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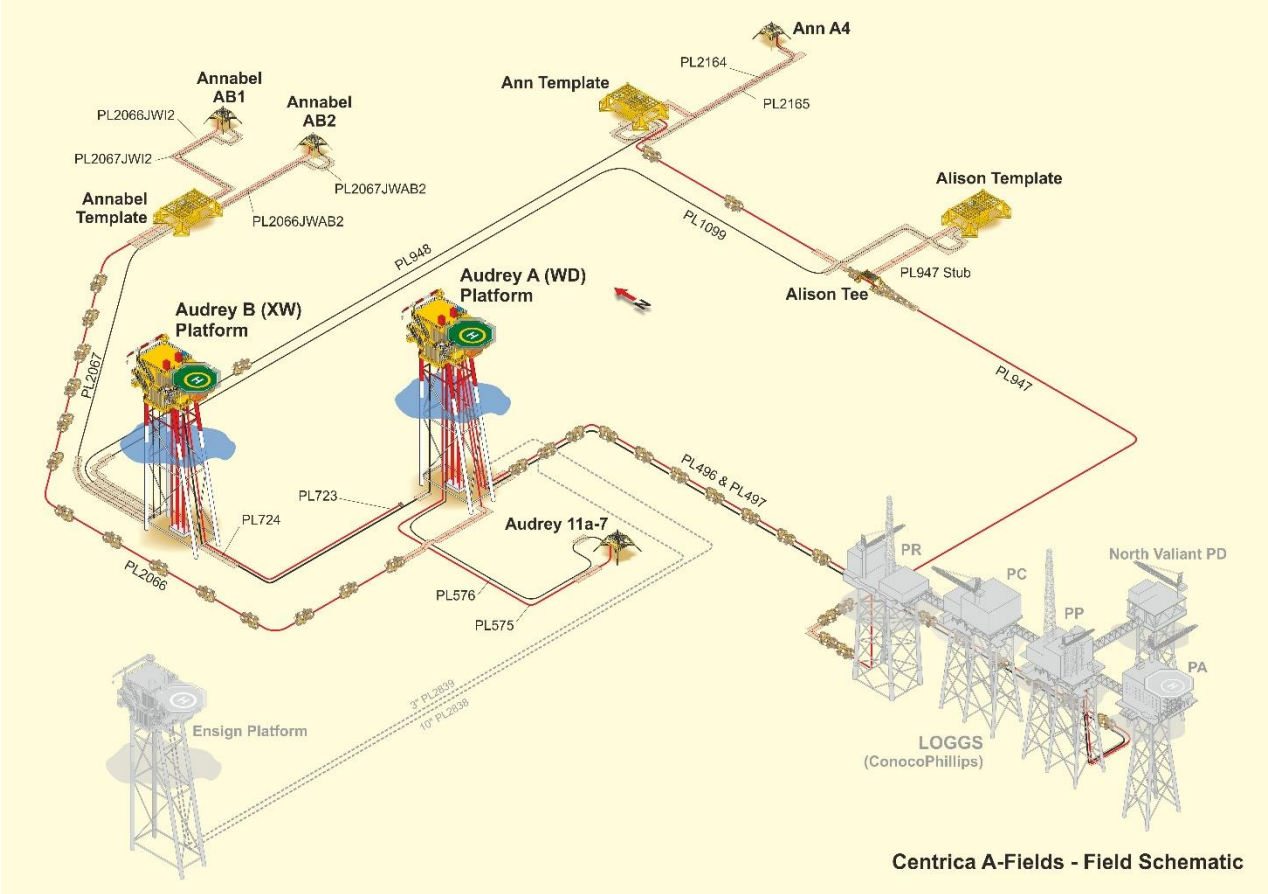
Saturn (Annabel) & Audrey Decommissioning Comparative Assessment



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Prepared by:	S. Axon	S Axon	1/9/17
Reviewed by:	S. Mackenzie	S Mackenzie	1/9/17
Approved by:	W. Black	W Black	01/09/2017

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1. EXECUTIVE SUMMARY

A Comparative Assessment of pipeline decommissioning options is a key consideration within Decommissioning Programmes submitted to the Department of Business, Energy and Industrial Strategy (BEIS).

Collectively the A Fields series of developments lies approximately 110km north-north-east of the English coastal town of Great Yarmouth, in the southern sector of the North Sea. 'A Fields' is a collective term used to describe the Audrey, Ann, Alison and Annabel (Saturn) Fields.

Annabel

In official documentation such as Pipeline Works Authorisations, the "Annabel" development is often referred to as the "Saturn (Annabel)" development. For consistency the development is referred to simply as "Annabel" herein.

The export route for Annabel is **PL2066**. This 10" production pipeline is routed to Audrey A (WD) and is 17.8km long. **PL20266** is trenched and buried but with intermittent sections buried under rock. Annabel incorporates a piping arrangement that allows the commingling of gas (and lesser quantities of other produced fluids) from Annabel AB1 and AB2. These small subsea tiebacks use short surface laid 8" production jumper arrangements **PL2066JW12** and **PL2066JWAB2**. They are 34.7m and 133m long respectively and are stabilised and protected using concrete mattresses.

Annabel derives its power, controls and chemicals from Audrey B (XW) via umbilical pipeline **PL2067** approximately 13.4km long. The umbilical is trenched and buried except for a pipeline crossing and cable crossing that are buried locally under rock. Annabel AB1 and AB2 wellheads derive their power, controls and chemicals indirectly from Audrey B (XW) via **PL2067** and the Annabel template using short, surface laid electro-hydraulic jumpers **PL2067JW12** and **PL2067JWAB12**. These electro-hydraulic jumpers are approximately 88m and 198m long respectively and are protected and stabilised using concrete mattresses.

Audrey

The export route for both Annabel and Audrey A (WD) is **PL496**. This is a 20" concrete coated pipeline 16.9km long that is routed to LOGGS PP. It is piggybacked with **PL497**, a 3" methanol pipeline. Both these pipelines are extensively buried under rock.

Audrey B (XW) used to export gas to Audrey A (WD) via **PL723**, approximately 4.3km long, but this pipeline is no longer operating and has been disconnected and filled with seawater. **PL723** is piggybacked with a 3" methanol line, **PL724**. These pipelines are trenched and buried.

Audrey 11a-7 is a subsea tieback that exports gas via **PL575**, an 8" pipeline 492m long. Audrey 11a-7 derives its power, controls and chemicals from Audrey A (WD) via umbilical pipeline **PL576** approximately 650m long. Both **PL575** and **PL576** are fully contained within the current Audrey A (WD) 500m safety zone, trenched and buried, but with parts exposed.

Pipeline decommissioning options

This document summarises a comparative assessment of the most feasible options for decommissioning Audrey pipeline numbers **PL496/7**, **PL723/4**, **PL575**, and **PL576** as well as Annabel pipeline numbers **PL2066**, **PL2066JW12**, **PL2066JWAB2**, **P2067**, **PL2067JW12**, and **PL2067JWAB2**.

Up to three decommissioning options are considered for the pipelines:

- **Complete removal** – This involves the complete removal of the pipelines by whatever means would be most practicable and acceptable from a technical perspective;
- **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.

Since the decommissioning of the pipeline (and umbilical) approaches is the same irrespective of which option is pursued, decommissioning of these is not included in the assessment. All options include removal of features such as spool pieces, mattresses and grout bags in accordance with mandatory requirements.

Fronded mattress decommissioning options

Two decommissioning options were considered for the fronded mattresses:

- Complete removal;
- Leave *in situ*

Comparative assessment

The options were assessed using the BEIS Decommissioning Guidance Notes and Centrica Comparative Assessment guidelines for the A Fields decommissioning project. During the assessment process, evaluations were made principally on a qualitative basis using Centrica's established corporate risk assessment tables. The following components were assessed from a short-term (project) and longer-term (legacy) perspective:

- Safety
- Environmental
- Technical
- Societal
- Cost

Pipeline decommissioning assessment

The results of the assessment showed the risks and impacts of all pipeline decommissioning options to be broadly acceptable, although the technical and safety risks associated with complete removal PL496/7, PL723/4, PL2066, and PL2067 would be 'tolerable' rather than 'broadly acceptable'. This is primarily due to there being limited experience in removing trenched and buried pipelines [7], especially those that are buried under rock (e.g. **PL496/7** and **PL2066**, intermittently) for a substantial proportion of their length.

Excepting **PL575** and **PL576**, for all buried pipelines in the short-term the complete removal option would result in the Special Area of Conservation objectives being impacted and this was classed as 'tolerable' rather than 'broadly acceptable'. For **PL575** and **PL576** the impact on SAC is assessed as being broadly acceptable.

From an environmental perspective, lower risks and impacts would be incurred for the leave *in situ* option than for any of the other decommissioning options.

The societal assessments showed that complete removal would be marginally beneficial because of continuation of employment due to extension of vessel use and onshore waste management activities. Although in the short-term, fishing activities might proportionately be disrupted as decommissioning activities increase. Conversely fishing activities could be affected by legacy pipeline surveys and possible remedial work in future, but there is nothing that significantly differentiates the options.

Finally, the leave *in situ* and partial removal options would cost less to adopt in the short-term than complete removal. For the longer pipelines the cost of complete removal is an order of magnitude greater than for partial removal (where applicable) or leave *in situ*.

Drill cuttings assessment

One area of anthropogenic rock at each of the installations show elevated levels of hydrocarbons and other contaminants associated with drill cuttings. Survey data and sample

analysis shows both areas to be **below** the OSPAR thresholds [11]. In accordance with OSPAR Recommendation 2006/5 on a Management Regime for Offshore Cuttings 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. Therefore, we propose to leave the drill cuttings pile *in situ*.

Summary of decommissioning proposals

On the approaches buried pipelines will be cut below the seabed at trench depth approximately 600mm below mudline, and the transition sections, pipelines on the seabed, and pipe spools, pipelines on the seabed will be removed. The intention is that all the pipeline protection materials such as concrete mattresses and grout bags will be removed to gain access to the pipelines.

As a result of the comparative assessment we propose to leave the longer pipelines *in situ*. **PL2066JW12**, **PL2067JW12**, **PL2066JWAB2** and **PL2067JWAB2** are surface laid and will be completely removed. **PL575** and **PL576**, the short pipeline and umbilical currently contained within the Audrey A (WD) 500m safety zone will be completely removed so that potential snagging hazards exposed to fishing activities in the area are no longer present.

Decommissioning of the different pipeline components are summarised below.

PL496/7, 16.9km long	**Leave *in situ***	**Partial removal**	**Complete Removal**
Audrey A (WD) approaches/transition zone (rock)		●	
Infield 20” pipeline, 3” MEOH piggybacked	●		
LOGGS PP approaches / transition zone (rock)		●	
PL575, 492m long	**Leave *in situ***	**Partial Removal**	**Complete Removal**
8” pipeline (fully contained within 500m zone)			●
PL576, 650m long	**Leave *in situ***	**Partial Removal**	**Complete Removal**
Umbilical (fully contained within 500m zone)			●

PL723/4, 4.4km long	**Leave *in situ***	**Complete Removal**
Audrey B (XW) approaches/transition zone		●
14” pipeline, 3” MEOH piggybacked	●	
Audrey A (WD) approaches / transition zone		●

PL2066, 17.8km long	**Leave *in situ***	**Complete Removal**
Annabel (Saturn) approaches & transition zone		●
10” pipeline	●	

Audrey A (XW) approaches & transition zone		●
PL2067, 13.4km long	**Leave *in situ***	**Complete Removal**
Audrey B (WD) approaches & transition zone		●
Control and chemical injection jumper and umbilical line	●	
Annabel (Saturn) approaches & transition zone		●

PL2066JW12 & PL2066JWAB2, 34.7m & 133m long	**Leave *in situ***	**Complete Removal**
Surface laid 8" pipeline		●
PL2067JW12 & Pl2067JWAB2, 88m & 198m long	**Leave *in situ***	**Complete Removal**
Control and chemical injection jumper and umbilical line		●

We propose that the frond mattresses around the Annabel template and Audrey B (WD) approaches will be left *in situ*.

Post-decommissioning overtrawl

Finally, although overtrawl activities will cause damage to the seabed we can expect the seabed to recover. To minimise the short-term impact in the seabed and thus the SAC, we would propose to carry out overtrawl activities only within the 500m safety zones.

TABLE OF CONTENTS

FIGURES AND TABLES

TERMS AND ABBREVIATIONS

ABBREVIATION	DESCRIPTION	ABBREVIATION	DESCRIPTION
ALARP	As Low As Reasonably Practicable.	LOGGS	Lincolnshire Offshore Gas Gathering System.
Annabel	Often referred to as "Saturn (Annabel)" development in official documentation such as Pipeline Works Authorisations (PWA), but referred to as just "Annabel" herein.	MBES	Multi-Beam Echo Sounder. A type of sonar that can be used to map the seabed.
Approach	Initial or final stretch of pipeline (or umbilical) as it leaves its point of origin or reaches its destination.	MM	Million.
BEIS	Department of Business, Energy and Industrial Strategy.	nb	Nominal Bore
Centrica	Centrica North Sea Limited.	N/A	(Data) Not Available
CO_2	Carbon Dioxide.	NORM	Naturally Occurring Radioactive Material.
CSV	Construction Support Vessel.	OGUK	Oil & Gas UK.
c/w	…complete with.	Piggybacked	Usually refers to a smaller pipeline that is adjacent and clamped to a larger pipeline throughout its length (e.g. PL497 is piggybacked to PL496)
°	Degree.	Pipeline(s)	Pipeline or umbilical as defined by BEIS. Includes PL496, PL497, PL575, PL576, PL2066, PL2067, etc.
DOB	Depth of burial. The depth between the blue line (DOC) and maroon line (DOL) on the burial profiles.	Pipespool(s)	Short sections of pipe that are typically flanged and bolted together.
DOC	The blue line on the burial profiles shows the profile of cover. The area between the blue line (DOB) and maroon line (DOL) shows the backfill.	PP	LOGGS PP Production Platform.
DOL	Pipeline trench profile; depth of lowering (to tom of pipe).	Qualitative	Result determined using judgement and use of risk and impact matrices
DSV	Dive Support Vessel.	Quantitative	Result determined using numerical data and by calculation
Exposure	A pipeline can be seen on the surface of the seabed but is not free-spanning.	ROV	Remotely Operated Vehicle
FishSAFE	The FishSAFE database contains a host of oil & gas structures, pipelines and potential fishing hazards. This includes information and changes as the data are reported for: pipelines and cables, suspended wellheads, pipeline spans, surface & subsurface structures, safety zones & pipeline gates (www.fishsafe.eu).	Scour	Local erosion of a sedimentary seabed, usually cumulative.
Free span	A pipeline is called to be at free span when a pipe segment is not supported by the seabed.	S-lay	This involves welding sections of pipe together on the deck of the vessel, then lowering the pipeline to the seabed as a continuous string of pipe, as the vessel moves forward; It is used for larger diameter pipelines.
HAZID	Hazard Identification Workshop.	pSAC	possible Special Area of Conservation.
HSE	Health, Safety, Environment	Spool pieces	Short sections of pipe that are typically flanged and bolted together (aka pipespools).
Hyperbaric weld	Hyperbaric welding is the process of welding at elevated pressures, normally	THC	Total Hydrocarbon Content

ABBREVIATION	DESCRIPTION	ABBREVIATION	DESCRIPTION
	underwater. Hyperbaric welding can either take place wet in the water itself or dry inside a purpose built enclosure.		
in (“)	Inch (25.4mm)	Te	Tonne(s)
infield	Portion of pipeline outside 500m safety zone and therefore already potentially exposed to fishing activity.	Template	Structure through which drilling activities are conducted. It also protects wellheads, Christmas trees and piping manifold inside. For consistency the Annabel structure is referred to as a “Template”, although strictly the structure is not a template but just a protection structure.
km, m	Kilometre(s), Metre(s)	UK	United Kingdom
KP	Kilometre Post, measured from place of origin	UKCS	United Kingdom Continental Shelf
LAT	Lowest Astronomical Tide		
Broadly Acceptable / Low[1] & least preferred	Risks broadly acceptable but controls shall be subject to continuous improvement through the implementation of the HSEQ Management System and in light of changes such as technology improvements; performance in other ‘broadly acceptable’ options marginally better	Tolerable / Medium[1]	Risks are tolerable and managed to ALARP. Controls and measures to reduce risks to ALARP require identification, documentation and approval by responsible leader
Broadly Acceptable / Low[1] & in-between least & most preferred	As above, but performance of this option is marginally better or marginally worse than others	Intolerable / High[1]	Impacts are intolerable. Controls and measures to reduce impact to ALARP (at least to Medium) and require identification, documentation, implementation and approval.
Broadly Acceptable / Low[1] & most preferred	As above but performance in other ‘broadly acceptable’ options marginally worse		

[1] The colour of this highlighted cell is used in the assessment tables

2. INTRODUCTION

2.1 Overview

The A Fields is a complex arrangement of sub-sea tiebacks and platforms: Ann, Alison, Annabel, and Audrey. These are all tied in to the ConocoPhillips' Lincolnshire Offshore Gas Gathering System (LOGGS) platform complex. Until the wells were shut in 01 May 2016 the A Fields had been in production since 1988. Figure 2.1 illustrates the field layout and infrastructure.

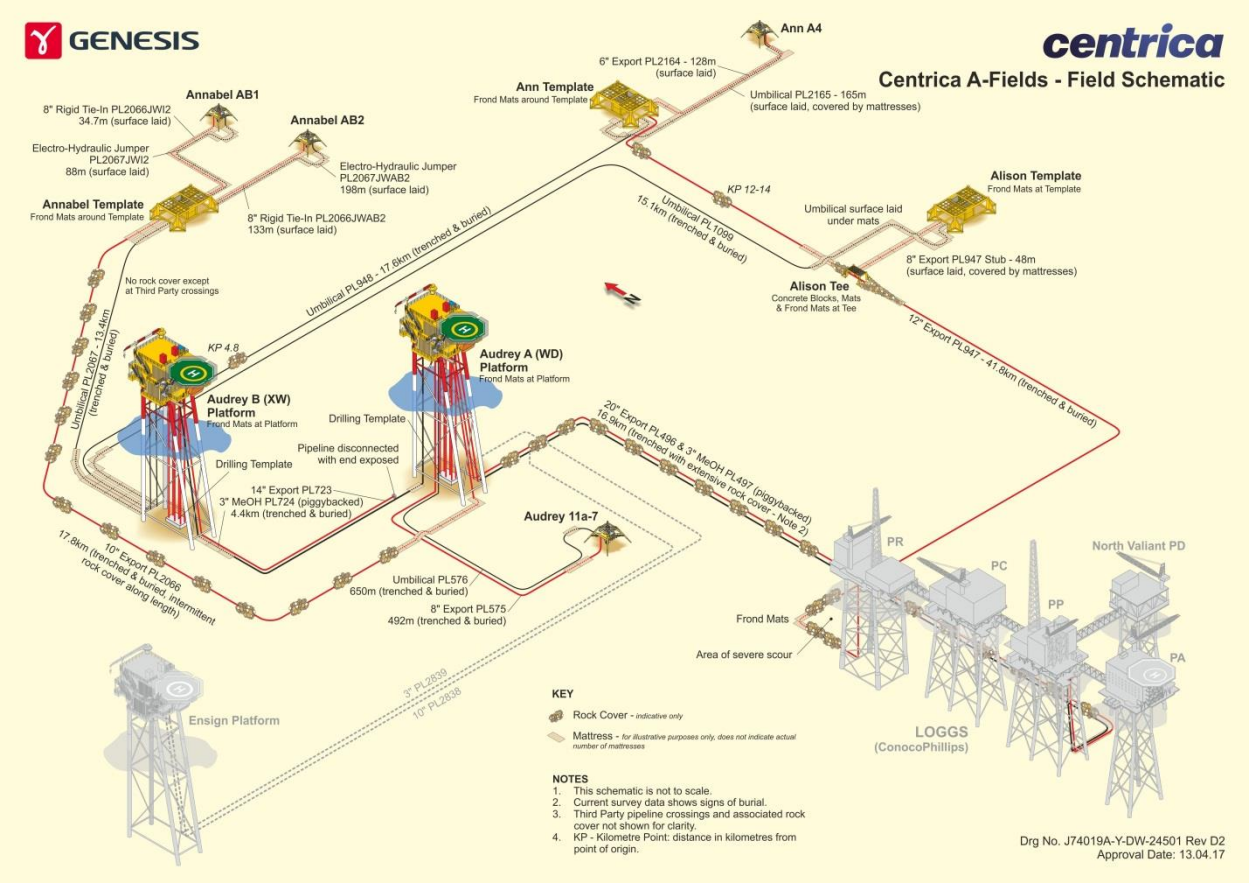

Figure 2.1: A Fields Infrastructure Schematic

2.1.1 Audrey

The Audrey gas field was developed using two platforms - Audrey A (WD) and Audrey B (XW) - and a single well subsea tie-back (Audrey 11a-7) and achieved first production in 1988. The Annabel gas field was developed as a two-well subsea tie-back that achieved first production in 2006. Production from all the assets (from Annabel via PL2066 and from Audrey B (XW) via PL723) used to be routed to LOGGS via Audrey A (WD) using 20" pipeline PL496. Power and control for Annabel is provided from Audrey B (XW) via PL2067 which in turn derives power and control from Audrey A (WD) via PL724. Audrey A (WD) derives methanol from LOGGS via PL497. Methanol is provided to Audrey B (XW) from Audrey A (WD) using 3" Methanol line PL724 and sent to Annabel via PL2067.

2.1.2 Annabel

The Annabel template incorporates a piping manifold that allows the commingling of gas (and lesser quantities of other produced fluids) from Annabel AB1 and AB2. Annabel AB1 exports gas via 8" pipeline PL2066JW12, which is surface laid and comprises pipe spools totalling

34.7m long. Annabel AB2 exports gas via 8" pipeline PL2066JWAB2, which is also surface laid but comprises pipe spools totalling 130m long. The surface laid pipespools from both assets are protected and stabilised using concrete mattresses. The gas from the field is exported via PL2066 to Audrey A (WD).

The Annabel manifold is provided with power, hydraulic fluids and chemicals via PL2067, which is 13.4km long. These are distributed to Annabel AB1 wellhead and Annabel wellhead AB2 via electro-hydraulic jumpers PL2067JW12 (88m long) and PL2067JWAB2 (198m long) respectively. Both pipelines are surface laid and protected and stabilised with concrete mattresses.

2.1.3 Combined infrastructure

The infrastructure components of Annabel and Audrey are:

Pipeline ID	Description, Size & Quantity
PL496	20" gas export pipeline, 75mm concrete coated, 16.9km long
PL497	3" methanol import line, piggybacked onto PL496, 17.0km long
PL575	8" gas pipeline, 492m long
PL576	Power, control & chemical umbilical line, 650m long
PL723	14" rigid pipeline, disconnected, 4.3km long
PL724	3" methanol import line, piggybacked onto PL723, 4.4km long
PL2066	10" production pipeline, 17.8km long
PL2067	Control and chemical injection jumper and umbilical line, 13.4km long
PL2066JW12	8" production jumper, 34.7m long
PL2067JW12	Control and chemical injection jumper (bundle[2]), 88m long
PL2066JWAB2	8" production jumper, 133m long
PL2067JWAB2	Control and chemical injection jumper (bundle[2]), 198m long
	Grout bags, 400 x 25kg, 21 x 1000kg
	Frond mattresses, various sizes, 41
	Concrete mattresses, various sizes, 244
	Deposited rock[3], approx. 15km long, 89,516 Tonnes

Table 2.1: Annabel & Audrey pipeline components[4]

There are three primary interfaces with other facilities and infrastructure:

- Audrey A (WD) – destination of PL575, PL723 & PL2066, source of PL576 & PL724 and main gas export route to LOGGS via PL496, destination of methanol via PL497 from LOGGS PP;
- Audrey B (XW) – source of PL2067 & gas exported via PL723;
- LOGGS – Destination of PL496, source of PL497.

2.2 Purpose

As per the BEIS Guidance Notes [1] pipeline decommissioning options require to be comparatively assessed. Further, if the condition of the mattresses or grout bags precludes their safe or efficient removal, then any proposal to leave them in place must be supported by an appropriate comparative assessment of the options.

There are drill cuttings near Audrey A (WD) and Audrey (XW) so a screening is required, and this is addressed as part of the comparative assessment.

[2] Bundle comprises 4x19.05mm diameter cores, 3x12.7mm diameter cores and 3x6.35mm diameter cores

[3] The quantity of deposited rock has been estimate from available data include historical 'as-built' reports and PWA applications

[4] Refer Appendix A.1 for more details of stabilisation features

Following public, stakeholder and regulatory consultation the Annabel & Audrey combined Decommissioning Programmes will be submitted in full compliance with the BEIS Guidance Notes [1]. The Annabel & Audrey Decommissioning Programmes [5] explain the principles of the removal activities and are supported by an environmental impact assessment [4] and this comparative assessment.

2.3 Environmental Setting

The pipeline area lies in a European Protected Site within the North Norfolk Sandbanks and Saturn Reef, and crosses the edge of the Indefatigable Banks and Swarfe Bank and the southern North Sea Harbour Porpoise pSAC. Details of the North Norfolk Sandbanks, pSAC and all other relevant environmental baseline data related to the area are provided in the environmental impact assessment [4].

The North Norfolk Sandbanks are the best example of linear sandbanks in UK waters. The banks are important not only as geological features but they also support a variety of fish, seabirds and important communities of invertebrates like crabs, starfish and worms.

The A Fields are also a feeding ground for thousands of birds who depend on the marine environment for their survival. The seabirds are vulnerable to the effects of hydrocarbon spills all year round, but especially in March, May, July, October and November.

The A Fields are right on the edge of an area protected for harbour porpoise. Two other protected species - common and grey seals can also be found here.

This location is also an important spawning and nursery ground for several different fish species. These include mackerel, herring, cod, lemon sole and the Norwegian lobster. The spawning periods will vary by species throughout the year, but all year round this location is considered highly sensitive as a nursery for important fish stocks. Fish stocks can be affected by disturbance to the seabed and discharges of chemicals or hydrocarbons.

2.3.1 The seabed in relation to the pipelines

PL496 is the 20” gas line from Audrey A (WD) to LOGGS. **PL497** is a 3” methanol line that is piggybacked onto PL496. **PL496** exits Audrey A (WD) on its eastern face. Much of the route (to KP15.6) lies within areas of mega-ripples and low sand waves.

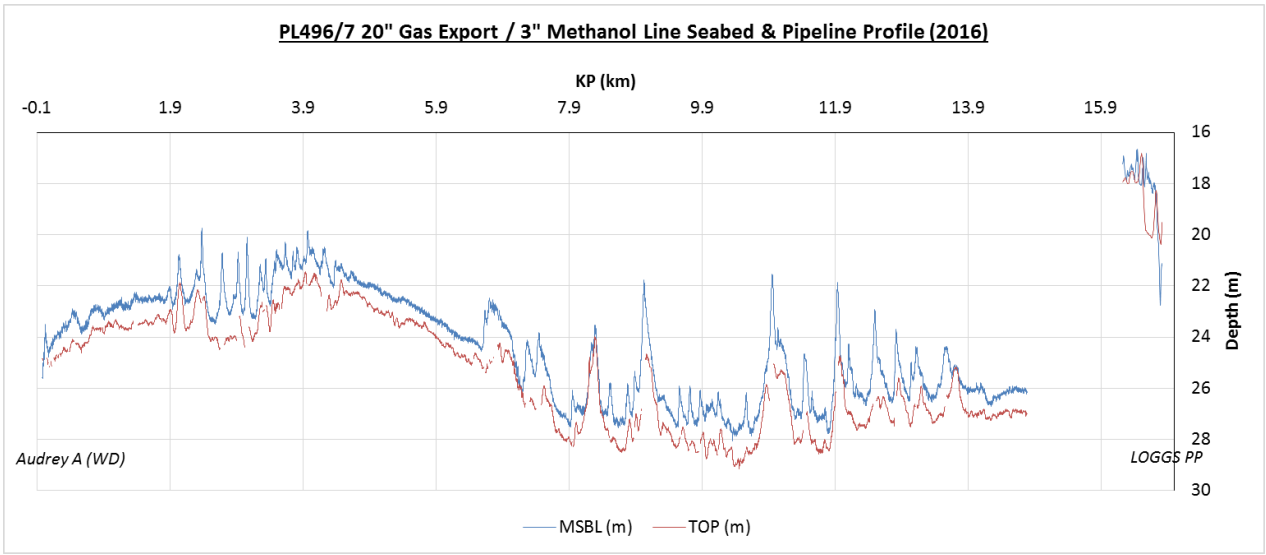

Figure 2.2: Seabed profile for PL496/7

Umbilical **PL576** runs between the Audrey A (WD) (water depth approximately 24m LAT) and Audrey 11a-7 WHPS (water depth approximately 26.5m LAT). The umbilical crosses smooth

upward sloping sand and gravel seabed for 220m or so to a water depth approximately 23m LAT before sloping downwards again until it meets **PL2066** 85m west of Audrey A (WD). Between **PL2066** and 11a-7 the umbilical crosses a mega-ripple field. **PL575** travels in the opposite direction to **PL576**. The water depth at Audrey11a-7 is approximately 26m LAT decreasing to approximately 22.5m LAT at KP0.33 and then increasing slightly to 24m LAT at Audrey A (WD). Between Audrey 11a-7 and PL2066 the pipeline crosses the same mega-ripple field and thereafter the pipeline crosses smooth seabed until it reaches Audrey A (WD).

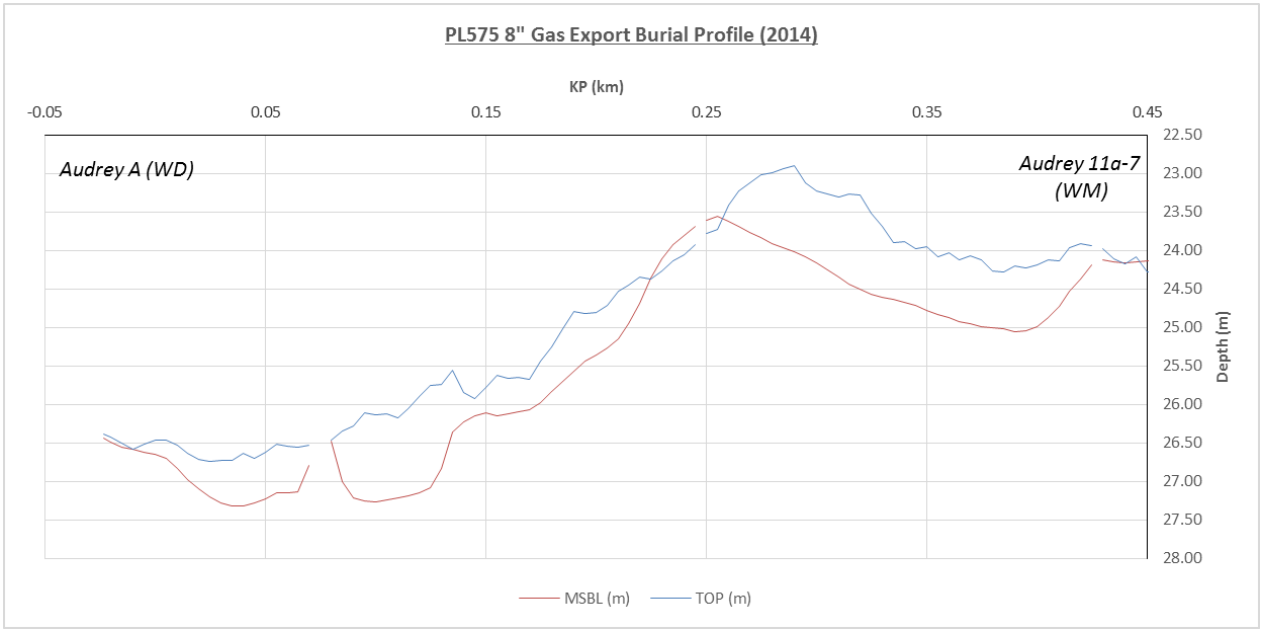

Figure 2.3: Seabed profile for PL575

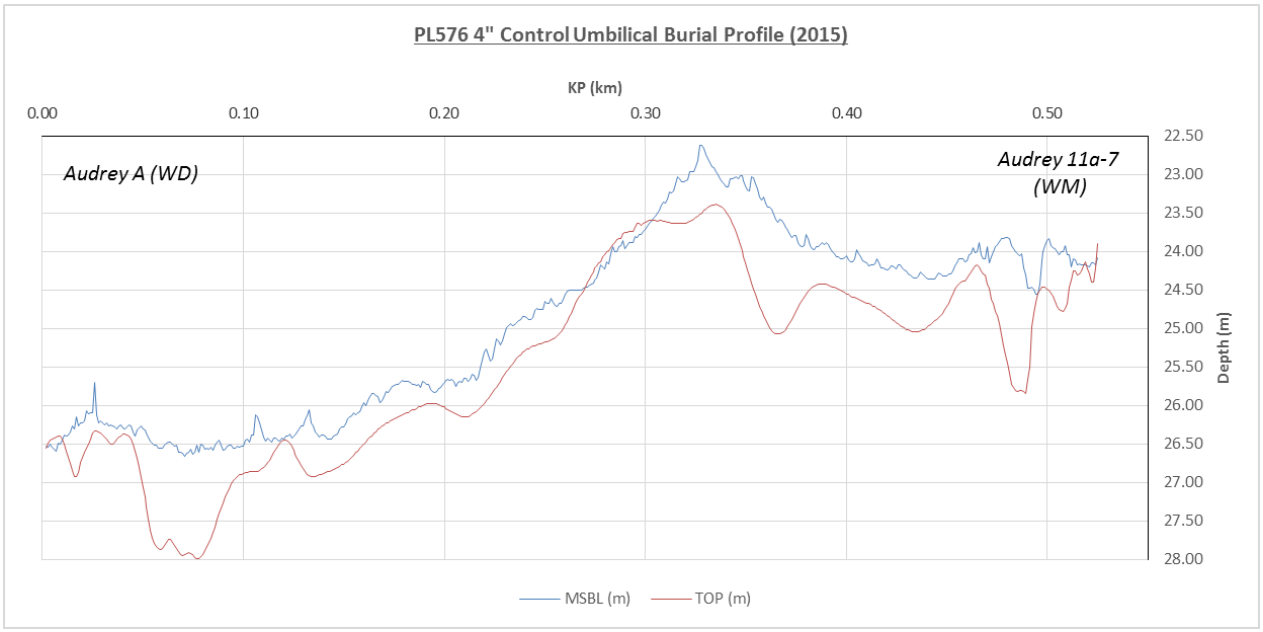

Figure 2.4: Seabed profile for PL576

PL723 is a disused 14" pipeline from Audrey B (XW) to Audrey A (WD). It is disconnected near Audrey A (WD). **PL724** is a 3" methanol line piggybacked onto **PL723** so it follows the same route. **PL723** exits Audrey B (XW) at its southern corner with **PL724** approximately 4m apart and enters a disturbed area of seabed 15m to 50m from the platform. The pipelines turn east approximately 40m and from there the piggybacked lines continue south east through a mega-ripple and sand wave field to KP3.606. The water depth increases from between 21.3m and

23.5m LAT near the Audrey B (XW) platform to between approximately 23m to 26m near Audrey A (WD). Between KP3.540 and KP4.165 the seabed is covered with low mega-ripples and a complex sand wave before gently undulating towards Audrey A (WD).

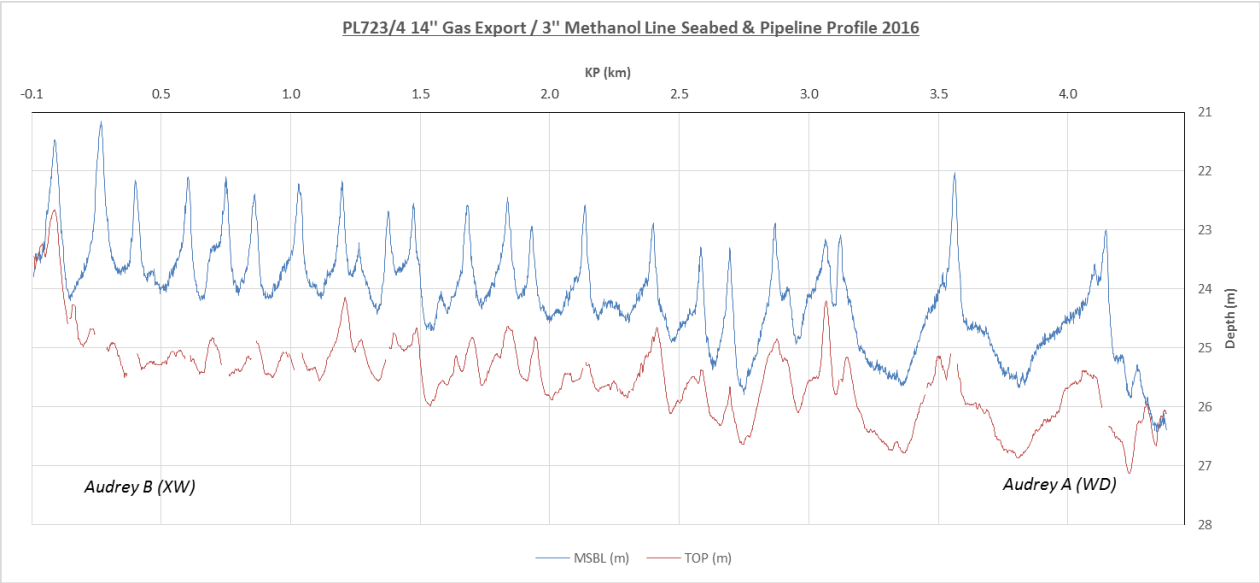

Figure 2.5: Seabed profile for PL723/4

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. In the immediate vicinity of the Annabel Template, the water depth averages 27.0m LAT. The structure lies within a north-west south-east trending strip of sand and gravel, with a sandier mega-rippled veneer to the south, north and east containing scattered boulders. Between Annabel and AB1 and AB2 WHPSs the pipelines and umbilical lines lie on a gravel and sand seabed with some evidence of slight sand accumulation on the south side of the WHPSs and their mattresses.

PL2066 exits Annabel at the manifold's south western face, initially heading west before turning abruptly south-south west approximately 30m from the manifold. From about 100m south of Annabel to approximately 2.3km north of Audrey B (XW), **PL2066** and **PL2067** run parallel and about 30m apart. The seabed falls from a depth of approximately 27m LAT at Annabel to a maximum depth of 36.5m 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 sand waves 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). This part of the route crosses a densely populated sand wave field, with sand waves initially being up to 5.5m high around KP10.0 falling to approximately 2m at KP16.0. From KP16.0 to within approximately 300m of Audrey A (WD) the sand waves have a wavelength of about 500m and stand up to 5m above the local seabed level.

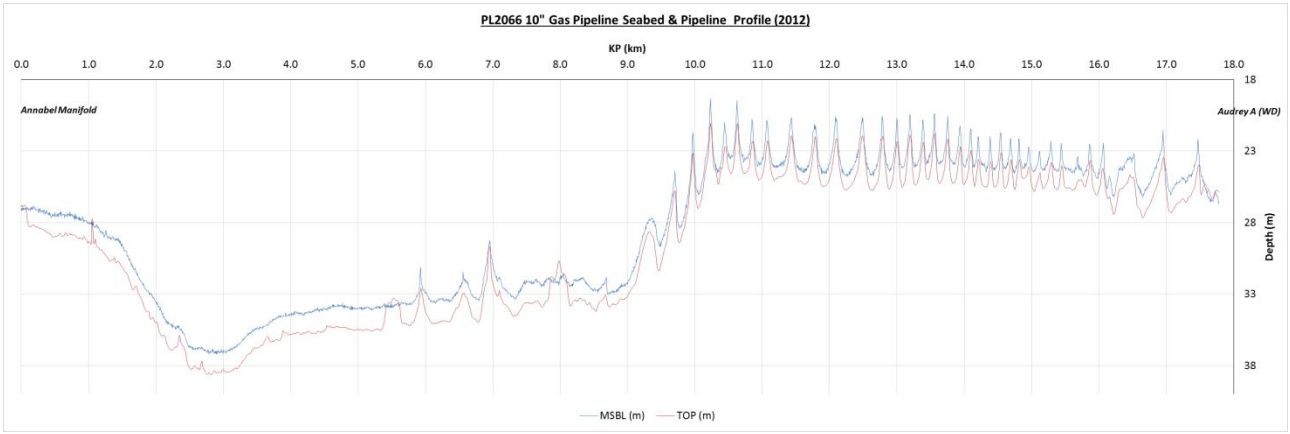

Figure 2.6: Seabed profile for PL2066

PL2067, the 5" control umbilical from Audrey B (XW) and **PL2066**, the 10" gas pipeline to Audrey A (WD), both arrive/exit Annabel on its south-west face. **PL2066** and **PL2067** cross a smooth sand and gravel seabed, which develops into a seabed with very low mega-ripples about 400m south of Annabel. They then cross a terrain of mega-ripples and smoother areas along their entire lengths, which develops into a mega-ripple and sand wave field about 9.4km south of Annabel. The seabed falls from a depth of approximately 27m LAT at Annabel to a maximum depth of 36.5m LAT in a broad shallow channel.

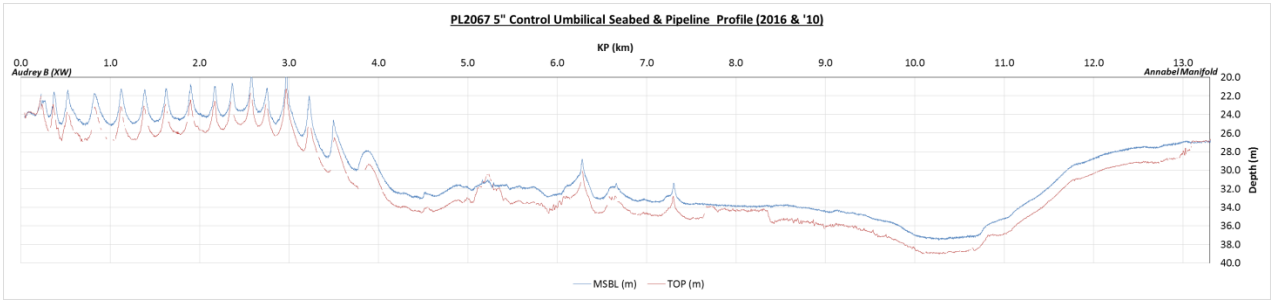

Figure 2.7: Seabed profile for PL2067

PL2066JW12 and **PL2067JW12** enter and exit Annabel on the manifold's north east face and run approximately 30m respectively from and to the AB1 WHPS across a flat seabed at a depth of 27m LAT.

PL2066JWAB2 enters Annabel at the manifold's north east face in close proximity to PL2066JW12 and PL2067JW12. **PL2067JWAB2** exits Annabel on the south-west face of the manifold, performs a tight curve to the south before joining with and running to Annabel AB2 WHPS beneath mattresses shared with **PL2066JWAB2**. Between the manifold and the wellhead the gravel and sand seabed is flat, lying at a depth of approximately 27m LAT.

2.3.2 Sand waves and sand banks

The area covered by the trenched pipelines lie within the North Norfolk Sandbanks, and crosses the edge of the Indefatigable Banks and Swarfe Bank and the southern North Sea Harbour Porpoise pSAC. Details of the North Norfolk Sandbanks, pSAC and all other relevant environmental baseline data related to the area are provided in the environmental impact assessment [4]. It is worth explaining what sand banks and sand waves are as this will provide context for some of the uncertainties we attempt to address in this comparative assessment.

Sand waves: Sand waves are a periodic bottom waviness generated by tidal currents in shallow tidal seas. Typical wavelengths range from 100 to 800 metres and they can be up to between 1 and 5 metres high. 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, sand waves 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.

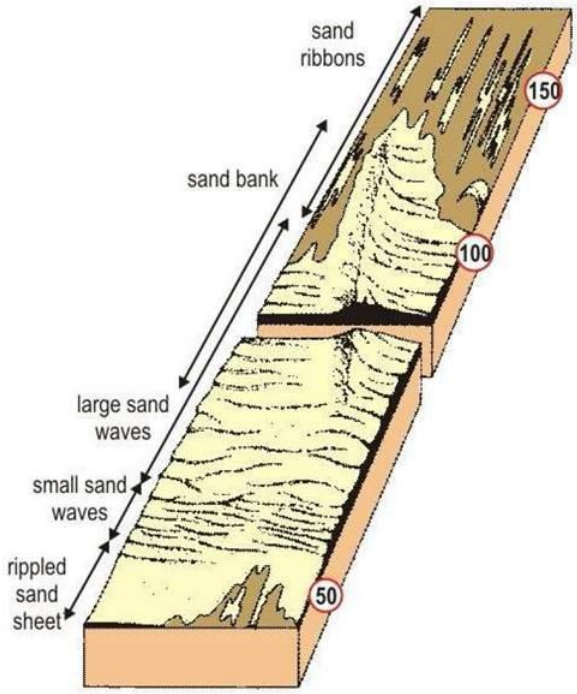

Figure 2.8: Sand waves and sand banks [2][5]

Sand banks: Most sand banks in the North Norfolk area of the southern North Sea 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 [12]. Sand banks are found widely on shallow continental shelves where there is an abundance of sand and where currents exceed a certain speed [8]. 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.

2.3.3 Deposited rock

While it is considered physically possible to remove deposited rock, the decommissioning philosophy in this document is consistent with the Guidance Notes [1], hence all deposited rock will be left *in situ*.

Material left in place will preserve the marine habitat that will have established over duration it has been on the seabed, and in this case its presence will not have a negative impact on the environment, conservation aims of the proposed conservation areas in the vicinity or impact on the safety and other uses of the sea.

Methods that could be used to remove the rock include:

[5] The numbers in red circles are mean spring near surface currents in cm/sec. i.e. divide by 100 to give speed in m/sec

- dredging the scour protection and disposing of the material at an approved offshore location
- dredging the scour protection and transporting the material to shore to be disposed of in an approved manner
- lifting the rock using a grab vessel, depositing in a hopper barge and transporting it to a shore for appropriate disposal.

All of these proposed methods would impact on the seabed and associated communities, create sediment plumes, and require additional vessel use with the associated environmental impacts, safety risks, impacts on other users of the sea and additional costs.

2.4 Assumptions, Limitations and Gaps in Knowledge

The most significant assumptions, limitations and knowledge gaps relating to the comparative assessment are listed below. In addition, it should be noted that the presentation of the different categories of risks for comparison has required a degree of engineering judgement.

- A purely qualitative approach has been taken. This has necessarily required a degree of judgement, but since most impacts are related to area impacted, duration of works and vessel time we felt this was appropriate;
- Unless noted otherwise, complete removal of the pipelines would be achieved by reverse reeling. However, we recognise that there is limited experience of reverse reeling trenched and buried pipelines from the seabed [7], so estimations of the safety risks, technical challenges and cost implications carry some uncertainty;
- The 'complete removal' option assumes that pipelines underneath any pipeline crossing would be cut on either side of the pipeline crossing;
- There are known exposures on the pipelines outside of the Audrey A (WD), Audrey B (XW), Annabel and LOGGS 500m safety zones, Centrica is not aware of any fishing gear snagging reports. To our knowledge no exposures have been of such a magnitude that they have not warranted being recorded as a snagging hazard via Kingfisher Information Services in FishSAFE (www.fishsafe.eu);
- An environmental survey would be required on completion of decommissioning activities;
- Any pipeline (or umbilical) being left *in situ* would be subject to at least two legacy burial surveys;
- The seabed sediment type is such that mounds created during any decommissioning operations would not present snagging hazards;
- In the longer-term, deposited rock berms would not present snagging hazards;
- Impacts on SAC are assumed to be proportional to the amount of work done on the seabed;
- The impact of the procurement of any new materials such as fabricated items or mining of new rock is ignored;
- Impact on commercial activities is inversely proportional to vessel activity;
- Societal benefits and vessel associated environmental impacts and risks are assumed to be proportional to vessel duration;
- Only a high-level comparison of what differentiates the costs is used.

3. THE PIPELINES

3.1 PL496 Audrey 20" gas export pipeline to LOGGS PP (& PL497)

PL496 is the 20" gas export pipeline that is approximately 16.9km long, and that it is piggybacked with PL497 (17.0km long). That is, PL497 is connected to PL496 using clamps. PL496 is routed from the Audrey A (WD) platform to the LOGGS PP platform. We believe 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.

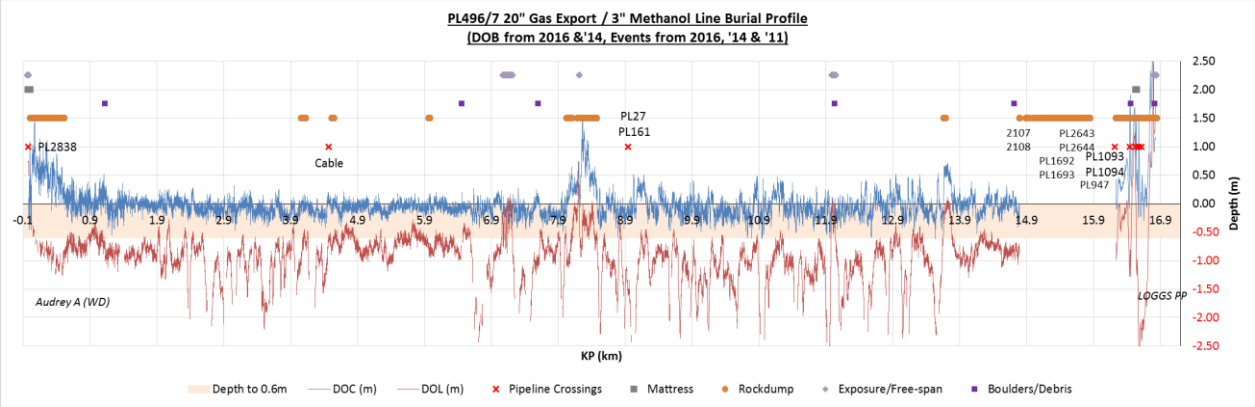

Figure 3.1: Overall burial of PL496/7 (Audrey A (WD) to LOGGS PP)

The 3" flexible pipe spools on the approach are bolted to the 3" methanol pipeline and the riser at Audrey A (WD). As-built data would suggest that at the riser end the 3" flexible methanol pipe spool (50m long) is protected with concrete mattresses. It does not follow the same route to the Audrey A (WD) platform as the 20" pipe spools and on the final approach to Audrey A (WD), after the pipeline to pipeline spool weld the 20" pipe spools appear to be exposed and not protected (Appendix B.5).

The burial profile in Figure 3.1 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 rock. Deposited rock can be found along the majority of the pipeline lengths and this is shown graphically in Figure 3.2.

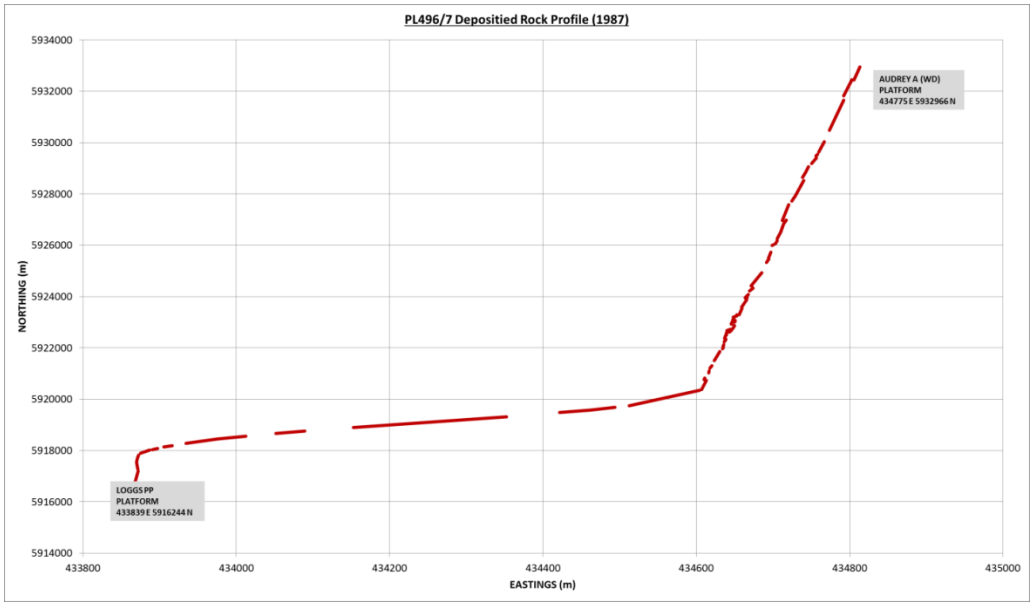

Figure 3.2: PL496/7 Original 'As-Built' Profile of Deposited Rock

Ignoring the pipespools at the platform approaches, short exposed lengths of pipeline can be 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, KP12.0 for 5m and KP12.02 for 6m. Note that the infield pipeline exposures are outside the 500m safety zones and will have been subject to any fishing activities in the area.

Details are scant, but on the final LOGGS PP approach the last 10-15 metres of the 20" pipeline pipe spools and the piggybacked flexible 3" methanol line appear to be exposed.

Several pipeline[6] and cable crossings have been identified and are shown in Figure 3.6 and listed in Table 3.5.

Pipeline or Cable Description	KP	Protection
PL2838 10" gas export pipeline from Ensign NPAI to Audrey A (WD)	-0.02	PL496/497 on sea bed, overlain with mattresses & grout bags before PL2838 and additional mattress protection
BT Telecoms cable from Weybourne to Fano (Dead) N/A	4.48	Cable not found during PL496 installation; no physical crossing
PL27 28" gas export line from Viking AR to Mablethorpe	8.95	PL27/161 trenched & buried, mattress protection under PL496/497, overlain with stabilisation mattresses & rock
PL161 3" methanol piggy back line from Viking AR to Mablethorpe		
Cable from Mundersley to Nordeney (Dead)	N/A	Buried
PL2107 14" gas export pipeline from Saturn ND to LOGGS PR	16.22	Rock
PL2108 3" methanol pipeline LOGGS PR to Saturn ND		
PL1962 12" gas export pipeline from Vampire OD to LOGGS PR	16.44	Rock
PL1963 3" methanol pipeline from LOGGS PR to Vampire OD		
PL947 12" gas export pipeline from Ann to LOGGS RP	16.54	PL496/497 trenched & buried, rock & mattresses under PL947 and overlain with rock
PL2643 12" gas export pipeline from Viking to LOGGS RP	16.58	Rock
PL2644 3" methanol pipeline from LOGGS PR to Viking		
PL1093 18" gas export pipeline from Ganymede ZD to LOGGS RP	16.62	Rock
PL1094 3" methanol pipeline from LOGGS PR to Ganymede ZD		

Table 3.1: PL496/7 Pipeline & Cable crossings

PL496, PL497, and PL2383 are owned by Centrica, while the rest of the pipelines are owned by ConocoPhillips.

Given the profile of the pipeline, we believe that the pipeline will remain stable. It is buried – in many instances to depths up to 2m, and it is protected along much of its length with deposited rock. Pipeline surveys over the years suggest that over time much of the rock has become covered in sediment to such an extent that it has become indistinguishable from the surrounding habitat. On the LOGGS approach the seabed has experienced significant scour as well as deposition of sediment.

The BEIS Guidance Notes state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. The majority of the pipeline is buried to a depth greater than 0.6m below mean seabed albeit with some short exposures but not spans.

The presence of the pipeline crossings over PL496/7 has not unduly influenced the comparative assessment for the pipelines, although clearly such influences would need to be accounted for.

[6] A higher pipeline number crosses over the top of a pipeline with a lower identification number, so for example, PL2383 crosses **over** PL496/7

3.2 PL575 Audrey 11a-7 to Audrey A (WD) 8” pipeline

PL575 is an 8” gas export pipeline that is approximately 492m long and routed from the Audrey 11a-7 subsea tie-back to Audrey A (WD). Ostensibly PL575 shares the same trench as PL576 and is fully contained within the current Audrey A (WD) 500m safety zone.

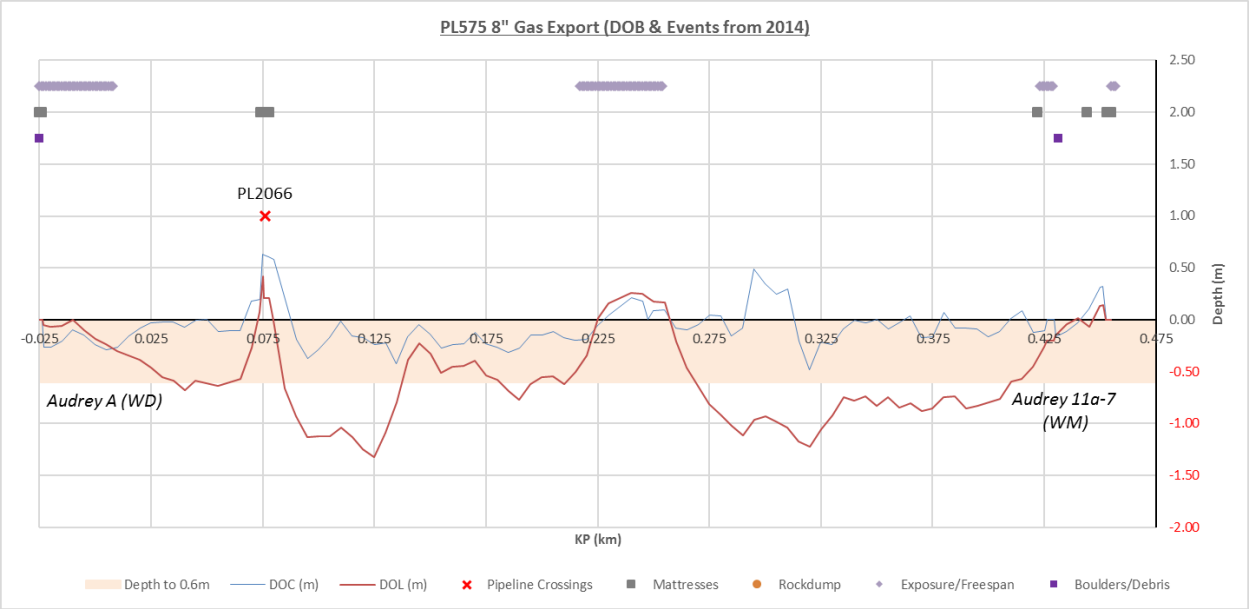

Figure 3.3: Overall burial of PL575[7] (Audrey 11a-7 gas export pipeline)

The profile shown in Figure 3.3 indicates that the pipeline exhibits a somewhat erratic burial profile. The pipeline appears to be reasonably well buried for most of its length, with burial being almost 1.5 metres 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.

A pipeline[8] crossing has been identified and are shown in Figure 3.3 and listed in Table 3.2.

Pipeline or Cable Description	KP	Protection
PL2066 10” gas export pipeline from Annabel manifold to Audrey A (WD)	0.076	PL575/PL576 trenched, 5 mattresses & 2 gravel gabions at cross-over point, overlain by PL2066 with additional mattresses on top of PL2066

Table 3.2: PL575 Pipeline crossings

PL2066 is owned by Centrica.

Given the burial profile of the pipeline, we believe that the pipeline will remain stable. It is buried – in some instances to depths up to 1.5m, although it experiences some exposures along its length. The BEIS Guidance Notes [1] state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. The majority of the pipeline is buried to a depth at or around than 0.6m below mean seabed albeit with some short exposures.

Proposals for decommissioning this pipeline are examined in this comparative assessment.

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

[8] A higher pipeline number crosses over the top of a pipeline with a lower identification number, so for example, PL2066 crosses **over** PL575

3.3 PL576 Audrey A (WD) to Audrey 11a-7 umbilical

PL576 is an umbilical line that provides power, control and chemicals to Audrey 11a-7. It is approximately 650m long and routed from the Audrey A (WD) platform to Audrey 11a-7. Ostensibly PL576 shares the same trench as PL575.

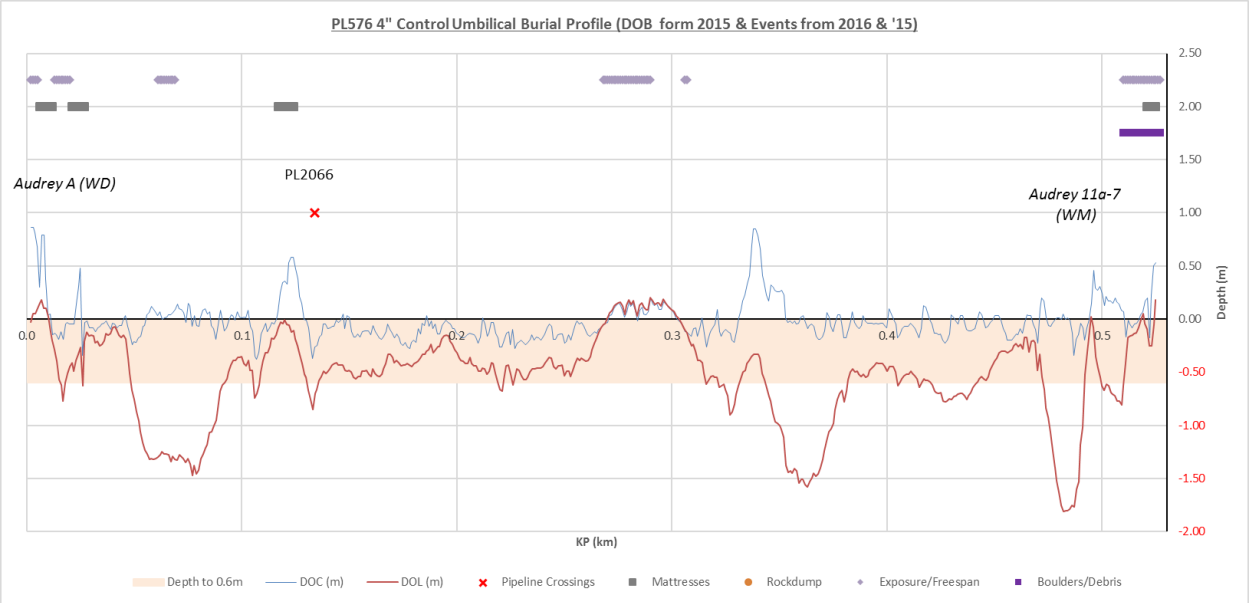

Figure 3.4: Overall burial of PL576 (Audrey A (WD) to Audrey 11a-7)[9]

The profile shown in Figure 3.4 indicates that the pipeline exhibits a somewhat erratic burial profile. The pipeline appears to be reasonably well buried for most of its length, with burial of the pipeline being around 1.5 metres deep in three locations. However, the pipeline is exposed at the start and end as well as at two points approximately one-third and two-thirds along.

The BEIS Guidance Notes state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. The majority of the pipeline is buried to a depth at or around 0.6m below mean seabed albeit with some short exposures.

A pipeline crossing has been identified (PL2066). It is shown in Figure 3.4 and listed in Table 3.3 above.

Pipeline or Cable Description	KP	Protection
PL2066 10" gas export pipeline from Annabel manifold to Audrey A (WD)	0.134	PL575/PL576 trenched, 5 mattresses & 2 gravel gabions at cross-over point, overlain by PL2066 with additional mattresses on top of PL2066

Table 3.3: PL576 Pipeline crossings

Proposals for decommissioning this pipeline are examined in this comparative assessment.

3.4 PL723/4 Audrey B (XW) to Audrey A (WD) 14" & 3" pipelines

PL723 is the 14" gas export pipeline that is approximately 4.3km long, and that it is piggybacked with PL724. PL724 is a 3" methanol line that exports methanol from Audrey A (WD) to Audrey B

[9] 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

(XW). PL724 is connected to PL723 using clamps. PL723 is routed from the Audrey B (XW) to the Audrey A (WD) platform but is no longer used and has been disconnected from the base of the Audrey A (WD) riser.

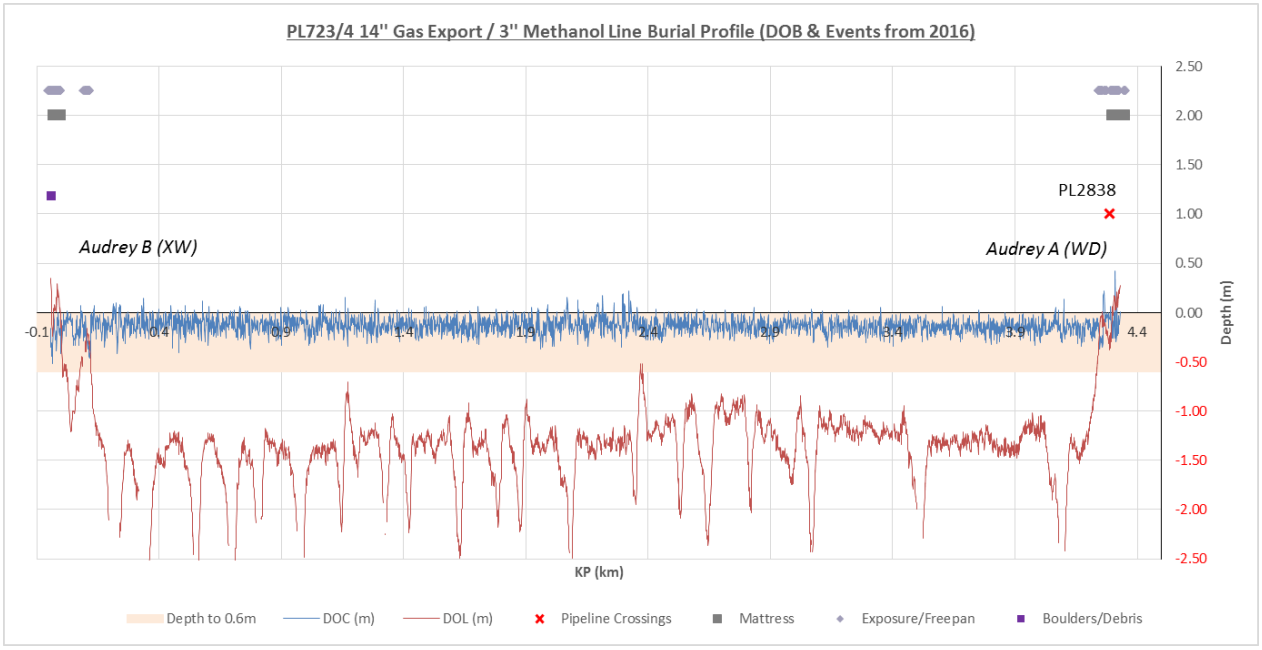

Figure 3.5: Burial profile for PL723/4 (Audrey B (XW) to Audrey A (WD))

Based on the burial profile presented in Figure 3.5 we believe that the pipeline is buried and remains stable. There is one pipeline crossing at KP4.29 and this is where the 10" gas export pipeline from Ensign (PL2383) crosses PL724 and with no protection. Refer Figure 3.5 and Table 3.4.

Pipeline or Cable Description	KP	Protection
PL2838 10" gas export pipeline from Ensign to Audrey A (WD)	4.29	None

Table 3.4: PL723/4 Pipeline crossing

The BEIS Guidance Notes [1] state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. Most of the pipeline is buried to a depth greater than 0.6m below mean seabed albeit with some short exposures.

The presence of the one pipeline crossing (PL2838) over PL723 & PL724 has not influenced the comparative assessment for the pipeline.

Proposals for decommissioning this pipeline are examined in this comparative assessment.

3.5 PL2066 Annabel 10" gas export pipeline to Audrey A (WD)

PL2066 is the 10" gas export pipeline that is approximately 17.8km long and routed from the Annabel manifold inside the Annabel template through to Audrey A (WD). When installed in 2006 the pipeline was trenched and buried, but throughout its length the pipeline is intermittently protected by deposited rock. The approaches to both Annabel template and the Audrey A (WD) platform are stabilised and protected with concrete mattresses, although the mattress cover on the approach to the Annabel template is not continuous.

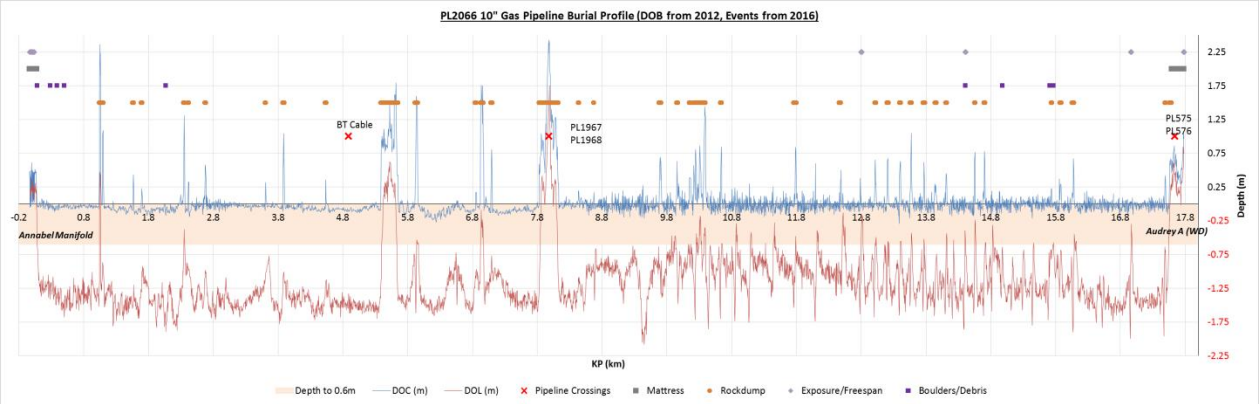

Figure 3.6: Overall burial of PL2066 (10" gas export line Annabel to Audrey A (WD)

Several pipeline and cable crossings[10] have been identified and are shown in Figure 3.6 and listed in Table 3.5.

Pipeline or Cable Description	KP	Protection
NSO-1 BT Telecoms cable from Weybourne to ACMI MASTER (under PL2066)	4.89	Cable trenched, mattress protection under PL2066, overlain with rock
PL1967 20" gas export pipeline from Carrack South to Clipper PR	7.98	Shares crossing with PL2067, as reflected in crossing number. PL2066/2067 raised above PL1967/1968 with plinths & rock, overlain with rock. Crossing also contains mattresses & gabions
PL1968 4" methylene glycol pipeline from Clipper PR to Carrack QA		
PL575 8" gas export line from Audrey 11a-7 well to Audrey A (WD)	17.65	PL575/576 trenched, 5 mattresses & 2 gravel gabions at cross-over point, overlain with PL2066 with additional mattresses overlain on PL2066
PL576 4" umbilical from Audrey A (WD) to Audrey 11a-7 well		

Table 3.5: PL2066 Pipeline & Cable crossings

PL1967 and PL1968 are owned by Shell while PL575 and PL576 are owned by Centrica.

Survey data obtained since the original installation would suggest that the majority of the pipeline has remained relatively stable throughout its entire length. Relatively short lengths of the pipeline close to the Annabel manifold and near the Audrey A (WD) platform (up to a maximum of 21m in any one location, 2009 & 2012, to a greater or lesser degree) have been exposed over the years although no free spans have been recorded. The approaches at Audrey A (WD) and Annabel template are stabilised and protected with concrete mattresses.

The BEIS Guidance Notes [1] state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. The majority of the pipeline is buried to a depth greater than 0.6m below mean seabed.

Proposals for decommissioning this pipeline are examined in this comparative assessment.

3.6 PL2066JW12 Annabel AB1 8" production jumper to Annabel manifold

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

[10] A higher pipeline number crosses over the top of a pipeline with a lower identification number, so for example, PL2066 crosses **over** PL575

pipeline is protected and stabilised using concrete mattresses.

As this pipeline is surface laid, from a comparative assessment perspective we believe that the benefits of removal would outweigh those for leaving the pipeline *in situ*. Therefore, as this approach is in full compliance of para 10.8 of the BEIS Guidance Notes [1], we propose not to subject this pipeline to comparative assessment.

3.7 PL2066JWAB2 Annabel AB2 8" production jumper to Annabel manifold

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 this pipeline is surface laid, from a comparative assessment perspective we believe that the benefits of removal would outweigh those for leaving the pipeline *in situ*. Therefore, as this approach is in full compliance of para 10.8 of the BEIS Guidance Notes [1], we propose not to subject this pipeline to comparative assessment.

3.8 PL2067 Annabel umbilical line from Audrey B (XW) to Annabel manifold

The Annabel manifold valves and wellhead derive power, hydraulic fluids and chemicals from Audrey B (XW) via pipeline PL2067. This is an umbilical line. The pipeline is approximately 13.4km long and when installed in 2006 it was trenched and buried. The third-party pipeline crossings are protected with rock. The approaches to both Annabel template and the Audrey B (XW) platform are stabilised and protected with concrete mattresses.

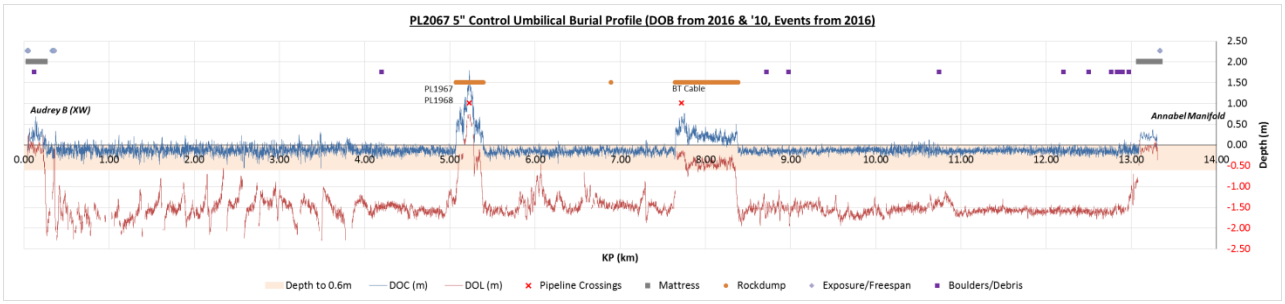

Figure 3.7: Burial for PL2067 (Umbilical Audrey B (XW) to Annabel)

Two pipeline crossings[10] have been identified and are shown in Figure 3.7. PL2067 crosses over the live 'BT Telecoms Cable from Weybourne to ACMI MASTER' cable at KP8 and crosses over PL1967 and PL1968 Clipper pipelines at KP5.2. Both pipeline crossings are protected and stabilised with rock. The pipelines that PL2067 crosses over are as follows:

Pipeline or Cable Description	KP	Protection
NSO-1 BT Telecoms cable from Weybourne to ACMI MASTER (under PL2066)	8.0	Cable trenched, mattress protection under PL2067, overlain with rock
PL1967 20" gas export pipeline from Carrack QA to Clipper PR	5.20	Shares crossing with PL2066, as reflected in crossing number. PL2066/2067 raised above PL1967/1968 with plinths & rock, overlain with rock. Crossing also contains mattresses & gabions
PL1968 4" methylene glycol import pipeline from Clipper PR to Carrack QA		

Table 3.6: PL2067 Pipeline & Cable crossings

PL1967 & PL1968 are both owned by Shell.

The pipeline was trenched and buried along its length, and in just two locations rock was placed to provide protection to the BT cable crossing and the PL1967 & PL1968 pipeline crossings. As can be seen in the burial profile (Figure 3.7), PL2067 experiences a good burial profile with most of the pipeline buried to a depth greater than 0.6m below the local seabed. The umbilical remains comparatively stable.

The BEIS Guidance Notes state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. The majority of the pipeline is buried to a depth below mean seabed greater than 0.6m.

Notwithstanding the placed rock associated with them, the presence of third-party cable or pipeline crossings underneath PL2067 does not influence the comparative assessment for this pipeline.

Proposals for decommissioning this pipeline are subject to comparative assessment.

3.9 PL2067JW12 Annabel AB1 umbilical jumper from manifold

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 this pipeline is surface laid, from a comparative assessment perspective we believe that the benefits of removal would outweigh those for leaving the pipeline *in situ*. Therefore, as this approach is in full compliance of para 10.8 of the BEIS Guidance Notes [1], we propose not to subject this pipeline to comparative assessment.

3.10 PL2067JWAB2 Annabel AB2 umbilical jumper from Annabel manifold

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 this pipeline is surface laid, from a comparative assessment perspective we believe that the benefits of removal would outweigh those for leaving the pipeline *in situ*. Therefore, as this approach is in full compliance of para 10.8 of the BEIS Guidance Notes [1], we propose not to subject this pipeline to comparative assessment.

3.11 Pipeline crossings

The pipelines considered in this comparative assessment either cross over cables and pipelines installed previously or are crossed by newer pipelines as illustrated in Figure 3.8. This can be determined by the pipeline number. A higher pipeline number crosses over the top of a pipeline with a lower identification number, so for example, PL2066 crosses over PL575 and PL576.

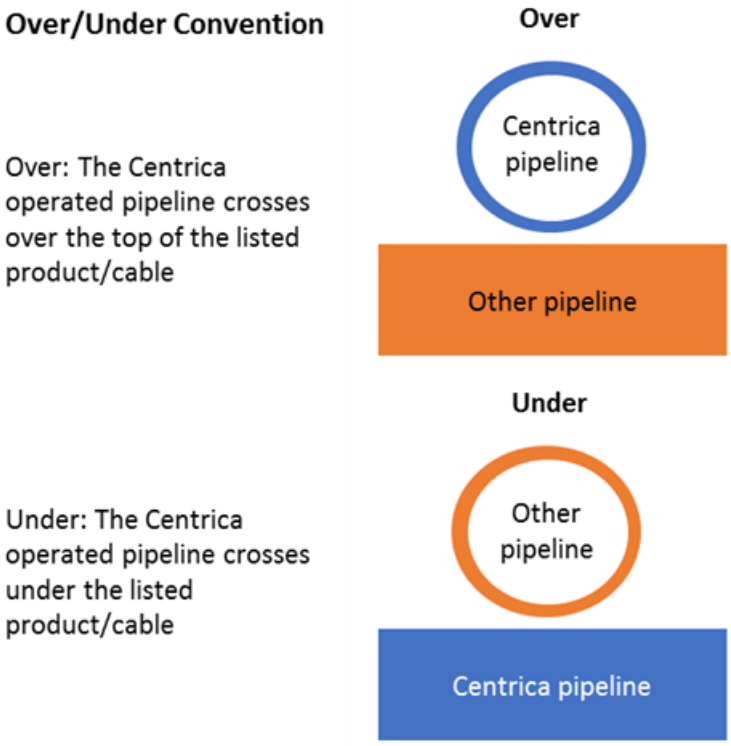

Figure 3.8: Over/under convention for pipeline crossings

4. DECOMMISSIONING OPTIONS

4.1 Decommissioning the pipelines

The options detailed in this section are those that have been included in the comparative assessment process. Except for the piggybacked pipelines, the pipelines are separate and are therefore considered individually. Therefore, the options for decommissioning these pipelines are independent.

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 comparative assessment; 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, all options would involve removing the exposed ends lying on the seabed as well as the pipelines in the trench transition areas not covered with rock, so these elements are not considered as differentiators in this comparative assessment process. All options include removal of features such as spool pieces, mattresses and grout bags in accordance with

mandatory requirements.

The short ends associated with the pipeline approaches and exposed on the seabed are illustrated for Audrey in Figure 4.1 as follows:

PL496/PL497: Items 15, 16, 17, 18, 19, 20

PL575: Items 13

PL576: Items 12, 14

PL723/PL724: Items 3, 4, 5, 6, 8, 9, 10

Further details of the pipeline decommissioning options for Audrey are described in Sections 4.1.1, 4.1.2, 4.1.3, and 4.1.4. The activities detailed in these sections are expected to be undertaken using different vessel types. Vessel types might include a construction support vessel, a dive support vessel, or a pipelay vessel or a mixture of all three, depending on the activities being undertaken.

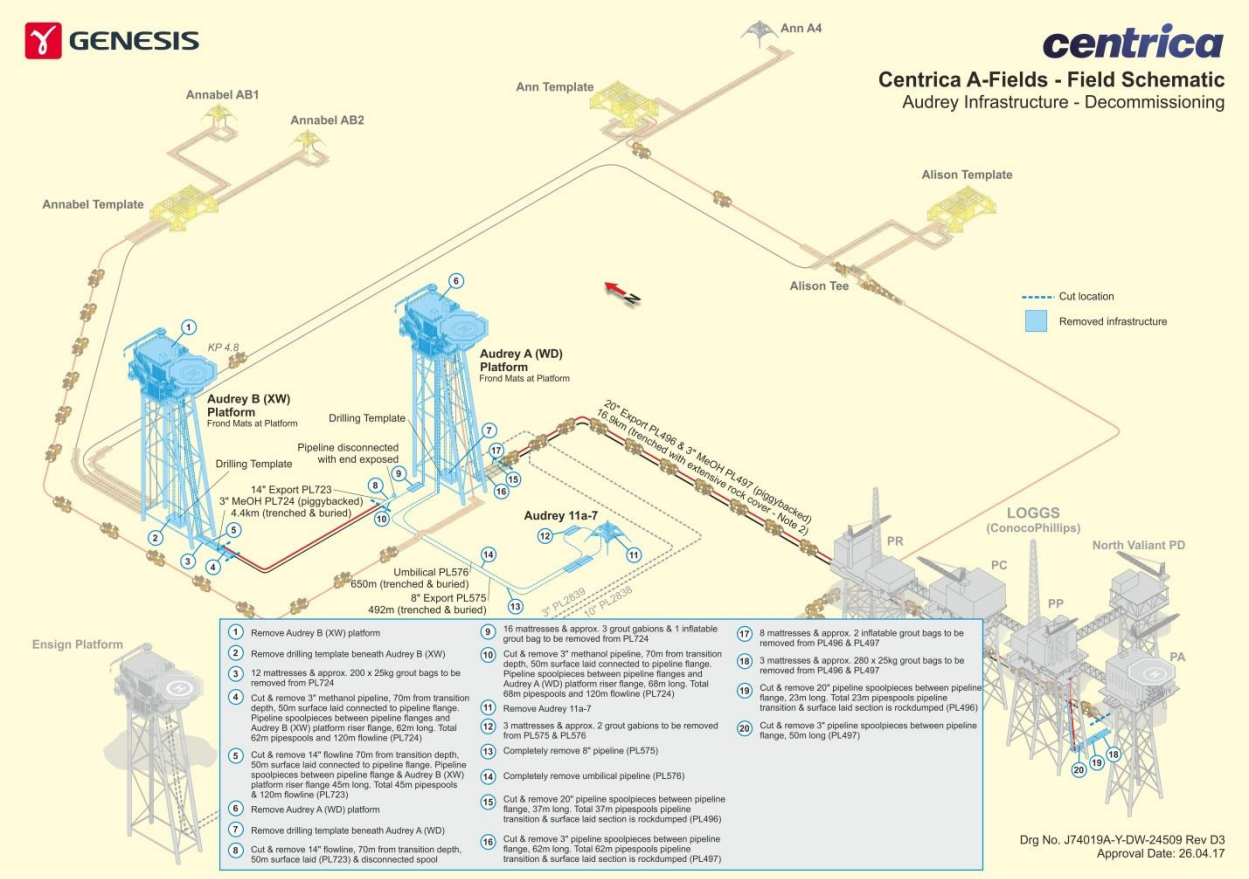

Figure 4.1: Audrey proposed decommissioning solution

The short ends associated with the pipeline approaches and exposed on the seabed are illustrated for Annabel in Figure 4.2 as follows:

PL2066: Items 8, 9, 12, 13

PL2066JW12: Items 3, 4

PL2066JWAB2: Items 5, 6

PL2067: Items 10, 11, 14, 15

PL2067JW12: Items 3, 4

PL2067JWAB2: Items 5, 6

Further details of the pipeline decommissioning options for Annabel are described in Sections 4.1.5, and 4.1.6. The activities detailed in these sections are expected to be undertaken using different vessel types. Vessel types might include a CSV, a DSV, or a pipelay vessel or a mixture of all three, depending on the activities being undertaken.

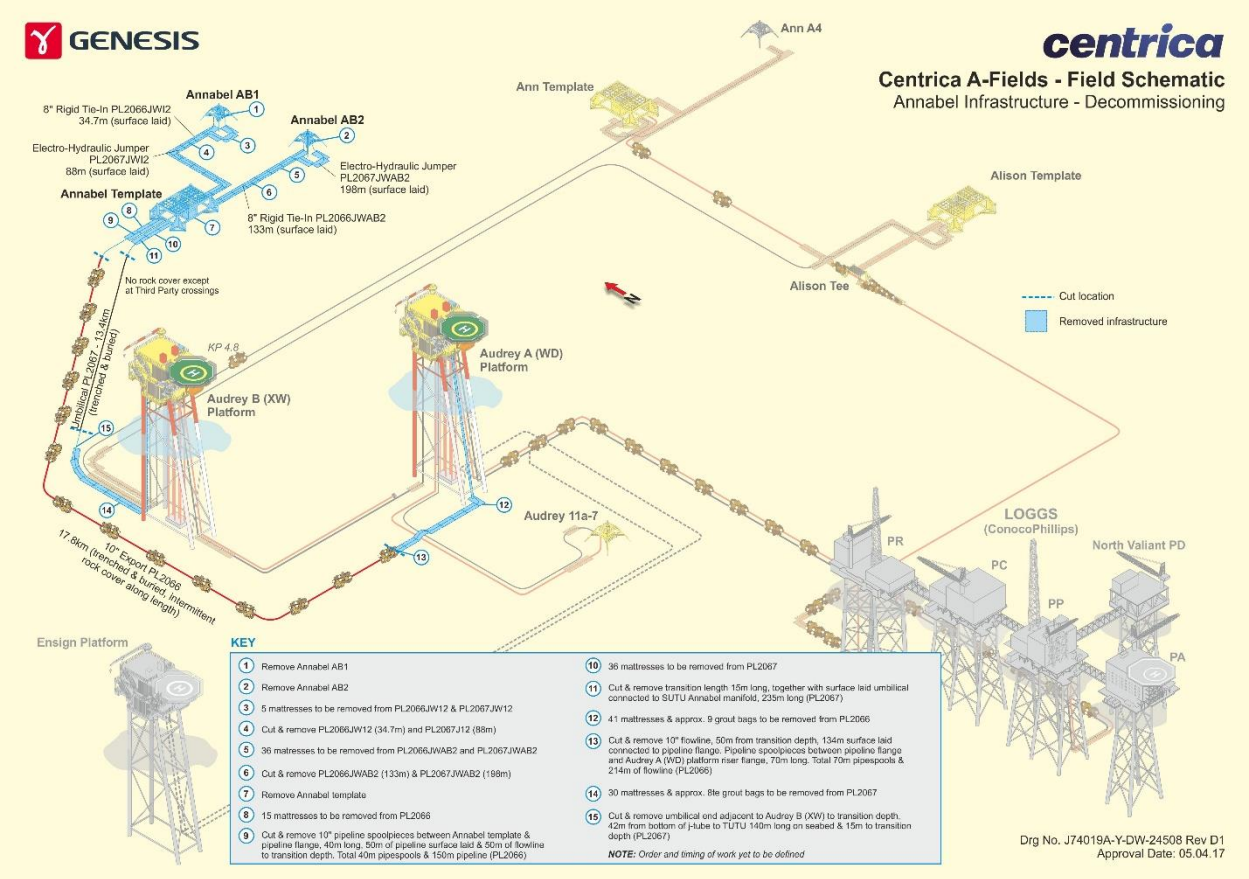

Figure 4.2: Annabel proposed decommissioning solution

4.1.1 Options and methods for decommissioning PL496/7

ID[11]	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) at LOGGS PP. Total to be removed approx. 23m (PL496) & 70m (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 4.1: Options for decommissioning PL496/7

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

4.1.2 Options and methods for decommissioning PL575

ID[12]	Item	Option 1 Complete Removal	Option 2 Partial Removal[7]	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 4.2: Options for decommissioning PL575

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

4.1.3 Options and methods for decommissioning PL576

ID[13]	Item	Option 1 Complete Removal	Option 2 Partial Removal[7]	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. *Cut umbilical at bottom of J-tube. Excavate buried section to transition depth. This may also involve local water jetting. Recover surface laid umbilical from bottom of J-tube through to transition depth 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 4.3: Options for decommissioning PL576

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

4.1.4 Options and methods for decommissioning PL723/4

ID[14]	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[15] 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 4.4: Options for decommissioning PL723/4

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

[15] 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

4.1.5 Options and methods for decommissioning PL2066

Item	Option 1 Complete Removal	Option 3 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 4.5: Options for decommissioning PL2066

4.1.6 Options and methods for decommissioning PL2067

Item	Option 1 Complete Removal	Option 3 Leave *it 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. *Cut umbilical at bottom of J-tube. Excavate buried section to transition depth. This may also involve local water jetting. Recover surface laid umbilical from bottom of J-tube through to transition depth 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 4.6: Options for decommissioning PL2067

4.2 Dealing with pipeline crossings

The various pipeline and cable crossings will impact or be impacted by the decommissioning options described in section 4.1. The potential impacts are summarised in Table 4.7.

Decommissioning Option	Newer pipeline on top	Older pipeline or cable underneath[16]
Full removal	Cut Centrica pipeline either side of third-party pipeline crossing	No impact on option
Partial removal or remedial work	No impact on option; leave Centrica pipeline *in situ*	No impact on option
Leave *in situ*	No impact on option; leave Centrica pipeline *in situ*	No impact on option

Table 4.7: Impact of pipeline crossings on pipeline decommissioning options

4.3 Decommissioning of the concrete mattresses

The quantity of mattresses that need to be removed is detailed in Appendix A. An interrogation of recent survey data (May 2016) would suggest that the concrete mattresses are of the 'flexible' concrete mattress type, articulated to flexible along and across pipeline being protected, rather than the 'log'-type which is only flexible in one direction. These are available from a number of different manufacturers, including Subsea Protection Systems Ltd (1990s), Pipeshield (1999), etc.

Typically mattresses are provided in a standard size 6m x 3m or 6m x 2m and can be supplied with blocks that are 150mm, 300mm and 450mm thick. Typically, the concrete blocks are held together with polypropylene rope, and this is also looped around the edges to allow the mats to be lifted and moved into positon.

The concrete material of manufacture can be customised in a range of densities from standard (1850kg/m^3) to high (4850kg/m^3). The availability of the different dimensions and type depend on manufacturer.

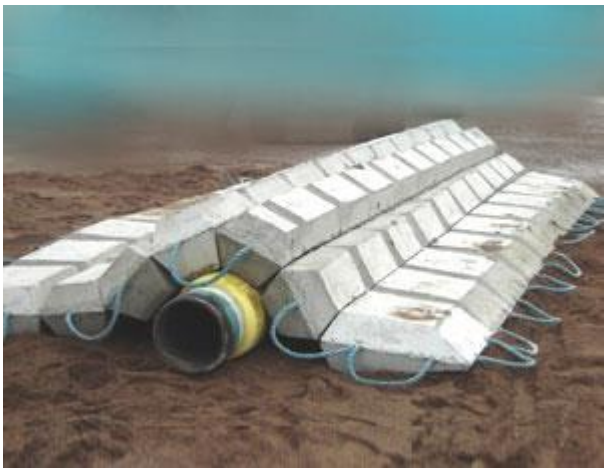

Figure 4.3: Typical Concrete Mattresses[17]

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

[16] Although it is noted here that there would be discernible impact on the decommissioning option, permission would need to be granted from the owner of the older pipeline to carry out any works

[17] Picture courtesy of Subsea Protection Systems Limited and Pipeshield Limited

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 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 we have test lifted one of the concrete mattresses at Ann template in January 2016, and as the mattresses are of a similar vintage as those at Audrey we believe that the condition of the concrete mattresses at Audrey and Annabel is such that they can be fully recovered. Should we encounter any difficulties during recovery operations we shall discuss possible solutions with BEIS.

4.4 Decommissioning of the 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, and this is called scour. Scour around a structure or pipeline will undermine its stability, and so is undesirable.

Fronded mattresses is put in place to provide protection against scour, and when they do their job 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.

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

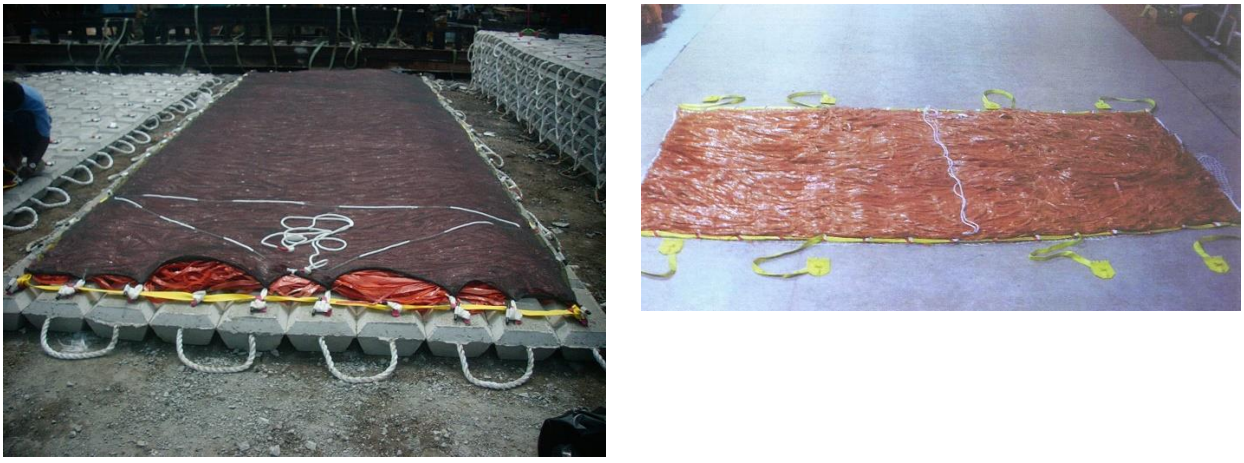

Figure 4.4: Typical Fronded Mattress Types (gravity based & anchored)[18]

Frond mattresses are used to a lesser extent than concrete mattresses in the south North Sea [9]. We have identified that a number of frond mattresses were installed to protect the Annabel template structure although we have not been able to determine the design details or how they were designed to stay in place. The indications are that they have performed their function and are now quite indistinguishable from the surrounding seabed.

- 10 frond mattresses 6m x 2m wide x unspecified height around the Annabel template

Their height is manufactured from flexible material design to accumulate seabed sediment and as such we don't believe that they would present a snagging hazard. Therefore, we would

[18] Photos courtesy of http://www.sscsystems.com/

propose to decommission the frond mattresses by leaving them *in situ*.

4.5 Decommissioning of the 'grout bags'

The number of grout bags (Appendix A.1) has been estimated using engineering judgement based available data such as as-built drawings, design sketches and Pipeline Works Authorisations.

The intention will be to remove all the grout bags when decommissioning the pipelines. However, although several different methods could theoretically be used to remove the grout bags, from a practical perspective we don't know whether the bag material has remained intact.

5. COMPARATIVE ASSESSMENT FOR PIPELINES

5.1 Method

The majority of the comparative assessment is qualitative, carried out at a level sufficient to differentiate between the options. However, in some cases, such as cost, it is necessary to examine the differences in more detail and quantitatively to provide clarity. The comparative assessment considers the following generic evaluation criteria and specific sub-criteria in line with BEIS and Centrica Guidance [1] and [3]. These elements are considered for short-term work as the assets are decommissioned as well as over the longer-term as 'legacy' impacts and risks.

- Health & Safety:
  - Health & Safety risk to offshore project personnel
  - Health & Safety risk to other users of the sea
  - Health & Safety risk to onshore project personnel
- Environment:
  - Environmental impacts of operations during offshore works
  - Environmental impacts due to legacy aspects that would need to be undertaken over the longer-term
- Technical:
  - Risk of major project failure
- Societal:
  - Effect on commercial activities
  - Employment
  - Communities or impact on amenities
- Cost

Environmental impacts include consideration of such impacts on the atmosphere, seabed, Special Area of Conservation, the water column and waste in the short-term due to project related activities and over the longer–term due to legacy activities offshore.

No scores have been determined but risk matrices have been used to determine if the planned impacts and unplanned impacts would be for example broadly acceptable, possibly acceptable unlikely to be acceptable or not acceptable. Cells coloured red indicate high risk or high impact and less desirable outcomes. Green coloured cells indicate less risk, less impact and more desirable outcomes. Cells coloured orange sit bin-between red and green and may or may not be less, or more, desirable. High costs also attract a 'less desirable outcome' but cost differences are compared relative to each other. A relatively high cost therefore would be coloured red whereas a relatively low cost would be coloured green. It should be noted that societal score looked at beneficial outcomes as well as detrimental outcomes.

The following paragraphs describe the philosophy and processes followed for the Comparative Assessment using generic, high level evaluation sub-criteria. The results of the assessment are summarised in Sections 5.2, 5.3, 5.4, 5.5, 5.6 and 5.7.

We describe an 'approach' as the first part of a pipeline as it leaves its point of origin or the final part of the pipeline as it reaches its destination. On leaving its point of origin, a pipeline approach might typically entail a stretch of pipeline that is surface laid and protected by concrete mattresses, grout bags or rock, or combinations thereof, as it leaves and progresses along a transition until it reaches the design trench depth or the reverse as the pipeline reaches its destination.

As described earlier we propose to decommission the approaches for each pipeline in the same way irrespective of the decommissioning option chosen for the pipeline segments, so the approaches are not included in this assessment. However, for completeness they are included

in Table 4.1, Table 4.2, Table 4.3, Table 4.4, Table 4.5, Table 4.6, Table 5.1 and Table 5.2.

PL496/7Segments	PL575/6 Segments	PL723/4
Audrey A (WD) approach	Audrey A (WD) approach (within 500m zone)	Audrey B (XW) approach
Infield section of pipelines		Infield section of pipelines
LOGGS PP approach		Audrey A (WD) approach

Table 5.1: Segmentation of PL496/7, PL575/6, PL723/4

PL2066 Segments	PL2067 Segments
Annabel approach	Audrey B (XW) approach
Infield section of pipeline	Infield section of umbilical
Audrey A (WD) approach	Annabel approach

Table 5.2: Segmentation of PL2066 & PL2067

5.1.1 Technical Assessment

The technical aspect of the assessment is concerned with the risk of major project failure. Technical feasibility confirms whether the approach being assessed is physically possible given the technical issues to be addressed.

The technical evaluation is simply the application of a measure to express the complexity of a job, which can be expected to proceed without major consequence, or failure, if it is adequately planned and executed.

5.1.2 Health & Safety Assessment

Definition: An assessment of the potential health and safety risk to people directly or indirectly involved in the programme of work offshore and onshore, or who may be exposed to risk as the work is carried out. Health and safety risk is assessed using three specific sub-criteria.

Sub-criteria:

1. The health and safety risk for project personnel who would be engaged in carrying out decommissioning activities offshore are presented in Table 5.3:

Example Description of Hazard	Who is at risk?
Loss of dynamic positioning leading to uncontrolled movement of vessel and pipeline(s), hydrocarbon release, dropped objects	Diving personnel underwater
Limited experience surrounding the process for recovering trenched and buried pipelines [7]. Pipeline parting or buckling during reverse reeling operations; uncontrolled movement of pipelines and associated reeling and recovery equipment	Vessel based personnel
Sudden movements during pipeline recovery works leading to dropped objects or swinging loads	Diving personnel, vessel based personnel, vessel based assets (e.g. Remotely Operated Vehicles)
Collision between vessels and offshore structures due to mix of shipping lane traffic, product transport vessels, supply and maintenance barges and boats, drifting boats	Offshore personnel and assets
Residual hazardous materials such as methanol, chemicals from umbilical cores, wax deposits, hydrocarbons or NORM from within pipelines released to the local marine environment	Divers and vessel based personnel

Table 5.3: Description of offshore hazards

2. The residual risks to marine users on successful completion of the assessed decommissioning option are presented in Table 5.4:

Example Description of Hazard	Who is at risk?
Exposed pipeline or umbilical sections leading to snagging risk	Other users of the sea, predominantly fishing vessels

Table 5.4: Description of residual hazards to mariners

3. The safety risks for project personnel who would be engaged in carrying out decommissioning activities onshore are presented in Table 5.5:

Example Description of Hazard	Who is at risk?
Residual hazardous materials such as methanol, chemicals from umbilical cores, wax deposits, hydrocarbons or NORM from within pipelines released to the local onshore environment	Hazardous or toxic substances affecting onshore personnel
Onshore cutting – sharp edges and repetitive operations when dismantling pipelines	Onshore personnel
Unplanned sudden movements during pipeline dismantling works leading to dropped objects or swinging loads	Onshore personnel

Table 5.5: Description of onshore hazards

Assessment of sub-criteria:

The difference in potential safety risks between the options is sufficiently large that a HAZID was not deemed to be required at this stage. A Hazard Identification (HAZID) workshop will be carried out when the selected option is developed in more detail. For the purposes of the comparative assessment in lieu of a HAZID a high-level review of the differences was undertaken and correlated to the duration of activities that would be required.

As many of the hazards are common between the complete removal and the partial removal options, only those hazards giving rise to difference between the options were assessed. Examples of this are:

- Where a hazard exists for one option but not the other (e.g. risks relating to pipeline failure during reverse reel lay recovery)
- Where the hazard exists for both options but is different in magnitude (e.g. risks relating to dropped objects if whole pipeline is recovered to shore (to be cut into transportable pieces)

5.1.3 Environmental Assessment

The comparative assessment uses four sub-criteria for the assessment of environmental impacts. These are described below.

Definition: An assessment of the significance of the risks/impacts to the environmental receptors because of activities or the legacy aspects. Environmental impact is assessed using the following specific sub-criteria.

Sub-criteria:

1. Short-term environmental impacts of operational activities;
    - Emissions to atmosphere
    - Effect on seabed
    - Impact on Special Area of Conservation
    - Effect on water column
    - Waste
2. Legacy environmental impacts due to what would be left behind
    - Emissions to atmosphere
    - Effect on seabed
    - Impact on Special Area of Conservation
    - Effect on water column
    - Waste

Assessment of sub-criteria:

The environmental assessment considers the impacts of the decommissioning options. The findings were summarised in an environmental management worksheet and these formed the input to the comparative assessment. Environmental impacts include consideration of such impacts on the atmosphere (energy and emissions), seabed (area impacted and material mobilised into water column), Special Area of Conservation (area impacted as a percentage of the overall SAC), the water column (vessel discharges and effect of material lifted in the water column) and waste (fate and quantity of material) in the short-term due to project related activities and over the longer–term due to legacy activities offshore.

Only the *differentiators* between decommissioning options were included in the overall assessment.

The sub-criteria are qualitative and assessed per the Centrica Environmental Impact Assessment matrix [3]. Based on experience we can conclude that energy use and the associated emissions to air are unlikely to significantly contribute to greenhouse gas emissions or global warming impacts: total direct carbon dioxide (CO_2) emissions generated by the proposed decommissioning operations are 16,410Te. In relation to the total CO_2 produced from domestic shipping the direct CO_2 emissions from the decommissioning of the Audrey and Annabel facilities is c.0.17%. The numbers and the effect on the overall environmental scoring are trivial.

A full assessment of the environmental impacts of the selected decommissioning option can be found in the Environmental Impact Assessment [1].

Sub-criteria definitions:

1. Environmental impacts of operations

The severity of environmental risks associated with unplanned events or the impact to the marine and terrestrial environments from planned operational events.

2. Legacy environmental impacts

The severity of environmental risks associated with unplanned legacy events or the impact to the marine and terrestrial environments from planned legacy activities.

Note that the emissions to air and energy requirements are *representative,* although not exactly the same, of the fuel and energy input data used for waste handling activities.

The environmental assessment was developed by identifying the interactions with the environment for the activities required for each of the options. Activities that were not differentiators were screened out. Those remaining activities with associated interactions with the environment were assessed for consequence and duration to ascertain the potential level of significance of the environmental impact. The interactions with the environment were grouped into the four comparative assessment sub-criteria but the assessment remained qualitative.

5.1.4 Societal Assessment

Definition: An assessment of the significance of the impacts on societal activities, including offshore and onshore activities associated with the complete programme of work for each option and the associated legacy impact. This includes all the “direct” societal effects (e.g. employment on vessels undertaking the work) as well as “indirect” societal effects (e.g. employment associated with services in the locality to onshore work scope, accommodation, etc.).

Sub-criteria:

1. Effects on commercial activities
2. Employment
3. Communities or impact on amenities

Assessment of sub-criteria:

A qualitative assessment has been undertaken to differentiate between options from a societal perspective. This was undertaken through review of relevant data, discussion and textual descriptions.

5.1.5 Cost Assessment

Only the incremental costs of the main offshore decommissioning activities are compared, with owners' costs such as engineering, management, insurance, procurement and logistical costs contributing to the difference as a percentage (12.5%) of the offshore work. To simplify the assessment, we have concentrated on the different vessel types that would be required for a specific activity and how long the vessel would be required for. Although different for different activities, common elements such as mobilisation costs and decommissioning of pipeline ends are not included on the assumption that they would be decommissioned in much the same way irrespective of which option was being pursued.

For this assessment, complete removal represents the full scope and other options are compared to this.

We compare the difference in cost for like-for-like activities in the short-term as well as for legacy related activities in the longer-term. From a legacy perspective, all decommissioning options would involve carrying out an environmental survey at the end of the so this would not differentiate the costs over the longer-term, but legacy survey costs will be different depending on the option. For example, no legacy surveys would be required for the complete removal option.

This shows the difference in incremental cost as being comparable to the other evaluation criteria (i.e. safety, environmental, technical and societal) and it allows an understanding of the *significance* of the difference.

In the assessment tables that follow we indicate the acceptability or otherwise of the costs. We do, however, recognise that the cost of an option would only be *acceptable* if the other aspects of the comparative assessment show that this would be preferred.

If the incremental difference in cost for one option is assessed to be an order to magnitude greater than the other options being considered it is assessed as being 'Tolerable & non-preferred'.

5.2 PL496 & PL497 Comparative Assessment

5.2.1 Technical Assessment

Please note that dealing with the pipeline approaches will be common for all decommissioning options and so is not used to differentiate the options.

We believe that as the pipeline was installed using the s-lay technique the pipeline would not be a candidate for reverse reeling. Therefore, we believe that the pipeline would need to be recovered either in sections using 'cut and lift' or using reverse S-lay. Reverse S-lay is unlikely to be feasible for concrete coated and piggybacked pipeline. We believe although somewhat repetitive, the 'cut and lift' method would be the most feasible but would take a significant amount of time to carry out. This is the preferred method for short or discrete lengths of pipe, when it is impractical or prohibitively expensive to mobilise major removal equipment.

In contrast, operations that involve removal of relatively short lengths of pipe in discrete areas are well-established activities with little technical uncertainty. This option has been widely used for removing a short pipeline in its entirety, or for removing discrete lengths. It is usually the recommended removal option for short sections of pipe when it is impractical or prohibitively expensive to mobilise major equipment for removal.

For the pipeline to be removed either in its entirety or for removal of discrete lengths, apart from the short-exposed sections at each end, as can be seen in Figure 3.2 the pipeline would need to be removed from underneath rock for much of its length. It may be possible to achieve this using a flow mass excavator, but the operation would be time consuming and problematic to achieve.

The pipeline is concrete coated. The two pipelines would need to be cut and lifted together should their condition allow. The potential for concrete spalling would add to the technical complications.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Technical feasibility	**Short-term:** There is limited experience of using the 'cut and lift' method for removing concrete coated and piggy-backed pipelines of this scale. Most of the pipelines are buried under rock, and in many areas this is now indistinguishable from the local seabed, making it more problematic to locate and recover the pipeline	**Short-term:** Buried pipe has been uncovered and 'cut and lift' method can and has been used for removing relatively short sections of pipe so we know this is achievable, although the presence of rock will complicate the process	**Short-term:** Stable and buried pipelines have been left *in situ* before and we know this is achievable
	Legacy: No pipeline surveys would be required	**Legacy:** Pipeline surveys have been undertaken in the past. From a technical perspective this is achievable with no complications	**Legacy:** Pipeline surveys have been undertaken in the past. From a technical perspective this is achievable with no complications
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.6: PL496/7 Technical Assessment

Summary of technical assessment

Three options were considered for PL496 and PL497 that is piggybacked. Theoretically, given the right conditions all three options can be considered technically feasible.

However, to achieve complete removal the pipeline would need to fully excavated from underneath rock to be exposed and then removed in sections using the 'cut and lift' method. Although the 'cut and lift' method has been used for relatively short lengths of pipeline this

approach has not been undertaken for pipelines 16.9km long. Therefore, complete removal has been classed as 'tolerable but non-preferred.

As noted, the medium / tolerable rating is driven by uncertainties in the probability of success of using the 'cut and lift' method, which although feasible is a non-preferred way of removing long pipelines, is considered to present risks to the delivery of the project.

As mentioned already, the cut and lift method has been used for recovery of short pipelines and so this option and leave *in situ* can both be regarded as technically feasible and would be preferred for completely removing the pipelines.

5.2.2 Safety Assessment

Safety Risk to Offshore Project Personnel

All hazards were assessed as broadly acceptable although we would want to avoid the 'cut and lift' method of removal due to the length of pipeline being recovered.

The key differences between the decommissioning options are as follows.

- Risk to personnel on the vessel from hydrocarbon or hazardous substance releases from recovered pipelines will be greater for complete removal than for partial removal or leave *in situ* due to the larger volume of material that would be recovered;
- Exposure to potentially NORM contaminated materials increases with the volume of material being recovered;
- The risk to personnel and assets are greater for complete removal option compared to partial removal option or leave *in situ* where only a small part of the overall pipeline would be removed;
- Increased risk to all activities due to adverse weather is greater for complete removal than for partial removal or leave *in situ* as the time the vessel would be in the field is greater, irrespective of the removal method adopted;
- Risk associated with legacy survey activities that is, the risks associated with vessels being used is greater for partial removal than for complete removal. At least two legacy surveys would be required to confirm the condition of any pipelines or sections thereof left *in situ*;

There is little experience recovering a concrete coated and buried (under rock) and piggybacked pipeline 16.9km long, but we believe that although associated risks would be higher for complete than for either partial removal or leave *in situ*, they would still be tolerable should sufficient mitigation and control measures be put in place.

Using the 'cut and lift' method, since the activities and techniques associated with pipeline removal are used in the North Sea, albeit not at this scale for complete removal, it is presumed that the risks from all hazards would be broadly acceptable providing sufficient mitigations are put in place for such repetitive work. This risk only really relates to the complete removal option since such activities would be more tolerable for partial removal or leave *in situ*.

Operational Safety Risk to Fishermen and Other Marine Users

There remains the possibility of interaction with other mariners while decommissioning works are being carried out in the field and this potentially would increase with the number of vessels, the location of the work and the frequency of marine traffic. Decommissioning activities involve vessels working in the field, and over the longer term will be related to the amount of surveys and any pipeline remedial works that may be required in future. By way of example, for PL496/7 vessel durations associated with the complete removal option will be greater than for the partial removal and leave *in situ*.

The greatest risk relating to marine users is likely to be concerned with snagging of fishing gear.

The type of fishing in the area is predominantly demersal trawling for flatfish. Therefore, there is

a potential for snagging on equipment and spoil mounds left on the seabed. Data relating to pipeline burial status are shown in Figure 3.6. The data shows that in-between deposited rock there are instances of exposed pipeline but these are in areas that are already regularly fished. Survey data obtained periodically since would suggest that most of the pipeline has remained relatively stable throughout its entire length albeit with short exposures.

From this it can be reasoned that decommissioning activities that minimise the disturbance to the seabed will reduce the likelihood of creating new snag hazards and avoid leaving an open trench. Both complete removal and partial removal will leave the seabed free of equipment, while leave *in situ* will present risks that will remain as they are now. Although the complete removal option has the potential to leave open trenches that could present snagging hazards, it is possible that with extra effort these could be filled, or they would disappear over time as occurred following installation.

The risk of snagging fishing gear and the risk of snagging equipment were assessed as broadly acceptable. The key differences between the options are:

- There would be a risk of snagging fishing gear on the pipeline in future for partial removal or leave *in situ* should the burial status change but this would be eliminated for complete removal;
- As the partial removal and leave *in situ* options leave a significant portion of the pipeline *in situ*, legacy surveys are required for these options. These legacy surveys have risks associated with the use of vessels that are not required for the complete removal option, but their work can be considered routine. Legacy related survey vessels would also be in the field for significantly less time than vessels involved in the complete removal and partial removal activities.

Safety Risk to Onshore Project Personnel

All hazards associated with the handling of a large number of pipe lengths or associated with a heavy object (pipeline) on or near the vessel during reverse reeling were assessed as 'tolerable and non-preferred' for the complete removal option. The key differences between the options are as follows:

- Risks associated with cutting the pipeline and exposure of any residues with a potential to result in injury, are greater for complete removal due to the higher quantity of material returned to shore compared with the partial removal and leave *in situ* options;
- Risks associated with lifting and handling pipeline sections are also greater for complete removal, due to larger quantity of material being returned to shore;
- Risks associated with lifting and handling pipeline sections with concrete coating are also greater for complete removal, due to larger quantity of material that could potentially spall when being dealt with onshore;
- Exposure to potentially NORM contaminated materials increases with the volume of material recovered.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal	Option 3 Leave *in situ*
Health & safety risk offshore project personnel	**Short-term:** More offshore work and more onshore handling than partial removal. Little experience in the North Sea of 'cut and lift' of concrete coated pipelines buried under rock. 'Cut and lift' activities are assessed as tolerable for the 16.9km pipeline	**Short-term:** Less offshore work than complete removal. Limited experience in the North Sea of removal of concrete pipeline sections	**Short-term:** Less offshore work than complete removal
	Legacy: No pipeline surveys or remediation related activities	**Legacy:** Pipeline burial surveys required	**Legacy:** Pipeline burial surveys required
Health & safety risk to mariners	**Short-term:** Duration of vessels in the field would be longer than for partial removal or leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field	**Short-term:** Duration of vessels in the field would be shorter than for complete removal but longer than for leave *in situ*	**Short-term:** Duration of vessels in the field would be shorter than for complete removal and partial removal
	Legacy: Infrastructure completely removed so no residual snag hazards remain	**Legacy:** Degradation of the remaining pipeline with spalling concrete within seabed sediment will occur over a long period. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited	**Legacy:** There is little to differentiate option 2 and 3
Safety risk onshore project personnel	**Short-term:** Significantly more onshore cutting, lifting and handling associated with disposal of the pipelines presents an increased safety risk to personnel	**Short-term:** Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	**Short-term:** No material handling required onshore
Colour Key:			
Medium / Tolerable & non - preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.7: PL496/7 Safety Assessment

Summary of safety assessment

Many of the hazards described above are common to all decommissioning options. Based on the differences, in the short-term the partial removal and leave *in situ* options give rise to lower risks to project personnel for the following three reasons:

- Less offshore work;
- Less onshore handling;
- Little experience in the removal of piggybacked and concrete coated pipelines buried under rock in the North Sea [7], resulting in an increase in perceived risk.

By completely removing the pipelines the risk of snagging is removed in perpetuity. Therefore, the complete removal option results in lower residual risks to mariners and other users of the sea.

There is likely to be no increased snagging risk associated with the partial removal or leave *in situ* options due to the burial status of the pipeline (Figure 3.1). However, although status surveys will need to be done in future to verify that the risk of snagging remains low for the foreseeable future.

5.2.3 Environmental impact of operational activities

In all cases the duration vessels would be required in the field for complete removal was longer than either the partial removal and leave *in situ* options. The leave *in situ* option would result in least duration of vessels working in the field. The impact of this on liquid discharges to sea, noise, emissions to air and energy requirements, water column, seabed, waste, etc. are summarised in Table 5.8.

Operational Environmental factors impacted	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Atmosphere (energy & emissions)	Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Emissions and energy use for this option fall in-between complete removal and leave *in situ*	Least amount of energy used and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new material
Seabed disturbance; area affected	The amount of seabed disturbed is directly related to the length of pipeline (or umbilical) being removed. The area affected would be largest for this option	This area of seabed disturbed would fall in-between the complete removal and leave *in situ* options	The least area of seabed would be disturbed with this option
Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal	Discharges and release would be less than generated for complete removal but slightly more than leave *in situ*	Discharges and releases would be least for this option, particularly in the short-term
Waste creation and use of resources such as landfill. Recycling and replacement of materials	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	This option sits in-between option 1 and option 3	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.8: PL496 & PL497 Operational Environmental Impacts

We can expect emissions to air and energy requirements to demonstrate that there are differences between the options, but since this would be related to the duration that vessels would be in the field we have not calculated the difference but have examined this qualitatively. Based on our experience with previous assessments we can say that the gap in emissions to air and energy requirements between complete removal, partial removal and leave *in situ* narrow when indirect emissions and energy requirements – such as that required to manufacture new material to replace the material left *in situ* – are taken into account.

From Table 5.8, while there will be different impacts for each of the options, the overall impact of the 'complete removal' option will be higher on the atmosphere, seabed disturbance, and water column and lowest in terms of material being left *in situ* and needing to be replaced. The reality, however, is that there is little to differentiate the three options, especially between partial removal and leave *in situ* options.

Conversely, the legacy survey requirements for leave *in situ* are greater than for partial or complete removal and these will mostly affect the atmosphere and water column. However, in real terms there will be little to distinguish between the options.

In Table 5.8 the boxes coloured darker green would be the most favourable option for each individual pipeline while lighter green boxes would the least favourable. However, we believe that there is little to differentiate the options.

5.2.4 Environmental impact of legacy activities

On completion of decommissioning activities, a final environmental survey would be carried out, and this would be common for all options and is not a differentiator. For longer-term legacy related activities, a differentiator between options would be the number of pipeline burial surveys that would be required as well as any possible remedial works.

The environmental impact of legacy activities associated with future requirements of ensuring that concrete coated PL496 and piggybacked PL497 remain buried under rock and stable are assessed in much the same way as operational activities. The impacts of legacy related activities can be expected to be significantly less than those brought about by operational activities during decommissioning work.

Operational Environmental factors impacted	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Atmosphere (energy & emissions)	No pipeline burial surveys required	We anticipate that future survey requirements would be about the same for either option 2 or option 3	
Seabed disturbance; area affected	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact		
Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	No pipeline burial surveys required	We anticipate that future survey requirements would be about the same for either option 2 or option 3	
Waste creation and use of resources such as landfill. Recycling and replacement of materials	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective		
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.9: PL496 & PL497 Legacy Environmental Impacts

5.2.5 Environmental impact on SAC

Our assessment of the short-term impact of decommissioning PL496 and piggybacked PL497 and longer term impact of legacy related activities such as surveys, potential remedial work on the Special Area of Conservation is summarised in Table 5.10.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Environmental impacts on SAC due to decommissioning activities	Dredging to access the pipeline for complete recovery would open a trench and introduce sediment into the water column. We would expect the area to recover relatively quickly as the survey data doesn't show much evidence of the original trench. Assuming a 4m wide corridor along the pipeline being disturbed, the area affected would be 0.0676km^2, 6.76ha equivalent to c. 0.002% of the SAC	Dredging to access the sections of the pipeline for recovery would open a trench and introduce sediment into the water column We would expect the area to recover relatively quickly as the survey data doesn't show much evidence of the original trench. The area affected would be much less than that affected by complete recovery	Limited or no impact on the SAC during offshore decommissioning operations
Legacy: Environmental impacts on SAC	No impact. Only environmental survey following completion of decommissioning activities	Environmental survey and pipeline status survey only, assuming no remedial work would be required – as suggested by historical	Impact on SAC would be the same as option 2 assuming no remedial work would be required over the longer term

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
		survey data. Survey data suggests that the presence of the buried pipeline in the seabed is not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks)	
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.10: PL496 & PL497 Environmental Impact on SAC

The significance of the impacts associated with the interactions with the environment was assessed using the Environmental Impact Matrix in the comparative assessment guidance document [3]. This was done to allow an understanding of the significance of the impacts and to aid decision making where conflicts arose between assessment criteria and sub-criteria. These are reflected in the traffic light colour coding.

The orange rating for complete removal in the above table is driven by the absolute area that would be disturbed because of removing the pipeline from its buried position, although the proportion of the SAC affected is very small.

5.2.6 Summary of environmental assessment

The environmental assessment was split into short-term operational impacts, legacy impacts and both short-term and long-term impacts due to legacy related activities on the Special Area of Conservation.

In the short-term, and from operational perspective, leave *in situ* would be the favoured option although in practical terms there is little to differentiate partial removal from leave *in situ*. Conversely complete removal would result in no legacy activities being required, and there would be little to choose between partial removal and leave *in situ* from a legacy perspective, especially as it can be legitimately assumed that no remedial works would be required in future. Indeed, historically it appears as though much of the rock deposited when the pipelines were installed has become covered in sediment and merged with the local habitat. All impacts for all options were assessed as broadly acceptable.

The complete removal option would result in recovery of all the pipeline material for recycling whereas the leave *in situ* and partial removal options would result in most of the pipeline material being left where it is, and therefore unavailable for recycling. Any raw material not recovered would need to be replaced with newly manufactured material.

In the short-term, the leave *in situ* decommissioning option was considered to cause the least disruption to the SAC and so would be the most preferred. Over the longer-term the leave *in situ* option would be preferred to either the partial removal or the complete removal options, although in practical terms there would be little to differentiate partial removal and leave *in situ*.

In the short-term and due to operational activities, the complete removable option would be least favourable but was nevertheless assessed as ‘tolerable’. However, the area can be expected to fully recover within 20 years after the initial impact of decommissioning works, and so in the longer-term complete removal was assessed to be the marginally preferred option.

5.2.7 Societal Assessment

The assessment of the other criteria (safety, environment, cost and technical) considers the level of detrimental effect whereas the assessment of impacts on employment considers the level of benefit, a positive effect. We use vessel durations as an indicator of magnitude of the *continuation* of employment rather than creating new employment. We can discuss short-term effects due to decommissioning operations – 'project' activities - and longer-term impacts due to legacy related activities.

The societal issues around the pipeline are discussed below.

Commercial activities

The main commercial activity in the area is fishing. The potential effects could be loss of fishing revenue due to exclusion from fishing grounds, disturbance of the seabed or loss or damage of fishing equipment.

While the vessels are present in the field and activities are being undertaken, the area will not be accessible for fishing. Therefore, the magnitude of the impact on commercial activities is related to the vessel duration. In the short-term, irrespective of which pipeline (or umbilical) is being considered, the complete removal activities will incur longer vessel activities. Conversely, the leave *in situ* option would require the least vessel activity. Where available the partial removal option will involve vessel activities with durations that would sit somewhere in-between complete removal and leave *in situ*. We try to differentiate the options using different shades of green in the summary table.

Decommissioning activities common to all decommissioning options such as dealing with the pipeline ends or removing surface laid pipelines, are not considered here as they do not differentiate the options.

Activities which involve removal, reburial will implicitly disturb the seabed. Therefore, since complete removal will require more activities on the seabed it will have a higher short-term impact on commercial fishing compared to partial removal or leave *in situ* options.

Therefore, during decommissioning activities the complete removal option is expected to have a greater impact on fishing activities as it has the longest duration and the greatest amount of activity disturbing the seabed. Partial removal leaves much of the infrastructure *in situ* and, the leave *in situ* option would leave most of the infrastructure in the seabed resulting in less work offshore, so there would be less of an impact on commercial fishing activities.

While all decommissioning options would require an environmental survey to be completed, only the partial removal; and leave *in situ* options would require pipeline burial surveys and stability assessments. The degree to which these will be required will be governed by the results of each survey, and if it can be demonstrated that the pipeline remains stable and pose no snagging risk such surveys may no longer be required. This would be assessed on a case by case basis.

While any such surveys are being undertaken, fishing activity may be disrupted for a short time but the impact can be expected to be minimal. Typically, one post-decommissioning environmental survey would be required, and for each decommissioning option we have assumed the number of pipeline surveys that would be required so that we can compare the impact of the options. The exact magnitude of the impact will be dependent on the type, frequency and duration of the surveys required.

Employment

The complete removal option has greater vessel duration and waste management requirements and therefore impacts more positively on employment than partial removal. The effect on employment will be the continuation of existing jobs, as opposed to the creation of new opportunities; therefore, the significance of the positive impact has been assessed as low.

Communities

Vessels would be in the field for relatively short duration, both within and outside the 500m safety zones. Fishing vessels would be excluded from the area outside the 500m zone but we believe that when compared to the wider area this would have a relatively small effect. There is little to differentiate between the options. Aggregate extraction area is north of the area where decommissioning activities would be undertaken. Shipping will be notified and continue an alternative route. There could be an effect on other users of the ports and there would be a marginally higher impact for complete removal but overall, we believe that there is little to differentiate the options.

The port and the disposal site for recovered materials have yet to be established. However, they will be existing sites which are used for oil and gas activities and hold the required permits for waste management. The communities around the port and the waste disposal sites are therefore, expected to be adapted to the types of activities required and the decommissioning activities will be an extension of the existing situation. Therefore, the effect on communities is not considered a differentiator between options.

The results of the societal assessments for PL496 and piggybacked PL497 are presented in Table 5.11. In the short-term, commercial activities would be affected most by the amount of time the vessels were in the field undertaking partial removal activities. We believe that generally however, there is very little to differentiate the options for each.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for complete removal and more that for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for complete removal
Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal and less than for leave *in situ.*	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option but there is little to differentiate option 2 and option 3
Short term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal.	Decommissioning activities would contribute to continuity of employment less than for complete removal and more that for leave *in situ* option.	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Once the pipeline had been partially removed the opportunity for continuation of employment would be associated with survey work would be like the leave *in situ* option. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for option 2 and Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*, otherwise there is little to differentiate options 2 & 3.
Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal	Decommissioning activities would contribute to continuity of work in ports and disposal sites less than for complete removal and more that for leave *in situ* option	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ*
Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
	sites	and disposal sites other than associated with survey related and possible remedial work	sites other than associated with survey related and possible remedial work. There is little to differentiate options 2 & 3.
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.11: PL496 & PL497 Societal Assessment

Summary of societal assessment

We use vessel durations as an indicator of magnitude of the *continuation* of employment rather than creating new employment, and we have considered short-term effects due to decommissioning operations – 'project' activities - and longer-term impacts due to legacy related activities. We have also examined potential disruption to commercial activities resulting from the presence of vessels specifically to carry out the decommissioning work. We have taken a somewhat holistic approach.

Disruption to commercial activities would be least when the decommissioning effort in the field is minimised, and this is the case for leave *in situ*, whereas complete removal could potentially result in the most disruption to commercial activities with partial removal being in-between.

Conversely, legacy related disruption on commercial activities in the area would be greatest for leave *in situ*, since there would be no legacy activities once decommissioning activities associated with complete removal had been completed because there would be no infrastructure left to inspect, whereas the leave *in situ* and partial removal options would require legacy activities to be carried out at least for the foreseeable future.

Employment opportunities would be greatest for the complete removal option owing to the larger amount of vessel time and onshore dismantling and recycling works. Such opportunities would be least for the leave *in situ* option but slightly greater for the partial removal option.

Conversely, legacy related employment opportunities would be least for complete removal and greatest for leave *in situ*, with opportunities associated with partial removal being like leave *in situ*. This is because the leave *in situ* and partial removal options would require legacy activities to be carried out, at least for the foreseeable future.

5.2.8 Cost Assessment

The incremental difference in cost between complete removal and partial removal – including the requirement for legacy surveys - on a like-for-like basis would be at least £24.3MM, and the incremental difference in cost between partial removal and leave *in situ* would be at least £0.3MM. The incremental difference in cost between complete removal and leave *in situ* would be at least £24.5MM. For this reason, because of the order of magnitude difference involved the short-term costs for complete removal in Table 5.12 are classed as "Medium, or tolerable but non-preferred". The incremental differences in cost for each option are compared in Appendix F.2.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Cost	The cost of complete removal would be an order of magnitude higher than for either of the partial removal or the leave *in situ* options	The cost of removing a few short-exposed sections would be less than for complete removal but more than for leave *in situ*	The cost of leave *in situ* would be the least expensive of all options
Legacy: Cost	Once the pipeline had been completely removed no pipeline burial surveys after	Future burial surveys will be required. The premise is that if two successive surveys	Future burial surveys will be required. The premise is that if two successive surveys

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
	decommissioning works had been completed or over the longer-term	demonstrate that the pipeline remains stable, no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term	demonstrate that the pipeline remains stable, no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.12: PL496 & PL497 Cost Assessment

5.2.9 Overall Summary of Assessment

However, as reported previously, in the immediate vicinity of the LOGGS area is subject to continual scour, and the effectiveness of pipeline stability features such as concrete mattresses and grout bags in this area is uncertain. Therefore, we would propose to remove stability features such as concrete mattresses and grout bags where we can see them, but otherwise monitor the situation at least until some of the uncertainty is reduced to a satisfactory level.

The results of the assessment are summarised in Table 5.13. Overall this option has been assessed as having the lowest safety risk, lowest environmental impact and risk, lowest technical uncertainty and lowest cost. Waste recovery and societal elements were the only criterion where complete removal was assessed as being beneficial and this was due to the potential extension of employment opportunities associated with this option.

Being the best option over the longer-term, the complete removal option would involve several elements that would be considered 'medium or tolerable and non-preferred'. These elements concern technical risks and short-term risk to the safety of project personnel during recovery operations and dealing with the pipeline as it is transferred to shore and finally dealt with. From an environmental perspective one aspect of the assessment that appears prominently is the effect on the objectives of the SAC, and we have assessed that these would be adversely affected most by activities associated with complete removal. In other words, even though complete removal might be achievable it is non-preferred when considering the objectives of the SAC. Finally, we estimate that complete removal would be an order of magnitude greater than either of the other two options.

The biggest differentiators between the complete removal and the leave *in situ* options are safety, technical elements and impact on SAC. Examination of the criteria within these categories shows that the issues relate to:

- Uncertainties as to the recovering a 20" rigid pipeline piggybacked by a 3" pipeline and buried for a substantial proportion of its length under rock using the 'cut and lift' method that has not been tried and tested on a 17km long pipeline;
- The large amount of handling and particularly lifting involved in recovering the pipeline to shore, where it will need to be cut and moved in transportable lengths;
- The likely short-term damage to the seabed – and thus impact on the conservation objectives of the SAC,

It can also be seen that environmental assessment favours leaving the pipeline *in situ*. This is primarily because complete removal would require disturbance to the SAC as the pipeline runs through the area. Historical records however, do suggest that over the longer term the seabed will recover.

Also, there would be fewer disturbances to ecosystems from removal activities and less impact associated with emissions to air, discharges to sea, noise, and disposal requirements for vessel. These factors were considered to outweigh the impact of the ongoing surveys needed for the pipeline line remaining *in situ* after decommissioning.

Aspect	Sub-criterion	Short-term or legacy?	Option 1 Complete removal	Option 2 Partial removal	Option 2 Leave *in situ*
Technical	Technical feasibility	Short-term			
		Legacy			
Safety	Safety risk to offshore project personnel	Short-term			
		Legacy			
	Safety risk to mariners	Short-term			
		Legacy			
	Safety risk to onshore project personnel	Short-term			
Environmental	Atmosphere (energy & emissions)	Short-term			
		Legacy			
	Seabed disturbance area affected	Short-term			
		Legacy			
	Water column disturbance	Short-term			
		Legacy			
	Impact on SAC	Short-term			
		Legacy			
	Waste creation	Short-term			
		Legacy			
Societal	Commercial fisheries	Short-term			
		Legacy			
	Employment	Short-term			
		Legacy			
	Communities	Short-term			
		Legacy			
Cost		Short-term			
		Legacy			

Table 5.13: PL496 & PL497 Summary of Comparative Assessment

5.3 PL575 Comparative Assessment

5.3.1 Technical Assessment

Please note that dealing with the pipeline ends will be common for all decommissioning options and so is not used to differentiate the options.

We believe that all decommissioning options for PL575 are technically feasible.

There is limited experience in reverse reeling trenched & buried pipelines in the UKCS [7], and as such the technical uncertainty was deemed likely to have an adverse impact on technical risk. The alternative is that it would need to be recovered in sections using 'cut and lift'. We believe although somewhat repetitive, the 'cut and lift' method would be feasible. It may take longer than reverse reeling to carry out, but given that this is a short pipeline we expect there would be a trade-off between off between mobilising vessel and equipment for reverse reeling versus equipment associated with the more rudimentary 'cut and lift' approach. The 'cut and lift' approach is the preferred method for short or discrete lengths of pipe, when it is impractical or prohibitively expensive to mobilise major removal equipment. Most significantly, the 'cut and lift' method does create greater risks to the personnel carrying out the offshore operations, although today's remotely operated equipment can help reduce the exposure of divers to the hazards of such work. In this instance, we believe that the pipeline is too short for the reverse reeling method to be the most efficient approach.

In contrast, operations that involve removal of relatively short lengths of pipe in discrete areas are well-established activities with little technical uncertainty. This option has been widely used for removing a short pipeline in its entirety, or for removing discrete lengths. It is usually the recommended removal option for short sections of pipe when it is impractical or prohibitively expensive to mobilise major equipment for removal.

For the pipeline to be removed in its entirety, apart from the short-exposed sections at each end, and the short-exposed sections along its length, the pipeline would need to be removed from the backfill. Subject to integrity checks this could be achieved by either pulling it through the seabed material or by removing the material first using specialist equipment such as mass excavation tools or water jetting machines. Jetting to remove the cover has been widely used for short lengths of pipeline, although given that some parts of the pipeline along its length appear to be exposed, this would be slightly more time consuming and costly for the entire pipeline, but not by an order of magnitude.

The technical uncertainties associated with the pipeline decommissioning options have been assessed using the risk assessment matrix in the comparative assessment guidance for the project [3], the results of which are presented in Table 5.23 below.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Technical feasibility	**Short-term:** There is limited experience of using the 'cut and lift' method but achievable for this relatively short pipeline	Removal of the exposure in the middle would leave two sections (@100m on each side), leaving two additional ends to rebury	**Short-term:** Stable and buried pipelines have been left *in situ* before and we know this is achievable
	Legacy: No pipeline surveys would be required in future	**Legacy:** Pipeline surveys have been undertaken in the past so this is achievable with no complications	**Legacy:** Pipeline surveys have been undertaken in the past so this is achievable with no complications
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.14: PL575 Technical Assessment

Summary of technical assessment

Three options were considered for PL575, and theoretically, given the right conditions - for example, no integrity issues can be foreseen - all three options can be considered technically feasible.

The 'cut and lift' method has been used for recovery of short pipeline sections already in the southern North Sea so the complete removal, partial removal and leave *in situ* can both be regarded as technically feasible. Given the short length of the pipeline, in practical terms there is very little to differentiate the three decommissioning options.

5.3.2 Safety Assessment

Safety Risk to Offshore Project Personnel

PL575 is a relatively short pipeline, so in principle the assessment for safety risk of personnel offshore for PL575 would be broadly similar to that derived for PL496, albeit on a much smaller scale. Also the pipeline is not concrete coated and is not piggybacked by another pipeline. The offshore safety risks to project personnel can be expected to be less.

The risks associated with legacy survey activities (risks associated with vessels being used) are greater for partial removal or leave *in situ* than for complete removal

Operational Safety Risk to Fishermen and Other Marine Users

There remains the possibility of interaction with other mariners while decommissioning works are being carried out in the field and this potentially would increase with the number of vessels, the location of the work and the frequency of marine traffic. Decommissioning activities involve vessels working in the field, and over the longer term will be related to the amount of surveys and any pipeline remedial works that may be required in future. By way of example, for PL575 the short vessel durations associated with the complete removal option will be very similar to partial removal, but longer than for leave *in situ*. The differences are not significant.

The greatest risk relating to marine users is likely to be concerned with snagging of fishing gear; as the pipeline is fully contained within the Audrey A (WD) 500m safety zone, any fishing activity would not have encountered the exposed sections of the pipeline.

Decommissioning activities that minimise the disturbance to the seabed will reduce the likelihood of creating new snag hazards and avoid leaving an open trench. Decommissioning activities that leave the seabed free of equipment will minimise the impact on local fishing activities. Both complete removal and partial removal will leave the seabed free of equipment, while leave *in situ* will present risks that will be different to what they are now. Although the complete removal option has the potential to leave open trenches that could present snagging hazards, these will likely disappear over time.

The risk of snagging fishing gear and the risk of snagging equipment were assessed as broadly acceptable. The key differences between the options are:

- There would be a risk of snagging fishing gear on the pipeline in future for partial removal or leave *in situ* should the burial status change but this would be eliminated for complete removal;
- As the partial removal and leave *in situ* options leave the pipeline *in situ*, legacy surveys will be required for these options. These legacy surveys have risks associated with the use of vessels that are not required for the complete removal option, and their work can be considered to be routine. Legacy related survey vessels would also be in the field for less time than vessels involved in the complete removal and partial removal activities, but the difference is not significant.

Safety Risk to Onshore Project Personnel

All hazards associated with the handling of the small number of pipe lengths were assessed as

'low and broadly acceptable' for the complete removal and partial removal options. There is very little to choose between the options because the pipeline is so short. For the record, the key differences between the options are as follows:

- Risks associated with cutting the pipeline and exposure of any residues, resulting in injury are slightly greater for complete removal due to the slightly larger quantity of material returned to shore compared with the partial removal and leave *in situ* options;
- Risks associated with lifting and handling pipeline sections are also slightly greater for complete removal, due to larger quantity of material being returned to shore;
- Exposure to potentially NORM contaminated materials increases with the volume of material recovered;

Our assessment for this pipeline is summarised in

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal	Option 3 Leave *in situ*
Health & safety risk offshore project personnel	**Short-term:** Slightly more offshore work and more onshore handling than partial removal. Little experience in the North Sea of 'cut and lift' of buried pipelines but short pipeline	**Short-term:** Slightly less offshore work than complete removal. Experience in the North Sea of removal of pipeline sections	**Short-term:** Less offshore work than complete removal or partial removal.
	Legacy: No pipeline surveys or remediation related activities	**Legacy:** Pipeline surveys will be required, but this activity has been done before	**Legacy:** Pipeline surveys will be required, but this activity has been done before
Health & safety risk to mariners	**Short-term:** Duration of vessels in the field would be longer than for partial removal or leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field	**Short-term:** Duration of vessels in the field would be marginally shorter than for complete removal but in practical terms there is unlikely to be much difference	**Short-term:** No offshore work
	Legacy: Infrastructure completely removed so no residual snag hazards remain	**Legacy:** Degradation of the remaining pipeline will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited	**Legacy:** There is little to differentiate option 2 and 3
Safety risk onshore project personnel	**Short-term:** Significantly more onshore cutting, lifting and handling associated with disposal of the pipelines presents an increased safety risk to personnel	**Short-term:** Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	**Short-term:** No onshore work
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.15: PL575 Safety Assessment

Summary of safety assessment

Many of the hazards described above are common to all decommissioning options. Based on the differences, in the short-term the leave *in situ* option give rise to lower risks to project personnel for the following three reasons:

- Less offshore work;
- Less onshore handling;

- Little experience in the removal of trenched and buried pipelines in the North Sea [7], resulting in an increase in perceived risk.

By removing just part of the pipeline the potential risk of snagging would remain. By completely removing the pipelines the risk of snagging is removed in perpetuity. Therefore, the complete removal option results in lower residual risks to mariners and other users of the sea. Given the length of the pipeline there is little to choose between the options from a safety perspective whether in the short or longer term.

5.3.3 Environmental impact of operational activities

Please refer section 5.2.3 as we believe that the environmental impacts of operational activities for PL575 are broadly similar but on a much smaller scale and with much less to differentiate the options. Therefore, for brevity, we propose not to repeat the discussion here.

5.3.4 Environmental impact of legacy activities

Please refer section 5.2.4 as we believe that the environmental impacts of legacy related operational activities for PL575 are broadly similar but on a much smaller scale and with much less to differentiate the options. Therefore, for brevity, we propose not to repeat the discussion here.

5.3.5 Environmental impact on SAC

Please refer section 5.2.5 as we believe that the environmental impacts of operational activities for PL575 on the SAC are broadly similar but on a much smaller scale. Therefore, for brevity, we propose not to repeat the discussion here. As the pipeline is short, for the complete removal option the impact on the SAC objectives to be much less marked (the area affected would be 0.00246 km^2, 0.246ha equivalent to c. 0.0001% of the SAC) as all operations would be conducted along the pipeline within the existing 500m zone, and as a result we have assessed the impact to be low or broadly acceptable and the least preferred (c.f. 'Medium / Tolerable & non-preferred' assessed for PL496/7) of the options, but in practical terms there is little to differentiate the options in the short-term.

5.3.6 Summary of environmental assessment

Please refer section 5.2.6 as we believe that the various environmental impacts for PL575 are broadly similar but on a much smaller scale and with much less to differentiate the options. Therefore, for brevity, we propose not to repeat the discussion here.

5.3.7 Societal Assessment

Please refer section 5.2.7 as we believe that the environmental impacts of operational activities for PL575 are broadly similar but on a much smaller scale and with much less to differentiate the options. Therefore, for brevity, we propose not to repeat the discussion here.

5.3.8 Cost Assessment

The incremental difference in cost between complete removal and partial removal – including the requirement for legacy surveys - on a like-for-like basis would be least £0.2MM, and the incremental difference in cost between partial removal and leave *in situ* would be at least £0.3MM. The incremental difference in cost between complete removal and leave *in situ* would be at least £0.4MM. For this reason, because of the difference involved the short-term costs for complete removal in Table 5.12 are classed as "low and broadly acceptable but least preferred". The incremental differences in cost for each option are compared in Appendix F.4.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Cost	The cost of complete removal would be higher than for either of the partial removal or the leave *in situ* options	The cost of removing a few short-exposed sections would be less than for complete removal but more than for leave *in situ*	The cost of leave *in situ* would be the least expensive of all options
Legacy: Cost	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.16: PL575 Cost Assessment

5.3.9 Overall Summary of Assessment

The results of the assessment are summarised in Table 5.17. Given the short length of the pipeline there is little to differentiate the options. Overall, but marginally the leave *in situ* option has been assessed as having the lowest short-term safety risk, lowest environmental impact and risk, lowest technical uncertainty and lowest cost.

Over the short-term, complete removal would involve several elements considered 'low and broadly acceptable, but least preferred' in the assessment. These elements concern technical risks and short-term risk to the safety of project personnel during recovery operations and dealing with the pipeline as it is transferred to shore and finally dealt with. Both complete removal and partial removal would deal with the issue of residual snag hazards arising from short exposed lengths of the pipeline. From an environmental perspective, no aspect of the assessment features prominently. Finally, we estimate that complete removal costs more than either of the other two options, but not an order of magnitude more.

Complete removal would mean that any residual snagging hazards would be removed along with any future monitoring obligations, while the leave *in situ* option means that the snagging hazards would remain and would need to be monitored at least for the foreseeable future. This would be a potential snagging hazard not encountered previously by fishermen as it was within the Audrey A (WD) 500m safety zone.

These factors were considered to outweigh the impact of future surveys that would be needed for the pipeline line remaining *in situ* after decommissioning. Therefore, in view of the relatively small cost difference we would propose to remove this pipeline in its entirety.

Aspect	Sub-criterion	Short-term or legacy?	Option 1 Complete removal	Option 2 Partial removal	Option 2 Leave *in situ*
Technical	Technical feasibility	Short-term			
		Legacy			
Safety	Safety risk to offshore project personnel	Short-term			
		Legacy			
	Safety risk to mariners	Short-term			
		Legacy			
	Safety risk to onshore project personnel	Short-term			
Environmental	Atmosphere (energy &	Short-term			

Aspect	Sub-criterion	Short-term or legacy?	Option 1 Complete removal	Option 2 Partial removal	Option 2 Leave *in situ*
	emissions)	Legacy			
	Seabed disturbance area affected	Short-term			
		Legacy			
	Water column disturbance	Short-term			
		Legacy			
	Impact on SAC	Short-term			
		Legacy			
	Waste creation	Short-term			
		Legacy			
Societal	Commercial fisheries	Short-term			
		Legacy			
	Employment	Short-term			
		Legacy			
	Communities	Short-term			
		Legacy			
Cost		Short-term			
		Legacy			

Table 5.17: PL575 Summary of Comparative Assessment

5.4 PL576 Comparative Assessment

5.4.1 Technical Assessment

Please note that dealing with the pipeline ends will be common for all decommissioning options and so is not used to differentiate the options.

We believe that all the umbilical decommissioning options are technically feasible for this short length of umbilical. Complete removal would involve reverse reeling to remove the umbilical from its trench. There is limited experience of reverse reeling of *trenched* and *buried* umbilical lines in the UKCS [10] and as such we considered that the technical uncertainty has an adverse impact on technical feasibility and risk. The technical difficulties concern securing the umbilical and pulling it up from the seabed and ensuring that it retains its integrity while being recovered. The partial removal option would require removal and uncovering or a discrete section of umbilical that would be relatively easy to handle. This is a routine activity and as such is considered less likely to result in a negative impact on technical safety and risk.

The results of the assessment are presented in Table 5.18.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Technical feasibility	**Short-term:** Reverse reeling is a viable option albeit with technical challenges as the umbilical is unburied and pulled from the seabed. Considered more technically difficult than options 2 and 3	**Short-term:** This option only requires 'cut and lift' of discrete sections of the umbilical and this can be considered a relatively routine operation. Minimum number of operations therefore minimum technical risk	**Short-term:** Stable and buried umbilical lines have been left *in situ* before and we know this is achievable. From a technical perspective this would be the least challenging option
	Legacy: No umbilical surveys would be required	**Legacy:** Umbilical surveys have been undertaken in the past and are technically feasible with no complications	**Legacy:** Umbilical surveys have been undertaken in the past and are technically feasible with no complications
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.18: PL576 Technical Assessment

5.4.2 Safety Assessment

Much of the discussion here will be very like that presented for PL575 in section 5.3.2, the exception being that for complete removal the umbilical is removed by reverse reel rather than 'cut and lift'.

Safety Risk to Offshore Project Personnel

PL576 is a relatively short umbilical line, so in principle the assessment for safety risk of personnel offshore for PL576 would be broadly similar to that derived for PL575. The offshore safety risks to project personnel can be expected to be similar.

All hazards were assessed as broadly acceptable. However, there were some key differences:

- Risk to personnel on vessel from methanol or hazardous substance releases would be greater for partial removal than for complete removal[19] than for partial removal;
- There would be a risk associated with the presence of an object on or near the vessel during reverse reeling for the complete removal option but eliminated for the partial removal and

[19] Recent attempts (winter 2016/17) to flush the umbilical cores have proved unsuccessful; this means that the umbilical cores will contain hazardous fluids within. These fluids could be retained inside the umbilical for complete removal, but not for partial removal where they could be lost to sea.

leave *in situ* options;

- There would also be more risk of the umbilical failing during recovery operations associated with complete removal;
- For partial removal, discrete individual lengths of the umbilical would need to be recovered to the deck of the vessel, potentially posing more as individual threats to personnel working on deck;
- The increase in risk to all activities due to adverse weather is greater for complete removal than for either partial removal or leave *in situ;*
- Risks associated with legacy survey activities (risks associated with vessels being used) are greater for partial removal or leave *in situ* than for complete removal

The risks associated with legacy survey activities (risks associated with vessels being used) are greater for partial removal or leave *in situ* than for complete removal

Operational Safety Risk to Fishermen and Other Marine Users

Please refer section 5.3.2 as we believe that the operational safety risk to fishermen and other users of the sea are broadly similar. Due to the short length of pipeline and associated short durations of activity we don't believe there is much that differentiates the options. Therefore, for brevity, we propose not to repeat the discussion here.

Safety Risk to Onshore Project Personnel

Due to the short length of umbilical line and associated short durations of activity we don't believe there is much that differentiates the options.

All hazards were assessed as broadly acceptable. The key difference between the options is as follows.

- Risks associated with cutting and handling sections of the umbilical onshore;
- Risks associated with dealing with any residues within the umbilical

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal	Option 3 Leave *in situ*
Health & safety risk offshore project personnel	**Short-term:** Slightly more offshore work and more onshore handling than partial removal. Some experience in the North Sea of removing umbilical lines by reverse reeling	**Short-term:** Slightly less offshore work than complete removal. Some experience in the North Sea of removal of umbilical sections	**Short-term:** Less offshore work than complete removal or partial removal
	Legacy: No umbilical surveys or remediation related activities	**Legacy:** Umbilical surveys will be required, but this activity has been done before	**Legacy:** Umbilical surveys will be required, but this activity has been done before
Health & safety risk to mariners	**Short-term:** Duration of vessels in the field would be longer than for partial removal or leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field	**Short-term:** Duration of vessels in the field would be marginally shorter than for complete removal but in practical terms there is unlikely to be much difference	**Short-term:** There is little to differentiate option 2 and 3
	Legacy: Infrastructure completely removed so no residual snag hazards remain	**Legacy:** Degradation of the remaining umbilical will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited	**Legacy:** There is little to differentiate option 2 and 3
Safety risk onshore	**Short-term:** Significantly more onshore cutting, lifting and	**Short-term:** Safety risk is directly associated with the	**Short-term:** No onshore work

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal	Option 3 Leave *in situ*
project personnel	handling associated with disposal of the umbilical presents an increased safety risk to personnel	duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	
Colour Key:			
Medium / Tolerable & non - preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.19: PL576 Safety Assessment

Summary of safety assessment

Table 5.19 Summarises the safety assessment for the PL576 decommissioning options. Many of the hazards associated with decommissioning PL576 are common to all three options and are assessed as broadly acceptable. The partial removal and leave *in situ* options give rise to lower risks to personnel for the following reasons:

- The reverse reeling required to remove the umbilical carries more risk than partial removal or leave *in situ*;
- Partial removal or leave *in situ* present lower risks to onshore personnel due to less material needing to be dealt with when cutting, lifting and handling onshore

Complete removal would give rise to lower residual risks to mariners and other users of the sea because there would be no potential snagging hazards occurring in future.

5.4.3 Environmental impact of operational activities

Please refer section 5.2.3 as we believe that the environmental impacts of operational activities for PL576 are broadly similar but on a much smaller scale and with much less to differentiate the options. Therefore, for brevity, we propose not to repeat the discussion here.

5.4.4 Environmental impact of legacy activities

Please refer section 5.2.4 as we believe that the environmental impacts of legacy related operational activities for PL576 are broadly similar but on a much smaller scale and with much less to differentiate the options. Therefore, for brevity, we propose not to repeat the discussion here.

5.4.5 Environmental impact on SAC

Please refer section 5.2.5 as we believe that the environmental impacts of operational activities for PL576 on the SAC are broadly similar but on a much smaller scale. Therefore, for brevity, we propose not to repeat the discussion here. As the pipeline is short, for the complete removal option the impact on the SAC objectives to be much less marked (area affected would be 0.0013 km^2, 0.13ha equivalent to less than 0.0001% of the SAC) as all operations would be conducted along the pipeline within the existing 500m zone, and as a result we have assessed the impact to be low or broadly acceptable and the least preferred (c.f. 'Medium / Tolerable & non-preferred' assessed for PL496/7) of the options, but in practical terms there is little to differentiate the options in the short-term.

5.4.6 Summary of environmental assessment

Please refer section 5.2.6 as we believe that the various environmental impacts for PL576 are broadly similar but on a much smaller scale and with much less to differentiate the options. Therefore, for brevity, we propose not to repeat the discussion here.

5.4.7 Societal Assessment

Please refer section 5.2.7 as we believe that the societal impacts of operational activities for PL576 are broadly similar but on a much smaller scale and with much less to differentiate the options. Therefore, for brevity, we propose not to repeat the discussion here.

5.4.8 Cost Assessment

The incremental difference in cost between complete removal and partial removal – including the requirement for legacy surveys is marginal. That is, there is little to differentiate the costs. The incremental difference in cost between complete removal, partial removal and leave *in situ* would be at least £0.2MM. For this reason, because of the difference involved the short-term costs for complete removal in Table 5.20 are classed as "low and broadly acceptable but least preferred". The incremental differences in cost for each option are compared in Appendix F.6.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Cost	The cost of complete removal would be slightly higher than for partial removal	The cost of removing a few short-exposed sections might be slightly less than for complete removal	The cost of leave *in situ* would be the least expensive of all options
Legacy: Cost	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the umbilical remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.20: PL576 Cost Assessment

5.4.9 Overall Summary of Assessment

Please refer section 5.3.9 and Table 5.17, as we believe that the overall summary of the assessment is broadly captured there. The main difference is that PL576 is a short umbilical line that would be completely removed by reverse reel rather than a pipeline that would be completely removed using the by the 'cut and lift' method. Therefore, for brevity, we propose not to repeat the discussion here.

5.5 PL723/4 Comparative Assessment

5.5.1 Technical Assessment

Please note that dealing with the pipeline ends will be common for all decommissioning options and so is not used to differentiate the options.

Please refer section 5.2.1 as we believe that the technical aspects for the removal of PL723/4 are broadly similar, except that in this instance the partial removal option wasn't considered. There are some key differences, however, and these are:

- PL723/4 is about ¼ the length of PL496/7 (4.4km c.f. 16.9km);
- PL723/4 comprises a 14" pipeline piggybacked with a 3" methanol pipeline compared with a 20" concrete coated pipeline piggybacked with a 3" methanol pipeline;
- PL723/4 is buried under the natural seabed for most of its length, whereas PL496/7 was

artificially buried under rock when first installed. As stated earlier, PL496 is also concrete coated.

However, overall these differences don't affect the outcome of the assessment, and the technical feasibility of complete removal remains 'amber' as per Table 5.6 in section 5.2.1.

5.5.2 Safety Assessment

Please refer section 5.2.2 as we believe that the safety assessment for PL723/4 is broadly similar but with shorter pipeline lengths to consider. Only the complete removal and leave *in situ* options are considered as the partial removal is discounted. Therefore, for brevity, we propose not to repeat the discussion here.

5.5.3 Environmental impact of operational activities

Please refer section 5.2.3 as we believe that the environmental impacts of operational activities for PL723/4 are broadly similar but with shorter pipeline lengths to consider. Only the complete removal and leave *in situ* options are considered as the partial removal is discounted. Therefore, for brevity, we propose not to repeat the discussion here.

5.5.4 Environmental impact of legacy activities

Please refer section 5.2.3 as we believe that the environmental impacts of legacy related operational activities for PL723/4 are broadly similar but with shorter pipeline lengths to consider. Only the complete removal and leave *in situ* options are considered as the partial removal is discounted. Therefore, for brevity, we propose not to repeat the discussion here.

5.5.5 Environmental impact on SAC

Please refer section 5.2.5 as we believe that the environmental impacts of operational activities for PL723/4 on the SAC are broadly similar but with shorter pipeline lengths to consider. Only the complete removal and leave *in situ* options are considered as the partial removal is discounted. Therefore, for brevity, we propose not to repeat the discussion here.

As the pipeline is shorter (about ¼ of the length of PL496/7), for the complete removal option we expect the impact on the SAC objectives to be much less marked because 0.0005% (0.0176km^2, or 1.76ha) of the SAC would be affected compared to 0.002% for PL496/7 (ref Table 5.10) and as a result we have assessed the impact to be 'medium or tolerable & non-preferred' as was assessed for PL496/7, but in practical terms there is little to differentiate the options in the short-term.

5.5.6 Summary of environmental assessment

Please refer section 5.2.6 as we believe that the various environmental impacts for PL723/4 are broadly similar but with shorter pipeline lengths to consider. Therefore, for brevity, we propose not to repeat the discussion here.

5.5.7 Societal Assessment

Please refer section 5.2.7 as we believe that the societal impact of the various activities for PL723/4 are broadly similar but with shorter pipeline lengths to consider. Only the complete removal and leave *in situ* options are considered as the partial removal is discounted. Therefore, for brevity, we propose not to repeat the discussion here.

5.5.8 Cost Assessment

The incremental difference in cost between complete removal and leave *in situ* would be at least £4.0MM. For this reason, because of the order of magnitude difference involved the short-term costs for complete removal in Table 5.21 are classed as "Medium, or tolerable but non-preferred". The incremental differences in cost for each option are compared in Appendix F.8.

Sub-Criterion	Option 1 Complete removal	Option 3 Leave *in situ*
Short-term: Cost	The cost of complete removal would be an order of magnitude higher than for the leave *in situ* option	The cost of leave *in situ* would be the least expensive option
Legacy: Cost	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.21: PL723/4 Cost Assessment

5.5.9 Overall Summary of Assessment

The results of the assessment are summarised in Table 5.22. Overall this option has been assessed as having the lowest safety risk, lowest environmental impact and risk, lowest technical uncertainty and lowest cost. Waste recovery and societal elements were the only criteria where complete removal was assessed as being beneficial and this was due to the potential extension of employment opportunities associated with this option.

Being the best option over the longer-term, the complete removal option would involve several elements that would be considered 'medium or tolerable and non-preferred'. These elements concern technical risks and short-term risk to the safety of project personnel during recovery operations and dealing with the pipeline as it is transferred to shore and finally dealt with. From an environmental perspective one aspect of the assessment that appears prominently is the effect on the objectives of the SAC, and we have assessed that these would be adversely affected most by activities associated with complete removal. In other words, even though complete removal might be achievable it is non-preferred when considering the objectives of the SAC. Finally, we estimate that complete removal would be an order of magnitude greater for complete removal than either of the other two options.

The biggest differentiators between the complete removal and the leave *in situ* options are safety, technical elements and impact on SAC. Examination of the criteria within these categories shows that the issues relate to:

- Uncertainties as to the recovering a 14" rigid pipeline piggybacked by a 3" pipeline and buried for all of its length using the 'cut and lift' method that has not been tried and tested over significant lengths of pipeline;
- The large amount of handling and particularly lifting involved in recovering the pipeline to shore, where it will need to be cut and moved in transportable lengths;
- The likely short-term damage to the seabed – and thus impact on the conservation objectives of the SAC,

It can also be seen that environmental assessment favours leaving the pipeline *in situ*. This is primarily because complete removal would require disturbance to the SAC as the pipeline runs through the area. Historical records however, do suggest that over the longer term the seabed will recover.

Also there would be fewer disturbances to ecosystems from removal activities and less impact

associated with emissions to air, discharges to sea, noise, and disposal requirements for vessel. These factors were considered to outweigh the impact of the ongoing surveys needed for the pipeline line remaining *in situ* after decommissioning.

Aspect	Sub-criterion	Short-term or legacy?	Option 1 Complete removal	Option 2 Leave *in situ*
Technical	Technical feasibility	Short-term		
		Legacy		
Safety	Safety risk to offshore project personnel	Short-term		
		Legacy		
	Safety risk to mariners	Short-term		
		Legacy		
	Safety risk to onshore project personnel	Short-term		
Environmental	Atmosphere (energy & emissions)	Short-term		
		Legacy		
	Seabed disturbance area affected	Short-term		
		Legacy		
	Water column disturbance	Short-term		
		Legacy		
	Impact on SAC	Short-term		
		Legacy		
	Waste creation	Short-term		
		Legacy		
Societal	Commercial fisheries	Short-term		
		Legacy		
	Employment	Short-term		
		Legacy		
	Communities	Short-term		
		Legacy		
Cost		Short-term		
		Legacy		

Table 5.22: PL723/4 Summary of Comparative Assessment

5.6 PL2066 Comparative Assessment

5.6.1 Technical Assessment

Please note that dealing with the pipeline ends will be common for all decommissioning options and so is not used to differentiate the options.

We believe that all decommissioning options for PL2066 are technically feasible.

There is limited experience in reverse reeling trenched & buried pipelines in the UKCS [10], and as such the technical uncertainty was deemed likely to have an adverse impact on technical risk. The alternative is that it would need to be recovered in sections using 'cut and lift'. We believe although somewhat repetitive, the 'cut and lift' method would be feasible but would take a long-time to carry out. This is the preferred method for short or discrete lengths of pipe, when it is impractical or prohibitively expensive to mobilise major removal equipment. Most significantly, the 'cut and lift' method does create greater risks to the personnel carrying out the offshore operations, although today's remotely operated equipment can help reduce the exposure of divers to the hazards of such work.

In contrast, operations that involve removal of relatively short lengths of pipe in discrete areas are well-established activities with little technical uncertainty. This option has been widely used for removing a short pipeline in its entirety, or for removing discrete lengths. It is usually the recommended removal option for short sections of pipe when it is impractical or prohibitively expensive to mobilise major equipment for removal.

For the pipeline to be removed in its entirety, apart from the short-exposed sections at each end, the pipeline would need to be removed from the backfill and large quantities of rock that have been deposited on the pipeline. Subject to integrity checks this could be achieved by either pulling it through the seabed material or by removing the material first using specialist equipment such as mass excavation tools or water jetting machines. Jetting to remove the cover has been widely used for short lengths of pipeline, although this would be more time consuming and costly for the entire pipeline.

Removal of surface laid pipespools would be relatively easy to achieve assuming the concrete mattresses can be removed, and this has been done before in the southern North Sea on many occasions as part of decommissioning operations.

The technical uncertainties associated with the pipeline decommissioning options have been assessed using the risk assessment matrix in the comparative assessment guidance for the project [3], the results of which are presented in Table 5.23 below.

Sub-Criterion	Option 1 Complete removal	Option 2 Leave *in situ*
Technical feasibility	**Short-term:** There is limited experience of reverse reeling of trenched & buried pipelines in the North Sea [7]. Further, there is limited experience of using the 'cut and lift' method for removing pipelines of this scale	**Short-term:** Stable and buried pipelines have been left *in situ* before and we know this is achievable
	Legacy: No pipeline surveys would be required in future	**Legacy:** Depth of burial pipeline surveys have been undertaken by Centrica in the past, and although obtaining depth of burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications
Colour Key:		
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.23: PL2066 Technical Assessment

Summary of technical assessment

Two options were considered for PL2066, and theoretically, given the right conditions - for example, no integrity issues can be foreseen - all three options can be considered technically feasible.

However, to achieve complete removal the pipeline would need to be fully excavated to be exposed and then either reverse reeled onto a pipelay vessel or removed in sections using the cut and lift method. The reverse reel method has not been used before in the North Sea and although the 'cut and lift' method has been used for relatively short lengths of pipeline this approach has not been undertaken for pipelines 17.8km long. Therefore, complete removal has been classed as 'tolerable but non-preferred.

As noted, the medium / tolerable rating is driven by uncertainties in the probability of success of either reverse reeling or the 'cut and lift' method, which although feasible is a non-preferred way of removing long pipelines, is considered to present risks to the delivery of the project.

As mentioned already, the cut and lift method has been used for recovery of short pipelines and so this option and leave *in situ* can both be regarded as technically feasible and would be preferred to complete removal using either of the methods described.

5.6.2 Safety Assessment

Safety Risk to Offshore Project Personnel

All hazards were assessed as broadly acceptable except for the risk associated with the heavy object on or near the vessel during reverse reeling. This was assessed as tolerable but non-preferred for complete removal. Similarly, although technically feasible - albeit repetitive - we would want to avoid the 'cut and lift' method of removal due to the length of pipeline being recovered.

The key differences between the options are as follows.

- Risk to divers and personnel on vessel from hydrocarbon or hazardous substance releases from recovered pipelines will be greater for complete removal than for leave *in situ* as no material would be recovered in the leave *in situ* option;
- Risk associated with the object on or near the vessel during reverse reeling but eliminated for leave *in situ*. The risk to personnel and assets is greater for complete removal option compared to leave *in situ* where none of the infield pipeline would be removed;
- Increased risk to all activities due to adverse weather is greater for complete removal than for leave *in situ* due to the time the vessel would be in the field;
- Risk associated with legacy survey activities that is, the risks associated with vessels being used is greater for partial removal than for complete removal. At least two legacy surveys would be required to confirm the condition of the pipelines or sections thereof left *in situ*.

Since the activities and techniques associated with pipeline removal are used in the North Sea, albeit not at this scale for full removal, it is presumed that the risks from all hazards would be broadly acceptable providing sufficient mitigations are put in place for such repetitive work over such a long length. There is little experience recovering a trenched and buried pipeline 17.8km long, but we believe that although associated risks would be higher for complete removal than for leave *in situ*, they would still be tolerable should sufficient mitigation and control measures be adopted. This risk only really relates to the complete removal option since such activities would be eliminated for leave *in situ* where no offshore work would be taking place.

Residual Safety Risk to Fishermen and Other Marine Users

The greatest risk relating to marine users is likely to be concerned with snagging of fishing gear.

The type of fishing in the area is predominantly demersal trawling for flatfish. Therefore, there is a potential for snagging on equipment and spoil mounds left on the seabed. Data relating to pipeline trenching and burial status are shown in Figure 3.6. However, recent (2016) MBES data

suggest that the pipeline is not exposed in any area outside the approaches at either end of the pipeline. Survey data obtained periodically since would suggest that most of the pipeline has remained relatively stable throughout its entire length albeit with short exposures.

From this it can be reasoned that decommissioning activities that minimise the disturbance to the seabed, reduce the likelihood of creating snag hazards / spoil mounds and that leave the seabed free of equipment will minimise the impact on local fishing activities. This will be no different from the current situation. Complete removal will leave the seabed free of equipment, while leave *in situ* will present risks that will remain as they are now. Although the complete removal option has the potential to leave spoil mounds that present snagging hazards, it is possible that with extra effort these could be dispersed, and they would disappear over time.

The key differences between the options are:

- There would be a risk of snagging fishing gear on the pipeline in future for leave *in situ* but this would be eliminated for complete removal;
- There would be a potential risk of snagging equipment during other offshore construction (e.g. wind) for leave *in situ* but it would be eliminated for complete removal;
- As the leave *in situ* option leaves a significant portion of the pipeline *in situ*, legacy surveys are required for this option. Legacy surveys have risks associated with the use of vessels that are not required for the complete removal option.

Safety Risk to Onshore Project Personnel

The key differences between the options are as followed:

- Risks associated with cutting the pipeline resulting in injury are greater for complete removal due to the higher quantity of material returned to shore compared with the leave *in situ* option;
- Risks associated with lifting and handling pipeline sections are also greater for complete removal, due to larger quantity of material being returned to shore. No material would be brought to shore for the leave *in situ* option.
- Exposure to potentially NORM contaminated materials increases with the volume of material recovered;

Summary of safety assessment

Many of the hazards described above are common to both decommissioning options. Based on the differences, in the short-term the leave *in situ* option gives rise to lower risks to project personnel for the following three reasons:

- Less offshore work;
- Less onshore handling;
- Little experience in the removal of trenched and buried pipelines in the North Sea [7], resulting in an increase in perceived risk.

By completely removing the pipeline the risk of snagging is removed in perpetuity. Therefore, the complete removal option results in lower residual risks to mariners and other users of the sea.

There is likely to be no increased snagging risk associated with the leave *in situ* option due to the burial status of the pipeline (Figure 3.6). However, although status surveys will need to be done in future to verify that the risk of snagging remains low for the foreseeable future.

Table 5.24 summarises the assessment for the pipeline. The colour coding - green being best - indicates whether the risks are broadly acceptable or tolerable. It should be noted that these risks are for the *differences* between options only.

Sub-Criterion	Option 1 Complete Removal	Option 3 Leave *in situ*
Health & safety risk offshore project personnel	**Short-term:** More offshore work and more onshore handling than partial removal. Little experience in the North Sea of either reverse reeling or 'cut and lift' of trenched and buried pipelines. Both reverse reeling and 'cut and lift' activities are assessed as tolerable for the 17.8km pipeline	**Short-term:** Less offshore work than required for complete removal
	Legacy: No depth of burial surveys or remediation related activities	**Legacy:** Assume up to four depth of burial related surveys
Health & safety risk to mariners	**Short-term:** Duration of vessels in the field would be longer than for leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field	**Short-term:** Duration of vessels in the field would be shorter than for complete removal
	Legacy: Infrastructure completely removed so no residual snag hazards completely removed	**Legacy:** Degradation of the remaining pipeline will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited
Safety risk onshore project personnel	**Short-term:** Significantly more onshore cutting, lifting and handling associated with disposal of the pipelines presents an increased safety risk to personnel	**Short-term:** Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel
Colour Key:		

Medium / Tolerable & non - preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.24: PL2066 Safety Assessment

5.6.3 Environmental impact of operational activities

In all cases the duration vessels would be required in the field for complete removal was longer than the leave *in situ* option. The leave *in situ* option would result in least vessel time working in the field. The impact of this on liquid discharges to sea, noise, emissions to air and energy requirements, water column, seabed, waste, etc. are summarised in Table 5.25.

Operational Environmental factors impacted	Option 1 Complete removal	Option 3 Leave *in situ*
Atmosphere (energy & emissions)	**Short-term:** Emissions and use of energy greatest for this option but no offset would be generated as a result of the energy and emissions needed to create new material to replace any that may be left *in situ*	**Short-term:** Least amount of energy used and least emissions generated in the short-term, although this is slightly counteracted by the energy and emissions required to create new material
Seabed disturbance; area affected	**Short-term:** The amount of seabed disturbed is directly related to the length of pipeline (or umbilical) being removed. The area affected would be largest for this option	**Short-term:** The least area of seabed would be disturbed with this option
Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	**Short-term:** Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal	**Short-term:** Discharges and releases would be least for this option, particularly in the short-term

Operational Environmental factors impacted	Option 1 Complete removal		Option 3 Leave *in situ*
Waste creation and use of resources such as landfill. Recycling and replacement of materials	**Short-term:** This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*		**Short-term:** No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.25: PL2066 Summary of Operational Environmental Impacts

We can expect emissions to air and energy requirements to demonstrate that there are differences between the options, but since this would be related to the duration that vessels would be in the field. We have not calculated the difference but have examined this qualitatively. Based on our experience with previous assessments we can say that the gap in emissions to air and energy requirements between complete removal and leave *in situ* narrow when indirect emissions and energy requirements – such as that required for replacement of unrecovered material – are accounted for.

From Table 5.25, while there will be different impacts for each of the options, the overall impact of the 'complete removal' option will be higher on the atmosphere, seabed disturbance, and water column and lowest in terms of material being left *in situ* and needing to be replaced. The reality, however, is that there is little to differentiate the two options for PL2066.

Conversely, the legacy survey requirements for leave *in situ* are greater than for complete removal and these will mostly affect the atmosphere and water column. However, in real terms there will be little to distinguish between the options for any of the pipelines.

In Table 5.25 the boxes coloured darker green would be the most favourable option for each individual pipeline while lighter green boxes would the least favourable. However, we believe that there is little to differentiate the options.

5.6.4 Environmental impact of legacy activities

On completion of decommissioning activities, a final environmental survey would be carried out, and this would be common for all options and is not a differentiator. For longer-term legacy related activities, a differentiator between options would be the number of pipeline burial surveys that would be required as well as any possible remedial works.

The environmental impact of legacy activities associated with future requirements of ensuring that PL2066 remains buried and stable are assessed in much the same way as operational activities. The impacts of legacy related activities can be expected to be significantly less than those brought about by operational activities during decommissioning work. The results of the assessment are summarised in Table 5.26.

Operational Environmental factors impacted	Option 1 Complete removal	Option 2 Leave *in situ*
Atmosphere (energy & emissions)	No pipeline burial surveys required	Assume up to four depth of burial related surveys
Seabed disturbance; area affected	No pipeline burial surveys required	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact
Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	No pipeline burial surveys required	Assume up to four depth of burial related surveys

Operational Environmental factors impacted	Option 1 Complete removal	Option 2 Leave *in situ*
Waste creation and use of resources such as landfill. Recycling and replacement of materials	We assume that no pipeline remedial activities would be required as the trends to date have indicated that the pipeline remains stable. Therefore, as part of legacy related activities there is nothing to differentiate the options from a waste perspective	

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.26: PL2066 Summary of Legacy Environmental Impacts

5.6.5 Environmental impact on SAC

Our assessment of the short-term impact of decommissioning PL2066 and longer term impact of legacy related activities such as surveys on the Special Area of Conservation is summarised in Table 5.27.

Sub-Criterion	Option 1 Complete removal	Option 2 Leave *in situ*
Short-term: Environmental impacts on SAC due to decommissioning activities	Dredging to access the pipeline for complete recovery would open a trench and introduce sediment into the water column. We would expect the area to recover relatively quickly as the survey data doesn't show much evidence of the original trench in the 10 years since the pipeline was installed. Assuming a 4m wide corridor along the pipeline being disturbed, the area affected would be 0.164km^2, 16.4ha equivalent to c. 0.005% of the SAC.	Limited or no impact on the SAC during offshore decommissioning operations
Legacy: Environmental impacts on SAC	No impact. Only environmental survey following completion of decommissioning activities, and this is required for both options	Environmental survey and pipeline status survey only, assuming no remedial work would be required – as suggested by historical survey data. Survey data suggests that the presence of the buried pipeline in the seabed is not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks)

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.27: PL2066 SAC Environmental Assessment

The significance of the impacts associated with the interactions with the environment was assessed using the Environmental Impact Matrix in the comparative assessment guidance for the decommissioning project [3]. This was done to allow an understanding of the significance of the impacts and to aid decision making where conflicts arose between assessment criteria and sub-criteria. These are reflected in the traffic light colour coding.

The orange rating for complete removal in the above table is driven by the area that would be disturbed because of removing the pipeline from its buried position.

5.6.6 Summary of environmental assessment

The environmental assessment was split into short-term operational impacts, legacy impacts and both short-term and long-term impacts due to legacy related activities on the Special Area of Conservation.

In the short-term, and from operational perspective, leave *in situ* would be the favoured option

although in practical terms there is little to differentiate partial removal from leave *in situ*. Conversely complete removal would result in no legacy activities being required. All impacts for all options were assessed as broadly acceptable.

The complete removal option would result in recovery of all the pipeline material for recycling whereas the leave *in situ* option would result in most of the pipeline material being left where it is, and therefore unavailable for recycling. Any raw material not recovered would need to be replaced with newly manufactured material.

In the short-term, the leave *in situ* decommissioning option was considered to cause the least disruption to the SAC and so would be the most preferred. Over the longer-term the leave *in situ* option would be preferred to the complete removal option.

In the short-term and due to operational activities, the complete removable option would be least favourable but was nevertheless assessed as 'tolerable'. However, the area can be expected to fully recover within 10 years after the initial impact of decommissioning works, and so in the longer-term complete removal was assessed to be the marginally preferred option.

5.6.7 Societal Assessment

Please refer section 5.2.7 as we believe that the societal impacts of the various activities for PL2066 are broadly similar. Only the complete removal and leave *in situ* options are considered as the partial removal is discounted. Therefore, for brevity, we propose not to repeat the discussion here.

5.6.8 Cost Assessment

The incremental difference in cost between complete removal and leave *in situ* would be at least £4.7MM. For this reason, because of the order of magnitude difference involved the short-term costs for complete removal in Table 5.28 are classed as "Medium, or tolerable but non-preferred". The incremental differences in cost for each option are compared in Appendix F.10.

Sub-Criterion	Option 1 Complete removal	Option 3 Leave *in situ*
Short-term: Cost	The cost of complete removal would be an order of magnitude higher than for the leave *in situ* option	The cost of leave *in situ* would be the least expensive option
Legacy: Cost	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable, no more surveys would be required

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.28: PL2066 Cost Assessment

5.6.9 Overall Summary of Assessment

Once the approaches at Annabel, Audrey A (XW) and Audrey B (WD) have been decommissioned, leave *in situ* is the recommended decommissioning option for pipeline PL2066.

The results of the assessment are summarised in Table 5.29. Overall this option has been assessed as having the lowest safety risk, lowest environmental impact and risk, lowest technical uncertainty and lowest cost. Waste recovery and societal elements were the only criteria where complete removal was assessed as being beneficial and this was due to the potential extension of employment opportunities associated with this option.

Being the best option over the longer-term, the complete removal option would involve several

elements that would be considered 'broadly acceptable'. These elements concern short-term risk to the safety of project personnel during recovery operations and dealing with the pipeline as it is removed from the reel and cut into manageable lengths for transportation. Furthermore, the field work involved with assuring that the integrity of the pipeline is sufficient to endure the stresses and strains of removal without incident would be insignificant. From an environmental perspective one aspect of the assessment that appears prominently is the effect on the objectives of the SAC, and we have assessed that these would be adversely affected most by activities associated with complete removal. In other words, even though complete removal might be achievable it is non-preferred when considering the objectives of the SAC. Finally, we estimate that complete removal would be an order of magnitude greater for complete removal than either of the other two options.

The biggest differentiators between the complete removal and the leave *in situ* options are safety and technical elements. Examination of the criteria within these categories shows that the issues relate to:

- Uncertainties as to the reliability of recovering a 10" rigid pipeline of unknown condition to a pipeline reel on the deck of the vessel and effect on those working in proximity should the pipeline fail during recovery or cutting;
- The lack of experience in reverse reeling [10] pipelines, leading to higher safety risks and higher probability that the project will significantly over-run in both cost and schedule;
- The large amount of handling and particularly lifting involved in recovering the pipeline to shore, where it will need to be cut and moved in transportable lengths.

It can also be seen that environmental assessment favours leaving the pipeline *in situ*. This is primarily because complete removal would require disturbance to the SAC as the pipeline runs through the area. Also, there would be fewer disturbances to ecosystems from removal activities and less impact associated with emissions to air, discharges to sea, noise, and disposal requirements for vessel. These factors were considered to outweigh the impact of the ongoing surveys needed for the pipeline line remaining *in situ* after decommissioning.

Aspect	Sub-criterion	Short-term or legacy?	Option 1 Complete removal	Option 2 Leave *in situ*
Technical	Technical feasibility	Short-term		
		Legacy		
Safety	Safety risk to offshore project personnel	Short-term		
		Legacy		
	Safety risk to mariners	Short-term		
		Legacy		
	Safety risk to onshore project personnel	Short-term		
Environmental	Atmosphere (energy & emissions)	Short-term		
		Legacy		
	Seabed disturbance area affected	Short-term		
		Legacy		
	Water column disturbance	Short-term		
		Legacy		
	Impact on SAC	Short-term		
		Legacy		
	Waste creation	Short-term		
		Legacy		
Societal	Commercial fisheries	Short-term		
		Legacy		

	Employment	Short-term		
		Legacy		
	Communities	Short-term		
		Legacy		
Cost		Short-term		
		Legacy		

Table 5.29: PL2066 Summary of Comparative Assessment

5.7 PL2067 Comparative Assessment

5.7.1 Technical Assessment

All the umbilical decommissioning options are technically feasible. Complete removal and partial removal operations – where the length of umbilical justifies the approach, that involve reverse reeling to remove the umbilical from its trench. There is limited experience of reverse reeling trenched and buried umbilical lines in the UKCS [10] and as such we considered that the technical uncertainty has an adverse impact on technical feasibility and risk. The difficulties are however considered to be of a lesser order than those associated with removing the rigid steel pipeline. The technical difficulties concern securing the umbilical and pulling it up from the seabed and ensuring that it retains its integrity while being recovered.

The results of the assessment are presented in Table 5.30.

Sub-Criterion	Option 1 Complete removal	Option 3 Leave *in situ*
Technical feasibility	**Short-term:** Reverse reeling is a viable option albeit with technical challenges as the umbilical is pulled from the seabed. Considered more technically difficult than leave *in situ*	**Short-term:** Stable and buried umbilical lines have been left *in situ* before and we know this is achievable. From a technical perspective this would be the least challenging option
	Legacy: No pipeline surveys would be required in future	**Legacy:** Depth of burial pipeline surveys have been undertaken by Centrica in the past, and although obtaining depth of burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications
Colour Key:		
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.30: PL2067 Technical Assessment

Three options were considered for PL2066, and theoretically, given the right conditions - for example, no integrity issues can be foreseen – all three options can be considered technically feasible.

However, to achieve complete removal the umbilical would need to be extracted from the seabed and reverse reeled onto any vessel fitted with a carousel or reel. Therefore, complete removal has been classed as ‘broadly acceptable’ but not as favourable as leave *in situ*.

5.7.2 Safety Assessment

Safety Risk to Offshore Project Personnel

All hazards were assessed as broadly acceptable. However, there were some key differences:

- Risk to divers and personnel on vessel from methanol or hazardous substance releases would be greater for complete removal than for leave *in situ*;
- There would be a risk associated with the presence of an object on or near the vessel during

reverse reeling for the complete removal option but eliminated for the leave *in situ* option;

- There would also be more risk of the umbilical failing during recovery operations associated with complete removal;
- The increase in risk to all activities due to adverse weather is greater for complete removal than for leave *in situ*;
- Risks associated with legacy survey activities (risks associated with vessels being used) are greater for leave *in situ* than for complete removal

Residual Safety Risk to Fishermen and Other Marine Users

The residual safety hazards identified as differences between the options were assessed as broadly acceptable. There are some key differences:

- Due to the leave *in situ* option leaving a portion of the umbilical in situ, there is a potential snagging hazard that does not exist for the complete removal option. However, this is only expressed as having minimal impact, given the trenched status of the umbilical;
- As the leave *in situ* option leaves a significant portion of the umbilical *in situ*, legacy surveys are required for this option. The legacy surveys have risks associated with the use of vessels that are not required for the complete removal option;

For the leave *in situ* option degradation of the umbilical wouldn't change the risk if it remains buried, but having degraded and if exposed the risks of snagging may increase. No remedial work has been required to date, so it is anticipated that no additional monitoring – if any - over and above what might be considered normal would be needed to establish what remedial works would be required in future.

Safety Risk to Onshore Project Personnel

The hazards identified as *differences* between the options were assessed as broadly acceptable. The key differences between the options are:

- Risks associated with onshore cutting of umbilical resulting in injury. These risks are considered greater for complete removal compared to the leave *in situ* option which recovers no material to shore;
- Risks associated with onshore lifting and handling umbilical sections. Again, these risks are considered greater for complete removal compared to the leave *in situ* which recovers no material to shore.

Sub-Criterion	Option 1 Complete removal	Option 2 Leave *in situ*
Health & safety risk offshore project personnel	**Short-term:** More offshore work involving vessels and possibly divers and more onshore handling than leave *in situ*. Considered broadly acceptable if safety risks are driven to ALARP	**Short-term:** Least amount of work done offshore than that undertaken for complete removal
	Legacy: No depth of burial surveys or remediation related activities	**Legacy:** Assume up to four depth of burial related surveys
Health & safety risk to mariners	**Short-term:** Duration of vessels in the field would be longer than for leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field	**Short-term:** Vessels would spend less time in the field for this option, therefore the potential for interaction with other mariners and any associated risk would be minimised
	Legacy: No depth of burial surveys or remediation related activities	**Legacy:** Assume up to four depth of burial related surveys so there is potential for interaction with other mariners, although any associated risks can be expected to be minimal
Safety risk onshore project personnel	**Short-term:** Significantly more onshore cutting, lifting and handling associated with disposal of the umbilical presents an increased but broadly acceptable safety risk to personnel	**Short-term:** This option presents less of a safety risk to onshore project personnel and this option would involve no material being returned to shore for processing
Colour Key:		

Sub-Criterion	Option 1 Complete removal		Option 2 Leave *in situ*	
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred		Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.31: PL2067 Safety Assessment

Summary

Table 5.26 summarises the safety assessment for the PL2067 decommissioning options. Many of the hazards associated with decommissioning PL2067 are common to both options and are assessed as broadly acceptable. The leave *in situ* option give rise to lower risks to personnel for the following reasons:

- The reverse reeling required to remove the umbilical carries more risk than leave *in situ*;
- The vessels are in the field for far less time, thereby minimising the chances of interaction with other users of the sea;
- The leave *in situ* option presents lower risks to onshore personnel due to less material needing to be dealt with when cutting, lifting and handling onshore

Complete removal would give rise to lower residual risks to mariners and other users of the sea because there would be no potential snagging hazards occurring in future.

5.7.3 Environmental impact of operational activities

Please refer section 5.6.3 as we believe that the environmental impacts of operational activities for PL2066 and PL2067 are broadly similar. Therefore, for brevity, we propose not to repeat the discussion here.

5.7.4 Environmental impact of legacy activities

Please refer section 5.6.4 as we believe that the environmental impacts of operational activities for PL2066 and PL2067 are broadly similar. Therefore, for brevity, we propose not to repeat the discussion here.

5.7.5 Environmental impact on SAC

Please refer section 5.6.5 as we believe that the environmental impacts of operational activities for PL2066 and PL2067 are broadly similar. Therefore, for brevity, we propose not to repeat the discussion here.

5.7.6 Summary of environmental assessment

Please refer section 5.6.6 as we believe that the summary of the environmental impacts of operational and legacy related activities for PL2066 and PL2067 are broadly similar. We also believe that the effects on the SAC are broadly similar. Therefore, for brevity, we propose not to repeat the discussion here.

5.7.7 Societal Assessment

Please refer section 5.2.7 as we believe that the societal impacts of the various activities for PL2067 are broadly similar. Only the complete removal and leave *in situ* options are considered as the partial removal is discounted. Therefore, for brevity, we propose not to repeat the discussion here.

5.7.8 Cost Assessment

The incremental difference in cost between complete removal and leave *in situ* would be at least £3.4MM. For this reason, because of the order of magnitude difference involved the short-term costs for complete removal in Table 5.32 are classed as "Medium, or tolerable but non-preferred". The incremental differences in cost for each option are compared in Appendix F.12.

Sub-Criterion	Option 1 Complete removal	Option 3 Leave *in situ*
Short-term: Cost	The cost of complete removal would be an order of magnitude higher than for the leave *in situ* options	The cost of leave *in situ* would be the least expensive option
Legacy: Cost	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable, no more surveys would be required

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.32: PL2067 Cost Assessment

5.7.9 Overall Summary of Comparative Assessment

Once the approaches at Audrey B (WD) and Annabel have been decommissioned, leave *in situ* is the recommended decommissioning option for pipeline PL2067.

The results of the assessment are summarised in Table 5.29. Overall this option has been assessed as having the lowest safety risk, lowest environmental impact and risk, lowest technical uncertainty and lowest cost. Waste recovery and societal elements were the only criterion where complete removal was assessed as being beneficial and this was due to the potential extension of employment opportunities associated with this option.

Being the best option over the longer-term, the complete removal option would involve several elements that would be considered 'broadly acceptable'. These elements concern short-term risk to the safety of project personnel during recovery operations and dealing with the umbilical as it is removed from the reel and cut into manageable lengths for transportation. Furthermore, the field work involved with assuring that the integrity of the pipeline is sufficient to endure the stresses and strains of removal without incident would be insignificant. From an environmental perspective one aspect of the assessment that appears prominently is the effect on the objectives of the SAC, and we have assessed that these would be adversely affected most by activities associated with complete removal. In other words, even though complete removal might be achievable it is non-preferred when considering the objectives of the SAC. Finally, we estimate that complete removal would be an order of magnitude greater than for leave *in situ*.

It can also be seen that environmental assessment favours leaving the pipeline *in situ*. This is primarily because complete removal would require disturbance to the SAC as the pipeline runs through the area. Also, there would be fewer disturbances to ecosystems from removal activities and less impact associated with emissions to air, discharges to sea, noise, and disposal requirements for vessel. These factors were considered to outweigh the impact of the ongoing surveys needed for the pipeline line remaining *in situ* after decommissioning.

Aspect	Sub-criterion	Short-term or legacy?	Option 1 Complete Removal	Option 2 Leave *in situ*
Technical	Technical feasibility	Short-term		
		Legacy		
Safety	Safety risk to offshore project personnel	Short-term		
		Legacy		
	Safety risk to mariners	Short-term		
		Legacy		
	Safety risk to onshore project personnel	Short-term		
Environmental	Atmosphere (energy & emissions)	Short-term		
		Legacy		
	Seabed disturbance area affected	Short-term		
		Legacy		
		Legacy		
	Water column disturbance	Short-term		
		Legacy		
	Impact on SAC	Short-term		
		Legacy		
	Waste creation	Short-term		
		Legacy		
Societal	Commercial fisheries	Short-term		
		Legacy		
	Employment	Short-term		
		Legacy		
	Communities	Short-term		
		Legacy		
Cost		Short-term		
		Legacy		

Table 5.33: PL2067 Summary of Comparative Assessment

More significant differences are found between the safety assessment with more work required offshore and onshore for the complete removal – where significant offshore and onshore work would be required - than leave *in situ* where in the short-term there would be no offshore work required apart from burial status surveys following on from decommissioning the umbilical ends. Conversely there is lower safety risk to mariners from complete removal than for leave *in situ* due to the complete removal of the pipeline as a potential snag hazard.

6. DRILL CUTTINGS COMPARATIVE ASSESSMENT

As identified in the pre-decommissioning survey report [7] one area of anthropogenic rock at each of the installations shows 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 [11] 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/yr). 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^2yrs).

The results of this process are compared against the following two criteria:
1. Rate of oil loss to water column: 10 tonnes/yr;
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 (5784µg/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/yr.

The second criterion is a measure of recovery of the area contaminated where 500km^2yrs 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 [11] 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.

7. OVERTRAWL AND VERIFICATION OF CLEAN SEABED

Upon completion of each decommissioning operation, appropriate surveys should be taken to identify and recover any debris located on the seabed which has arisen from the decommissioning operation or from past development and production activity. The area to be covered will depend on the circumstances of each case, but the minimum required will be a radius of 500 metres from the location of an installation [1].

Debris surveying and removal may be required up to 100 metres either side of a decommissioned pipeline over its whole length, and following this, independent verification of seabed clearance will be required [1].

The advisability of post-decommissioning over-trawl to confirm that the area is clear of debris will be considered on a case-by-case basis and will be dependent upon the extent of relevant circumstances [1].

In the southern North Sea, the verification of a clean 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 Clean Seabed Certificate is issued. These overtrawl surveys are carried out to make sure the seabed is safe for normal fishing.

In our assessment of complete removal of the longer pipelines (e.g. PL496/7, PL723/4, PL2066, PL2067) we considered that the impact on the SAC would be 'medium; tolerable & non-preferred'. This was due to the scale of the impact that decommissioning works would have on the seabed, and by implication, the conservation objectives of the SAC.

Our assessment was based on a corridor on the seabed between 2m and 5m wide depending on the nature of the pipeline or umbilical, along the full length of the pipeline being affected compared with a 200m wide corridor affected by an overtrawl. A comparison of the area of seabed affected outside of the 500m zones reveals that the area affected by complete removal would be 0.2km^2 (0.006% of SAC) compared to 8.94km^2 (0.25% of SAC) the area impacted by an overtrawl. For details refer Appendix G.

The in-field lengths of pipelines outside of the 500m safety zones will already have been subject to fishing activity. All our pipeline decommissioning activities will be undertaken within the existing Audrey A (WD), Audrey B (XW), Annabel and LOGGS 500m safety zones. Therefore, although we can expect the seabed to recover following the overtrawl activities, to minimise the short-term impact in the seabed and thus the conservation objectives of the SAC, we would propose to carry out overtrawl activities only within the 500m safety zones.

8. CONCLUSIONS

Comparative assessment was undertaken with a focus on the decommissioning options for the various pipelines and umbilical lines for Audrey and Annabel.

The assessments considered five criteria in both the short-term for decommissioning activities and the longer term for any 'legacy' related activities. The criteria were: safety related risks (three sub-criteria), environment (three sub-criteria), technical feasibility, societal effects (three sub-criteria), and cost.

Since the decommissioning of the pipeline and umbilical approaches is the same irrespective of which option is pursued, decommissioning of these is not included in the assessment. Therefore, any differences are incremental to the activities associated with dealing with the pipeline approaches.

8.1 PL496/7 Conclusion of Comparative Assessment

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 (please refer section 3.1). 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.

8.2 PL575 Conclusion of Comparative Assessment

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.

8.3 PL576 Conclusion of Comparative Assessment

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.

8.4 PL723/4 Conclusion of Comparative Assessment

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.

8.5 PL2066 Conclusion of Comparative Assessment

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.

8.6 PL2067 Conclusion of Comparative Assessment

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.

8.7 Drill Cuttings

The survey data and sample analysis shows the drill cutting contamination to be below the OSPAR thresholds. Therefore, we conclude that the best environmental strategy would be to leave the drill cuttings pile *in situ* for natural degradation.

9. REFERENCES

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APPENDIX A STABILISATION FEATURES QUANTIFIED

Appendix A.1 Summary of stabilisation features (excl. rock)[20]

Pipeline	No. of concrete mattresses or plinths and locations	No. of grout bags and locations	Number of Frond Mattresses and location
PL496/7	3 Audrey A (WD) 6 LOGGS PP 21 over PL27 & PL161 at pipeline crossing	2x1Te Audrey A (WD) (Gabion bags) 2x1Te LOGGS PP (Gabion bags) 100 LOGGS PP	5 LOGGS PP
PL575	3 at Audrey 11a-7	N/A	N/A
PL576	N/A	N/A	N/A
PL723/4	16 Audrey A (WD) 12 Audrey B (XW)	4x1Te Audrey A (WD) 200 Audrey B (XW)	17 Audrey A (WD) 9 Audrey B (XW)
PL2066	15 Annabel template 41 Audrey A (WD) 6 over BT Telecoms Cable 2 over PL1967 & PL1968 at pipeline crossing; 3 over PL1967 & PL1968 at pipeline crossing (plinths) 9 over PL575 at pipeline crossing near Audrey A (WD)	100 Audrey A (WD) 2x1Te between PL575 crossing and Audrey A (WD) 3x1Te Audrey A (WD) (Gabion bags)	None
PL2066JW12	5 between Annabel template & AB1	N/A	N/A
PL2066JWAB2	22 between Annabel template & AB2	N/A	N/A
PL2067[21]	30 Audrey B (XW) 36 Annabel template	8x1 Te on approach to Annabel template	N/A
PL2067JW12	Shared with PL2066JW12	N/A	N/A
PL2067JWAB2	14 (plus 22 shared with PL2066JWAB2)	N/A	N/A
Annabel template	None	None	10 around Annabel template
AUDREY SUB-TOTAL:	**Crossings:** 21 **Approaches:** 40	**Crossings:** N/A **Approaches:** 300 x 25kg; 8 x 1000kg	**Pipelines:** 31 **Installations:**
ANNABEL SUB-TOTAL:	**Crossings:** 15 **Approaches:** 168	**Crossings:** **Approaches:** 100 x 25kg; 13 x 1000kg	**Pipelines:** **Installations:** 10

Table A.1: Summary of stabilisation features (excl. rock)

[20] Sub-total quantities split by pipeline

[21] For PL1967 & PL1968 pipeline crossings refer PL2066

Appendix A.2 Summary of stabilisation features (rock)

Pipeline	Location of Placed Rock	Quantity
PL496/7	Refer Figure 3.2 in section 3.1	69,516 tonnes
PL575	N/A	N/A
PL576	N/A	N/A
PL723/4	N/A	N/A
PL2066	BT Telecoms Cable crossing, approx. 200m long PL1967 & PL1968 pipeline crossing, approx. 180m long Intermittent along pipeline route	3,000 tonnes 4,800 tonnes 12,200 tonnes
PL2066JW12	N/A	None
PL2066JWAB2	N/A	None
PL2067	N/A	None
PL2067JW12	N/A	None
PL2067JWAB2	N/A	None
SUB-TOTAL:		**Audrey:** 77,316 tonnes **Annabel:** 12,200 tonnes

Table A.2: Summary of stabilisation features (rock)

APPENDIX B PIPELINE STABILISATION FEATURES ILLUSTRATED

Appendix B.1 Audrey A (WD)

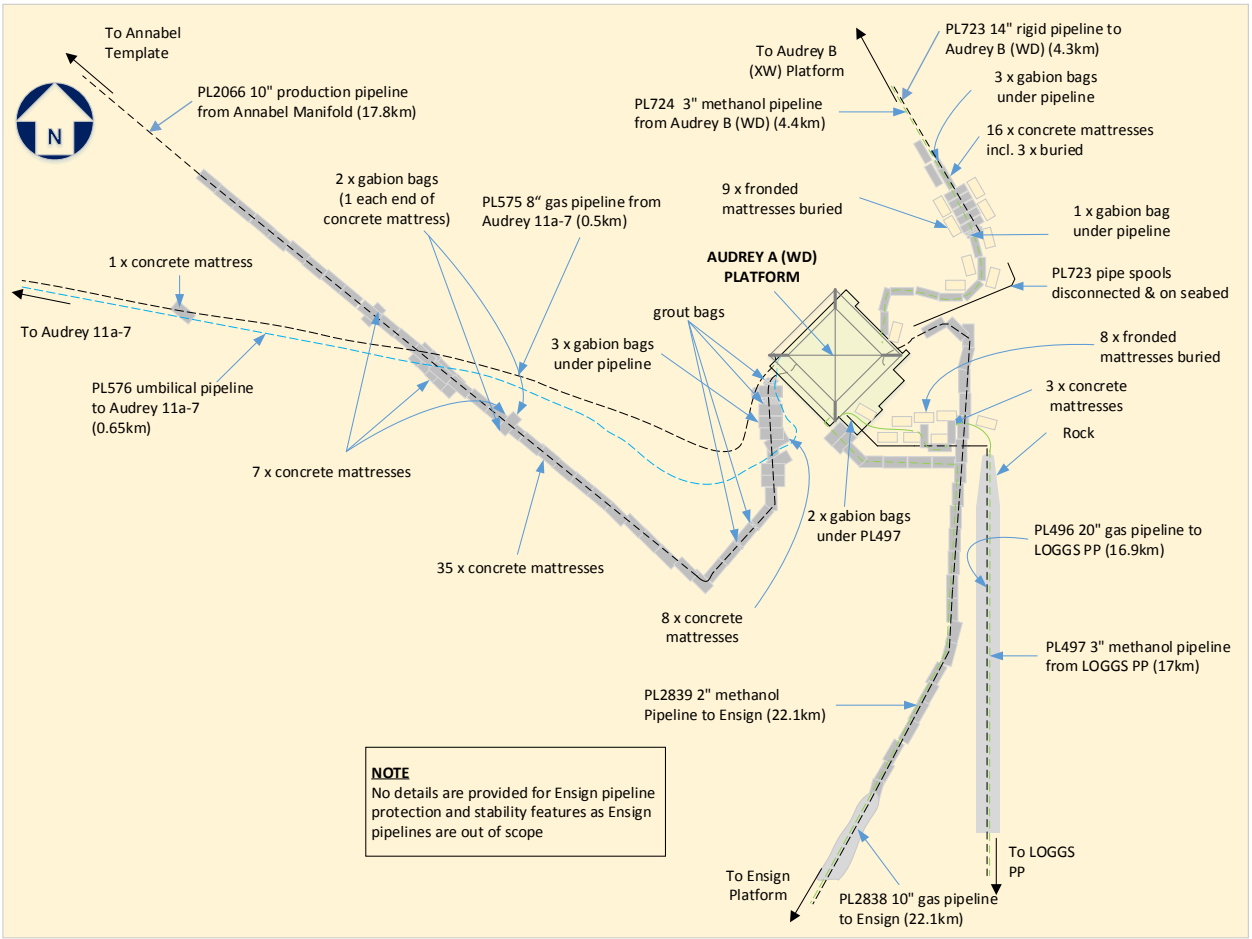


Figure B.1: Pipeline infrastructure @Audrey A (WD)

Appendix B.2 Audrey B (XW)

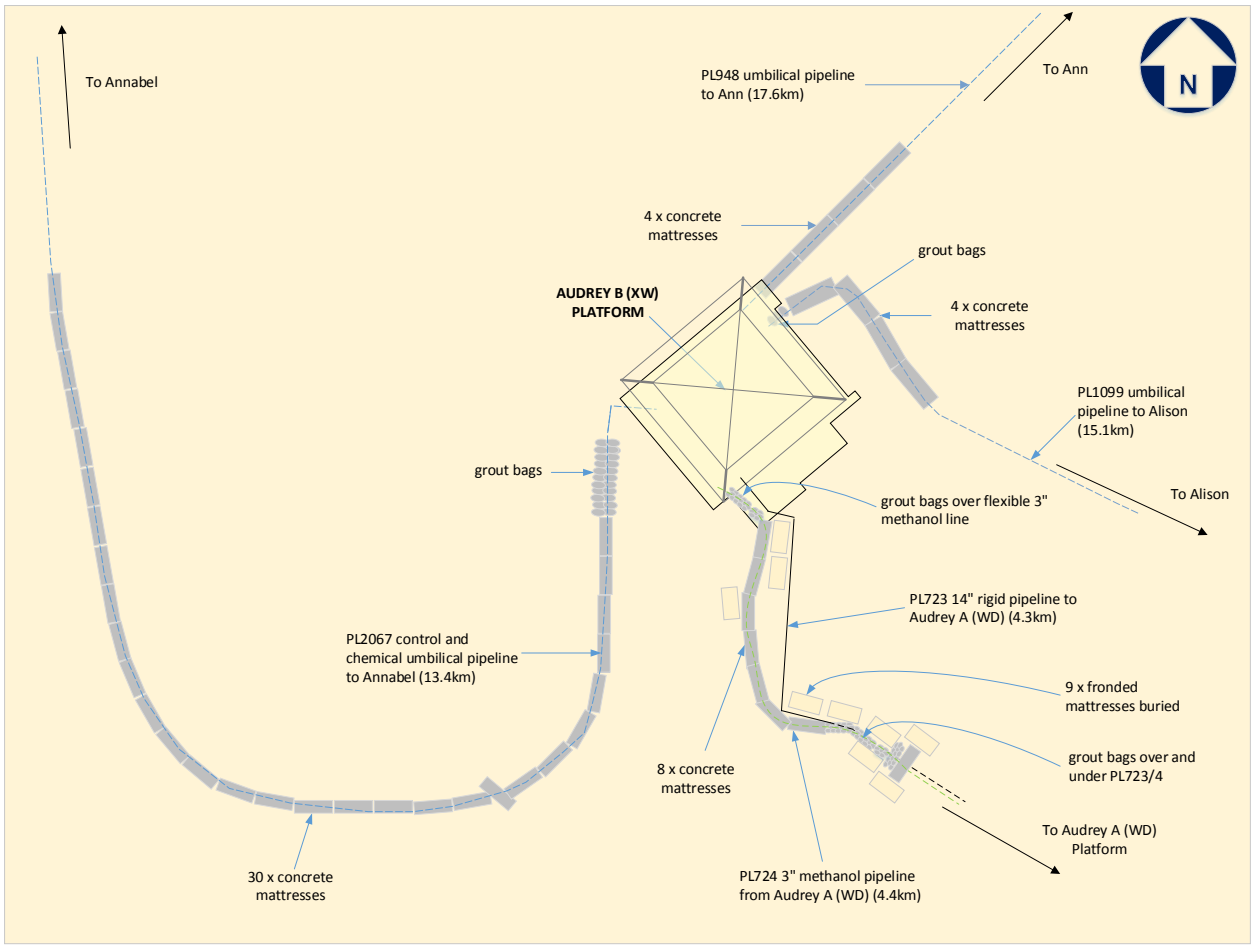


Figure B.2: Pipeline infrastructure @Audrey B (XW)

Appendix B.3 Audrey 11a-7

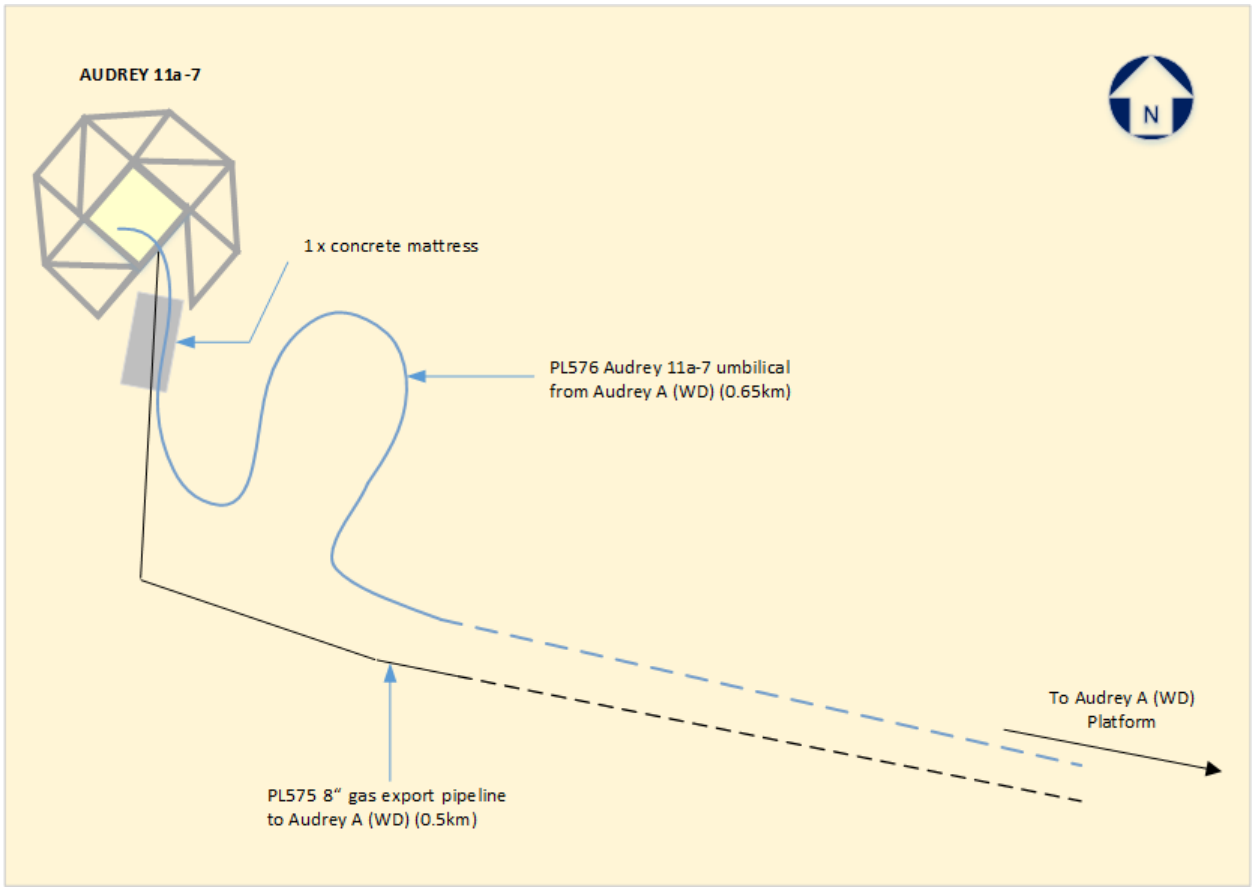


Figure B.3: Pipeline infrastructure @Audrey 11a-7

Appendix B.4 Annabel

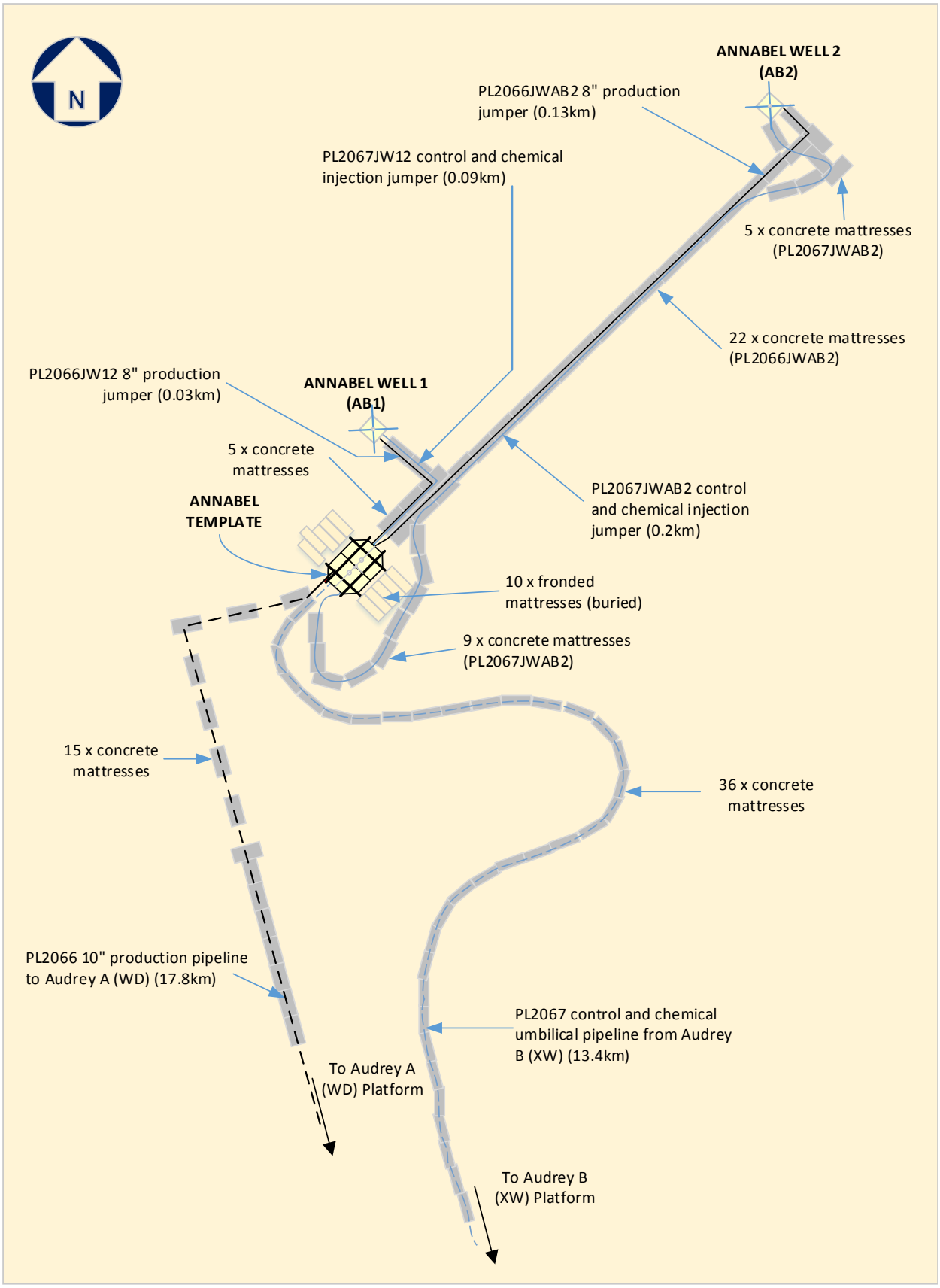


Figure B.4: Pipeline infrastructure @Annabel

Appendix B.5 LOGGS PP

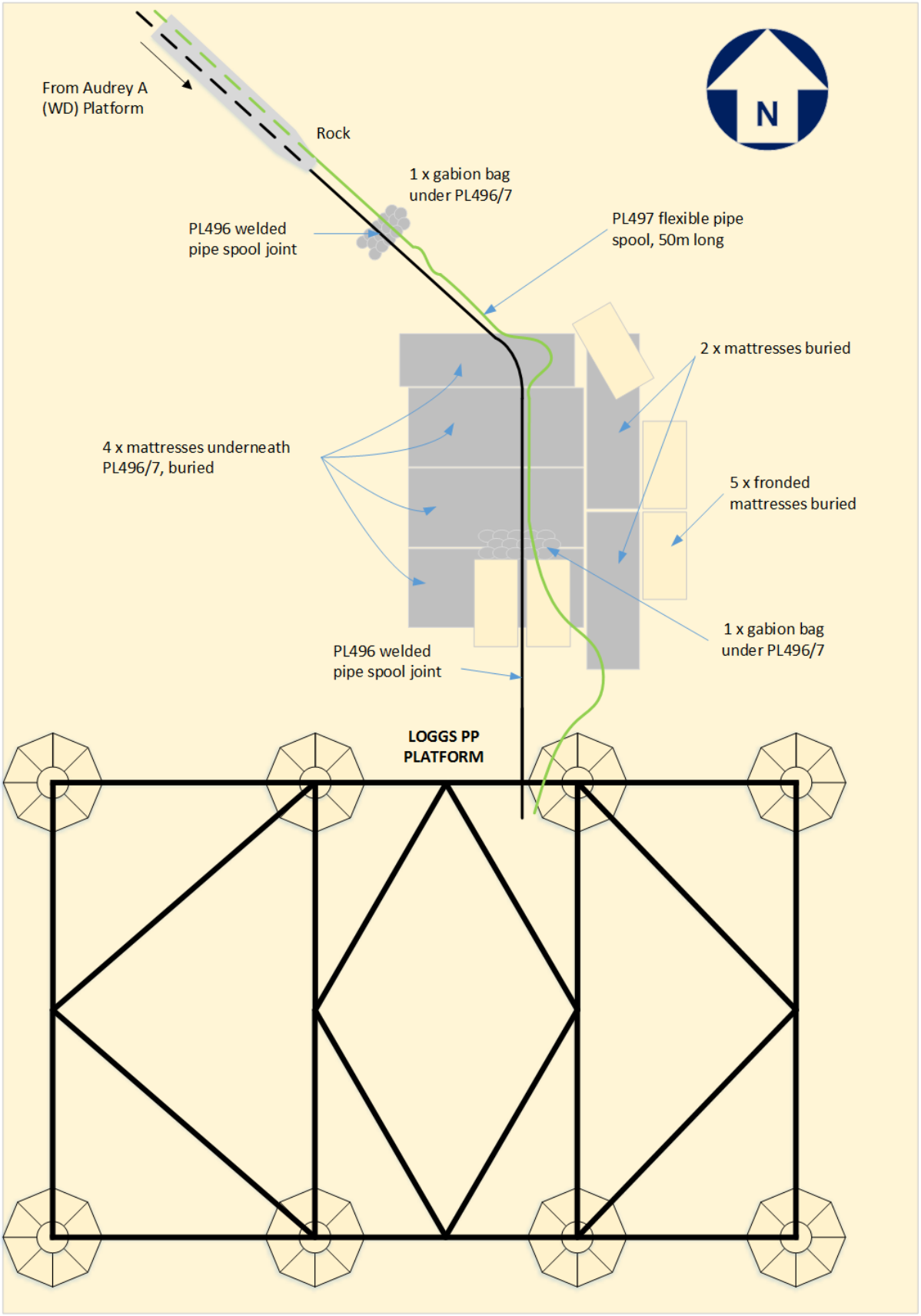
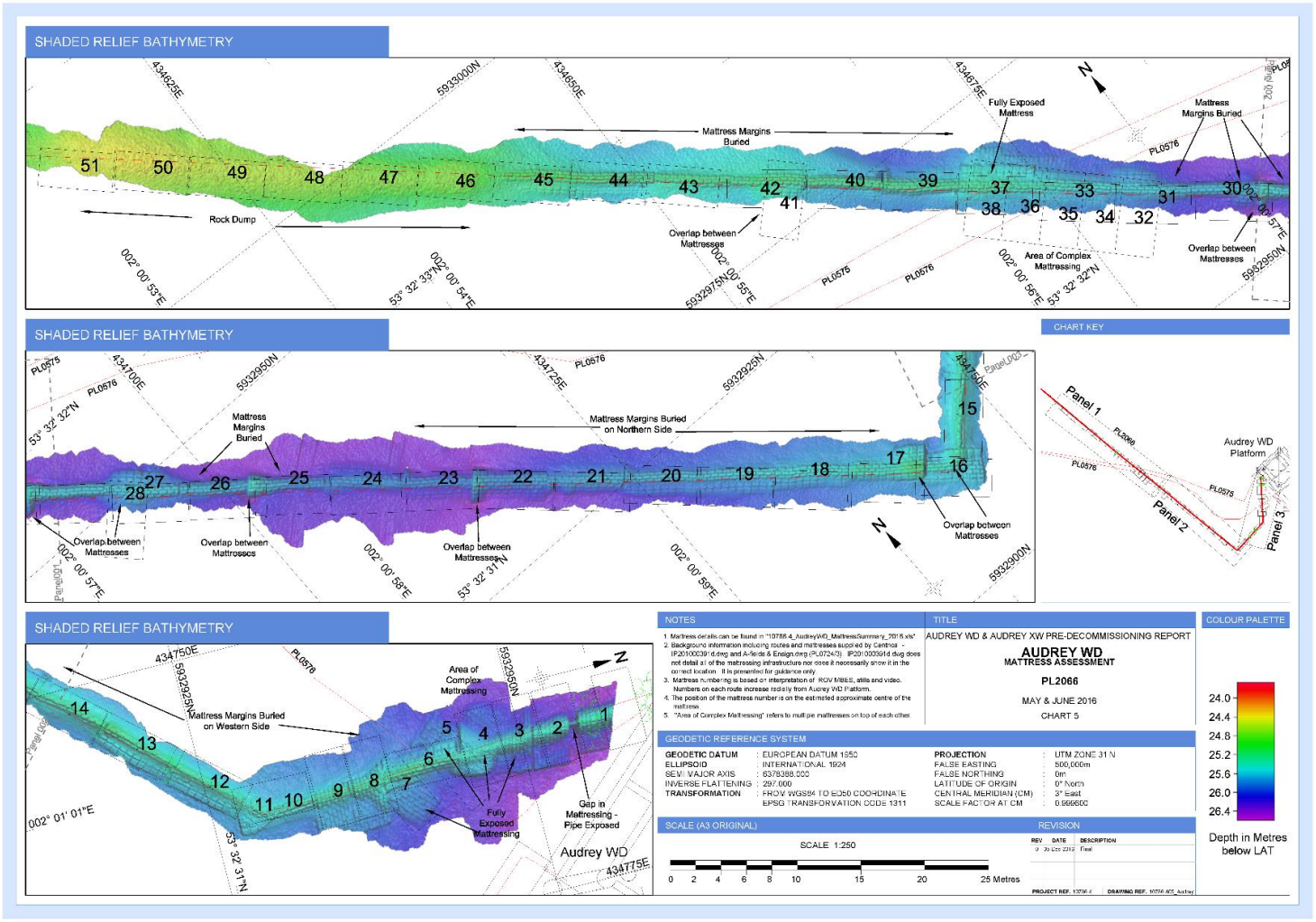
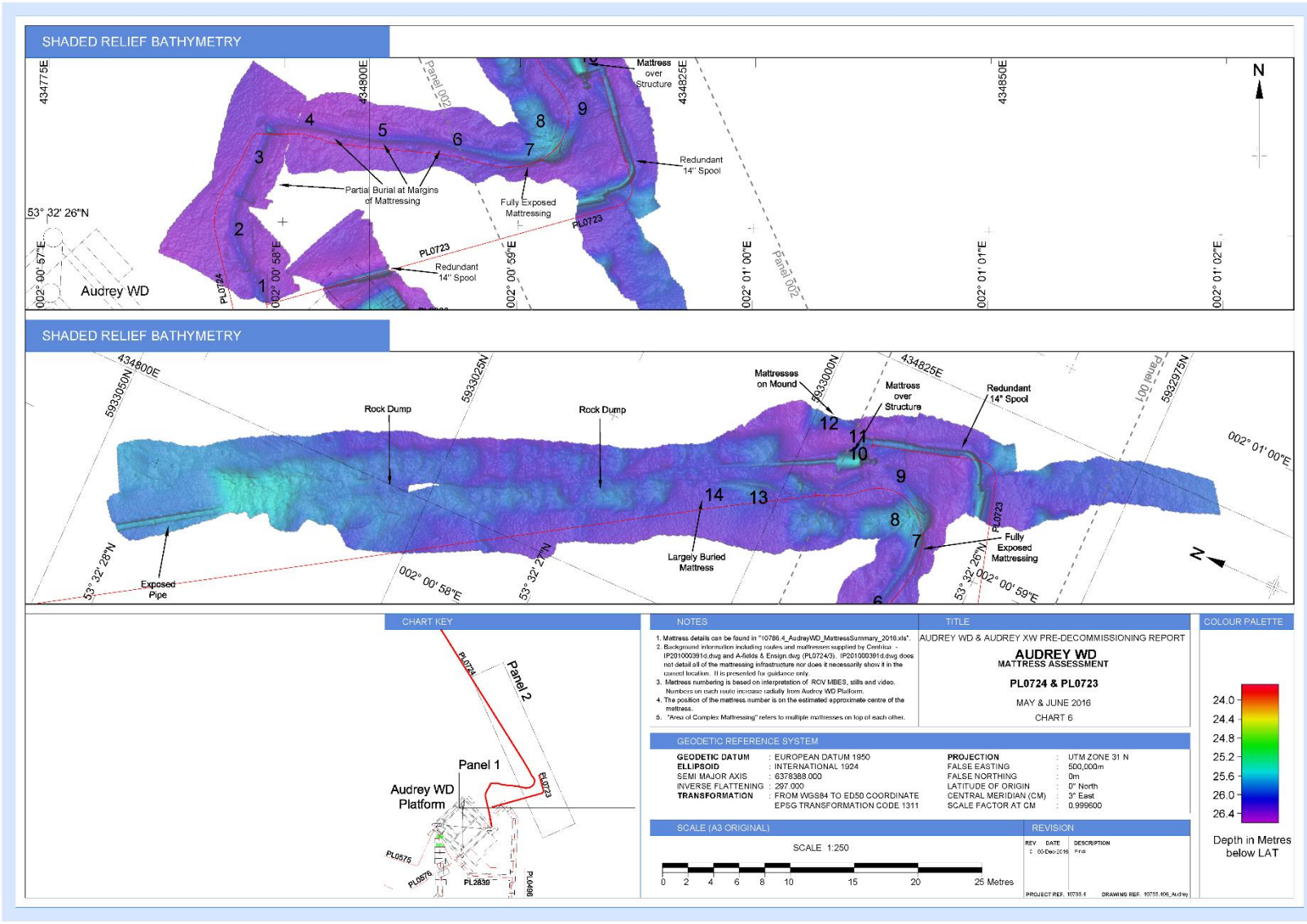


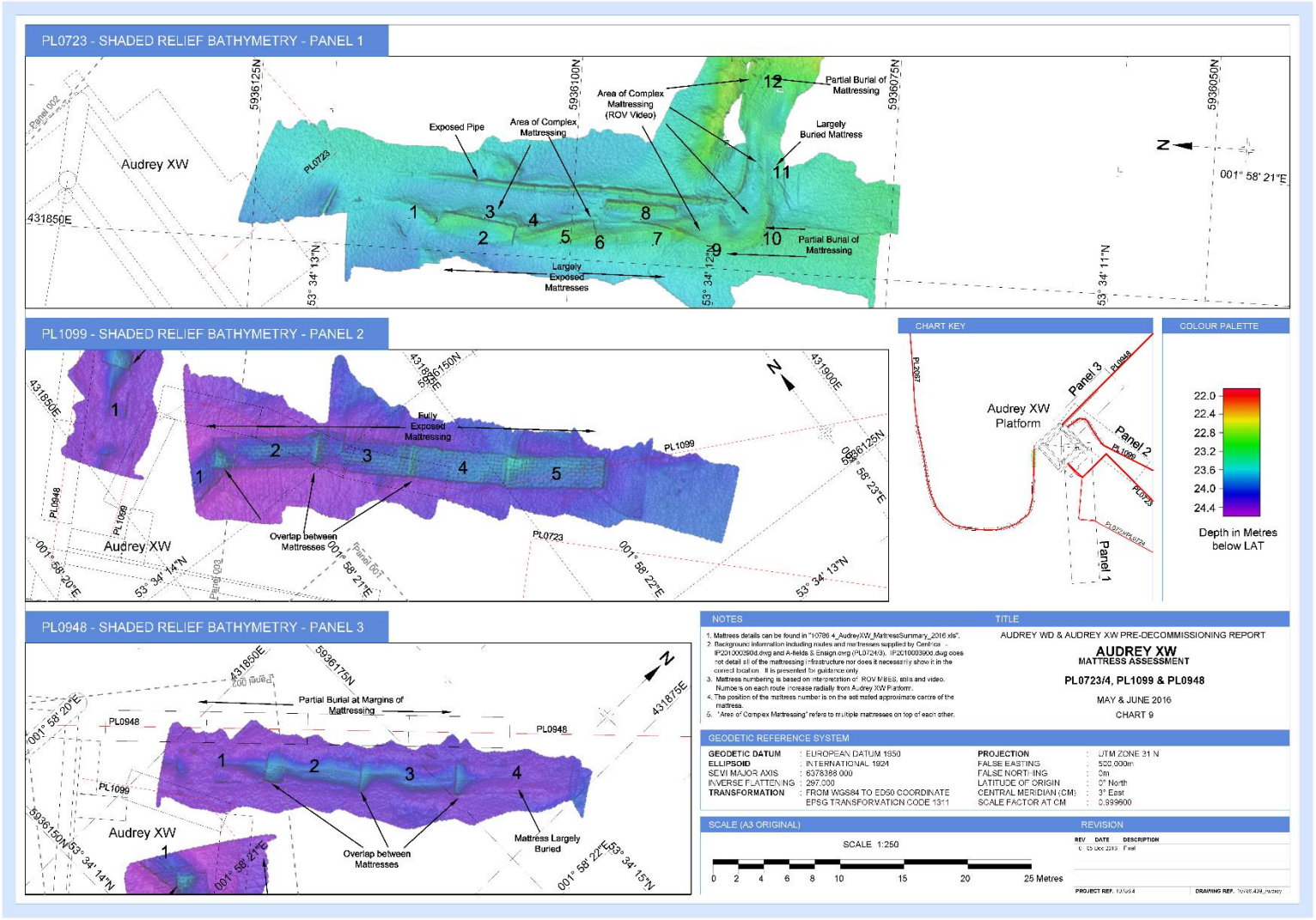
Figure B.5: Pipeline infrastructure @LOGGS PP

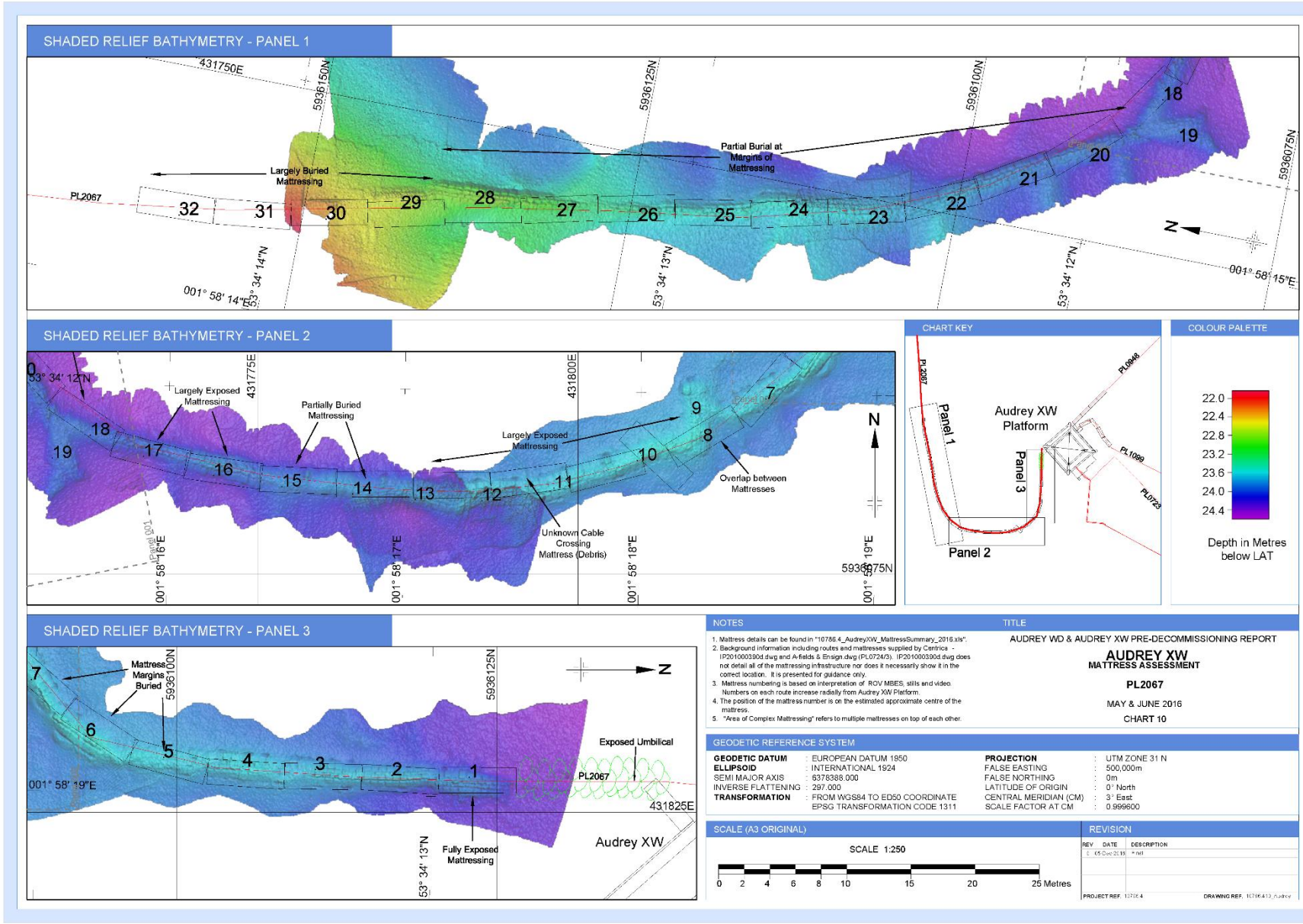
APPENDIX C BATHYMETRY @AUDREY A (WD) PLATFORM



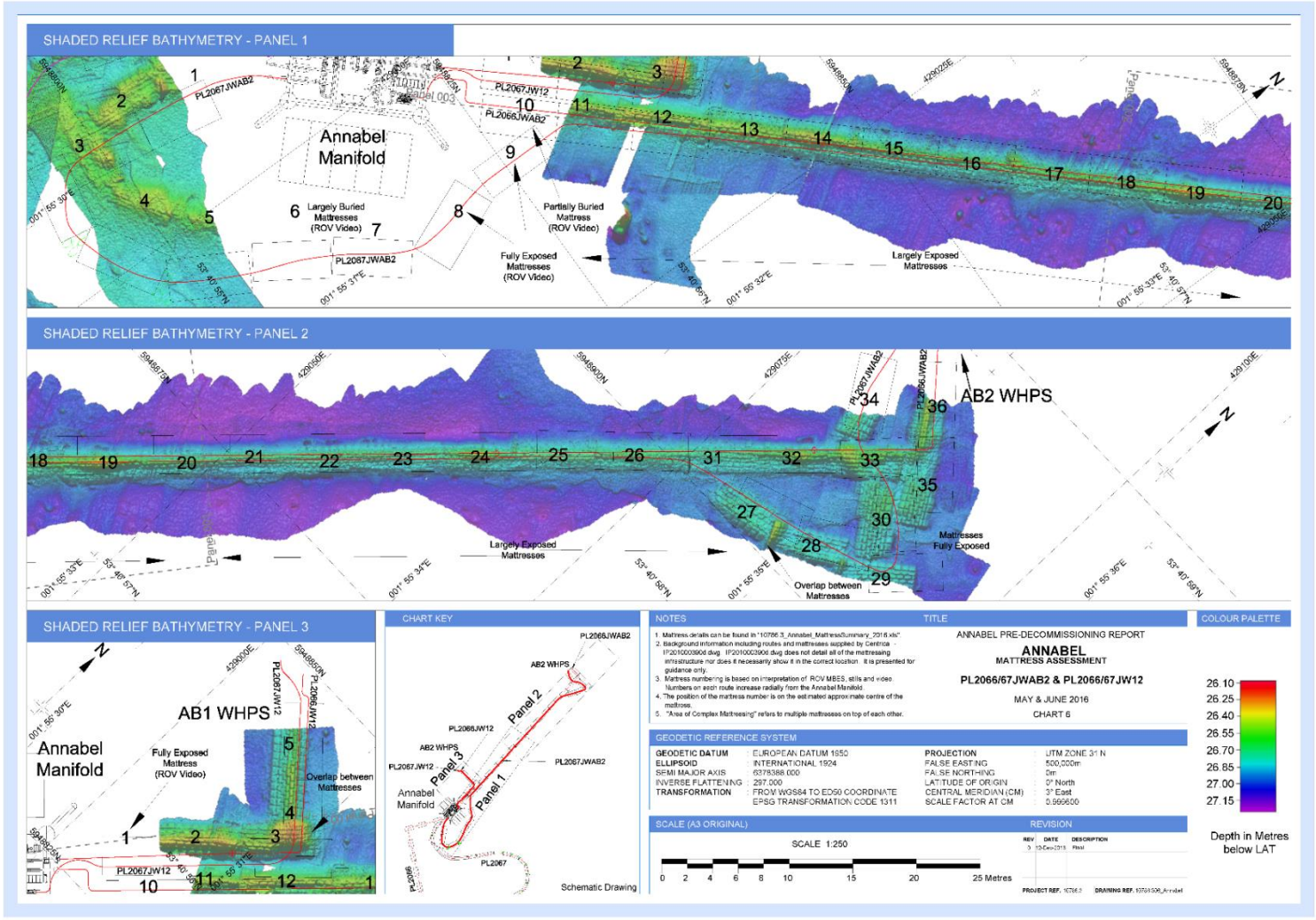

SHADED RELIEF BATHYMETRY
Mattress over Structure
Redundant 14" Spool
Partial Burial at Margins of Mattressing
Fully Exposed Mattressing
Redundant 14" Spool
Audrey WD
PL0723
PL0724
Panel 002
Panel 001
SHADED RELIEF BATHYMETRY
Rock Dump
Rock Dump
Mattresses on Mound
Mattress over Structure
Redundant 14" Spool
Largely Buried Mattress
Fully Exposed Mattressing
Exposed Pipe
CHART KEY
Panel 2
Panel 1
Audrey WD Platform
PL0724
PL0723
PL0575
PL0576
PL2839
PL0496
NOTES
1. Mattress details can be found in "10786.4_AudreyWD_MattressSummary_2016.xls".
2. Background information including routes and mattresses supplied by Centrica - IP201000391d.dwg and A-fields & Ensign.dwg (PL0724/3). IP201000391d.dwg does not detail all of the mattressing infrastructure nor does it necessarily show it in the correct location. It is presented for guidance only.
3. Mattress numbering is based on interpretation of ROV MBES, stills and video. Numbers on each route increase radially from Audrey WD Platform.
4. The position of the mattress number is on the estimated approximate centre of the mattress.
5. "Area of Complex Mattressing" refers to multiple mattresses on top of each other.
TITLE
AUDREY WD & AUDREY XW PRE-DECOMMISSIONING REPORT
AUDREY WD
MATTRESS ASSESSMENT
PL0724 & PL0723
MAY & JUNE 2016
CHART 6
GEODETIC REFERENCE SYSTEM
GEODETIC DATUM : EUROPEAN DATUM 1950
ELLIPSOID : INTERNATIONAL 1924
SEMI MAJOR AXIS : 6378388.000
INVERSE FLATTENING : 297.000
TRANSFORMATION : FROM WGS84 TO ED50 COORDINATE EPSG TRANSFORMATION CODE 1311
PROJECTION : UTM ZONE 31 N
FALSE EASTING : 500,000m
FALSE NORTHING : 0m
LATITUDE OF ORIGIN : 0° North
CENTRAL MERIDIAN (CM) : 3° East
SCALE FACTOR AT CM : 0.999600
SCALE (A3 ORIGINAL)
SCALE 1:250
0 2 4 6 8 10 15 20 25 Metres
REVISION
REV DATE DESCRIPTION
0 03-Dec-2016 Final
COLOUR PALETTE
24.0
24.4
24.8
25.2
25.6
26.0
26.4
Depth in Metres below LAT

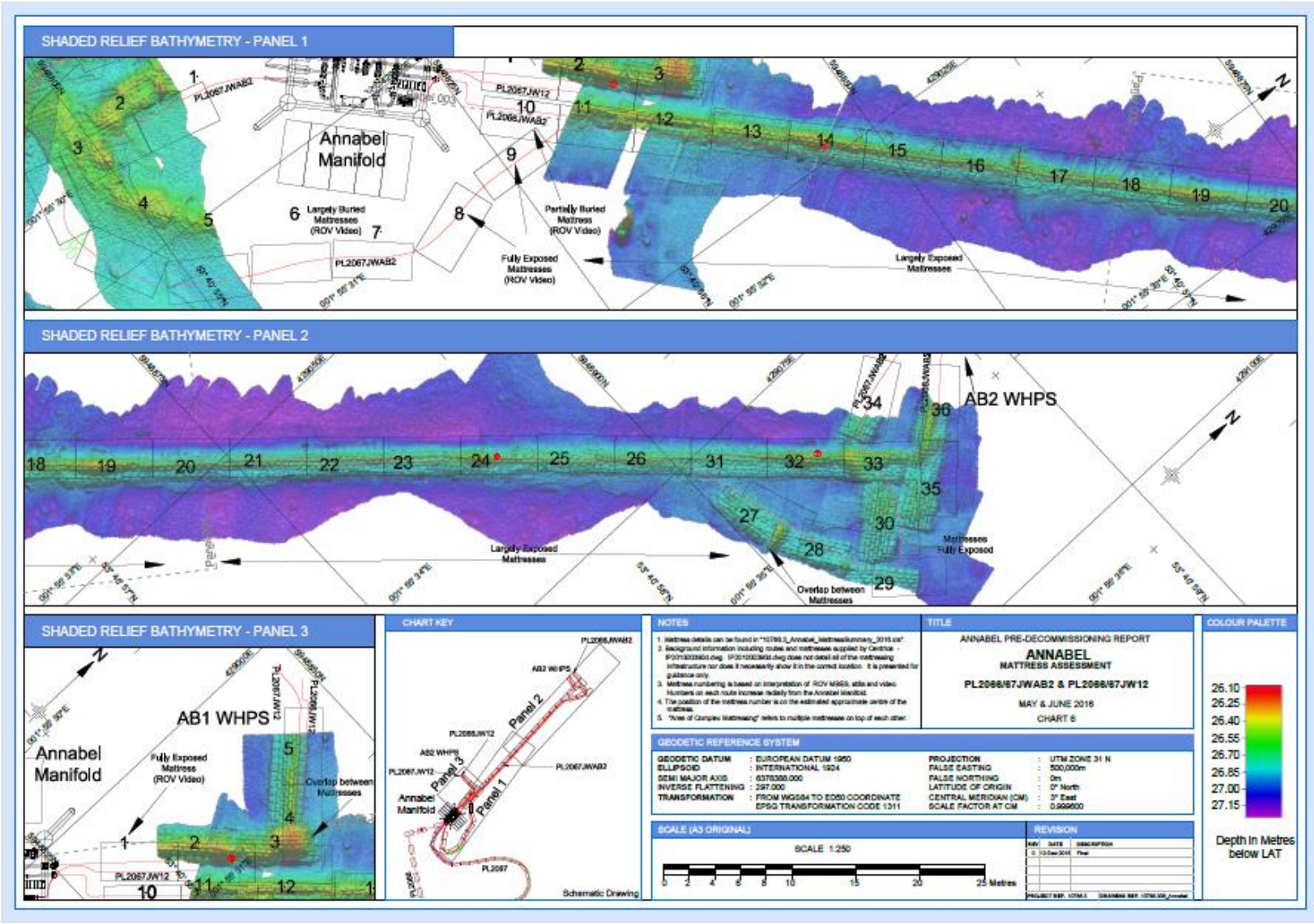
APPENDIX D BATHYMETRY @ AUDREY B (XW) PLATFORM




SHADED RELIEF BATHYMETRY - PANEL 1
431750E
5936150N
5936125N
5936100N
5936075N
Largely Buried Mattressing
Partial Burial at Margins of Mattressing
PL2067
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
53° 34' 14"N
53° 34' 13"N
53° 34' 12"N
001° 58' 14"E
001° 58' 15"E
N
SHADED RELIEF BATHYMETRY - PANEL 2
53° 34' 12"N
431775E
431800E
Largely Exposed Mattressing
Partially Buried Mattressing
Largely Exposed Mattressing
Overlap between Mattresses
Unknown Cable Crossing Mattress (Debris)
001° 58' 16"E
001° 58' 17"E
001° 58' 18"E
001° 58' 19"E
5936075N
N
CHART KEY
Panel 1
Panel 2
Panel 3
Audrey XW Platform
PL2067
PL0949
PL1099
PL0723
COLOUR PALETTE
22.0
22.4
22.8
23.2
23.6
24.0
24.4
Depth in Metres below LAT
SHADED RELIEF BATHYMETRY - PANEL 3
Mattress Margins Buried
5936100N
5936125N
7
6
5
4
3
2
1
Exposed Umbilical
PL2067
001° 58' 19"E
431825E
Audrey XW
Fully Exposed Mattressing
53° 34' 13"N
N
NOTES
1. Mattress details can be found in "10786.4_AudreyXW_MattressSummary_2016.xls".
2. Background information including routes and mattresses supplied by Centrica - IP201000390d.dwg and A-fields & Ensign.dwg (PL0724/3). IP201000390d.dwg does not detail all of the mattressing infrastructure nor does it necessarily show it in the correct location. It is presented for guidance only.
3. Mattress numbering is based on interpretation of ROV MBES, stills and video. Numbers on each route increase radially from Audrey XW Platform.
4. The position of the mattress number is on the estimated approximate centre of the mattress.
5. "Area of Complex Mattressing" refers to multiple mattresses on top of each other.
TITLE
AUDREY WD & AUDREY XW PRE-DECOMMISSIONING REPORT
AUDREY XW
MATTRESS ASSESSMENT
PL2067
MAY & JUNE 2016
CHART 10
GEODETIC REFERENCE SYSTEM
GEODETIC DATUM : EUROPEAN DATUM 1950
ELLIPSOID : INTERNATIONAL 1924
SEMI MAJOR AXIS : 6378388.000
INVERSE FLATTENING : 297.000
TRANSFORMATION : FROM WGS84 TO ED50 COORDINATE EPSG TRANSFORMATION CODE 1311
PROJECTION : UTM ZONE 31 N
FALSE EASTING : 500,000m
FALSE NORTHING : 0m
LATITUDE OF ORIGIN : 0° North
CENTRAL MERIDIAN (CM) : 3° East
SCALE FACTOR AT CM : 0.999600
SCALE (A3 ORIGINAL)
SCALE 1:250
0 2 4 6 8 10 15 20 25 Metres
REVISION
REV DATE DESCRIPTION
1 05 Dec 2016 Final
PROJECT REF. 10786.4
DRAWING REF. 10786.413_Audrey

APPENDIX E BATHYMETRY @ ANNABEL




SHADED RELIEF BATHYMETRY - PANEL 1
Annabel Manifold
Largely Buried Mattresses (ROV Video)
Partially Buried Mattress (ROV Video)
Fully Exposed Mattresses (ROV Video)
Largely Exposed Mattresses
PL2067JWAB2
PL2067JW12
PL2066JWAB2
SHADED RELIEF BATHYMETRY - PANEL 2
AB2 WHPS
Largely Exposed Mattresses
Overlap between Mattresses
Mattresses Fully Exposed
SHADED RELIEF BATHYMETRY - PANEL 3
AB1 WHPS
Annabel Manifold
Fully Exposed Mattress (ROV Video)
Overlap between Mattresses
CHART KEY
Panel 1
Panel 2
Panel 3
Schematic Drawing
NOTES
1. Mattress details can be found in "10780.3_Annabel_MattressSummary_2018.xls".
2. Background information including routes and mattresses supplied by Centrica - P2010003960.dwg. (P2010003960.dwg does not detail all of the mattressing infrastructure nor does it necessarily show it in the correct location. It is presented for guidance only.
3. Mattress numbering is based on interpretation of ROV MMSS, stills and video. Numbers on each route increase radially from the Annabel Manifold.
4. The position of the mattress number is on the estimated approximate centre of the mattress.
5. "Rows of Complex Mattressing" refers to multiple mattresses on top of each other.
TITLE
ANNABEL PRE-DECOMMISSIONING REPORT
ANNABEL
MATTRESS ASSESSMENT
PL2066/67JWAB2 & PL2066/67JW12
MAY & JUNE 2018
CHART 6
GEODETIC REFERENCE SYSTEM
GEODETIC DATUM : EUROPEAN DATUM 1950
ELLIPSOID : INTERNATIONAL 1924
SEMI MAJOR AXIS : 6378388.000
INVERSE FLATTENING : 297.000
TRANSFORMATION : FROM WGS84 TO ED50 COORDINATE EPSG TRANSFORMATION CODE 1311
PROJECTION : UTM ZONE 31 N
FALSE EASTING : 500,000m
FALSE NORTHING : 0m
LATITUDE OF ORIGIN : 0° North
CENTRAL MERIDIAN (CM) : 3° East
SCALE FACTOR AT CM : 0.999600
SCALE (A3 ORIGINAL)
SCALE 1:250
0 2 4 6 8 10 15 20 25 Metres
REVISION
COLOUR PALETTE
26.10
26.25
26.40
26.55
26.70
26.85
27.00
27.15
Depth in Metres below LAT

APPENDIX F COMPARATIVE ASSESSMENT TABLES

The following section details the qualitative comparative assessment made to distinguish the decommissioning options.

The assessment was carried out in accordance with the Centrica Comparative Assessment Guidance [3]. Safety criteria were assessed with the HSE Risk Matrix, environmental and societal criteria were assessed with the Environmental Impact Matrix and the technical criteria were assessed with the Project Risk Assessment Matrix.

The colour coding is as follows:

Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Appendix F.1 PL496 & PL497 Comparative Assessment Tables

PL496 & PL497 Piggybacked pipeline and methanol line			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in situ***
Technical Short-term	There is limited experience of using the 'cut and lift' method for removing concrete coated and piggy-backed pipelines of this scale. Most of the pipelines are buried under rock, and in many areas this is now indistinguishable from the local seabed, making it more problematic to locate and recover the pipeline. Cut and lift would be the only option. The rock would need to be removed and the sediment removed. The two pipelines would be cut and lifted together, if the condition allows. There is a risk of concrete falling from the pipeline during cutting and lifting in the water and on the deck. Possible, but there are risks associated with each stage of the activity.	Cut and lift the exposed sections. Removal of the whole section with intermittent exposures. Buried pipe would need to be uncovered and 'cut and lift' method can and has been used for removing relatively short sections of pipe so we know this is achievable, although the presence of rock will complicate the process Lift through water column to deck. Assumed ends of covered with existing sediment if possible	Stable and buried pipelines have been left *in situ* before and we know this is achievable No activity required. Feasible.
Technical Legacy	No pipeline surveys would be required.	Pipeline surveys have been undertaken in the past. From a technical perspective this is achievable with no complications	Pipeline surveys have been undertaken in the past. From a technical perspective this is achievable with no complications
Safety Short-term: Health & safety risk offshore project personnel	More offshore work and more onshore handling than partial removal. Little experience in the North Sea of 'cut and lift' of pipelines buried under rock. 'Cut and lift' activities are assessed as tolerable for the 16.9km pipeline. Repetitive nature of the removal activities.	Less offshore work than complete removal. Experience in the North Sea of removal of concrete coated pipeline sections Handling and cutting on the deck.	No activity required. Feasible.

PL496 & PL497 Piggybacked pipeline and methanol line			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in situ***
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field would be longer than for partial removal or leave in situ. The risk to mariners would be aligned with the duration the activities are undertaken in the field. Therefore highest risk from complete removal as duration will be longest.	The duration that the vessel(s) will be in the field affects the activities of mariners. Therefore risk from partial removal will be less than for complete removal but more than leave *in situ*.	The duration that the vessel(s) will be in the field affects the activities of mariners. Therefore lowest risk from leave *in situ* as duration will be shortest.
Safety Short-term: Safety risk onshore project personnel	Significantly more onshore cutting, lifting and handling associated with disposal of the pipelines presents an increased safety risk to personnel. Repetitive nature of the disposal activities along the 16.9km pipeline. Potential for concrete coating dropping from the pipeline.	Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel than complete removal.	No activity required. Feasible.
Safety Legacy: Health & safety risk offshore project personnel	No pipeline surveys or remediation related activities.	Pipeline burial surveys required (assume no remedial work required).	Pipeline burial surveys required (assume no remedial work required).
Safety Legacy: Health & safety risk to mariners	Infrastructure completely removed so no residual snag hazards remain	Degradation of the remaining pipeline within seabed sediment will occur over a long period. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited. Survey vessels in the field. Potential to snag on ends or new exposures or spalled concrete, if any. The fact that the pipeline is piggybacked is thought to increase the risk of snagging, depending on the location of the piggyback on the main pipeline, if exposed.	Degradation of the remaining pipeline within seabed sediment will occur over a long period. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited. Survey vessels in the field. Potential to snag on ends or new exposures or spalled concrete, if any. The fact that the pipeline is piggybacked is thought to increase the risk of snagging, depending on the location of the piggyback on the main pipeline, if exposed.
Safety Legacy: Safety risk onshore project personnel	None	None (assuming no remedial action).	None (assuming no remedial action).
Environmental Short-term: Atmosphere	Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Emissions and energy use for this option fall in-between complete removal and leave *in situ*	Least amount of energy used and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new material
Environmental Short-term: Seabed	The amount of seabed disturbed is directly related to the length of pipeline (or umbilical) being removed. The area affected would be largest for this option	This area of seabed disturbed would fall in-between the complete removal and leave *in situ* options	The least area of seabed would be disturbed with this option

PL496 & PL497 Piggybacked pipeline and methanol line			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in situ***
Environmental Short-term: SAC	Dredging to access the pipeline for complete recovery would open a trench and introduce sediment into the water column. We would expect the area to recover relatively quickly as the survey data doesn't show evidence of the original trench. Assuming a 4m wide corridor along the pipeline being disturbed, the area affected would be 0.0676 km^2, 6.76ha equivalent to c. 0.002% of the SAC.	Dredging to access the sections of the pipeline for recovery would open a trench and introduce sediment into the water column We would expect the area to recover relatively quickly as the survey data doesn't show much evidence of the original trench. The area affected would be much less than that affected by complete recovery.	Limited or no impact on the SAC during offshore decommissioning operations compared with complete removal or partial removal.
Environmental Short-term: Water column	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal	Discharges and release would be less than generated for complete removal but slightly more than leave *in situ*	Discharges and releases would be least for this option, particularly in the short-term
Environmental Short-term: Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	This option sits in-between option 1 and option 3	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Environmental Legacy: Atmosphere	In line with survey vessel duration. No surveys required for complete removal.	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*.	We anticipate that future survey requirements would be about the same for either partial removal or leave in situ.
Environmental Legacy: Seabed	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact
Environmental Legacy: SAC	No impact. Only environmental survey following completion of decommissioning activities.	Environmental survey and pipeline status survey, assuming no remedial work would be required – as suggested by historical survey data. Survey data suggests that the presence of the buried pipeline in the seabed is not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks).	Impact on SAC would be the same as partial removal assuming no remedial work would be required over the longer term.
Environmental Legacy: Water column	In line with survey vessel duration. No surveys required for complete removal.	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*.	We anticipate that future survey requirements would be about the same for either partial removal or leave in situ.
Environmental Legacy: Waste	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective

PL496 & PL497 Piggybacked pipeline and methanol line			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in situ***
Societal Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for complete removal and more that for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for complete removal
Societal Short-term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal.	Decommissioning activities would contribute to continuity of employment less than for complete removal and more that for leave *in situ* option.	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Societal Short-term: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate options 2 & 3.
Societal Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal and less than for leave *in situ.*	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option but there is little to differentiate option 2 and option 3
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Once the pipeline had been partially removed the opportunity for continuation of employment would be associated with survey work would be like the leave *in situ* option. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for option 2 and Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*, otherwise there is little to differentiate options 2 & 3.
Societal Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate options 2 & 3.
Cost Short-term	The cost of complete removal would be an order of magnitude higher than for either of the partial removal or the leave *in situ* options	The cost of removing a few short-exposed sections would be less than for complete removal but more than for leave *in situ*	The cost of leave *in situ* would be the least expensive of all options

PL496 & PL497 Piggybacked pipeline and methanol line			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in situ***
Cost Legacy	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term

Table F.1: PL496 & PL497 Comparative Assessment Table

Appendix F.2 PL496/7 High-Level cost comparison by difference

PL496/7	Complete Removal (£M)	Partial Removal (£M)	Leave *in situ* (£M)
Cost	£24.61	£0.29	£0.12
Sub-total Normalised	**5**	**0.1**	**0.0**

Table F.2: PL496/7 Decommissioning options costs by difference[22]

[22] Cost by difference is considered an order of magnitude higher if the cost difference is at least 10 times higher for one option versus another

Appendix F.3 PL575 Comparative Assessment Tables

PL575 Pipeline			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
Technical Short-term	There is limited experience of using the 'cut and lift' method but achievable for this relatively short pipeline Cut and lift as too short to make reeling practicable. The pipeline would need to be exposed prior to cutting and lifting. Feasible and has been done in the area before. Little to differentiate between complete and partial removal, given the relatively short length of buried pipeline.	Removal of the exposure in the middle would leave two sections of about 100m on each side. This would leave two additional ends to rebury to 0.6m. Could deposit rock over the 50m section. Little to differentiate between complete and partial removal.	Stable and buried pipelines have been left in situ before and we know this is achievable.
Technical Legacy	No pipeline surveys would be required in future	Pipeline surveys have been undertaken in the past so this is achievable with no complications	Pipeline surveys have been undertaken in the past so this is achievable with no complications
Safety Short-term: Health & safety risk offshore project personnel	Slightly more offshore work and more onshore handling than partial removal. Little experience in the North Sea of 'cut and lift' of buried pipelines but short pipeline. More cut and lifts than for partial option.	Slightly less offshore work than complete removal. Experience in the North Sea of removal of pipeline sections. Fewer cut and lifts than for complete removal option. Vessel would most likely spend less time in the field.	Less offshore work than complete removal or partial removal.
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field would be longer than for partial removal or leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field.	Duration of vessels in the field would be shorter than for complete removal and marginally longer than for leave *in situ*.	There is little to differentiate option 2 and 3
Safety Short-term: Safety risk onshore project personnel	Significantly more onshore cutting, lifting and handling associated with disposal of the pipelines presents an increased safety risk to personnel.	Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	No onshore work
Safety Legacy: Health & safety risk offshore project personnel	No survey	Pipeline surveys will be required, but this activity has been done before	Pipeline surveys will be required, but this activity has been done before
Safety Legacy: Health & safety risk to mariners	Infrastructure completely removed so no residual snag hazards remain.	Degradation of the remaining pipeline will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited.	Degradation of the remaining pipeline will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited.
Safety Legacy: Safety risk onshore project personnel	None	None (assuming no remedial action).	None (assuming no remedial action).
Environmental Short-term: Atmosphere	Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Emissions and energy use for this option fall in-between complete removal and leave *in situ*	Least amount of energy used and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new

PL575 Pipeline			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
			material
Environmental Short-term: Seabed	The amount of seabed disturbed is directly related to the length of pipeline (or umbilical) being removed. The area affected would be largest for this option	This area of seabed disturbed would fall in-between the complete removal and leave *in situ* options	The least area of seabed would be disturbed with this option
Environmental Short-term: SAC	Dredging to access the pipeline for complete recovery would open a trench and introduce sediment into the water column. We would expect the area to recover relatively quickly as the survey data doesn't show evidence of the original trench. Assuming a 4m wide corridor along the pipeline being disturbed, the area affected would be 0.00246 km^2, 0.246ha equivalent to c. 0.0001% of the SAC.	Dredging to access the sections of the pipeline for recovery would open a trench and introduce sediment into the water column We would expect the area to recover relatively quickly as the survey data doesn't show much evidence of the original trench. The area affected would be much less than that affected by complete recovery.	Limited or no impact on the SAC during offshore decommissioning operations compared with complete removal or partial removal.
Environmental Short-term: Water column	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal	Discharges and release would be less than generated for complete removal but slightly more than leave *in situ*	Discharges and releases would be least for this option, particularly in the short-term
Environmental Short-term: Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	This option sits in-between option 1 and option 3	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Environmental Legacy: Atmosphere	In line with survey vessel duration. No surveys required for complete removal.	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*.	We anticipate that future survey requirements would be about the same for either partial removal or leave in situ.
Environmental Legacy: Seabed	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact
Environmental Legacy: SAC	No impact. Only environmental survey following completion of decommissioning activities.	Environmental survey and pipeline status survey, assuming no remedial work would be required – as suggested by historical survey data. Survey data suggests that the presence of the buried pipeline in the seabed is not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks).	Impact on SAC would be the same as partial removal assuming no remedial work would be required over the longer term.
Environmental Legacy: Water column	In line with survey vessel duration. No surveys required for complete removal.	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*.	We anticipate that future survey requirements would be about the same for either partial removal or leave in situ.
Environmental Legacy: Waste	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective

PL575 Pipeline			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
Societal Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for complete removal and more that for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for complete removal
Societal Short-term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal.	Decommissioning activities would contribute to continuity of employment less than for complete removal and more that for leave *in situ* option.	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Societal Short-term: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate options 2 & 3.
Societal Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal and less than for leave *in situ.*	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option but there is little to differentiate option 2 and option 3
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Once the pipeline had been partially removed the opportunity for continuation of employment would be associated with survey work would be like the leave *in situ* option. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for option 2 and Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*, otherwise there is little to differentiate options 2 & 3.
Societal Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate options 2 & 3.
Cost Short-term:	The cost of complete removal would be an order of magnitude higher than for either of the partial removal or the leave *in situ* options	The cost of removing a few short-exposed sections would be less than for complete removal but more than for leave *in situ*	The cost of leave *in situ* would be the least expensive of all options
Cost Legacy:	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term

Table F.3: PL575 Comparative Assessment Table

Appendix F.4 PL575 High-Level cost comparison by difference

PL575	Complete Removal (£M)	Partial Removal (£M)	Leave *in situ* (£M)
Cost	£0.50	£0.27	£0.12
Sub-total Normalised	**5**	**2.7**	**1.2**

Table F.4: PL575 Decommissioning options costs by difference[22]

Appendix F.5 PL576 Comparative Assessment Tables

PL576 Umbilical			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial removal**	**Option 3 - Leave *in situ***
Technical Short-term:	Reverse reeling is a viable option albeit with technical challenges as the umbilical is unburied and pulled from the seabed. Considered more technically difficult than partial removal and leave *in situ*. Assumption has been made that the pipeline and umbilical are separate in the same trench; therefore they could be removed separately, without impacting each other. (The umbilical was laid after the pipeline.)	This option only requires 'cut and lift' of discrete sections of the umbilical and this can be considered a relatively routine operation. Minimum number of operations therefore minimum technical risk.	Stable and buried umbilical lines have been left in situ before and we know this is achievable. From a technical perspective this would be the least challenging option.
Technical Legacy:	No umbilical surveys would be required in future	Umbilical surveys have been undertaken in the past so this is achievable with no complications	Umbilical surveys have been undertaken in the past so this is achievable with no complications
Safety Short-term: Health & safety risk offshore project personnel	Slightly more offshore work and more onshore handling than partial removal. Little experience in the North Sea of reverse reeling of trenched and buried umbilicals.	Slightly less offshore work than complete removal. Experience in the North Sea of removal of umbilical sections. Vessel would most likely spend less time in the field.	Less offshore work than complete removal or partial removal.
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field would be longer than for partial removal or leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field.	Duration of vessels in the field would be shorter than for complete removal and marginally longer than for leave in situ.	There is little to differentiate option 2 and 3
Safety Short-term: Safety risk onshore project personnel	Significantly more onshore cutting, lifting, exposure to chemical content and handling associated with disposal of the pipeline presents an increased safety risk to personnel	Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	No onshore work
Safety Legacy: Health & safety risk offshore project personnel	No survey	Umbilical surveys will be required, but this activity has been done before	Umbilical surveys will be required, but this activity has been done before
Safety Legacy: Health & safety risk to mariners	Infrastructure completely removed so no residual snag hazards remain	Degradation of the remaining umbilical will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited.	Degradation of the remaining umbilical will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited
Safety Legacy: Safety risk onshore project personnel	None	None (assuming no remedial action)	None (assuming no remedial action)
Environmental Short-term: Atmosphere	Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Emissions and energy use for this option fall in-between complete removal and leave *in situ*	Least amount of energy used and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new material

PL576 Umbilical			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial removal**	**Option 3 - Leave *in situ***
Environmental Short-term: Seabed	The amount of seabed disturbed is directly related to the length of umbilical being removed. The area affected would be largest for this option	This area of seabed disturbed would fall in-between the complete removal and leave *in situ* options	The least area of seabed would be disturbed with this option
Environmental Short-term: SAC	Pulling the umbilical out of the trench would introduce sediment into the water column. We would expect the area to recover relatively quickly as the survey data doesn't show evidence of the original trench. Assuming a 2m wide corridor along the pipeline being disturbed, the area affected would be 0.0013 km^2, 0.13ha equivalent to less than 0.0001% of the SAC.	Dredging to access the sections of the umbilical for recovery would open a trench and introduce sediment into the water column. We would expect the area to recover relatively quickly as the survey data doesn't show evidence of the original trench. The area affected would be much less than that affected by complete recovery.	Limited or no impact on the SAC during offshore decommissioning operations compared with complete removal or partial removal.
Environmental Short-term: Water column	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal.	Discharges and release would be less than generated for complete removal but slightly more than leave *in situ.*	Discharges and releases would be least for this option, particularly in the short-term
Environmental Short-term: Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	This option sits in-between option 1 and option 3	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Environmental Legacy: Atmosphere	In line with survey vessel duration. No surveys required for complete removal.	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*.	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*
Environmental Legacy: Seabed	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact
Environmental Legacy: SAC	No impact. Only environmental survey following completion of decommissioning activities.	Environmental survey and umbilical status survey, assuming no remedial work would be required – as suggested by historical survey data. Survey data suggests that the presence of the buried umbilical in the seabed is not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks).	Impact on SAC would be the same as partial removal assuming no remedial work would be required over the longer term.
Environmental Legacy: Water column	In line with survey vessel duration. No surveys required for complete removal.	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*.	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*.
Environmental Legacy: Waste	If we assume that no remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective
Societal Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for complete removal and more that for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for complete removal

PL576 Umbilical			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial removal**	**Option 3 - Leave *in situ***
Societal Short-term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal.	Decommissioning activities would contribute to continuity of employment less than for complete removal and more that for leave *in situ* option.	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Societal Short-term: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate options 2 & 3.
Societal Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal and less than for leave *in situ.*	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option but there is little to differentiate option 2 and option 3
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Once the pipeline had been partially removed the opportunity for continuation of employment would be associated with survey work would be like the leave *in situ* option. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for option 2 and Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*, otherwise there is little to differentiate options 2 & 3.
Societal Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate options 2 & 3.
Cost Short-term:	The cost of complete removal would be higher than for either of the partial removal or the leave *in situ* options	The cost of removing a few short-exposed sections would be less than for complete removal but more than for leave *in situ*	The cost of leave *in situ* would be the least expensive of all options
Cost Legacy:	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term

Table F.5: PL576 Comparative Assessment Table

Appendix F.6 PL576 High-Level cost comparison by difference

PL576	Complete Removal (£M)	Partial Removal (£M)	Leave *in situ* (£M)
Cost	£0.30	£0.27	£0.12
Sub-total Normalised	**5**	**4.6**	**2.1**

Table F.6: PL576 Decommissioning options costs by difference[22]

Appendix F.7 PL723 & PL724 Comparative Assessment Tables

PL723 & PL724 Piggybacked pipeline and methanol line		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
Technical Short-term:	There is limited experience of using the 'cut and lift' method for removing piggy-backed pipelines of this scale. Cut and lift would be the only option. The rock would need to be removed and the sediment removed. The two pipelines would be cut and lifted together, if the condition allows. Possible, but there are risks associated with each stage of the activity	Stable and buried pipelines have been left *in situ* before and we know this is achievable No activity required. Feasible
Technical Legacy:	No pipeline surveys would be required.	Pipeline surveys have been undertaken in the past. From a technical perspective this is achievable with no complications
Safety Short-term: Health & safety risk offshore project personnel	More offshore work and more onshore handling than leave *in situ*. Little experience in the North Sea of 'cut and lift' of piggy-backed pipelines. 'Cut and lift' activities are assessed as tolerable for the 4.4km pipeline. Repetitive nature of the removal activities.	No activity required. Feasible
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field would be longer than for partial removal or leave in situ. The risk to mariners would be aligned with the duration the activities are undertaken in the field. Therefore highest risk from complete removal as duration will be longest.	The duration that the vessel(s) will be in the field affects the activities of mariners. Therefore lowest risk from leave *in situ* as duration will be shortest.
Safety Short-term: Safety risk onshore project personnel	Significantly more onshore cutting, lifting and handling associated with disposal of the pipelines presents an increased safety risk to personnel. Repetitive nature of the disposal activities along the 4.4km pipeline.	No activity required. Feasible
Safety Legacy: Health & safety risk offshore project personnel	No pipeline surveys or remediation related activities	Pipeline burial surveys required (assume no remedial work required)
Safety Legacy: Health & safety risk to mariners	Infrastructure completely removed so no residual snag hazards remain	Degradation of the remaining pipeline within seabed sediment will occur over a long period. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited. Survey vessels in the field. Potential to snag on ends. The fact that the pipeline is piggybacked is thought to increase the risk of snagging, depending on the location of the piggyback on the main pipeline, if exposed.
Safety Legacy: Safety risk onshore project personnel	None	None (assuming no remedial action).
Environmental Short-term: Atmosphere	Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Least amount of energy used and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new material

PL723 & PL724 Piggybacked pipeline and methanol line		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
Environmental Short-term: Seabed	The amount of seabed disturbed is directly related to the length of pipelines being removed. The area affected would be largest for this option	The least area of seabed would be disturbed with this option
Environmental Short-term: SAC	Dredging to access the pipeline for complete recovery would open a trench and introduce sediment into the water column. We would expect the area to recover relatively quickly as the survey data doesn't show evidence of the original trench. Assuming a 4m wide corridor along the pipeline being disturbed, the area affected would be 0.0176 km^2, 1.76ha equivalent to c. 0.0005% of the SAC.	Limited or no impact on the SAC during offshore decommissioning operations compared with complete removal or partial removal.
Environmental Short-term: Water column	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal	Discharges and releases would be least for this option, particularly in the short-term
Environmental Short-term: Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Environmental Legacy: Atmosphere	In line with survey vessel duration. No surveys required for complete removal.	We anticipate that future survey requirements would be less than for complete removal.
Environmental Legacy: Seabed	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact
Environmental Legacy: SAC	No impact. Only environmental survey following completion of decommissioning activities.	Environmental survey and pipeline status survey, assuming no remedial work would be required – as suggested by historical survey data. Survey data suggests that the presence of the buried pipelines in the seabed are not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks).
Environmental Legacy: Water column	In line with survey vessel duration. No surveys required for complete removal.	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*
Environmental Legacy: Waste	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective
Societal Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for complete removal
Societal Short-term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal.	Decommissioning activities would contribute to continuity of employment less than for complete removal.
Societal Short-term: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work.
Societal Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than complete removal.
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Should the pipelines be left *in situ* surveys would need to be carried out. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ.*

PL723 & PL724 Piggybacked pipeline and methanol line		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
Societal Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work.
Cost Short-term:	The cost of complete removal would be an order of magnitude higher than for the leave *in situ* option.	The cost of leave *in situ* would be the least expensive of both options.
Cost Legacy:	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable no more surveys would be required.

Table F.7: PL723 & PL724 Comparative Assessment Table

Appendix F.8 PL723/4 High-Level cost comparison by difference

PL723/4	Complete Removal (£M)	Partial Removal (£M)	Leave *in situ* (£M)
Cost	£4.10	£0.72	£0.12
Sub-total Normalised	**5**	**0.9**	**0.1**

Table F.8: PL723/4 Decommissioning options costs by difference[22]

Appendix F.9 PL2066 Comparative Assessment Tables

PL2066 Pipeline		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
Technical Short-term:	There is limited experience of reverse reeling of trenched & buried pipelines in the North Sea. Further, there is limited experience of using the 'cut and lift' method for removing pipelines of this scale. The method of removal is to dredge, cut and lift sections of pipeline. This work is repetitive. The large volume of rock would also have to be moved / disturbed therefore increasing durations and complexity.	Stable and buried pipelines have been left *in situ* before and we know this is achievable
Technical Legacy:	No pipeline surveys would be required in future	Depth of burial pipeline surveys have been undertaken by Centrica in the past, and although obtaining depth of burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications
Safety Short-term: Health & safety risk offshore project personnel	More offshore work and more onshore handling than partial removal. Little experience in the North Sea of either reverse reeling or 'cut and lift' of trenched and buried pipelines. Both reverse reeling and 'cut and lift' activities are assessed as tolerable for the 17.8km pipeline. The work is repetitive and will also require the rock to be moved.	Less offshore work than required for complete removal. The risks are associated with the use of vessels and divers, if required. These are considered broadly acceptable if driven to ALARP. Significantly shorter than for complete removal
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field is longer than for leave *in-situ.* The risk to mariners is aligned with the duration the activities are undertaken in the field	Duration of vessels in the field is shorter than for complete removal. The risk to mariners is aligned with the duration the activities are undertaken in the field.
Safety Short-term: Safety risk onshore project personnel	Safety risk is linked to the mass of material returned to shore. Therefore there would be more onshore cutting, lifting and handling for complete removal than for *leave in-situ.*	Safety risk is linked to the mass of material returned to shore and with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel
Safety Legacy: Health & safety risk offshore project personnel	No depth of burial surveys or remediation related activities	Assume up to four depth of burial related surveys with no planned remediation
Safety Legacy: Health & safety risk to mariners	Infrastructure completely removed so no residual snag hazards completely removed	Degradation of the remaining pipeline will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited
Safety Legacy: Safety risk onshore project personnel	N/A	N/A
Environmental Short-term: Atmosphere	Emissions and use of energy greatest for this option but no offset would be generated as a result of the energy and emissions needed to create new material to replace any that may be left *in situ*	Least amount of energy used and least emissions generated in the short-term, although this is slightly counteracted by the energy and emissions required to create new material
Environmental Short-term: Seabed	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed, the amount of rock disturbed and the amount of remedial activity required. Area impacted is greater for complete removal than for leave *in-situ*.	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed, the amount of rock disturbed and the amount of remedial activity required. Area impacted is greater for complete

PL2066 Pipeline		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
		removal than for leave *in-situ*.
Environmental Short-term: SAC	Dredging to access the pipeline to completely recover would open a trench and introduce sediment into the water column and move rock. The area is anticipated to recover relatively quickly as the survey data doesn't show much evidence of the original trench. The rock would remain therefore a change in sediment type. It would be more spread over the seabed. Assuming 5m wide corridor affected the area affected would be 0.089km^2, 8.9ha equivalent to c. 0.003% of the SAC.	Limited or no impact on the SAC during the execute phase.
Environmental Short-term: Water column	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal.	Discharges and releases would be least for this option, particularly in the short-term.
Environmental Short-term: Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*.	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss.
Environmental Legacy: Atmosphere	Emissions to air are aligned with survey requirements. No burial surveys are planned therefore is less for complete removal than for leave *in-situ.*	Emissions to air are aligned with survey requirements. Four burial surveys are assumed therefore is greater for leave *in-situ* than for complete removal.
Environmental Legacy: Seabed	No remedial activities planned therefore no impact.	No remedial activities planned therefore no impact.
Environmental Legacy: SAC	No impact. Only environmental survey following completion of decommissioning activities and this is required for both options.	Environmental survey and pipeline status survey only, assuming no remedial work would be required – as suggested by historical survey data. Survey data suggests that the presence of the buried pipeline in the seabed is not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks).
Environmental Legacy: Water column	Discharges and releases to the water column are aligned survey requirements. No surveys planned therefore no impact.	Discharges and releases to the water column are aligned survey requirements. Four surveys are assumed therefore greater impact than for complete removal.
Environmental Legacy: Waste	No remedial activities planned therefore no waste.	No remedial activities planned therefore no waste.
Societal Short-term: Commercial activities	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for the leave *in situ* option.	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be less than for complete removal.
Societal Short-term: Employment	Decommissioning activities would contribute most to continuity of employment for complete removal on the basis that vessel will be longer in the field.	Decommissioning activities would contribute little or nothing to continuity of employment for leave *in situ.*
Societal Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal.	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ.*

PL2066 Pipeline		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
Societal Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required.	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal.
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal.	Should the pipeline be left *in situ* surveys would need to be carried out.
Societal Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites.	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related.
Cost Short-term:	The cost of complete removal would be an order of magnitude higher than for the leave *in situ* option.	The cost of leave *in situ* would be the least expensive option.
Cost Legacy:	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term.	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required.

Table F.9: PL2066 Comparative Assessment Table

Appendix F.10 PL2066 High-Level cost comparison by difference

PL2066	Complete Removal (£M)	Leave *in situ* (£M)
Cost	£4.77	£0.12
Sub-total Normalised	**5**	**0.1**

Table F.10: PL2066 Decommissioning options costs by difference[22]

Appendix F.11 PL2067 Comparative Assessment Tables

PL2067 Umbilical		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
Technical Short-term:	Reverse reeling is a viable option albeit with technical challenges as the umbilical is pulled from the seabed. Considered more technically difficult than leave *in situ*.	Stable and buried umbilical lines have been left *in situ* before and we know this is achievable. From a technical perspective this would be the least challenging option.
Technical Legacy:	No pipeline surveys would be required.	Depth of burial pipeline surveys have been undertaken by Centrica in the past, and although obtaining depth of burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications.
Safety Short-term: Health & safety risk offshore project personnel	More offshore work involving vessels and possibly divers and more onshore handling than leave in situ. Considered broadly acceptable if safety risks are driven to ALARP. The umbilical would need to be handled on a reel and transferred to shore or more likely it would be cut into sections on the deck.	Least amount of work done offshore than that undertaken for complete removal.
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field would be longer than for leave in situ. The risk to mariners would be aligned with the duration the activities are undertaken in the field.	Vessels would spend less time in the field for this option, therefore the potential for interaction with other mariners and any associated risk would be minimised.
Safety Short-term: Safety risk onshore project personnel	Safety risk is linked to the mass of material returned to shore. Significantly more onshore cutting, lifting and handling associated with disposal of the umbilical presents an increased but broadly acceptable safety risk to personnel.	This option presents less of a safety risk to onshore project personnel and this option would involve no material being returned to shore for processing.
Safety Legacy: Health & safety risk offshore project personnel	No depth of burial surveys or remediation related activities.	Assume up to four depth of burial related surveys.
Safety Legacy: Health & safety risk to mariners	No depth of burial surveys or remediation related activities.	Assume up to four depth of burial related surveys so there is potential for interaction with other mariners, although any associated risks can be expected to be minimal
Safety Legacy: Safety risk onshore project personnel	N/A	N/A
Environmental Short-term: Atmosphere	Emissions and use of energy greatest for this option but no offset would be generated as a result of the energy and emissions needed to create new material to replace any that may be left *in situ*.	Least amount of energy used and least emissions generated in the short-term, although this is slightly counteracted by the energy and emissions required to create new material.
Environmental Short-term: Seabed	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed, the amount of rock disturbed and the amount of remedial activity required. Area impacted is greater for complete removal than for leave *in-situ*.	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed, the amount of rock disturbed and the amount of remedial activity required. Area impacted is greater for complete removal than for leave *in-situ*.
Environmental Short-term: SAC	Larger area of the SAC impacted due to the disturbance of the seabed as the umbilical is pulled out of the trench. Assuming 2m wide corridor affected the area affected would be 0.027km^2, 2.7ha equivalent to c. 0.00074% of the SAC	Limited or no impact on the SAC during the execute phase

PL2067 Umbilical		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
Environmental Short-term: Water column	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal.	Discharges and releases would be least for this option, particularly in the short-term.
Environmental Short-term: Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*.	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss.
Environmental Legacy: Atmosphere	Emissions to air are aligned with survey requirements. No burial surveys are planned therefore is less for complete removal than for leave *in-situ.*	Emissions to air are aligned with survey requirements. Four burial surveys are assumed therefore is greater for leave *in-situ* than for complete removal.
Environmental Legacy: Seabed	No remedial activities planned therefore no impact.	No remedial activities planned therefore no impact.
Environmental Legacy: SAC	No impact. Only environmental survey following completion of decommissioning activities and this is required for both options.	Environmental survey and pipeline status survey only, assuming no remedial work would be required – as suggested by historical survey data. Survey data suggests that the presence of the buried pipeline in the seabed is not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks).
Environmental Legacy: Water column	Discharges and releases to the water column are aligned survey requirements. No surveys planned therefore no impact.	Discharges and releases to the water column are aligned survey requirements. Four surveys are assumed therefore greater impact than for complete removal.
Environmental Legacy: Waste	No remedial activities planned therefore no waste.	No remedial activities planned therefore no waste.
Societal Short-term: Commercial activities	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for the leave *in situ* option.	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be less than for complete removal.
Societal Short-term: Employment	Decommissioning activities would contribute most to continuity of employment for complete removal on the basis that vessel will be longer in the field.	Decommissioning activities would contribute little or nothing to continuity of employment for leave *in situ.*
Societal Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal.	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ.*
Societal Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required.	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal.
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal.	Should the pipeline be left *in situ* surveys would need to be carried out.
Societal Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites.	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related.
Cost Short-term:	The cost of complete removal would be an order of magnitude higher than for the leave *in situ* options.	The cost of leave *in situ* would be the least expensive option.
Cost Legacy:	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term.	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required.

Table F.11: PL2067 Comparative Assessment Table

Appendix F.12 PL2067 High-Level cost comparison by difference

PL2067	Complete Removal (£M)	Leave *in situ* (£M)
Cost	£3.55	£0.12
Sub-total Normalised	**5**	**0.2**

Table F.12: PL2067 Decommissioning options costs by difference[22]

APPENDIX G ACTIVITY & AREA OF SEABED (SAC) AFFECTED

PIPELINE	LENGTH KM	WIDTH M	COMPLETE REMOVAL KM^2	% SAC	OVERTRAWL KM^2	% SAC	START 500m ZONE	FINISH 500m ZONE	EXCL. 500m ZONE	NO. OF 500m ZONES	OVERTRAWL (EXCL. 500m ZONES) KM^2
					0.200 km				0.200 km		
PL496/7	16.9km	5.0m	0.085km^2	0.002%	3.380km^2	0.094%	Audrey A (WD)	LOGGS	0.199km^2	2	2.983km^2
PL575	0.5km	4.0m	0.002km^2	0.000%	0.098km^2	0.003%	Audrey A (WD)	Audrey A (WD)	0.099km^2	1	0.000km^2
PL576	0.7km	2.0m	0.001km^2	0.000%	0.130km^2	0.004%	Audrey A (WD)	Audrey A (WD)	0.099km^2	1	0.031km^2
PL723/4	4.4km	5.0m	0.022km^2	0.001%	0.880km^2	0.024%	Audrey B (XW)	Audrey A (WD)	0.199km^2	2	0.483km^2
PL2066	17.8km	4.0m	0.071km^2	0.002%	3.560km^2	0.099%	Annabel	Audrey A (WD)	0.199km^2	2	3.163km^2
PL2066JW12	0.0km	0.0m	0.000km^2	0.000%	0.007km^2	0.000%	Annabel	Annabel	0.099km^2	1	0.000km^2
PL2066JWAB2	0.1km	0.0m	0.000km^2	0.000%	0.018km^2	0.000%	Annabel	Annabel	0.099km^2	1	0.000km^2
PL2067	13.4km	2.0m	0.027km^2	0.001%	2.680km^2	0.074%	Audrey B (XW)	Annabel	0.199km^2	2	2.283km^2
PL2067JW12	0.1km	0.0m	0.000km^2	0.000%	0.027km^2	0.001%	Annabel	Annabel	0.099km^2	1	0.000km^2
PL2067JWAB2	0.2km	0.0m	0.000km^2	0.000%	0.040km^2	0.001%	Annabel	Annabel	0.099km^2	1	0.000km^2
SUB-TOTALS:			**0.208km^2**	**0.003%**	**10.819Km^2**	**0.300%**			**1.391km^2**		**8.911km^2**

Table G.1: Activity & Area of Seabed (SAC) Affected[23]

[23] Complete removal figure includes pipeline approaches and length of pipeline located within 500m safety zone.