marine growth processed at the decommissioning yard. In these examples the decommissioning yards had been expecting *c.*40-50Te of marine growth per jacket. The estimate of marine growth is therefore between:

- Worst case – 10% of jacket weight (Audrey A (WD), *c.*106Te and Audrey B (XW) *c.*87Te); and
- Best case – 7Te.

6.6.2.2 Naturally Occurring Radioactive Material

Centrica holds a permit issued by the Environment Agency allowing it to accumulate and dispose of radioactive waste containing NORM in the form of solid waste arising from the production of oil and gas at its Annabel and Audrey Fields. The permit limits the amount of solid radioactive waste that can be held on site at any one time, and requires solid wastes to be disposed of within certain time limits by transfer to operators who are themselves permitted to receive and dispose of these wastes.

Suitably maintained and calibrated contamination monitors are required to be used offshore to identify the presence of NORM on recovered materials which are known to have been exposed to well fluids during production and are therefore known to be susceptible to NORM contamination. Samples of material demonstrating activity will be sent to an onshore laboratory for radiochemical analysis to determine whether the material is 'radioactive' or 'exempt'. No materials will be cleaned offshore. Confirmed NORM contaminated material will be handled, transported to shore and processed in strict accordance with the approved procedures of Centrica's subsea decommissioning contractors.

6.6.3 Impacts and Receptors

The potential impacts from waste management are principally associated with the onshore environment and landfills. The impacts typically include:

- Use of sometimes scarce landfill space (resource use);
- Degradation of local/regional air quality as a result of emissions from onshore transport;
- Potential degradation of the water environment if any leachate is produced by the landfill site and reaches surface water and/or groundwater; and
- Nuisance to the local community from traffic, odour and visual impacts.

Where possible, materials brought to shore which cannot be reused will be recycled. The impacts associated with recycling will occur at existing processing plants:

- Degradation of local/regional air quality as a result of emissions from transport;
- Degradation of local/regional air quality as a result of plant emissions;
- Degradation of the water environment (surface water and groundwater) associated with any discharges from processing plant; and
- Nuisance to the local community from traffic and visual impacts.

Marine growth will be dealt with by the selected shore base in line with accepted practices. This normally involves landfilling or composting. The major sources of odour following removal of structures can be associated with degradation of marine growth.

Only existing permitted facilities (under the Environmental Permitting regime (England) or the Pollution Prevention and Control regime (Scotland)) will be used and for those permits to have been approved, the impacts to air, land, water and to the local community, will have already been assessed as acceptable. Therefore, the use of existing permitted facilities for recycling or disposal has been assessed as resulting in **low** environmental significance.

6.6.4 Transboundary and cumulative impacts

It is unknown at the time of writing whether the shore base for receiving recovered materials and infrastructure will be located in the UK or abroad. Only permitted facilities would be used for recycling or disposal in the UK or elsewhere and therefore the potential significance of the transboundary impact from onshore waste handling has been assessed as **low**.

The SNS is a well-developed area of oil and gas infrastructure with many mature assets and as such the cumulative impacts of decommissioning should be considered. The timing of the A-Fields decommissioning activities may overlap with the other decommissioning projects in the vicinity though the exact dates are yet to be defined. Discussions will be held with waste management contractors to ensure that there is capacity and suitable recycling and disposal routes for waste once the precise dates are known. In addition, Centrica are working with other operators in the area to identify opportunities to collaborate where possible. The potential significance of the cumulative impact from onshore waste handling has been assessed as **low**.

6.6.5 Control and mitigation measures

Centrica will have a Waste Management Plan (WMP) in place which will be used to describe and quantify waste arising from decommissioning activities and identify available processing, treatment, recycling and disposal options for those wastes. Segregating materials at source and maintaining the separation between hazardous and non-hazardous streams during and after recovery to shore will reduce the amount of material requiring onshore treatment.

If hazardous waste is produced it will be pre-treated to reduce hazardous properties or, in some cases, render it non-hazardous prior to recycling or landfilling. Under the Landfill Directive, pre-treatment will be necessary for most hazardous wastes which are destined to be disposed of to landfill sites. Other non-hazardous wastes that cannot be reused or recycled will be disposed of to landfill.

Any NORM contaminated equipment must be handled, transported, stored, maintained or disposed of in a controlled manner. Protocols are required to ensure that equipment is not released or handled without controls to protect the worker and prevent contamination of the environment.

6.6.6 Conclusion

All wastes returned to shore will be handled and disposed of in accordance with legislation and the waste hierarchy. All regulatory and company procedures for segregation, transport, recycling or disposal, as set out in the project Waste Management Plan (WMP), will be strictly adhered to and only fully permitted facilities will be used for transfer, treatment, recycling or disposal.

In summary, with the identified control and mitigation measures in place ensuring that the majority of the materials recovered to shore will be recycled, the overall significance of the impact of waste as a result of decommissioning the Annabel and Audrey facilities is considered to be **low**.

6.7 Socio-economic impacts

This section examines the various offshore and onshore sources (or types) of socio-economic impact (beneficial as well as detrimental) that will (or may) result from the decommissioning activities.

Following the adoption of appropriate control and mitigation measures, detrimental residual effects and impacts are assessed in terms of the sensitivity of known receptors.

6.7.1 Sources

The principal planned decommissioning activities, including their location and estimated duration, are described in Section 3. Of these, the use of vessels, the onshore processing and management of recovered materials, and the use of miscellaneous services have been identified as the activities warranting further assessment in terms of their potential socio-economic impact.

In addition, the *in situ* decommissioning of subsea infrastructure will inherently and permanently present a small, residual risk of interaction to third party users of the seabed.

6.7.1.1 Physical presence of vessels, onshore processing and management of recovered materials, and use of miscellaneous services

Denial of access and interference with navigation

The physical presence of vessels engaged in decommissioning activities may temporarily deny commercial fishing vessels access to fishing grounds, or oblige shipping vessels to alter their course.

Contribution to the economy

Vessels will require the use of a range of port facilities and will likely also need to purchase a variety of local goods and services. The light processing (cleaning, crushing, cutting e*tc.*) of recovered infrastructure and materials will be undertaken at a local shore base which will support local employment in the short term.

6.7.1.2 Physical presence of infrastructure

Decommissioned *in situ*

The physical presence of the majority of the pipelines and umbilical following their decommissioning presents a permanent snagging risk to fishing vessels deploying bottom-trawled gear should sufficiency of trench or burial cover fail to be maintained for any reason.

Removal of HSE 500m zones

The removal of the HSE 500m safety zones presents a potential for a beneficial impact due to opening up the area to the fishing industry.

6.7.2 Impacts and receptors

6.7.2.1 Physical presence of vessels, onshore processing and management of recovered materials, and use of miscellaneous services

While decommissioning activities are being carried out other users of the sea will not have access to the area where the works are being undertaken.

The impact (loss of opportunity) associated with any denial of access to, or denial of navigation through an area of sea is a function of the requirement of third parties to access or transit that area and the time over which their free access or navigation will be denied.

Third party vessels are already prevented from entering the HSE 500m safety zones that have been established around the Annabel template, Annabel AB1 WHPS, Annabel AB2 WHPS, Audrey A (WD) platform, Audrey B (XW) platform and the Audrey 11a-7 WHPS.

Given the localised and infrequent nature of the activities and small area that other users of the sea will be excluded from the significance of the impact has been assessed as **low**.

Specialist vessel management services (including shore base and waste management services) will be required to support the decommissioning activities and if sourced from ports and harbours local to the A-Fields will support offshore and onshore employment.

Given the relatively small scale and short duration of decommissioning activities, the significance of this beneficial impact has been assessed as **low**.

6.7.2.2 Physical presence of infrastructure

The impact associated with sections of the pipelines and umbilicals that have been decommissioned *in situ* will be a function of the snagging risk associated with insufficiently trenched and buried pipeline, and the requirement of third parties (predominantly commercial fishing vessels) to deploy equipment that may interact with this hazard. Centrica are not aware of any historical interaction with the buried sections of pipelines or umbilicals.

An over-trawl assessment and a burial status survey will be undertaken when all infrastructure and materials have either been removed or decommissioned *in situ* (Section 3.8.1). Any requirement for additional ‘legacy’ burial status surveys will be established in agreement with BEIS.

The removal of the Annabel template, Annabel AB1 and AB2 WHPSs, the Audrey A (WD) and Audrey B (XW) jackets, Audrey 11a-7 WHPS, spool pieces and their protection will permanently remove the risk of snagging presented to third parties by this infrastructure and provide them full access to this area of seabed.

Given that some subsea infrastructure will be removed, and Centrica’s commitment to the ongoing trench/burial status monitoring of that which will be decommissioned *in situ*, the significance of the impact of physical presence of infrastructure decommissioned *in situ* has been assessed as **low**.

6.7.3 Transboundary and cumulative impacts

The A-Fields are located approximately 55km west of the UK/NL median line. Given this distance, and the short duration, relatively small scale and localised nature of the decommissioning activities, no substantive transboundary socio-economic impacts are anticipated.

The following socio-economic activities, if they occur at the same time, and in the same area as the decommissioning activities, could result in an 'in-combination' effect:

- Oil and gas production (including inspection, maintenance, supply);
- Oil and gas development (surveys, drilling, installation of infrastructure);
- Oil and gas decommissioning (installation or pipelines removal and recovery); and
- Wind farm development and operation.

The third party oil and gas infrastructure in the vicinity of the Annabel and Audrey Fields is mature. There is no known planned installation of oil and gas infrastructure that would lead to construction activity taking place at the same time as the decommissioning of the A-Fields.

The closest operational wind farm to Annabel and Audrey infrastructure is Sheringham Shoal at a distance of over 69km and the nearest wind farm under construction is Dudgeon at a distance of over 48km. The Heron West, Njord and Heron East consented blocks are being developed by Dong Energy as the Hornsea Project One at a distance of approximately 16km north of Annabel at the closest point

The impacts associated with Annabel and Audrey decommissioning activities have been assessed to be localised and therefore no substantive in-combination effects are anticipated with respect to neighbouring oil and gas surface installations (the closest of which is the Saturn ND platform at approximately 5km from Annabel).

Should other pipelines (or sections of pipelines) in the area be decommissioned *in situ* there could be a cumulative socio-economic impact. The total area potentially affected is considered relatively small. The potential significance of the cumulative impact has therefore been assessed as **low**.

6.7.4 Control and mitigation measures

The following measures will be adopted to ensure that detrimental socio-economic impacts are minimised to 'as low as reasonably practicable':

- The timing and location of decommissioning activities, and the location of infrastructure decommissioned *in situ*, will be advertised via the Kingfisher bulletin and via Notices to Mariners;
- Necessary seabed debris surveys, seabed over-trawl assessment, depth of burial surveys and environmental surveys will be conducted; and
- The vessels' work programme will be optimised to minimise use.

6.7.5 Conclusion

The principal source of socio-economic impact associated with the Annabel and Audrey facilities' decommissioning activities concerns the use of vessels.

The physical presence of vessels engaged in decommissioning activities will deny commercial fishing access in the vicinity of the Annabel and Audrey Fields. The approximately 322 individual vessel days is however of relatively short duration and spread over a multi-year period. Furthermore, the area to which access is denied on any one of these days is limited and in the most part within existing HSE 500m safety zones.

The *in situ* decommissioning of subsea infrastructure will present a very small but permanent potential for interaction with commercial fishing activities. This residual risk however will be mitigated by a commitment to ongoing trench/burial status monitoring.

Beneficial impacts will arise through short-term job creation for specialist vessel management services and onshore processing of recovered materials. In addition, the removal of the HSE 500m safety zones will re-open these areas to commercial exploitation by the fishing industry.

In summary, due to the localised and short duration of decommissioning activities, and with the identified control and mitigation measures in place, the overall significance of the socio-economic impact from the decommissioning of the Annabel and Audrey facilities is considered to be **low**.

7. CONCLUSIONS

The Annabel and Audrey facilities are to be decommissioned by Centrica during 2018 to 2024. A CA has been carried out in order to identify the recommended decommissioning option. The selected option was to decommission PL2066, PL2067, PL496, PL497, PL723 and PL724 *in situ* and the complete removal of PL575, PL576, PL2066JW12, PL2066JWAB2, PL2067JW12 and PL2067JWAB2. Included in the decommissioning activities is the complete removal of the Annabel template and the AB1 and AB2 WHPS's, the complete removal of the Audrey A (WD) and Audrey B (XW) platforms and drilling templates and the top section of the platform piles, the complete removal of the Audrey 11a-7 WHPS and the top section of the WHPS piles, the ends of the pipelines and umbilicals which are insufficiently buried, and the complete removal of the concrete mattresses and grout bags. Deposited rock and frond mattresses will be decommissioned *in situ*.

The EIA process presented in this document considers the impact of the planned activities associated with the decommissioning of the Annabel and Audrey facilities. The impact was determined by considering the duration/frequency of each of the planned activities and environment to determine the overall significance of impact as either low, medium or high. The significance of the impact of all planned activities were considered to be **low**.

The impacts of all activities were assessed at a workshop, with the following areas being considered in more detail: energy use and atmospheric emissions, underwater sound, seabed disturbance, discharges and releases to sea, large hydrocarbon releases and oil spill response, waste and socio-economic impacts,

Accidental events were also considered in terms of the likelihood of such an event occurring and the significance on people, the environment, the asset, Centrica's reputation and the stakeholder. This provides a risk of low, medium or high. Accidental events identified to potentially have a medium environmental risk were all associated with vessel collisions prior to mitigation measures being identified. Measures to mitigate this risk include only contracting vessels which meet Centrica's Marine Standard.

Centrica will follow routine environmental management activities for example contractor vessel audits and legal requirements to report discharges and emissions, such that the environmental impact of the decommissioning activities will be minimised. Following the EIA process, it can be concluded that activities associated with the decommissioning of the Annabel and Audrey facilities are unlikely to significantly impact the environment or other sea users, for example shipping traffic and fishing, provided that the proposed mitigation and control measures are put in place. The key points from the EIA are summarised below.

7.1 Energy use and atmospheric emissions

The principal energy use and generation of emissions to air will arise from fuel combustion for propulsion and power generation by the vessels required for the decommissioning activities. These emissions will include components which have the potential to contribute to global warming, acid rainfall, dry deposition of particulates and photochemical pollution or cause impacts on local air quality. It is expected that impacts will be of low significance as they will be short term.

The energy usage from the decommissioning of the Annabel and Audrey Facilities is estimated to be 221,017GJ direct (vessel use) and 281,521GJ indirect requirements (manufacture of new materials to replace those decommissioned *in situ*).

Emissions to atmosphere from the decommissioning activities are unlikely to significantly contribute to greenhouse gas emissions or global warming impacts; total direct CO_2 emissions generated by the proposed decommissioning are 16,410Te. In relation to the total CO_2 produced from domestic shipping the direct CO_2 emissions from the decommissioning of the Annabel and Audrey facilities is *c.*0.17%.

Standard mitigation measures to optimise energy usage by vessels will include operational practices and power management systems for engines, generators and any other combustion plant and planned preventative maintenance systems for all equipment for peak operational efficiency.

In summary, due to the localised and relatively short durations of activities and with the identified control and mitigation measures in place, the overall significance of the impact of energy use and associated atmospheric emissions arising from decommissioning the Annabel and Audrey facilities is considered to be **low**.

7.2 Underwater sound

The principal sources of underwater sound associated with the Annabel and Audrey decommissioning are associated with the use of vessels, surveying equipment and cutting tools.

The vessels' programme (comprising a total of approximately 322 individual vessel days spread over a multi-year period) is of relatively short duration and represents only small increment to existing vessel traffic in the area. Cutting tools will only require to be used intermittently over this period and at point locations.

Although there are marine mammals and fish in the area around the Annabel and Audrey facilities, the level of sound that will be generated is not expected to cause physiological harm or substantive behavioural interference to either fish or mammals known to inhabit the area. The greatest potential disturbance is as a result of vessels. However, given that the Annabel and Audrey facilities are in an area of established oil and gas activity with high shipping activity, marine mammals are likely to be accustomed to similar sound levels and this reduces the level of impact.

Standard measures that will be applied to control sound include planned maintenance of equipment and optimisation of the work programme to minimise vessel use.

In summary, due to the localised, and short duration or intermittent nature of the activities, and with the identified control and mitigation measures in place, the overall significance of the impact of underwater sound generated during decommissioning of the Annabel and Audrey facilities is considered to be **low**.

7.3 Seabed disturbance

The principal sources of seabed disturbance associated with the Annabel and Audrey decommissioning concern the over-trawl assessment at the end of decommissioning, positioning of HLV anchors and chains and removal of pipeline ends, spools, mattresses and grout bags and cutting operations around the Audrey platforms, the Audrey 11-a7 WHPS, the Annabel template and the Annabel WHPSs. The base case for the over-trawl assessment is that it will be conducted in the 500m safety zones and over a 200m corridor along the pipeline lengths. These activities will result in the displacement of substrate and the suspension and subsequent settlement of sediment.

Standard measures to control disturbance include operational planning and equipment selection.

The species and habitats observed in the vicinity of Annabel and Audrey are relatively widespread throughout the SNS and the area anticipated to be impacted represents a very small percentage of the available habitat. Furthermore, the environment in the vicinity of the Annabel and Audrey Fields is dynamic due to the shallow water depth therefore all disturbed sediments/habitats are expected to recover rapidly and species recruitment would be expected from adjacent undisturbed areas.

In summary, due to the localised and relatively short duration of the decommissioning activities, and with the identified control and mitigation measures in place, the overall significance of the impact of seabed disturbance as a result of the decommissioning of the Annabel and Audrey facilities is considered to be **low**.

7.4 Discharges to sea

The principal sources of discharges to sea associated with the Annabel and Audrey decommissioning are associated with vessels and the breaking of containment/lifting of sections of the pipelines.

The vessel use is of relatively short duration. Operational discharges from vessels during this time are expected to be rapidly diluted and dispersed under prevailing hydrodynamic conditions.

The pipelines (including spool pieces), and the umbilical cores containing methanol (with the exception of those of PL576) will be flushed with, and left containing filtered seawater prior to decommissioning. Recent attempts to flush PL576 have proved unsuccessful. It is planned however to completely remove the entire length of this umbilical by the reverse installation method such that no discharge of chemical to the environment will occur.

The seabed and the water column are the primary receptors. Control measures include permitting of chemical discharges and strict vessel operating procedures.

In summary, given the localised, and short duration or intermittent nature of the activities, and with the identified control and mitigation measures in place, the overall significance of the impact of discharges and releases to sea as a result of decommissioning the Annabel and Audrey facilities is considered to be **low**.

7.5 Large hydrocarbon releases and oil spill response

Whilst there is the potential for a major diesel release during the Annabel and Audrey decommissioning activities, it is considered unlikely and that a rare combination of factors would be required for an event to occur. Taking into account the types of sediment and receptors in the area and the mitigations and controls that will be put in place, the overall significance of the impact has been assessed as moderate.

The worst case scenario of an accidental hydrocarbon release would result from a complete loss of fuel inventory from on-site vessels or collision. In the unlikely event of such an incident the vessels will have a SOPEP in place in order to reduce the impact. Centrica will minimise the likelihood of such an event occurring by awarding the contract only to vessels that meet Centrica’s Marine Standard. Given that the diesel would disperse and dilute quickly and is unlikely to impact on any coastline, the significance of the risk of this impact, given its very unlikely probability of occurrence, is considered to be **low**.

7.6 Waste

All wastes returned to shore will be handled and disposed of in accordance with legislation and the waste hierarchy. All regulatory and company procedures for segregation, transport, recycling or disposal, as set out in the project Waste Management Plan(s) (WMPs), will be strictly adhered to and only fully permitted facilities will be used for transfer, treatment, recycling or disposal.

In summary, with the identified control and mitigation measures in place ensuring that the majority of the materials recovered to shore will be recycled, the overall significance of the impact of waste as a result of decommissioning the Annabel and Audrey facilities is considered to be **low**.

7.7 Socio-economic impacts

The primary socio-economic activities that could be impacted are commercial activities, such as oil and gas operations, shipping and fishing.

Access to the area for fishing will be restricted whilst decommissioning is undertaken and this will lead to short term impacts on the fishing industry; however, the impact is considered to be low due to the short duration of operations, the relatively small scale of the activities and the existing HSE 500m safety zones.

A beneficial socio-economic impact is the short-term continuation of jobs in onshore yards and on vessels. It is expected that the overall impact will be low since the local socio-economic system is already altered owing to the presence of the oil industry itself.

The Annabel and Audrey facilities are located within an area licensed for wind farm developments. However, it is unlikely that there will be an impact on any windfarm developments as initial commissioning is expected to be in a different area to the north of the Annabel and Audrey facilities. Post decommissioning, the presence of the buried pipeline may present a small restriction to the potential area for locating wind turbines but in the context of the size of the area licensed for a windfarm, the impact is expected to be minor.

A decommissioning over-trawl assessment will verify that there are no remaining obstructions likely to snag fishing trawls.

In summary, due to the localised and short duration of decommissioning activities, and with the identified control and mitigation measures in place, the overall significance of the socio-economic impact from the decommissioning of the Annabel and Audrey facilities is considered to be **low**.

7.8 Designated conservation sites impacts

The Audrey platforms and the majority of the Annabel and Audrey pipelines lie within the North Norfolk Sandbanks and Saturn Reef SAC and the SNS cSAC for harbour porpoise. The impacts associated with activities that could impact the sites (e.g. cutting, jetting, anchoring) are localised. Sound associated with vessels and the activities could impact the area, however given the existing level of shipping in the area the significance of the impact is considered to be **low**.

The principal sources of seabed disturbance associated with the Annabel and Audrey decommissioning concern the removal of spools, mattresses and grout bags and cutting operations around the Audrey platforms, the Audrey 11-a7 WHPS, the Annabel template and the Annabel WHPSs the use of anchors and anchor chains on the Heavy Lift Vessel in addition to the over-trawl assessment at the end of decommissioning. These activities will result in the displacement of substrate and the suspension and subsequent settlement of sediment. All disturbed sediments are expected to recover rapidly though recruitment from adjacent undisturbed areas therefore the significance of the impact of seabed disturbance is considered to be **low**.

A large hydrocarbon release could impact the SAC and cSAC however modelling has shown the risk is relatively low and with control and mitigation measures in place the significance is considered to be **low**.

Given that the impacts on North Norfolk Sandbanks and Saturn Reef SAC and SNS cSAC for harbour porpoise is considered to be **low**, the impact on the Markham's Triangle recommended MCZ which is approximately 55km north-east of the Annabel infrastructure is also considered to be **low**.

7.9 Summary of control and mitigation measures

Centrica will follow routine environmental management activities for example contractor vessel audits and legal requirements to report discharges and emissions, such that the environmental impact of the decommissioning activities will be minimised. Following the EIA process, it can be concluded that activities associated with the decommissioning of the Annabel and Audrey facilities are unlikely to significantly impact the environment or other sea users, for example shipping traffic and fishing, provided that the proposed mitigation and control measures are put in place.

A summary of proposed control and mitigation measures is shown in Table 7-1.

MITIGATION AND CONTROL MEASURES
General
Lessons learnt from previous decommissioning scopes will be reviewed and implemented.
Energy use and atmospheric emissions
Prior to mobilisation, vessels will be audited to ensure that their management system appropriately plans maintenance of both generator and engine efficiency in line with manufacturers specifications.
Fuel use for mobilised vessels will be monitored and comply MARPOL requirements, in particular with regard to low sulphur content.
Decommissioning activities will be planned to minimise vessel use (e.g. the vessels' work programme will be optimised to minimise vessel use).
Fuel consumption will be minimised by operational practices and power management systems for engines, generators and any other combustion plant (as required under the contract with the subcontractor).
Planned and preventative maintenance systems will be required for all vessels to ensure that all equipment is maintained at peak operating efficiency for minimum overall fuel usage (as required under the contract with the subcontractor).
Underwater sound
Machinery, tools and equipment will be in good working order and well-maintained (as will be required under the contract with the subcontractor).
The vessels' work programme will be optimised to minimise vessel use.
The number of required cuts will be minimised consistent with operational (including safety) considerations.
Seabed disturbance
All activities which may lead to seabed disturbance will be planned, managed and implemented in such a way that disturbance is minimised.
The careful planning, selection of equipment, and management and implementation of activities.
A debris survey will be undertaken at the completion of the decommissioning activities. Any debris identified as resulting from decommissioning activities will be recovered from the seabed where possible.
Optimise the area that requires an over-trawl assessment through discussion with the NFFO and the regulators.
Discharges and releases to sea
Pigging and/or flushing procedures will be followed to minimise residual contaminants within pipelines and umbilicals.
Procedures and systems for the minimisation of waste and effluent generation (maintained as required under the contract with the subcontractor).
Procedures and systems for the management of ballast and bilge water (maintained as required under the contract with the subcontractor).
Accident prevention measures will be in place in order to minimise the potential for accidental spillages of hydrocarbons or other polluting materials.
Vessels will be selected and audited to ensure that effective operational systems and onboard control measures are in place.
The vessels' work programme will be optimised to minimise vessel use.
Large hydrocarbon releases and oil spill response
Comprehensive management and operational controls plan developed to minimise the likelihood of large hydrocarbon releases and to mitigate their impacts should they occur. These include the Marine

Standard and the A-Fields OPEP.
All vessels undertaking decommissioning activities will have an approved SOPEP.
Waste
A WMP will be in place.
If hazardous waste is produced it will be pre-treated to reduce hazardous properties or, in some cases, render it non-hazardous prior to recycling or landfilling.
Any NORM contaminated equipment will be handled, transported, stored, maintained or disposed of in a controlled manner.
Socio-economic impacts
The timing and location of decommissioning activities, and the location of infrastructure decommissioned *in situ*, will be advertised via the Kingfisher bulletin and via Notices to Mariners.
Necessary seabed debris surveys, seabed over-trawl assessment, depth of burial surveys and environmental surveys will be conducted.
The vessels' work programme will be optimised to minimise vessel use.

Table 7-1: Summary of proposed control and mitigation measures

7.10 Transboundary and cumulative impacts

Given the location of the location of the Annabel and Audrey facilities, there will be minimal impact on the Dutch sector. All impacts including transboundary following the application of suitable mitigation measures, have been assessed as of **low** significance.

The cumulative impact of the Annabel and Audrey decommissioning activities has been assessed as **low** based on the relatively short duration of the activities, the associated low significance of the impacts combined with Annabel and Audrey being located in an area developed for oil and gas activities with existing shipping activity in the area.

7.11 Overall

Overall, the EIA concludes that the potential for significant impacts as a consequence of decommissioning the Annabel and Audrey facilities is **low**. Generally, the impacts identified were assessed as localised and short term with low potential for long term or transboundary and cumulative impacts.

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APPENDIX A – ENVIRONMENTAL IMPACT ASSESSMENT TABLE

Potential impacts of each phase of the development and the associated environmental effect before and after mitigation measures.

Key	High	Medium	Low

Vessel Management

Vessel Management												
General Activity	Detailed Activity	Summary of Environmental Impact Description	Initial Ranking - After standard engineering or physical, administrative or procedural controls				Comments/Mitigation - Control measures shown in *Italics* are Best Proactive Controls in addition to the standard engineering or physical, administrative or procedural controls	Residual Ranking - Following the implementation of Best Practice controls, if any.			
			Consequence (Severity)	Duration/Frequency of planned event	Probability of an unplanned event	Initial Risk		Consequence (Severity)	Duration/Frequency of planned event	Probability of an unplanned event	Final Risk
Buoyancy Management	Ballasting	Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge; planktonic organisms most vulnerable receptor.	1	2		Low	Severity depending if invasive species introduced. Ballasting procedures will be in place. All discharges monitored and records maintained	1	2		Low
		Pollution of the marine ecosystem. Organic enrichment, chemical contaminant and possible introduction of invasive species.	3		1	Low		3		1	Low
Chemical Management	Hydraulic fluid controls	Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments.	1		3	Low	Small fluid inventory from hose will undergo large dilution on entering sea with expected negligible effects. All vessel to be in compliance with Centrica's Marine Assurance Standard (MAS).	1		3	Low

Vessel Management											
							1) Planned maintenance, especially of ISM critical equipment 2) Pre operation inspection/checks.				
Cooling systems	Chemical use	Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge; planktonic organisms most vulnerable receptor.	**2**	**2**			All vessels to be in compliance with Centrica's MAS. All discharges monitored and records maintained	**2**	**2**		
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	**2**		**3**			**2**		**3**	
Emergency Incident	Fire / Explosion	Increased degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**		**3**		All vessels to be in compliance with Centrica's MAS. Vessel Assurance Inspection Pre-hire vessel audit shall be used to establish nature of fire fighting systems: Vessels also align to COSHH. The vessel operators have environmental management systems /ISO certification. Ensure vessel SOPEP in place Selection of least environmentally damaging fire fighting chemicals will reduce the consequence to minor but not from liquid HC releases.	**1**		**3**	
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	**3**		**3**			**2**		**3**	
	HCFC Fire Fighting Systems	Increased degradation of local / regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**2**		**3**			**2**		**3**	
Handling and storage	Bunkering	Potential interference with fishing vessels and their gear minimal provided stakeholder communications executed as per stakeholder management plan	**1**	**2**			All vessels to be in compliance with Centrica's MAS. Regular Vessel Assurance Inspection Permit to work system in operation. Spill prevention and clean-up activities as documented in ship's SOPEP. Chamber of Shipping. North West European Area	**1**	**2**		

Vessel Management											
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	**3**		**3**		(NWEA) Guidelines for the Safe Management of Offshore Supply and Anchor Handling Operations, 2006. UK: DECC Alert 2012/01 advises universal standard of risk analysis and management to be used for bunkering of bulk chemicals as well as oil or oil-based chemicals. Centrica expects all vessel to comply with GOMO (Guidelines for Offshore Marine Operations)	**2**		**3**	
	Cargo transfer	Loss overboard of dropped object -water column impact Impact is related directly to scale of loss and quality(hazardous/non-hazardous nature) of goods	**2**		**3**		All vessels to be in compliance with Centrica's MAS. Regular Vessel Assurance Inspection. Permit to work system in operation. Chamber of Shipping. NWEA Guidelines for the Safe Management of Offshore Supply and Anchor Handling Operations. 2006.	**2**		**2**	
Machinery cooling systems	Maintenanc e	Degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**		**3**		Permit to Work system	**1**		**3**	
Maintenance	Machinery space drainage	Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge; planktonic organisms most vulnerable receptor.	**2**	**2**			All vessels to be in compliance with Centrica's MAS. Centrica's MAS requires all vessel hires to be in legislative compliance with MARPOL and IMO; This requires maintaining an Oil Record Book and recording all oily water discharges; maintaining an in-date United Kingdom oil pollution prevention (UKOPP) certificate (renewable every 5 years); reporting any overboard discharges of >15ppm. Oily water separators (OWS) maintained to ensure it is operating efficiently and only discharging water less than 15ppm oil content.	**2**	**2**		

Vessel Management											
	Painting	Degradation of local /regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO2);	**2**	**2**			All vessels to be in compliance with Centrica's MAS. 1) Compliance with relevant legislation. The vessel carry a letter of compliance (no TBT) 2) Vetting of dry-dock facilities Policy on reducing environmental impact	**2**	**2**		
		Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge; planktonic organisms most vulnerable receptor.	**2**	**2**				**2**	**2**		
	Tank cleaning	Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge; planktonic organisms most vulnerable receptor.	**2**	**2**			All vessels to be in compliance with Centrica's MAS	**2**	**2**		
Navigation	Use of foghorn		**2**	**1**			All vessels to be in compliance with Centrica's MAS. Maritime Regulations on use of fog horns	**2**	**1**		
Power generation	Fuel combustion	Degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO2);	**2**	**3**			All contracted vessels in compliance with Centrca's MAS. *Centrica aspires to charter vessels of quiet and clean design and aged less than 25 years;* *It seeks an awareness of SCR technology which can reduce NOx emissions (important in Norwegian sector due to NOX Tax);* *Preference for diesel/electric propulsion system which reduces fuel consumption;* *fuel consumption at Most Economical Speed.* Demonstration of ALARP for impacts. *Best Practice - encourage use of ultra low sulphur (10ppm max) in preference to low sulphur (1000 ppm max)*	**2**	**3**		
		Increased degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO2);	**2**		**3**			**2**		**3**	
Power generation for onboard operational equipment	Fuel combustion	Degradation of local /regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO2);	**2**	**2**				**2**	**2**		

Vessel Management											
Propulsion	Operation of thrusters	Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge; planktonic organisms most vulnerable receptor.	**1**	**3**			All contracted vessels in compliance with Centrica's MAS. Every vessel required to carry a SOPEP. Planned maintenance of critical equipment.	**1**	**3**		
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	**2**		**3**			**2**		**3**	
		Physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	**1**	**3**				**1**	**3**		
		Increased physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	**1**		**3**			**1**		**3**	
	Propeller movement	Damage to marine mammals	**1**		**1**		All vessels to be compliant with Centrica's MAS. Routine crew watch keeping/observations should enable avoidance measures to be taken when necessary.	**1**		**1**	
	Running Engines	Physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	**2**	**3**			All contracted vessels in compliance with Centrica's MAS Monitoring of engines, visual inspections, planned maintenance schedule of engines; Minimise duration on location;	**2**	**3**		
		Increased physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	**2**		**3**			**2**		**3**	

Vessel Management											
Routine Maintenance	Fire fighting systems	Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge; planktonic organisms most vulnerable receptor.	**1**	**1**			All contracted vessels in compliance with Centrica's MAS; CE E&P MAS includes fire fighting system requirements. Vessel Assurance Inspection Pre-hire vessel audit shall be used to establish nature of fire fighting systems: Ensure vessel SOPEP in place.	**1**	**1**		
	Lighting	Attraction of birds to unsafe location; Visual impact to seabirds affecting navigation and migration;	**1**	**3**			Lights for safety and location in remote location - no visual impact for humans and isolated location so no cumulative impact on migratory birds.	**1**	**3**		
Shore Activities	Running Engines	Nuisance to commercial / residential neighbourhood	**2**	**3**			All contracted vessels in compliance with Centrica's MAS; All vessel to be in compliance with Centrica's MAS.	**2**	**3**		
Vessel in transit	Physical Presence	Potential interference with fishing vessels and their gear minimal provided stakeholder communications executed as per stakeholder management plan	**1**	**2**			All contracted vessels in compliance with Centrica's MAS; Navigational Warnings, Fisheries Liaison Officer Collaboration with Fisheries authorities (Division and Department), Vessel Collision Risk Assessment.	**1**	**2**		
		Impact on multiple users especially commercial fisheries. Collision with towed fishing gear causing damage to same	**3**		**1**		Navigation aids eg COLREGS - international signage Collision with 3rd party vessel (Possible cause = Loss of power or DP due to malfunctioning engines, thrusters or DP system during vessel positioning) Collision is possible, but with the navigational controls in place and the lower frequency of traffic the likelihood of collision is reduced	**3**		**1**	
		Interference with fishing vessels and their gear minimal provided stakeholder communications executed as per stakeholder management plan	**3**		**3**			**3**		**2**	
		Unplanned physical disturbance of seabed and disturbance to seabed habitats	**3**		**3**			**3**		**2**	
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	**3**		**3**			**3**		**2**	

Vessel Management											
Waste Production	Bilge system	Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge; planktonic organisms most vulnerable receptor.	**2**	**2**			All contracted vessels in compliance with Centrica's MAS. All bilge discharges monitored and records maintained. Segregation of machinery space and deck drains achieved through drain design. Bilge Cleaning using environmentally "safe" products. No planned discharges of hazardous substances.	**2**	**2**		
	Blackwater production	Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge; planktonic organisms most vulnerable receptor.	**1**	**2**			All vessel to be in compliance with Centrica's MAS. Biological sewage treatment plant onboard is managed by: 1. Planned maintenance of equipment 2. Vacuum toilets with minimal water usage 3. Control of cleaning liquids which may affect plant performance. Cleaning liquids (detergents) and fat-dissolving agents are all "environmentally friendly" with no negative impact on the sewage plant performance. Location isolated therefore cumulative impacts low and high dilution factor reducing acute impact prior to degradation	**1**	**2**		
	Greywater Production	Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge; planktonic organisms most vulnerable receptor.	**1**	**2**			All vessels to be in compliance with Centrica's MAS. Location isolated therefore cumulative impacts low and high dilution factor reducing acute impact prior to degradation	**1**	**2**		
	Incineration Offshore	Degradation of local / regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**	**2**			Monitoring of incinerator operations to be carried out by appropriately trained crew member(s). Location isolated therefore cumulative impacts low and high dilution factor reducing acute impact prior to degradation	**1**	**2**		

Vessel Management											
	Oily liquid disposal	Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	**2**		**3**		All vessels to be in compliance with Centrica's MAS. Contractor Waste Management Procedure/Plan to be aligned with Centrica's Waste Management Standard (CEU-HSEQ-GEN-STA-0010) and MAS. and to include: 1) Marine Garbage procedure, 2) Waste log book 3) Waste management plan, 4) Use of approved waste management contractors only, 5) Routines for correct storage and segregation is part of job specific training 6) SOPEP Location isolated therefore cumulative impacts low and high dilution factor reducing acute impact prior to degradation.	**2**		**2**	
	Onshore waste disposal	Use of landfill and landfill resource take	**2**	**3**			All vessels to be in compliance with Centrica's MAS. General segregation of waste required by all Centrica's contractors/ alliance partners.	**2**	**3**		
		Increased use of landfill and landfill resource take	**2**		**3**			**2**		**2**	
		Degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO2);	**2**	**3**				**2**	**3**		
		Increased degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO2);	**2**		**3**			**2**		**3**	
		Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water and non-continuous discharge;	**2**	**3**				**2**	**3**		
		Water quality in immediate vicinity of discharge will be reduced, further than planned	**2**		**3**			**2**		**3**	
	Packaging disposal	Loss overboard of dropped object -water column impact Impact is related directly to scale of loss and quality(hazardous/non-hazardous nature) of goods	**2**		**3**			**2**		**2**	

Vessel Management											
	Waste liquid production	Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	**2**		**3**			**2**		**2**	

Topsides and Jacket Recovery Activities

Topsides and Jacket Recovery Activities											
General Activity	Detailed Activity	Summary of Environmental Impact Description	Initial Ranking After standard engineering or physical, administrative or procedural controls				Comments/Mitigation	Residual Ranking Following the implementation of Best Practice controls, if any.			
			Consequence (Severity)	Duration/Frequency of planned event	Probability of an unplanned event	Initial Risk		Consequence (Severity)	Duration/Frequency of planned event	Probability of an unplanned event	Final Risk
Locating of HLCV	Anchoring	Localised seabed disturbance resulting in community disturbance. Recovery dependent on type of seabed and species present. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of re-suspended particles.	1	2			The anchor and catenary from the chains impacts on seabed. The weather window is small for HLCV therefore less seabed disturbance associated with the chain sweep. Eight anchors based on Stanislav Yudin or similar vessel and c. 6 days on location. HLCV anchoring procedures.	1	1		
		Extensive seabed disturbance resulting in significant community change. Recovery time and extent dependent on type of seabed and species present. Significant lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Extensive smothering of organisms following settlement of re-suspended particles.	1		2			1		3	
	Dynamic Positioning	Disturbance to marine mammals and fish.	1	2			Vessel controls. Duration will be short term (days rather than months) however the noise will be higher than for most vessels due to the size of the engine required for HLCV.	1	2		
		Disturbance to marine mammals and fish.	1		2			1		2	

Topsides and Jacket Recovery Activities											
Power Generation on HLCV	Fuel Combustion	Degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**	**3**			All contracted vessels in compliance with Centrica's MAS. *Centrica aspires to charter vessels of quiet and clean design and aged less than 25 years;* *It seeks an awareness of SCR technology which can reduce NOx emissions (important in Norwegian sector due to NOX Tax);* *Preference for diesel/electric propulsion system which reduces fuel consumption; fuel consumption at Most Economical Speed.* *Demonstration of ALARP for impacts. Best Practice - encourage use of ultra low sulphur (10ppm max) in preference to low sulphur (1000 ppm max)*	**1**	**2**		
		Increased degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**		**3**			**1**		**2**	
		Impact on climate change and reduction of resources of hydrocarbons	**1**	**3**				**1**	**2**		
		Excessive impact on climate change and reduction of resources of hydrocarbons	**1**		**3**			**1**		**2**	
Marine Growth (Jacket)	Offshore discharge	Increased suspended solids in the water column and dilution and dispersion before biodegradation.	**1**	**1**			Drying out of marine growth which for the most part will remain attached to the structure, though some may fall into sea. Marine growth will fall off structure into sea and onto vessel during transit. It will be naturally dispersed in the marine environment. (Invasive species not considered as structures in UK waters and going to UK port).	**1**	**1**		
		Excessive increase in suspended solids in the water column and dilution and dispersion before biodegradation.	**1**		**3**			**1**		**3**	
		Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water; planktonic organisms most vulnerable receptor.	**1**	**1**				**1**	**1**		
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	**1**		**3**			**1**		**3**	
		Excessive impact on climate change and reduction of resources of hydrocarbons	**1**		**2**			**1**		**2**	

Topsides and Jacket Recovery Activities											
Cutting for single lift recovery of topsides	Jacket	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	**1**	**1**			A suitable tool will be selected for the cutting of the topsides to ensure that impacts are minimised and the risk of repeating the activity as low as reasonably practicable. Procedures will be in place for the activity.	**1**	**1**		
		Excessive increase in suspended solids in water column and on seabed with potential to change the physical chemical characteristics of the seabed.	**2**		**2**			**2**		**2**	
		Nuisance to commercial/residential neighbourhood	**1**	**1**				**1**	**1**		
		Nuisance to commercial/residential neighbourhood	**2**		**3**			**2**		**3**	
		Physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	**1**	**1**				**1**	**1**		
		Increased physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	**2**		**2**			**2**		**2**	
Removal of topsides	Lifting	Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments. NORM could also be present in the topsides pipework.	**2**		**3**		An OPPC permit will be in place for the possibility of small discharges which are still possible following cleaning. Drains and vessels to be checked prior to lifting. PON 2 reporting for dropped object into the sea. Contractor procedures will be checked for securing and lifting. All vessels and drains to be checked prior to lifting (drain points and low points to be	**2**		**2**	
		Excessive increase in suspended solids in water column. Potential to change the physical chemical or habitat characteristics of the seabed. Navigation or socio-economic impact e.g. to fisheries.	**2**		**3**			**2**		**2**	

Topsides and Jacket Recovery Activities											
		Navigation or socio-economic impact e.g. to fisheries. Potential to change the physical chemical or habitat characteristics of the seabed. Extensive seabed disturbance resulting in significant community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Significant lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Extensive smothering of organisms following settlement of re-suspended particles.	**2**		**3**		checked prior to lifting. Then closed again (unless if found to be a safety risk) to stop spills. There is a requirement to know the weight for lifting, therefore there is a need to know how much fluid is in the pipes. Environmental Permit will be obtained for the accumulation and disposal of radioactive waste.	**2**		**2**	
Waste Production (Topsides, jacket and subsea)	Onshore waste disposal Taking topsides to shore for cutting and disposal	Degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**	**2**			Waste Management Plan. Waste handling and transportation procedures. Offshore waste management procedure in place which should allow for effective management of the waste when it arrives onshore. Waste segregated to allow recycling where possible. Assessment of potential contaminants prior to arrival onshore. Lift transportation company may need certificate before lift to ensure not hazardous for transportation and proof before shipping. Waste segregation and minimisation of waste by design of the operation. Possible quarantine of contaminated equipment on the barge/vessel for segregation.	**1**	**2**		
		Increased degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**		**3**			**1**		**3**	
		Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in receiving body of water. Planktonic organisms most vulnerable receptor.	**1**	**2**				**1**	**2**		
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and sediments.	**1**		**3**			**1**		**3**	
		Nuisance to commercial/residential neighbourhood.	**1**	**1**				**1**	**1**		
		Nuisance to commercial/residential neighbourhood.	**1**		**3**			**1**		**3**	
		Use of landfill and landfill resource take	**1**	**2**				**1**	**2**		
		Increased use of landfill and landfill resource take	**1**		**3**			**1**		**3**	

Topsides and Jacket Recovery Activities											
Power generation	Fuel Combustion	Degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**	**1**			All contracted vessels in compliance with Centrica's MAS. *Centrica aspires to charter vessels of quiet and clean design and aged less than 25 years;* *It seeks an awareness of SCR technology which can reduce NOx emissions;* *Preference for diesel/electric propulsion system which reduces fuel consumption; fuel consumption at Most Economical Speed.* *Demonstration of ALARP for impacts. Best Practice - encourage use of ultra low sulphur (10ppm max) in preference to low sulphur (1000 ppm max)*	**1**	**1**		
		Increased degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**		**3**			**1**		**2**	
		Impact on climate change and reduction of resources of hydrocarbons	**1**	**1**				**1**	**1**		
		Excessive impact on climate change and reduction of resources of hydrocarbons	**1**		**3**			**1**		**2**	
Cutting legs/piles, jacket	Cutting	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	**1**	**1**			Cutting 3m below seabed. Disturbance to the seabed from the cutting and removal of the feet. A suitable tool will be selected for the cutting of the feet to ensure that impacts are minimised and the risk of repeating the activity as low as reasonably practicable. Procedures will be in place for the activity.	**1**	**1**		
		Excessive increase in suspended solids in water column and on seabed with potential to change the physical chemical characteristics of the seabed.	**1**		**3**			**1**		**2**	
		Behavioural modifications to birds and marine mammals.	**1**	**1**				**1**	**1**		
		Behavioural modifications to birds and marine mammals.	**1**		**3**			**1**		**3**	
		Physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	**1**	**1**				**1**	**1**		

Topsides and Jacket Recovery Activities											
		Increased physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	**1**		**3**			**1**		**2**	
Removal of jacket	Lifting	Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in receiving body of water; planktonic organisms most vulnerable receptor.	**2**		**3**		A lifting plan will be in place.	**1**		**3**	
		Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	**2**	**3**				**2**	**3**		
		Excessive increase in suspended solids in water column and on seabed with potential to change the physical chemical characteristics of the seabed.	**2**		**3**			**2**		**3**	
		Navigation or socio-economic impact eg to fisheries. Potential to change the physical chemical or habitat characteristics of the seabed. Extensive seabed disturbance resulting in significant community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Significant lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Extensive smothering of organisms following settlement of re-suspended particles.	**1**		**3**			**1**		**3**	

Topsides and Jacket Recovery Activities											
		Localised physical seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of re-suspended particles.	1	1				1	1		
Marine Growth on jacket	Offshore waste disposal.	Increased suspended solids in the water column and dilution and dispersion before biodegradation.	2	1			Marine growth falling from structure then vessel during transit and organic liquid as a result of biodegradation from vessel during transit. Drying out of marine growth which for the most part will remain attached to the structure. It will be naturally dispersed in the marine environment. (Invasive species not considered as structures in UK waters and going to UK port).	2	1		
		Excessive increase in suspended solids in the water column and dilution and dispersion before biodegradation.	2		3			2		3	
		Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water; planktonic organisms most vulnerable receptor.	1	1				1	1		
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	1		3			1		3	
Waste Production during recovery of jacket	Onshore waste disposal	Including methane emissions from biodegradation in landfill. Degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	1	3			Waste Management Plan. Waste handling and transportation procedures. Offshore waste management procedure in place which should allow for effective management of the waste when it arrives onshore. Waste segregated to allow recycling where possible. Assessment of potential contaminants prior to arrival onshore. Lift transportation company may need certificate	1	3		
		Including methane emissions from biodegradation in landfill. Increased degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	1		3			1		3	

Topsides and Jacket Recovery Activities											
		Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in receiving body of water; planktonic organisms most vulnerable receptor.	**1**	**1**			before lift to ensure not hazardous for transportation and proof before shipping. Waste segregation and minimisation of waste by design of the operation. Possible quarantine of contaminated equipment on the barge/vessel for segregation.	**1**	**1**		
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and sediments.	**2**		**3**			**2**		**3**	
		Nuisance to commercial/residential neighbourhood	**1**	**1**				**1**	**1**		
		Nuisance to commercial/residential neighbourhood	**2**		**3**			**2**		**3**	
		Use of landfill and landfill resource take	**1**	**1**				**1**	**1**		
		Increased use of landfill and landfill resource take	**2**		**3**			**2**		**3**	
Power Generation during recovery of jacket	Fuel Combustion	Degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**	**1**			All contracted vessels in compliance with Centrica's MAS. *Centrica aspires to charter vessels of quiet and clean design and aged less than 25 years;* *It seeks an awareness of SCR technology which can reduce NOx emissions (important in Norwegian sector due to NOX Tax);*	**1**	**1**		
		Increased degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	**1**		**3**			**1**		**3**	
		Impact on climate change and reduction of resources of hydrocarbons	**1**	**1**			Preference for diesel/electric propulsion system which reduces fuel consumption; fuel consumption at Most Economical Speed.	**1**	**1**		
		Excessive impact on climate change and reduction of resources of hydrocarbons	**1**		**3**		Demonstration of ALARP for impacts. Best Practice - encourage use of ultra low sulphur (10ppm max) in preference to low sulphur (1000 ppm max)	**1**		**3**	

Topsides and Jacket Recovery Activities											
Legacy of all Activities	Seabed	Disturbance of the ecosystem within the recovery estimate in the EIA. Localised seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of re-suspended particles.	2	1			After removal the over trawling will sweep seabed encouraging levelling. Coarse sediments and dynamic water currents also encouraging sediment movement. In addition there will be a debris survey after removal.	2	1		
		Disturbance of the ecosystem exceeding the recovery estimate in the EIA. Extensive seabed disturbance resulting in significant community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Significant lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Extensive smothering of organisms following settlement of re-suspended particles.	2		3			2		3	
	Socioeconomic Use	Complete removal and return of seabed to pre-development status for socioeconomic use e.g. fishing	1	1				1	1		
		Incomplete removal and return of seabed to pre-development status for socioeconomic use e.g. fishing, due to unplanned presence of infrastructure and/or contamination	2		2			2		2	
	Navigation	Other sea users are able to have complete use of the area for navigation and not confined by infrastructure	1	1			The Safety exclusion zone will be removed as the infrastructure will have been removed, therefore the risk of collision has been eliminated.	1	1		
		Other sea users are unable to have complete use of the area for navigation and continue to be confined by infrastructure longer and/or for a greater area than estimated	2		2			2		2	

Topsides and Jacket Recovery Activities											
		Extensive seabed disturbance resulting in significant community change.	**2**		**2**			**2**		**2**	
		Obstacle for navigation longer than expected - or in a slightly different location	**2**		**2**			**2**		**2**	
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	**2**		**2**			**2**		**2**	

Subsea Infrastructure Recovery Activities

Subsea Infrastructure Recovery Activities												
General Activity	Detailed Activity	Summary of Environmental Impact Description	Initial Ranking After standard engineering or physical, administrative or procedural controls				Comments/Mitigation	Residual Ranking Following the implementation of Best Practice controls, if any.			
			Consequence (Severity)	Duration/Frequency of planned event	Probability of an unplanned event	Initial Risk		Consequence (Severity)	Duration/Frequency of planned event	Probability of an unplanned event	Final Risk
Accessing infrastructure	Jetting: required to clear sediment away to access pipe or material prior to cutting and removal.	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	**2**	**1**			A suitably sized jetting tool will be used to ensure the minimum area of the seabed is impacted.	**2**	**1**		
		Excessive increase in suspended solids in water column and on seabed with potential to change the physical chemical characteristics of the seabed.	**2**		**3**			**2**		**3**	
Infrastructure sectioning	Cutting below the seabed resulting in disturbance	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	**2**	**1**			A suitable technology for cutting will be selected to ensure that the effectiveness of the cutting, minimising the duration, disturbance and risk of requiring the activity to be repeated.	**2**	**1**		

Subsea Infrastructure Recovery Activities											
	to the seabed.	Excessive increase in suspended solids in water column and on seabed with potential to change the physical chemical characteristics of the seabed. Excessive release of liquid, gas or solid eg solids generated during cutting activities	1		2			1		2	
	Cutting below the seabed resulting in underwater noise	Physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	2	1				2	1		
		Increased physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	2		3			2		2	
Spool Isolation	Cutting below seabed. Disturbance to the seabed from the cutting resulting in increased suspended solids	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	1	1			A suitable technology for cutting will be selected to ensure that the effectiveness of the cutting, minimising the duration, disturbance and risk of requiring the activity to be repeated.	1	1		
		Excessive increase in suspended solids in water column and on seabed with potential to change the physical chemical characteristics of the seabed.	1		3			1		3	
		Physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	1	1				1	1		

Subsea Infrastructure Recovery Activities											
		Increased physiological harm, behavioural modifications to marine mammals and potentially fish. Population impacts due to cumulative impact or impacting a reproductively significant number of individuals or location.	**1**		**3**			**1**		**3**	
Infrastructure (including mattresses and grout bags)	Lifting. Any liquid/oil left after flushing/cleaning. Retrieved with both ends open - water moving through.	Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments. Planktonic organisms most vulnerable receptor. Impacts from the possible presence of NORM.	**2**		**3**		An OPPC permit will be in place for which the volume of hydrocarbon potentially discharged to sea will have been calculated from sampling the flushing fluid during cleaning. Lifting procedures will be in place to reduce the likelihood of dropped items and the area of the seabed impacted. Test lift of mattresses to inform lifting procedures.	**2**		**3**	
	Lifting. Suspension of sediment when lifting (no cuttings pile)	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	**2**	**1**				**2**	**1**		
	Lifting. Lose pieces from cutting	Excessive increase in suspended solids in water column and on seabed with potential to change the physical chemical characteristics of the seabed.	**1**		**3**			**1**		**3**	

Subsea Infrastructure Recovery Activities											
	Lifting. Dropping of the pipelines and spools	Navigation or socio-economic impact e.g. to fisheries. Potential to change the physical chemical or habitat characteristics of the seabed. Extensive seabed disturbance resulting in significant community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Significant lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Extensive smothering of organisms following settlement of re-suspended particles.	**2**		**3**			**2**		**3**	
	Lifting. When the sections are pulled free the ecosystem will be impacted	Localised physical seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of re-suspended particles.	**2**	**2**				**2**	**2**		
Mattresses	Lifting	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	**2**	**1**			Lifting procedures will be in place to reduce the likelihood of dropped items and the area of the seabed impacted.	**2**	**1**		
	Lifting Dropping of the mattresses	Navigation or socio-economic impact e.g. to fisheries. Potential to change the physical chemical or habitat characteristics of the seabed. Extensive seabed disturbance resulting in significant community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Significant lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Extensive smothering of organisms following settlement of re-suspended particles.	**2**		**3**			**2**		**3**	

Subsea Infrastructure Recovery Activities												
Grout bags	Lifting	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	1	1			Lifting procedures will be in place to reduce the likelihood of dropped items and the area of the seabed impacted.	1	1		
		Navigation or socio-economic impact e.g. to fisheries. Potential to change the physical chemical or habitat characteristics of the seabed. Extensive seabed disturbance resulting in significant community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Significant lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Extensive smothering of organisms following settlement of re-suspended particles.	1		3			1		3	
		Excessive increase in suspended solids in water column and on seabed with potential to change the physical chemical characteristics of the seabed.	1		3			1		3	
Burial	Trench and Jetting (contingency)	Increased suspended solids in the water column and dilution and dispersion before settling on seabed.	1	1			A suitable sized jetting tool will be selected to minimise the area impacted to achieve the required depth of lowering.	1	1		
		Excessive increase in suspended solids in water column and on seabed with potential to change the physical chemical characteristics of the seabed.	1		3			1		3	
Marine Growth	Offshore discharge	Increased suspended solids in the water column and dilution and dispersion before biodegradation.	1	1			Marine growth will fall off items into sea and onto vessel during recover and transit. It will be naturally dispersed in the marine environment. (Invasive species not considered as structures in UK waters and going to UK port).	1	1		
		Excessive increase in suspended solids in the water column and dilution and dispersion before biodegradation.	1		3			1		3	

Subsea Infrastructure Recovery Activities											
		Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in massive receiving body of water; planktonic organisms most vulnerable receptor.	1	1				1	1		
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	1		3			1		3	
Waste Production	Onshore waste disposal	Including methane emissions from biodegradation in landfill. Degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2).	1	3			Waste Management Plan. Waste handling, transportation and disposal procedures. Offshore waste management procedure in place which should allow for effective management of the waste when it arrives onshore. Waste segregated to allow recycling where possible. Assessment of potential contaminants prior to arrival onshore. Lift transportation company may need certificate before lift to ensure not hazardous for transportation and proof before shipping. Waste segregation and minimisation of waste by design of the operation. Possible quarantine of contaminated equipment on the barge/vessel for segregation. Assurance of waste disposal sites.	1	3		
		Including methane emissions from biodegradation in landfill. Increased degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2).	1		3			1		3	
		Water quality in immediate vicinity of discharge will be reduced, but effects are usually minimised by rapid dilution in receiving body of water; planktonic organisms most vulnerable receptor.	1	1				1	1		
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and sediments.	2		3			2		3	
		Nuisance to commercial/residential neighbourhood	1	1				1	1		
		Nuisance to commercial/residential neighbourhood	2		3			2		3	
		Use of landfill and landfill resource take	1	1				1	1		

Subsea Infrastructure Recovery Activities											
		Increased use of landfill and landfill resource take	1		3			1		3	
Power Generation	Fuel Combustion	Degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	1	1			Temporary equipment will be required for preparation / flushing. The equipment will be managed under the contractor assurance process.	1	1		
		Increased degradation of local/regional air quality (NOx and particulates). Transboundary air pollution. Contributing to global warming (CO_2);	1		3			1		3	
		Impact on climate change and reduction of resources of hydrocarbons	1	1				1	1		
		Excessive impact on climate change and reduction of resources of hydrocarbons	1		3			1		3	
Result of subsea activities - Legacy Issues	Seabed	Disturbance of the ecosystem within the recovery estimate in the EIA. Localised seabed disturbance resulting in community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Smothering of organisms following settlement of re-suspended particles.	2	1			After removal the over trawling will sweep seabed encouraging levelling. Coarse sediments and dynamic water currents also encouraging sediment movement. Debris survey after removal. Opportunities to minimise the area that needs to be overtrawled will be investigated.	2	1		
		Disturbance of the ecosystem exceeding the recovery estimate in the EIA. Extensive seabed disturbance resulting in significant community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Significant lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Extensive smothering of organisms following settlement of re-suspended particles.	1		3			1		3	

Subsea Infrastructure Recovery Activities											
	Socioeconomic Use	Complete removal and return of seabed to pre-development status for socioeconomic use e.g. fishing	**1**	**1**			Removing the Safety exclusion zone for e.g. fishing and wind farm use.	**1**	**1**		
		Incomplete removal and return of seabed to pre-development status for socioeconomic use e.g. fishing, due to unplanned presence of infrastructure and/or contamination	**2**		**3**			**2**		**3**	
	Navigation	Other sea users are able to have complete use of the area for navigation and not confined by infrastructure	**1**	**1**			Removing the Safety exclusion zone around the platform.	**1**	**1**		
		Other sea users are unable to have complete use of the area for navigation and continue to be confined by infrastructure longer and/or for a greater area than estimated	**1**		**3**			**1**		**3**	
		Extensive seabed disturbance resulting in significant community change.	**1**		**3**			**1**		**3**	
		Obstacle for navigation longer than expected - or in a slightly different location	**1**		**3**			**1**		**3**	
		Pollution of the marine ecosystem. Organic enrichment and chemical contaminant effects in water column and seabed sediments	**1**		**3**			**1**		**3**	
Pipeline Burial - Legacy	Deposition of material for pipeline should a	Other sea users are unable to have complete use of the area for navigation and continue to be confined by infrastructure longer and/or for a greater area than estimated	**1**	**3**			If a span appears in the pipeline, the appropriate action, whether to retrench or jet in the pipeline or to bury the pipeline will be explored. The activities will be undertaken	**1**	**3**		

Subsea Infrastructure Recovery Activities											
	span appear	Disturbance of the ecosystem exceeding the recovery estimate in the EIA. Extensive seabed disturbance resulting in significant community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Significant lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Extensive smothering of organisms following settlement of re-suspended particles.	**1**	**3**			following approved procedures to minimise impact on the marine environment.	**1**	**3**		
		Increased suspended solids in the water column and dilution and dispersion before biodegradation.	**1**	**3**				**1**	**3**		
		Other sea users are unable to have complete use of the area for navigation and continue to be confined by infrastructure longer and/or for a greater area than estimated	**1**		**3**			**1**		**3**	
		Disturbance of the ecosystem exceeding the recovery estimate in the EIA. Extensive seabed disturbance resulting in significant community change. Recovery time and extent dependent on type of seabed and species present and location specific estimate within the relevant EIA. Significant lethal/sub-lethal effects on benthic and epibenthic fauna from physical abrasion; Extensive smothering of organisms following settlement of re-suspended particles.	**2**		**3**			**2**		**3**	
		Increased suspended solids in the water column and dilution and dispersion before biodegradation.	**2**		**3**			**2**		**3**	