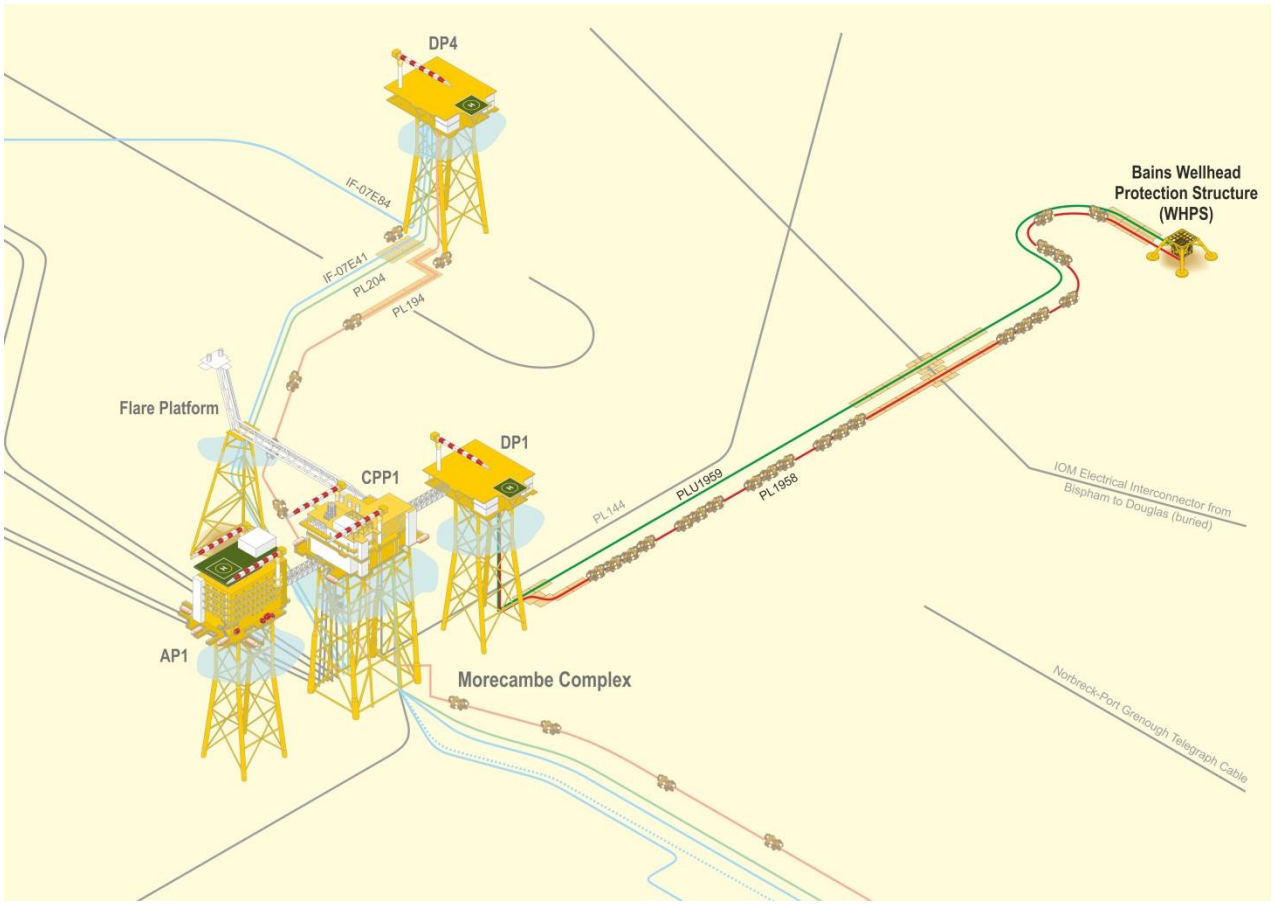
Bains Decommissioning
Comparative Assessment



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 Bains development lies in the East Irish Sea, approximately 27km west of the English coastal town of Blackpool, west coast of Lancashire and about 70km north of the town of Rhyl on the North Wales coast.

Bains

The export route for Bains is **PL1958**. This is an 8" flexible flowline routed to DP1 platform which is part of the Morecambe platform complex. Power, controls and chemicals are supplied from the DP1 platform using umbilical **PLU1959**. Both **PL1958** and **PLU1959** are 8.3km long. Both these pipelines were originally trenched and remain extensively buried under the seabed. PL1958 is also protected and stabilised to prevent upheaval buckling using deposited rock inside the trench.

There are several fronded mattresses installed over the pipelines on the approach to DP1, at the Bispham to IOM Electrical Interconnector crossing and on the approach to Bains. There are also four concrete mattresses (i.e. not fronded) at the Bispham to IOM Electrical Interconnector crossing but these are overlain with fronded concrete mattresses.

The fronded mattresses on the approach to DP1 and at the Electrical Interconnector crossing are buried. We believe that the presence of the Bains wellhead protection structure has led to local scouring of the seabed and this has the potential to leave part or all of the fronded mattress edges to be exposed.

Pipeline decommissioning options

This document summarises a comparative assessment of the preferred options for decommissioning Bains pipeline numbers **PL1958** and **PLU1959.**

Two decommissioning options are considered for the pipelines:

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

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

Fronded mattress decommissioning options

Two decommissioning options were considered for the fronded mattresses:

- Complete removal;
- Leave *in situ.*

Comparative assessment

The options were assessed using the OPRED Decommissioning Guidance Notes and Spirit Energy's Comparative Assessment guidelines for the Bains 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 **PL1958** and **PLU1959** would be 'tolerable' rather than 'broadly acceptable'. This is primarily due to there being limited experience in removing trenched and buried flexible pipelines and umbilical pipelines [1], especially those that are buried under rock (e.g. **PL1958**, intermittently) for a substantial proportion of their length.

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

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

Finally, the leave *in situ* option would cost less to adopt in the short-term than complete removal, but not an order of magnitude less, so we do not consider cost as a significant driver for the decommissioning proposals offered.

Mattress decommissioning assessment

The results of the assessment showed that as the fronded mattresses on the DP1 approaches and the Bispham to IOM Electrical Interconnector are buried it would be appropriate to leave them *in situ*.

However, there is historical evidence that the seabed in the vicinity of Bains has experienced scour. The scour may cause the edge of a fronded mattress to become exposed, in which case in order to minimise the potential snagging hazards we would propose to attempt recovery of the mattress and underlying pipeline followed by an overtrawl. Visibility in the area is poor, however, so in the event that we are unable to verify whether the edge of a fronded mattress is exposed we would propose to implement contingency measures that would involve the deposition of rock next to the exposed edges.

Summary of decommissioning proposals

As a result of the comparative assessment we propose to leave both **PL1958** and **PLU1959** and the associated fronded mattress protection at the DP1 end and at the Bispham/Isle of Man Electrical Interconnector crossing *in situ*. Depending on the extent of scour, attempts will be made to recover fronded mattresses on the approach to Bains, but in the event that visibility is poor or recovery is not possible, rock may be deposited locally, but this will be preceded by an overtrawl to establish if this is necessary.

On the approaches buried pipelines will be cut below the seabed at trench depth approximately 600mm below mudline, and due to the presence of fronded mattresses on the pipeline approaches only the exposed sections will be removed. The intention is that all the pipeline ramp and protection materials such as gabion sacks and grout bags will be removed.

Decommissioning of the different pipeline components is summarised below.

PL1958, 8” flexible flowline 8.3km long	Complete Removal	Leave *in situ*
Any short exposed end sections of the 8” flexible flowline within the J Tube at DP1 will be removed along with the DP1 platform; total length approx. 59m. (Table 4.1.1 ID 1).	●	
8” flexible flowline, including ends buried under fronded mattresses over Bispham to IOM Electrical Interconnector crossing and at each end of the flexible flowline; total length approx. 8.189km[1]. (Table 4.1.1 ID 2, 3 & 4).		●
Short exposed end of the rigid pipespool connected to the Bains end of the 8” flexible flowline will be cut and completely removed (c.6m). If the overlying fronded mattresses can be recovered, the additional exposed length of flowline (max. c.54m) will also be recovered. Total length = c.60m (Table 4.1.1 ID 5 & 6).	●	
PLU1959, 101mm diameter umbilical pipeline, 8.3km long	**Complete Removal**	**Leave *in situ***
Any short exposed end sections of the umbilical on the seabed on approach to DP1 and within the J Tube up to the Topsides Umbilical Termination Unit will be removed along with the DP1 platform; total length approx. 59m. (Table 4.1.2 ID 1).	●	
Umbilical including ends buried under fronded mattresses over Bispham to IOM Electrical Interconnector crossing and at each end of the umbilical; total length approx. 8.215m[1]. (Table 4.1.2 ID 2, 3 & 4).		●
Short exposed end sections of the umbilical connected to the Subsea Umbilical Termination Unit at Bains end will be cut and completely removed; total length approx. 61m. If the overlying fronded mattresses are recovered, the additional exposed length of umbilical (max. c.55m) will also be recovered. (Table 4.1.2 ID 5 & 6).	●	

[1] Excludes max c.55m of flexible flowline or max c.54m of umbilical underlying fronded mattresses at Bains that may be recovered.

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FIGURES AND TABLES

TERMS AND ABBREVIATIONS

ABBREVIATION	DESCRIPTION	ABBREVIATION	DESCRIPTION
ALARP	As Low As Reasonably Practicable	MM	Million
Approach	Initial or final stretch of pipeline (or umbilical) as it leaves its point of origin or reaches its destination	nb	Nominal Bore
CO_2	Carbon Dioxide	N/A	(Data) Not Available
CSV	Construction Support Vessel	NORM	Naturally Occurring Radioactive Material
c/w	…complete with.	OGUK	Oil & Gas UK.
°	Degree	OPRED	Offshore Petroleum Regulator for Environment & Decommissioning
DOB	Depth of burial. The depth between the blue line (DOC) and maroon line (DOL) on the burial profiles	Pipeline(s)	Pipeline, flexible flowline or umbilical as defined by OPRED. Includes PL1958, and PLU1959, etc.
DOC	The blue line on the burial profiles shows the profile of cover. The area between the blue line (DOB) and maroon line (DOL) shows the backfill	Pipespool(s)	Short sections of pipe that are typically flanged and bolted together
DOL	Pipeline trench profile; depth of lowering (to top of pipe)	pPSA	Proposed Special Protection Area.
DSV	Dive Support Vessel.	Qualitative	Result determined using judgement and use of risk and impact matrices
Exposure	A pipeline can be seen on the surface of the seabed but is not free-spanning	Quantitative	Result determined using numerical data and by calculation
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)	ROV	Remotely Operated Vehicle
Flexible Flowline	Non-rigid pipeline constructed using a variety of materials	Scour	Local erosion of a sedimentary seabed, usually cumulative
HAZID	Hazard Identification Workshop	SENSL	Spirit Energy North Sea Limited
HSE	Health, Safety, Environment	Spirit Energy	Spirit Energy Production UK Limited, wholly owned subsidiary of Spirit Energy Limited. In November 2017 Centrica Exploration and Production and Bayerngas formed a Joint Venture called Spirit Energy.
ID	Identity (as in tabulated feature)	SPA	Special Protection Area
in (“)	Inch (25.4mm)	Suction piles	One of four foundation piles that anchor the Bains WHPS to the seabed
IOM (EI)	Isle of Man (Electrical Interconnector)	Te	Tonne(s)
km, m	Kilometre(s), Metre(s)	TUTU	Topsides Umbilical Termination Unit
KP	Kilometre Post, measured from place of origin	UK	United Kingdom
LAT	Lowest Astronomical Tide	UKCS	United Kingdom Continental Shelf
MBES	Multi-Beam Echo Sounder. A type of sonar that can be used to map the seabed	WHPS	Wellhead Protection Structure

ABBREVIATION	DESCRIPTION	ABBREVIATION	DESCRIPTION
Broadly Acceptable / Low[2] & 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	Tolerable / Medium[2]	Risks are tolerable and managed to ALARP. Controls and measures to reduce risks to ALARP require identification, documentation and approval by responsible leader
Broadly Acceptable / Low[2] & most preferred	As above but performance in other 'broadly acceptable' options is marginally worse	Intolerable / High[2]	Impacts are intolerable. Controls and measures to reduce impact to ALARP (at least to Medium) and require identification, documentation, implementation and approval.

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

2. INTRODUCTION

2.1 Overview

The Bains field is a single subsea well tied back to the DP1 platform within the Morecambe Complex. The Bains field started production in November 2002. Production ceased December 2009.

Figure 2.1.1 illustrates the field layout and infrastructure.

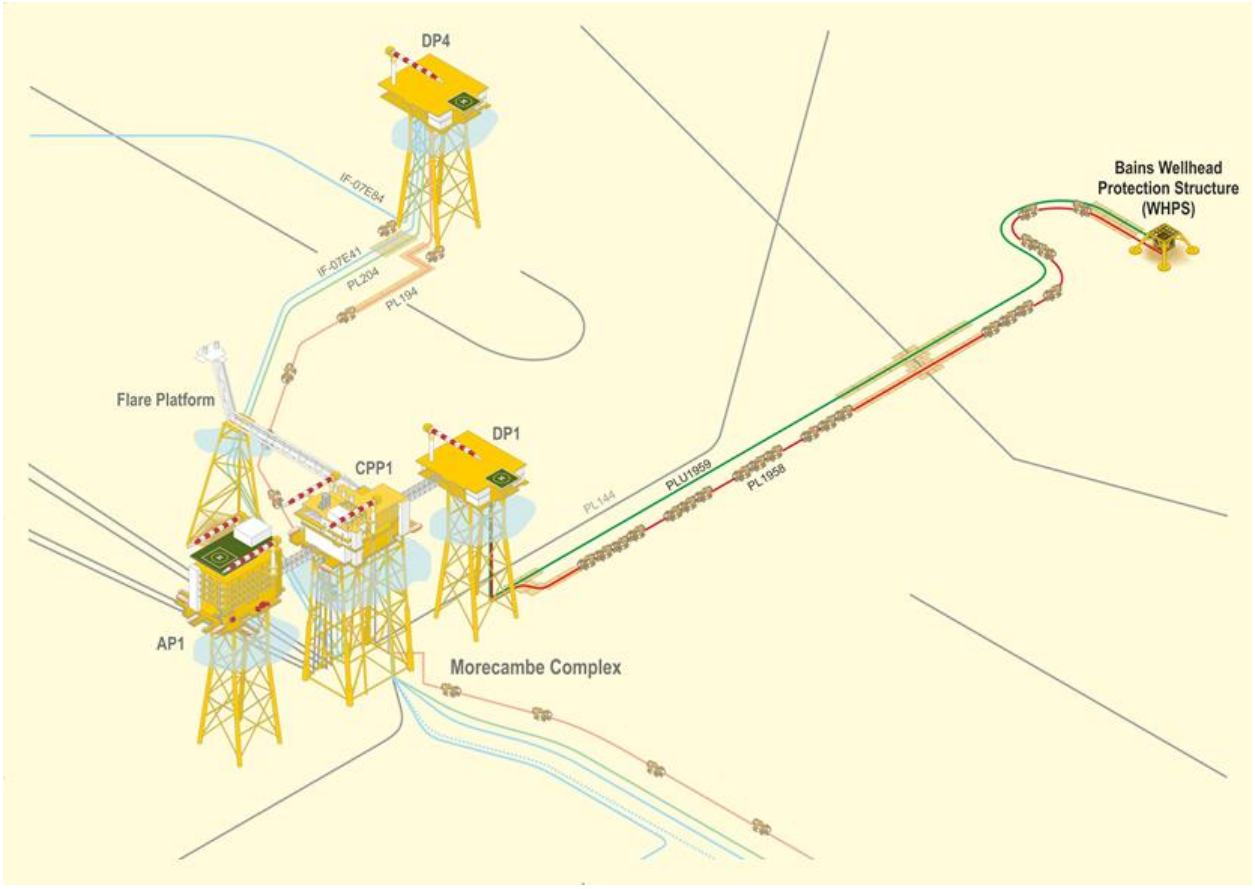


Figure 2.1.1: Bains Infrastructure Schematic

2.1.1 Combined infrastructure

PL1958 is the 8" gas and condensate flowline from Bains to DP1 platform at the Morecambe complex. **PLU1959** is an umbilical that provides electrical power and chemicals to Bains from the DP1 platform.

The infrastructure components of Bains are:

Pipeline ID	Description, Size & Quantity
PL1958	8" gas and condensate flexible flowline, 8.309km long
PLU1959	101mm diameter umbilical pipeline, 8.335km long
	For details of pipeline stabilisation features please refer Decommissioning Programmes [5]

Table 2.1.1: The Bains pipeline components[3]

[3] Refer section 4.2 and Appendix A for more details of stabilisation features.

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 Bains 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

The depth of seabed along the pipelines generally increases from 18m at Bains to 27m below LAT at DP1 Platform. The greatest water depth can be observed within a seabed depression of scour 55m to the north-east of DP1 platform centre. The shallowest water depths occur 30m west-north-west of the Bains well. Seabed gradients of up to 20° can be observed within a seabed depression associated with scour that surrounds the Bains well.

Over the last few years there have been signs of slight erosion along the length of the pipelines.

Other relevant environmental data related to the area are provided in the environmental appraisal [6].

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.

2.3.1 The seabed in relation to the pipelines

Much of the route lies within areas of flat and featureless seabed.

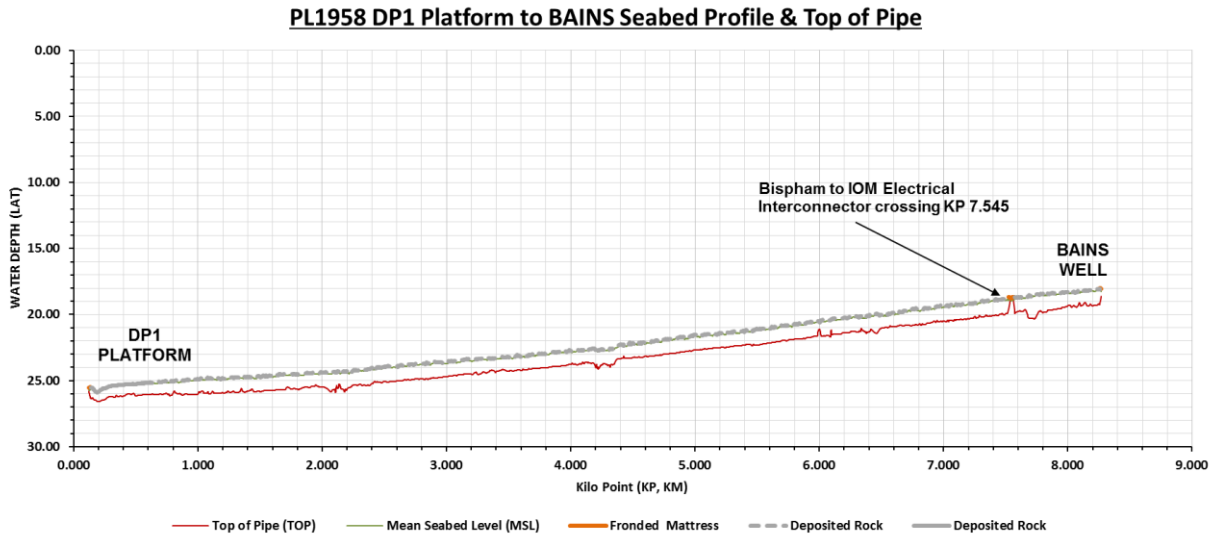


Figure 2.3.1: As-built (2002) seabed profile for PL1958[4]

[4] Not all subsequent surveys of the Bains pipelines have adopted the same KP (kilometre post) sequences. For the purposes of this document the flowline and umbilical KPs are both numbered from DP1 (as-built notation 2002); KP0.0 is at the topsides tie-in, the subsea pipeline sections emerging from the J Tube start at KP0.059. The Bains WHPS is at KPs 8.309 and 8.335 for PL1958 & PLU1959 respectively (see also Table 2.1.1).

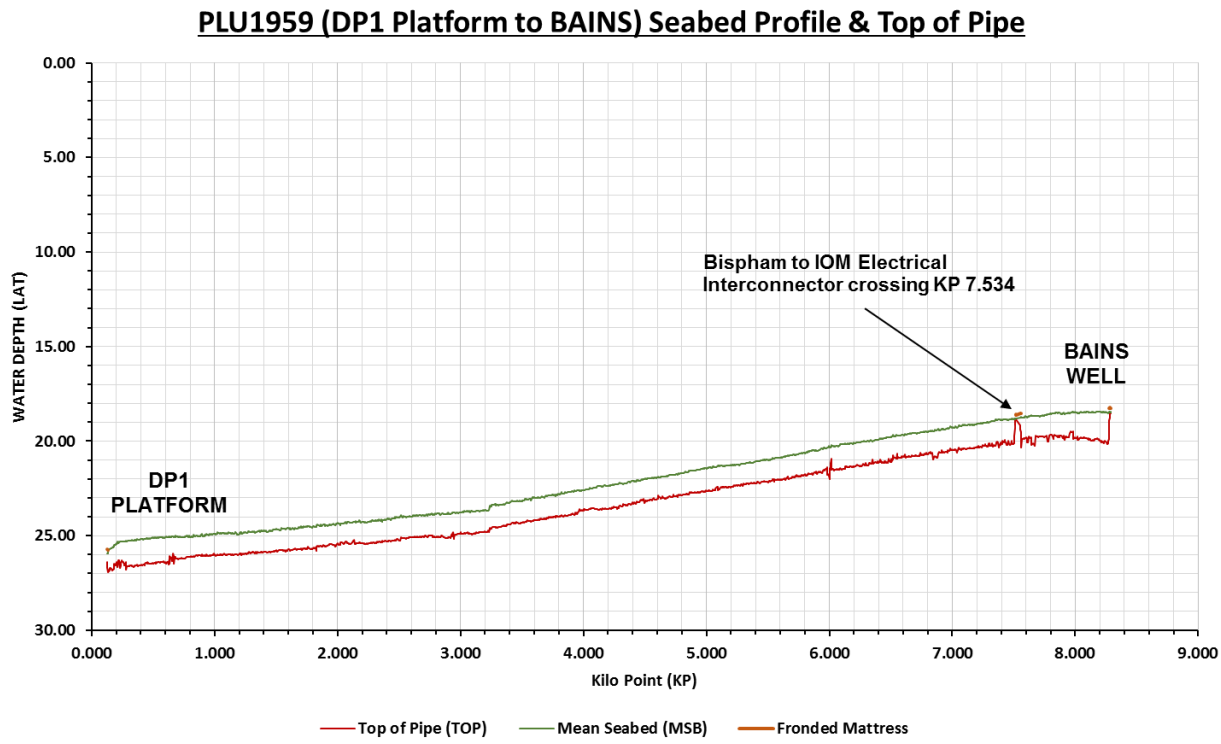


Figure 2.3.2: As-built (2002) seabed profile for PLU1959[5]

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

2.4 Assumptions, Limitations and Gaps in Knowledge

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

[5] Much of the umbilical was 'out of range' of detection which means that depth of cover is at least 0.8m.

- A purely qualitative approach has been taken. This has necessarily required a degree of judgement, but since most impacts are related to area impacted, duration of works and vessel time we felt this was appropriate;
- Unless noted otherwise, complete removal of the pipelines would be achieved by reverse reeling. However, we recognise that there is limited experience of reverse reeling trenched and buried pipelines from the seabed [1], so estimations of the safety risks, technical challenges and cost implications carry some uncertainty;
- The 'complete removal' option assumes that pipelines underneath any pipeline crossing would not be disturbed;
- There are no known exposures on either pipeline outside of the 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);
- 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 PL1958 Bains to DP1 flexible flowline

PL1958 is an 8" flexible flowline that is approximately 8.3km long and routed from the Bains 110/3c-5 subsea tie-back connected to DP1. It lies in a separate trench to **PLU1959**. At DP1 59m of the flexible flowline is contained within the platform's J Tube and topsides.

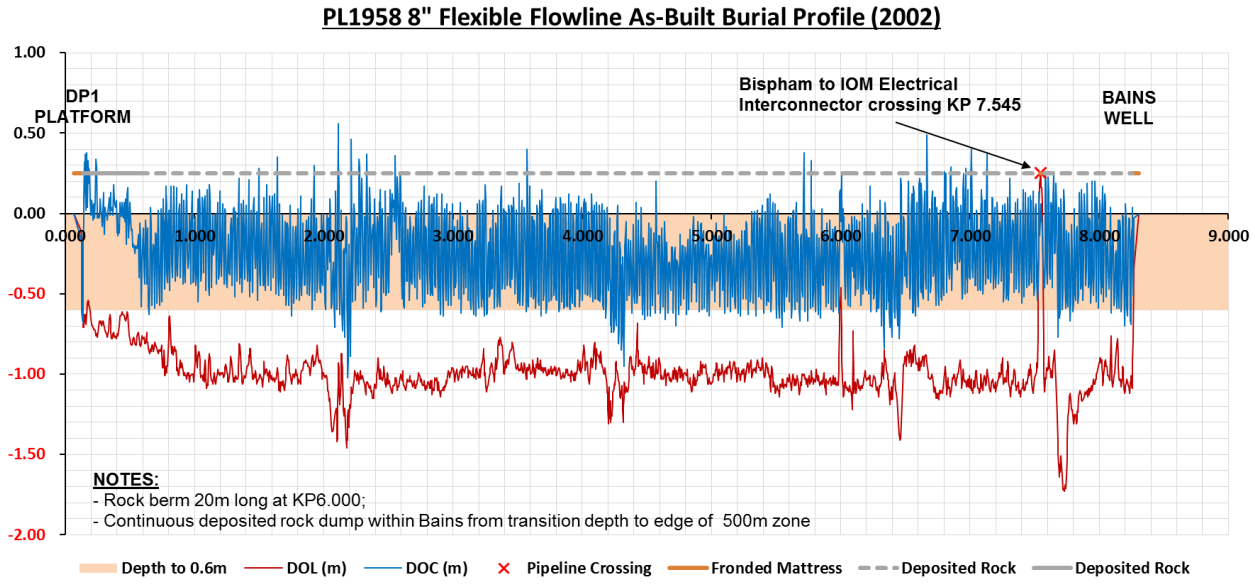


Figure 3.1.1: As-built burial of PL1958 (Bains flexible flowline)[4]

The profile shown in Figure 3.1.1 indicates that the flexible flowline exhibits a somewhat erratic burial profile. The flexible flowline is well buried, with burial being approximately 1.0m deep for most of its length. Further, according to as-built data, 10,294Te of rock was deposited in 7m lengths at approximate 20m intervals along the whole length of the flowline. No free spans, exposures or damage to the flowline have been found in surveys conducted in 2004, 2007, 2011 and 2014. There is evidence of local seabed scouring adjacent to the flowline as it approaches Bains.

A cable crossing has been identified and is shown in Figure 3.1.1 and listed in Table 3.1.1.

Pipeline or Cable Description	KP	Protection
Bispham to IOM Electrical Interconnector	7.545	The IOM Electrical Interconnector is buried 1.5m under the surface of the seabed. It is overlain by two concrete mattresses on the seabed over which PL1958 is routed. PL1958 is protected by an additional seven fronded concrete mattresses on top.

Table 3.1.1: PL1958 IOM Electrical Interconnector crossing

The Bispham/IOM Electrical Interconnector is owned by Manx Cable Company.

Given the burial profile, we believe that the flowline will remain stable and sufficiently buried underneath the seabed. The OPRED Guidance Notes [3] state that in most cases burial or trenching to a minimum depth of 0.6m above the top of a pipeline would be necessary for pipelines decommissioned *in situ*. The majority of the flowline is buried to a depth greater than 0.6m below mean seabed with no exposures documented.

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

3.2 PLU1959 DP1 to Bains 110/3c umbilical pipeline

PLU1959 is an umbilical that provides power, control and chemicals to the Bains Well 110/3c-5. It is approximately 8.3km long and routed from the DP1 Platform. The first 59m of the umbilical is contained within the platform's J tube and topsides. Ostensibly PLU1959 runs parallel to PL1958 at an approximate 20m separation to the north.

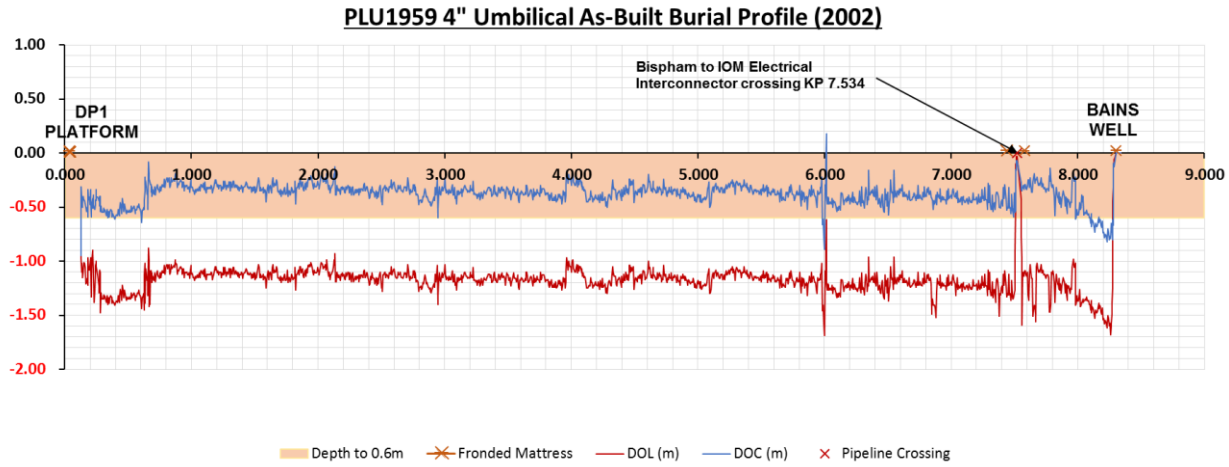


Figure 3.2.1: As-built burial of PLU1959 (Bains umbilical)[5]

The original as-built burial profile shown in Figure 3.2.1 is shown but many of the data points are out of range. Ostensibly this is interpreted as meaning that the umbilical is buried too deeply to be detected. On this basis we believe that the umbilical appears to be well buried for all its length, with the original burial records confirming that the umbilical was originally buried to at least 0.8 metre below the seabed except at the Bispham to IOM Electrical Interconnector crossing. There is evidence of local seabed scouring adjacent to the umbilical as it approaches Bains.

The OPRED Guidance Notes [3] state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*.

A cable crossing has been identified and is shown in Figure 3.2.1 and listed in Table 3.2.1.

Pipeline or Cable Description	KP	Protection
Bispham to IOM Electrical Interconnector	7.534	The Bispham to IOM Electrical Interconnector is buried 1.5m under the surface of the seabed. It is overlain by two concrete mattresses on the seabed over which PLU1959 is routed. PLU1959 is protected by an additional seven fronded concrete mattresses on top.

Table 3.2.1: PLU1959 IOM Electrical Interconnector crossing

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

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 flexible flowline and umbilical 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 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 are now buried under fronded mattresses as well as the lengths of pipeline buried in the trench and in the case of **PL1958**, the flexible flowline is covered intermittently with deposited rock.

Leave *in situ* would mean leaving the complete flexible flowline or umbilical *in situ*, along with the ends that were installed lying on the seabed but are now buried under fronded mattresses. Any short exposed lengths of both pipelines outside the buried sections will be removed.

All gabion sacks and grout bags at each end of both pipelines will be fully removed in accordance with mandatory requirements.

Further details of the decommissioning options for the Bains pipelines are described in Sections 4.1.1 and 4.1.2. The activities detailed in these sections could be undertaken using a variety different vessel types. 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 PL1958

ID[6]	Item	Option 1 Complete Removal	Option 2 Leave *in situ*
1	The flexible flowline is pulled up the J Tube at DP1 and is connected directly to the topsides pipework at the top of the riser using an 8" Grayloc hub. Length to just past bottom of J tube removed approx. 59m.	Remove. *Disconnect or cut at base of J Tube at DP1 platform. Completely remove exposed section leading up to bell mouth of J Tube as well as section within J tube using cut and lift technique using remotely operated cutting equipment and lift pipe to DSV. Return pipe to shore for processing.*	Remove*. As option 1.*
2	Short length of 8" flexible flowline from transition depth up to seabed as well as section lying on seabed but overlain with twelve fronded mattresses at DP1 (Some shared with PLU1959). Length approx. 73m.	Remove. *Excavate or dredge and fully recover fronded mattresses by whatever mechanical means necessary (refer section 4.2 for methods) to expose underlying flexible flowline. Cut flowline at transition depth. Return severed section of flowline to shore for processing.*	Leave *in situ*.
3	8" flexible flowline, approx. 8,055m long excluding sections described in ID 1, 2, 4, 5 & 6.	Remove. *Uncover the buried pipeline ahead of removal operations using mass flow excavator; and recover the pipeline on four separate reels using the reverse reel technique mounted on a vessel such as a DSV, CSV or pipelay vessel. The vessel used would be dependent on cost, but essentially recovery works would be supported by ROVSV. Return pipe to shore for cutting into transportable lengths and processing.*	Leave *in situ*.
4	Short length of 8" flexible flowline from transition depth up to seabed as well as section lying on seabed but overlain with fronded mattresses at Bispham to IOM Electrical Interconnector crossing. Length approx. 62m.	Remove. *Excavate or dredge and fully recover fronded mattresses by whatever mechanical means necessary (refer Section 4.2 for methods) to expose full extent of underlying flexible flowline; Continue from ID3 to use the reverse reel technique to recover the flowline. Return severed section of flowline to shore for processing. Recover plain concrete mattresses lying underneath the flexible flowline.*	Leave *in situ*.
5	Short length of 8" flexible flowline from transition depth up to seabed as well as section lying on seabed but overlain with fronded mattresses at Bains. Length approx. 54m.	Remove. *Excavate or dredge and fully recover fronded mattresses by whatever mechanical means necessary (refer section 4.2 for methods) to expose underlying flexible flowline and tie-in spool. Cut flowline at transition depth. Return severed section of flowline and tie-in spool to shore for processing.*	Leave *in situ*.
6	8" flexible flowline on approach connected to the Bains xmas tree. Completely remove exposed length of tie-in spool, approx. 6m.	Remove. *Completely remove* g*abion sacks and grout bags to expose tie-in spool. Cut adjacent to where tie-in spool is buried and remove exposed section. Return pipe to shore for processing. If necessary cover end with small quantity of rock (e.g. 1 or 2 x 1 tonne sacks of rock)*	Remove*. As option 1.*

Table 4.1.1: Options for decommissioning PL1958

[6] Items 1 & 6 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 PLU1959

ID[7]	Item	Option 1 Complete Removal	Option 2 Leave *in situ*
1	The umbilical is pulled up the same J Tube at DP1 as the flexible flowline. It is connected to the TUTU. Length to bottom of J tube to be removed approx. 59m.	Remove. *Disconnect or cut at base of J Tube at DP1 platform. Completely remove exposed section leading up to bell mouth of J Tube as well as section within J tube using cut and lift technique using remotely operated cutting equipment and lift pipe to DSV. Disconnect umbilical from TUTU. Return pipe to shore for processing.*	Remove*. As option 1.*
2	The short length of 101mm umbilical section from transition depth to seabed as well as length lying on seabed but overlain with eleven fronded mattresses (some shared with PL1958) at DP1. Length approx. 67m.	Remove. *Excavate or dredge and fully recover fronded mattresses[8] by whatever mechanical means necessary (refer section 4.2 for methods) to expose underlying umbilical. Excavate and cut umbilical at transition depth. Return severed section of umbilical to shore for processing.*	Leave *in situ*.
3	The 101mm umbilical, approx. 8,098m long excluding ends described in ID 1, 2, 4, 5 & 6.	Remove. *Uncover the buried umbilical ahead of removal operations using mass flow excavator; and recover the umbilical on one reel using the reverse reel technique mounted on a vessel such as a DSV, CSV or pipelay vessel. The vessel used would be dependent on cost, but essentially recovery works would be supported by ROVSV. Return umbilical to shore for cutting into transportable lengths and processing.*	Leave entire umbilical pipeline *in situ*.
4	Short length of 101mm umbilical from transition depth up to seabed as well as section lying on seabed but overlain with fronded mattresses at Bispham/IOM Electrical Interconnector crossing. Length approx. 50m.	Remove. *Excavate or dredge and fully recover fronded mattresses by whatever mechanical means necessary (refer Section 4.2 for methods) to expose full extent of underlying umbilical. Cut flowline at transition depths. Return severed section of umbilical to shore for processing. Recover underlying plain concrete mattresses.*	Leave *in situ*.
5	Short length of 101mm umbilical from transition depth up to seabed as well as length lying on seabed but overlain with fronded mattresses at Bains. Length approx. 55m.	Remove. *Excavate or dredge and fully recover fronded mattresses by whatever mechanical means necessary (refer section 4.2 for methods) to expose underlying umbilical. Cut flowline at transition depth. Return severed section of umbilical to shore for processing.*	Leave *in situ*.
6	The short exposed 101mm umbilical on approach connected to the Bains xmas tree. Completely remove exposed length of tie-in umbilical, approx. 6m.	Remove. *Cut adjacent to where umbilical is buried and remove exposed section. Return short length of umbilical to shore for processing. If necessary cover end with small quantity of rock (e.g. 1 or 2 x 1 tonne sacks of rock)*	Remove*. As option 1.*

Table 4.1.2: Options for decommissioning PLU1959

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

[8] Note that an additional four fronded mattresses are shared with the flexible flowline

4.2 Decommissioning of the fronded mattresses

4.2.1 Overview

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

Fronded mattresses are put in place to provide protection against scour, and when they do their job the fronds act like natural seaweed, and silt and sediment that is carried in the water column builds up within the fronds. They reinforce the depth of seabed locally and eventually they become buried. Given the right conditions they can be very effective.

A number of gravity-based fronded mattresses were installed to protect and stabilise both the 8" flexible flowline and the umbilical at otherwise exposed locations (Figure 4.2.1). The mattresses are dimensioned 6m x 3m x 0.3m and the edges are tapered to avoid snagging of on-bottom fishing gear. They are present on top of PL1958 and PLU1959 at the DP1 platform and Bains approaches as well as on the Bispham to IOM Electrical Interconnector crossing.

Figure 4.2.1: Typical Fronded Mattress Types (gravity based)[9]

4.2.2 Proposal and contingency measures

The indications are that where they were installed at the DP1 approach and at the Bispham to IOM Electrical Interconnector crossing they have performed their function and are now quite homogenous with the surrounding seabed (Figure 4.2.2). Therefore, the base proposal would be to decommission the fronded mattresses by leaving them *in situ*, but the adequacy of this as a proposal will be tested by carrying out an overtrawl.

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

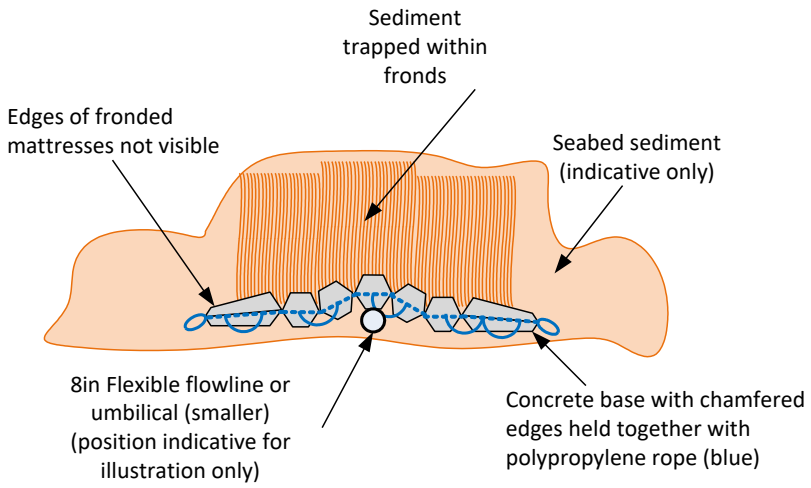


Figure 4.2.2: Fronded mattress - buried edges

However, there is historical evidence that the seabed in the vicinity of the pipeline approaches and WHPS at Bains has experienced scour (Figure 4.2.3). The scour may cause the edge of a fronded mattress to become exposed, in which case we would propose to attempt recovery of the mattress and underlying pipeline followed by an overtrawl. Visibility in the area is poor, however, so in the event that we are unable to verify whether the edge of a fronded mattress is exposed we would propose to implement contingency measures, starting with an overtrawl to establish any snagging risk they may present.

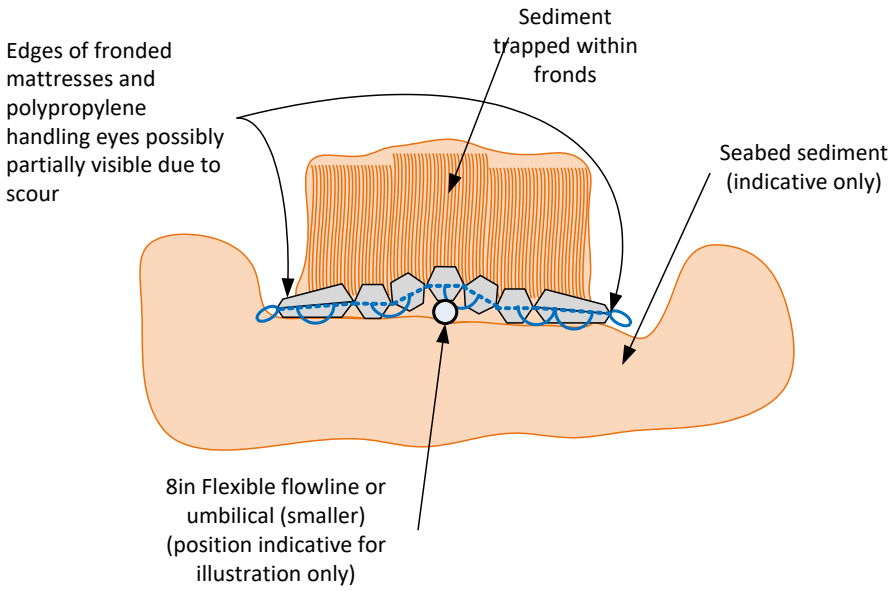
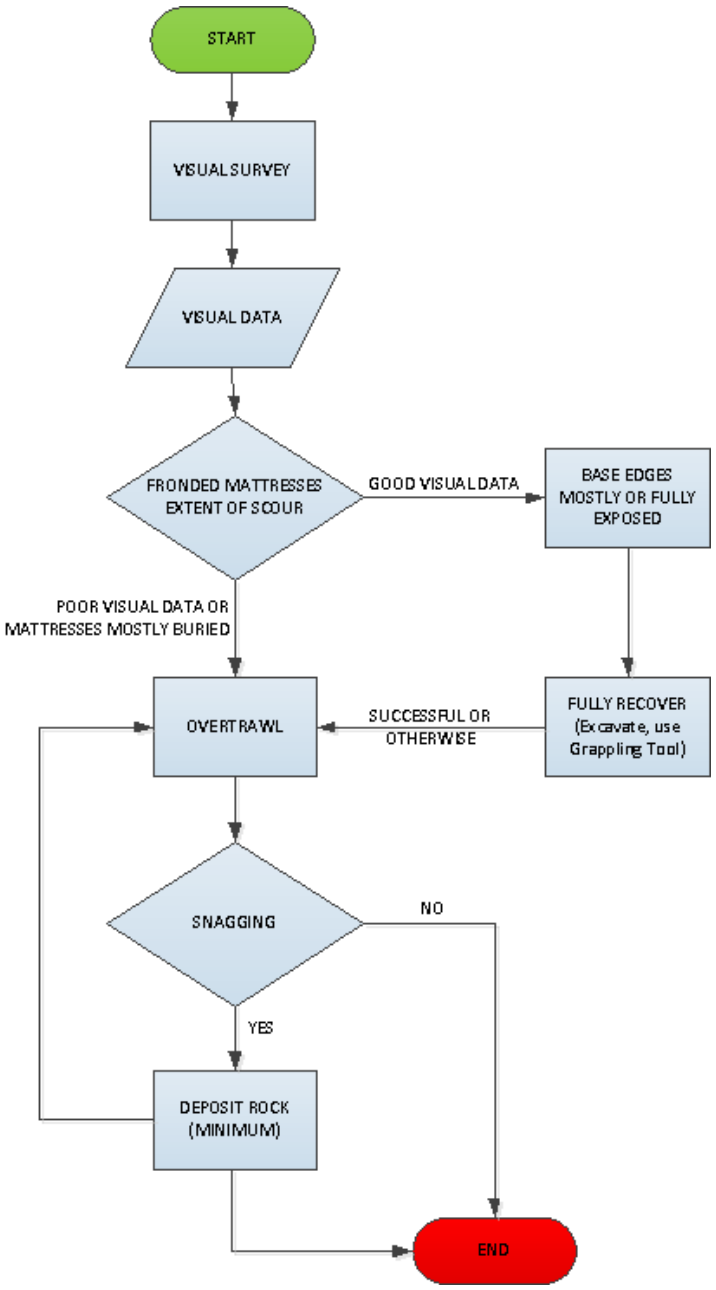


Figure 4.2.3: Fronded mattresses - exposed edges

Should the overtrawl demonstrate that the fronded mattresses do not pose snagging hazards no further work will be carried out. Should the overtrawl demonstrate that the fronded mattresses would pose a snagging hazard, we would propose to implement contingency measures, which would involve depositing up to 350m^3 (520Te, initial estimate) of rock adjacent to the fronded mattresses in the scoured area.

In order to aid decision making we propose to use the following flowchart:



SUMMARY

- Visibility on seabed in EIS is often poor;
- Presence of the WHPS probably give rise to scour;
- If visibility good and established that fronded mattress edges are mostly or fully exposed, we will attempt to recover them and then perform overtrawl (e.g. Figure 4.2.3);
- If visibility is poor or established that fronded mattress edges are buried we will perform overtrawl (e.g. Figure 4.2.2);
- If fronded mattresses remain, underlying pipeline will be left *in situ*;

If fronded mattresses are recovered, underlying pipeline will be recovered.

Figure 4.2.4: Fronded mattress decommissioning option flowchart

4.3 Decommissioning of the 'gabion sacks' and 'grout bags'

The number of gabion sacks and 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

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

- Health & Safety:
  - Health & Safety risk to offshore project personnel;
  - Health & Safety risk to other users of the sea;
  - Health & Safety risk to onshore project personnel.
- Environment:
  - Environmental impacts of operations during offshore works;
  - Environmental impacts due to legacy aspects that would 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 results of the assessment are summarised in Section 5.2.

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.

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

5.1.2 Health & Safety Assessment

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

Sub-criteria:

1. The health and safety risks for project personnel engaged in 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. The residual risks to marine users on successful completion of each decommissioning option 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. The 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 exactly the same, of the fuel and energy input data used for waste handling activities.

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

5.1.4 Societal Assessment

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

Sub-criteria:

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

Assessment of sub-criteria:

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

5.1.5 Cost Assessment

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

For this assessment, complete removal represents the full scope and 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'.

5.2 Combined Comparative Assessment

Although the constructions of PL1958 and PLU1959 differ, the approach to their decommissioning will fundamentally be the same. Therefore, we have combined the comparative assessment for both, noting any differences that may arise.

5.2.1 Technical Assessment, PL1958 & PLU1959

Dealing with the short exposed pipeline ends is common to all decommissioning options and so is not a differentiator between the options.

For complete removal the flexible flowline would need to be retrieved from the trench. We assume that it would not be strong enough to be lifted directly through the sediment and rock cover. It would be flooded with seawater and is therefore significantly heavier than when it was installed. The flexible flowline or umbilical could be removed either by reverse reel or by using 'cut and lift', although we consider that in this instance removal by reverse reel would be the most efficient method.

Although some design uncertainties would need to be overcome, we believe that both decommissioning options for **PL1958** and **PLU1959** are technically feasible. In 2009 Spirit Energy recovered a similar 2.9 km long 8" flexible flowline by reverse lay - transferred to reels and stored onshore. In that instance however, the flexible pipeline was trenched and buried but without deposited rock. Note that the original design documentation suggests that it would have been implausible to remove the flexible flowline were it buried.

There is more technical uncertainty associated with complete removal irrespective of which pipeline, and as such was deemed likely to have an adverse impact on technical risk. Although somewhat repetitive, we believe that the more rudimentary 'cut and lift' method would also be feasible although it would take longer than reverse reeling to carry out; the 'cut and lift' approach is the preferred method for short or discrete lengths of pipe, when it is impractical or prohibitively expensive to mobilise major removal equipment. In this instance, we believe that the pipelines would be most efficiently removed using the reverse reel method, although for the flexible pipeline this would likely involve using at least four reels[10]. The umbilical would most likely be recovered using a single reel.

A trenched and buried the pipeline removed in its entirety would need to be removed from the backfill and in the case of the flexible flowline through rock intermittently deposited throughout its length. Subject to integrity checks this could be achieved by either pulling it through the seabed material or by removing the material first using specialist equipment such as mass excavation tools or water jetting machines. Jetting to remove the cover has

[10] This was the number of reels used when the 8" flexible flowline was originally installed. The approach would be similar for the umbilical, although we would expect a fewer number of reels to be required.

been widely used for short lengths of pipeline, but this would be more time consuming and costly for the entire pipeline, as well as expanding the environmental footprint.

The technical uncertainties associated with the pipeline decommissioning options 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 is limited experience of complete removal of pipelines that are trenched and buried (less so for rock covered pipelines), but we know it has been done before for shorter pipelines.	**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: PL1958 and PLU1959 Technical Assessment

Summary of technical assessment

Two options were considered for both **PL1958** and **PLU1959**, and theoretically, given the right conditions - for example, no integrity issues can be foreseen – both options can be considered technically feasible for both pipelines.

The 'cut and lift' method has been used for recovery of short pipeline sections already in the southern North Sea, but with care could be adopted for longer pipelines, and we know that removal of an 8" flexible flowline using reverse reel has been achieved before so both the complete removal and leave *in situ* options can be regarded as technically feasible. In practical terms while leave *in situ* would be easier to achieve technically, there is otherwise little to differentiate the two decommissioning options.

5.2.2 Health & Safety Assessment

Safety Risk to Offshore Project Personnel

In principle the assessment for safety risk of personnel offshore for PL1958 and PLU1959 would be broadly similar.

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

- Risk to personnel on vessel from methanol or hazardous substance releases would be greater for complete removal than for leave *in situ*;
- There would be a risk associated with the presence of an object on or near the vessel during reverse reeling for the complete removal option but eliminated for the leave *in situ* option;
- There would also be more risk of the 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 and this potentially would increase with the number of

vessels, the location of the work and the frequency of marine traffic. Decommissioning activities involve vessels working in the field, and over the longer term will be related to the amount of surveys and any pipeline remedial works that may be required in future. By way of example, for PL1958 the vessel durations associated with the complete removal options will be longer than for leave *in situ*.

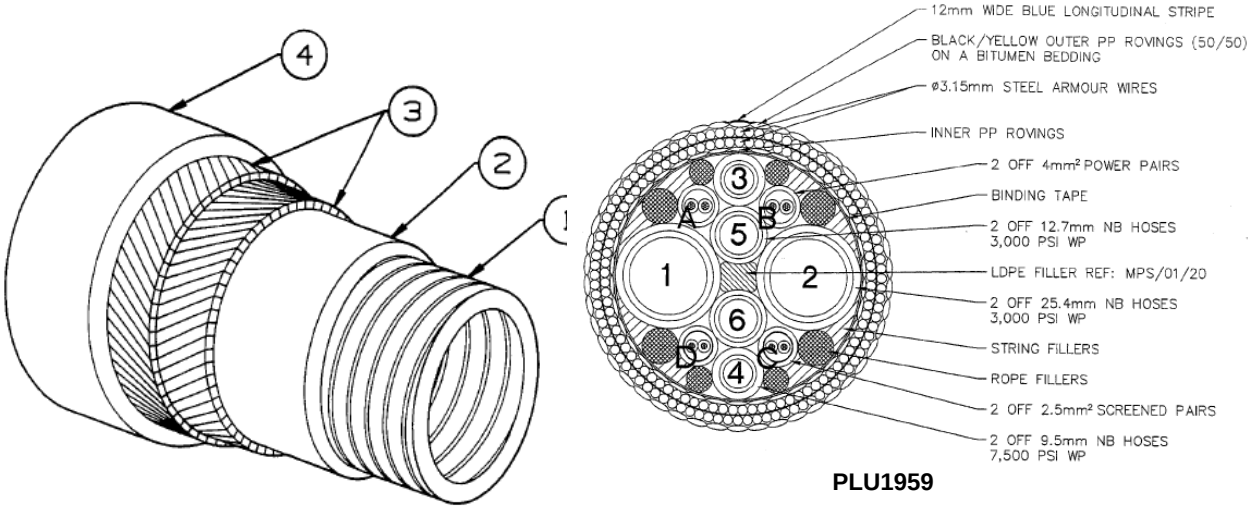
Decommissioning activities that minimise disturbance to the seabed will reduce the likelihood of creating new snag hazards and avoid leaving an open trench. Decommissioning activities that leave the seabed free of equipment will minimise the impact on local fishing activities. Complete removal will leave the seabed free of equipment, while leave *in situ* will present risks similar to what they are now with the exception of those areas currently contained within the 500m safety zones at DP1 and Bains. Although the complete removal option has the potential to leave open trenches that could present snagging hazards, these will can be 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 to be 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 significant.

Health & Safety Risk to Onshore Project Personnel

Both the flexible flowline and umbilical are constructed using a mixture of materials that would need to be separated and segregated onshore for recycling.



1. Internal carcass
2. Pressure sheath
3. Winding (tensile armour)
4. Outer sheath

PL1958

PLU1959

Figure 5.2.1: Construction of PL1958 & PLU1959

All hazards associated with the handling of the fully recovered flexible flowline and umbilical pipeline 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 unravelling the flexible flowline - resulting in injury, are greater for complete removal due to the quantity of material returned to shore compared with the

leave *in situ* option;

- It is possible that small amounts of gas and condensate remain trapped in the flexible pipeline as it is recovered. These small quantities would need to be catered for when stripping the flowline into its constituent components;
- Risks associated with separating the umbilical into its individual flowline 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, although no NORM has been encountered from Bains;
- Risks associated with dealing with any residues within either the flexible flowline or the umbilical onshore would be greater for complete removal.

Our assessment for both the flexible flowline and the umbilical is summarised in Table 5.2.2.

Sub-Criterion	Option 1 Complete Removal	Option 2 Leave *in situ*
Health & safety risk offshore project personnel	**Short-term:** More offshore work than leave *in situ*. Limited experience in the UKCS of removal of buried pipelines several km long; although there is experience with removal of shorter pipelines.	**Short-term:** No offshore work.
	Legacy: No pipeline surveys or remediation related activities.	**Legacy:** Pipeline surveys will be required, but this activity has been done before and will be of short duration.
Health & safety risk to mariners	**Short-term:** Duration of vessels in the field would be much longer than for leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field.	**Short-term:** No offshore work.
	Legacy: Infrastructure completely removed so no residual snag hazards remain.	**Legacy:** Pipeline surveys will be required, but this activity has been done before. Assume remain buried.
Safety risk onshore project personnel	**Short-term:** Significantly more onshore separation, cutting, lifting and handling associated with disposal of either pipeline presents an increased safety risk to personnel. Risk of gas or condensate residues remaining after flushing percolating through the sheaths of the flexible pipeline (PL1958) as the layers are deconstructed and segregated.	**Short-term:** No onshore work.
Colour Key:		
Medium / Tolerable & non -preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.2: PL1958 & PLU1959 Health & Safety Assessment

Summary of safety assessment

Many of the hazards described above are common to all decommissioning options. Based on the differences, in the short-term the leave *in situ* option 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 flexible flowlines and umbilical pipelines in the UKCS [1], 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. Therefore, the complete removal option results in lower residual risks to mariners and other users of the sea. Fundamentally however, we believe that there is little to choose between

the options from a safety perspective whether in the short or longer term.

5.2.3 Environmental impact of operational activities

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 5.2.3.

Operational Environmental factors impacted	Option 1 Complete removal	Option 2 Leave *in situ*
Atmosphere (energy & emissions)	**Short-term:** Emissions and use of energy is greatest for this option but no offset would be generated as a result of the energy and emissions needed to create new material to replace any that may be left *in situ.*	**Short-term:** Least amount of energy used and 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	**Short-term:** The amount of seabed disturbed is directly related to the length of pipeline being removed. The area affected would be largest for this option.	**Short-term:** 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	**Short-term:** Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal.	**Short-term:** Discharges and releases would be least for this option, particularly in the short-term.
Disturbance to protected areas	**Short-term:** 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.	**Short-term:** 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	**Short-term:** This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ.*	**Short-term:** No material would be returned to shore for recycling and 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 5.2.3: PL1958 & PLU1959 Operational Environmental Impacts

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 PL1958 and PLU1959 respectively 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 5.2.4.

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 would be required otherwise, so no impact.
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 to date have indicated that both pipelines 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 5.2.4: PL1958 & PLU1959 Legacy Environmental Impacts

5.2.5 Summary of environmental assessment

The environmental assessment for both the flexible flowline and the umbilical 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 but was nevertheless 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 both pipelines.

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 activities will incur longer vessel activities. Conversely, the leave *in situ* option would require the least vessel activity. We try to differentiate the options using different shades of green in the summary table.

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.

Therefore, during decommissioning activities the complete removal option is expected to have a greater impact on fishing activities as it has the longest duration and the greatest amount of activity disturbing the seabed. 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 for each decommissioning option we have assumed the number of pipeline surveys that would be required so that we can compare the impact of the options. The exact magnitude of the impact will be dependent on the type, frequency and duration of the surveys required.

Employment

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

Communities

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

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

The results of the societal assessments for **PL1958** and **PLU1959** are presented in Table 5.2.5. 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*
Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal.	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for complete removal.
Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required.	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option.
Short term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal.	Decommissioning activities would contribute the least to continuity of employment for leave *in situ.*
Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed.	Should the pipeline be left *in situ* surveys would need to be carried out. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*.
Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal.	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ.*
Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites.	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work.
Colour Key:		
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.5: PL1958 & PLU1959 Societal Assessment

Summary of societal assessment

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

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

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

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

The incremental difference in cost between complete removal and leave *in situ* – including

the requirement for legacy surveys - on a like-for-like basis would be least £3.1MM – slightly different for the flexible flowline and the umbilical (refer Appendix B.1 and Appendix B.2 respectively). Although the difference in cost would be significant, it is not an order of magnitude[11] greater. For this reason, because of the difference involved the short-term costs for complete removal in Table 5.2.6 are classed as "low and broadly acceptable but least preferred". The difference between the two options is compared in Table 5.2.6.

Sub-Criterion	Option 1 Complete removal	Option 2 Leave *in situ*
Short-term: Cost	The cost of complete removal would be higher than for the leave *in situ* option, but not an order of magnitude higher.	The cost of leave *in situ* would be the least expensive of the two options.
Legacy: Cost	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term.	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable no more surveys would be required.
Colour Key:		
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable & most preferred

Table 5.2.6: PL1958& PLU1959 Cost Assessment

5.2.8 Overall Summary of Assessment

The results of the assessment are summarised in Table 5.2.7. Overall, but marginally, the leave *in situ* option has been assessed as having the lowest short-term safety risk, lowest environmental impact and risk, lowest technical uncertainty and lowest cost.

Over the short-term, complete removal would involve several elements considered 'low and broadly acceptable, but least preferred' in the assessment. These elements concern technical risks and short-term risk to the safety of project personnel during recovery operations and dealing with the pipeline as it is transferred to shore and finally dealt with. Complete removal would deal with the issue of residual snag hazards arising from any short exposed lengths of the pipeline. From an environmental perspective, no aspect of the assessment features prominently. Finally, we estimate that complete removal costs would be greater than the leave *in situ* option. The difference is significant, but not an order of magnitude so.

Small differences are found between the safety assessment with more work required offshore and onshore for the complete removal than leave *in situ* and consequently higher safety risk. The leave *in situ* option means that the snagging hazards would remain and would need to be monitored at least for the immediately foreseeable future.

Conversely there would be lower safety risks to mariners arising from complete removal than for leave *in situ* because the pipeline would no longer be present as a potential snag hazard.

[11] i.e. larger than 10 times greater.

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

Table 5.2.7: PL1958& PLU1959 Summary of Comparative Assessment

6. CONCLUSIONS

Comparative assessment was undertaken with a focus on the decommissioning options for the Bains pipelines.

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.

PL1958 is an 8" flexible flowline approximately 8.3km, long trenched and buried. It is also intermittently buried with rock stitched in 7m lengths every 20m within the trench.

PLU1959 is an umbilical approximately 8.3km, long trenched and buried.

Most recent survey data indicates that there are no exposures anywhere along the flexible flowline or umbilical and the fronded mattresses that overlie both pipelines on the approach to DP1 platform and the Bispham to IOM Electrical Interconnector are now indistinguishable from the local seabed. However, historically seabed scour has occurred at Bains leading to less certainty with regards to the burial status of the fronded mattresses.

The assessment found the environmental and safety risks and impacts associated with the decommissioning options to be broadly acceptable for all impacts.

Small differences are found between the safety assessment with more work required offshore and onshore for the complete removal than leave *in situ* and consequently slightly higher safety risk. Conversely there would be lower safety risks to mariners arising from complete removal than for leave *in situ* because each of the pipelines would no longer be present as a potential snag hazard.

Finally, the cost associated with complete removal will be higher than for leave *in situ* and least preferred rather than intolerable.

In conclusion, given the burial status of each pipeline and based on the comparative assessment, leave *in situ* is the preferred option for decommissioning both pipelines. Depending on the extent of scour attempts will be made to recover fronded mattresses on the approach to Bains, but in the event that visibility is poor or recovery is not possible, rock may be deposited locally, but this will be preceded by an overtrawl to establish if this is necessary.

7. REFERENCES

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[3] OPRED (2011) Guidance Notes, Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998, Version 6, Department of Business, Energy, and Industrial Strategy. Weblink last accessed 28 Sept 2017: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69754/Guidance_Notes_v6_07.01.2013.pdf

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[5] SENSL (2017) Decommissioning Programmes, CEU-DCM-EIS0046-REP-0001;

[6] SENSL (2017) Environmental Appraisal, CEU-DCM-EIS0046-REP-0003.

APPENDIX A PIPELINE STABILISATION FEATURES ILLUSTRATED

Appendix A.1 DP1 Platform Approaches

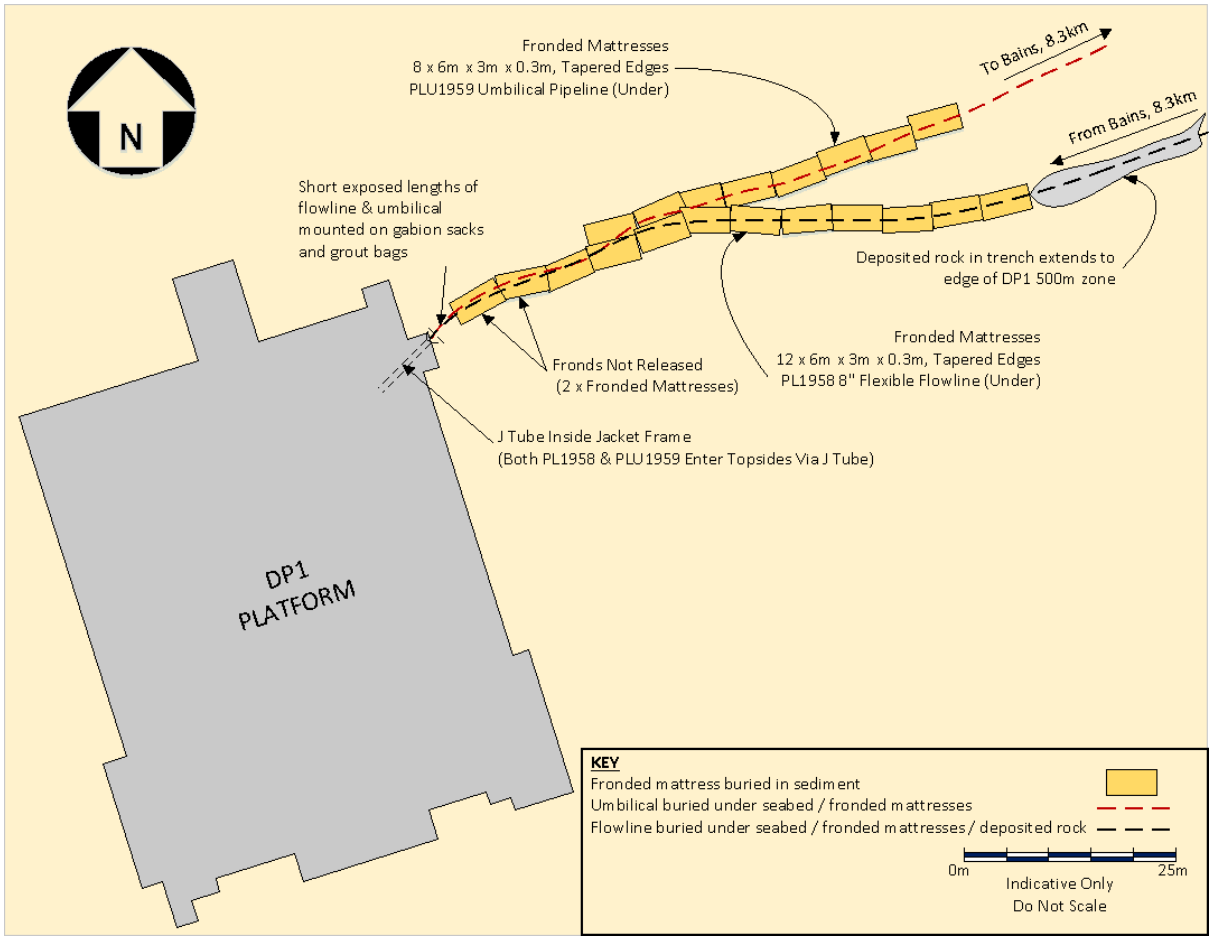

Figure A.1: Pipeline infrastructure @DP1 Platform

Appendix A.2 Bispham to IOM Electrical Interconnector crossing

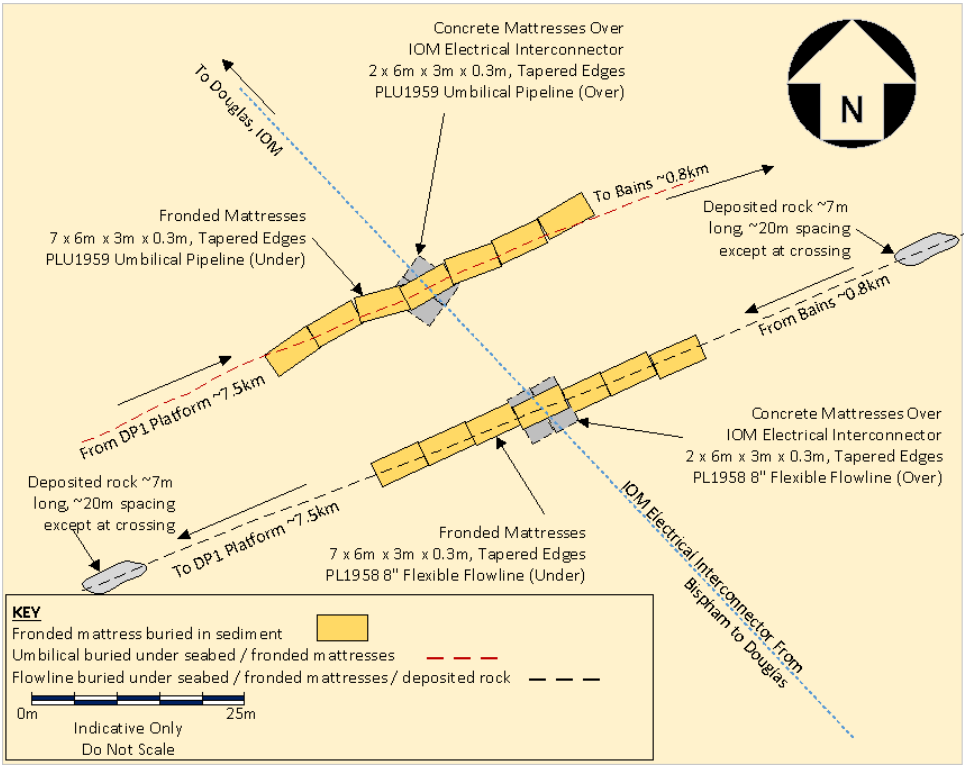

Figure A.2: Bispham to IOM Electrical Interconnector crossing

Appendix A.3 Bains Approaches

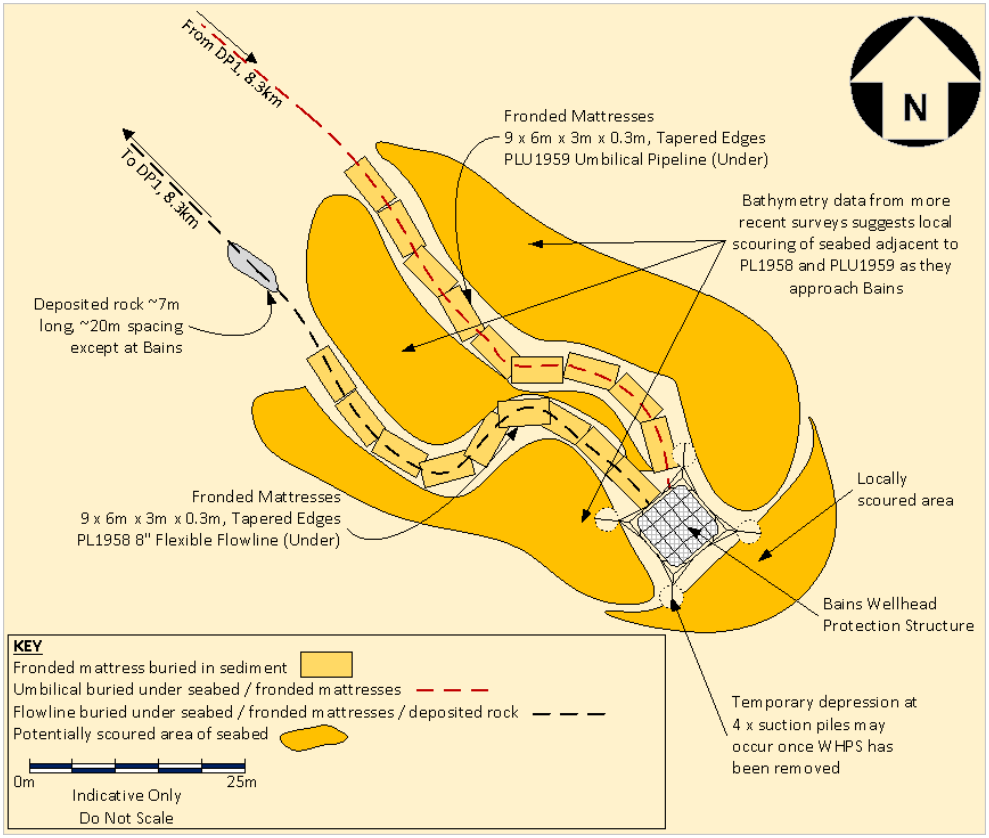

Figure A.3: Bains Approaches

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 HSE 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:

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

Appendix B.1 PL1958 High-Level cost comparison by difference

PL1958	Complete Removal (£M)	Leave *in situ* (£M)
Cost	£3.83	£0.74
Sub-total Normalised	**5**	**1.0**

Table B.1: PL1958 Decommissioning options costs by difference

Appendix B.2 PLU1959 High-Level cost comparison by difference

PLU1959	Complete Removal (£M)	Leave *in situ* (£M)
Cost	£4.16	£0.64
Sub-total Normalised	**5**	**0.8**

Table B.2: PLU1959 Decommissioning options costs by difference