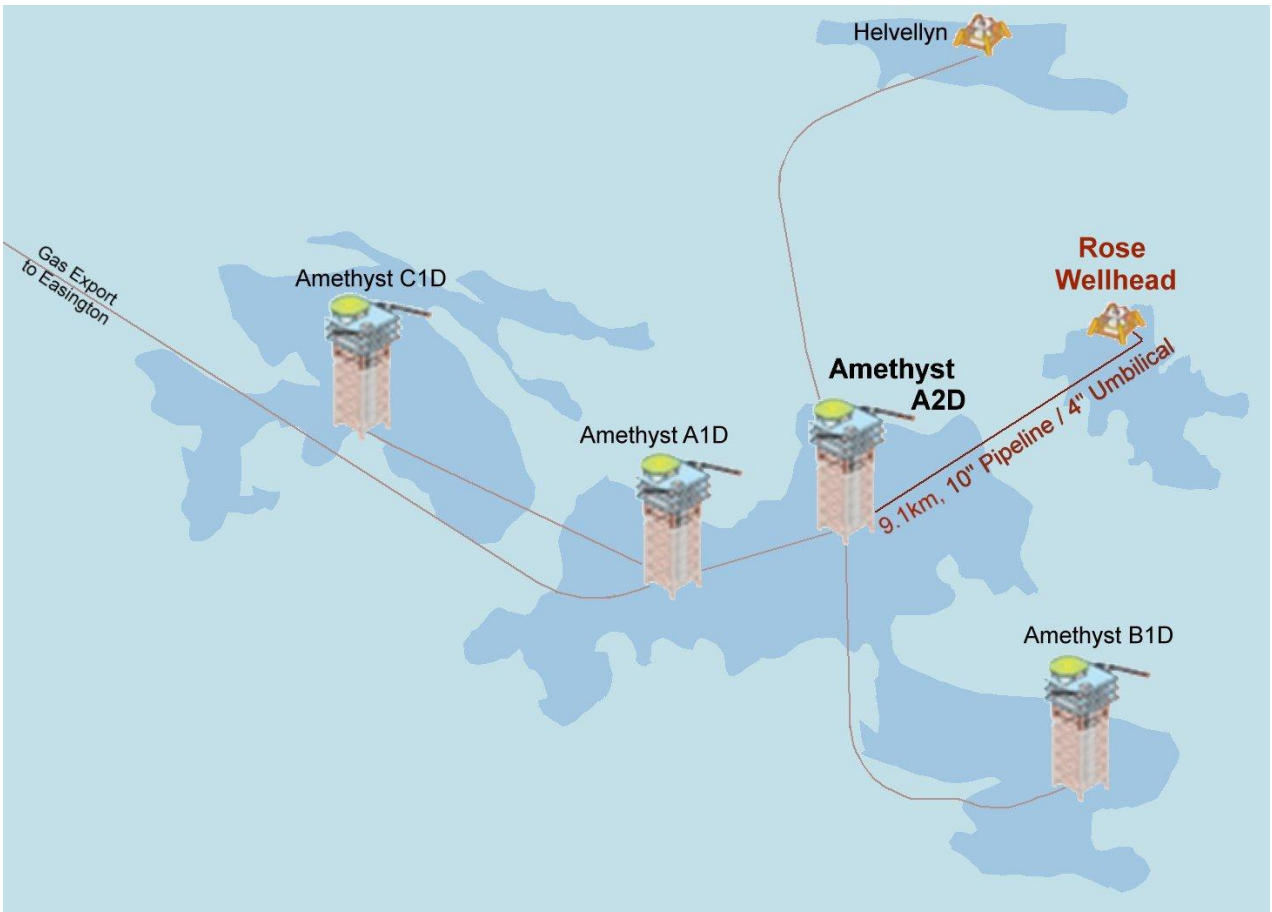
centrica energy

Rose Field Decommissioning Comparative Assessment



DOCUMENT CONTROL

Document ID:		CEU-PRJ-SNS0057-REP-0009	
Document Classification:		PUBLIC	
Document Ownership:		Projects & Decommissioning	
Date of Document	24/03/15	Signature	Date
Prepared by:	S. Axon	S Axon	24/3/15
Reviewed by:	S. Mackenzie	S Mackenzie	24/3/15
Approved by:	I. Whitehead		24/3/15

REVISION RECORD

Revision No.	Date of Revision	Reason
A1	19-12-14	For Client Review
A2	03-03-15	Re-issued For Review and Comment
A3	12-03-15	Issued for Approval
A4	24-03-15	Issued for Consultation

1. EXECUTIVE SUMMARY

A Comparative Assessment of pipeline decommissioning options is a key consideration within Decommissioning Programmes submitted to the Department of Energy and Climate Change (DECC).

The Rose field, located in the UKCS, is tied back to the Amethyst A2D platform with a 9.042km 10" Nominal Bore gas pipeline. Chemical supply and control of the tree at Rose is by means of a 9.400km nominal 4" diameter umbilical. For the most part the pipeline and umbilical are trenched and buried. The pipeline was mechanically backfilled after trenching, whereas the umbilical was left to backfill naturally. Both the pipeline and the umbilical remain at a satisfactory depth below general seabed level and appear stable. Although the umbilical trench has not completely backfilled over a reasonable portion of its length there is no indication that the burial status is likely to change. The pipeline is connected to the platform via a bolted connection to a 10" rigid riser. The umbilical is routed topsides through a J-tube and terminates at a Topsides Umbilical Termination Unit.

There are eighteen individual rock emplacements along the pipeline to mitigate against upheaval buckling. Within the Amethyst A2D platform 500m exclusion zone and around the Rose wellhead the pipeline and umbilical are protected with grout bags and concrete mattresses.

Between the Rose wellhead and the platform there are two locations where midline mattresses have been placed on the umbilical to protect it in areas where the trench depth is relatively shallow. Recent survey data shows these have become buried [9].

This document summarises a comparative assessment of the most feasible options for the decommissioning of the Rose subsea pipeline and umbilical.

Pipeline and umbilical options

- Complete removal;
- Partial removal, leaving the buried pipeline or umbilical *in situ* and making safe the ends by cutting and removing the short ends exposed in the trench transition areas
- Umbilical only. As partial removal, but with rock emplacement to compensate those areas where the original trench has not completely backfilled;
- Umbilical only. As partial removal, but with removal of a 3.5km length of umbilical measured from the Amethyst A2D platform to compensate for those areas where the original trench had not completely backfilled.

All options include removal of features such as mattresses and grout bags in accordance with mandatory requirements. Emplaced rock will remain *in situ* due to the technical uncertainties and environmental impact.

Options for the four buried mattresses placed along the umbilical were also assessed and these are:

Umbilical Midline Mattress Options

- Complete removal with no remedial works;
- Complete removal and replace mattresses with graded rock;
- Leave *in situ.*

The options were assessed using the DECC Decommissioning Guidance Notes and Centrica Comparative Assessment guidelines. During the assessment process, evaluations were made principally on a qualitative basis using Centrica's established corporate risk assessment tables

but also combined with deterministic values from the cost and energy use estimates which were normalised to provide a consistent measure against all Comparative Assessment evaluation criteria of:

- Safety
- Environmental
- Technical
- Societal
- Cost

The results of the assessment showed the risks and impacts of *all* pipeline and umbilical options to be broadly acceptable, although it could be argued that the technical and safety risks associated with complete removal of a pipeline or umbilical would be tolerable rather than be completely acceptable. This is primarily due to the limited experience of removing trenched and buried pipelines on the UKCS [7]. From an environmental perspective lower risks and impacts will be incurred for the partial removal case than for any of the other decommissioning options.

The societal assessment 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.

Finally, the partial removal options would cost less to adopt than any of the other options.

Therefore, this Comparative Assessment recommends that the partial removal options be adopted for both the pipeline and umbilical. This means that after flushing and left full of seawater the majority of the pipeline and the umbilical will be left *in situ* with no disruption for the majority of their lengths. The pipeline and umbilical will cut below the seabed and the sections between the trench and the platform or Xmas tree will be removed.

The Comparative Assessment also recommends that the four umbilical midline mattresses will be left buried *in situ.*

TABLE OF CONTENTS

FIGURES AND TABLES

TERMS AND ABBREVIATIONS

ABBREVIATION	DESCRIPTION	ABBREVIATION	DESCRIPTION
ALARP	As Low As Reasonably Practicable	Broadly Acceptable / Low[1]	Risk are 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
Centrica	Centrica Energy, Centrica Resources Limited	CO_2	Carbon Dioxide
DECC	Department of Energy and Climate Change	DSV	Dive Support Vessel
GJ	Giga-Joules	HAZID	Hazard Identification Workshop
Intolerable / High[1]	Impacts are intolerable. Controls and measures to reduce impact to ALARP (at lease to Medium) require identification, documentation, implementation and approval.	HSE	Health, Safety and Environment
KP	Kilometre Post	km	Kilometre
m	Metre	LAT	Lowest Astronomical Tide
NB	Nominal Bore	MM	Million
OGUK	Oil & Gas UK	NORM	Naturally Occurring Radioactive Material
rMCZ	Recommended Marine Conservation Zone	P&A	Plug and Abandonment
SWOT	Strengths, Weaknesses, Opportunities and Threats	ROV	Remotely Operated Vehicle
Te	Tonne	SUTU, TUTU	Subsea / Topsides Umbilical Termination Unit
Tolerable / Medium[1]	Risks are tolerable and managed to ALARP. Controls and measures to reduce risks to ALARP require identification, documentation and approval by the responsible leader	UK	United Kingdom
UKCS	United Kingdom Continental Shelf	WHPS	Wellhead Protection Structure

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

2. INTRODUCTION

2.1 Overview

The Rose field (block 47/15) is wholly owned by Centrica Resources Limited. It comprises a single subsea well (47/15b-6W) tied back to the Perenco operated Amethyst A2D Platform via a 9.042km 10" NB pipeline (actual diameter 10.75"), and a 10" NB rigid riser. Chemical supply and control of the tree at Rose is by means of a nominal 4" diameter umbilical (actual diameter 96.5mm), 9.400km in length, from the Amethyst A2D platform to the tree. The umbilical terminates at a subsea umbilical termination unit (SUTU) from which jumpers deliver the hydraulic fluid and methanol / corrosion inhibitor mix to the interfaces on the tree.

First gas from Rose was achieved in 2004. The well is currently live but not producing and is scheduled for plug and abandonment (P&A) in mid-2015. Pipeline isolation will precede this.

Following public, stakeholder and regulatory consultation, the Rose Decommissioning Programmes will be submitted in full compliance with the DECC Guidance Notes [6]. The Rose Decommissioning Programmes [1] explain the principles of the removal activities and are supported by an environmental impact assessment [5] and this Comparative Assessment.

Rose facilities comprise:

- Subsea Installation – wellhead protection structure (WHPS) (x1)
- 10" NB Gas Pipeline – 9.042km
- 4" Umbilical – 9.400km
- Umbilical Ballast – 9 x 1.0km lengths of 36mm wire rope strapped to umbilical where it is buried)
- Production Well (x1)
- Spool Pieces (x10) – approx. 185m
- Stabilisation and Protection Features:
    - Concrete mattresses (x116, 4 of which are along the umbilical midline
    - Grout bags (x200 approx.)
    - Rock (5,547Te, deposited in 18 locations above pipeline to mitigate upheaval buckling

Sections of both the pipeline and umbilical are located in the Silver Pit and Holderness Offshore recommended Marine Conservation Zones (rMCZ). Although these areas have not achieved full Marine Conservation Zone status, they may be designated as such over the coming years. Details of rMCZs and all other relevant environmental baseline data related to the Rose field are provided in the Environmental Impact Assessment [5].

At the Amethyst A2D platform the umbilical passes through a 6" J-tube within a 30" caisson. The 30" caisson also houses the 10" NB pipeline riser. These items belong to the Amethyst A2D platform.

Figure 1 shows the Rose and related Amethyst A2D platform infrastructure and the battery limits. The umbilical ballast wire and stabilisation features are omitted for clarity.

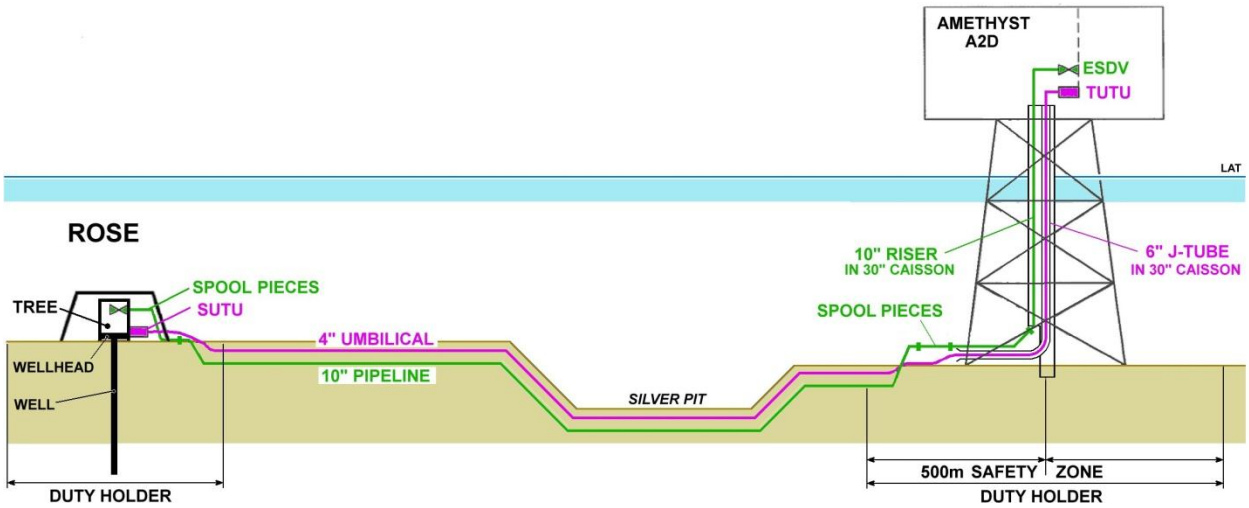


Figure 1: Rose installation & pipelines prior to decommissioning

Pipeline and umbilical

The pipeline is trenched and backfilled and has localised areas of emplaced rock at eighteen locations along its length. The rock emplacement is used to prevent upheaval buckling of the pipeline rather than for protection. Details of rock emplacements are provided in Appendix A.1.

The umbilical is in a trench which was open cut and left to backfill naturally.

The DECC Guidance Notes state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. The pipeline has a depth of burial cover consistently greater than 0.6m along its length. Both Complete removal and partial removal options are considered as part of the Comparative Assessment for the pipeline.

Around 90% of the length of the umbilical is trenched to at least 0.6m below mean seabed level. The percentage of the umbilical with a depth of cover of greater than 0.6m (i.e. material actually covering the umbilical) is approximately 60%. Approximately 90% of the umbilical is covered with greater than 0.3m of seabed material.

Survey data indicates that the trench has never completely backfilled, with shallow burial most evident in the deeper water, Silver Pit area. However, given the lie of the umbilical in the open trench, it is clear that it has operated with areas of partial burial throughout life. The predominant type of fishing in the area is by static line, with no evidence of scarring on the seabed from trawler activity. Therefore, two options have been considered for decommissioning the pipeline, four options have been considered for decommissioning the umbilical and three options have been considered for decommissioning the mid-line mattresses on the umbilical.

The options are as follows:

Pipeline options

- Complete removal of the pipeline;
- Partial removal, leaving the buried pipeline in place and cutting and removing the short ends exposed in the trench transition areas.

Umbilical options

- Complete removal;
- Partial removal and make safe the pipeline (or umbilical) ends;

- As partial removal, but with rock emplacement to compensate those areas where the original trench has not completely backfilled;
- As partial removal, but with removal of a 3.5km length of umbilical measured from the Amethyst A2D platform to compensate for those areas where the original trench had not completely backfilled.

For all options it is assumed that surface laid protection structures at the pipeline and umbilical ends will be removed, as will all spool pieces. Areas of the pipeline system or activities which are common to all of the decommissioning options (such as spool piece removal) are not discussed in this report as they do not influence the Comparative Assessment.

However, a comparative assessment was carried out for four buried mattresses placed along the umbilical. The options considered were as follows:

Umbilical Midline Mattress Options

- Complete removal with no remedial works;
- Complete removal and replace mattresses with graded rock;
- Leave *in situ.*

Details of pipeline and umbilical trench, backfill, rock placements and midline mattresses are presented in Appendix A.

Pipeline stabilisation features

The exposed end sections of umbilical and pipeline and spool pieces are protected by concrete mattresses at the platform approach and at the Rose Wellhead. At two midline locations along the umbilical, four further mattresses have been placed to provide cover at areas of shallow trenching. Two surveys carried out in 2012 [8], [9] indicate that all the midline mattresses have become buried. Locations of the midline mattresses are provided in Figure 13 & Figure 15 in Appendix A.2.

To provide additional weight to stabilise the umbilical in the seabed material, it has been laid strapped to a series of nine 1km lengths of steel wire rope of 36mm diameter (termed the ‘umbilical ballast’).

While it is considered physically possible to actually remove the rock emplacements, the decommissioning philosophy in this document is consistent with the Guidance Notes [6], hence all placed rock on the will be left *in situ*.

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

Methods that could be used to remove the rock include:

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

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

2.2 Purpose

The purpose of this document is to present a Comparative Assessment for the Rose pipeline, umbilical and midline mattresses in support of the Rose Decommissioning Programmes [1]. The document describes the decommissioning options considered, the method used in the Comparative Assessment, and the findings in line with the DECC Guidance Notes [6] and the Centrica Guidance Notes [4].

3. DECOMMISSIONING OPTIONS

The options detailed in this section are those that have been included in the Comparative Assessment process. Details of the engineering assessments and SWOT analysis used to determine which options were suitable for inclusion for both the pipeline and umbilical are detailed in Appendix A and Appendix C, respectively.

For all options the surface laid protection (mattresses and grout bags) at the pipeline and umbilical end sections will be removed, as will all spool pieces.

Elements of the pipeline system which will be decommissioned using the same methodology whichever option is selected are not discussed in this report as they do not have an influence on the Comparative Assessment.

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

The options considered for decommissioning the 10” NB pipeline are:

- **Complete removal** – Complete removal of the pipeline by reverse reeling out of the trench.
- **Partial removal** – Leaving the majority of the pipeline *in situ* underneath existing burial cover and rock emplacements. Pipeline end sections will be unbolted/cut and removed from the point in the trench transitions where the pipeline is determined to be at an acceptable depth below the seabed such that it does not present a risk to other users of the sea.

The options considered for decommissioning the 4” umbilical are:

- **Complete removal** – Complete removal of the umbilical by reverse reeling out of the trench.
- **Partial removal (ends only)** – Leaving the majority of the umbilical *in situ* in the trench and under existing burial cover. Umbilical end sections will be cut and removed from the point at the trench transitions where the umbilical is determined to be at an acceptable depth below the seabed. The umbilical ballast wire does not extend into these regions; therefore, none of it will be recovered.

Due to shallow cover and/or depth of lowering in some areas of the umbilical trench, the following variations on the partial removal option have also been considered:

- **Partial removal (rock emplacement)** – Leaving the majority of the umbilical *in situ* underneath existing burial cover. Umbilical ends will be cut and removed at the trench transitions, as above. Rock will be placed over approximately 40% of the line where the depth of burial is less than 0.6m.
- **Partial removal (3.5km removal)** – The first 3.5km of the umbilical from the Amethyst A2D platform end within Silver Pit will be removed by reverse reeling. The umbilical end at the Rose wellhead will be cut and removed at the point of acceptable depth below the seabed, as above. The remainder of the umbilical will remain *in situ* underneath existing burial cover.

Different decommissioning options for the buried midline mattresses over the umbilical have also been considered as part of this Comparative Assessment. However, options for these mattresses are only considered together with the umbilical partial removal options as the complete removal option automatically includes their removal.

The options considered for decommissioning the buried midline mattresses are:

- **Complete removal** – The mattresses will be excavated and completely removed.
- **Excavation and backfill with rock** – The seabed will be excavated and the concrete mattresses completely removed. Graded rock from cargo bags will then be placed by diver or remotely operated vehicle (ROV) to re-cover the umbilical.
- **Leave *in situ*** – The buried mattresses will not be excavated and will be left in place with no intervention.

The pipeline and umbilical decommissioning options are shown pictorially in Figure 2 to Figure 5. The umbilical ballast wire and midline mattresses are omitted for clarity. It should be noted that the figures show both the pipeline and the umbilical; however, the decommissioning options for the pipeline and the umbilical are independent of each other, i.e. it is possible to recommend complete removal of the pipeline or the umbilical and partial removal for the other.

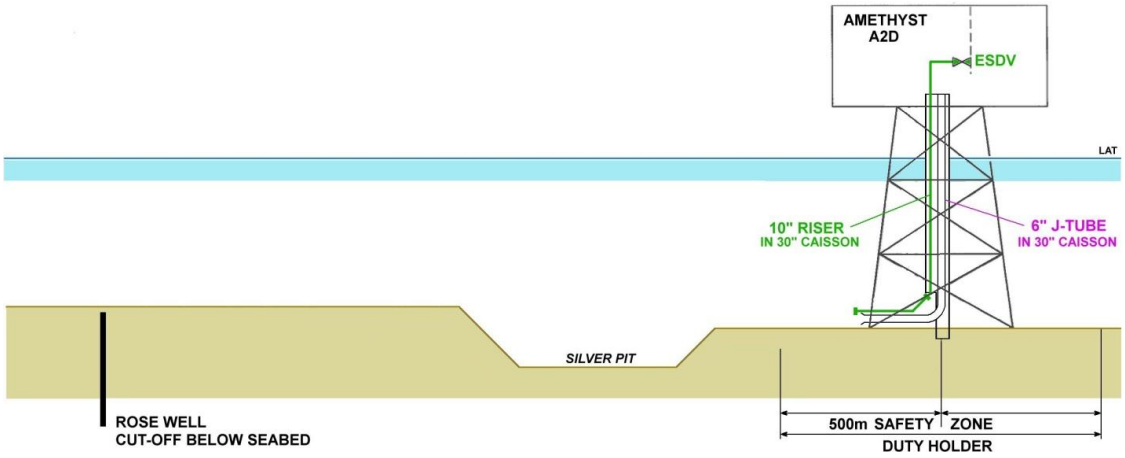


Figure 2: Complete removal pipeline and umbilical

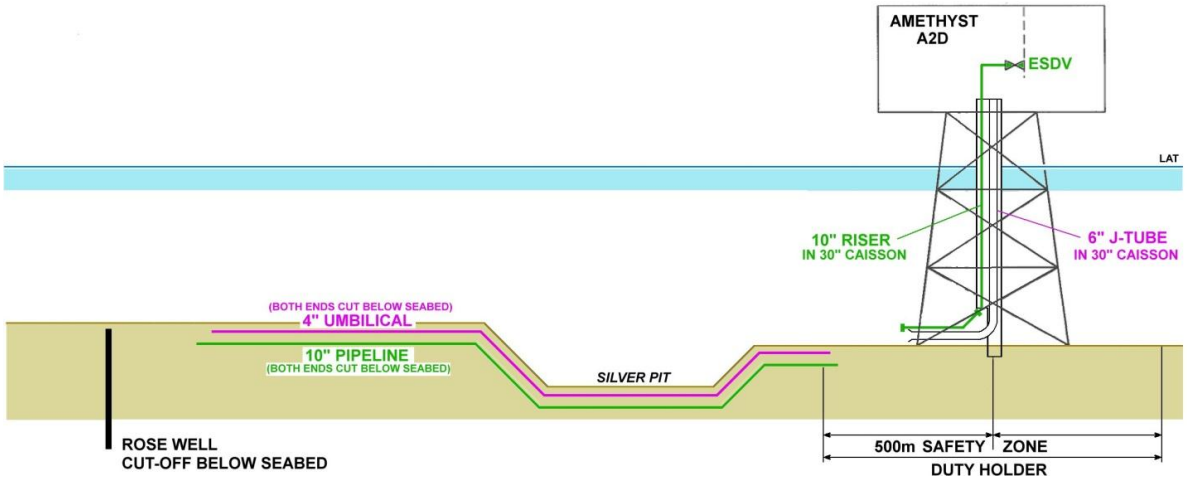


Figure 3: Pipeline partial removal & umbilical partial removal (ends only)

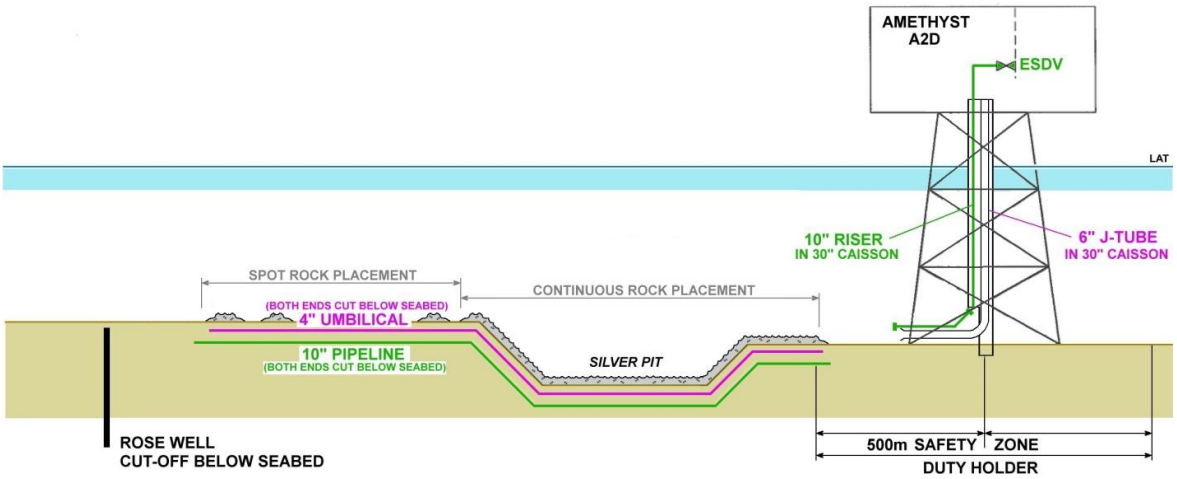


Figure 4: Pipeline partial removal & umbilical partial removal (rock emplacement)

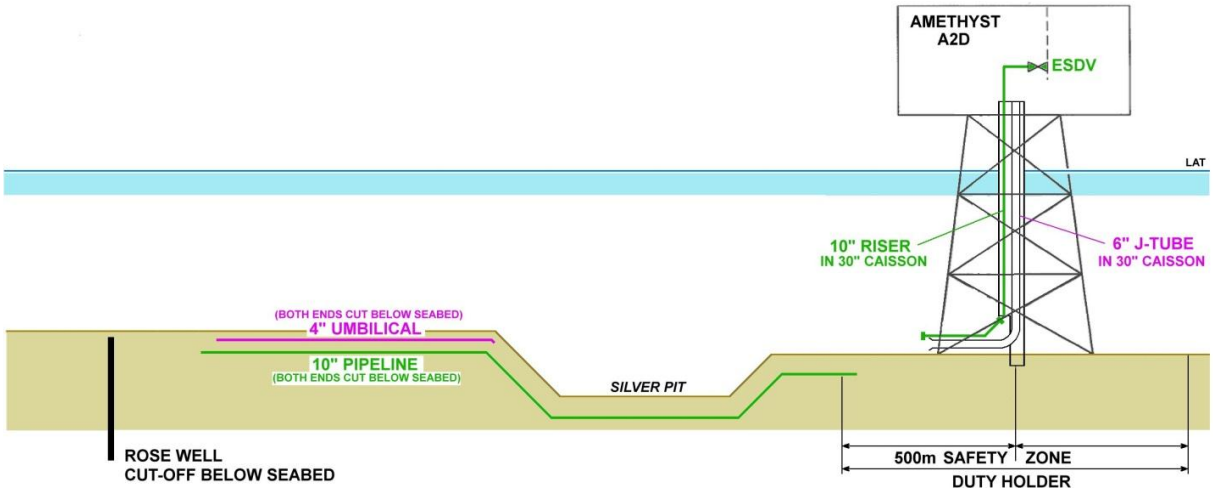


Figure 5: Pipeline partial removal & umbilical partial removal (3.5km removal)

Further details of the pipeline, umbilical and midline mattresses decommissioning options are shown in Table 1, Table 2 and Table 3 respectively. The majority of the activities detailed in these tables are expected to be undertaken with a dive support vessel (DSV), except the removal of the buried pipeline, which would be undertaken by a reel lay vessel.

The cut positions of the pipeline and umbilical for the different options are detailed in Figure 6.

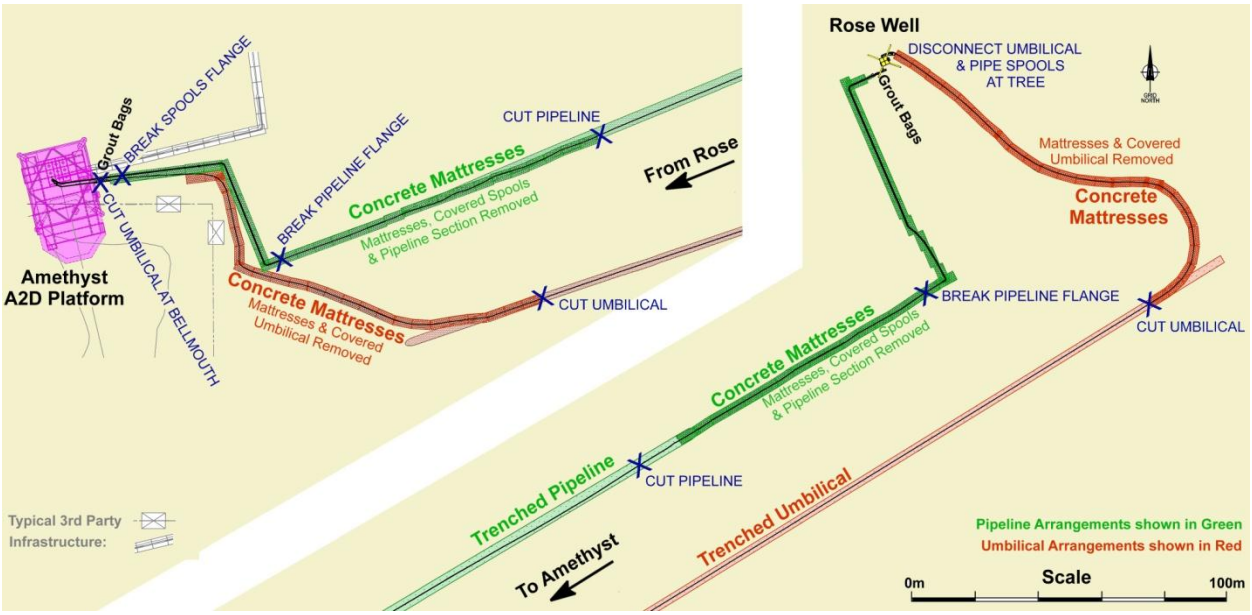


Figure 6: Pipeline and umbilical end cut locations

Item	Option 1 Complete Removal	Option 2 Partial Removal
Buried pipeline	Remove. *Use pipe reel lay construction vessel to pull pipeline out through covered trench and onto reel using "reverse lay" technique. Return pipe to shore for cutting into transportable lengths and processing*	Leave *in situ.* No work
Exposed pipeline ends	Remove. *Recover with reel lay vessel as part of reverse lay process*	Cut and remove. *Use divers from DSV to unbolt buried pipeline from riser, excavate local areas to give access for cutting pipeline and allow seabed to backfill naturally. This may also involve local water jetting.*
6 spool pieces at Rose wellhead, and 3 spool pieces at Amethyst A2D platform	Remove. *Divers disconnect flanges and rig spools for lifting to Dive Support Vessel*	Remove. *As option 1.*
Single spool piece adjacent to rigid riser inside jacket at Amethyst A2D platform	Leave *in situ* with the Amethyst A2D platform for possible reuse (to be decommissioned in future)	Leave *in situ.* As option 1.

Table 1: Pipeline decommissioning options

Item	Option 1 Complete Removal	Option 2 Partial Removal (ends only)	Option 3 Partial Removal (rock emplacement)	Option 4 Partial Removal (3.5km removal)
Buried Umbilical	Remove. *Pull umbilical out through covered trench and onto a reel mounted on a vessel, possibly a reel lay vessel, but probably the Dive Support Vessel. Return umbilical to shore for cutting into transportable lengths / weights and processing*	Remove poorly buried or potentially unstable sections and leave acceptably buried sections *in situ*. Locate poorly buried sections, excavate extremities by local water jetting, cut, and connect to winch for recovering to deck of vessel	As option 2, but also place graded rock over areas with relatively shallow cover	As option 2 but remove additional length of umbilical 3.5km long measured from Amethyst A2D platform with relatively shallow cover within Silver Pit area
Umbilical ends within Amethyst A2D platform 500m exclusion zone	Remove. *Disconnect from TUTU on topsides, connect rigging to subsea end and pull section out from bottom of J tube to deck of DSV using winch*	Remove. *As option 1*	Remove. *As option 1*	Remove. *As option 1*
SUTU and umbilical ends at Rose wellhead	Remove. *As part of reverse reel process*	Remove with umbilical end section As "Complete Removal."	Cut and Remove	Cut and Remove

Table 2: Umbilical decommissioning options

Item	Option 1 Complete Removal	Option 2 Excavation and backfill with rock	Option 3 Leave *in situ*
Buried Midline Mattresses	Excavate local area and remove	Excavate local area and remove mattresses. Thereafter, backfill excavated area with graded rock	Leave *in situ*

Table 3: Umbilical buried midline mattress decommissioning options

3.1 Decommissioning options – methods for removal

The methods that would be used for executing each of the decommissioning options are

summarised in Table 4, Table 5 and Table 6.

Item	Option 1 Complete Removal	Option 2 Partial Removal
Buried Pipeline	Remove. *Use reel lay vessel to pull pipeline out through covered trench and onto reel using "reverse lay" technique. Return pipe to shore for cutting into transportable lengths and processing*	Leave *in situ*. *No work*
Exposed Pipeline Ends	Remove. *Recovered with reel lay vessel as part of reverse lay process*	Cut and Remove. *Use divers from DSV to unbolt pipeline end flange from spool pieces. Cut pipeline at 0.75m depth to top of pipe in trench. This may also involve local water jetting*
Spool pieces	Remove. *Divers disconnect flanges and rig spool pieces, lifting to DSV*	Remove. *As option 1*

Table 4: Details of options for decommissioning the pipeline

Item	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Emplacement)	Option 4 Partial Removal (3.5km Removal)
Buried Umbilical	Remove. *Pull umbilical and ballast wire simultaneously out through covered trench onto a vessel mounted reel probably the DSV. Return both elements to shore for cutting into transportable lengths / weights and processing.*	Leave *in situ*. *No work.*	Leave *in situ* with rock emplacement. *Remediate areas with relatively shallow cover by emplacement of rock using a rock installation vessel.*	Remove 3.5km section, leave remaining umbilical *in situ*. *Remove approximately 3.5km of umbilical from Amethyst A2D end (using the same method as "complete removal"). Leave the remaining umbilical in situ.*
SUTU and Umbilical end at Rose wellhead	Remove with umbilical. *SUTU is part of umbilical and will be recovered by DSV*	Remove. *Disconnect SUTU from wellhead and cut umbilical at point of sufficient burial, and then remove end section with DSV*	Remove. *As option 2*	Remove. *As option 2*
Umbilical end at Amethyst A2D	Remove. *Disconnect from TUTU on topsides, cut subsea end, connect rigging and pull section out from bottom of J-tube to deck of DSV using winch*	Remove. *As option 1*	Remove. *As option 1*	Remove. *As option 1*

Table 5: Details of options for decommissioning the umbilical

Item	Option 1 Complete Removal	Option 2 Excavation and backfill with rock	Option 3 Leave *in situ*
Buried Midline Mattresses	Remove. *Expose mattresses by diver/ROV operated water jetting or air lifting and recover using via DSV*	Remove. *As "Complete removal", then using diver or ROV to emplace graded rock to refill the excavated area*	Leave *in situ*. *No intervention*

Table 6: Details of options for decommissioning the buried midline mattresses

4. COMPARATIVE ASSESSMENT

4.1 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 to provide clarity. The Comparative Assessment considers the following generic evaluation criteria and specific sub-criteria in line with DECC and Centrica Guidance [6] and [4]:

- Safety:
  - Safety risk to offshore project personnel
  - Safety risk to other users of the sea
  - Safety risk to onshore project personnel
- Environment:
  - Environmental impacts of operations
  - Legacy environmental impacts
  - Gaseous emissions (CO_2) (quantitative)
  - Energy use (GJ) (quantitative)
- Technical:
  - Risk of major project failure
- Societal:
  - Effect on commercial activities
  - Employment
  - Communities or impact on amenities
- Cost

The options are compared in terms of absolute performance relative to existing benchmarks and relative performance of the options to each other, allowing an assessment of actual difference between options and significance of these differences.

Scoring is achieved using risk matrices, with high figures indicating high risk and less desirable outcomes. High costs also attract a high score.

The following paragraphs describe the philosophy and processes followed for the Comparative Assessment using generic, high level evaluation criteria. The results of the assessment are summarised in Section 4.8.

4.2 Safety

Definition: An assessment of the potential 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. Safety risk is assessed using three specific sub-criteria.

Sub-criteria:

1. The safety risk for project personnel who would be engaged in carrying out decommissioning activities offshore are presented in Table 7:

Hazard Description	Example Sources of Harm
Personnel under water (Diving)	Vessel loss of dynamic positioning, hydrocarbon release
Overhead equipment (Lifting)	Vessel-based lifts, uncertainty surrounding structural integrity of pipeline sections and lift points
Reverse reeling	Pipeline parting or buckling, limited experience surrounding process for trenched and buried pipelines [7]
Boat collision hazard to other vessels and offshore structures	Shipping lane traffic, product transport vessels, supply and maintenance barges and boats, drifting boats
Environmental conditions	Poor weather that prohibits work and increases the number of man hours required offshore
Hazardous substances	Residual materials within pipelines such as methanol, chemicals from umbilical cores, wax deposits, hydrocarbons or NORM

Table 7: Description of offshore hazards

2. The residual risks to marine users on successful completion of the assessed decommissioning option are presented in Table 8:

Hazard Description	Example sources of harm
Snagging risk	Exposed pipeline or umbilical sections

Table 8: Description of residual hazards to mariners

3. The safety risks for project personnel who would be engaged in carrying out decommissioning activities onshore are presented in Table 9:

Hazard Description	Example sources of harm
Hazardous substances	Residual materials within pipelines such as methanol, chemicals from umbilical cores, wax deposits, hydrocarbons or NORMs
Onshore cutting	Dismantling of structures, pipeline, umbilical
Overhead equipment (Lifting)	Onshore lifts, uncertainty surrounding structural integrity of aged pipeline sections, mattresses and lift points

Table 9: Description of onshore hazards

Assessment of sub-criteria:

At a Hazard Identification (HAZID) workshop the different types of hazards relating to the decommissioning options were listed and then grouped into a total of 15 categories. The list and categorisation of the hazards is given in the tables in Appendix D, together with their evaluation. The assessment was carried out in accordance with the Centrica Comparative Assessment Guidance [4].

As many of the hazards are common across the complete removal and the partial removal options, only those hazards giving rise to differences 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)

The groups of hazards identified in the HAZID workshop were then categorised and grouped further according to the sub-criteria [1].

The differences were then assessed against the Risk Matrix [4] to allow an understanding of the level of significance of the risk and the differences in risk between options. A consistent approach, discussed and agreed through consultation within a group of discipline technical specialists, was taken when scoring hazards. Hazards were scored on a credible / most probable basis, as opposed to a worst case scenario.

The following steps were taken to assess each of the sub-criteria:

1. Create a list of hazards for each sub-criterion;
2. Rate each of the sub-criteria for impact and probability;
3. Discount any hazards which are not differentiators between complete and partial removal;
4. Take the score for each sub-criterion and assign a colour based on the Centrica matrices and a traffic light system to indicate level of acceptability[2]

The results of the safety assessment for the pipeline and umbilical were initially expressed numerically using the risk matrix for the sub-criteria. Numerical value were translated to colours based on the traffic light system to assign broad categories of risk to the sub-criteria. A numerical approach was not applied to the assessment of the decommissioning options for the umbilical midline mattresses because of their small number; instead relative advantages and disadvantages were discussed and recorded as comments within the Comparative Assessment tables.

The safety evaluation for the pipeline, umbilical and buried midline mattresses are given in Appendix D.1, Appendix D.7 and Appendix D.13, respectively.

Pipeline Assessment

Safety Risk to Offshore Project Personnel

All hazards were assessed as broadly acceptable with the exception of the risk associated with the handling of heavy object (pipeline) of unknown condition on or near the vessel during reverse reeling. This risk, which relates only to the complete removal option was assessed as tolerable. The key differences between the options are as follows.

- Risk to divers and personnel on vessel from hydrocarbon or hazardous substance releases was greater for complete removal than for partial removal;
- Risk associated with the heavy object on or near the vessel during reverse reeling but eliminated for partial removal;
- Risk associated with cutting of pipeline ends. There are more cuts for the partial removal option compared to the complete removal option;

[2] Using a traffic light system: a risk associated with green is low and broadly acceptable, if yellow the risk is medium and broadly requires attention, and a risk identified as red is high and broadly intolerable.

- Increased risk to all activities due to adverse weather greater for complete removal than for partial removal;
- Risk associated with legacy survey activities (risks associated with vessels being used) greater for partial removal than for complete removal. Typically a minimum of two legacy surveys would be required to confirm the condition of subsea facilities left *in situ*.

Residual Safety Risk to Fishermen and Other Marine Users

It was recognized before the Comparative Assessment that the greatest risk relating to marine users was likely to be concerned with snagging of fishing gear, in particular for the umbilical because of its relatively shallow burial cover. Data relating to pipeline and umbilical trenching and burial status examples are shown in Appendix B.1. The types of fishing in the area were examined and it was found that the predominant type of fishing is by static line, with no evidence of scarring on the seabed from trawler activity. Therefore, snagging potential is very low for equipment left *in situ*. From this it can be reasoned that decommissioning activities that minimise the amount of disturbance to the local area will also minimise the impact on local fishing activities.

Safety Risk to Onshore Project Personnel

Both hazards identified as differences between the two options were assessed as being tolerable for complete removal, and broadly acceptable for partial removal. The key differences between the options are:

- Risks associated with cutting of pipeline resulting in injury are greater for complete removal due to the higher quantity of material returned to shore compared with the partial removal option.
- Risks associated with lifting and handling pipeline sections are greater for complete removal, again, due to quantity of material returned to shore.

Summary

Many of the hazards described above are common to both decommissioning options. Based on the differences, the partial removal option gives rise to lower risks to personnel for the following three reasons:

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

By completely removing the pipeline, the risk of snagging is removed in perpetuity; therefore, the complete removal option results in lower residual risks to mariners and other users of the sea. However, residual snagging hazards for the partial removal option are also very low, given the type of fishing activity in the area and the trenching and burial status of the line (Appendix B.1).

Residual snagging risks associated with the partial removal option may not necessarily be present in perpetuity, but surveys will need to be done in order to verify that the risk of snagging will remain low for the foreseeable future.

Table 10 summarises this assessment. The colour coding (green being best) indicates whether the risks are broadly acceptable or tolerable. It should be noted that these risks are for the *differences* between options only.

Individual hazard scores can be seen in Appendix D.1.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal
Safety risk offshore project personnel	More offshore work than partial removal. Little experience in the North Sea of reverse reeling trenched and buried pipelines [7]. Reverse reeling activity is assessed as medium / tolerable as a result of the risks associated with handling of heavy object of unknown integrity on vessel	Less offshore work than complete removal. Experience in the North Sea of removal of pipeline sections
Safety risk to mariners	Marginally lower risk as potential snag hazards completely removed	Degradation of remaining pipeline will occur over a long period of time within seabed sediment and not expected to represent a hazard to other users of the sea. Slightly higher legacy risk as potential snag hazards not completely removed, although the pipeline is buried and the predominant type of fishing in the area is static line, with no evidence of scarring from trawling activity
Safety risk onshore project personnel	Significantly more onshore cutting, lifting and handling associated with disposal of 9km of pipeline, presents an increased safety risk to personnel	Less onshore cutting, lifting and handling

Table 10: Safety assessment for the pipeline

The evaluations in Table 10 suggest low / broadly acceptable results. However, the reverse reeling of the pipeline in option 1 is yellow-rated (i.e. medium/tolerable) among the wider group of offshore risks. As this activity is dominant it could be argued that the box should be coloured yellow to reflect this.

Umbilical Assessment

Safety Risk to Offshore Project Personnel

All hazards were assessed as broadly acceptable with the exception of the risk associated with the handling of a heavy object (umbilical) on or near the vessel during reverse reeling. This risk, which relates only to the complete removal and partial removal (3.5km removal) options was assessed as tolerable. The key differences between the options are as follows.

- Risk to personnel on the vessel deck is considered greater for the partial removal options than the complete removal option due to the requirement to lift the cut umbilical ends;
- There is a risk associated with the presence of a heavy object on or near the vessel during reverse reeling. The inclusion of reverse reeling in the complete removal and partial removal (3.5km removal) options is the largest single differentiator between the options as the risks associated with this activity are completely eliminated for the partial removal (ends only) and the partial removal (rock emplacement) options;
- The increase in risk to offshore personnel due to adverse weather is greater for complete removal and partial removal (3.5km removal) options than for the other partial removal options. This is due to the increase in vessel duration required to complete the reverse reeling process for these options. In comparison, subsea rock installation vessel activities

associated with the partial removal (rock emplacement) option are limited due to short campaign duration and no divers; hence, the addition of the subsea rock installation vessel is not a differentiator;
- As all the partial removal options leave a significant portion of the umbilical *in situ*, legacy surveys are required for these options. These legacy surveys have risks associated with the use of vessels that are not required for the complete removal option.

Residual Safety Risk to Fishermen and Other Marine Users

Residual safety risks associated with leaving the umbilical *in situ* are discussed in the Pipeline Assessment section above and so shall not be discussed here.

The hazards identified as differences between the options were assessed as broadly acceptable. The key difference between the options relates to future snagging hazards.

Due to the partial removal options leaving a portion of the umbilical in situ, there is a potential snagging hazard that does not exist for the complete removal option. However, this is only expressed as having minimal impact, given the trenched status of the umbilical and the type of fishing activity in the area.

Safety Risk to Onshore Project Personnel

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

- Risks associated with onshore cutting of umbilical resulting in injury. These risks are considered greater for the complete removal and partial removal (3.5km removal) options due to the increased length of umbilical that would be recovered;
- Risks associated with onshore lifting and handling umbilical sections. Again, these risks are considered greater for the complete removal and partial removal (3.5km removal) options due to the increased length of umbilical that would be recovered.

Summary

All hazards were assessed as broadly acceptable with the exception of the risk associated with the handling of a heavy object (umbilical) on or near the vessel during reverse reeling. This risk, which relates only to the complete removal and partial removal (3.5km removal) options, was assessed as tolerable. The necessity to carry out both reverse reeling and umbilical end cut and lifts has resulted in the partial removal (3.5km removal) option having a higher risk to offshore personnel than the others.

Reverse reeling is the biggest single differentiator between the options. Although all sub-criteria are assessed as green (broadly acceptable), partial removal (ends only) and partial removal (rock emplacement) options give rise to lower risks to personnel for the following key reasons:

- The reverse reeling required to remove the umbilical carries more risk than leaving *in situ.* This is due to the limited experience associated with this activity [7] and the increased vessel times required to complete it;
- Partial removal (ends only) and partial removal (rock emplacement) options represent a lower risk to onshore personnel due to less material being dealt with during cutting, lifting and handling.

However, complete removal gives rise to marginally lower residual risks to mariners and other users of the sea because there is no potential snagging hazard in future.

Table 11 summarises this assessment. The colour coding (green being best) indicates whether the risks are broadly acceptable or tolerable. It should be noted that these risks are for the

differences between options only.

Individual hazard scores can be seen in Appendix D.7.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Emplacement)	Option 4 Partial Removal (3.5km Removal)
Safety risk offshore project personnel	More offshore work than Partial removal options. Little experience in the North Sea of reverse reeling trenched and buried umbilicals [7]. This particular activity within the sub-criterion has been assessed as medium/tolerable due to uncertainties over handling of a heavy object on a vessel. No legacy activities.	No reverse reeling required. Risks associated with cutting and lifting umbilical ends. However, these are routine activities.	No reverse reeling required. Risks associated with cutting and lifting umbilical ends. However, these are routine activities.	Involves both reverse reeling and cutting and lifting of umbilical ends. Reverse reeling activity has been assessed as tolerable due to uncertainties over handling of a heavy object on a vessel.
Safety risk to mariners	Lower risk as potential snag hazards completely removed.	Slightly higher risk as potential snag hazards not completely removed. However, fishing type in the area is assessed as having minimal snagging potential.	Rock emplacement further reduces risk of potential snagging from Option 2.	Removal of the first 3.5km at the Amethyst A2D platform end further reduces risk of potential snagging from Option 2.
Safety risk onshore project personnel	More onshore cutting, lifting and handling.	Less onshore cutting, lifting and handling.	Less onshore cutting, lifting and handling.	More onshore cutting, lifting and handling compared to Options 2 and 3.

Table 11: Safety assessment for the umbilical

The evaluations in Table 11 suggest low / broadly acceptable results. However, the reverse reeling of the umbilical in option 1 and option 4 is yellow-rated (i.e. medium/tolerable) among the wider group of offshore risks. As this activity is dominant it could be argued that the box should be coloured yellow to reflect this.

Combined Pipeline and Umbilical Assessment

Table 12 shows a combined summary of the Safety criteria assessments for the pipeline and umbilical decommissioning options. The only sub-criterion where the assessment of the equivalent pipeline and umbilical options differ is risk to onshore project personnel for complete removal which has been assessed as medium / tolerable for the pipeline and low / broadly acceptable for the umbilical. This risk is considered greater for the pipeline due to the larger mass of material that would be returned to shore, transported, handled, and disposed of. Although the lengths are similar, the overall mass of material is significantly less for the

umbilical. There are further differences between the options related to the duration that vessels are required and the mass of material that would be handled. However, these are not significant enough to change the other sub-criteria ratings. The remainder of the assessment shows the impacts and risks to be broadly acceptable.

Asset	Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Emplacement)	Option 4 Partial Removal (3.5km Removal)
Pipeline	Safety risk offshore project personnel			N/A	
	Safety risk to mariners				
	Safety risk onshore project personnel				
Umbilical	Safety risk offshore project personnel				
	Safety risk to mariners				
	Safety risk onshore project personnel				

Table 12: Safety assessment summary

Umbilical Midline Mattresses Assessment

Safety Risk to Offshore Project Personnel

The Excavation and backfill with rock option requires the greatest amount of offshore work and, therefore, carries the greatest associated risk. All the offshore activities associated with the complete removal and excavation and backfill with rock options are considered to be largely routine.

The Leave *in situ* option requires legacy surveys but these are not a differentiator as the non-recovery of the mattresses would form part of an umbilical partial removal option for which legacy surveys would already need to be carried out.

Residual Safety Risk to Fishermen and Other Marine Users

The mattresses are currently buried. The Leave *in situ* option maintains this status without intervention. Snagging risks are low, evidenced by the predominance of static line fishing and lack of trawling in the area. Leaving the mattresses *in situ* also involves the least disturbance to the fishery.

The excavation and backfill with rock option temporarily exposes the umbilical but will involve an appropriate mitigation measure such as localised rock emplacement to re-fill the excavation and restore cover to the umbilical. The complete removal option will leave a large depression in the seabed and potentially leave the umbilical exposed. Further, there is the possibility that the burial of the pipeline could also be disturbed.

Safety Risk to Onshore Project Personnel

For the Leave *in situ* option, nothing is recovered so there will be no onshore work carried out

and hence no associated risks. Both the removal options will require onshore work to handle and possibly break up the mattresses, and therefore have greater safety implications. However, it is expected that these activities will be routine and involve minimal manual effort.

Summary

The Leave *in situ* option is the recommended option as it has the smallest associated safety risks for both offshore and onshore activities.

Individual hazard comments can be seen in Appendix D.13.

4.3 Environmental

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

Definition: An assessment of the significance of the risks/impacts to the environmental receptors as a result of activities or the legacy. Environmental impact is assessed using four specific sub-criteria.

Sub-criteria:

1. Environmental impacts of operations
2. Legacy environmental impacts
3. Gaseous emissions
4. Energy use

Assessment of sub-criteria:

An environmental assessment workshop was held where the impacts of the decommissioning options were discussed. The findings from the workshop were summarised in an environmental Management Worksheet and these were then assessed to form the input to the Comparative Assessment.

Common risks were treated in the same way as the Safety Assessment, i.e. only those risks where there was a difference between decommissioning options were included in the overall score.

Two of the evaluation sub-criteria (Gaseous emissions and Energy use) are quantitative (tonnes of emissions and GJ) while the others are qualitative and assessed according to the Centrica Environmental Impact Assessment matrix [4]. To align them with the Environmental Impact Assessment matrix, gaseous emissions and the energy use figures are normalised against a value of 5, with the option requiring greatest energy usage scoring 5; and the option(s) with lesser energy usage scored proportionately less. There is little difference (when put into the context of emissions from the UKCS 20,671,000 tonnes CO_2) between gaseous emissions and energy for the options. The numbers are not dissimilar, and the effect of the normalisation on the overall environmental scoring is trivial. The values used for the Comparative Assessment do not include removal of the spool pieces as their removal does not differentiate the options.

A full assessment of the environmental impacts of the selected decommissioning option can be found in the Environmental Impact Assessment [2].

Sub-criteria definitions:

1. Environmental impacts of operations

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

2. Legacy environmental impacts

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

3. Gaseous emissions (CO_2)

The total emissions of CO_2 from the proposed offshore and onshore activities associated with the complete programme of work for each option. This includes all the "direct" emissions from vessel use and the transportation, treatment, recycling and disposal of any recovered materials or waste. It also includes an estimate of the "indirect" emissions that would arise during the new manufacture of material that would theoretically be required to replace otherwise recyclable materials that were deliberately not recovered or recycled.

4. Energy use

The total predicted energy use required to complete the proposed offshore and onshore activities to complete the programme of work for each option. This includes all the "direct" energy use from vessel use and the transportation, treatment, recycling and disposal of any recovered materials or waste. It also includes an estimate of the "indirect" energy that would theoretically be required for the new manufacture of material to replace otherwise recyclable materials that were deliberately not recovered or recycled.

It should be noted that emissions to air and energy requirements are representations of the same input data, fuel use and energy for waste handling activities.

The environmental assessment was developed by identifying the interactions with the environment for each of the activities for each of the options. The 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. The scores were averaged to give a score for the sub-criteria. A numerical approach was not applied to the midline mattresses, instead relative advantages and disadvantages were discussed and recorded as comments within the Comparative Assessment tables.

Pipeline Assessment

The assessment of decommissioning the pipeline considered the key activities which resulted in differences in the level of impact to the environment. These were:

- Durations of vessels used in the field for the decommissioning activities and legacy surveys. The interactions with the environment (activity which has the potential to impact the environment) which differed between the options were:
  - liquid discharges from vessels
  - noise in water from vessels
- Amount of cutting, lifting and disposal required. The interactions with the environment which differed between options were:
  - liquid discharges to sea
  - noise in water
  - seabed disturbance
  - resource use – landfill space
- Emissions to air
- Energy requirements

The duration vessels are required in the field for the partial removal option is estimated to be

approximately 2/3 of the time for the complete removal; therefore, this is reflected in the liquid discharges to sea, noise, emissions to air and energy requirements. Conversely the legacy survey requirements for partial removal are greater than for complete removal.

The amount of cutting, lifting and disposal requirements is related to the length of pipeline to be recovered. Therefore, the discharge to sea from the pipeline, noise in water from cutting, seabed disturbance from lifting, and the use of landfill space are all greater for complete removal than for partial removal.

Estimated emissions to air and energy requirements showed that there is a difference between options. However, the gap between complete removal and partial removal narrows when indirect emissions and energy requirements – such as that required for replacement of unrecovered material – are taken into account.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal
Environmental impacts of operations	Although the impacts (discharges to sea and noise from vessels and cutting, disturbance to the seabed, disposal requirements) are localised, the duration of the activities is longer than for partial removal option which puts the assessment into the medium region, where additional controls and mitigation measures are required.	Assessed as broadly acceptable due to shorter duration of vessel use.
Legacy environmental impacts	Assessed as no environmental significance due to no legacy survey requirements.	Some environmental significance due to vessel use associated with legacy survey requirements.
Gaseous emissions (CO_2)	Greater environmental significance due to longer duration of vessel use (direct emissions).	Lower environmental impact due to shorter duration of vessel use (direct emissions).
Energy use (GJ)	Greater environmental impact due to longer duration of vessel use (direct emissions).	Lower environmental impact due to shorter duration of vessel use (direct emissions).

Table 13: Environmental assessment for the pipeline

The significance of the impacts associated with the interactions with the environment was assessed using the Environmental Impact Matrix in the Comparative Assessment guidance document [4]. This was done to allow an understanding of the significance of the impacts and to aid in decision making where conflicts between assessment criteria and sub-criteria arise. These are reflected in the traffic light colour coding. The results are presented in Table 13 with a more detailed breakdown available in Appendix D.2.

The yellow rating for complete removal in the above table is driven by the duration of vessel activities. The factors include liquid discharges to surface water from waste management activities, noise in water, and extent of seabed disturbance as a result of removing the pipeline from its buried position.

Umbilical Assessment

The assessment for the umbilical decommissioning options identified the activities and the interactions with the environment that had a different level of impact on the environment for each option. These were:

- Duration of vessel use (during decommissioning and legacy surveys)
  - Liquid discharges to sea
  - Noise in water
- Amount of lifting and disposal requirements
  - Liquid discharges to surface water
  - Noise in air
  - Disturbance of the seabed
  - Use of space in landfills
- Emissions to air
- Energy requirements

It should be noted that emissions to air and energy requirements are representations of the same input data, fuel use and energy for waste handling activities.

For the options involving reverse reeling, the duration of vessel usage is greater, as are all related vessel associated impacts. Likewise impacts associated with the lifting and removal activities are higher for the options involving removal of a significant portion of the umbilical. These options and the partial removal (rock emplacement) option also cause a greater disturbance to the local ecosystem when compared with the partial removal (ends only) option.

There are impacts associated with the legacy surveys for partial removal options (and not complete removal) due to the remaining infrastructure and associated survey requirements.

Estimated emissions to air and energy requirements showed that there is a difference between options. However, the difference between complete removal and partial removal narrows when indirect emissions and energy requirements, as used for replacement of unrecovered material, are taken into account. When taking direct and indirect factors into account the emissions to air are lowest for the complete removal option and are highest for the partial removal (rock emplacement) option. Similarly for energy use, when both indirect and direct factors are taken into account the partial removal (rock emplacement) option has the highest energy use. The complete removal and partial removal (ends only) options have the lowest total energy use.

The significance of the impacts associated with the interactions with the environment was assessed using the Environmental Impact Assessment Matrix in the Comparative Assessment guidance document [4], the results of which are presented in Table 14. All impacts were assessed as low. The assessment of the significance is reflected in the traffic light colour coding in Table 14 which is a summary of the environmental assessment. A more detailed breakdown can be found in Appendix D.8.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Emplacement)	Option 4 Partial Removal (3.5km Removal)
Environmental impacts of operations	Greater environmental impact due to longer duration of vessel use (discharges to sea and noise from vessels and cutting, disturbance to the seabed, disposal requirements).	Lower environmental impact due to shorter duration of vessel use and minimum disturbance to seabed.	Lower environmental impact due to shorter duration of vessel use compared to Options 1 and 4. However longer vessel durations and disturbance of seabed compared to Option 2.	Greater environmental impact compared to Options 2 and 3 due to longer duration of vessel use (discharges to sea and noise from vessels and cutting, disturbance to the seabed, disposal requirements).
Legacy environmental impacts	No environmental impact due to no legacy survey requirements.	Some environmental impact due to vessel use associated with legacy survey requirements.	Some environmental impact due to vessel use associated with legacy survey requirements.	Some environmental impact due to vessel use associated with legacy survey requirements.
Gaseous emissions (CO_2)	Lowest environmental impact due to lesser indirect emissions.	Slightly higher environmental impact than Option 1 due to higher indirect emissions. Smallest Direct emissions.	Greatest environmental impact due to highest direct emissions and higher indirect emissions as well.	Greater environmental impact than Options 1 and 2 due to a combination of higher direct emissions and equivalent indirect emissions
Energy use (GJ)	Slightly higher environmental impact than Option 2 due to higher direct energy use, but lower indirect energy use.	Lowest environmental impact due to lowest direct energy use.	Greatest environmental impact due to highest direct and indirect energy uses.	Greater environmental impact than Options 1 and 2 due to a combination of higher direct and equivalent indirect energy uses.

Table 14: Environmental assessment for umbilical

It is noted from the above table that all evaluations yield Low/Broadly Acceptable results.

Umbilical Midline Mattress Assessment

As with the pipeline and umbilical the environmental impacts are proportional to the vessel durations and the amount of lifting and disposal associated with each option. The leave *in situ* option involves no work in comparison to the removal options and hence has no environmental impact. While the complete removal and excavation and backfill with rock options have a higher comparable environmental impact, all impacts were considered broadly acceptable.

A more detailed breakdown can be found in Appendix D.14.

Combined Pipeline and Umbilical Assessment

Table 15 shows a combined summary of the environmental criteria assessments for the pipeline and umbilical decommissioning options. The only sub-criterion where the assessment of the equivalent pipeline and umbilical options differ is environmental impacts from the operations for complete removal, which has been assessed as medium / tolerable for the pipeline and low / broadly acceptable for the umbilical. This risk is considered greater for the pipeline due to the longer vessel duration required which has greater emissions of sound, liquid discharges and the greater disturbance to the seabed due to the larger volume material being recovered. There are further differences between the options related to the duration that vessels are required and the mass of material that would be handled with associated noise emissions, liquid discharges, disturbance to the seabed and waste. However these are not significant enough to change the sub-criteria ratings. The remainder of the assessment shows the impacts and risks to be broadly acceptable.

Asset	Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Emplacement)	Option 4 Partial Removal (3.5km Removal)
Pipeline	Environmental impacts of operations			N/A	
	Legacy environmental impacts				
	Gaseous emissions (CO_2)				
	Energy use (GJ)				
Umbilical	Environmental impacts of operations				
	Legacy environmental impacts				
	Gaseous emissions (CO_2)				
	Energy use (GJ)				

Table 15: Environmental assessment summary

4.4 Technical

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

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

Pipeline Assessment

Both pipeline decommissioning options are technically feasible. The technical option for complete removal of the pipeline is by reeling, a reverse method of installation.

There is limited experience in reverse reeling trenched & buried pipelines in the UKCS [7], and as such the technical uncertainty was deemed likely to have an adverse impact on technical risk. The alternative is that the pipeline would need to be recovered in sections using 'cut and lift'; due to the length of the pipeline this was not considered a practicable approach.

In contrast, partial removal requires just the pipeline ends to be cut and lifted. This is a well-established activity with little technical uncertainty. This option has been widely used for removing shorter sections of pipe, either for the removal of a short pipeline in its entirety, or when discrete sections are being removed for decommissioning. It is usually the recommended removal option for short sections of pipe, when it is impractical or prohibitively expensive to mobilise major equipment for removal.

For the Rose pipeline to be removed, either in its entirety or the end sections only, it must be removed from the backfill and areas of spot rock emplacement. This can be achieved by either pulling it through the material or by removing the material first by jetting. Reverse reeling a buried, and in some places rock covered, pipeline adds further uncertainty as there is little previous experience of this [7]. Jetting to remove the cover has been widely used for short lengths of pipeline, although this would be time consuming and costly for the entire pipeline.

The technical uncertainties associated with the pipeline decommissioning options have been assessed using the Project Risk Assessment Matrix in the Comparative Assessment guidance document [4], the results of which are presented in Table 16 below. A more detailed breakdown can be found in Appendix D.3.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal
Technical feasibility	Limited experience of reverse reel of trenched & buried pipelines in UKCS [7], cut and lift method to be avoided.	'Cut and lift' method can be used for short sections of pipe.

Table 16: Technical assessment for pipeline

As noted, the medium / tolerable rating is driven by uncertainties in the probability of success of the reverse reeling operation, which is considered to present risks to the delivery of the project.

Umbilical Assessment

All of the umbilical decommissioning options are technically feasible. The complete removal and partial removal (3.5km removal) options involve reverse reeling to remove the umbilical from its trench. There is limited experience of reverse reeling in the UKCS [7] and as such the technical uncertainty was deemed likely to have an adverse impact on technical feasibility and risk. The difficulties are however considered to be of a lesser order than those associated with reverse

reeling the rigid steel pipeline. Technical difficulties are around securing the umbilical and pulling it up from the seabed. The partial removal options would require removal of the end sections only. This is a routine activity and as such is considered less likely to result in a negative impact on technical safety and risk.

The rock emplacement activities related to the partial removal (rock emplacement) option are also considered routine, involving a vessel designed specifically for this task.

The results of the assessment are presented in Table 17. A more detailed breakdown can be found in Appendix D.9.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Placement)	Option 4 Partial Removal (3.5km Removal)
Technical feasibility	Reverse reeling is a viable option albeit with technical challenges associated as umbilical is pulled from the seabed. Considered more technically difficult than Options 2 and 3	Only requires cut and lift of umbilical ends which is considered a routine operation. Minimum number of operations therefore minimum technical risk	All operations associated with this option are considered routine. Some increased technical challenge compared to Option 2 due to the additional rock emplacement required. Less technically challenging than Options 1 and 4	Option involves both reverse reeling and cut and lift of exposed umbilical ends. Therefore, considered to be the most technically challenging option

Table 17: Technical assessment for umbilical

It is noted from the above table that all evaluations yield low/ broadly acceptable results.

Umbilical Midline Mattresses Assessment

All of the midline mattresses options are considered technically feasible. As with the umbilical and pipeline assessments the technical risk associated with the options is proportional to the type and number of activities undertaken. The Leave *in situ* option involves no additional work and therefore has no associated technical risks. The complete removal and Excavation and backfill with rock options have a higher comparable technical risk, all activities are considered routine. However, as the mattresses are buried their condition is currently unknown therefore removal operations have the potential to become more complicated.

A more detailed breakdown can be found in Appendix D.15.

Combined Pipeline and Umbilical Assessment

Table 18 shows a combined summary of the Technical criteria assessments for the pipeline and umbilical decommissioning options. The only option where the assessment of the pipeline and umbilical differ is complete removal, which has been assessed as medium / tolerable for the pipeline and low / broadly acceptable for the umbilical. The main differentiator between the pipeline and umbilical is the level of technical risk associated with reverse reeling activity for each. While both complete removal options involve reverse reeling the risk is considered greater for the pipeline as it is heavier and stiffer than the umbilical and is more substantially buried. It will therefore, take longer and require greater effort to lift the pipeline from seabed and reel it compared to the umbilical. This also means that pipeline operations are more likely to be

adversely affected by changes in the weather and sea states.

The remainder of the assessment shows the impacts and risks for the other options to be broadly acceptable.

Asset	Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Emplacement)	Option 4 Partial Removal (3.5km Removal)
Pipeline	Technical feasibility			N/A	
Umbilical	Technical feasibility				

Table 18: Technical assessment summary

4.5 Societal

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 using the Environmental Impact Matrix [4] has been undertaken to differentiate between options from a societal perspective.

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 asses the level of benefit, a positive effect. Vessel use duration is used as an indicator of magnitude of the continuation of employment.

The societal issues around the pipeline, umbilical and buried midline mattress options are discussed together below.

Commercial activities

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

While the vessels are present 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.

Activities which involve removal or reburial will implicitly disturb the seabed. Therefore, options which require more activities at the seabed will have a higher impact on commercial fishing.

Options that leave infrastructure that could present a snag hazard could have a higher impact on commercial fishing as there is a greater chance that fishing gear could be lost or damaged, although this does depend on the type of fishing in the area. For all options overtrawl assessments and risk assessments will be done to verify that residual snag hazards are unlikely to occur.

Therefore, during the decommissioning activities complete removal is expected to have a greater impact on fishing activities as it has the longest duration and the greatest amount of activity that will disturb the seabed. The partial removal options leave infrastructure *in situ* and, therefore, could present residual snag hazards. For the partial removal options pipeline surveys to be undertaken to identify if the infrastructure remains buried. While these surveys are being undertaken fishing activity may be disrupted for a short time while surveys are carried out but the impact can be expected to be minimal. Typically at least two post decommissioning surveys are required; 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 scores more positively than the partial removal options. 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

The port and the disposal site 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 Rose decommissioning will be an extension of the existing situation. Therefore, the effect on communities is not considered a differentiator between options.

Pipeline Assessment

The results of the pipeline assessment are presented in Table 19 below. A more detailed breakdown can be found in Appendix D.4.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal
Commercial activities	Greater immediate effect on fishing activities but no legacy surveys	Smaller immediate impact compared to the complete removal option, but some potential future impact associated with legacy surveys
Employment	Greater vessel duration and waste management requirements compared to partial removal option. Therefore greater employment levels	Shorter vessel duration and lower waste management requirements compared to complete removal option
Communities	Not a differentiator as existing port and disposal sites will be selected, therefore community not anticipated to materially change from existing.	

Table 19: Societal assessment for pipeline

Umbilical Assessment

The results of the umbilical assessment are presented in Table 20. A more detailed breakdown can be found in Appendix D.10.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Emplacement)	Option 4 Partial Removal (3.5km Removal)
Commercial activities	Greater immediate effect on fishing activities but no legacy surveys	Smaller immediate impact compared to the option 1, but some potential future disturbance associated with legacy surveys. In the short-term impact is slightly greater than for options 3 & 4; in the longer term the impact is marginally greater than for option 4	Smaller immediate impact compared to the option 1, but some potential future disturbance associated with legacy surveys. In the short-term impact is comparable with option 4 but marginally greater than impact of option 2	Smaller immediate impact compared to the Option 1, but some potential future disturbance associated with legacy surveys. In the short-term impact is comparable with option 3 but marginally greater than impact of option 2. In the longer term the impact will be marginally less than for options 2 and 3
Employment	Greater vessel duration and waste management requirements compared to Options 2, 3 and 4. Therefore greater employment levels	Less vessel duration and waste management requirements compared to Options 1 and 4	Less vessel duration and waste management requirements compared to Options 1 and 4	Greater vessel duration and waste management requirements compared to Options 2 and 3
Communities	Not a differentiator as existing port and disposal sites will be selected, therefore community not anticipated to materially change from existing.			

Table 20: Societal assessment for umbilical

Combined Pipeline and Umbilical Assessment

Table 21 shows a combined summary of the Societal criteria assessments for the pipeline and umbilical decommissioning options. All the options will have an acceptable impact on commercial activities and a positive impact on employment. The assessment shows the impacts to be broadly acceptable for all options considered.

Asset	Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Emplacement)	Option 4 Partial Removal (3.5km Removal)
Pipeline	Commercial activities			N/A	
	Employment				
	Communities				
Umbilical	Commercial activities				
	Employment				
	Communities				

Table 21: Societal assessment summary

Umbilical Midline Mattresses Assessment

As with the umbilical and pipeline assessments the societal impact associated with the options is proportional to the type and number of activities undertaken. The leave *in situ* option involves no additional work and therefore has no impact on commercial activities but also provides no additional employment opportunities. While the complete removal and excavation and backfill with rock options have a slightly higher short term impact on commercial fishing activities, they may also marginally increase employment relative to the leave *in situ* option.

A more detailed breakdown can be found in Appendix D.16.

4.6 Cost

At the time of writing a full cost estimate had not been prepared, so only the incremental costs of the main offshore decommissioning activities are compared. Common elements such as project management, owner's costs, etc. are not included in the figures. For this assessment complete removal represents the full scope and is assigned the maximum normalised score of 5, and the other options are compared to this and calculated as a fraction.

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.

Pipeline Assessment

The difference in incremental cost between the complete removal and partial removal options is in the region of £3MM which is approximately 50% greater for complete removal than for partial removal.

The results of the pipeline cost assessment are presented in Table 22 below. Quantitative costs can be found in Appendix D.5.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal
Cost	The cost of complete removal is higher than the cost of partial removal	The incremental cost of partial removal is approximately 50% of the cost of complete removal

Table 22: Cost assessment for pipeline

Umbilical Assessment

The biggest difference in cost is between the complete removal option and the partial removal (ends only) option, it is in the region of £2MM which is 40% greater for complete removal than for partial removal (ends only).

The results of the umbilical cost assessment are presented in Table 23 below. Quantitative costs can be found in Appendix D.11.

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Emplacement)	Option 4 Partial Removal (3.5km Removal)
Cost	The cost of complete removal is higher than all other options	The incremental cost of partial removal (ends only) is approximately 60% of the cost of complete removal	The incremental cost of partial removal (rock emplacement) is approximately 80% of the cost of complete removal	The incremental cost of partial removal (3.5km removal) is approximately 90% of the cost of complete removal

Table 23: Cost assessment for umbilical

Umbilical Midline Mattresses Assessment

Costs for the midline mattresses have been assessed on a semi quantitative basis. It is estimated that two days of DSV time would be required to uncover and remove the mats, and a further day to backfill the excavated areas with placed rock from cargo bags. A further half day of DSV time would be required to undertake as-left surveys of the area of work before demobilisation. Required DSV vessel days are thus:

Leave *in situ*: 0 days

Complete removal: 2.5 days

Removal and backfill with graded rock: 3.5 days

Quantitative costs can be found in Appendix D.17. Given DSV day rates, there is therefore a relatively insignificant cost differential between the options.

4.7 Assumptions, Limitations and Gaps in Knowledge

The most significant assumptions, limitations and knowledge gaps relating to the Comparative Assessment are listed below:

- No fully quantitative assessment of risk has been undertaken;
- Presentation of the different categories of risks in a manner which allows their comparison has required a degree of engineering judgement and application of techniques such as

normalisation;

- There is limited experience of reverse reeling trenched and buried pipelines from the seabed [7], so estimations of the safety risks, technical challenges and cost implications carry some uncertainty;
- Societal benefits are assumed to be proportional to vessel duration;
- Safety hazards were scored on a credible / most probable basis, as opposed to a worst case scenario;
- A full cost estimate has not yet been prepared, so only incremental cost differences for the main offshore activities are used in the assessment.

4.8 Comparative Assessment Summary

Pipeline Assessment

Partial removal is the recommended decommissioning option.

This option has been assessed as having the lowest safety risk, lowest environmental impact and risk, lowest technical uncertainty and lowest cost. Societal was the only criterion where complete removal was assessed to be beneficial; this was due to the potential additional employment opportunities associated with this option.

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

- Uncertainties as to the reliability of recovering a 10” rigid pipeline of unknown condition to the deck of the vessel and effect on those working in close proximity if pipeline fails during reeling;
- The lack of experience in reverse reeling [7], leading to higher safety risks and higher probability that the project will significantly over-run in both cost and schedule;
- The large amount of handling and particularly lifting involved in recovering the pipeline to shore, where it will need to be cut and moved in transportable lengths.

It can also be seen that environmental assessment favours leaving the pipeline *in situ*. This is primarily because of the lesser disturbance to ecosystems from removal activities and less impact associated with vessel use (emissions to air, discharges to sea, noise and disposal requirements), these factors were considered to outweigh the impact of the ongoing and occasional surveys needed for the sections of pipeline remaining *in situ* after decommissioning.

Umbilical Assessment

Partial removal (ends only) is the recommended decommissioning option.

The Comparative Assessment shows that there is little difference between the decommissioning options for the umbilical; the differences between options have been assessed as low

Small differences are found in the safety assessment, with more work required offshore and onshore for the complete removal option than for the partial removal (ends only) option and consequently higher safety risk. Conversely there is lower safety risk to mariners from complete removal than for partial removal because of potential snagging hazard considerations. The concerns are however, mitigated by the predominant type of fishing in the area.

Modest differences are found in the environmental assessment, with partial removal (ends only) favoured because of minimum ecosystem disturbance from removal activities and less impact associated with vessel use (emissions to air, discharges to sea, noise and disposal requirements).

Partial removal (ends only) was also assessed as better than all other options for technical risk and has the lowest associated costs. In the safety, environmental and technical assessment the partial removal (3.5km removal) is assessed as being the worst option. This is a result of it having the associated issues of both the complete removal and the partial removal options.

Societal was the only evaluation criterion where complete removal was rated preferentially; this was due to the continuation of employment. However, the complete removal option is also associated with the greatest impact on fisheries because of the length of time the area will be unavailable for fishing and the area of the seabed that will be disturbed.

Combined Pipeline and Umbilical Summary

Table 24 shows a combined summary of the assessments for the pipeline and umbilical decommissioning options. The sub-criteria where the assessment of the equivalent pipeline and umbilical options differ (low or medium) and the reasons why are as follows.

- Safety risk to onshore project personnel – This risk is considered greater for the pipeline due to the larger mass of material that would be returned to shore, handled, cut and disposed.
- Environmental impacts of operations – This risk is considered greater for the pipeline due to the longer vessel duration required which has greater emissions of sound, liquid discharges and disturbance to the seabed.
- Technical feasibility – The risk is considered greater for the pipeline as it is heavier and stiffer than the umbilical and is more substantially buried. It will therefore, take longer and require greater effort to lift the pipeline from seabed and reel it compared to the umbilical. It is also more likely to be adversely affected by changes in the weather and sea states.

The remainder of the assessment shows the impacts and risks to be broadly acceptable, although there are differences they do not move risks and impacts between regions.

Asset	Aspect	Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal (Ends Only)	Option 3 Partial Removal (Rock Emplacement)	Option 4 Partial Removal (3.5km Removal)
Pipeline	Safety	Safety risk to offshore project personnel			N/A	
		Safety risk to mariners				
		Safety risk to onshore project personnel				
	Environmental	Environmental impacts of operations				
		Legacy environmental impacts				
		Gaseous emissions (CO2)				
		Energy use (GJ)				
	Technical	Technical feasibility				
	Societal	Effect on commercial fisheries				
		Employment				
		Communities				
	Cost					
Umbilical	Safety	Safety risk to offshore project personnel				
		Safety risk to mariners				
		Safety risk to onshore project personnel				
	Environmental	Environmental impacts of operations				
		Legacy environmental impacts				
		Gaseous emissions (CO2)				
		Energy use (GJ)				
	Technical	Technical feasibility				
	Societal	Effect on commercial fisheries				
		Employment				
		Communities				
	Cost					

Table 24: Combined Assessment Summary

Umbilical Midline Mattress Assessment

The qualitative comparative assessment tables for the umbilical midline mattresses are provided in Appendix D.13 to Appendix D.17. The evaluation showed that all options were considered as acceptable. However, there are significant differences between the decommissioning options with Leave *in situ* being assessed as best in terms of safety risk, environmental impact and risk, technical risk and cost. Therefore, leave *in situ* is the recommended decommissioning option.

The leave *in situ* option involves no additional work from the partial removal of the umbilical options. The leave *in situ* option requires legacy surveys but these are not a differentiator as the non-recovery of the mattresses would form part of an umbilical partial removal option for which legacy surveys would need to be arranged. The mattresses are currently buried. The leave *in situ* option maintains this status without intervention.

The removal options require the greatest amount of offshore and onshore activities and therefore carry the greatest associated Safety and Technical risk, although the associated activities are considered to be largely routine. The environmental impacts are proportional to the vessel durations and the amount of lifting and disposal associated with each option. Therefore, the removal options also have the greatest environmental impact and risk.

However, the leave *in situ* option involves no additional employment opportunities compared to the removal options and therefore is assessed as the weakest in terms of societal benefit.

The leave *in situ* option attracts no cost compared to the removal options as it requires no additional work from the partial removal of the umbilical options.

5. CONCLUSION

The Comparative Assessment was undertaken with a focus on the decommissioning options for the 10” pipeline, the 4” umbilical and the midline mattresses on the umbilical. The assessments considered five criteria: safety related risks (three sub-criteria), environment (four sub-criteria), technical feasibility, Societal effects (three sub-criteria), and cost.

Two options were compared for the pipeline, complete removal and partial removal. The assessment found that the partial removal option for the pipeline was materially better for safety, environment, technical and cost considerations.

Four options were compared for the umbilical, complete removal, partial removal (ends only), partial removal (rock emplacement) and partial removal (3.5km removal). The assessment found the risks and impacts associated with the options to be broadly acceptable, however there are differences with partial removal (ends only) being better for safety, environment, technical and cost, albeit the differences being relatively small.

Three options were compared for the umbilical midline mattresses, complete removal, excavation and backfill with rock and leave *in situ*. In all areas other than societal the leave *in situ* option was found to be better as it involves the least amount of offshore and onshore work, thereby minimising risks and impacts.

For both the pipeline and the umbilical complete removal options would incur higher cost, unplanned risk and greater short-term impact on the environment. Offshore there would be an increased risk to safety of personnel and environmental impacts associated with transferring and disposing of any recovered material onshore.

By completely removing the pipeline, umbilical and midline mattresses the risk of snagging is removed in perpetuity and therefore the complete removal option results in lower residual risks to mariners and other users of the sea. However, residual snagging hazards for the partial removal and Leave *in situ* options are also deemed low on the basis that the predominant type

of fishing in the area is static line, not trawling, and the exposed ends at the Rose Field Wellhead and A2D Amethyst platform approach will be removed. This also means that a minimal disturbance option is likely to also minimise any adverse impacts on local fishing activities.

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

In conclusion, based on the Comparative Assessment the recommended option for decommissioning both the Rose pipeline and umbilical is partial removal. The majority of the pipeline and the umbilical will be left *in situ* underneath existing burial cover. The pipeline and umbilical ends will be cut and removed at the trench transitions where they are determined to be at an acceptable depth below the seabed. The umbilical midline mattresses will also be left *in situ* and remain buried.

6. REFERENCES

[1]. Atkins (2014) Decommissioning HAZID Report, 29 October 2014, 5134994-HAZ-SA-001

[2]. Atkins (2014) Environmental Statement, 5134994-REP-EN-001

[3]. CEU (2015) Decommissioning Programmes, CEU-PRJ-SNS0057-REP-0012

[4]. CEU (2014) Comparative Assessment Guidance for Decommissioning, CEU-HSEQ-GEN-GUI-0029

[5]. CEU (2015) Environmental Impact Assessment, CEU-HSEQ-SNS0057-REP-0001

[6]. DECC (2011) Guidance Notes, Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998, Version 6, Department of Energy and Climate Change

[7]. OGUK (2013) Decommissioning of Pipelines in the North Sea Region 2013, Oil & Gas UK

[8]. Fugro (2013) Environmental Survey Environmental Baseline Study and Habitat Assessment

[9]. 2012 Hydrographic Survey Data files - Bathymetry and Events Listing, November 2012

APPENDIX A PIPELINE & UMBILICAL PROFILES

Appendix A.1 Pipeline – Burial Profile

Rose pipeline survey data from 2012 is presented in Figure 7 and Figure 9 below, with cut locations marked. KP0 is located at the pipeline flange at Rose, with KP increasing heading west. The survey data does not extend into the Amethyst A2D platform 500m exclusion zone, hence cut locations in this area are not shown. The pipeline shows excellent levels of burial along the majority of the length.

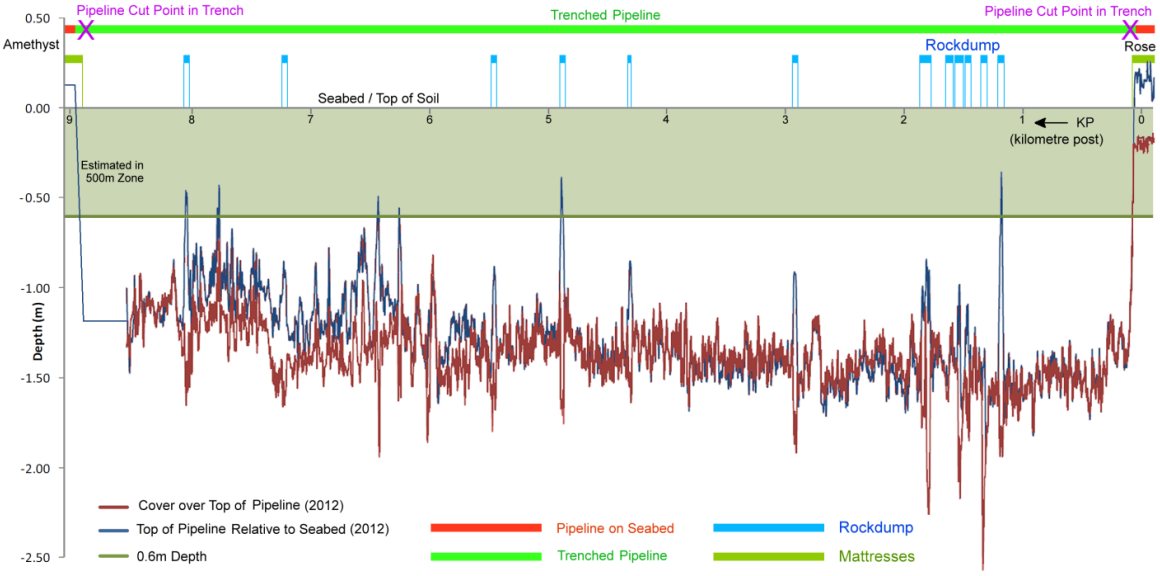


Figure 7: Pipeline burial profile - condensed[3]

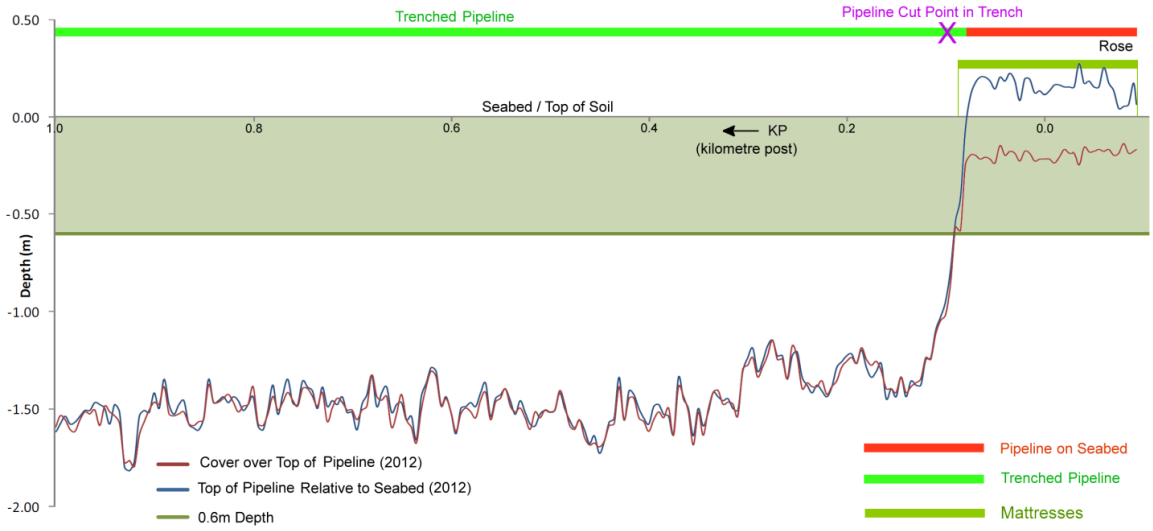


Figure 8: Pipeline burial profile at Rose well end[3]

[3] The more negative the depth of cover the greater the depth of cover over top of pipeline or umbilical.

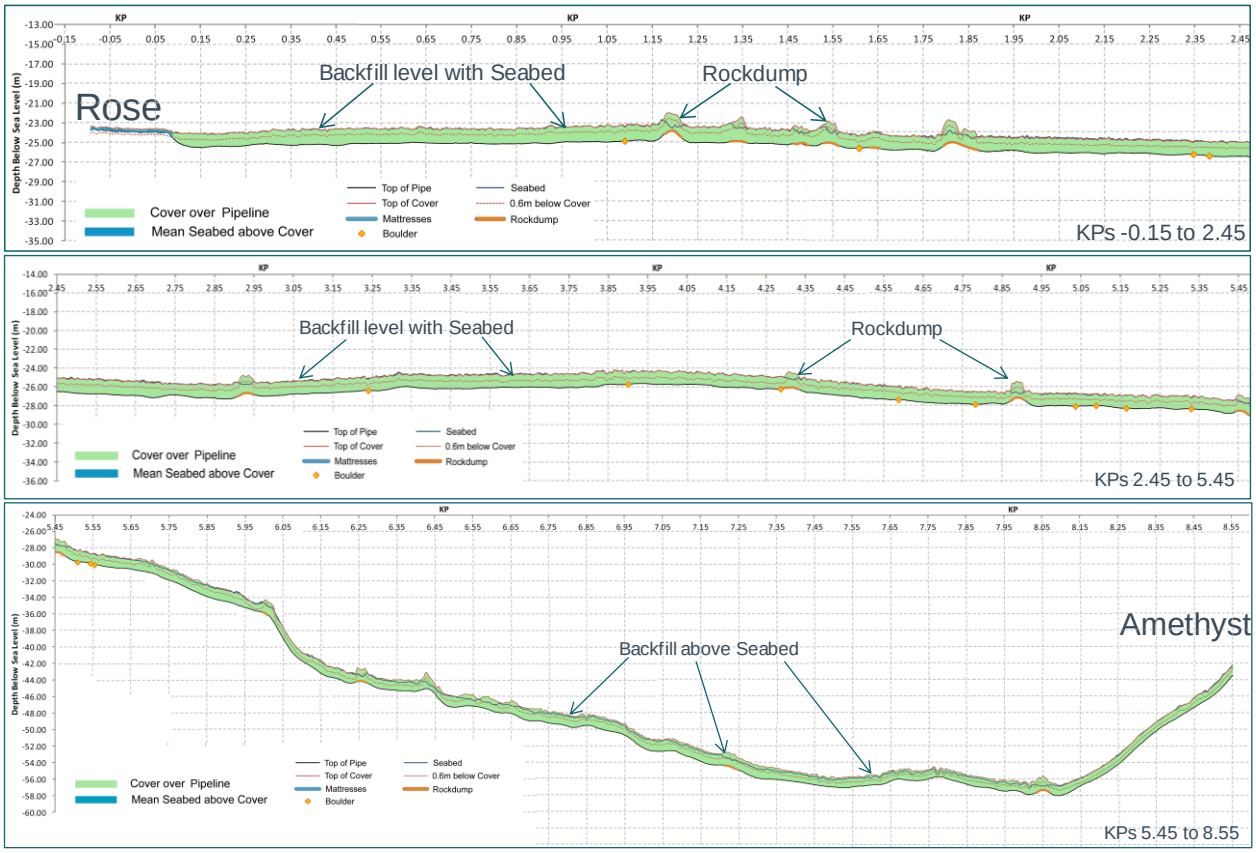


Figure 9: Pipeline trench profile (2012 survey data)

From the 2012 survey data it is clear that the pipeline has remained sufficiently buried throughout life. All rock emplacements are also in the same position as shown in the as-built alignment sheets. All of this suggests that the pipeline has been undisturbed throughout operation. Due to the stable nature of the pipeline position the partial removal option has been included as part of the Comparative Assessment process.

The as-built alignment sheets show 18 specific rock emplacement locations. Table 25 below shows the length and location of the emplacements as specified in the as-built alignment sheets.

Start KP	End KP	Length (m)
1.186	1.225	39
1.329	1.368	39
1.473	1.505	32
1.533	1.572	39
1.636	1.67	34
1.801	1.878	77
2.92	2.954	34
4.305	4.351	46
4.879	4.913	34
5.454	5.494	40
6.008	6.04	32
6.252	6.285	33
6.428	6.47	42
7.218	7.255	37
8.043	8.077	34
8.553	8.586	33
8.674	8.718	44
8.792	8.825	33

Table 25: Pipeline rock emplacements

Appendix A.2 Umbilical – Burial Profile & Midline Mattresses

Rose umbilical survey data from 2012 is presented in Figure 10, Figure 11 and Figure 13 below, with cut locations marked. KP0 is located at the top of the J-tube on the Amethyst A2D platform, with KP increasing heading east. The survey data does not extend into the A2D platform 500m exclusion zone. There is varying depth of cover along the length of the umbilical, with some sections within the first 3.5km of shallow cover. However, there are no exposures along the length, even where the top of the umbilical is higher than the adjacent seabed (e.g. at around KP1.45, more detail shown in Figure 11), and an interrogation of historical survey data has shown that the seabed has been stable over a number of years. The four buried midline mattresses are also shown Figure 14 and Figure 15.

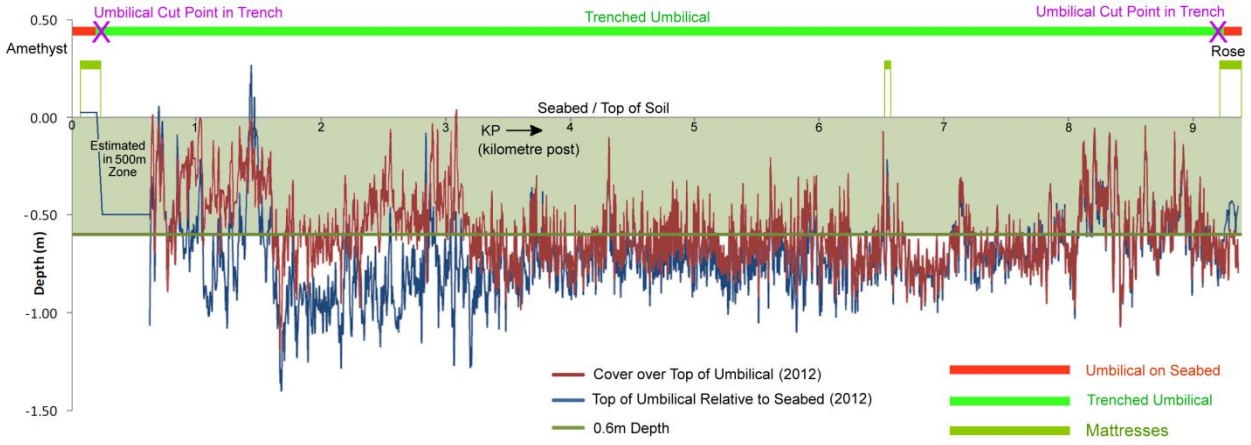


Figure 10: Umbilical burial profile – condensed[3]

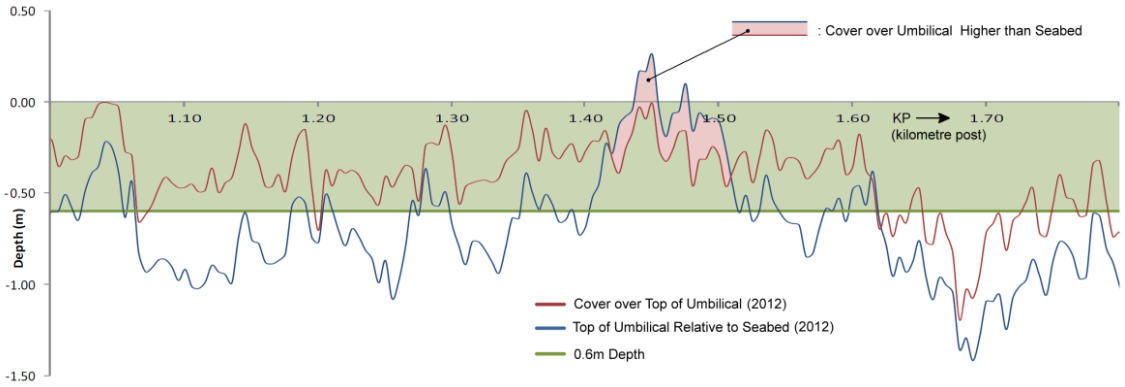


Figure 11: Umbilical burial profile @ KP1.45[3]

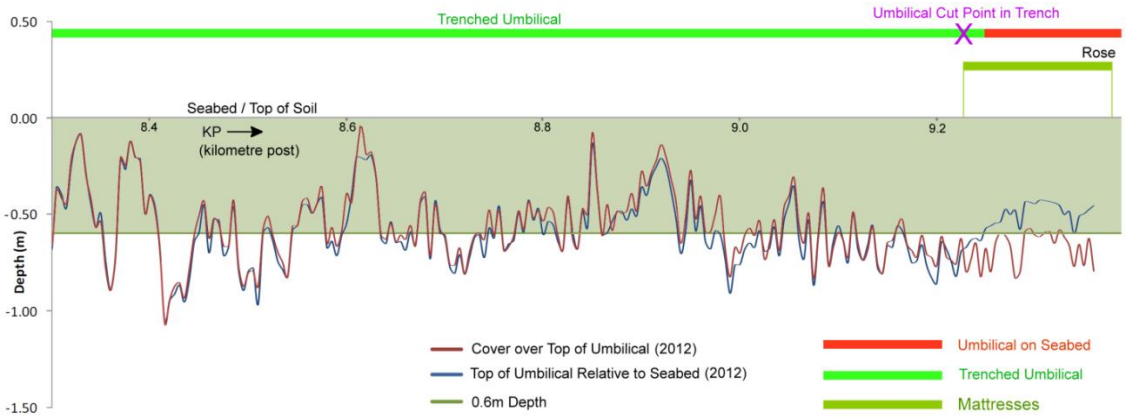


Figure 12: Umbilical burial profile at Rose well end[3]

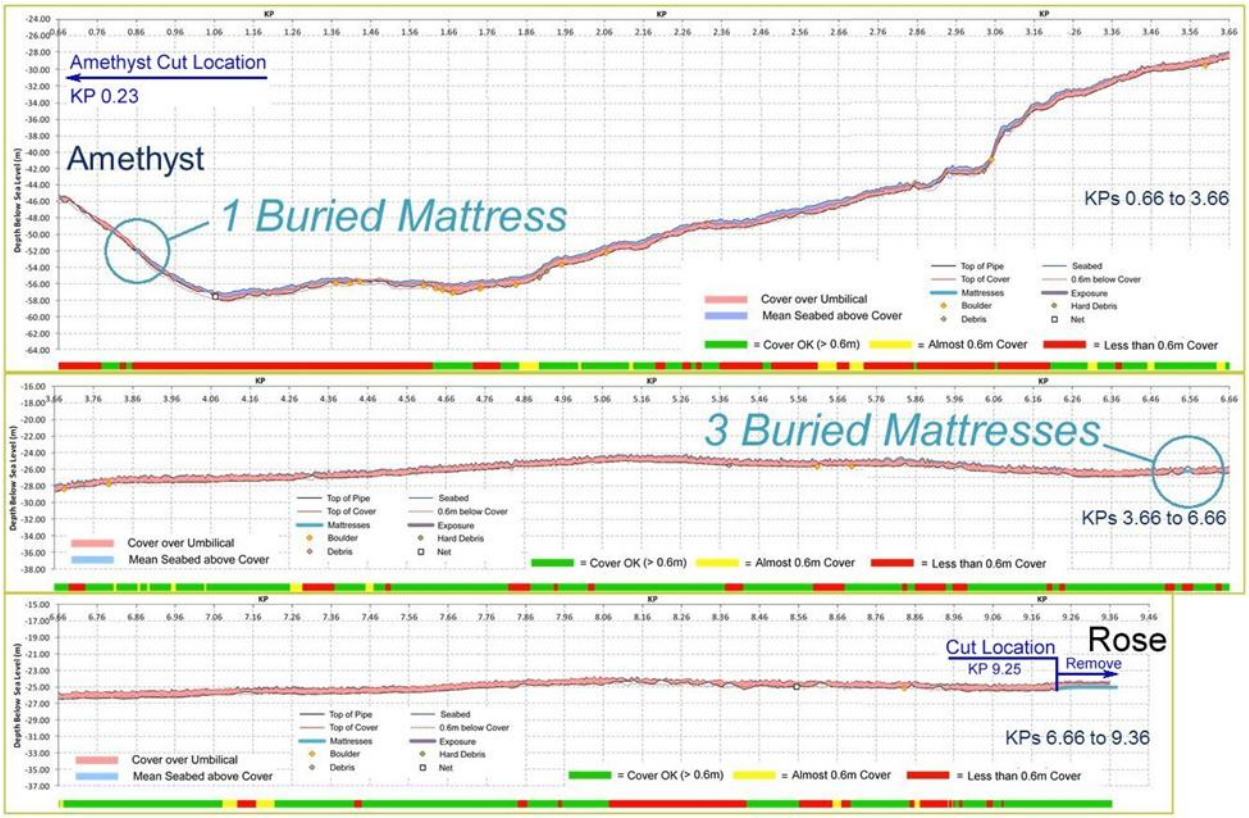


Figure 13: Umbilical trench profiles (2012 survey data)

The 2012 survey data shows that a degree of natural backfill has occurred throughout the trenched section. However, unlike the pipeline in some areas the trench has not been completely backfilled. Approximately 40% of the umbilical is not backfilled to a depth greater than or equal to 0.6m. The least consistent area of burial occurs within the first 3.5km of the route from the Amethyst platform end. In this region the umbilical sits within the deeper waters of the Silver Pit recommended Marine Conservation Zone where the current velocities are anticipated to be smaller and the seabed appears less mobile, making it less likely for natural backfilling to occur. While the trench is not as consistently backfilled as the pipeline, the umbilical is buried and it has been operating with this level of cover since installation. Therefore, a case can be made for leaving most of the umbilical *in situ* without remediation work.

Independently of the protection mattresses placed at the platform and wellhead ends, mattresses have been placed at two separate locations along the midline of the umbilical. These mattresses have been placed in areas of shallow trench depth. Figure 14 and Figure 15 show the 2012 bathymetry data with the locations of the mattresses highlighted. The anomaly shown in the dotted circle in Figure 14 is recorded in the survey data to be a net [9].

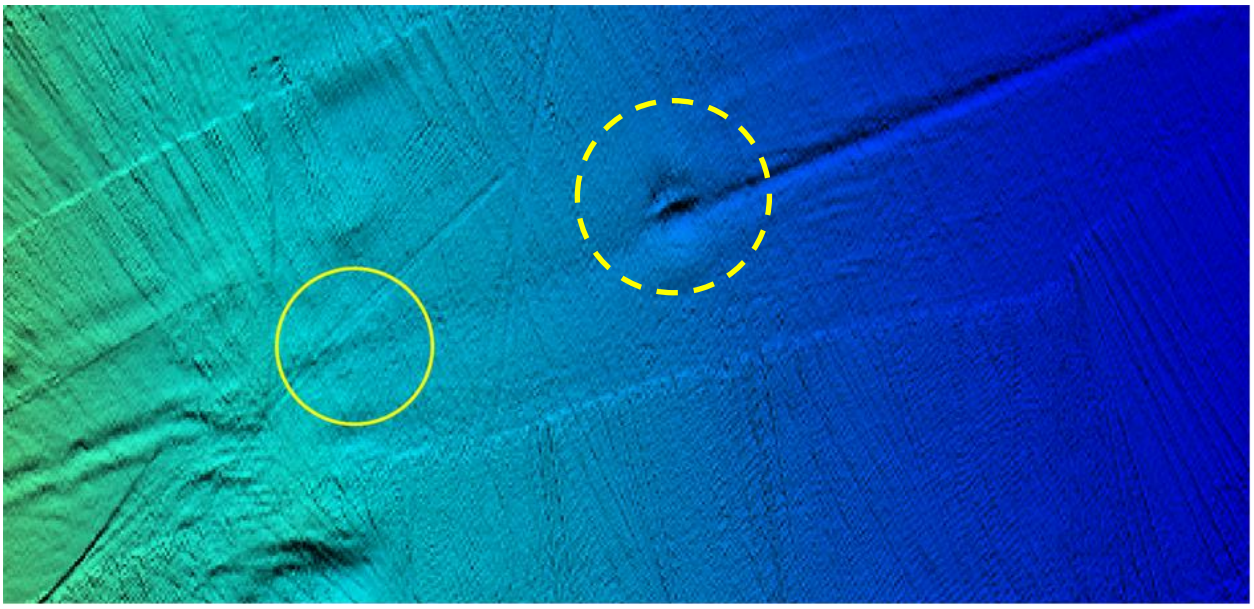


Figure 14: One midline mattress at KP 0.86 (2012 bathymetry plot)

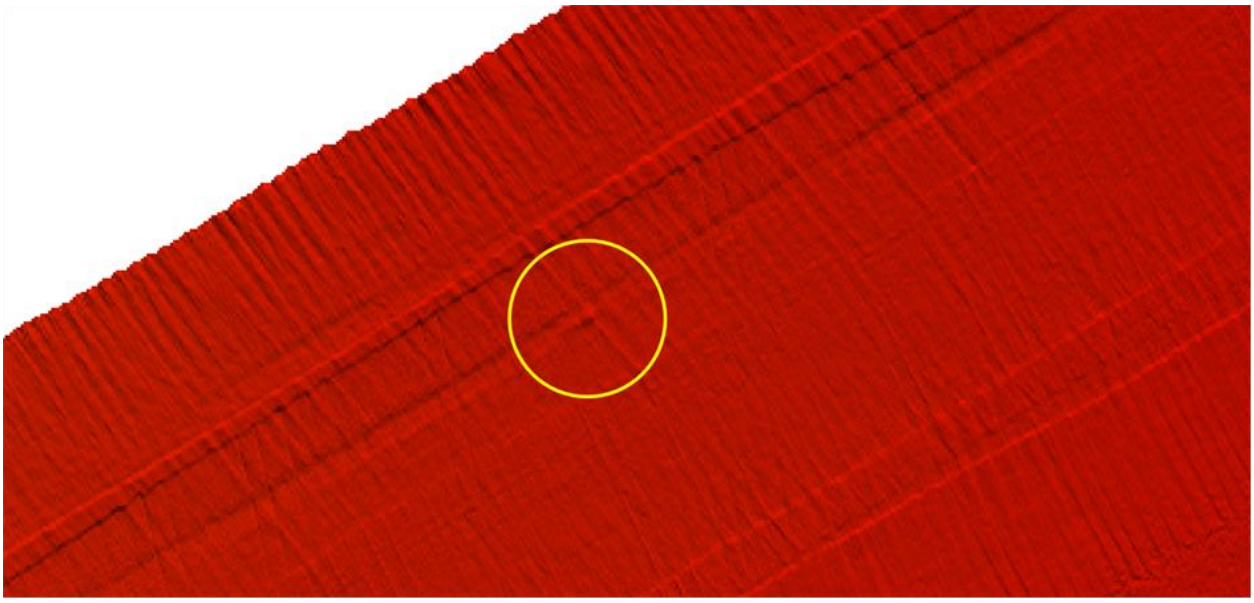


Figure 15: Three midline mattresses at KP 6.56 (2012 bathymetry plot)

In the images above the mattresses are not visible at their specified locations. This would suggest that the mattresses have become buried. Therefore if the umbilical was left *in situ*, the removal of the mattresses may require remediation of the excavation.

Potential snagging hazards in the future are expected to be unlikely as the predominant type of fishing in the area is static line rather than trawling.

APPENDIX B PIPELINE AND UMBILICAL STABILISATION FEATURES

Appendix B.1 Pipeline and Umbilical Overview

Figure 16 shows the 2012 bathymetry plot of the Rose pipeline and umbilical. It extends from the Rose wellhead to the edge of the Amethyst A2D platform 500m exclusion zone. A number of more detailed sections are also shown in Figure 17 to Figure 20. The plots provide an impression of the level of backfill within the pipeline and umbilical trenches as well as any areas of debris and rock emplacement along the lines.

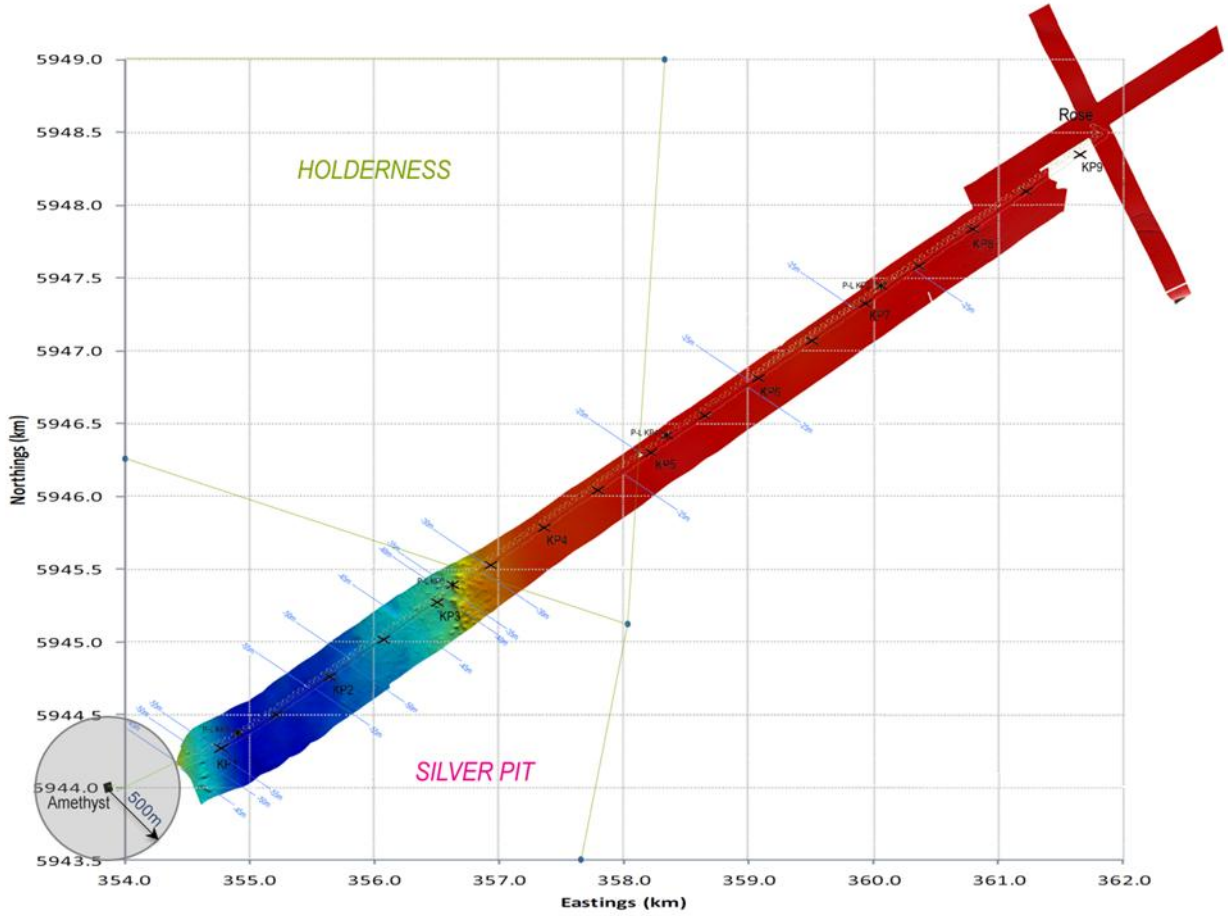


Figure 16: 2012 bathymetry plot

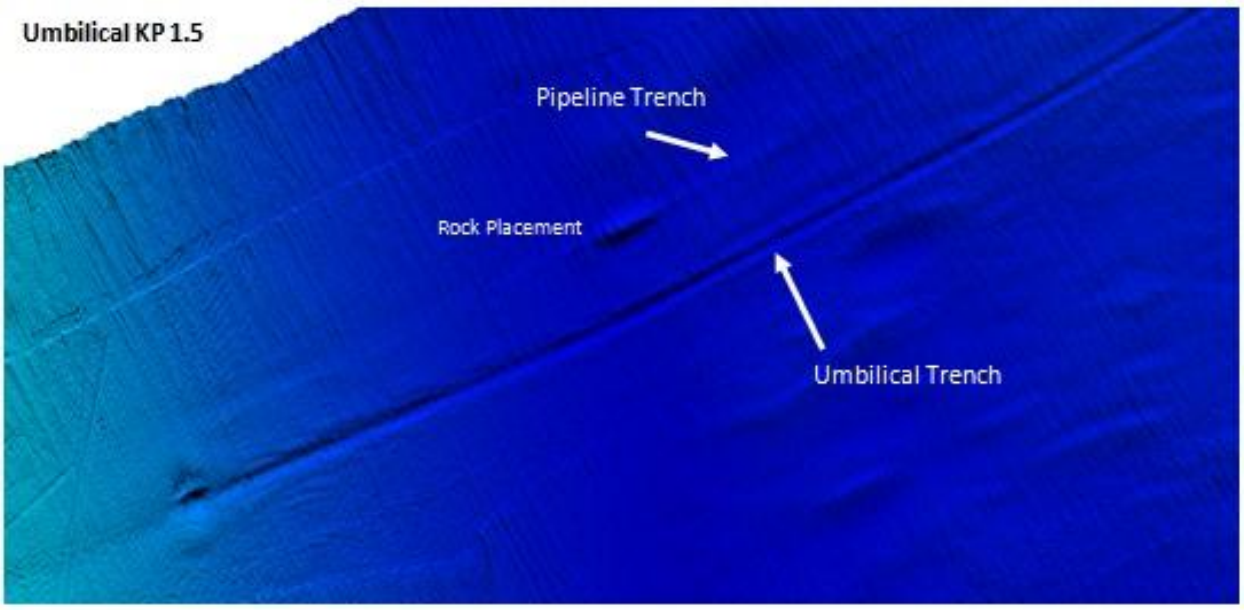


Figure 17: Umbilical trench at KP 1.5 (2012 bathymetry plot)

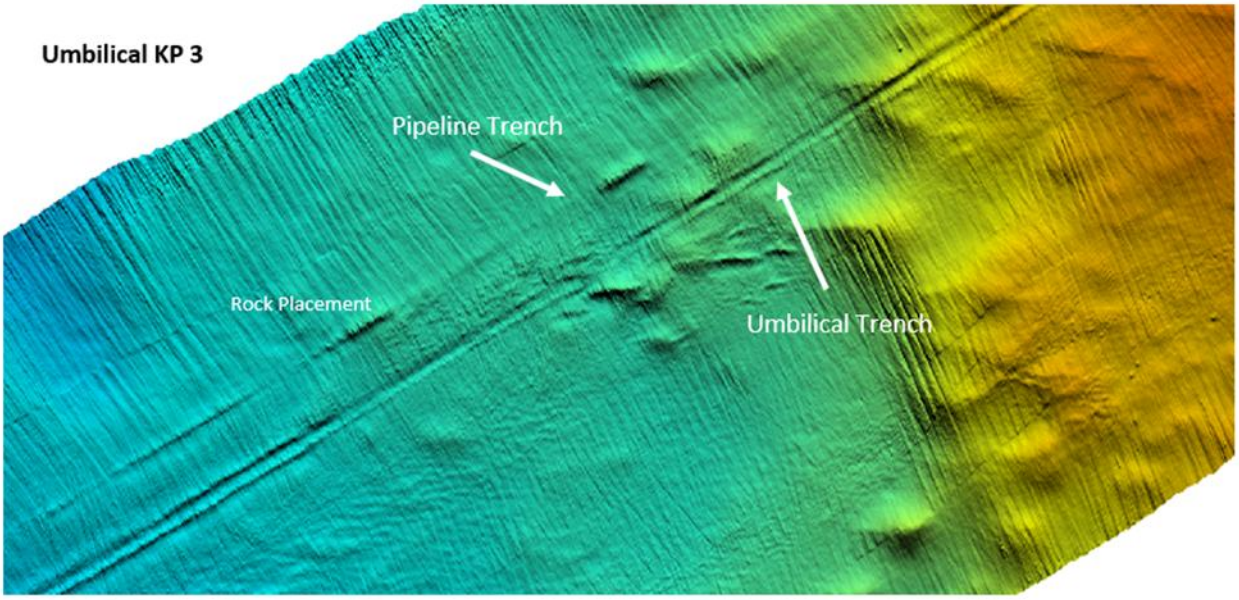


Figure 18:– Umbilical trench at KP 3 (2012 bathymetry plot)

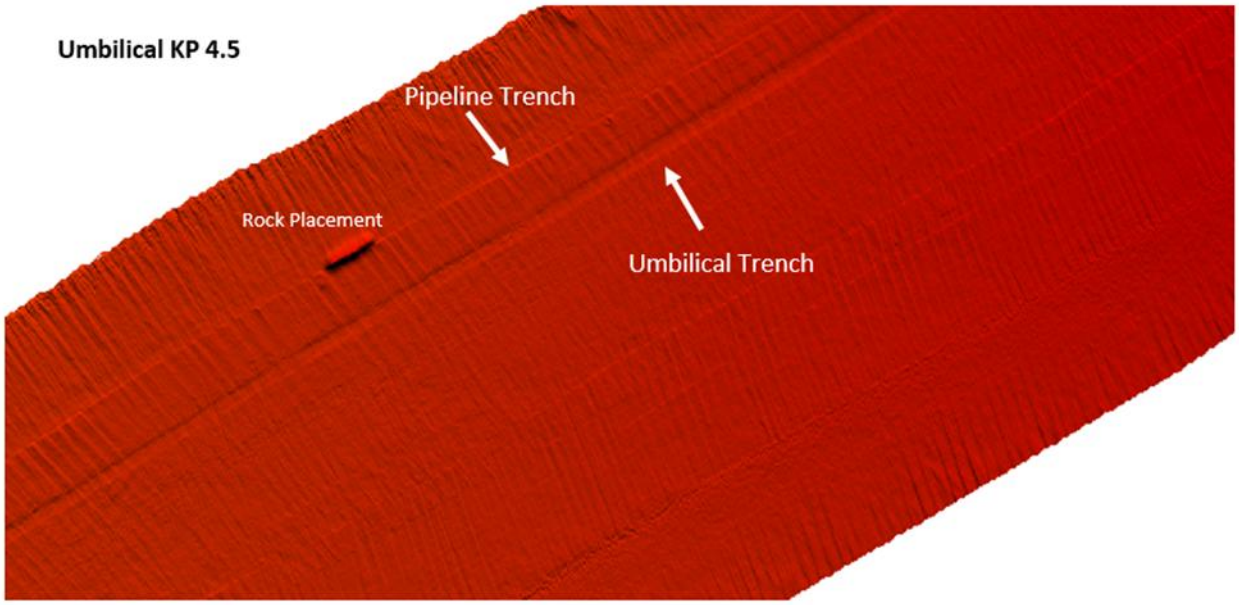


Figure 19: Umbilical trench at KP 4.5 (2012 bathymetry plot)

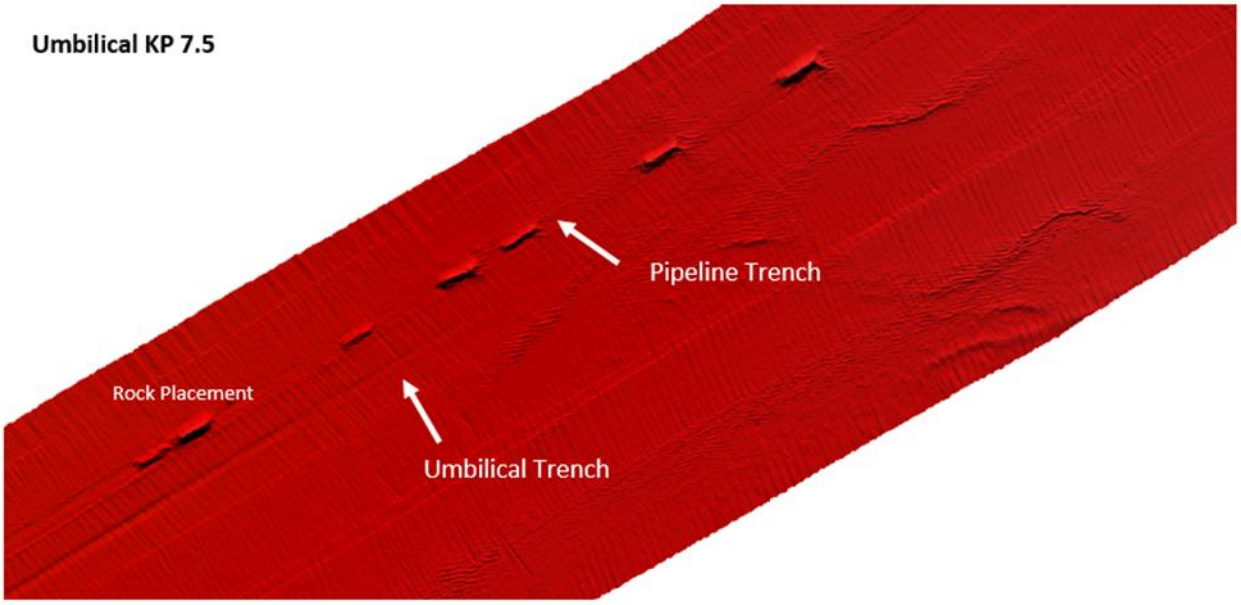


Figure 20: Umbilical trench at KP 7.5 (2012 bathymetry plot)

APPENDIX C OPTION SELECTION

A number of plausible options were identified for the decommissioning of the Rose umbilical and a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis was undertaken to assess these options. This was undertaken as a high level screening exercise to determine which options would be taken forward to the full Comparative Assessment. Every option would require the removal of the unburied end sections of umbilical and mattresses at the Rose wellhead and the Amethyst A2D platform approaches, but the approach varied in the decommissioning the trenched section of the umbilical.

Options to be assessed by SWOT were identified as follows:

Complete removal – Complete removal of the umbilical via reverse reel out of trench.

Partial removal (ends only) – Majority of the umbilical left *in situ* underneath existing burial cover. Umbilical ends cut and removed at the trench transitions where the umbilical is determined to have reached an acceptable depth below the seabed.

Partial removal (rock emplacement) – Majority of the umbilical left *in situ* underneath existing burial cover. Umbilical ends cut and removed at the trench transitions where the umbilical is determined to have an acceptable depth below the seabed. Rock will placed over approximately 40% of the line where the depth of burial is less than 0.6m.

Partial removal (midline cutting) – Majority of the umbilical left *in situ* underneath existing burial cover. Umbilical ends cut and removed at the trench transitions where the umbilical is determined to have reached an acceptable depth below the seabed. Sections with shallow cover will be exposed and cut, then removed. The remaining ends will be made safe with jetting or graded rock placement.

Partial removal (jetting) – Majority of the umbilical left *in situ* underneath existing burial cover. Umbilical ends cut and removed at the trench transitions where the umbilical is determined to have reached an acceptable depth below the seabed. Sections with shallow cover will be remediated by jetting to increase the depth of trench.

The SWOT analysis was not intended to be an exhaustive list of all issues pertinent to each potential option, but rather a record of the salient points in deciding which options to take on to the Comparative Assessment stage. The SWOT analysis can be seen in Table 26.

The Rose pipeline was not included within the SWOT analysis as the trenching was deemed sufficient to preclude further analysis (as discussed in Appendix B.1, above).

			OPTIONS WHICH INVOLVE WORKS ON THE ~40% OF THE UMBILICAL WHICH IS LESS THAN 0.6 M BURIED		
	COMPLETE REMOVAL	PARTIAL REMOVAL (ENDS ONLY)	PARTIAL REMOVAL (ROCK PLACEMENT)	PARTIAL REMOVAL (MID-LINE CUTTING)	PARTIAL REMOVAL (JETTING)
STRENGTHS	No legacy issues - snagging concerns eliminated, no remedial work No further survey requirements to asses exposure of pipe (but anticipated to be relatively minor effect) Legacy costs savings due to avoidance of need for any future remedial work to eg re-bury or remove line Reputation enhanced as nothing left Employment to carry out the work - offshore activities Employment - onshore - waste disposal Limited diving time - associated with ends only - lower risk Continuous decommissioning operation No exposure to changes in current legislation	Potentially cheapest option Best environmental option: least seabed disturbance, shortest vessel duration, least non recyclable waste to shore - least noise Best safety option both onshore (material not needing handling and offshore (shortest vessel time) Least technical risk	Potential snagging hazards eliminated	Not adding to the seabed Does recover some "lost" material Removes any doubt about mid-line exposures - no snagging hazards	Not adding to the seabed No landfill No diving time
WEAKNESSES	High safety risk due to duration of vessels working Level of environmental disturbance - high sensitivity of the area May be most expensive option - based estimate info for Stamford High energy use and emissions due to long vessel duration Onshore waste handling including some going to landfill Onshore safety risk - handling waste materials Potential short term impact on fishing activities - static fishing activities Removal activities are potentially bad for herring spawning High traffic area - may be an issue with long vessel times	Potential legacy issues - at least 2 post decomm surveys Potentially biggest legacy risk to other users of the sea Perceived reputation issues as this option is the minimum possible effort Lowest recovery of materials Not investing in the local economy through provision of work Potentially 40% of the umbilical left with limited levels of cover Need to carry out more engineering work to confirm option is viable	Use of resources - rock - potentially 3.5km of rock required (40%) Smothering of benthos - blanket rock will cover a relatively large area Perceived reputation - use of rock placement is adding material to seabed Safety risks associated with rock emplacement process - onshore quarry Energy associated with rock emplacement process? - onshore quarry	Most diving involved - hence probably highest safety risk Umbilical needs to be exposed before cutting in two locations for each cut. Exposed ends vulnerable to future snag, so corrective measures required. Multiple diving ops, safety, emissions etc. Long length of umbilical to be - retrieved, maybe easier to remove entirely. Up to approx 100 cut locations Expensive - lots of DSV time Instantaneous discharge from exposed umbilical ends particularly lifted sections	Very disruptive to the seabed - environmental impact Requires umbilical exposure in order to then bury it No recovered material
OPPORTUNITIES	Enhanced opportunity for recycling (because umbilical includes ballast wire)	Explore option with fishermen - leave in place may be seen as attractive	Potential use of locally dredged material (nearby aggregates areas)? Use of local equipment (dredging) to perform backfilling? Explore option with stakeholders - fishermen	Potential to place limited amounts of rock locally with DSV - more accurate	
THREATS	Likely to be the highest technical risk - reeling operation on buried line Reverse reeling umbilical with ballast wire - addtional complexity	May have to do remedial work in future Potential future developments (technology or legislation) may mean further work required	Desired rock profile may result in crown of placed rock being above seabed - issue with consents, given relatively shallow water in some areas of route?		May not work - jetting may not result in the umbilical becoming sufficiently - buried
Appraisal of options	Mixture of positives and negatives. Requires further investigation by Comparative Assessment	Mixtrure of positives and negatives. Requires further investigation by Comparative Assessment	Does not appear a reasonable approach however may be viable if extent of rock placement is limited, ie as a hybrid of the "Leave-in-situ, No Intervention" option	Not preferred. Placement of rock preferable if mitigation work is needed	Not preferred. Placement of rock preferable if mitigation work is needed

Table 26: Umbilical decommissioning options - SWOT Analysis

After the population of the SWOT table, the following options were discarded prior to the Comparative Assessment stage:

Partial removal (midline cutting) – The amount of diving involved in this option gave rise to concerns over safety and cost. Furthermore, the requirement to make the exposed ends safe would result in rock emplacement, making this option very unlikely to be preferable to partial removal (rock emplacement).

Partial removal (jetting) – This option resulted in the largest disturbance to the seabed, as significant amounts of sediment would be dispersed. The option may not work as jetting will expose the umbilical, and may not leave it sufficiently buried.

The following options were retained for the Comparative Assessment:

Complete removal

Partial removal (ends only)

Partial removal (rock emplacement)

A further option was added after the SWOT had taken place:

Partial removal (3.5km removal) – The first 3.5km of the umbilical from the Amethyst A2D platform end within the Silver Pit area removed via reverse reeling process. The umbilical end at the Rose wellhead is cut and removed at the trench transition where the umbilical is determined to have reached an acceptable depth below the seabed. The remainder of the umbilical remains *in situ* underneath existing burial cover.

APPENDIX D COMPARATIVE ASSESSMENT TABLES

The following section details the numerical comparative assessment made between decommissioning options. Scores for sub sub-criteria are in accordance with Centrica guidance notes. Sub-criteria scores are calculated by taking the average of each constituent sub sub-criterion. Criteria scores are calculated by taking the average of each constituent sub sub-criterion (as opposed to the average of each sub-criterion). Numerical scores were derived qualitatively, and are not to be used prescriptively, but rather are given to guide the overall decision by providing an indication of the broad level of acceptability of each sub-criterion.

Sub sub-criteria are “greyed” when they are not a differentiator.

The assessment was carried out in accordance with the Centrica Comparative Assessment Guidance [4]. Safety criteria were assessed with the HSE Risk Matrix, Environmental and Societal criteria were assessed with the Environmental Impact Matrix and the Technical Criteria was assessed with the Project Risk Assessment Matrix.

Appendix D.1 Pipeline Safety

Criterion	Sub Criteria	Activity	Component activity	Issues associated with main activity	Impact	Mitigation	Option 1 - Complete Removal			Option 2 - Partial Removal		
							Post Mitigation			Post Mitigation		
							Impact Rating	Probability Rating	Rating	Impact Rating	Probability Rating	Rating
Safety	Safety risk offshore project personnel	Diving	Rigging of items to be lifted Cutting of pipeline ends	Loss of DP	Diver looses connection with vessel.	Follow DP certification and operation procedures						
				Hydrocarbon or hazardous substance release	Contamination of diver.	Pipeline cleaned before spools disconnected, pig trap residue will be bagged and sealed. Follow procedures.	1	2	3	1	1	1
				Dropped objects	Diver hit with equipment or debris	Follow procedures to ensure divers are not in high risk zones during lifts and all deck equipment is safely fastened						
				Cutting	Diver injury due to cutting, debris, faulty equipment	Follow procedures, ensure equipment is suitable and in good repair	2	1	4	2	2	8
		Lifts	Pipeline End Lifts	Deck handling	Personnel hit with equipment or debris.	Follow procedures to ensure safe handling and clear lift areas						
		Reverse Reeling	Pick up pipe and spool on Unspooling of pipe	Pipeline failure, large energy release	Uncontrolled heavy object on or near vessel	Pipeline condition evaluation. Follow procedures, ensure vessel and reel equipment are suitable and in good repair	5	1	19	0	0	0
		Other	General Vessel Activities	Risk of collision with installation due to requirement of vessels working within 500m zone	Damage to installation and potential injury	Follow procedures, ensure vessels are suitable and in good repair. Minimise sim ops						
			All	Adverse Weather	All activities become more hazardous	Adhere to clear weather windows, determined for each vessel and activity	1	3	6	1	2	3
			Ongoing inspection activities	Risks associated with vessel in water	Risks associated with vessel in water	Adhere to existing procedures	0	0	0	1	2	3
		Subtotal							32			15
		Subtotal (Average)							6.4			3.0
	Safety risk to mariners	Snagging	Snagging on pipeline (if it becomes exposed)	Fishing gear irretrievably snagged on wellhead	Possible capsizing of fishing vessel.	Guard vessel stationed after protection structure removed						
				Fishing gear irretrievably snagged on pipeline	Possible capsizing of fishing vessel.	Ongoing surveys to ensure pipeline remains buried. Remedial work if pipeline becomes exposed.	0	0	0	3	1	10
		Subtotal							0			10
		Subtotal (Average)							0			10
	Safety risk onshore project personnel	Disposal of hydrocarbons and hazardous waste	Disposal of NORM/Hg in pipeline	Unplanned contact with hazardous material	Contamination of onshore personnel	Appropriate precautions will be taken for NORM/Hg						
		Onshore Cutting	Dismantling of pipeline sections	Cutting	Injury due to cutting, debris, faulty equipment	Follow procedures, ensure equipment is suitable and in good repair	2	3	12	2	2	8
		Lifts	Lifts from port to transit	Lift handling	Personnel hit with equipment or debris.	Follow procedures to ensure safe handling and clear lift areas	3	2	13	3	1	10
		Subtotal							25			18
		Subtotal (Average)							12.5			9
	Subtotal (Average of all Sub criteria)								6.3			7.2
	Subtotal (Average of all Sub-Sub criteria)								**7.1**			**5.4**

Appendix D.2 Pipeline Environmental

Sub criteria	Interaction with the environment (Evaluation Criteria)	Detailed Activity (s)		Differentiators	Assumptions	Option 1 (Complete Removal)			Rationale	Option 2 (Partial Removal)			Rationale
						Consequence	Duration	Scr		Consequence	Duration	Scr	
1	Liquid discharge to sea	Water Flushing	N/A	No difference	Assuming that the same level of cleanliness is required for both leave in situ and recovery. This might not be the case, depending on the disposal route, handling requirements (occupational health issues) and waste management requirements.								
		Chemical use	N/A	No difference	Assuming that the same level of cleanliness is required for both leave in situ and recovery. This might not be the case, depending on the disposal route, handling requirements (occupational health issues) and waste management requirements.								
		Lifting	N/A	Related to the number of sections or length of pipe recovered from the seabed. For complete removal the contents of the pipeline is anticipated to be released to sea during the recovery activities. For option 2 only the content of the sections of pipeline recovered and the end sections of the pipeline left in place will be released to the sea.	Greater number of lifts or a longer duration of lifting the end of the pipeline as it is reeled. All content will be released to sea which ever option is selected but over a different time frame.	1	4	8		1	2	3	
		Marine Growth - waste disposal	N/A	No difference	Assuming that the pipeline is completely buried and therefore not covered in marine growth.								
		Breaking containment	N/A	No difference									
		From vessels	N/A	Duration of vessels in the field is greater therefore the discharges are proportional to the duration in the field.	Discharges unlikely to be detectable.	1	4	8		1	2	3	
1	Liquid discharge to surface water	From waste treatment onshore	N/A	Proportional to the length of pipeline returned to shore.	Discharges of residual fluids onto the waste disposal site could include NORM or heavy metals.	2	4	16		2	2	5	
1	Noise in air	From onshore waste treatment and disposal	N/A	Proportional to the length of pipeline returned to shore.	Assuming the selected yard frequently undertakes cutting, therefore the noise isn't new to the surrounding area, but rather a continuation of the existing.	1	4	8		1	2	3	
1	Noise in water	Cutting	N/A	Proportional to the number of cuts.	Depends on the method used for complete recovery, assumes reverse reeling	2	3	7		2	2	5	
		Vessel use	N/A	Proportional to the duration and number of vessels in the field.	N/A	2	4	16		2	2	5	
1	Odour	Maine Growth	N/A	No difference	Assuming that the pipeline is completely buried and therefore not covered in marine growth.								
1	Resource use - Ecosystem disturbance	Disturbance of sediment	N/A	Proportional to the length of pipeline recovered.	This doesn't consider recovery time.	2	4	16	Seabed area disturbed is approx 0.1km^2	2	2	5	Seabed area disturbed is approx 0.002km2
1	Resource use - Physical area	Anchoring	N/A	No difference	Assuming pipeline removal vessel (DSV) is DP rather than anchored.								
		Landfill space	N/A	Proportional to the length of pipeline recovered, although the intention would be to recycle as much as possible, in line with the waste hierarchy.	N/A	2	3	7		2	2	5	
		Socioeconomic use	Removal of safety zone	No difference	No safety zone around the pipeline								
1	Subtotal							86				34	
	Relative change							1.0				1.0	
2	Liquid discharges to sea	Survey Vessels	N/A	Duration of vessels in the field is greater therefore the discharges are proportional to the duration in the field.	Discharges unlikely to be detectable.	1	2	3		1	3	6	
2	Noise in water	Survey Vessels	N/A	Proportional to the duration and number of vessels in the field.	N/A	1	2	3		2	3	7	
2	Subtotal							6				13	
	Relative change							1.0				2.2	
3	Gaseous Emissions to Air	Vessel movements (DSV)	Fuel Combustion	Difference in duration of vessel for removal	N/A	4301		5.1		4214		5	
		Vessel movements (supply, survey, standby)	Fuel Combustion	Difference in support vessels during removal	N/A								
		Vessel movements (survey)	Fuel Combustion	Difference in survey vessels for legacy	N/A								
		Waste Production	Power Generation	Difference in volume of waste returning to shore between options	N/A								
			Biodegradation	Difference in volume of waste returning to shore between options	N/A								
			Incineration	Difference in volume of waste returning to shore between options	N/A								
3	Subtotal							5				5	
	Relative change							1.0				1.0	
4	Resource use - Energy	Power generation	N/A	Proportional to the vessel use duration and the volume of waste sent to shore.	See separate calculation sheet.	56118		5.2		53723		5	
		Replacement of material not recovered	N/A	Proportional to the volume of material left in situ.	See separate calculation sheet.								
4	Subtotal normalised							5				5	

Appendix D.3 Pipeline Technical

		Technically Possible?	Issues (E.g. impact on Safety, Environment, Cost, Reputation and Schedule)	Complete Removal			Partial Removal		
				Severity of Impact	Likelihood of Occurrence	Rating	Severity of Impact	Likelihood of Occurrence	Rating
Technical	Technical Feasibility	Yes	Reverse Reeling - Uncertainties over pipeline buckling, and possibility of occurrence may significantly impact schedule and cost (and also limited safety, environmental and societal) Cut Exposed Sections - Limited, routine activity, no expected issues with soil	5	2	19	1	2	2
	Subtotal					19			2
	Subtotal (Average)					19.0			2.0

Appendix D.4 Pipeline Societal

Sub criteria	Interaction with the environment (Evaluation Criteria)	Detailed Activity (s)		Differentiators	Assumptions	Option 1 Complete Removal			Rationale	Option 2 Partial Removal			Rationale
						Consequence	Duration	Scr		Consequence	Duration	Scr	
Societal	Community and socio-economic interaction	Effects on commercial activities	Short term impact on fishing activities and long term impact on seabed	Duration of vessel activities	Assuming the pipeline is buried to below 0.6m and there has not been a history of spans and there are no significance spoil heaps left following overtrawable surveys.	2	3	7		2	2	5	
			Legacy Survey	N/A	Doesn't include transit time for all future surveys. Survey window can also be planned to minimise disturbance.	0	0	0		2	2	5	
		Employment	N/A	Greater number of jobs maintained, in line with greater vessel use duration and waste management requirements.	Assuming that it isn't within ullage of existing vessel availably and waste management capacity.	-1	-3	-6.0		-1	-2	-3.0	
		Communities or impact on amenities	N/A	No difference	Possible impacts on communities at disposal site. Unable to evaluate if this is positive or negative as the location has not been selected. Therefore assume no difference.								
Societal	Subtotal							1				7	

Appendix D.5 Pipeline Decommissioning Cost Estimate

	Complete Removal (£M)	Partial Removal (£M)
Cost	£6.23	£3.38
Subtotal Normalised	**5**	**2.7**

Appendix D.6 Pipeline Summary

Aspect	Sub-Criterion	Complete Removal	Partial Removal	Notes
Safety	Safety risk offshore project personnel	6.4	3.0	*Assessment to Centrica HSE Matrix*
	Safety risk to mariners	0.0	10.0	
	Safety risk onshore project personnel	12.5	9.0	
	SAFETY SCORE	**7.1**	**5.4**	*Mean of the 9 sub-sub criteria*
Environmental	Environmental impacts of operations	12.3	4.9	*Assessment to Environmntal Impact Matrix*
	Legacy environmental impacts	2.0	4.3	
	Gaseous emissions (CO_2)	5.1	5.0	
	Energy use (GJ)	5.2	5.0	*(normalised against 5)*
	ENVIRONMENT SCORE	**8.5**	**4.8**	*Mean of the 18 sub-sub criteria*
Technical	Technical feasibility	Feasible	Feasible	
	Technical uncertainty risk to safety, environment, cost & schedule	19.0	2.0	*Assessment to Centrica Project Matrix*
	TECHNICAL SCORE	**19.0**	**2.0**	
Societal	Effect on commercial fisheries	3.5	5.0	*Assessment to Environmntal Impact Matrix*
	Employment	-6.0	-3.0	*Negative value used to reflect positive effect*
	Communities	None	None	
	SOCIETAL SCORE	**1.0**	**7.0**	
Cost	Cost	5.0	2.7	*From Cost Estimate, normalised against 5*
	COST SCORE	**5.0**	**2.7**	
	OVERALL SCORE (Mean of all values)	**8.1**	**4.4**	*Mean of all major criterion scores*

Appendix D.7 Umbilical Safety

Criterion	Sub Criteria	Activity	Component activity	Issues associated with main activity	Impact	Mitigation	Complete Removal			Option 2 - Partial Removal			Option 3 - Partial Removal (Rock Placement)			Option 4 - Partial Removal (3.5km)		
							Post Mitigation			Post Mitigation			Post Mitigation			Post Mitigation		
							Impact Rating	Probability Rating	Rating	Impact Rating	Probability Rating	Rating	Impact Rating	Probability Rating	Rating	Impact Rating	Probability Rating	Rating
Safety	Safety risk offshore project personnel	Diving	Rigging of items to be lifted Cutting umbilical ends	Loss of DP	Diver looses connection with vessel.	Follow DP certification and operation procedures												
				Hazardous substance release	Contamination of diver.	Umbilical flushed before being cut. Follow procedures.												
				Dropped objects	Diver hit with equipment or debris	Follow procedures to ensure divers are not in high risk zones during lifts and all deck equipment is safely fastened												
				Cutting	Diver injury due to cutting, debris, faulty equipment	Follow procedures, ensure equipment is suitable and in good repair												
		Lifts	Umbilical ends lifts	Deck handling	Personnel hit with equipment or debris.	Follow procedures to ensure safe handling and clear lift areas	0	0	0	2	2	8	2	2	8	2	2	8
		Reverse Reeling	Load on reel Pick up umbilical and spool on Unspooling of umbilical	Drop umbilical	Uncontrolled heavy object leaving vessel	Follow procedures, ensure vessel and reel equipment are suitable and in good repair	2	3	12	0	0	0	0	0	0	2	3	12
		Chemical Release	Open end of umbilical on deck leaking chemicals	Personnel exposed to hazardous chemicals	First aid injury	Standard working procedures, PPE												
		Other	All	Adverse Weather	All activities become more hazardous	Adhere to clear weather windows, determined for each vessel and activity	1	3	6	1	2	3	1	2	3	1	3	6
			Ongoing inspection activities	Risks associated with vessel in water	Risks associated with vessel in water	Adhere to existing procedures	0	0	0	1	2	3	1	2	3	1	2	3
		Subtotal							18			14			14			29
		Subtotal (Average)							4.5			4			4			7
	Safety risk to mariners	Snagging	Snagging on umbilical (if it becomes exposed)	Fishing gear irretrievably snagged	Possible capsizing of fishing vessel.	Ongoing surveys to ensure umbilical remains buried. Remedial work if umbilical becomes exposed.	0	0	0	3	1	10	3	1	10	3	1	10
		Subtotal							0			10			10			10
		Subtotal (Average)							0			10			10			10
	Safety risk onshore project personnel	Onshore Cutting	Dismantling of umbilical	Cutting	Injury due to cutting, debris, faulty equipment	Follow procedures, ensure equipment is suitable and in good repair	1	3	6	1	2	3	1	2	3	1	3	6
		Lifts	Lifts from port to transit	Lift handling	Personnel hit with equipment or debris.	Follow procedures to ensure safe handling and clear lift areas	1	3	6	1	2	3	1	2	3	1	3	6
		Chemical Release	Removed umbilical in yard leaking chemicals	Personnel exposed to hazardous chemicals	First aid injury	Standard working procedures, PPE	1	3	6	1	2	3	1	2	3	1	3	6
		Subtotal							12			6			6			12
		(Average of all Sub-subtotals)							6			3			3			6
	Subtotal (Average of all Sub-Sub criteria)								**4.5**			**4.1**			**4.1**			**7.1**

Appendix D.8 Umbilical Environmental

Sub criteria	Interaction with the environment (Evaluation Criteria)	Detailed Activity (s)		Differentiators	Assumptions	Option 1 (Complete Removal)			Rationale	Option 2 (Partial Removal)			Rationale	Option 3 (Partial Removal (Rock Placement))			Rationale	Option 4 (Partial Removal (3.5km))			Rationale
						Consequence	Duration	Scr		Consequence	Duration	Scr		Consequence	Duration	Scr		Consequence	Duration	Scr	
1	Liquid Discharge to Sea	Lifting	N/A	No difference	Umbilical will be capped so no discharge in addition to the discharge at the time of cutting and capping.																
		Marine Growth - waste disposal	N/A	No difference	Assuming that the umbilical is completely buried and therefore not covered in marine growth.																
		Breaking containment	N/A	No difference																	
		From vessels	N/A	Duration of vessels in the field is greater therefore the discharges are proportional to the duration in the field.	Discharges unlikely to be detectable.	1	4	8		1	2	3		1	2	3		1	2	3	
1	Liquid discharge to surface water	From waste treatment onshore	N/A	Proportional to the length of umbilical returned to shore.	Discharges of residual fluids onto the waste disposal site. Umbilical may contain residual chemicals.	2	1	2	Seepage/cleaning from umbilical likely to be short-term.	1	1	1		1	1	1		2	1	2	Seepage/cleaning from umbilical likely to be short-term.
1	Noise in air	From onshore waste treatment and disposal	N/A	Proportional to the length of umbilical returned to shore.	Assuming the selected yard frequently undertakes cutting, therefore the noise isn't new to the surrounding area, but rather a continuation of the existing.	1	2	3		1	1	1		1	1	1		1	2	3	
1	Noise in water	Cutting	N/A	Proportional to the number of cuts.	Depends on the method used for complete recovery. Assumed reel vessel to be used therefore cuts minimal.																
		Vessel use	N/A	Proportional to the duration and number of vessels in the field.	N/A	1	2	3		1	1	1		1	1	1		1	1	1	
1	Odour	Marine Growth	N/A	No difference	Assuming that the umbilical is completely buried and therefore not covered in marine growth.																
1	Resource use - Ecosystem disturbance	Disturbance of sediment	N/A	Proportional to the length of umbilical recovered.	Assumed recovery within 2 years.	2	2	5	Seabed area disturbed is approx 0.1km^2	1	1	1	Seabed area disturbed is approx 0.004km^2	2	2	5	Seabed area disturbed is approx 0.035km^2	2	2	5	Seabed area disturbed is approx 0.035km^2
1	Resource use - Physical area	Anchoring	N/A	No difference	Assuming umbilical removal vessel (DSV) is DP rather than anchored.																
		Landfill space	N/A	Proportional to the length of umbilical recovered, although the intention would be to recycle as much as possible, in line with the waste hierarchy.	N/A	2	3	7		1	1	1		1	1	1		2	2	5	
1	Subtotal							28				8				12				19	
Subtotal Averaged								7				2				3				5	
2	Liquid discharges to sea	Survey Vessels	N/A	Duration of vessels in the field is greater therefore the discharges are proportional to the duration in the field.	Discharges unlikely to be detectable.	0	0	0		1	3	6		1	3	6		1	3	6	
2	Noise in water	Survey Vessels	N/A	Proportional to the duration and number of vessels in the field.	N/A	0	0	0		1	3	6		1	3	6		1	3	6	
2	Subtotal							0				12				12				12	
Subtotal Averaged								0				3				3				3	
3	Gaseous Emissions (Tonnes)	Hydrocarbon Management	Breaking containment	No difference	N/A																
		Power Generation	Fuel Combustion	No difference	N/A																
		Vessel movements (DSV)	Fuel Combustion	Difference in duration of vessels for removal	N/A	661		5		670		5		964		7		730		6	
		Vessel movements (supply, survey, standby)	Fuel Combustion	Difference in support vessels during removal	N/A																
		Vessel movements (survey)	Fuel Combustion	Difference in survey vessels for legacy	N/A																
		Waste Production	Power Generation	Difference in volume of waste returning to shore between options	N/A																
			Biodegradation	Difference in volume of waste returning to shore between options	N/A																
			Incineration	Difference in volume of waste returning to shore between options	N/A																
3	Subtotal							5				5				7				6	
Subtotal Averaged								1				1				1				1	
4	Resource use - Energy	Power generation	N/A	Proportional to the vessel use duration and the volume of waste sent to shore.	See separate calculation sheet.	8621		5		8551		5		12430		7		9407		5	
		Replacement of material not recovered	N/A	Proportional to the volume of material left in situ.	See separate calculation sheet.																
4	Subtotal normalised							5				5				7				5	
	TOTAL							11				11				14				14	
	Subtotal Averaged							1				1				1				1	
TOTAL Averaged over all Sub Subcritical								3.8				3.0				3.9				4.2	

Appendix D.9 Umbilical Technical

		Technically Possible?	Issues (E.g. impact on Safety, Environment, Cost, Reputation and Schedule)	Complete Removal			Partial Removal			Partial Removal (Rock Placement)			Partial Removal (3.5km)		
				Severity of Impact	Likelihood of Occurrence	Rating	Severity of Impact	Likelihood of Occurrence	Rating	Severity of Impact	Likelihood of Occurrence	Rating	Severity of Impact	Likelihood of Occurrence	Rating
Technical	Technical Feasibility	Yes	Reverse Reeling - Gripping umbilical and pulling through seabed Recovery of Umbilical ends - There is nothing unusual or challenging about the work Placement of rock - If rock is not placed correctly could lead to further remediation works	2	2	5	1	1	1	1	1	1	2	2	5
	Subtotal					5			1			1			5
	Subtotal (Average)					5.00			1.00			1.00			5.00

Appendix D.10 Umbilical Societal

Sub criteria	Interaction with the environment (Evaluation Criteria)		Detailed Activity (s)	Differentiators	Assumptions	Option 1 Complete Removal			Rationale	Option 2 Partial Removal			Rationale	Option 3 Partial Removal (Rock Placement)			Rationale	Option 4 Partial Removal (3.5km)			Rationale
						Consequence	Duration	Scr		Consequence	Duration	Scr		Consequence	Duration	Scr		Consequence	Duration	Scr	
Societal	Community and socio-economic interaction	Effects on commercial activities	Short term impact on fishing activities and long term impact on seabed	Duration of vessel activities	Assuming the umbilical is buried and there has not been a history of spans and there are no significance spoil heaps left following overtrawable surveys.	2	3	7		2	2	5		2	2	5		2	2	5	
			Legacy Survey	N/A	Doesn't include transit time for all future surveys. Survey window can also be planned to minimise disturbance.	0	0	0		2	2	5		2	2	5		2	2	5	
		Employment	N/A	Greater number of jobs maintained, in line with greater vessel use duration and waste management requirements.	Assuming that it isn't within ullage of existing vessel availability and waste management capacity.	-1	-3	-6.0		-1	-2	-3.0		-1	-2	-3.0		-1	-3	-6.0	
		Communities or impact on amenities	N/A	No difference	Possible impacts on communities at disposal site. Unable to evaluate if this is positive or negative as the location has not been selected. Therefore assume no difference.																
Societal	Subtotal							1.0				7.0				7.0				4.0	

Appendix D.11 Umbilical Decommissioning Cost Estimate

	Complete Removal (£M)	Partial Removal (£M)	Partial Removal (Rock Placement) (£M)	Partial Removal (3.5km Removal) (£M)
Cost	£4.29	£2.63	£3.31	£3.92
Subtotal Normalised	**5**	**3.1**	**3.9**	**4.6**

Appendix D.12 Umbilical Summary

Aspect	Sub-Criterion	Complete Removal	Partial Removal (ends only)	Partial Removal (Rock Placement)	Partial Removal (3.5km Removal)	Notes
Safety	Safety risk offshore project personnel	5	4	4	7	
	Safety risk to mariners	0	10	10	10	
	Safety risk onshore project personnel	6	3	3	6	
	SAFETY SCORE	**4.5**	**4.1**	**4.1**	**7.1**	
Environmental	Environmental impacts of operations	5	1	2	3	
	Legacy environmental impacts	0	4	4	4	
	Gaseous emissions (CO_2)	5	5	7	6	
	Energy use (GJ)	5	5	7	5	
	ENVIRONMENT SCORE	**3.8**	**3.0**	**3.9**	**4.2**	
Technical	Technical feasibility	Feasible	Feasible	Feasible	Feasible	
	Technical uncertainty risk to safety, environment, cost & schedule	5.0	1.0	1.0	5.0	
	TECHNICAL SCORE	**5.0**	**1.0**	**1.0**	**5.0**	
Societal	Effect on commercial fisheries	3.5	5	5	5	
	Employment	-6	-3.0	-3.0	-6.0	
	Communities	None	None	None	None	
	SOCIETAL SCORE	**1**	**7**	**7**	**4**	
Cost	Cost	5	3.1	3.9	4.6	
	COST SCORE	**5**	**3.1**	**3.9**	**4.6**	
	OVERALL SCORE (Mean of all values)	**3.9**	**3.6**	**4.0**	**5.0**	*Mean of all major criterion scores*

Appendix D.13 Umbilical Midline Mattresses Safety

Criterion	Sub Criteria	Activity	Component activity	Issues associated with main activity	Impact	Mitigation	Option 1 - Complete Removal	Option 2 - Removal & Remediation	Option 3 - Leave In-Situ
Safety	Safety risk offshore project personnel	Diving	Removal of mattresses Rigging of items to be lifted Removal of burial material Remediation of area	Loss of DP	Diver looses connection with vessel.	Follow DP certification and operation procedures	Relatively limited number of diving hours, activities largely routine	As Complete Removal plus remedial activities (placement of graded rock in diver - placed sacks)	No diving activities
				Dropped objects	Diver hit with equipment or debris	Follow procedures to ensure divers are not in high risk zones during lifts and all deck equipment is safely fastened			
				Jetting	Diver injury due debris/ faulty equipment	Follow procedures, ensure equipment is suitable and in good repair			
		Lifts	Mattress Lifts - Multiple	Deck handling	Personnel hit with equipment or debris.	Follow procedures to ensure safe handling and clear lift areas	Four mattresses loaded onto deck	lete removal, plus deployment of gra	No lifting activities
		Other	All	Adverse Weather	All activities become more hazardous	Adhere to clear weather windows, determined for each vessel and activity	Less vessel time than removal and remediation	Longest duration therefore greatest chance of adverse weather	N/A
			Ongoing inspection activities	Risks associated with vessel in water	Risks associated with vessel in water	Adhere to existing procedures	All options relate to partial removal of umbilical for which legacy inspections will be required. Mattresses will form part of this		
	Safety risk to mariners	Snagging	Snagging on mid-line mattresses (if it becomes exposed)	Fishing gear irretrievably snagged	Possible capsizing of fishing vessel.	Ongoing surveys to ensure umbilical remains buried. Remedial work if mattresses becomes exposed.	Potential for snagging on remaining exposed umbilical. However post decommissioning approriate measure will be taken to ensure that there will be no potential snagging hazards for trawling.	Graded rock remediation will be subject to ensuring there are no resulting snagging hazards	Mattresses were placed to provide protection in areas of shallow trenching. Mattresses are covered and have been in place for a number of years with no history of snagging.
	Safety risk onshore project personnel	Onshore Disposal	Breaking up Mattresses	Use of heavy tools	Injury due to cutting, debris, faulty equipment	Follow procedures, ensure equipment is suitable and in good repair	Mechanised crushing of mattresses. Therefore, limited manual handling	As complete removal	N/A
		Lifts	Lifts from port to transit	Lift handling	Personnel hit with equipment or debris.	Follow procedures to ensure safe handling and clear lift areas	Small number of lifts, routine activity	As complete removal	N/A

Appendix D.14 Umbilical Midline Mattresses Environmental

Sub criteria	Interaction with the environment (Evaluation Criteria)	Detailed Activity (s)		Differentiators	Assumptions	Option 1 (Complete Removal)	Option 2 (Removal & Remediation)	Option 3 (Leave In Situ)
1	Liquid Discharge to Sea	From vessels	N/A	Duration of vessels in the field is greater therefore the discharges are proportional to the duration in the field.	Discharges unlikely to be detectable.	Impact related to vessel durations, therefore, leave in situ option has lowest impact and removal and remediation has the highest.		
1	Liquid discharge to surface water	From waste treatment onshore	N/A	Proportional to the length of umbilical returned to shore.	Process for onshore handling of mattresses are unlikely to involve discharge of harmful liquids to surface water.	Not considered a differentiating factor		
1	Noise in air	From onshore waste treatment and disposal	N/A	Proportional to volume of mattresses returned to shore.	Assuming the selected yard frequently undertakes cutting, therefore the noise isn't new to the surrounding area, but rather a continuation of the existing.	Impact related to number of mattresses recovered, therefore, leave in situ option has lowest impact. However, total impact expected to be small.		
1	Noise in water	Cutting	N/A	Proportional to the number of cuts.	Depends on the method used for complete recovery. Assumed each mattress will be loaded whole and broken up onshore	Not considered a differentiating factor		
		Vessel use	N/A	Proportional to the duration and number of vessels in the field.		Impact related to vessel durations, therefore, leave in situ option has lowest impact and removal and remediation has the highest.		
1	Odour	Marine Growth	N/A	No difference	Assuming that the mattresses are buried and therefore not covered in marine growth.	Not considered a differentiating factor		
1	Resource use - Ecosystem disturbance	Disturbance of sediment	N/A	Proportional to number of mattresses recovered.	Assumed recovery within 2 years.	Impact related to number of mattresses recovered, therefore, leave in situ option has lowest impact.		
1	Resource use - Physical area	Anchoring	N/A	No difference	Assuming removal vessel (DSV) is DP rather than anchored.	Not considered a differentiating factor		
		Landfill space	N/A	Proportional to number of mattresses recovered, although the intention would be to recycle as much as possible, in line with the waste hierarchy.	N/A	Impact related to number of mattresses recovered, therefore, leave in situ option has lowest impact.		
2	Liquid discharges to sea	Survey Vessels	N/A	Duration of vessels in the field is greater therefore the discharges are proportional to the duration in the field.	Discharges unlikely to be detectable.	Not considered a differentiating factor as all options form part of an overall partial removal scheme that will require legacy surveys		
2	Noise in water	Survey Vessels	N/A	Proportional to the duration and number of vessels in the field.	N/A	Not considered a differentiating factor as all options form part of an overall partial removal scheme that will require legacy surveys		
3	Gaseous Emissions (Tonnes)	Vessel movements (DSV)	Fuel Combustion	Difference in duration of vessels for removal	N/A	Impact related to vessel durations, therefore, leave in situ option has lowest impact and removal and remediation has the highest.		
		Vessel movements (supply, survey, standby)	Fuel Combustion	Difference in support vessels during removal	N/A			
		Vessel movements (survey)	Fuel Combustion	Difference in survey vessels for legacy	N/A			
		Waste Production	Power Generation	Difference in volume of waste returning to shore between options	N/A			
			Biodegradation	Difference in volume of waste returning to shore between options	N/A			
			Incineration	Difference in volume of waste returning to shore between options	N/A			
4	Resource use - Energy	Power generation	N/A	Proportional to the vessel use duration and the volume of waste sent to shore.	N/A	For mattress recovery the greatest impact comes from vessel durations, therefore, leave in situ option has lowest impact and removal and remediation has the highest.		
		Replacement of material not recovered	N/A	Proportional to the volume of material left in situ.	N/A			

Appendix D.15 Umbilical Midline Mattresses Technical

		Technically Possible?	Issues (E.g. impact on Safety, Environment, Cost, Reputation and Schedule)	Complete Removal	Removal & Remediation	Leave In-Situ
Technical	Removal of burial material/ jetting	Yes	Removal of burial material/ jetting - Very limited, as there is nothing unusual or challenging about the work Lifting Mattresses - Has been done before but condition of mattresses is currently unknown, may not be suitable for conventional lifting methods Remediation work/ re-burying/ rock placement - Very limited, as there is nothing unusual or challenging about the work	Burial material will need to be removed for this option Four mattresses loaded onto deck. Routine activity depending on the condition of the mattresses No remediation work	As complete removal with graded rock remediation placed by divers/ ROV	No disturbance of the seabed required No lifting involved No remediation work involved

Appendix D.16 Umbilical Midline Mattresses Societal

Sub criteria	Interaction with the environment (Evaluation		Detailed Activity (s)	Differentiators	Assumptions	Option 1 Complete Removal	Option 2 Removal and Remediation	Option 3 Leave In Situ
Societal	Community and socio-economic interaction	Effects on commercial activities	Short term impact on fishing activities and long term impact on seabed	Duration of vessel activities	Assuming the umbilical is buried and there has not been a history of spans and there are no significance spoil heaps left following overtrawable surveys.	Immediate impact on fishing is related to the duration of operation. Therefore, the leave in situ option will have no comparative impact and the removal and remediation option will have the greatest impact.		
			Legacy Survey	Not a differentiator		Not considered a differentiating factor as all options form part of an overall partial removal scheme that will require legacy surveys		
		Employment	N/A	Greater number of jobs maintained, in line with greater vessel use duration and waste management requirements.	Assuming that it isn't within ullage of existing vessel availability and waste management capacity.	Generation of employment is related to the duration and number of activates required for each option. Therefore, the removal and remediation option provides the potentially greatest employment opportunities and the leave in situ provides no comparative increase in employment opportunities.		
		Communities or impact on amenities	N/A	No difference	Possible impacts on communities at disposal site. Unable to evaluate if this is positive or negative as the location has not been selected. Therefore assume no difference.	Not considered a differentiating factor as the communities around the port and the waste disposal sites are expected to be adapted to the types of activities required.		

Appendix D.17 Umbilical Midline Mattresses Decommissioning Cost Estimate

	Complete Removal (£M)	Removal and Remediation (£M)	Leave In Situ (£M)
Cost	£0.44	£0.57	£0.00