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# Juliet Comparative Assessment Report

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<td>Information which may be made public without consequences for the entity or Neptune Energy.</td>
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<td>Information intended to remain within Neptune Energy. Permission from a direct manager is required to disclose it outside Neptune Energy.</td>
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<td>Restricted</td>
<td>Information which, if disclosed outside the appropriate perimeter, may have a serious impact on the entity or a serious impact on Neptune Energy. Access is limited to specific individuals or groups.</td>
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<tr>
<td>Confidential</td>
<td>Information which, if disclosed to people other than those specifically designated to receive it, would have a major impact on the entity or a major impact on Neptune Energy. In such cases, very strict rules apply to the information chain.</td>
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<td>Contractor Revision</td>
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*where CONTRACTOR aligns to COMPANY Document Numbering convention there is no requirement to complete this information

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## TERMS, ABBREVIATIONS AND ACRONYMMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AHP</td>
<td>Analytical Hierarchy Process</td>
</tr>
<tr>
<td>BAT</td>
<td>Best Available Technology</td>
</tr>
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<td>BEIS</td>
<td>Department of Business, Energy and Industrial Strategy</td>
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<tr>
<td>BEP</td>
<td>Best Environmental Practice</td>
</tr>
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<td>CA</td>
<td>Comparative Assessment</td>
</tr>
<tr>
<td>CoP</td>
<td>Cessation of Production</td>
</tr>
<tr>
<td>CSV</td>
<td>Construction Support Vessel</td>
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<td>DSV</td>
<td>Dive Support Vessel</td>
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<td>Environmental Management Team</td>
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<td>ENVID</td>
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<td>JNCC</td>
<td>Joint Nature Conservation Committee</td>
</tr>
<tr>
<td>MCDA</td>
<td>Multi-Criteria Decision Analysis</td>
</tr>
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<td>MFE</td>
<td>Mass Flow Excavation</td>
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<td>NFFO</td>
<td>National Federation of Fisherman’s Organisations</td>
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<td>ODU</td>
<td>Offshore Decommissioning Unit</td>
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<td>OGA</td>
<td>Oil &amp; Gas Authority</td>
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<td>OPRED</td>
<td>Offshore Petroleum Regulator for Environment &amp; Decommissioning</td>
</tr>
<tr>
<td>OSPAR</td>
<td>Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)</td>
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<td>P&amp;A</td>
<td>Plugging &amp; Abandonment</td>
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<tr>
<td>PLL</td>
<td>Potential for Loss of Life</td>
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<tr>
<td>TGT</td>
<td>Theddlethorpe Gas Terminal</td>
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<td>ToR</td>
<td>Terms of Reference</td>
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<td>UKCS</td>
<td>United Kingdom Continental Shelf</td>
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1 EXECUTIVE SUMMARY

A Comparative Assessment (CA) Evaluation Workshop for the short-listed decommissioning options for the Juliet subsea pipelines and infrastructure was held at Neptune Energy Aberdeen office on Thursday 20th September with external stakeholders. This followed an internal workshop involving Neptune, Juliet field partners and Xodus.

Included in the Evaluation Workshop was one minimal intervention option and two full removal options. These options are summarised below.

- Option 1B – Leave in situ Minimal Intervention – Disconnect Ends, Rockdump Ends
- Option 5A – Full Removal – Deburial and Reverse Reel
- Option 5C – Full Removal – Deburial, Pipeline Cut and Lift, Umbilical Reverse Reel

These options were compared based on the CA sub-criteria previously agreed with Neptune. The sub-criteria were based on Safety, Environmental, Technical, Societal and Economic considerations. The results of the assessment showed that Option 1B (Leave in situ) ranked the highest for eight of the twelve sub-criteria (four of the five main criteria). These findings are summarised in Figure 1.1.

![Figure 1.1: Results of Juliet Comparative Assessment Workshop](image)
As the above figure shows, Option 1B is the overall preferred decommissioning solution for the Juliet pipelines and associated stabilisation material. Based on the discussions from all CA workshops (internal and external), sensitivities were performed on many of the sub-criteria including:

- Sub-Criteria 1.2 – Safety risk to other users of the sea
- Sub-Criteria 3.1 – Technical risk
- Sub-Criteria 4.1 – Societal impact on fishing activities
- Sub-Criteria 4.2 – Socio-economic impact on communities and amenities
- Sub-Criteria 5.1 – Operational and legacy costs.

The sensitivity cases did not alter the findings of the assessment therefore no single criterion was adversely driving the results of the CA.

Please note that these findings are based on the discussions from the external CA workshop however the conclusions are consistent with the internal session held on Wednesday 22nd August.
2 INTRODUCTION

2.1 BACKGROUND

The Juliet Field is located in Block 47/14b of the UK Southern North Sea some 40km due east from the Humberside estuary and approximately 9km to the south of the Amethyst gas field. Juliet was discovered in December 2008 with well 47/14b-10 and subsequently developed by a two well subsea tieback in a water depth of 55m to the Pickerill A facilities.

The Juliet Field layout is shown in Figure 2.1 below.

![Figure 2.1 Juliet Field Layout](image)

Gas from the two Juliet wells is comingled into a subsea manifold and transported back to Pickerill A via a 22 km long 12” pipeline (PL3121). The subsea manifold comprises three production piping slots, two that are used for each of the production wells and one spare designated for future use. The Juliet pipeline ties into the base of the Pickerill A platform via a 12” riser. Control between Pickerill A and the Juliet wells is via a dedicated subsea electro-hydraulic control and chemical injection umbilical (PLU3122). The Juliet pipeline and
Umbilical were trenched and buried for protection from trawl gear and dragged anchors. On the platform, the gas from Juliet is commingled with the other Pickerill production gases, and then exported through a 24" pipeline back to Theddlethorpe Gas Terminal (TGT).

The Juliet field came onto production in Jan 2014 from 47/14b-G1. 47/14b-G2 well came into production in March 2014. Cessation of Production (CoP) has been submitted for Juliet in July 2018.

2.2 COMPARATIVE ASSESSMENT OVERVIEW

The decommissioning of offshore oil and gas installations and pipelines on the United Kingdom Continental Shelf (UKCS) is controlled through the Petroleum Act 1998, as amended by the Energy Act 2008. In the UK, decommissioning is also regulated under the Marine and Coastal Act 2009 and Marine (Scotland) Act 2010. The UK's international obligations on decommissioning are primarily governed by the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (the OSPAR Convention). The responsibility for ensuring compliance with the Petroleum Act 1998 rests with Department of Business, Energy and Industrial Strategy (BEIS). BEIS is also the Competent Authority on decommissioning in the UK for OSPAR purposes and under the Marine Acts.

The Juliet subsea infrastructure is the subject of a comparative assessment (CA) of options under guidance provided by the BEIS forming a core part of the overall decommissioning planning process. The methodology for Comparative Assessment is described in detail in the Juliet Comparative Assessment Terms of Reference Report [1]. This Comparative Assessment Report will be submitted alongside the DP (BEIS).

2.3 COMPARITIVE ASSESSMENT PROCESS

The Comparative Assessment utilises a Multi Criteria Decision Analysis (MCDA) tool which employs pairwise comparisons of quantitative and qualitative data [2]. A detailed description of this process is described in the Juliet Comparative Assessment Terms of Reference [1].

A schematic of the Comparative Assessment process is detailed in Figure 2.2 below.
Figure 2.2   Overview of the Comparative Assessment process

- **Scope**
  - Decide on appropriate CA method, confirm criteria, identify boundaries of CA (physical and phase).

- **Screen**
  - Consider alternative uses and deselect unfeasible options.

- **Prepare**
  - Undertake technical, safety, environmental and other appropriate studies. Undertake stakeholder engagement.

- **Evaluate**
  - Evaluate the options using the chosen evaluation methodology.

- **Recommend**
  - Create recommendation in the form of narrative supported by charts explaining key trade-offs.

- **Review**
  - Review the recommendation with internal and/or external stakeholders.

- **Submit**
  - Submit to BEIS as part of/alongside Decommissioning Programme.
3  COMPARATIVE ASSESSMENT WORKSHOP

3.1 OVERVIEW

As outlined in the Juliet Comparative Assessment Terms of Reference Report [1], the Juliet Field Decommissioning Project External CA Workshop was held from 08:30 to 12:00 on Thursday 20th September at Neptune Energy’s Aberdeen Office at 16 North West Esplanade, Aberdeen, AB11 5RJ. The workshop was facilitated by Xodus Group.

3.2 ATTENDEES

The attendees of the Juliet Field Decommissioning Project CA Stakeholder Workshop are detailed in Table 3-1 below.

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<thead>
<tr>
<th>Name</th>
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<tr>
<td>Alan Muirhead</td>
<td>Neptune Energy</td>
<td>Developments and Decommissioning Manager</td>
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<tr>
<td>Pierre Girard</td>
<td>Neptune Energy</td>
<td>Asset Manager</td>
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<td>Eddie Anderson</td>
<td>Neptune Energy</td>
<td>HSE</td>
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<td>David Hawkins</td>
<td>Neptune Energy</td>
<td>Environment</td>
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<td>Joanne Rostant</td>
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<td>Tech Safety</td>
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<td>Justin Heath</td>
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<td>Communications</td>
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<tr>
<td>Francis Barrett</td>
<td>Xodus Group</td>
<td>Subsea and Pipelines</td>
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<tr>
<td>Rebecca Allan</td>
<td>Xodus Group</td>
<td>Project Representation</td>
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<tr>
<td>Gareth Jones</td>
<td>Xodus Group</td>
<td>Facilitator</td>
</tr>
<tr>
<td>Kim Woods</td>
<td>BEIS OPRED ODU</td>
<td>Stakeholder Representative</td>
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<tr>
<td>Audrey Banner</td>
<td>BEIS OPRED</td>
<td>Stakeholder Representative</td>
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<tr>
<td>Fiona Livingston</td>
<td>BEIS</td>
<td>Stakeholder Representative</td>
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Table 3.1  CA Workshop Attendees

Please note that a representative from the NFFO was invited to the workshop but unfortunately could not attend. The NFFO were informed of the workshop outcome and confirmed they were in agreement with what had been presented and had no further comments to add.

3.3 OUTCOMES AND ACTIONS

This report summarises the finding from the external presentation of the Juliet Field Decommissioning Project CA Workshop.
4 PROJECT DESCRIPTION

4.1 GROUPINGS

The decommissioning programme underwent a scoping process in which four groupings of subsea infrastructure were identified (Table 4.1). Each component has been allocated to a common scoping group based on physical properties and installation conditions. Two of these groupings were surface laid infrastructure to be fully removed (groups J2 and J3), and thus did not require comparative assessment. The other two groupings contain buried infrastructure; they include: trenched and buried pipelines and umbilicals (group J1); and buried mattresses and grout bags (group J4).

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<tr>
<th>Group Number</th>
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<td>Trenched and Buried Pipelines and Umbilicals</td>
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<tr>
<td></td>
<td>- PL3121</td>
</tr>
<tr>
<td></td>
<td>- PLU3122</td>
</tr>
<tr>
<td>J2</td>
<td>Surface Laid Spoolpieces and Control Jumpers</td>
</tr>
<tr>
<td>J3</td>
<td>Subsea Structures</td>
</tr>
<tr>
<td></td>
<td>- Manifold Structure</td>
</tr>
<tr>
<td></td>
<td>- Wellhead Protection Structures</td>
</tr>
<tr>
<td>J4</td>
<td>Buried Mattresses and Grout Bags</td>
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Table 4.1 Juliet Scoping Groups

4.2 OPTIONS

Following the initial scoping and screening, two Groups were selected for the evaluation phase of the Comparative Assessment: Groups J1 and J4 (for buried mattresses and grout bags only). The process behind selection is detailed in reference [3]. During discussions in the internal CA workshop, it became apparent that the option for the Group 4 items were fully dependent on the Group 1 option. For example, if the pipeline is fully removed (Group 1), then all Group 4 items would be fully removed also. It was deemed unnecessary to take Group 4 items further in the CA process, since their outcome was dependent on Group 1.

A summary of the options identified for screening is detailed in Table 4.2. The highlighted options were selected in the internal validation workshop for further evaluation in the Comparative Assessment Workshop and subsequent External Stakeholder Engagement Workshop. These options are discussed in detail in below.
Table 4.2 Option Screening Summary; options put forth for Comparative Assessment in green

4.2.1 Option 1B: Disconnect & Rock-dump Ends

For this option, the trenched and buried pipeline and umbilical will be left *in situ* and disconnected at the ends (where the pipeline and umbilical exits rockdump) and the ends removed (note that the umbilical at Juliet manifold end exits rockdump at the manifold tie-in location). The surface laid pipeline/umbilical sections with rock cover shall be left on the seabed. Mattresses which are buried beneath rockdump shall also be left *in situ*.

A comparison of the existing infrastructure and the results of the minimal intervention decommissioning programme proposed in Option 1B is illustrated in Figure 4.1 below. Comparisons of the existing infrastructure to the outcomes of Option 1B are additionally provided for:

1. The manifold (Figure 4.2);
2. The riser (Figure 4.3); and
3. Crossings (Figure 4.4).

To aid clarity, the following schematics are provided on a larger scale in Appendix 3.
Figure 4.1  Comparison of existing infrastructure (left) with Option 1B decommissioning outcome (right)
Figure 4.2 Comparison of existing manifold infrastructure (top) with Option 1B manifold decommissioning outcome (bottom)
Figure 4.3  Comparison of existing riser infrastructure (top) with Option 1B riser decommissioning outcome (bottom)
Figure 4.4 Comparison of existing crossing infrastructure (top) with Option 1B crossing decommissioning outcome (bottom)
4.2.2 Option 5A: Deburial & Reverse Reel

The offshore operations for this option consist of performing a pre-works survey, deburial of the lines along its length using a mass flow excavator (by CSV, noting that this shall include the rockdumped CMS crossing section which shall be non-operational at the time of Juliet decommissioning), an additional inspection survey in order to establish the status of the lines and confirm feasibility of reverse reel operations, followed by DSV operations to connect recovery heads.

A reel vessel will then recover the pipeline and umbilical via reverse reeling. The items shall be returned to shore for recycling/ final disposal.

4.2.3 Option 5C: Deburial, Pipeline and Umbilical Cut & Lift

The offshore operations for this option consist of performing a pre-works survey, deburial of the lines along the length using a mass flow excavator, followed by operations to cut the pipeline in double joints, rigging of each section and recovery to surface (a CSV is assumed for deburial and cutting operations. Noting that deburial shall include the rockdumped CMS crossing section which shall be non-operational at the time of Juliet decommissioning. A DSV and barge are assumed for rigging and recovery of the cut pipeline and connection of recovery head). A reel vessel will then recover the umbilical via reverse reeling. The items shall be returned to shore for recycling/ final disposal.

A comparison of the existing infrastructure and the results of the full removal decommissioning programmes proposed in Options 5A and 5C are illustrated in Figure 4.5 below. Comparisons of the existing infrastructure to the outcomes of both Options 5A and 5C are additionally provided for:

(1) The manifold (Figure 4.6);

(2) The riser (Figure 4.7); and

(3) Crossings (Figure 4.8).
### Figure 4.5
Comparison of existing infrastructure (left) with Option 5A and 5C decommissioning outcomes (right)
Figure 4.6  Comparison of existing manifold infrastructure (top) with Option 5A and 5C manifold decommissioning outcome (bottom)
Figure 4.7  Comparison of existing riser infrastructure (top) with Option 5A and 5C riser decommissioning outcome (bottom)
Figure 4.8  Comparison of existing crossing infrastructure (top) with Option 5A and 5C crossing decommissioning outcome (bottom)
5 COMPARITIVE ASSESSMENT

5.1 QUANTITATIVE REVIEW

Following the scoping and internal validation processes, further work was needed to refine the three identified options using quantitative data. This work included: outlining the cost and schedule for each option through a detailed methods and technical feasibility (methodology) review; study of environmental factors (e.g. characterisation of natural habitat, noise, seabed disturbance, and vessel emissions); study of safety risk to fishermen; assessment of safety risk to operational personnel, quantified as Potential for Loss of Life (PLL); Hazard Identification Risk Assessment (HIRA); and Environmental factors Identification (ENVID), including quantification of impacts required for differentiation.

The resulting quantified attributes for each option are then compared through the Comparative Assessment Tool, as described in [1]. The attributes for each option are summarised in Table 5.1 below.

<table>
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<th>Option 1B</th>
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<th>Option 5C</th>
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<tr>
<td>Life Cycle Emissions</td>
<td>7,187 te</td>
<td>3,759 te</td>
<td>3,759 te</td>
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<tr>
<td>Vessel Days (Total)</td>
<td>47 (21 op.)</td>
<td>68</td>
<td>421</td>
</tr>
<tr>
<td>Overall PLL</td>
<td>5.2 e^4</td>
<td>5.5 e-3</td>
<td>4 e-2</td>
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<td>Seabed Disturbance</td>
<td>250 m^2</td>
<td>44,676 m^2</td>
<td>44,676 m^2</td>
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<tr>
<td>Risk to Fisherman</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td>Vessel CO₂ Emissions</td>
<td>1,251 te</td>
<td>4,702 te</td>
<td>30,131 te</td>
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<tr>
<td>Relative Cost</td>
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<td>10.9x</td>
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Note 1: Area of disturbance presented above is the differentiating element (i.e. excluding overtrawl footprint (2,203,300 m^2) which applies to all options).

Table 5.1 Quantitative data used in the Comparative Assessment of the three identified Options

Please note that the attributes given in Table 5.1 refer to the pipeline removal / remediation only. If the mattresses are to be removed, it will be executed in the same campaign as the pipeline activities hence the emissions, PLL, seabed disturbance and costs will be higher but only marginally. The safety risk to fisherman will still be classed as ‘Low’.

5.2 EVALUATION METHODOLOGY

The options were evaluated using criteria defined by BEIS; they include the following equally-weighted factors: Safety; Environment; Technical; Societal; and Economics. These five criteria, their sub-criteria and relative weightings are detailed in Table 5.2 below.
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<td>Other Users [6.67%]</td>
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<td></td>
<td>Legacy Risk [6.67%]</td>
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<td>Environmental [20%]</td>
<td>Operational Marine Impacts [4%]</td>
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<td>Fuel and Emissions [4%]</td>
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<td>Socio-economic impacts on communities and amenities [10%]</td>
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<tr>
<td>Economics [20%]</td>
<td>Operational and Legacy Costs [20%]</td>
</tr>
</tbody>
</table>

Table 5.2 Evaluation criteria for Comparative Assessment

The definitions of each sub-criteria addressed in the Comparative Assessment are specified in Table 5.3.
## Criteria | Sub-Criteria | Description | Approach to Assessment
---|---|---|---
### 1. Safety
| 1.1 Operations Personnel | This sub-criterion considers elements that impact risk to offshore and onshore personnel. The offshore assessment includes, project team, project vessel crew, diving teams, supply boat crew, and survey vessel crew. It should be noted that crew changes are performed via port calls. The onshore assessment considers any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel. | Potential for Loss of Life (PLL) metrics were calculated for each option. This allows a quantified direct comparison between options. A quantitative assessment based on the number of vessel days associated with each of the decommissioning options. This is considered acceptable as the safety impact on other users is a function of the operational vessel numbers / durations / movements. A coarse HIRA was conducted to identify elements associated with the options that had potential for High Consequence Events. The HIRA also addressed the legacy risk component associated with the options. |
| 1.2 Other Users | This sub-criterion covers the impact associated with the risk to other users. Considers elements such as collision impact whilst performing activities. Users such as fishing vessels, commercial transport vessels and military vessels are considered. | A qualitative risk assessment of the risk to fishermen as a result of potential subsea elements (pipelines / umbilicals and associated rock cover, mattresses and grout bags) left on/in the seabed was performed. |
| 1.3 Legacy Risk | This sub-criterion addresses any personnel risk exposure associated with long-term monitoring in a similar way to 1.1. The assessment considers all exposure activities associated with legacy future survey requirements and any intervention allowance. Hazards identified in the Safety Risk to Fisherman report are also considered here. |
### Criteria: Environmental

<table>
<thead>
<tr>
<th>Sub-Criteria</th>
<th>Description</th>
<th>Approach to Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Operational Marine Impacts</td>
<td>Marine environmental impact caused by: Project Vessels, Supply Boats, Survey vessels i.e. noise generated by vessels, cutting operations, any explosives etc. during the operational phase. This excludes any P&amp;A work.</td>
<td>Assessment based on number of vessel days for this activity and quantifying noise generated by decommissioning activities in the short term.</td>
</tr>
</tbody>
</table>
| 2.2 Fuel & Emissions                              | Marine environmental impact caused by: Project Vessels, Supply Boats, Survey vessels, etc. Assessment is for the atmospheric emissions associated with a particular option and covers fuel use which is tightly correlated to atmospheric emissions. This also includes energy / emissions / resource consumption required to replace materials not recovered for re-use or recycle i.e. indirect. NOTE: Onshore related emissions are excluded. This is calculated for both the operational phase and legacy phase of the project. Marine environmental impact caused by the amount of resource consumption associated with the option is included in this criterion. It covers elements such as environmental burden from processing returned materials, use of quarried rock or other new material and any production of replacement materials. | Assessment based on quantifying the volume of fuel used and the associated emissions. A life-cycle emissions assessment has been carried out capturing:  
  - Recycling of materials  
  - Reuse of materials  
  - Production of new materials  

These life-cycle CO₂ emissions figures allow a direct, quantitative comparison between options.
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sub-Criteria</th>
<th>Description</th>
<th>Approach to Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Environmental</td>
<td>2.3 Legacy Marine Impacts</td>
<td>Marine environmental impact caused by: Project Vessels, Supply Boats, Survey vessels i.e. noise generated by vessels, cutting operations, any explosives, survey/monitoring techniques or remediation requirements etc. during the legacy phase.</td>
<td>Combination of qualitative and quantitative assessments based on number of vessel days for this activity and quantifying noise generated by legacy inputs to the environment either from ongoing survey/monitoring requirements or from potential remediation works.</td>
</tr>
<tr>
<td>2. Environmental</td>
<td>2.4 Materials and Residuals</td>
<td>Assessment is made of the total weight/quantity of materials recovered or left in situ as well as the status of any minimal liquid volumes, including volume of hydraulic fluid left in the umbilical.</td>
<td>Assessment based on impact of weight of each type of material and final material location for each option. Weights based on asset inventory report. Volumes based on methods and technical feasibility (methodology) review.</td>
</tr>
<tr>
<td>2. Environmental</td>
<td>2.5 Seabed Disturbance</td>
<td>Both direct and indirect seabed disturbance, permanent and temporary in nature, caused by the operations.</td>
<td>Assessment based on quantifying the area (in m²) of disturbance by type of disturbance (rock placement, trenching, mass flow excavation and overtrawling), in combination with an understanding of the baseline environment in the area as shown by the outputs from the environmental surveys.</td>
</tr>
</tbody>
</table>
### Criteria

<table>
<thead>
<tr>
<th>Sub-Criteria</th>
<th>Description</th>
<th>Approach to Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3. Technical</strong></td>
<td><strong>3.1 Technical Risk</strong></td>
<td>This sub-criterion relates to the various technical risks that could result in a major project failure. Concepts such as: Technical Novelty and Potential for Showstoppers can be captured along with impact on the schedule due to overruns from technical issues such as operations being interrupted by the weather. Long offshore campaigns are susceptible to risk of WoW delays. Contracting strategy is assessed with focus on the risk to the project of whether the contracting strategy is restricted by a particular option (e.g. if the option involves only one possible vendor). Technical Feasibility and Technical Maturity is also considered.</td>
</tr>
<tr>
<td><strong>4. Societal</strong></td>
<td><strong>4.1 Fishing</strong></td>
<td>This sub-criterion addresses the impact of the option on commercial fishing operations. It includes consideration of impacts from both the decommissioning activities any residual impacts post decommissioning such as reinstatement of access to area.</td>
</tr>
<tr>
<td></td>
<td><strong>4.2 Socio-Economic Impact on Communities and Amenities</strong></td>
<td>This sub-criterion addresses any socio-economic impacts on other users both onshore where the impact may be from dismantling, treating, recycling and land filling activities relating to the option and offshore. Issues such as impact on the health, well-being, standard of living, structure or coherence of communities or amenities are considered here e.g. business or jobs creation, increase in noise, dust or odour pollution during the process which has a</td>
</tr>
<tr>
<td>Criteria</td>
<td>Sub-Criteria</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>negative impact on communities, residual risk of snagging gear and consequential loss of gear, etc.</td>
</tr>
<tr>
<td>5. Economic</td>
<td>5.1 Operational and Legacy Costs</td>
<td>This sub-criterion addresses the cost of delivering the option as described. This includes both operational phase and legacy phase costs (including intervention allowance).</td>
</tr>
</tbody>
</table>

Table 5.3 Definitions of sub-criteria addressed in the Comparative Assessment
6 RESULTS OF THE COMPARATIVE ASSESSMENT

6.1 SAFETY DIFFERENTIATION

The safety criteria assessed in the Comparative Assessment considered safety risks to operations personnel and other users, and any legacy impacts on safety. Operational hours, operational PLL, vessel days, vessel transits, the number of vessels, and safety risks to fishermen were considered in this assessment.

In the review of safety risks to operations personnel, the minimal intervention option (Option 1B) came out much stronger and very much stronger than the two full removal options, 5A & 5C, respectively. This decision reflects the safety risks associated with the pipeline removal requirements for Options 5A & 5C, particularly the greater demand for personnel and protracted operations hours of each. Option 5C poses the greatest safety risks to operations personnel due to the prolonged period of operations, and the fact that divers are required for cutting and lifting of the pipeline. Option 5A would involve reverse reeling of the pipeline, which is a non-routine activity, and could pose unforeseen hazards to personnel, particularly if the pipeline’s integrity is compromised. Consequently, the PLL values for Options 5A and 5C were one and two orders of magnitude greater than that of Option 1B, respectively.

In terms of safety impacts on other users, Option 1B had the least potential to generate vessel-related impacts. This option has 21 days of vessel time allocated to operations during a single transit, with a remaining balance of 26 days devoted to legacy operations and monitoring which are to be spread out over an anticipated 50-year period. Neither of the full removal options require legacy operations to be considered, however their vessel requirements during the operations phase is more extensive than the minimal intervention option. Option 5A has 68 vessel days allocated solely to operations; these are to be divided between 5 vessels and 6 vessel transits. Option 5C has a significantly greater vessel requirement: 421 total vessel days across divided between 6 vessels across 7 transits. The increased vessel days and number of transits are attributable to the technical and personnel constraints associated with cutting and lifting the production pipeline during its removal. Moreover, the full removal options may impact other users as increased vessel presence will include vessels moving along the entirety of the length of the pipeline during operations for both options.

As discussed, neither of the full removal options have an associated legacy impact therefore for this sub-criteria Option 1B was viewed as the weakest option.

Given the increased requirement for vessels and the intrinsic risks to operations personnel posed in the full removal options, Option 1B was identified as the recommended option for minimising safety risks during the decommissioning of the Juliet subsea infrastructure.

6.2 ENVIRONMENTAL DIFFERENTIATION

The Comparative Assessment addressed various environmental criteria, including operational marine impact, fuel and emissions, legacy marine impact, materials and residuals, and seabed disturbance. As with the safety criteria assessment, vessel days were also considered for impacts to the environment, but instead the cumulative marine noise emissions they generate were assessed. Total fuel usage, vessel CO₂ emissions, materials
life cycle energy consumption and CO₂ emissions, total tonnage of material types, the
requirement for additional rock-dump, discharge of control fluids, and Mass Flow Excavation
(MFE), trenching and overtrawling impacts on seabed sediments were all additionally
considered in the assessment of impacts of the project on the marine environment.

Noise formed the primary concern in the assessment of operational marine impacts. Although
the vessel noise levels generated are estimated to be marginally above the NOAA thresholds
for injury, due to the duration of activities being very short and the behavioural natures of the
marine mammals present, vessel noise was not considered a significant impact. This was
discussed and agreed with the stakeholders present during the CA workshop. Marine
mammals will avoid injury by temporarily displacing from the area during this short period of
concentrated vessel activity. The following table summarises the estimated marine noise
levels associated with each decommissioning option in relation to the NOAA thresholds.

<table>
<thead>
<tr>
<th>Option 1B</th>
<th>Option 5A</th>
<th>Option 5C</th>
<th>NOAA Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.12 TPa²S (245 dB)</td>
<td>22.92 TPa²S (254 dB)</td>
<td>189.73 TPa²S (263 dB)</td>
<td>173 dB</td>
</tr>
</tbody>
</table>

Note 2: Noise levels for Options 1B, 5A and 5C represent the cumulative noise experienced
at a distance of 1 metre from the source. The NOAA threshold quoted is the lowest
threshold of all hearing groups considered and is based upon the assumption that the
marine mammal would remain stationary during exposure which is very unlikely.

Table 6.1 Summary of Marine Noise Levels and NOAA Threshold

Noise from mechanical cutting associated with Option 5C’s removal method was considered
the biggest noise-related issue, however its potential impacts are minimised by the fact that
this activity will be temporary and spatially constrained. In this respect, Option 1B was only
considered marginally better than Option 5A & much better than Option 5C.

The total fuel usage and vessel CO₂ emissions were greatest for Option 5C, which had values
close to ten times greater than Option 5A and close to 20 times those of Option 1B. However,
the greatest materials lifecycle CO₂ emissions came from Option 1B, which was nearly double
both Option 5A and 5C. This is because the leave in situ method precludes recycling or
reuse of the Juliet infrastructure’s component parts. Still, when considering the total CO₂
emissions (from vessels and materials combined), Option 5C came out the worst and Options
1B and 5A roughly the same. In the end, the increased fuel consumption of Option 5A made
it slightly less desirable than Option 1B.

Legacy marine impacts were only described for Option 1B, as the full removal of the Juliet
subsea infrastructure precludes legacy operations obligations. Still, the legacy marine
impacts of Option 1B were deemed minor, in that the number of vessel days and cumulative
noise generated by legacy operations were minimal and the volume of additional rock-dump
is not expected to have any significant impacts on the seabed habitat, with any impact being
highly localised.

All three options had equivalent values for the discharge of control fluids, however, Option
1B would see residual fluids discharged over a period of decades rather than instantaneously,
as is the case with the full removal options. Neither full removal option would leave any volume of material remaining on the seabed, nor would they require additional rock-dump. Option 1B, however, would have nearly 3800 tons of steel, 300 tons of plastic and a little over 18 tons of non-ferrous materials decommissioned *in situ*. For this reason, Option 1B was seen as weaker than the other two options, which were equally desirable for their minimal materials and residuals impacts.

For the seabed disturbance impacts, decommissioning plans for Option 1B had an additional 250 m² (500 Te) of rock dump to consider, but this was considered to have a minor potential impact on the seabed habitat. The full removal options had significantly higher MFE values, however, making Option 1B a much stronger option for reducing seabed disturbance impacts.

Overall, Option 1B was identified as the recommended option because of its minimal impacts to the seabed habitat, reduced fuel and emissions impacts and its decreased marine impacts during the operations phase.

### 6.3 TECHNICAL DIFFERENTIATION

The technical risk criteria addressed in the Comparative Assessment included the contracting strategy, scheduling risk and technical maturity of each option. As the contracting strategies of each option are relatively flexible, the main differentiator for technical risk relates to scheduling. All of the options will incur risks associated with weather issues, but the potential impacts of scheduling issues are potentially more numerous and harder to recover from for both of the full removal options. The long schedule for Option 5C will inherently bring greater technical risk. The extended subsea works and risk of failure associated with this Option could result in significant cost and scheduling impacts and potentially the requirement for an alternative decommissioning method to be used.

There is significant technical risk associated with the reverse reeling of the pipeline in Option 5A. While reel installation of pipelines is a standard subsea operation and reverse reeling has been carried out elsewhere, there is a relatively limited track record of reverse reeling for removal of pipelines in the UKCS and a low track record of unburial over extensive distances. As such, the technical maturity of Option 5A is considered very low.

After considering the schedule and technical maturity associated with each of the options, it was determined than Option 1B was the preferred option for minimising technical risks.

### 6.4 SOCIETAL DIFFERENTIATION

In the assessment of societal impacts, impacts to the fishing industry and communities and amenities were considered.

In regard to the fishing industry, the current state of the Juliet subsea infrastructure is that it is overtrawlable. However, there is potential for segments of the pipeline to need additional rock-dump in future, should spans develop. Given Options 5A and 5C remove legacy risk altogether, and that dispersed rock from the removal of the pipelines is likely to be better for fisheries, Option 1B is considered the weaker option and both full-removal options are deemed equally weighted.

Despite Option 1B not returning any material to shore, the amount of material generated by the other two options is so small that there is very little difference between the options in
terms of socio-economic impacts on communities and amenities. While the majority of infrastructure can be recycled, all of the recycling will likely to be processed at an existing facility and so is unlikely to create any additional jobs. Moreover, as full removal is likely to generate equal amounts of recycling and waste to go landfill, the benefits of potential jobs created by recycling is outweighed by the cost of processing the waste going to landfill. As such, Options 5A and 5C are considered equally weighted and only slightly better than Option 1B.

6.5 ECONOMIC DIFFERENTIATION

The economic criteria covered in the Comparative Assessment focused on costs associated with operations and legacy activities. When undertaking the assessment, it was assumed that all activities are carried out successfully. As such, the economic assessment didn’t consider costs associated with any technical risks, such as issues arising during reverse reeling or bad weather days. Rather, a 30% contingency value was added to each option once the operations and legacy costs were summed. This qualitative assessment resulted in costings of the full removal options at 2.4 times and 10.9 times the value of Option 1B for Options 5A and 5C, respectively. As a result, the leave in situ option was viewed as being the best option in terms of reducing economic impacts on the project.

6.6 CONCLUSIONS

While the full removal options were preferred to the leave in situ option for four of the twelve sub-criteria, Option 1B was the preferred option overall. This is due to the fact that, when all of the sub-criteria were drawn together, Option 1B scored highest in four of the five main criteria categories.

The results suggest that there wasn’t a single driving factor for this decision, rather, the majority of the sub-criteria indicated that the leave in situ option is best at minimising risks associated with safety, environment, technical operations, and economic expenditures.

The results of the Comparative Assessment, in which each of the criteria are weighted against one another are presented in Figure 6.1 below.
Figure 6.1  Graphical representation of the results of the Comparative Assessment
6.6.1 Sensitivity Analysis

There were a series of sensitivity analyses undertaken to provide additional support for the results of the Comparative Assessment. This included evaluating the sensitivities of the following sub-criteria by testing the scorings of each option therein: safety impacts to other users; technical risks; societal impacts on the fishing industry; and socio-economic impacts on communities and amenities.

Moreover, the CA results were considered further by removing one criterion weighting at a time to look at the subsequent effects on the results for the other criteria. In this process, it became apparent that no single criterion was driving the results of the CA assessment. The following figure shows the assessment results with the Economics criteria removed.
Figure 6.2  Graphical representation of the results of the Comparative Assessment with economic risks removed
7 REFERENCES

7.1 SUPPORTING DOCUMENTATION

<table>
<thead>
<tr>
<th></th>
<th>Juliet Comparative Assessment Terms of Reference</th>
<th>JF00-09-AN-103-00001_C01, August 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Juliet and Minke Comparative Assessment Scoping and Screening Report</td>
<td>JF00-09AN-72-00302, C01, June 2018</td>
</tr>
<tr>
<td>4</td>
<td>API RP 17N</td>
<td>API RP 17N Recommended Practice for Subsea Production System Reliability, Technical Risk and Integrity Management 2014</td>
</tr>
</tbody>
</table>

All references available upon request.
# 8 APPENDICES

## 8.1 APPENDIX 1: MEETING RECORD

<table>
<thead>
<tr>
<th>Name</th>
<th>Position / Company</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alan Muirhead</td>
<td>Developments and Decommissioning Manager, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Pierre Girard</td>
<td>Asset Manager, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Eddie Anderson</td>
<td>HSE, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>David Hawkins</td>
<td>Environment, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Joanne Rostant</td>
<td>Tech Safety, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Justin Heath</td>
<td>Communications, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Francis Barrett</td>
<td>Subsea and Pipelines, Xodus Group</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Rebecca Allan</td>
<td>Project Representation, Xodus Group</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Gareth Jones</td>
<td>Facilitator, Xodus Group</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Kim Woods</td>
<td>Stakeholder Representative, BEIS OPRED ODU</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Audrey Banner</td>
<td>Stakeholder Representative, BEIS OPRED</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Fiona Livingston</td>
<td>Stakeholder Representative, BEIS</td>
<td>20/09/2018</td>
</tr>
</tbody>
</table>
8.2 APPENDIX 2: COMPARATIVE ASSESSMENT TOOL FOLLOWING INTERNAL WORKSHOP
**1B: Leave In-Situ Minimal Intervention - Disconnect ends, rockdump ends**

For this option, the trenched and buried pipeline and umbilical will be left in situ and disconnected at the ends (where the pipeline and umbilical exits rockdump and the ends removed note that the umbilical at Juliet manifold ends rockdump at the manifold tie-in location). The surface laid pipeline/umbilical sections with rock cover shall be left on the seabed. Mattresses which are buried beneath rockdump shall also be left in situ.

**Summary**

- **Total operational hours:** 8,908
- **Total Operational PLL:** 5.20E-04
- **Non-routine activities, relatively short duration.** No diving - ROV and shears only.

**Details**

- **Total Days:** 47 Vessel Days
- **Over half the total vessel days relate to legacy activities over a seven year period. Intensity of activity during decom operation is only 3 vessels over 21 days.**

**Options**

- **Option 1B** has 21 days of vessel time allocated to operations during a single transit, with a remaining balance of 26 days devoted to legacy operations and monitoring which are to be spread out over an anticipated 50-year period. Neither of the full removal options require legacy operations to be considered, however their vessel requirements during the operations phase is more extensive than the minimal intervention option, which impacts the scoring. Option 5A has 68 vessel days allocated solely to operations; these are to be divided between 5 vessels and 6 vessel transits. Options 1B has 21 days of vessel time allocated to operations during a single transit, with a remaining balance of 26 days devoted to legacy operations and monitoring which are to be spread out over an anticipated 50-year period. Neither of the full removal options require legacy operations to be considered, however their vessel requirements during the operations phase is more extensive than the minimal intervention option, which impacts the scoring. Option 5A has 68 vessel days allocated solely to operations; these are to be divided between 5 vessels and 6 vessel transits.

**Environmental Impact**

- **Total Legacy PLL = 2.01E-03**
- **Total Operational PLL = 5.20E-04**

**Note**

- The Juliet pipeline has more potential for spans. Trawling in the area tends to be Otter type which is more likely to result in a very low tawing activity level.
- The pipeline and umbilical presently cross the CMS, which shall be non-operational at the time of Juliet decommissioning.
- The pipeline and umbilical presently cross the CMS, which shall be non-operational at the time of Juliet decommissioning.
2. Environmental

2.2 Fuel and Emissions

Operational and Legacy Phase Vessel Fuel Usage:
- Total Fuel Usage = 1651 Te
- Total Vessel CO2 Emissions = 4782 Te

Materials Life Cycle Energy consumption, including recycling of steel, plastics etc:
- Materials Lifecycle CO2 Emissions = 7187 Te

2.3 Legacy Marine Impact

As all equipment is removed there is no legacy marine impact.
- Vessel Days = 0 days
- Cumulative Marine Noise = N/A

2.4 Materials and Residuals

The following volumes of material will remain once the option has been completed.
- Steel = 3793.3 te
- Plastic = 299.6 te
- Non-Ferrous = 18.2 te
- Rock dump required = 500 Te (includes legacy)
- Control fluids discharged = 8.8 m³ over an extended period

2.5 Seabed Disturbance

Sea bed disturbance data for this option is noted below.
- Rockdumping = N/A
- Mass flow excavation (MFE) = 44,676 m³
- Trenching = N/A
- Overtrawl = 220,300 m²

Summary

Combined CO2 emissions (vessel and lifecycle together) are comparable for Options 1B and 5A. The vessels are not yet selected. Comparison based on medium sized vessels using marine diesel fuel, however if larger vessel are used there could be heavy marine fuel (leading to stronger CO2 emissions). Note- Using IOP guidance on vessel emissions.

Operational and Legacy Phase Vessel Fuel Usage:
- Total Fuel Usage = 11,127 Te
- Total Vessel CO2 Emissions = 30,131 Te

Materials Life Cycle Energy consumption, including recycling of steel, plastics etc:
- Materials Lifecycle CO2 Emissions = 3759 Te

Summary

There are 2 surveys and crossing remediation accounted for in Option 1B. 500 Te rockdump is added for this option also.

Summary

The following volumes of material will remain once the option has been completed.
- Steel = 0 te
- Plastic = 0 te
- Non-Ferrous = 0 te
- Rock dump required = 0 Te
- Control fluids discharged = 8.8 m³3 instantaneous release during removal

There is no contingency for spans or additional rock dump for remediation of such spans.

Summary

Sea bed disturbance data for this option is noted below.
- Rockdumping = 250 m² (includes legacy)
- Mass flow excavation (MFE) = 44,676 m³
- Trenching = N/A
- Overtrawl = 220,300 m²

Have accounted for overtrawl in all three cases and it is therefore not a differentiator. Mass flow excavation is the significant contributor, which makes Option 1B stronger than the removal options.
VMS

5. Economic

5.1 Operational & Legacy Costs

5. Economic

5.1 Operational & Legacy Costs

Contracting Strategy - Established methods and technology. No special requirements that would limit number of available decommissioning contractors. Good flexibility in terms of contracting strategy.

Schedule - No particular technological factors or major risk factors that could extend schedule. In field time of 21 days.


Contracting Strategy - Reel vessel of suitable capacity required. Vessels are generally available from a number of vendors. Reasonably flexible contracting strategy.

Schedule - Field time of 70 days. Potential for extension to schedule due to possible entanglement of pipeline and umbilical within trench and possible failure of pipeline during reverse reeling.

Technical Maturity - Reel installation of pipelines is a standard subsea operation but, while reverse reeling has been carried out elsewhere, there is a relatively limited track record of reverse reeling for removal of pipelines in the UKCS. Low track record of unburial over extended distance.

Current understanding of pipeline integrity is that this option is feasible when considering production Life, pipeline age, wall thickness design report and required wall thickness for reverse reel scenario.

Technical risk with transition section and the number of reel changeouts required etc. Other unknowns are associated with how bending stresses, thermo cycling etc may have affected the integrity of the line for lifting or unburial. Nothing of this scale has been attempted before in the UKCS.

Total Cost including 30% contingency (Operational + Legacy) = 10.9X

Given limited track record of operation, and the recent span (now remediated), anticipate 2 further surveys

Availability of appropriate vessels may put up price or extend schedule

Total Cost including 30% contingency (Operational + Legacy) = 10.9X

The costs do not allow for issues arising from reverse reeling. There is a 30% contingency to reflect cost estimate accuracy.

W W W

4.1 Impact on Fishing Industry

Small area of natural seabed disturbed. Seabed would be left with rock dump of ends. No spaces or exposures.

Large area of seabed temporarily disturbed but this will revert to natural condition over time and there would be no impact on fisheries after this time. Pipeline and umbilical are permanently removed, leaving a clear seabed.

Dispersed rock will remain on seabed. Slight dip where infrastructure removed from trench. Use of MFE has potential to create a berm but this will be mitigated through testing in an over-trawl trial. Anticipate natural back filling of trench over time. No other legacy impact.

There is also a potential continued low risk to fishing gear for legacy Option 1B.

W W W

5.1 Technical

Small impact on communities and amenities only as no material returned to shore.

Some impact on communities and amenities as majority of pipeline and umbilical would be returned to shore for dismantling/recycling.

Some impact on communities and amenities as majority of pipeline and umbilical would be returned to shore for dismantling/recycling.

Overall there is very little difference between the options. For example, the majority of infrastructure can be recycled, all likely to be processed at an existing facility and unlikely to create any additional jobs. Assumption is receiving facility will also do the treatment, so no onshore transportation required. The volumes of recyclables and waste to landfill is small. Some of the subsea inventory is relatively new and shouldn’t be too degraded. Where possible items will be reused e.g. mattresses could be reused subject to testing. Most of the removed material shall be recycled.
8.3 APPENDIX 3: JULIET INFRASTRUCTURE SCHEMATICS – BEFORE AND AFTER DECOMMISSIONING

Figure 8.1 Existing Juliet Infrastructure
Figure 8.2  Option 1B Decommissioning Outcome - Disconnect Pipeline & Rock-Dump Ends
Figure 8.3 Existing Juliet Manifold

Figure 8.4 Option 1B Decommissioning Outcome - Removal of Manifold
Juliet Decommissioning

Riser - as existing

Figure 8.5   Existing Juliet Riser

Juliet Decommissioning

Riser - Option J1-1B: Minimal intervention

Figure 8.6   Option 1B Decommissioning Outcome - Minimal intervention