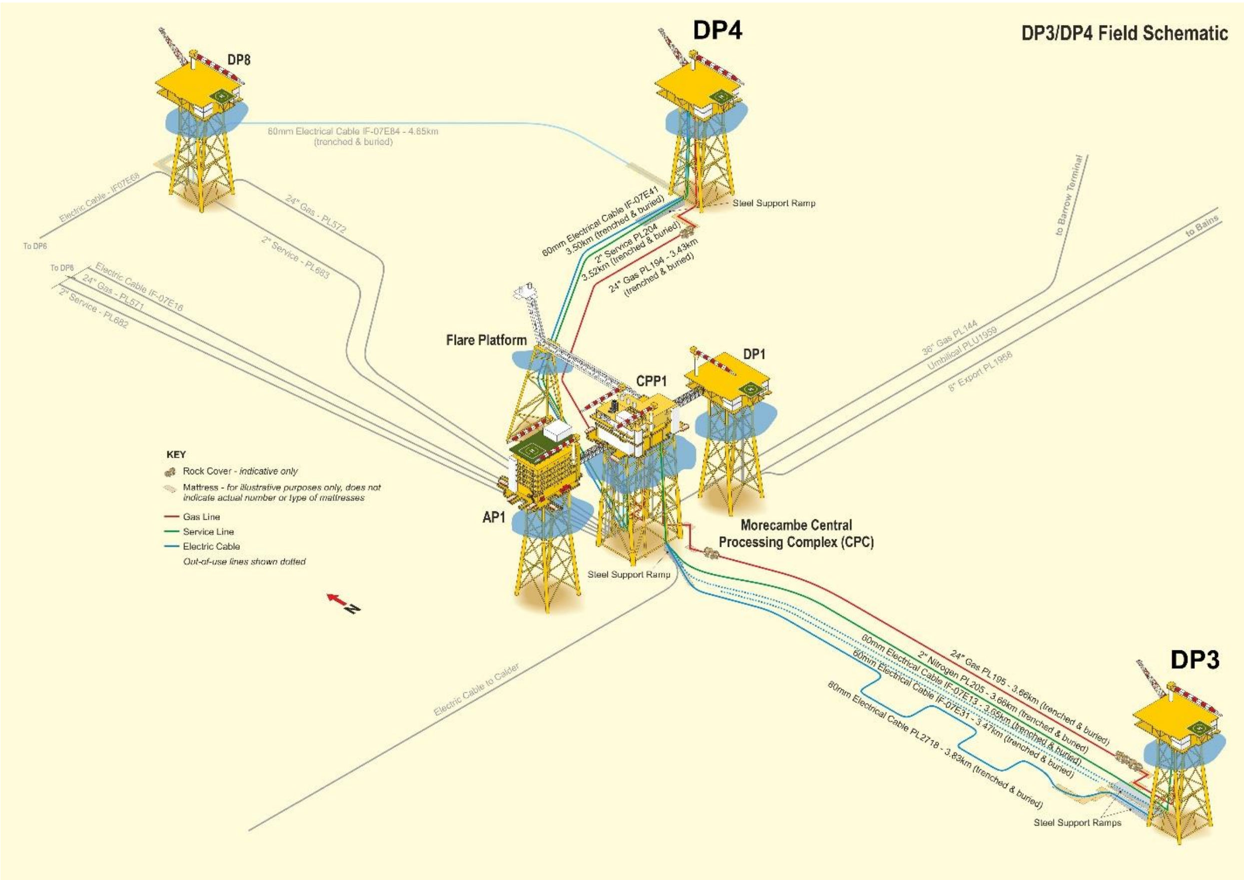
DP3 & DP4 Pipelines & Cables Decommissioning Comparative Assessment



SPIRIT ENERGY

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1. EXECUTIVE SUMMARY

A Comparative Assessment of pipeline decommissioning options is a key consideration within Decommissioning Programmes submitted to the Offshore Petroleum Regulator for Environment & Decommissioning (OPRED).

The DP3 and DP4 developments lie in the East Irish Sea, approximately 34km west of the English coastal town of Blackpool, west coast of Lancashire; DP3 is about 55km north of the town of Rhyl on the North Wales coast, DP4 is about 62km. This comparative assessment deals with decommissioning of the pipelines and cables connecting DP3 and DP4 to other infrastructure.

Acoustic survey data indicates that none of the pipelines or cables have experienced spans or exposures in open water, with some minor excursions on the platform approaches.

DP3

The export route for DP3 is via **PL195**. This is a 24” concrete-coated Gas pipeline routed to CPP1 platform, which is part of the South Morecambe platform complex. Monoethylene glycol is supplied from the CPP1 platform using a 2” pipeline **PL205** and a power and fibre-optic cable **PL2718**. Two redundant cables **IF-07E13** & **IF-07E31** remain installed, the latter having had its ends removed to make way for the replacement PL2718 (whose platform approaches are covered with concrete mattresses). All these lines were trenched and buried, with no exposures (other than occasionally at platform approaches) reported in recent surveys. The final 200m approaches of **PL195** at each platform were stabilised with bitumen mattresses, which have subsequently been covered in deposited rock. Except for **PL2718** which has been in place for about 10 years, all the pipelines and cables have been in place for over 35 years.

DP4

The export route for DP4 is via **PL194**. This is a 24” concrete-coated Gas pipeline routed to CPP1 platform, which is part of the South Morecambe platform complex. Monoethylene glycol is supplied from the CPP1 platform using a 2” pipeline **PL204** and a power cable **IF-07E41**. An additional power and fibre-optic cable to DP8 **IF-07E84** (whose platform approaches are covered with concrete mattresses) completes a ring-main connection via DP8 and DP6 to CPP1. All these lines were trenched and buried, with no exposures (other than occasionally at platform approaches) reported in recent surveys. The final 200m approaches of **PL194** at each platform were stabilised with bitumen mattresses; all of these have subsequently been covered in deposited rock, although we believe that the first such mattress on the approach from DP3 is exposed. All the pipelines and cables have been in place for over 35 years.

Pipeline decommissioning options

This document summarises a comparative assessment of preferred options for decommissioning DP3 and DP4 pipelines and cables, grouped as follows:

- 24” pipelines **PL194** and **PL195**;
- 2” pipelines **PL204** and **PL205**;
- Cable numbers **IF-07E13**, **IF-07E31**, **IF-07E41**, **IF-07E84** and **PL2718**.

Two decommissioning options are considered for the pipelines and cables:

- **Complete removal** – This involves the complete removal of a pipeline/cable by whatever means would be most practicable and acceptable from a technical perspective;
- **Leave *in situ*–** This involves leaving a pipeline/cable *in situ* with no remedial works but possibly verifying its stability via future surveys.

Since decommissioning of the pipeline/cable platform approaches is the same irrespective of which option is pursued, decommissioning of these is generally excluded from this assessment.

That **PL194** and **PL195** are buried under several bitumen mattresses and ~200m deposited rock on the final platform approaches at each end has not been considered in this assessment, but it would undoubtedly complicate the removal process quite significantly.

All options include removal of exposed features such as surface laid sections of the pipelines and cables, concrete mattresses and grout bags in accordance with mandatory requirements.

Comparative assessment

The options were assessed using Spirit Energy's comparative assessment guidelines for the DP3 and DP4 decommissioning project. During the assessment process, evaluations were made principally on a qualitative basis using Spirit Energy'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 of **PL194** and **PL195** would be tolerable and non-preferred rather than broadly acceptable. This is primarily due to the size and weight of these concrete-coated pipelines, and there being limited experience in removing trenched and buried pipelines such as these, especially those that are buried under rock and bitumen mattresses for 200m at each end.

For the small pipelines **PL204** and **PL205**, and **cables**, the risks and impacts of all decommissioning options were found to be broadly acceptable. In the assessment we recognise that for the smaller pipelines and cables, the complete removal option would avoid the need to cut the pipeline and cable ends (except **IF-07E31** the ends of which have already been recovered) at transition depth and would allow each to be removed in a continuous operation.

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 a continuation of employment due to an 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 significant to differentiate the options.

Finally, the leave *in situ* option would cost less to adopt in the short-term than complete removal but not by an order of magnitude for the small pipelines and cables, so we do not consider cost as a significant driver for decommissioning these. However, removal costs of **PL194** and **PL195** are significantly greater than for leave *in situ* – an order of magnitude more, which is another consideration for leaving these lines *in situ*.

Summary of decommissioning proposals

The comparative assessment results in the conclusion that we propose to leave both **PL194** and **PL195** *in situ* throughout their trenched and buried lengths, including the lengths buried under deposited rock on approach to the platforms. Exposed pipeline sections between the deposited rock and platforms will be removed.

For the small pipelines **PL204** and **PL205**, and the **cables,** the exposed sections on the platform approaches would be removed in any event, with buried pipelines and cables cut below the seabed at trench depth at least 600mm below mudline with all approach sections above that depth removed. The intention would be that all the exposed pipeline support and protection materials such as grout bags, and bitumen and concrete mattresses will be removed.

Current indications are that the two sets of isolated midline concrete mattresses on **PL2718** are buried as they weren't recorded in the most recent survey data, Autumn 2019. Should they remain buried, they will be left *in situ*, with the acceptability being verified by an overtrawl.

Otherwise for the main buried lengths of the small pipelines **PL204** and **PL205** and **cables** we have found that the difference between complete removal and leave *in situ* is comparatively small. The long-term result of complete removal is a slight improvement in legacy criteria.

In view of the small difference between complete removal and leave *in situ* for the buried lengths of the small pipelines **PL204** and **PL205** and **cables**, we propose to leave these *in situ*.

Decommissioning of the different pipeline components is summarised below, with the selected option highlighted with a green spot.

DP3 Pipeline Summary:

PL195, 24" concrete-coated steel pipeline 3.78km long between risers	**Complete removal**	**Leave *in situ***
The DP3 riser will be removed along with the jacket. The all-welded 24" Z-configuration concrete-coated expansion spools c/w bitumen support mattresses at DP3 (~60m) will be fully removed.	●	
The concrete-coated 24" pipeline trenched and buried throughout at depths 0.6m to 2.9m (~3.35km, including ~200m at each end buried under bitumen mattresses (15x at DP3 and 19x at CPP1)) and deposited rock will be left *in situ*.		●
The CPP1 riser will be removed along with the jacket, but the all-welded 24" Z-configuration concrete-coated expansion spools c/w bitumen support mattresses at CPP1 (~55m) will be fully removed.	●	
PL205, 2" FBE-coated steel pipeline 3.71km long between J-tubes	**Complete removal**	**Leave *in situ***
The 2" pipeline pulled through J-tube at DP3 will be removed along with the jacket. The 2" pipeline lying on steel support ramps c/w bitumen mattresses and grout bags at DP3 will be fully removed (~65m)	●	
The 2" pipeline (~3.44km) trenched and buried throughout at depths 0.6m to 1.2m will be left *in situ*.		●
The 2" pipeline pulled through J-tube at CPP1 will be removed along with the jacket. The 2" pipeline lying on steel support ramps c/w bitumen mattress and grout bags at CPP1 will be fully removed (~65m).	●	

DP3 Cable Summary:

IF-07E13, 84mm diameter power cable 3.70km long between J-tubes	**Complete removal**	**Leave *in situ***
The 84mm power cable pulled through the J-tube at DP3 will be removed along with the jacket. The power cable on support ramps c/w bitumen support mattresses at DP3 (~55m) will be fully removed.	●	
The 84mm power cable trenched and buried throughout at depths 0.7m to 1.0m (~3.80km) will be left *in situ*.		●
The 84mm power cable pulled through the J-tube at CPP1 will be removed along with the jacket. The power cable on support ramps c/w bitumen support mattresses at CPP1 (~55m) will be fully removed at the same time as the CPP1 jacket.	●	
PL2718, 79mm diameter power & fibre-optic cable 3.88km long between J-tubes	**Complete removal**	**Leave *in situ***
The 79mm cable pulled through the J-Tube at DP3 will be removed along with the jacket. The cable on steel support ramps c/w bitumen support mattresses at DP3 (~25m) will be fully removed, as will the surface laid section of cable (~185m) stabilised using 29x concrete mattresses.	●	
The 79mm cable trenched and buried throughout at depths 0.6m to 1.1m (~3.52km) and 5x buried midline concrete mattresses (3+2) will be left *in situ*.		●
The 79mm cable pulled through the J-tube at CPP1 will be removed along with the jacket. The cable on steel support ramps c/w bitumen support mattresses at CPP1 (~25m) as well the surface laid section of cable (~80m) and 14x concrete mattresses will be removed at the same time as the CPP1 jacket.	●	
IF-07E31, 84mm diameter power cable 3.56km remaining in seabed	**Complete removal**	**Leave *in situ***
3.56km of 84mm cable trenched and buried throughout at depths 0.7m to 1.0m. The ends on approach to DP3 and CPP1 have already been removed.		●

DP4 Pipeline Summary:

PL194, 24" concrete-coated steel pipeline 3.56km long between risers	**Complete removal**	**Leave *in situ***
The DP4 riser will be removed along with the jacket. The all-welded 24" Z-configuration concrete-coated expansion spools c/w bitumen support mattresses at DP4 (~65m) will be fully removed.	●	
The concrete-coated 24" pipeline trenched and buried throughout at depths 0.6m to 1.5m (~3.56km, including ~200m at each end buried under bitumen mattresses (15x at DP4 and 16x at CPP1) and deposited rock) will be left *in situ*.		●
The CPP1 riser will be removed along with the jacket but the all-welded 24" Z-configuration concrete-coated expansion spools c/w bitumen support mattresses at CPP1 (~65m) will be fully removed.	●	
PL204, 2" FBE-coated steel pipeline 3.55km long between J-tubes	**Complete removal**	**Leave *in situ***
The 2" pipeline pulled through J-tube at DP4 will be removed along with the jacket. The 2" pipeline lying on steel support ramps (on bitumen mattresses) and grout bags at DP4 will be fully removed (~80m)	●	
The 2" pipeline (~3.45km) trenched and buried throughout at depths 0.6m to 1.2m will be left *in situ*.		●
The 2" pipeline pulled through J-tube at CPP1 will be removed along with the jacket. The 2" pipeline lying on steel support ramps (on bitumen mattresses) and grout bags at CPP1 will be fully removed (~150m).	●	

DP4 Cable Summary:

IF-07E41, 84mm diameter power cable 3.57km long between J-tubes	**Complete removal**	**Leave *in situ***
The 84mm power cable pulled through the J-tube at DP4 will be removed along with the jacket. The power cable on support ramps c/w bitumen support mattresses at DP4 (~55m) will be fully removed.	●	
The 84mm power cable trenched and buried throughout at depths 0.6m to 1.1m (~3.55km) will be left *in situ*.		●
The 84mm power cable pulled through the J-tube at CPP1 will be removed along with the jacket. The power cable on support ramps c/w bitumen support mattresses at CPP1 (~150m) will be fully removed at the same time as the CPP1 jacket.	●	
IF-07E84, 84mm diameter power & fibre-optic cable 5.01km long between J-tubes	**Complete removal**	**Leave *in situ***
The 84mm power and fibre-optic cable pulled through the J-tube at DP4 will be removed along with the jacket. The cable through J-tube extension c/w concrete mattresses at DP4 (~55m) will be fully removed.	●	
The 84mm power and fibre-optic cable trenched and buried throughout at depths 0.6m to 1.3m (~4.84km) will be left *in situ*.		●
The 84mm power and fibre-optic cable pulled through Conductor Slot 1 at DP8 will be removed along with the jacket. The cable under concrete mattresses and grout bags at DP8 (~110m) will be fully removed when DP8 is removed, if not before.	●	

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FIGURES AND TABLES

TERMS AND ABBREVIATIONS

ABBREVIATION	DESCRIPTION
~	Approximately
ALARP	As Low As Reasonably Practicable
Approach	Initial or final stretch of pipeline (or umbilical) as it leaves its point of origin or reaches its destination
CO_2	Carbon Dioxide
CPP	Central Processing Platform (as in CPP1)
CSV	Construction Support Vessel
CTE	Coal Tar Epoxy (anti-corrosion pipeline coating)
c/w	…complete with.
°	Degree
DoB	Depth of burial.
DP	Drilling Platform (as in DP3, DP4, DP8)
DSV	Dive Support Vessel.
EIA	Environmental Impact Assessment
Exposure	A pipeline can be seen on the surface of the seabed but is not free-spanning
FBE	Fusion-Bonded Epoxy (anti-corrosion pipeline coating)
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)
HAZID	Hazard Identification Workshop
HLV	Heavy Lift Vessel
HSEQ	Health, Safety, Environment, Quality
ID	Identity (as in tabulated feature)
in (“)	Inch (25.4mm)
J-Lay	Method used for installing pipelines whereby pipe stalks with a length up to 6 joints are upended and welded to the seagoing pipe in a near vertical ramp. The ramp angle is chosen in such a way that it is in line with the pipe catenary to the seabed
J-tube	A vertical platform conduit curving to a horizontal outlet at its base (hence J-shaped) through which small diameter pipelines and cables can be pulled from seabed to surface.
km, m	Kilometre(s), Metre(s)
KP	Kilometre Post, measured from place of origin
kV	Kilovolt (1000 volts)
LAT	Lowest Astronomical Tide
MEG	Mono-Ethylene Glycol, a process additive to counteract adverse effects of water
MM	Million
N/A	(Data) Not Available
NORM	Naturally Occurring Radioactive Material
NUI	Normally Unattended Installation
OD	Outside Diameter (of pipe)
OGUK	Oil & Gas UK.
OPRED	Offshore Petroleum Regulator for Environment & Decommissioning
Order of Magnitude	Size difference by factor of 10: one (10^1) means 10-times, two (10^2) means 100-times difference
Pipeline(s)	Pipeline, flexible flowline, cable or umbilical as defined by OPRED. Includes PL194, PL2718 etc.
Pipespool(s)	Short sections of pipe that may be flanged and bolted or welded together
Power	Electrical power (using copper as a conductor) as opposed to hydraulic power
Qualitative	Result determined using judgement and use of risk and impact matrices
Quantitative	Result determined using numerical data and by calculation
ROV	Remotely Operated Vehicle
Scour	Local erosion of a sedimentary seabed, usually cumulative
SIMOPS	Simultaneous Operations
Spirit Energy (SPEUKL)	Spirit Energy Production UK Limited, wholly owned subsidiary of Spirit Energy Limited.
Stove piping	Using this method of pipeline installation, a pipeline is fabricated on the deck of a lay barge by welding together individual lengths of pipe as the pipe is paid out from the barge
UKCS	United Kingdom Continental Shelf
WT	Wall Thickness (of pipe)

ABBREVIATION	DESCRIPTION
yrs	Years
S-Lay	A pipelay method whereby pipe sections are welded together on a horizontal deck, their transition down to seabed taking the form of an elongated "S".
Te	Tonne(s)
UK	United Kingdom
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 is marginally better
Broadly Acceptable / Low[1] & most preferred	As above but performance in other 'broadly acceptable' options is marginally worse
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
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.

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

2. INTRODUCTION

2.1 Overview

The South Morecambe field was discovered in 1974 and commenced production in 1985; it extends over license blocks 110/2a, 110/3a and 110/3b on the UK Continental Shelf. DP3 and DP4 were installed in 1985 and are normally unattended installations (NUIs) supported by four leg steel jackets in 22m - 25m water depth, tied back to the CPP1 platform via subsea pipelines and cables.

There are many similarities between DP3 & DP4 (both are NUIs and subsea infrastructure), so their decommissioning is being addressed jointly. This comparative assessment is concerned with the subsea pipelines and cables routed to adjacent facilities. Figure 2.1.1 illustrates the field layout and infrastructure.

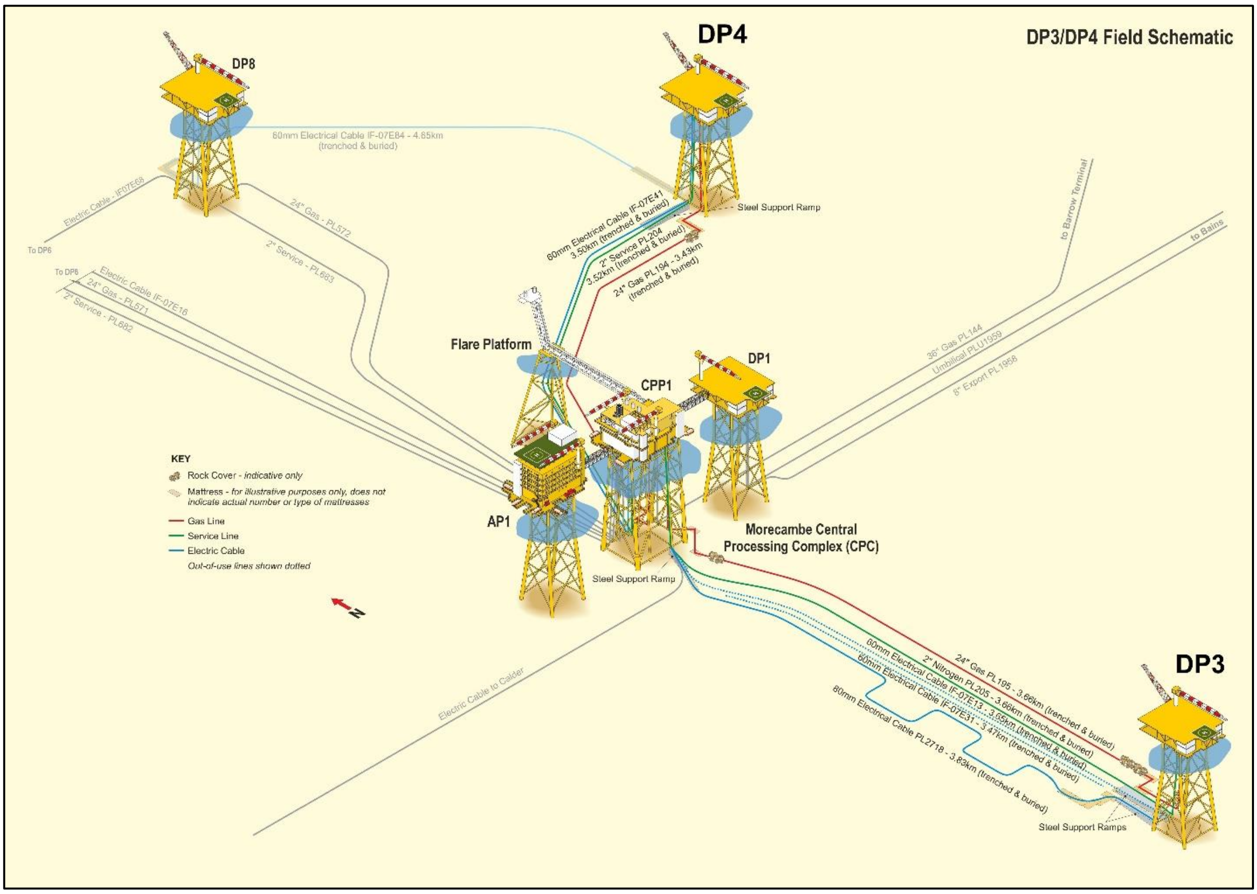

Figure 2.1.1: DP3 / DP4 Infrastructure

Illustrations of the individual pipeline and cable approaches to the platforms are presented in the Decommissioning Programmes [5] and shall not be repeated here.

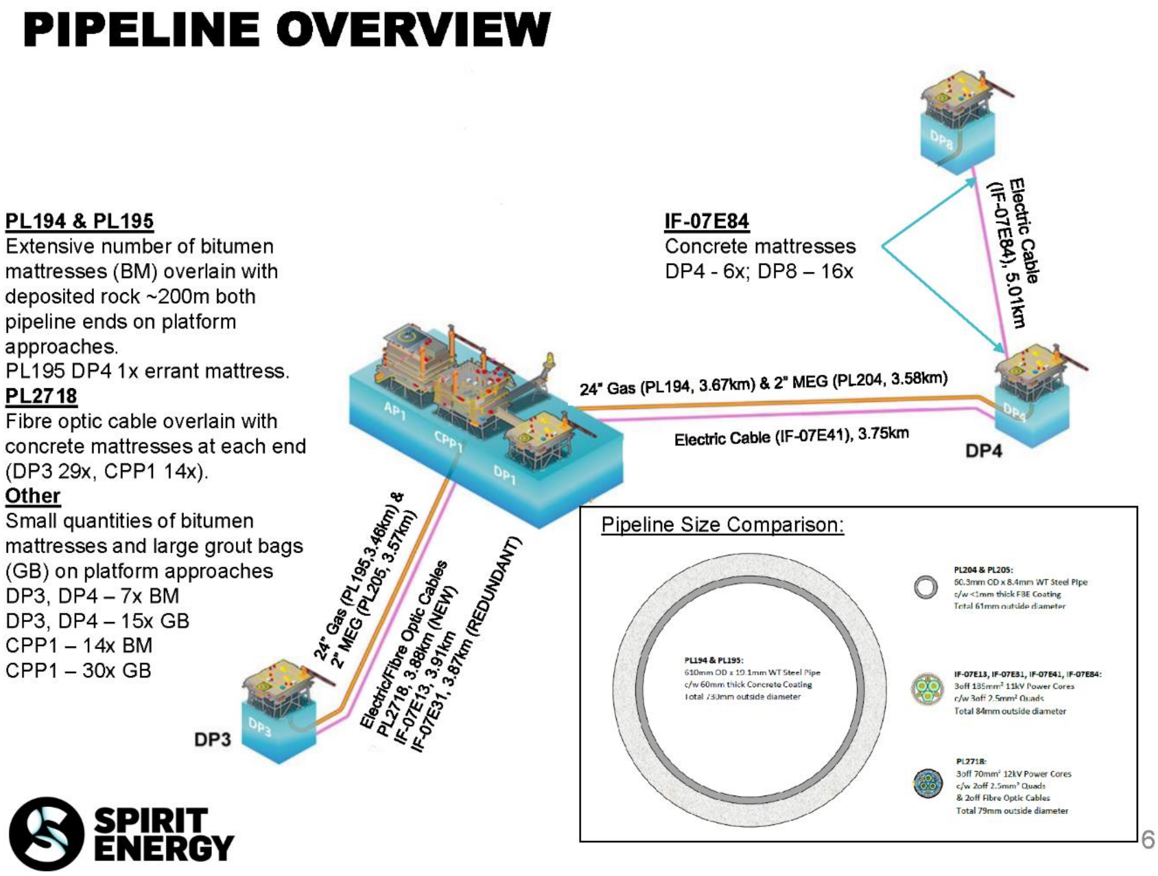

Figure 2.1.2: Pipeline & Cable Overview

2.1.1 DP3 Pipelines

PL195 is the 24" gas and condensate flowline from DP3 to CPP1 platform at the Morecambe complex. **PL205** is the 2" flowline supplying chemical services (initially mono-ethylene glycol (MEG), subsequently nitrogen) from CPP1 to DP3. **PL2718** is a power and fibre-optic cable providing power and communications to DP3 from the CPP1 platform; this replaces the two initial cables (**IF-07E13** & **IF-07E31**) that remain *in situ* but are no longer serviceable (the ends of **IF-07E31** having been removed to facilitate tie-in of the replacement cable **PL2718**).

The 24" gas line is connected at the platforms via seabed expansion spools of Z-configuration; these were retrofitted after pipelay and fully welded *in situ*. Pipeline length is quoted between the bottom of each riser and includes these expansion spools. The small diameter lines (2") and cables are supported on steel ramps at each jacket edge, which must be removed as part of jacket removal. Line lengths are quoted to the J-tube ends at the edge of each jacket, omitting the internal J-tube lengths that will be removed with the jacket. The remaining seabed length of cable IF-07E31 is estimated as having been cut 50m from the jacket edge.

As illustrated in Figure 2.1.3 the DP3 pipeline and cable components are:

Pipeline ID	Description, Size & Quantity
PL195	24" gas and condensate concrete-coated steel pipeline, 3.46km length between risers
PL205	2" glycol / nitrogen steel pipeline,3.57km length between J-tube bellmouths
PL2718	79mm diameter power & fibre-optic power-communications cable,3.88km between J-tube bellmouths
IF-07E13	84mm diameter power-communications cable, 3.70km between J-tube bellmouths
IF-07E31	84mm diameter power-communications cable, 3.56km remaining in seabed
	For details of pipeline stabilisation features please refer Decommissioning Programmes[5]

Table 2.1.1: The DP3 pipeline and cable components

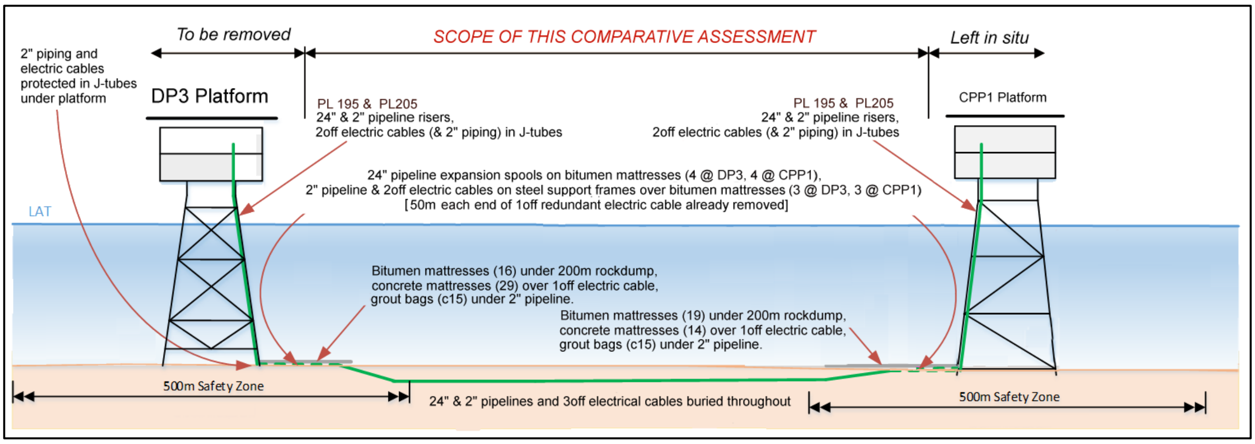

Figure 2.1.3: Extent of DP3 Pipelines & Protection Measures

2.1.2 DP4 Pipelines

PL194 is the 24” gas and condensate flowline from DP4 to the CPP1 platform. **PL204** is the 2” flowline supplying chemical services (initially mono-ethylene glycol (MEG), subsequently nitrogen) from CPP1 to DP4. **IF-07E41** is a power cable providing power and communications to DP4 from the CPP1 platform. **IF-07E84** is an additional power and fibre-optic cable from DP8, creating a power ring-main from CPP1 via DP6. Removal of the DP4-DP8 cable will not disrupt future DP6 & DP8 operations.

As illustrated in Figure 2.1.4 the DP4 pipeline and cable components:

Pipeline ID	Description, Size & Quantity
PL194	24” gas and condensate concrete-coated steel pipeline, 3.56km length between risers
PL204	2” glycol / nitrogen steel pipeline,3.55km length between J-tube bellmouths
IF-07E41	84mm diameter power-communications cable, 3.75km between J-tube bellmouths
IF-07E84	67mm diameter power & fibre-optic power-communications cable, 4.68km between J-tube bellmouths
	For details of pipeline stabilisation features please refer Decommissioning Programmes[5]

Table 2.1.2: The DP4 pipeline and cable components

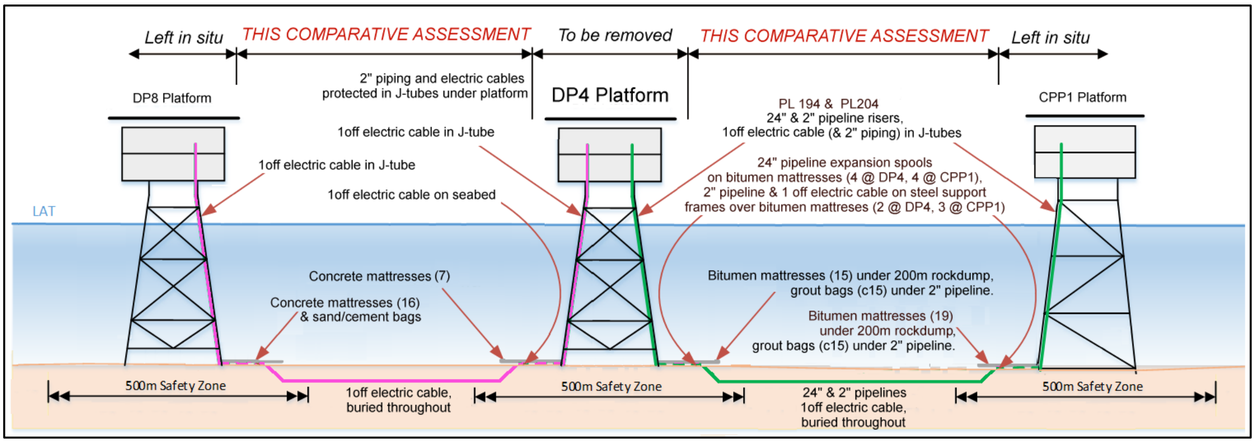

Figure 2.1.4: Extent of DP4 Pipelines & Protection Measures

2.1.3 Pipeline / Cable Construction Overview

When considering decommissioning options, the different pipeline / cable constructions and their relative sizes are pertinent, as illustrated to common scale in Figure 2.1.5 below.

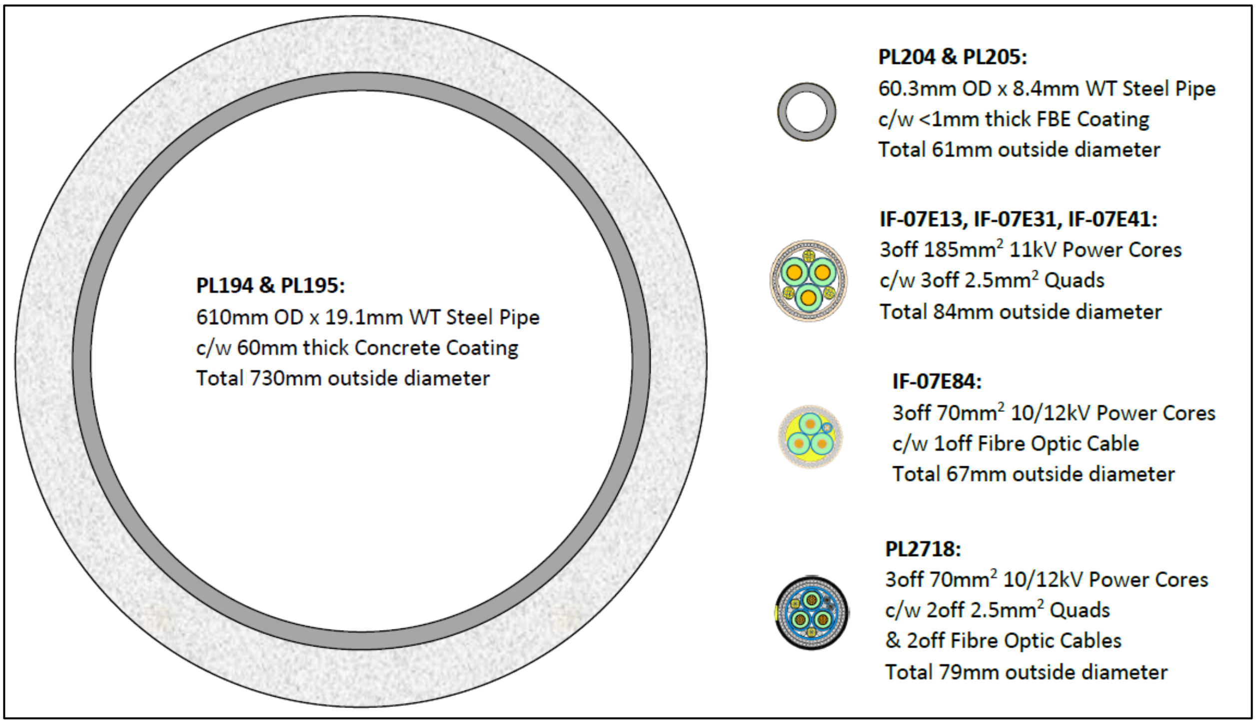

Figure 2.1.5: DP3 / DP4 Pipeline, Cable Construction and Sizes

2.2 Purpose

As per the OPRED guidance notes [3] 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.

Following public, stakeholder and regulatory consultation, the DP3 / DP4 Decommissioning Programmes will be submitted in full compliance with the OPRED guidance notes [3]. The Decommissioning Programmes [5] explain the principles of the removal activities and are supported by an Environmental Appraisal [6] and this Comparative Assessment.

2.3 Environmental Setting

2.3.1 The seabed in relation to the pipelines

Seabed depth along the pipelines generally varies steadily between LAT end depths as follows:

- 22m at DP3 to 26m at CPP1 south side;
- 25m at DP4 to 27m at CPP1 north side;
- 25m at DP4 to 29m at DP8.

Recent bathymetric surveys have indicated slight surficial variations (mobile mega-ripples) along the length of the pipelines, but overall the seabed level is little changed since 1986.

This location is an important fishing ground for queen scallops, small prawns and a variety of white fish, all of which involve use of bottom trawl fishing gear.

Much of the pipeline routes lie within areas of flat and featureless seabed. Recent surveys have not included depth of burial, but post-installation surveys show the pipelines to be generally buried to more than 0.6m depth, which is greater than surficial mobility (0.3m). It is therefore reasonable to assume that the pipelines are sufficiently well buried not to have moved, which is supported by no pipeline or cable exposures being reported over the trenched lengths.

Pipeline and cable buried profiles are illustrated in Section 0.

2.3.2 Deposited rock

While it is considered physically possible to remove deposited rock, the decommissioning philosophy in this document is consistent with the Guidance Notes [3], hence all deposited rock will be left *in situ*.

Material left in place will preserve the marine habitat that will have established over the time it has been on the seabed, and in this case its presence will not have a negative impact on the environment, nor impact on the safety of other users of the sea.

Methods that could be used to remove the rock include:

- dredging the rock and disposing of the material at an approved offshore location;
- dredging the rock 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 shore for appropriate disposal.

All 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.

A further complication in these circumstances is the presence of bitumen mattresses (about 70 in all) under the rock: these would probably be damaged by the rock removal process. It is therefore proposed that they remain under the protective rock, while any that are exposed will be recovered.

2.3.3 Bitumen mattresses buried in deposited rock

The ends of concrete-coated **PL194** & **PL195** laid on the seabed (before entering the trench) were initially stabilised with bitumen mattresses. For unknown reasons (possibly because their long-term exposure was deemed unacceptable) the bitumen mattresses were subsequently buried in deposited rock. This is consistent with industry experience that deposited rock presents little hazard to fishing activities, whereas mattresses can frequently be displaced by trawling gear.

Bitumen mattresses have long been discontinued, largely because of their hydrocarbons being brought into the environment. They have a propensity to solidify and break up when cooled to seabed temperatures, whereas latterly multicell concrete mattresses that retain their flexibility have been developed. Their removal is not directly comparable to that of concrete mattresses, which is nowadays largely routine, with the prospect of exposed bitumen contaminants from broken pieces left on the seabed. We believe therefore, that the only removal method is to be by rolling them carefully into nets for lifting onto the support vessel.

The removal sequence would proceed broadly as follows:

- Reposition rock to expose bitumen mattresses and pipeline. Probably by high velocity water pumping, which will disperse the rock over an unknown area, and probably (being more mobile) disperse much of the local seabed as well;
- Drag/roll each bitumen mattress (typically fifteen at each pipeline end) into nets for lifting onto the support vessel;

Based on the foregoing we would propose to leave the bitumen mattresses and associated deposited rock *in situ*.

2.3.4 PL2718 mid-line concrete mattresses

Five concrete mattresses have been placed on **PL2718**; referred to here and in the Decommissioning Programmes as 'mid-line' mattresses. As shown in the Decommissioning Programmes, Figure 3.4.5, the types of concrete mattress and location are:

- 2x Type 1 concrete mattresses (6m x 3m x 0.3m) at ~KP0.80;
- 3x Type 1 concrete mattresses (6m x 2.4m x 0.3m) at ~KP1.65.

These mattresses were installed outside the 500m safety zones to protect two short sections of the power and fibre-optic cable that were left exposed after difficulties appear to have been encountered during installation activities. These mattresses weren't found during the most recent pipeline surveys conducted in Autumn 2018.

Should they be removed, further remedial work may be required to reduce the chances of fishing gear snagging **PL2718**. In order of preference the remedial work would comprise one of the following:

- Deposition of a small quantity of rock over the top of the cable; or,
- Cut and remove the exposed section of cable;
- Local re-trenching and backfill of sediment material.

Any one of the options is technically achievable and would be acceptable from a safety and environmental perspective. However, it is worth examining the impacts from an environmental perspective and the threat each solution might pose to other users of sea.

Deposition of rock

Should the fibre-optic cable be exposed once any of the mattresses have been removed, in this instance the remedial works would involve depositing a small quantity of rock over the exposed area. The cable itself is just 79mm outside diameter. Assuming a rock density of up to 3Te per cubic metre, we calculate that up to 15Te of rock would be sufficient to provide a protective cover. This is equivalent to ~5 cubic metres of rock. The preference would be to use smaller granules of rock with sizes ranging from 19mm to 90mm to be used. The quantity of rock used would be minimised.

We believe that the minimal threat that this solution would pose to other users of the sea would be acceptable and this would be the preferred option.

Removal of exposed section of PL2718

Should the fibre-optic cable be exposed once the mattresses have been removed, removal of the exposed section would involve excavation and severance of the ends of the exposed sections up to 18m and 12m long respectively. The excavated areas would be backfilled with the excavated spoil. The quantities of material involved might typically be of the order of a few cubic metres.

We believe that the small threat that this solution would pose to other users of the sea would be acceptable but marginally greater that those associated with the deposition of rock.

Local re-trenching and backfill of sediment material

Should the fibre-optic cable be exposed once any of the mattresses have been removed, in this instance the remedial works would involve excavation of the local seabed and lowering the cable into the resulting trench. However, by inspection the area of seabed affected would be much larger than for either of the alternative remediation methods, and as difficulties appear to have been encountered during the original installation, it is possible that this might not be achievable.

We believe that the threat that this solution would pose to other users of the sea would be acceptable. However, as difficulties were encountered during the original installation we believe that there could be a low probability of success when using this approach, it is non-preferred.

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, which includes the following technical assumptions:

- A purely qualitative approach has been taken. This has necessarily required a degree of judgement, but since most impacts are related to the area impacted, duration of works and vessel time, we felt this was appropriate.
- Complete removal of the pipelines is considered unachievable by reverse reeling, either due to pipe size and concrete coating (24”) or materials uncertainty (the 2” was not installed by the reel method, nor designed for it). We recognise that there is limited experience of reverse installation of trenched and buried pipelines from the seabed [1], nor of cut-&-lift methods over such distances, so estimations of the safety risks, technical challenges and cost implications carry some uncertainty.
- Complete removal of the cables is considered achievable by reverse reeling, since the trenches have been allowed to backfill naturally, which material should be easily displaced with little overall disturbance. Bringing the cable onboard by reverse S-lay (as for the 2” pipelines) and cutting it into lengths offshore is also feasible.
- There are no known exposures on any of the pipelines or cables outside their respective 500m safety zones at each end. SEPUKL is not aware of any fishing gear snagging reports. To our knowledge no exposures have been of such a magnitude that they have warranted being recorded as a snagging hazard via Kingfisher Information Services in FishSAFE (www.fishsafe.eu).

The following legacy assumptions have also been made:

- An environmental survey would be required on completion of decommissioning activities;
- Any pipeline 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 would not present snagging hazards;
- 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 24” Gas pipelines

3.1.1 PL195 DP3 to CPP1 rigid pipeline

PL195 is a 24” concrete-coated steel pipeline that is approximately 3.46km long between risers and routed from the DP3 NUI to CPP1. It was laid in 1983 and trenched, becoming subsequently buried by natural backfill. It is connected to platform risers at each end via welded expansion spools of about 60m length, which rest on bitumen support mattresses (4off at each platform). Concrete coating thickness is 60mm along the pipeline and 100mm on the seabed expansion spools. On its approach to the expansion spools at each end, the pipeline lies on the seabed for about 200m and is protected by bitumen stabilisation mattresses which subsequently have been covered by deposited rock.

A burial depth survey was performed in 1986, which indicates top-of-pipe depths varying between 0.6m and 2.9m. Refer Figure 3.1.1. Note that the indicated bathymetry is based on Ordnance Datum Newlyn, which records water depths as being 4.3m greater than LAT values used elsewhere in this document.

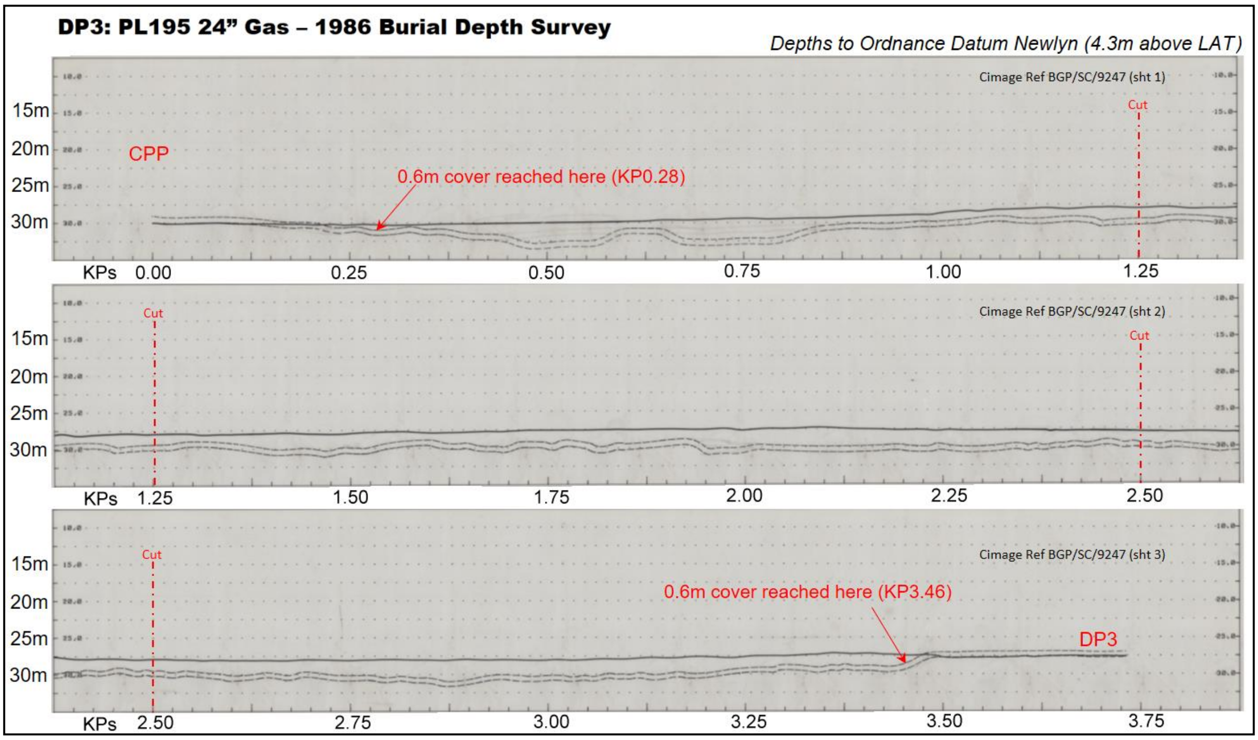

Figure 3.1.1: Post-build (1986) seabed profile for PL195

3.1.2 PL194 DP4 to CPP1 rigid pipeline

PL194 is a 24” concrete-coated steel pipeline that is approximately 3.67km long and routed from the DP4 NUI to CPP1. It was laid in 1983 in the same campaign as PL195, and in all respects other than length and burial profile is the same as described in Section 3.1.1 above. Its burial profile is illustrated in Figure 3.1.2, with top-of-pipe depths varying between 0.6m and 1.5m.

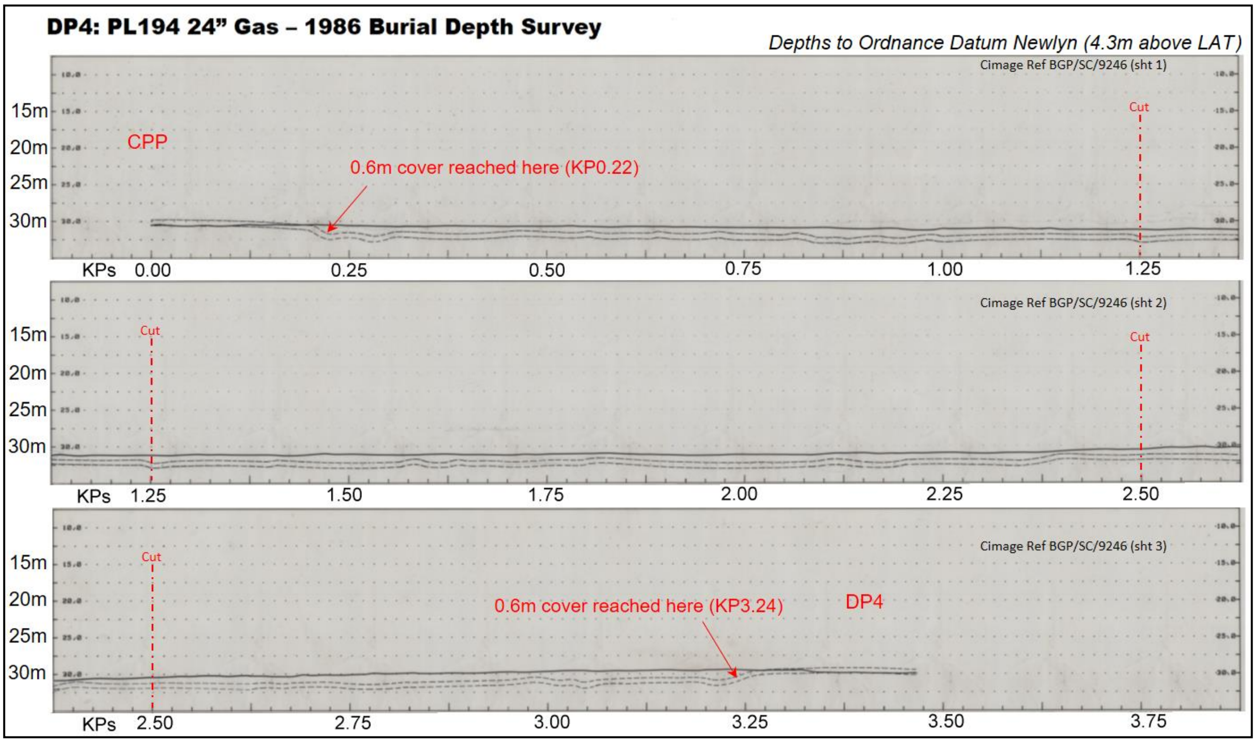

Figure 3.1.2: Post-build (1986) seabed profile for PL194

3.2 2" Glycol pipelines

3.2.1 PL205 CPP1 to DP3 rigid pipeline

PL205 is a 2" steel pipeline that is approximately 3.57km long and routed from CPP1 to the DP3 NUI. It was installed in 1985 by "stove-piping" double-jointed lengths into an S-lay deployment (i.e. not reel-laid) and trenched by jetting, becoming subsequently buried by natural backfill. It is connected to each platform via J-tubes through which it was pulled as part of the pipelay process. On its approach to each platform, the pipeline rests on a steel "anti-scour" support ramp hooked onto the base of the jacket, with its transition of ramp end to seabed being supported on grout bags, but it is otherwise buried throughout. Since this support ramp must be removed before jacket removal, this final section of the pipeline will also be removed as part of that process.

A post-installation burial depth survey was performed in 1985, which indicates top-of-pipe depths varying between 0.7m and 1.2m. Refer Figure 3.2.1.

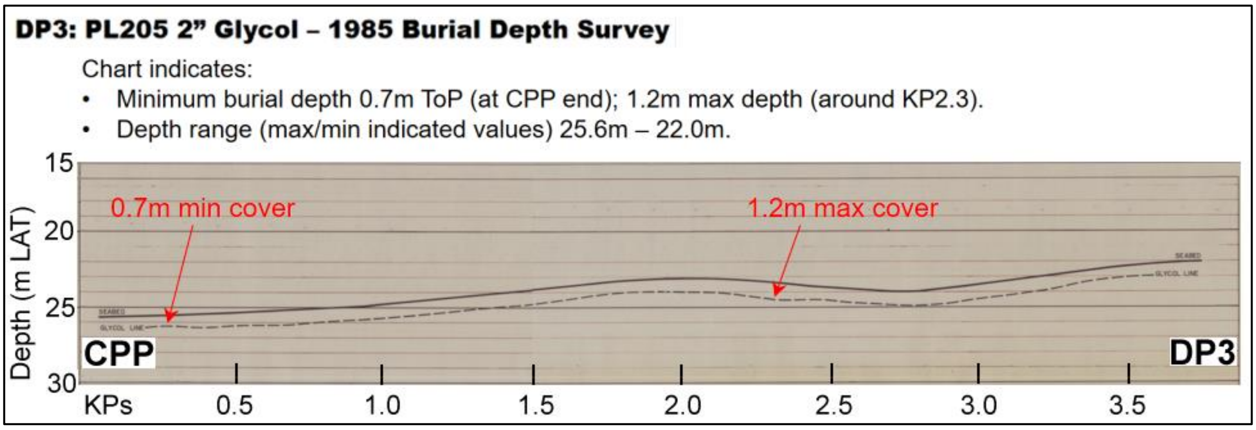

Figure 3.2.1: Post-build (1985) seabed profile for PL205

3.2.2 PL204 CPP1 to DP4 rigid pipeline

PL204 is a 2” steel pipeline that is approximately 3.58km long and routed from CPP1 to the DP4 NUI. It was laid in 1985 in the same campaign as PL205, and in all respects other than length and burial profile is the same as described in Section 3.2.1 above. Its burial profile is illustrated in Figure 3.2.2, with top-of-pipe depths varying between 0.6m and 1.2m.

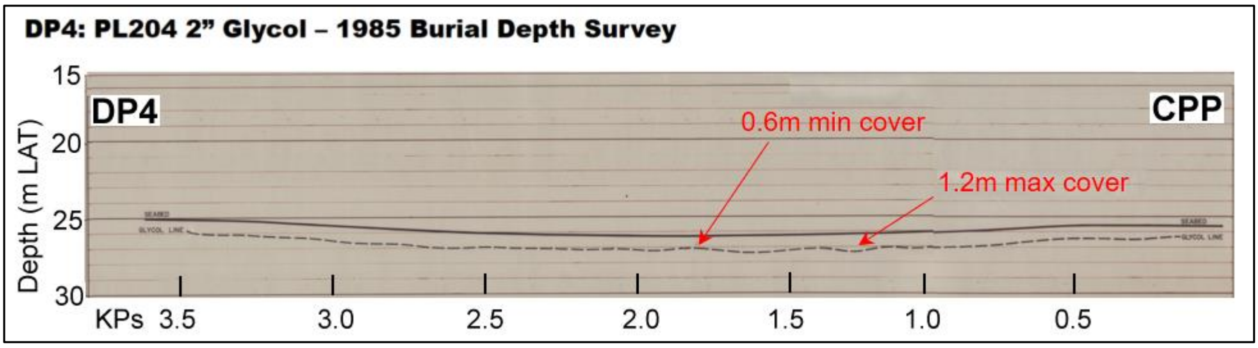

Figure 3.2.2: Post-build (1985) seabed profile for PL204

3.3 Cables

3.3.1 IF-07E13 CPP1 to DP3 (East) cable

IF-07E13 is an 84mm diameter power cable that is approximately 3.91km long and routed from CPP1 to the DP3 NUI. It was reel-laid in 1985 in the same campaign as PL205, pulled through its J-tube and trenched by jetting, becoming subsequently buried by natural backfill. Excess cable was removed at the jacket topsides, so there are no significant overage loops on the seabed to take-up surplus length. On its approach to each platform, the cable rests on a steel “anti-scour” support ramp hooked onto the base of the jacket but is otherwise buried throughout. Since this support ramp must be removed before jacket removal, this final section of the cable will also be removed as part of that process.

A post-installation burial depth survey was performed which indicates top-of-cable depths varying between 0.7m and 1.0m. This is shown in Figure 3.3.1.

A fault was found in this cable in 2007, since when it has been out of use. Tests indicated the fault was in the DP3 J-tube, excessive pull-in loads during installation being suspected as the most probable cause.

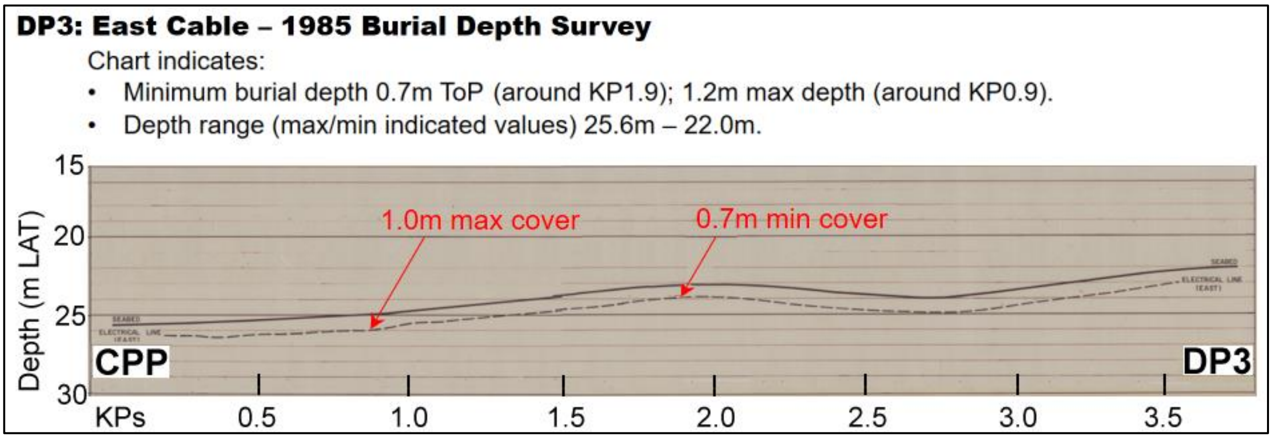

Figure 3.3.1: Post-build (1985) seabed profile for IF-07E13

3.3.2 IF-07E31 CPP1 to DP3 (West) cable

IF-07E31 is an 84mm diameter power cable approximately 3.56km long and routed from CPP1 to the DP3 NUI. It was reel-laid in 1985 in the same campaign as **IF-07E13**, and in all respects other than length and burial profile is the same as described in Section 3.3.1 above. Its burial profile is illustrated in Figure 3.3.2, with top-of-cable depths varying between 0.7m and 1.0m.

A fault was found in this cable in 2000, also in the DP3 J-tube, since when it has been out of use. 140m length (90m in J-tube + 50m on seabed) was removed from each end to allow J-tube access to the replacement cable **PL2718**.

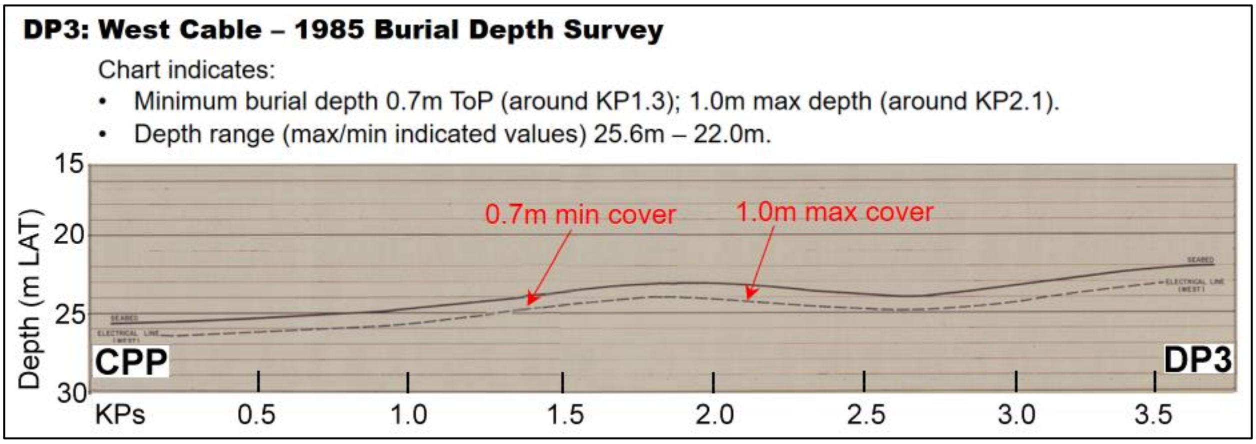

Figure 3.3.2: Post-build (1985) seabed profile for IF-07E31

3.3.3 IF-07E41 CPP1 to DP4 cable

IF-07E41 is an 84mm diameter power cable that is approximately 3.75km long and routed from CPP1 to the DP4 NUI. It was reel-laid in 1985 in the same campaign as **IF-07E13** and remains serviceable. Otherwise in all respects other than length and burial profile it is the same as described in Section 3.3.1 above. Its burial profile is illustrated in Figure 3.3.3, with top-of-cable depths varying between 0.6m and 1.2m.

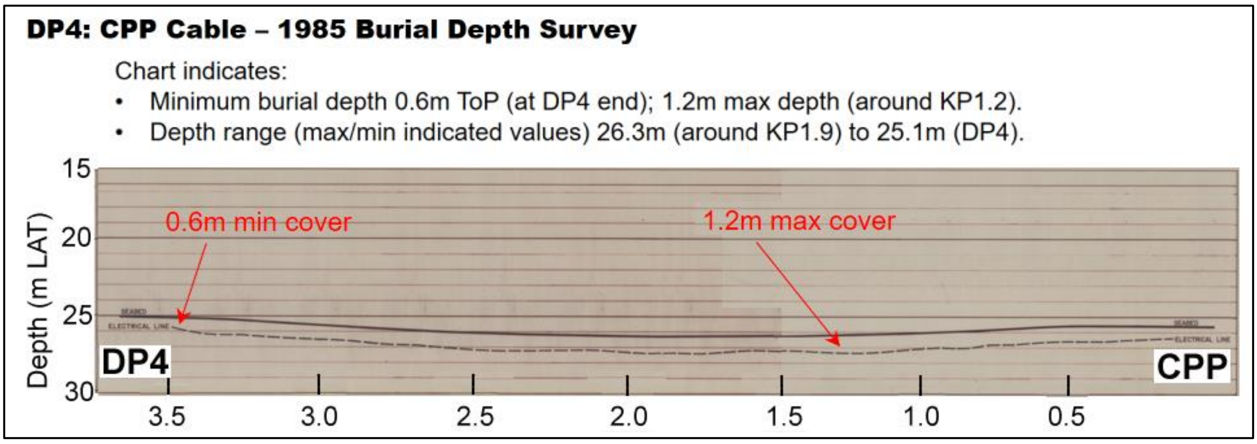

Figure 3.3.3: Post-build (1985) seabed profile for IF-07E41

3.3.4 IF-07E84 DP8 to DP4 cable

IF-07E84 is a 67mm diameter power and fibre-optic cable approximately 5.01km long routed between the DP8 and DP4 NUIs. It was reel-laid in 1993 in the same campaign as other cables between CPP1, DP6 and DP8, and then trenched by jetting, becoming subsequently buried by natural backfill. Instead of a steel anti-scour support frame at DP4, a 10m long J-tube extension supports the transition between jacket and seabed, outboard of which the cable is protected by 6off concrete mattresses before burial in the seabed. Surplus cable length is accommodated in the final curve towards DP8, where the cable is surface-laid and covered by 16off concrete mattresses. Its final approach into DP8 is protected by multiple grout bags, which would be removed as part of DP8 jacket removal. Its burial profile is illustrated in Figure 3.3.4, top-of-cable depths generally varying between 0.6m and 1.3m, although in isolated places cover falls to 0.5m; however, no cable exposures have been observed.

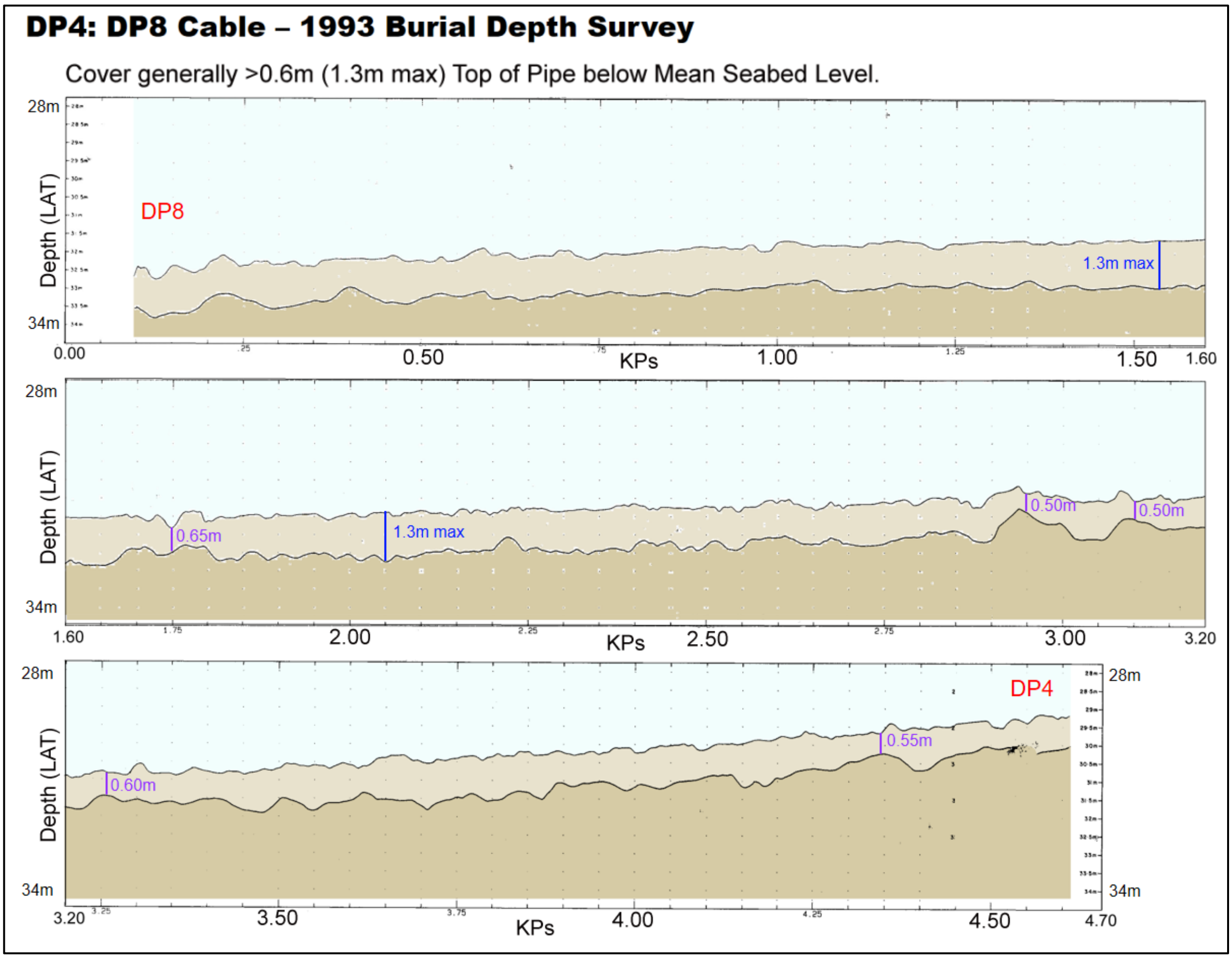

Figure 3.3.4: Post-build (1993) seabed profile for IF-07E84

3.3.5 PL2718 CPP1 to DP3 cable

PL2718 is a 79mm diameter power and fibre-optic cable approximately 3.88km long and routed from CPP1 to the DP3 NUI. It was reel-laid in 2010 to replace the failed cables **IF-07E13** & **IF-07E31**. Only the ends of **IF-07E31** were cut back and removed to provide access to the J-tubes, and then trenched by jetting, becoming subsequently buried by natural backfill. Surplus cable length is accommodated in two overage loops, at around KPs 1.8 and 2.1.

Both platform approaches are surface-laid and protected by concrete mattresses (14off at CPP1 and 29off at DP3), with further mattresses (2off at KP0.81 and 3off at KP1.65) covering exposures found as-laid, but the cable is otherwise buried throughout. At platform J-tube entry, the cable rests on a steel “anti-scour” support ramp hooked onto the base of the jacket. Since this support ramp must be removed before the jacket, the associated cable section will be removed at the same time and is not part of this comparative assessment.

The burial profile of PL2718 is illustrated in Figure 3.3.5: top-of-cable depths generally vary between 0.5m and 1.1m, although in various places cover is significantly less, particularly near the overage loops and towards DP3; however, no cable exposures have been observed.

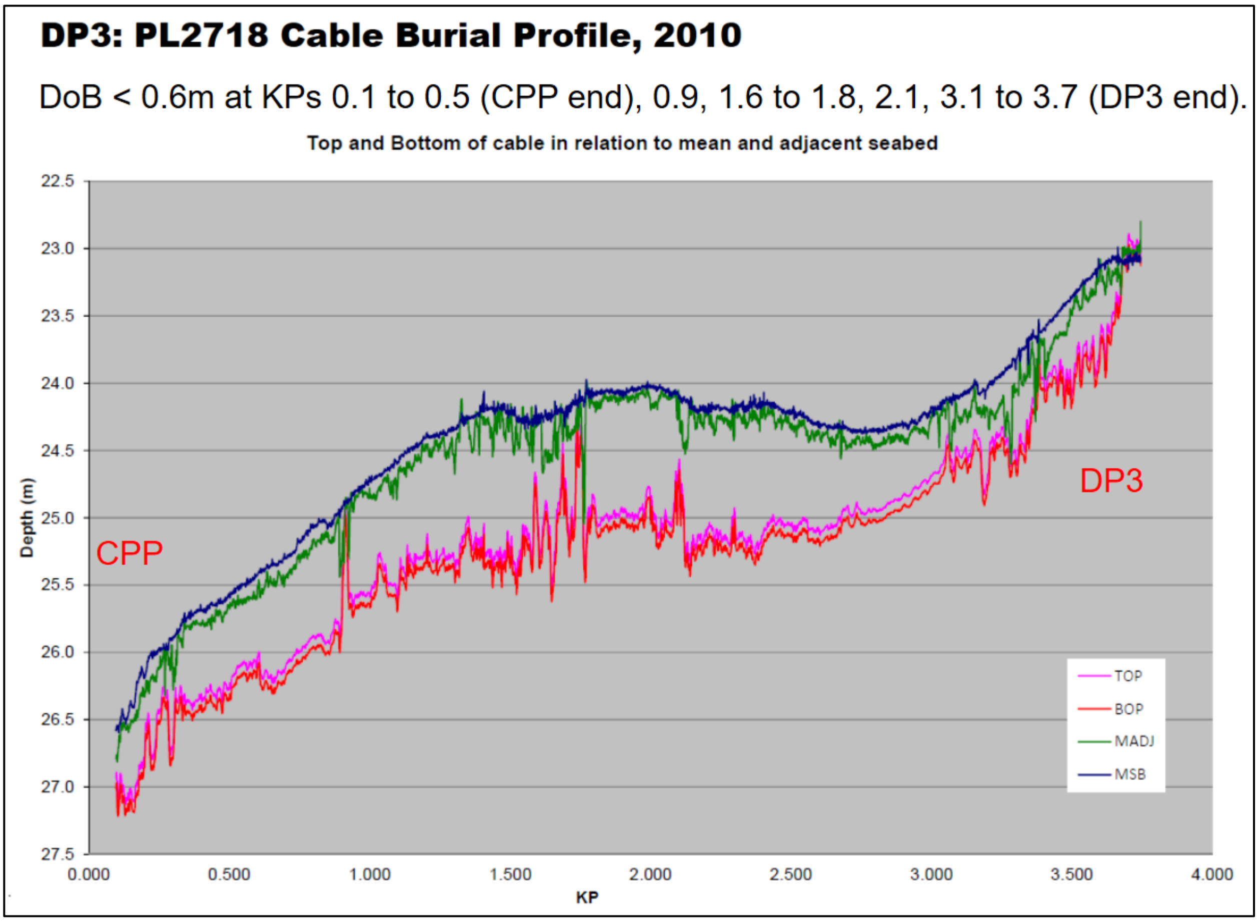

Figure 3.3.5: Post-build (2010) seabed profile for PL2718

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. The pipelines and cables are laid in separate trenches, and therefore the options for decommissioning them are considered independently. However, for reasons of brevity they are discussed together in the narrative since many aspects of the assessment are common to both. Any significant differences are highlighted in the discussion.

There is an implicit assumption that options for re-use of the pipelines and cables have been exhausted prior to the facilities moving into the decommissioning phase and associated comparative assessment; therefore, this option has been excluded. The two decommissioning options considered are:

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

Complete removal would involve removing the buried ends installed lying on the seabed but that are now buried under bitumen or concrete mattresses or deposited rock, as well as the lengths of pipeline buried in the trench.

Leave *in situ* would mean leaving the complete pipeline or cable *in situ*, along with the ends that were installed lying on the seabed but are now buried under bitumen or concrete mattresses or deposited rock. Any exposed lengths beyond the buried sections (at the platform approaches) will be removed.

All grout bags will be removed in accordance with mandatory requirements.

Because of pipeline & cable similarities, comparative assessment is performed in five parts:

- 24” Gas line trenched sections (**PL194** & **PL195**).
- 2” Glycol line trenched sections (**PL204** & **PL205**).
- Cable trenched sections (**IF-07E13**, **IF-07E31**, **IF-07E41**, **IF-07E84**, **PL2718**).
- Seabed sections under bitumen mattresses and deposited rock (**PL194** & **PL195**).
- Seabed sections under concrete mattresses (**IF-07E84** & **PL2718**).

The 1985-installed small diameter pipes and cables (**PL204** & **PL205**, **IF-07E13** & **IF-07E41**) are considered to trench-transition directly from the jacket section, and parts of **IF-07E31** have already been removed.

Further details of the decommissioning options for the DP3 / DP4 pipelines and cables are described in Sections 4.1.1 to 4.1.5. The activities detailed in these sections could be undertaken using a variety different vessel type. Vessel types might include a construction support vessel (CSV), a dive support vessel (DSV), or a pipelay vessel or a mixture of all three, depending on the activities being undertaken.

4.1.1 Options and methods for decommissioning 24" Gas lines PL194 & PL195

ID[2]	Item	Option 1 Complete Removal	Option 2 Leave *in situ*
1	The retrofitted 24" Gas riser is all-welded steel with elastomeric coating and anodes, ~48.5m long (DP3) or 51.8m long (DP4) and mounted on the external jacket face with an external protection frame.	Remove. C*ut at base of DP3 or DP4 platform as applicable. Completely remove, either before or as part of jacket removal, as determined by platform removal procedures. Return pipe to shore for processing.*	Remove*. As Option 1.*
2	The Z-configuration 24" expansion spool is all-welded steel with concrete weight-coating and anodes, ~65m (**PL194**) or 60m (**PL195**) long and resting on 4off 4.6m x 2.5m bitumen mattresses.	Remove. C*ut at base of DP3 or DP4 platform as applicable and at end of deposited rock. Perform additional cuts as necessary and lift onto CSV/DSV. Roll up and fully recover bitumen mattresses by whatever mechanical means necessary to clear seabed. Return severed pipeline sections and mattresses to shore for processing.*	Remove*. As Option 1.*
3	On approach to DP3 and DP4. 24" rigid pipelines, steel with concrete weight-coating and anodes, ~200m long, resting on seabed, stabilised with ~15off 3.7m x 2.5m bitumen mattresses and covered with deposited rock.	Remove. *Uncover the buried pipeline ahead of removal operations using mass flow excavator. Roll up and fully recover bitumen mattresses by whatever mechanical means necessary to clear pipeline. Cut pipeline into sections as necessary and lift onto CSV/DSV. Return severed pipeline sections and mattresses to shore for processing.*	Leave *in situ*.
4	24" rigid pipeline steel with concrete weight-coating and anodes, ~3.14km (**PL194**) or 2.95km (**PL195**) long trenched and naturally backfilled to depths of 0.6m to 1.5m / 2.9m max (**PL194** and **PL195** respectively).	Remove. *Uncover the buried pipeline ahead of removal operations using mass flow excavator. Identify field-joint locations and excavate locally to provide access for cutting equipment and lifting gear. Cut pipeline into sections as necessary and lift onto CSV/DSV/pipe-barge. Return severed pipeline sections to shore for processing.*	Leave *in situ*. *Note that pipe ends will require trimming where Option 1 is adopted for Items 3 & 5.*
5	On approach to CPP1. 24" rigid pipelines, steel with concrete weight-coating and anodes, ~200m long, resting on seabed, stabilised with ~20off 3.7m x 2.5m bitumen mattresses and covered with deposited rock.	Remove. *Uncover the buried pipeline ahead of removal operations using mass flow excavator. Roll up and fully recover bitumen mattresses by whatever mechanical means necessary to clear pipeline. Cut pipeline into sections as necessary and lift onto CSV/DSV. Return severed pipeline sections and mattresses to shore for processing.*	Leave *in situ*.
6	The Z-configuration 24" expansion spool is all-welded steel with concrete weight-coating and anodes, ~65m (**PL194**) or 55m (**PL195**) long and resting on 4off 4.6m x 2.5m bitumen mattresses.	Remove. C*ut at base of CPP1 platform and at end of deposited rock. Perform additional cuts as necessary and lift onto CSV/DSV. Roll up and fully recover bitumen mattresses by whatever mechanical means necessary to clear seabed. Return severed pipeline sections and mattresses to shore for processing.*	Remove*. As Option 1.*
7	Both the retrofitted 24" Gas risers are all-welded steel with elastomeric coating and anodes and ~52.5m long and mounted on the external jacket face, with an external protection frame.	Remove. C*ut at base of CPP1 platform. Completely remove, either before or as part of jacket removal, as determined by platform removal procedures. Return pipe to shore for processing.*	Remove*. As Option 1.*

Table 4.1.1: Options for decommissioning PL194 & PL195

[2]Items 1, 2, 6 & 7 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 2” Glycol lines PL204 & PL205

ID[3]	Item	Option 1 Complete Removal	Option 2 Leave *in situ*
1	2” rigid steel FBE-coated pipeline pulled up through a J-tube at CPP1 where it is connected to topsides pipework. Length to bottom of J-tube to be removed is ~95m (DP3) and ~75m (DP4).	Remove. C*ut at base of CPP1 platform. Completely remove, either before or as part of jacket removal, as determined by platform removal procedures. Return pipe to shore for processing.*	Remove*. As Option 1.*
2	The 150m (**PL204**) or 65m (**PL205**) length of 2” rigid steel FBE-coated pipeline that rests on a steel “anti-scour” support ramp from the CPP1 J-tube end and grout-bagged transition into the seabed.	Remove. C*ut at base of CPP1 platform. Completely remove, with steel support ramp, bitumen foundation mattresses and grout bags, either before or as part of jacket removal, as determined by platform removal procedures. Return pipe and grout bags to shore for processing.*	Remove*. As Option 1.*
3	2” rigid steel FBE-coated pipeline and anodes, ~3.35km (**PL204**) or ~3.44km (**PL205**) long trenched and naturally backfilled to depths of 0.6m to 1.2m max.	Remove. *If necessary, uncover the buried pipeline ahead of removal operations using mass flow excavator. Attach recovery cable to pipe end and remove pipeline by reverse S-lay method using CSV/DSV/pipe-barge. Cut pipeline into sections as necessary on CSV/DSV/pipe-barge. Return severed pipeline sections to shore for processing.*	Leave *in situ*.
4	The 80m (**PL204**) or 65m (**PL205**) length of 2” rigid steel FBE-coated pipeline that rests on a steel “anti-scour” support ramp from the DP3 or DP4 J-tube end and grout-bagged transition into the seabed.	Remove. C*ut at base of DP3 or DP4 platform as appropriate. Completely remove, with steel support ramp, bitumen foundation mattresses and grout bags, either before or as part of jacket removal, as determined by platform removal procedures. Return pipe and grout bags to shore for processing.*	Remove*. As Option 1.*
5	2” rigid steel FBE-coated pipeline pulled up through a J-tube at DP3 or DP4 where it is connected to topsides pipework. Length to bottom of J-tube to be removed is ~95m (DP3) 75m (DP4).	Remove. C*ut at base of DP3 or DP4 platform as appropriate. Completely remove, either before or as part of jacket removal, as determined by platform removal procedures. Return pipe to shore for processing.*	Remove*. As Option 1.*

Table 4.1.2: Options for decommissioning PL204 & PL205

[3]Items 1, 2, 4 & 5 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 cables IF-07E13, IF-07E31 & IF-07E41

ID[4]	Item	Option 1 Complete Removal	Option 2 Leave *in situ*
1	84mm cable pulled up through a J-tube at CPP1 where it is connected to topsides cabling. Length to bottom of J-tube to be removed is ~120m (‘**E13**), ~120m (‘**E41**).	Remove. C*ut at base of CPP1 platform. Completely remove, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing. (Cables E13 & E41 only, E31 already removed.)*	Remove*. As Option 1.*
2	The 55m (‘**E13**) or 150m (‘**E41**) length of 84mm cable rests on a steel “anti-scour” support ramp between the CPP1 J-tube end and pipe transition into the seabed.	Remove. C*ut at base of CPP1 platform. Completely remove, with steel support ramp and bitumen foundation mattresses, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing. (Cables* ***‘E13*** *&* ***‘E41*** *only,* ***‘E31*** *already removed.)*	Remove*. As Option 1.*
3	84mm cable, ~3.80km (‘**E13**), ~3.56km (‘**E31**) or 3.37km (‘**E41**) long trenched and naturally backfilled to depths of 0.7m to 1.0m max (‘**E13** & ‘**E31**), 0.6m to 1.1m max (‘**E41**).	Remove. *Attach recovery cable to cable end and remove cable by reverse reel-lay or S-lay method using CSV/DSV/pipe-barge. Cut cable into sections or separate reels as necessary on CSV/DSV/pipe-barge. Return severed cable sections to shore for processing.*	Leave *in situ*.
4	The 55m length of 84mm cable (both **‘E13** & **‘E41**) rests on a steel “anti-scour” support ramp between the DP3 or DP4 J-tube end and pipe transition into the seabed.	Remove. C*ut at base of DP3 / DP4 platform. Completely remove, with steel support ramp and bitumen foundation mattresses, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing. (Cables* ***‘E13*** *&* ***‘E41*** *only,* ***‘E31*** *already removed.)*	Remove*. As Option 1.*
5	84mm cable pulled up through a J-tube at DP3 (‘**E13**) or DP4 (‘**E41**) where it is connected to topsides. Length to bottom of J-tube to be removed is ~95m (DP3) and ~75m (DP4).	Remove. C*ut at base of DP3 / DP4 platform. Completely remove, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing. (Cables* ***‘E13*** *&* ***‘E41*** *only,* ***‘E31*** *already removed.)*	Remove*. As Option 1.*

Table 4.1.3: Options for decommissioning IF-07E13, IF-07E31 & IF-07E41

[4]Items 1, 2, 4 & 5 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 power & fibre-optic cable IF-07E84

ID[5]	Item	Option 1 Complete Removal	Option 2 Leave *in situ*
1	67mm power and fibre-optic cable pulled up through a J-tube at DP4 where it is connected to topsides cabling. Length to bottom of J-tube to be removed is ~95m.	Remove. C*ut at base of DP4 platform. Completely remove, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing.*	Remove*. As Option 1.*
2	The 11m length of 67mm power and fibre-optic cable is carried within a steel J-tube extension between the DP4 J-tube end and a concrete mattress support on the seabed.	Remove. C*ut at base of DP4 platform. Completely remove, with steel support tube, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing.*	Remove*. As Option 1.*
3	~44m of 67mm power and fibre-optic cable laid on seabed and into trench transition, covered by 6off concrete mattresses.	Remove. C*ut at base of DP4 platform. Completely remove concrete mattresses and underlying cable using CSV/DSV. Return cable and mattresses to shore for processing.*	Remove*. As Option 1.*
4	67mm power and fibre-optic cable, ~4.84km long trenched and naturally backfilled to depths generally of 0.6m to 1.3m max.	Remove. *Attach recovery cable to cable end and remove cable by reverse reel-lay or S-lay method using CSV/DSV/pipe-barge. Cut cable into sections or separate reels as necessary on CSV/DSV/pipe-barge. Return severed cable sections to shore for processing.*	Leave *in situ*.
5	~101m of 67mm power fibre-optic cable laid on seabed and into trench transition, covered by 16off concrete mattresses.	Remove. C*ut at base of DP8 platform. Completely remove concrete mattresses and underlying cable using CSV/DSV. Return cable and mattresses to shore for processing.*	Remove*. As Option 1.*
6	The 9m length of 67mm power and fibre-optic cable is protected by polypropylene sand or grout bags between the concrete mattresses and the end of DP8 Conductor Slot 1.	Remove. C*ut at base of DP8 platform. Completely remove, with steel support frame, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing.*	Remove*. As Option 1.*
7	67mm power and fibre-optic cable pulled up through Conductor Slot 1 at DP8 where it is connected to topsides cabling. Length to be removed to bottom of Slot 1 is ~60m.	Remove. C*ut at base of DP8 platform. Completely remove, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing.*	Remove*. As Option 1.*

Table 4.1.4: Options for decommissioning IF-07E84

[5]Items 1, 2, 3, 5, 6 & 7 are included for completeness, although the approach will be the same for all decommissioning options being considered

4.1.5 Options and methods for decommissioning cable PL2718

ID[6]	Item	Option 1 Complete Removal	Option 2 Leave *in situ*
1	79mm power and fibre-optic cable pulled up through a J-tube at CPP1 where it is connected to topsides cabling. Length to bottom of J-tube to be removed is ~95m.	Remove. C*ut at base of CPP1 platform. Completely remove, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing.*	Remove*. As Option 1.*
2	The 25m length of 79mm power and fibre-optic cable rests on a steel “anti-scour” support frame between the CPP1 J-tube end and pipe transition into the seabed.	Remove. C*ut at base of CPP1 platform. Completely remove, with steel support frame, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing.*	Remove*. As Option 1.*
3	~80m of 79mm power and fibre-optic cable laid on seabed and into trench transition, covered by 14off concrete mattresses.	Remove. C*ut at base of CPP1 platform. Completely remove concrete mattresses and underlying cable using CSV/DSV. Return cable and mattresses to shore for processing.*	Remove*. As Option 1.*
4	79mm power and fibre-optic cable, ~3.57km long trenched and naturally backfilled to depths generally of 0.6m to 1.1m, (various instances <0.6m, but no exposures), remedial concrete mattresses (2off @ KP0.81, 3off @ KP1.65).	Remove. *Completely remove concrete mattresses and underlying cable using CSV/DSV and return cable to shore for processing. Attach recovery cable to cable end and remove cable by reverse reel-lay or S-lay method using CSV/DSV/pipe-barge. Cut cable into sections or separate reels as necessary on CSV/DSV/pipe-barge. Return severed cable sections to shore for processing.*	Leave *in situ.*
5	~185m of 79mm power and fibre-optic cable laid on seabed and into trench transition, covered by 29off concrete mattresses.	Remove. C*ut at base of DP3 platform. Completely remove concrete mattresses and underlying cable using CSV/DSV. Return cable and mattresses to shore for processing.*	Remove*. As Option 1.*
6	The 25m length of 79mm power and fibre-optic cable rests on a steel “anti-scour” support frame between the DP3 J-tube end and pipe transition into the seabed.	Remove. C*ut at base of DP3 platform. Completely remove, with steel support frame, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing.*	Remove*. As Option 1.*
7	79mm power and fibre-optic cable pulled up through a J-tube at DP3 where it is connected to topsides cabling. Length to bottom of J-tube to be removed is ~95m.	Remove. C*ut at base of DP3 platform. Completely remove, either before or as part of jacket removal, as determined by platform removal procedures. Return cable to shore for processing.*	Remove*. As Option 1.*

Table 4.1.5: Options for cable decommissioning PL2718

[6]Items 1, 2, 3, 5, 6 & 7 are included for completeness, although the approach will be the same for all decommissioning options being considered

4.2 Decommissioning of the ‘grout bags’

The number of grout bags noted in the Decommissioning Programmes [5] has been estimated using engineering judgement based on available data such as as-built drawings and design sketches.

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

Much 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 OPRED[3] and Spirit Energy's Comparative Assessment Guidance. These elements are considered both for short-term work as the assets are decommissioned and 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 be addressed 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 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 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 in-between red and green and may or may not be less, or more, desirable. High costs also attract a 'less desirable outcome' but any differences in cost 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 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 assessment results for pipeline/cable removal are described in Section 5.2; the assessment of mattress removal is in Section 5.3.

5.1.1 Technical Assessment

The technical assessment is concerned with the risk of major project failure. Technical feasibility confirms whether the method being assessed is physically possible given the technical issues that would be encountered.

Definition: A technical evaluation of the complexity of a job that 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 & safety risk is assessed using three specific sub-criteria.

Sub-criteria:

1. Example health and safety risks for project personnel carrying out decommissioning activities offshore are presented in Table 5.1.1:

Example Description of Hazard	Who or What 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 [1]. 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), subsea infrastructure
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, hydrocarbons or NORM from within pipelines released to the local marine environment	Divers and vessel-based personnel

Table 5.1.1: Description of offshore hazards

2. Example residual risks to marine users on successful completion of decommissioning are presented in Table 5.1.2:

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

Table 5.1.2: Description of residual hazards to mariners

3. Example safety risks for project personnel engaged in carrying out decommissioning activities onshore are presented in Table 5.1.3:

Example Description of Hazard	Who is at risk?
Residual hazardous materials such as methanol, chemicals from umbilical cores, 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 5.1.3: 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 during detailed design and execution. For the purposes of the comparative assessment we examined the differences and took account of 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 two 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;
    - Disturbance to protected areas;
    - Effect on water column;
    - Waste.
2. Legacy environmental impacts due to what would be left behind
    - Emissions to atmosphere;
    - Effect on seabed;
    - Disturbance to protected areas;
    - Effect on water column;
    - Waste.

Assessment of sub-criteria:

The environmental assessment considers the impacts of the decommissioning options. Environmental impacts include consideration of such impacts on the atmosphere (energy and emissions), seabed (area impacted, and material mobilised into water column), 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 Spirit Energy Environmental Impact Assessment matrix. 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 as by way of example, they are likely to be a very small percentage of the total CO_2 produced from domestic shipping.

An assessment of the environmental impacts of the selected decommissioning option can be found in the Environmental Appraisal [6].

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 activities.

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 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 of 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 five-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 the leave *in situ* option is 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, 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-of-magnitude greater than the other options being considered it is assessed as being 'Tolerable & non-preferred'; a two orders-of-magnitude difference is assessed as 'Intolerable & non-preferred'.

5.2 Comparative Assessment

Although the various pipeline and cable constructions differ, the approach to decommissioning their trenched sections will fundamentally be the same. Therefore, we have combined their comparative assessments, noting any differences that may arise. A similar approach is adopted for dealing with pipeline and cable sections protected and stabilised by concrete mattresses sections in Section 5.3.

5.2.1 Technical Assessment

For complete removal the pipeline or cable would need to be retrieved from the trench in which it has been buried by natural backfill. We assume that the backfill sediment will be looser than deposited rock or mattresses, none of which are present in the trenched sections (other than five mattresses on **PL2718**), and therefore that retrieval through the backfill should be relatively straightforward. However, the different pipeline / cable constructions will affect the practicalities of removal, as discussed below. We also believe that the known seabed mobility contributing to natural backfill will adversely affect keeping trenches open during "cut and lift" removal.

5.2.1.1 24" Gas lines PL194 & PL195

Each concrete-coated pipeline was installed by S-lay from a large anchored pipelay barge under high tension in the shallow water. Before removal, the pipeline would be flooded with seawater and therefore significantly heavier than when it was installed, leading to recovery tensions being even higher than for installation. In view of uncertainty about the physical state of the pipelines after over 35yrs service, we believe removal by reverse-lay to be impractical. The only removal method is therefore believed to be by "cut and lift", although its practicalities are also questionable, for reasons including:

- Ability to keep the trench open for access to the pipeline;
- Size of cutting equipment for 60mm concrete coating on steel pipeline;
- Access to field-joints to avoid concrete coating;
- Deployment of safe lifting equipment onto / around pipeline;
- Length, weight and instability of recovered pipeline sections onto a moving vessel;
- Number of repeated lifts;
- Difficulty of subsea working in high current / poor visibility conditions.

The technical uncertainties associated with the decommissioning options for PL194 & PL195 have been assessed using the risk assessment matrix in the comparative assessment guidance, the results of which are presented in Table 5.2.1 below.

Sub-Criterion	Option 1 Complete removal	Option 2 Leave *in situ*
Technical feasibility	**Short-term:** There has been little experience of reverse-lay or cut-&-lift of trenched, buried and concrete coated pipelines in the UKCS. There is limited experience of using the cut-&-lift method for removing pipelines of this scale. **Reverse S-lay** is considered not achievable due to high tensions and uncertain pipe condition. **Cut-&-Lift** - Concrete coat could start to break up and fall from pipeline sections. Strong currents in the area. Poor visibility for ROV use with shears. Long duration. Handling of pipeline sections (concrete coated) difficult but achievable. May require the trench to be backfilled although naturally backfilled after installation, and/or any spoil mounds that may need to be spread or pushed back into the trench.	**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.

Colour Key:		
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.1: PL194 & PL195 Technical Assessment

5.2.1.2 2" Glycol lines PL204 & PL205

Each FBE-coated pipeline was installed from a DSV by "stove-piping" 24m lengths of pipe into a continuous length for S-lay. It is a variant of the manual or shielded metal arc welding technique and is used where the speed of joining pipes is critical. There is a degree of uncertainty on weld quality for reverse lay, and unlike the 24" lines there is no record of any internal inspection. The pipelines have been installed for over 35-years and short of excavating the pipes we are unable to confirm whether the integrity of the pipelines is suitable for reverse-reeling. We therefore believe that removal by reverse-reeling is impractical.

Each pipeline will be flooded with seawater and therefore significantly heavier than when it was installed, leading to recovery tensions higher than for installation. Although there is uncertainty about the physical state of the pipelines after over 35yrs service, we believe removal by reverse-installation to be feasible. However, it is possible that some over-bending could occur while pulling the pipe through the trench backfill, which could result in the pipeline being broken (most probably at a weld). We therefore believe that it might be prudent to expose the pipeline by localised jetting or mass excavation techniques, both of which have a negative environmental impact on the seabed and water column; this would need to be confirmed by more detailed study into the removal process.

In summary, we believe the most practical removal method for each 2" pipeline is to pull the pipe back onto a CSV/DSV as a reverse of the installation method, cutting it into manageable lengths onboard. Using the "cut and lift" method would also be feasible, although with many of the disadvantages listed in 5.2.1.1 it is non-preferred.

The technical uncertainties associated with the decommissioning options for **PL204** & **PL205** have been assessed using the risk assessment matrix in the comparative assessment guidance, the results of which are presented in Table 5.2.2 below.

Sub-Criterion	Option 1 Complete removal	Option 2 Leave *in situ*
Technical feasibility	**Short-term:** There has been limited experience of reverse reeling or reverse S-lay of trenched and buried rigid pipelines in the UKCS particularly in high-current mobile-seabed areas. However, since the lines are small diameter and naturally back-filled, CSV motions under reverse S-lay will help displace the overlying seabed which is known to be mobile. Considered more technically difficult than leave *in situ*.	**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.

Colour Key:		
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.2: PL204 & PL205 Technical Assessment

5.2.1.3 Cables IF-07E13, IF-07E31, IF-07E41, IF-07E84, PL2718

The power cables were installed by reeling from a CSV/DSV, and a reversal of this method appears viable for removal. The greater flexibility of power cable, compared with the 2” steel pipelines, suggests that it may be pulled through naturally-deposited backfill without tensile failure; we believe it should not be necessary to expose the cable by excavation beforehand, with vessel motions via the cable helping it cut through the backfill.

It would also be possible to recover the cables in sections as for the 2” pipelines described in 5.2.1.2 above. The preferred methodology would depend on factors such as:

- Whether the cable is to be re-used / recycled in a continuous length;
- Ease of handling / transporting heavy reels at onshore reception facilities;
- Equipment compatibility if cable removal is combined with that of the 2” pipelines.

In summary, we believe that the power cables could be removed either by reverse-reeling or by being pulled back onto a CSV/DSV and cut into manageable lengths onboard; it should not be necessary to expose the cable beforehand. The “cut and lift” method would also be feasible, although with many of the disadvantages listed in 5.2.1.1 it is non-preferred.

The technical uncertainties associated with the decommissioning options for **IF-07E13**, **IF-07E31**, **IF-07E41**, **IF-07E84** and **PL2718** have been assessed using the risk assessment matrix in the comparative assessment guidance, the results of which are presented in Table 5.2.3Table 5.2.7 below.

Sub-Criterion	Option 1 Complete removal	Option 2 Leave *in situ*
Technical feasibility	**Short-term:** Activities have been undertaken in the UKCS by another operator. Reverse reeling and reversed S-lay are viable options, although reversed S-lay may be preferred for commonality with removing the cables. Naturally backfilled trench in mobile seabed is not the most onerous. Considered more technically difficult than leave *in situ*.	**Short-term:** Activities have been done in the UKCS by Spirit Energy. Stable and buried cables 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 cable surveys would be required in future.	**Legacy:** Depth of burial and environmental surveys have been undertaken by Spirit Energy in the past, and although obtaining depth of burial for cables can be problematic (due to their small size), overall technically this is achievable with no complications. Remedial work / monitoring may be required.

Colour Key:		
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.3: IF-07E13, IF-07E31, IF-07E41, IF-07E84, PL2718 Technical Assessment

5.2.1.4 Summary - Technical

Although some design uncertainties would need to be overcome, we believe that decommissioning options for all the above pipelines and cables are technically feasible. However, there are differences in difficulty, with the 24" **PL194** & **PL195** being significantly more complex due to the implausibility of reverse-lay and a reliance on a cut-&-lift technique, which is viable more for short pipeline lengths. Due to the sizes involved, we believe in this instance that technical feasibility is pushing the bounds of practicality.

By comparison, **PL204** & **PL205** should be relatively straightforward to retrieve using a reversed S-lay technique, although de-burial beforehand is advised to mitigate against pipe fracture, with consequent environmental and cost impacts. Whereas the cables **IF-07E13**, **IF-07E31**, **IF-07E41**, **IF-07E84** & **PL2718**, being comparatively flexible and with tensile armouring, should be retrievable by reversed S-lay or reel-lay without prior de-burial.

5.2.2 Health & Safety Assessment

Safety Risk to Offshore Project Personnel

In principle the assessment for safety risk of personnel offshore for all the above pipelines and cables would be broadly similar.

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

- Risk to personnel on vessel from hazardous substance releases would be greater for complete removal than for leave *in situ*;
- There would be multiple risks associated with cut-&-lift operations for removal of large diameter concrete-coated pipelines in high currents, which are eliminated for the leave *in situ* option;
- There would be a risk associated with the presence of an object on or near the vessel during reverse reeling or reversed S-Lay for the complete removal option but eliminated for the leave *in situ* option;
- There would also be more risk of the pipeline 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.

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, which would potentially 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 cable **PL2718** the vessel durations associated with the complete removal options will be longer than for leave *in situ*; for 24” pipeline **PL194** the differential will be far greater.

Decommissioning activities that minimise 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. Complete removal will leave the seabed free of equipment, while leave *in situ* will present risks like what they are now, except for those areas currently contained within the 500m safety zones at CPP1, DP3, DP4 and DP8. Although the complete removal option has the potential to leave open trenches that could present snagging hazards, these are expected to 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 leave *in situ* should the burial status change, but this would be eliminated for complete removal;
- For the situation where a pipeline is left *in situ*, legacy surveys will be required. Legacy surveys will 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 less time than vessels involved in the complete removal activities, but the difference is not considered significant to this analysis.

Health & Safety Risk to Onshore Project Personnel

The 24” pipelines **PL194** & **PL195** are coated with 60mm thickness of concrete, which must be removed during recycling, with associated risk from materials splitting and handling for disposal; size of pipeline elements for handling carries its own risk. The 2” pipelines **PL204** & **PL205** are coated with less than 1mm thickness of fusion-bonded epoxy (FBE); there may be risk from fumes associated with FBE removal, although handling risks should decrease with the smaller pipe size. Internal contaminants may be present, although large quantities are not anticipated; there will be external contamination from exposure to marine environment.

Both cable types are constructed using a mixture of materials that would need to be separated and segregated onshore for recycling. Apart from the smaller conductors and provision of fibre-optic cores (**PL2718** and **IF07E84**), the principal difference is the use of polypropylene string in the original cables **IF-07E13**, **IF-07E31**, **IF-07E41**, **IF-07E84** (bitumen-slushed in the outer sheath), whereas the later replacement **PL2718**, uses extruded polyethylene.

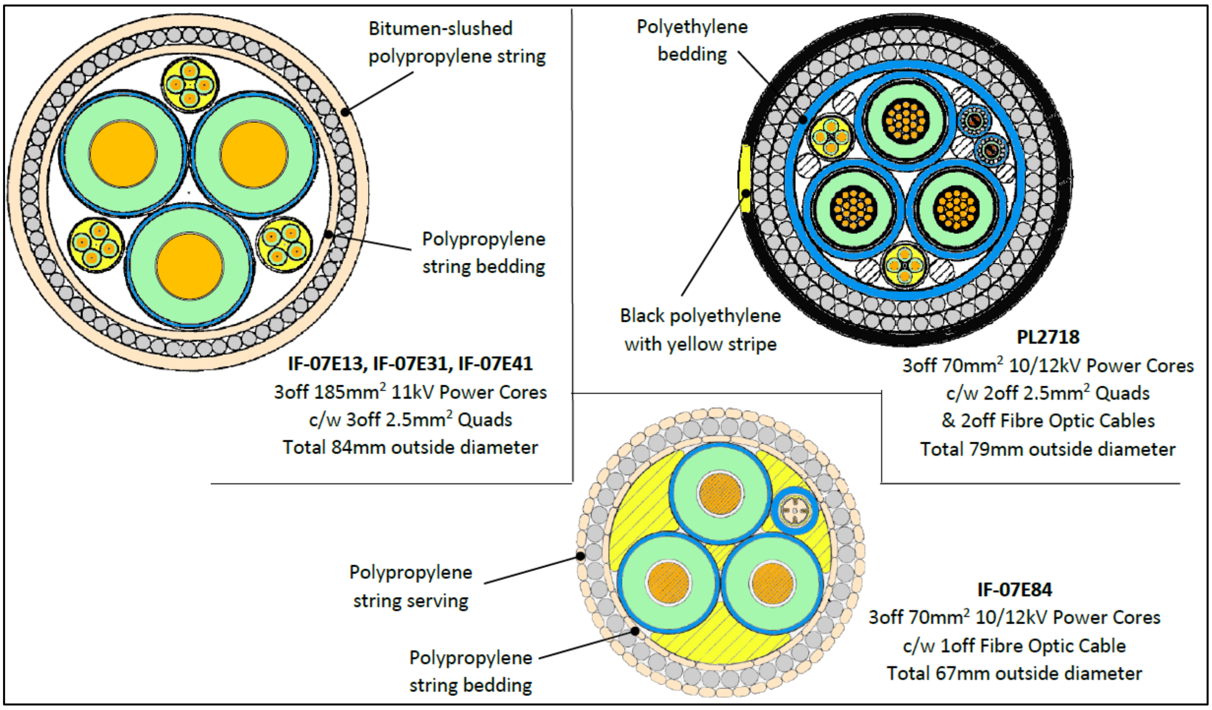

Figure 5.2.1: Construction of original and replacement cables

All hazards associated with the handling of the fully recovered flowlines and cables respectively were assessed as 'low and broadly acceptable' but least preferred. The key differences between the two decommissioning options for each are as follows:

- Risks associated with removal of concrete coating from large diameter steel pipe - resulting in injury - are greater for complete removal due to the quantity of material returned to shore compared with the leave *in situ* option;
- Risks associated with unravelling the flexible cable - resulting in injury - are greater for complete removal due to the quantity of material returned to shore compared with the leave *in situ* option;
- Risks associated with separating the cables into their individual components - resulting in injury, are greater for complete removal due to the 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;
- Exposure to potentially NORM contaminated materials increases with the volume of material recovered;
- Risks associated with dealing onshore with any residues within either the 2" flowlines or the cables would be greater for complete removal.

Summary Tables of our Health & Safety assessments for the pipelines and cables are structured as follows:

- Short term effects of large diameter pipelines **PL194** & **PL195** are summarised in Table 5.2.4;
- Short term effects of small diameter pipelines **PL204** & **PL205** are like those of the cables **IF-07E13**, **IF-07E31**, **IF-07E41**, **IF-07E84** & **PL2718**, with which they are combined in Table 5.2.5;
- Legacy effects are broadly common to all pipelines and cables and are summarised in Table 5.2.6. There are no legacy effects on onshore personnel, so this is not a differentiator.

Sub-Criterion	Option 1 Complete Removal	Option 2 Leave *in situ*
Health & safety risk offshore project personnel	More offshore work and more handling on the vessel than leave *in situ*. Excavation of the pipeline. Little or no experience in the UKCS of cut-&-lift of trenched, buried and concrete coated pipelines. Repetitive nature of relatively uncontrolled lifts (concrete coat possibly falling from pipe). Many similar lifts (c.100 sections) and moving pipe sections around the deck.	Negligible offshore work than complete removal. Significantly shorter than for complete removal. Ends only, little or no work.
Health & safety risk to mariners	Duration of vessels in the field is longer than for leave *in situ*. The removal method means that that the vessel is attached to the pipeline and can't move out of the way quickly. The risk to mariners in the short term is aligned with the duration the activities that are undertaken in the field.	Duration of vessels in the field would be shorter than for complete removal.
Safety risk onshore project personnel	Safety risk is linked to the mass of material returned to shore. There would be significantly more onshore cutting, lifting and handling for complete removal than for leave *in situ*. The handling of concrete coating, CTE and possible NORM adds complexity and increases risk.	No onshore cutting, lifting and handling therefore no safety risk to onshore personnel.
Colour Key:		
Medium / Tolerable & non -preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.4: PL194 & PL195 Health & Safety Assessment – Short Term

Sub-Criterion	Option 1 Complete Removal	Option 2 Leave *in situ*
Health & safety risk offshore project personnel	More offshore work and more onshore handling than for leave *in situ*. Little experience in the UKCS for Spirit Energy of reversed S-lay of trenched and buried pipelines, nor of reverse reeling or 'cut and lift' of trenched and buried cables. Hazards of pipeline snapping on recovery. Material handling. Longer offshore execution phase (indicator for exposure) than leave *in situ*. Reverse S-lay and cut using guillotine on vessel. Place sections into slings and move to storage area. Handling with increased risk with cable under tension. ROV activity, no divers assumed.	Negligible offshore work. Significantly lower than for complete removal. Shorter duration for offshore work than complete removal (less exposure). Experience in the UKCS leaving cables in place.
Health & safety risk to mariners	Duration of vessels in the field is longer than for leave *in situ*. Reverse reeling means that the vessel is attached to the cable and can't move out of the way quickly. The risk to mariners in the short term is aligned with the duration of activities undertaken in the field. Estimated to be less than a day removal activity for each line. The preparation activities are within the 500m zones.	Duration of vessels in the field would be shorter than for complete removal.
Safety risk onshore project personnel	Safety risk is linked to the mass of material returned to shore. There would be significantly more onshore cutting, lifting and handling for complete removal than for leave *in-situ*.	No onshore cutting, lifting and handling therefore no safety risk to onshore personnel.
Colour Key:		
Medium / Tolerable & non -preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.5: PL204, PL205 and Cables Health & Safety Assessment – Short Term

Sub-Criterion	Option 1 Complete Removal	Option 2 Leave *in situ*
Health & safety risk offshore project personnel	One environmental survey (if required). No depth of burial surveys or remediation-related activities	One environmental survey (if required); depth of burial and environmental surveys have been undertaken by Spirit Energy in the past. Assume up to two burial status surveys. May be a requirement for remedial work, or monitoring.
Health & safety risk to mariners	No infrastructure left therefore no residual snag hazards. Lower risk as potential snag hazards completely removed. Any deposited rock size (**PL194** & **PL195** only) should mean that it won't interact with the fishing gear. Likewise we assume that the fishing gear won't interact with the trench formed by cutting and removal operations.	Surveys indicate no pipeline / cable exposures to date other than in the 500m zone close to the ends that are being removed. Installation data show overage loops (**PL2718** only) to be buried to a shallower depth than the remainder of the cable. Future surveys will show that any exposures continue to be limited, with low risk to mariners from snagging. Pipeline / cable degradation only changes the risk where exposures (if any) occur. The seabed is mobile, but the mega-ripples' height is less than depth of burial. Ongoing risk-based inspection.
Safety risk onshore project personnel	Not applicable as no remedial activities planned.	Not applicable as no remedial activities planned. May require monitoring.
Colour Key:		
Medium / Tolerable & non -preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.6: Pipelines & Cables Health & Safety Assessment – Legacy

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 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 flowlines and cables in the UKCS, 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 by pipeline is removed in perpetuity – this assumes that the trench so-formed does not constitute a hazard, which is considered unlikely in the mobile seabed. Therefore, the complete removal option results in lower residual risks to mariners and other users of the sea.

Fundamentally, we believe that there is little to choose between the options from a safety perspective for the small diameter lines and cables, whether in the short or longer term. However, the scale of operations to remove the large diameter **PL194** & **PL195**, and their historic stability, increases the safety preference for leave *in situ*.

5.2.3 Environmental impact of operational activities

The environmental impact of operational activities is primarily a function of vessel duration in the field, and largely independent of pipeline or cable type. Seabed disturbances may be greater when removing the larger pipelines (e.g. 24” compared with 2”), but in the wider context of the seabed, this is not a significant differentiator, so the various pipelines and cables are compared in a common assessment.

The duration vessels for complete removal of either pipeline would be longer than for 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 5.2.7.

Sub-Criterion	Option 1 Complete removal	Option 2 Leave *in situ*
Atmosphere (energy & emissions)	Emissions and use of energy are greatest for this option, and 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 lowest 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	The amount of seabed disturbed is directly related to the length of pipeline being removed. The area affected would be largest for this option.	The smallest area of seabed would be disturbed with this option.
Water column disturbance: • liquid discharges or releases to sea • liquid discharges or releases 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 releases would be least for this option, particularly in the short-term.
Disturbance to protected areas	Disturbance to the Special Protection Area is related to the duration of activities being undertaken and the potential for releases and will therefore be greatest for the complete removal.	Disturbance to the Special Protection Area is related to the duration of activities being undertaken and the potential for releases and will therefore be least for the leave *in situ*.
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.*	No material would be returned to shore for recycling and therefore the material would be lost. New manufactured material would be needed to replace the lost material.

Colour Key:		
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.7: Pipelines & Cables Environmental Impacts – Short Term

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 the various pipelines and cables remain 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 5.2.8.

Operational Environmental factors impacted	Option 1 Complete removal	Option 2 Leave *in situ*
Atmosphere (energy & emissions)	No pipeline burial surveys required.	Assume pipeline burial surveys required.
Seabed disturbance; area affected	No work required in future.	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities (if any) would be minimal.
Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	No work would be required in future.	Assume pipeline burial surveys required.
Disturbance to protected areas	No work would be required in future.	Assume pipeline burial surveys required.
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 for the past 35 years have indicated that the pipelines and cables would remain 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 & most preferred

Table 5.2.8: Pipelines & Cables Environmental Impacts – Legacy

5.2.5 Summary of environmental assessment

The environmental assessment for both the pipelines and cables was split into short-term operational impacts and longer-term legacy impacts due to related activities on the seabed.

In the short-term, and from an operational perspective, leave *in situ* would be the favoured option while complete removal would result in no legacy activities being required. All impacts for both options for both pipelines were assessed as broadly acceptable.

In the short-term, the leave *in situ* decommissioning option was considered to cause the least disruption to the seabed and has the least risk of accidental release to sea so would be the most preferred. Over the longer-term the leave *in situ* option would be preferred.

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

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.

5.2.6 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 are discussed below. These are applicable for all pipelines and cables.

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 is being considered, the complete removal option will incur longer vessel activities. Conversely, the leave *in situ* option would require the least vessel activity.

Activities which involve removal or 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 the leave *in situ* option. 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. 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 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 each pipeline remains stable and poses 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 we have assumed up to two pipeline surveys 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; however, survey durations will less than those of removal activities, and more compliant in that the small survey vessels will be better able to work around fishing activities.

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, at which times fishing vessels would be excluded from the area outside the 500m zone; however, we believe that when compared to the wider area this would have a relatively small effect, so there is little to differentiate between the options. Aggregate extraction is north of the area where decommissioning activities would be undertaken. Shipping will be notified and continue alternative routing. There could be an effect on other users of the ports and 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 that 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 the pipelines and cables are presented in Table 5.2.9. 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 Leave *in situ*
Commercial activities	**Short-term:** Impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal.	**Short-term:** Impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for leave *in situ*.
	Legacy: An environmental survey would be required but this is the same for all options. No subsequent pipeline surveys would be required.	**Legacy:** Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option.
Employment	**Short-term:** Decommissioning activities would contribute greatest to continuity of employment for complete removal.	**Short-term:** Decommissioning activities would contribute the least to continuity of employment for leave *in situ.*
	Legacy: Once the pipelines and cables had been completely removed, the opportunity for continuation of employment would be minimal after completion of the environmental survey.	**Legacy:** Should the pipelines and cables 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 left *in situ*.
Communities	**Short-term:** Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal.	**Short-term:** Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ.*
	Legacy: Once the pipelines and cables had been removed there would be few opportunities for continuity of work in ports and disposal sites.	**Legacy:** Once the pipelines and cables had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than those associated with survey-related and possible remedial work.
Colour Key:		
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.9: Pipelines & Cables Societal Assessment

Summary of societal assessment

We use vessel durations as an indicator of magnitude of the *continuation* rather than creation of 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 result in more disruption to commercial activities.

Legacy-related disruption on commercial activities in the area would be greatest for leave *in situ.* 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. Conversely, the leave *in situ* would require legacy activities to be carried out at least for the foreseeable future.

Employment opportunities would be greatest during 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.

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

5.2.7 Cost Assessment

Detailed cost estimates have not been prepared, but a cost analysis based on vessel type and duration has been prepared. The estimates also include an allowance for project management costs as well as for dealing with any material once it has been recovered to shore. To enable a comparison the leave *in situ* option assumes a maximum of two pipeline or cable surveys as part of liability commitments. The costs for each pipeline and cable are compared on a case by case basis, with no allowance for synergistic opportunities – for example, combined mobilisation, and demobilisation costs.

Costs for complete removal and leave *in situ* options are listed in Table B.1 Appendix B.1(for DP3 lines) and Table B.2 (DP4 lines) below. The leave *in situ* costs are primarily for removing the pipeline ends and allow for two future liability inspections. The costs presented do NOT include the costs for removing stabilisation features since this is a common requirement for both options. In all instances the most cost-effective method of removal would be using 'cut and lift'.

The costs associated with completely removing **PL194** & **PL195** are estimated at more than 10-times that of leave *in situ*, and therefore categorised as medium or tolerable and non-preferred. The costs of completely removing the two 200m lengths of bitumen mattresses are not included but would increase the difference in cost.

Complete removal of **PL204** & **PL205** as well as the small **fibre-optic** and **electrical cables** the cost multiplier is less than 2-times and is therefore categorised as low or broadly acceptable and least preferred.

To summarise, the difference in short-term costs for **PL194** & **PL195** complete removal in Table 5.2.10 is classed as intolerable and non-preferred, whereas for the small lines **PL204** & **PL205** etc in Table 5.2.11 it is categorised as low and broadly acceptable but least preferred. Therefore, from a cost perspective in all cases the conclusion is that 'leave *in situ*' option would be the preferred option.

Criterion	**Option 1** **Complete removal**	**Option 2** **Leave *in situ***
Cost	**Short-term:** The cost of complete removal would be over 10-times higher than for the leave *in situ* option.	**Short-term:** Leave *in situ* would be the less expensive of the two options.
	Legacy: Once the pipelines and cables had been completely removed, there would be no pipeline burial surveys over the longer-term.	**Legacy:** Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipelines and cables remain stable, no more surveys would be required.

Colour Key:			
High / Intolerable & non-preferred	Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.10: PL194 & PL195 Cost Assessment

Criterion	**Option 1** **Complete removal**	**Option 2** **Leave *in situ***
Cost	**Short-term:** The cost of complete removal would be less than 10-times higher than for the leave *in situ* option.	**Short-term:** Leave *in situ* would be the less expensive of the two options.
	Legacy: Once the pipelines and cables had been completely removed, there would be no pipeline burial surveys over the longer-term.	**Legacy:** Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipelines and cables remain stable, no more surveys would be required.

Colour Key:			
High / Intolerable & non-preferred	Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.11: PL204, PL205 & Cables Cost Assessment

5.3 Overall Summary of Assessment

The results of the assessment are summarised in Table 5.3.1.

Overall, for all the pipelines and cables 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.

For **PL194** and **PL195** There is much to differentiate the completely remove and leave *in situ* decommissioning options from a technical, safety and cost perspective.

Both pipelines are buried and stable, with latest survey data indicating that no spans are present, posing no hazard to marine users. Minimal seabed disturbance, lower energy usage, reduced risk to personnel engaged in the activity.

For **PL204**, **PL205** and the various **cables**, apart from cost there is little to differentiate the completely remove and leave *in situ* decommissioning options.

The pipelines and cables are buried and stable, with latest survey data indicating that no spans are present, posing no hazard to marine users. Minimal seabed disturbance, lower energy usage, reduced risk to personnel engaged in the activity.

Aspect	**Sub-criterion**	**Short-term or Legacy?**	**Option 1 Complete removal**		**Option 2 Leave *in situ***	
			PL194 & PL195	**Small Lines & Cables**	**PL194 & PL195**	**Small Lines & Cables**
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				
		Legacy				
Environmental	Atmosphere (energy & emissions)	Short-term				
		Legacy				
	Seabed disturbance area affected	Short-term				
		Legacy				
	Water column disturbance	Short-term				
		Legacy				
	Disturbance to protected areas	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				

Colour Key:

High / Intolerable & non-preferred	Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.3.1: Summary of Comparative Assessment

6. CONCLUSIONS

Comparative assessment was undertaken with a focus on the decommissioning options for the DP3 & DP4 pipelines and cables. These are part of the wider Morecambe Bay infrastructure in the East Irish Sea. Acoustic survey data indicates that none of the pipelines or cables have experienced spans or exposures in open water, with some minor excursions on the platform approaches but these sections of the pipelines and cables will be removed.

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 (two sub-criteria), Technical feasibility, Societal effects (three sub-criteria), and Cost.

The results summarised in Table 5.3.1 replicate the colour-coding as developed in Section 5.2. General trends include the following:

- Leave *in situ* is preferred, although complete removal improves legacy aspects;
- There is no significant legacy difference between the options in terms of seabed disturbance and waste creation;
- Safety risks during removal are greater for the large diameter **PL194** & **PL195** than for the small diameter **PL204** & **PL205** and the cables;
- The complete removal vs. leave *in situ* decision for the small diameter **PL204** & **PL205** and **Cables** is balanced, with cost being the ultimate differentiator.

The assessment results in a strong preference for leaving the large diameter **PL194** & **PL195** pipelines *in situ*; whereas for the small diameter **PL204** & **PL205** and **Cables**, the situation is more finally balanced, with no obvious preference between complete removal and leave *in situ*.

6.1 Conclusion for PL194 & PL195

Two large diameter pipelines have been assessed: **PL194** is a 24" concrete-coated pipeline 3.67km long between risers, trenched and buried, with deposited rock over bitumen mattresses for about 200m at each end. **PL195** is similar, but 3.46km long between risers.

Significant differentiators were found in technical uncertainty, short-term safety of project personnel during recovery operations and dealing with the pipeline as it is transferred to shore and finally dealt with. For complete removal these elements were considered 'medium - tolerable and non-preferred'. For mariners, complete removal of the pipelines would remove potential snag hazards in perpetuity, but as the pipelines have already been in place for over 35 years with no evidence of exposures, we believe there is little to differentiate the long-term snagging risk to mariners. From an environmental perspective, no aspect of the assessment features prominently. The technical and short-term safety elements were compounded by the difference in cost, with the complete removal option being an order of magnitude higher that leave *in situ*, hence categorised as medium or tolerable and non-preferred.

6.2 Conclusion for PL204 & PL205

Two small diameter pipelines have been assessed: **PL204** is a 2" FBE-coated pipeline 3.58km long between J-tube ends, trenched and buried. **PL205** is similar, but 3.57km long between J-tube ends. Unlike conventional pipelines, these are not connected to risers in the traditional sense, but they pass directly through the J-tubes to topsides.

No significant differentiators were found in any of the categories being assessed. Small differences are found for the safety assessments, 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 leave *in situ* because the pipeline(s) would no longer be present as a potential snag hazard. We note however, that the pipelines have already been in place for over 35 years with no evidence of exposures, so we believe there is little to differentiate the short- and long-term snagging risk to mariners. Our assessment concludes that even with the pipeline(s) remaining *in situ* the snagging risk posed to fishermen and other users of the sea would remain low on the basis that the pipeline would remain buried.

We believe that there is little to differentiate the costs. The pipeline ends would be removed for either option. The complete removal option would avoid the need to cut the pipeline ends at transition depth and would allow each pipeline to be removed in a continuous process. The cost assessment for the two small pipelines concludes that the leave *in situ* would be the preferred option, but the difference in cost is less than an order of magnitude.

6.3 Conclusion for the cables

Five cables of about 3” diameter have been assessed: **IF-07E13** (3.91km), **IF-07E31** (3.56km), **IF-07E41** (3.75km), **IF-07E84** (5.01km) and **PL2718** (3.88km), trenched and buried; all quoted lengths are between J-tube ends, except for **IF-07E31** whose ends have been removed.

No significant differentiators were found in any of the categories being assessed. Small differences are found for the safety assessments, 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 leave *in situ* because the pipeline(s) would no longer be present as a potential snag hazard. We note however, that the pipelines have already been in place for over 35 years with no evidence of exposures, so we believe there is little to differentiate the short- and long-term snagging risk to mariners. Our assessment concludes that even with the pipeline(s) remaining *in situ* the snagging risk posed to fishermen and other users of the sea would remain low on the basis that the pipeline would remain buried.

We believe that there is little to differentiate the costs. The cable ends would be removed for either option. The complete removal option would avoid the need to cut the cable ends (except **IF-07E31**) at transition depth and would allow each cable to be removed in a continuous process. The cost assessment for the small cables concludes that the leave *in situ* would be the preferred option, but the difference in cost is less than an order of magnitude.

7. REFERENCES

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APPENDIX A CABLE CONSTRUCTION

Appendix A.1 Cable Construction IF-07E13, IF-07E31, IF-07E41

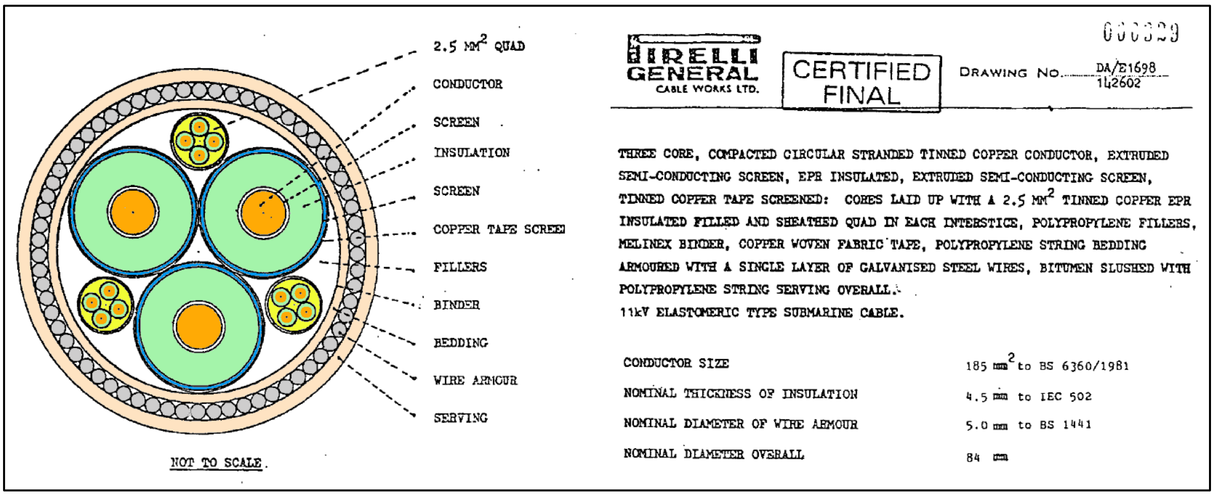


Figure A.1: Cable Construction IF-07E13, IF-07E31, IF-07E41

Appendix A.2 Cable Construction IF-07E84

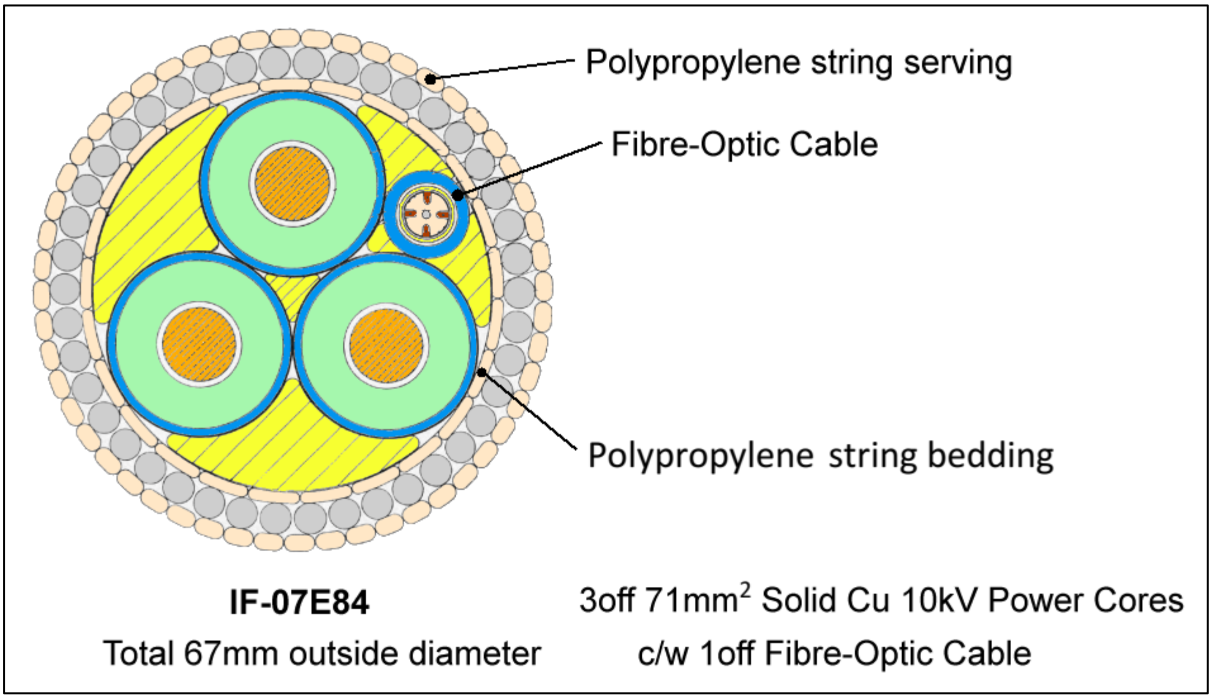
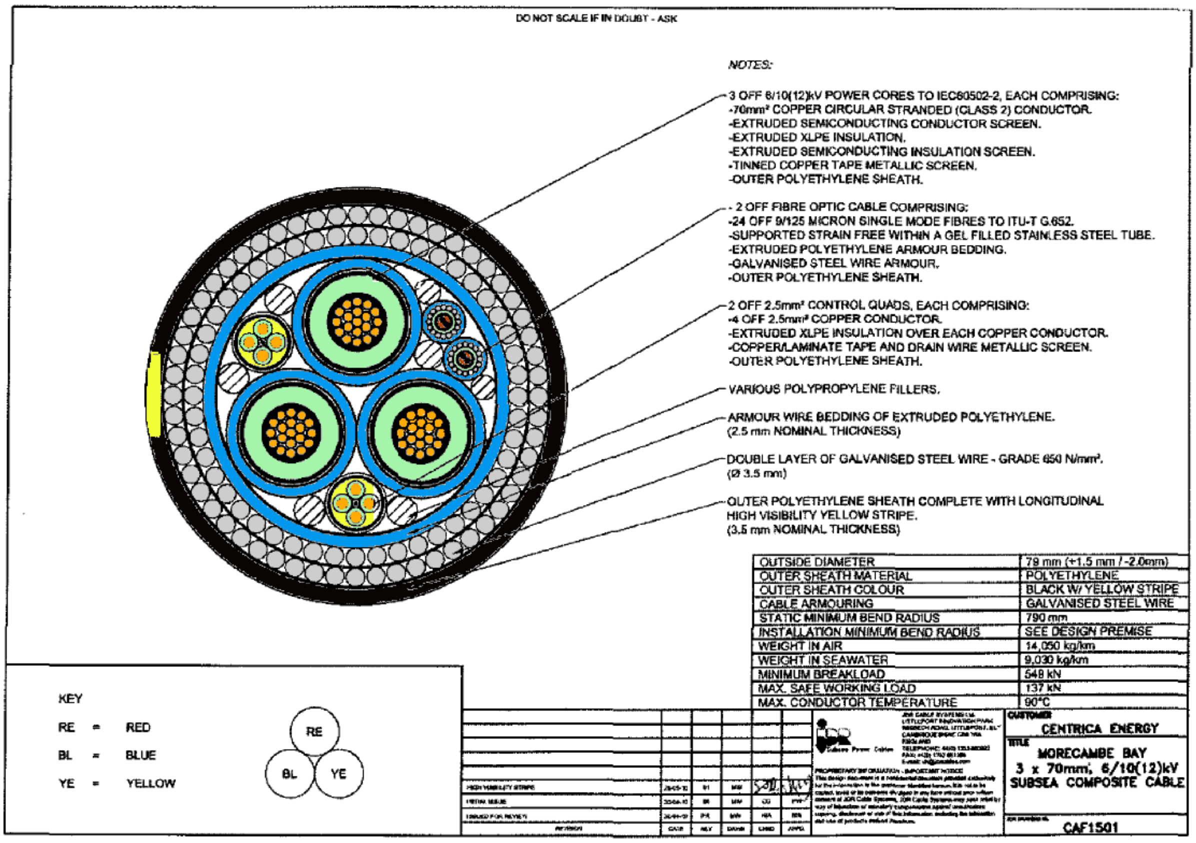


Figure A.2: Cable Construction IF-07E84

Appendix A.3 Cable Construction PL2718



Commercially in Confidence

Figure A.3: Cable Construction PL2718

APPENDIX B COST AS A DIFFERENTIATOR

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

The assessment was carried out in accordance with the Spirit Energy Comparative Assessment Guidance. Health and Safety criteria were assessed with the HSEQ Risk Matrix, environmental and societal criteria were assessed with the Environmental Impact table and the technical criteria were assessed with the Project Risk Assessment Matrix. The colour coding is as follows:

High / Intolerable & non-preferred (>100-times)	Medium / Tolerable & non-preferred (>10-times)	Low / Broadly Acceptable & least preferred (<10-times)	Low / Broadly Acceptable & most preferred (Normalised 1)

Costs for complete removal and leave *in situ* options are listed in Table B.1 Appendix B.1(for DP3 lines) and Table B.2 (DP4 lines) below. The leave *in situ* costs are primarily for removing the pipeline ends and allow for two future liability inspections. The costs presented do NOT include the costs for removing stabilisation features since this is a common requirement for both options. In all instances the most cost-effective method of removal would be using 'cut and lift'.

The costs associated with completely removing **PL194** & **PL195** are estimated at more than 10-times that of leave *in situ*, and therefore categorised as medium or tolerable and non-preferred. The costs of completely removing the 200m lengths of rock covered bitumen mattresses are not included but would increase the difference in cost.

Complete removal of **PL204** & **PL205** as well as the small **fibre-optic** and **electrical cables** the cost multiplier is less than 2-times and is therefore categorised as low or broadly acceptable and least preferred.

Appendix B.1 DP3 Lines - High-Level cost comparison by difference

DP3 Line ID	Complete Removal (£M)	Leave *In Situ* (£M)
PL195 24" concrete coated pipeline	£19.14	£1.00
Sub-total Normalised	**5.0**	**0.3**
PL205 2" pipeline	£0.99	£0.80
Sub-total Normalised	**5.0**	**4.0**
IF-07E13 84mm dia. Electric cable	£1.11	£0.77
Sub-total Normalised	**5.0**	**3.5**
IF-07E31 84mm dia. Electric cable	£1.10	£0.20
Sub-total Normalised	**5.0**	**0.9**
PL2718 79mm dia. Electric & Fibre-optic cable	£1.80	£0.92
Sub-total Normalised	**5.0**	**2.6**

Table B.1: DP3 Lines - Decommissioning options costs by difference

Appendix B.2 DP4 Lines - High-Level cost comparison by difference

DP4 Line ID	Complete Removal (£M)	Leave *In Situ* (£M)
PL194 24" concrete coated pipeline	£17.29	£0.86
Sub-total Normalised	**5.0**	**0.2**
PL204 Costs	£0.92	£0.86
Sub-total Normalised	**5.0**	**4.7**
IF-07E41 Costs	£1.08	£0.84
Sub-total Normalised	**5.0**	**3.9**
IF-07E84 Costs	£1.21	£0.81
Sub-total Normalised	**5.0**	**3.3**

Table B.2: DP4 Lines - Decommissioning options costs by difference