Supplier	**Xodus Group Limited**
Ref Number (Project/Job/PO)	**A-301649-S01**
Supplier Document Number	**A-301649-S01-REPT-006**
FEL Document Number	**FFL-DUN-MER-HSE-01-RPT-00001**

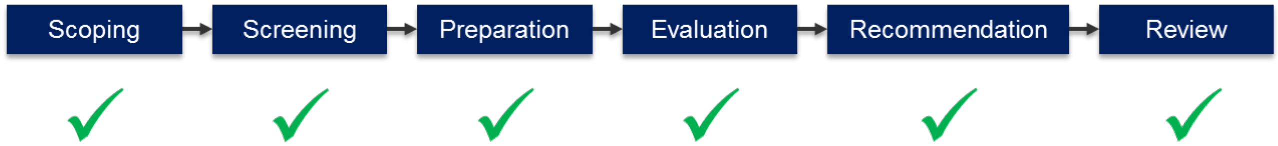
Merlin Field Subsea Infrastructure Comparative Assessment

APPROVAL STATUS (To be completed by FEL)		**SIGNED**	**DATE**
1	Not Approved		
2	Approved Subject To Comments		
3	Approved	G.F.	20/06/17
4	For Information Only		

REVISION HISTORY					
A02	17/04/17	Re-issued for Use	MB	PT	PT
A01	24/03/17	Issued for Use	PT	KC	PT
R02	13/03/17	Issued for Client Review	AMB	PT	PT
R01	20/02/17	Issued for Client Review	PT	JF	PT
Revision	**Date**	**Description**	**Originator**	**Checked**	**Approved**

Executive Summary

Fairfield has conducted a Comparative Assessment (CA) in support of the Merlin Subsea Infrastructure Decommissioning Programme. The following steps from the Oil and Gas UK CA Guidelines have been completed:



This CA report presents the methodology, decisions which needed to be taken, the preparation works carried out, and the outcomes (recommendations) from the internal and external (with stakeholders) workshops.

The CA for the Merlin Subsea Infrastructure Decommissioning Programme has focussed on three groups (Trenched and Rock Dumped Pipelines and Umbilicals, Trenched and Buried Pipelines, and Umbilical Riser). All other groups of Merlin subsea infrastructure were confirmed at the CA Scoping and Screening stage to be fully removed from the field. The outcome of the CA process has made the following recommendations:

Group	Infrastructure Type	Decommissioning Recommendation
1	Pipeline and Umbilical Components	Full Removal
2a	Deposits	Full Removal
2b	Structures	Full Removal
3	Structures and Deposits (Pipeline Route)	Full Removal
4	Surface Laid Flexible Jumpers	Full Removal
5	Surface Laid Rigid Spools	Full Removal
6	Surface Laid Umbilicals	Full Removal
7	Trenched and Rock Dumped Pipelines and Umbilicals	Leave in Situ – Minimal Intervention (Rock Placement)
8	Trenched and Buried Pipelines	Full Removal - Reverse Reeling
9	Umbilical Riser	Leave in Situ – Minor Intervention (Outboard Cut and Recovery)

Table 1 Final Merlin Recommendations

The three decisions (7, 8 and 9) were found, on completion of an appropriate amount of preparatory study work, to have clear decision outcomes. Sensitivities were performed where appropriate (e.g. relating to economics, or relating to uncertainty for some rankings) and found that these did not alter the overall decision outcomes.

The only infrastructure remaining from the Merlin field following decommissioning is proposed to be the already trenched and rock dumped pipelines and umbilicals, and the section of the umbilical riser which is within the J-Tube integral to the Dunlin Alpha CGB, all other infrastructure will be fully removed.

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1. Introduction

1.1. Overview

Fairfield Betula Limited (Fairfield) is the operator of the Dunlin, Osprey and Merlin fields, located in United Kingdom Continental Shelf (UKCS) Blocks 211/23 of the northern North Sea.

The Dunlin field was discovered by Shell UK in 1973 and the Dunlin Alpha platform subsequently installed in 1977; production from the field commenced in 1978. Prior to cessation of production, hydrocarbons from the Osprey and Merlin fields were transported to the Dunlin Alpha platform by pipeline for processing at a dedicated module.

Infrastructure associated with the Dunlin, Merlin and Osprey fields are currently being prepared for decommissioning. The Dunlin field lies approximately 137 km from the nearest landfall point, 196 km north east of Lerwick and 508 km north east of Aberdeen. The field sits 11 km from the UK/Norway median line and in a water depth of approximately 150 m (Figure 1.1). The Osprey field is a subsea tie-back located 6 km to the north-north west of the Dunlin Alpha platform and the Merlin field is a subsea tie-back located 7 km to the west-north west of the Dunlin Alpha platform. Production at the fields ceased following cessation of production in 2015 and Fairfield now intend to decommission all three fields.

1.2. Purpose

The purpose of this document is to present a Comparative Assessment (CA) for the Merlin subsea infrastructure in support of the decommissioning programme. The document describes the field infrastructure, the decommissioning options considered, the method used in the CA and the recommendations made during the CA process.

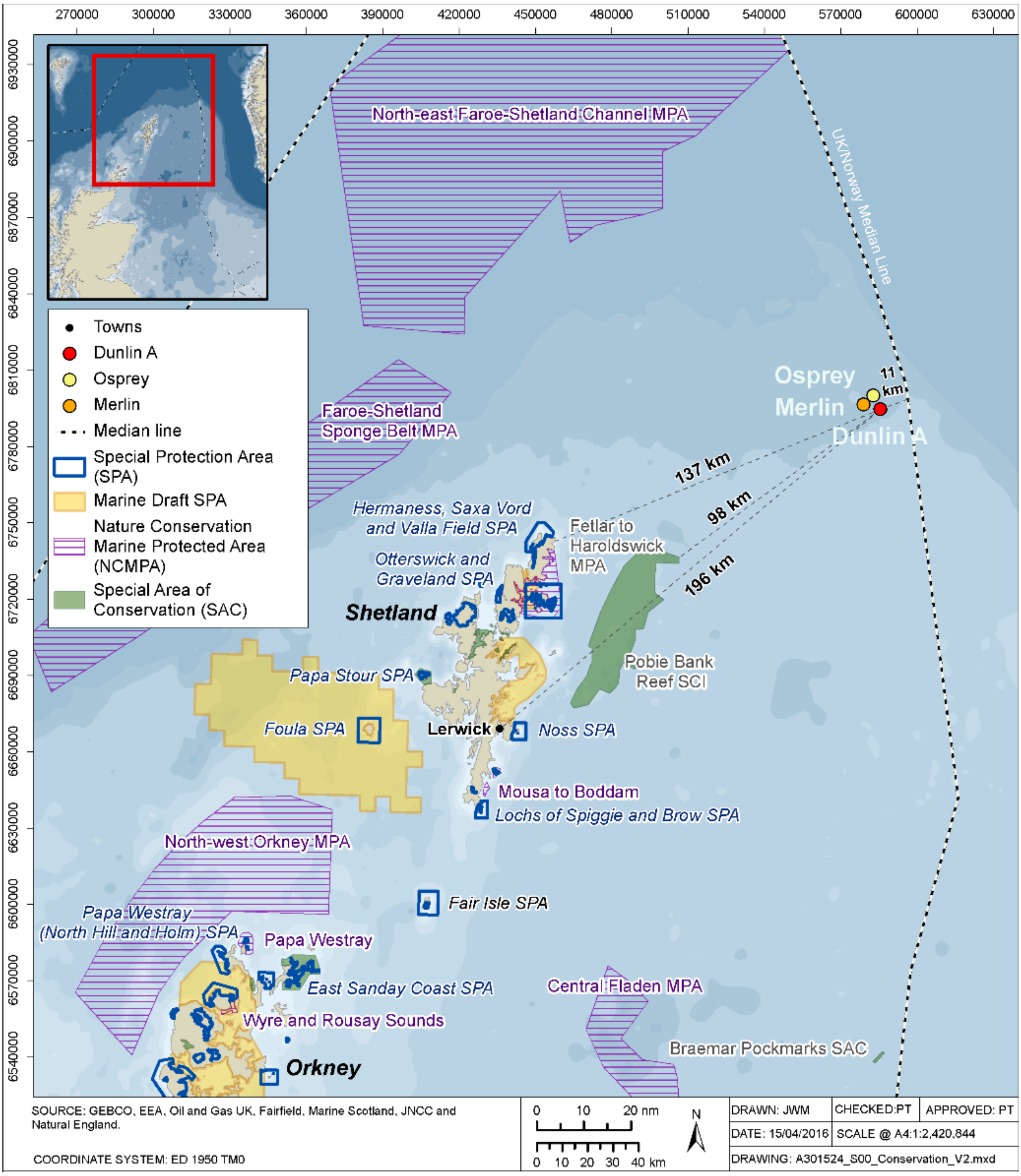


Figure 1.1 Location of Osprey, Merlin and Dunlin

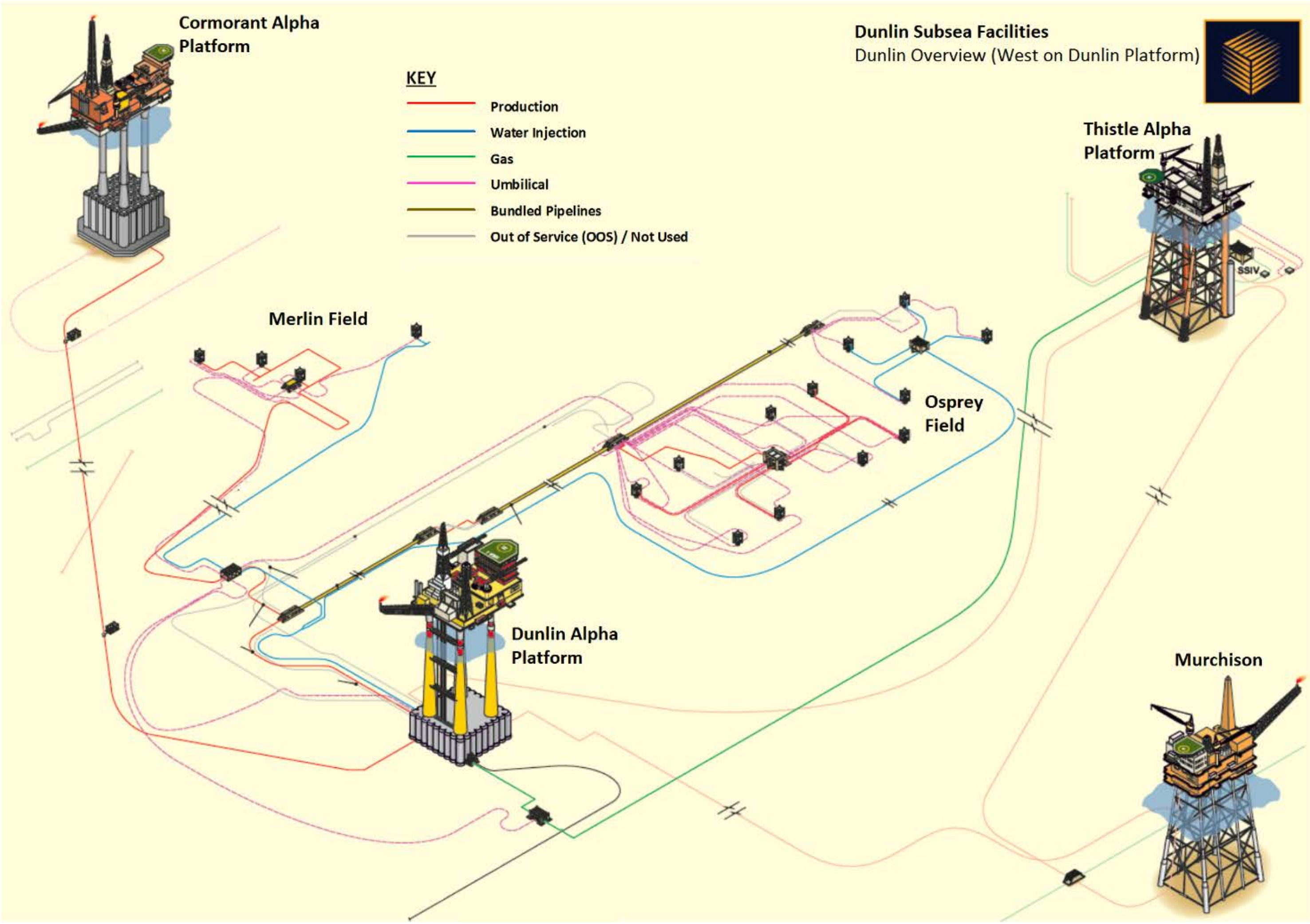


Figure 1.2 Dunlin Area Layout

1.3. Report Structure

This CA Report contains the following:

- Section 2 – An overview of the CA methodology;
- Section 3 – A description of each decision required to be made through the CA;
- Section 4 – A description of the study work undertaken to prepare for selecting a preferred option for each subsea infrastructure group;
- Section 5 – Presents the results of the CA process;
- Section 6 – Summary and recommendations;
- Section 7 – References
- Section 8 – Acronyms and glossary
- Appendix A – Pairwise Methodology Explanation
- Appendix B – CA Criteria
- Appendix C – Environment Criteria Assessment Methodologies
- Appendix D – Stakeholder CA Workshop Minutes
- Appendix E – Data Sheets (Exc. Costs)
- Appendix F – CA Attributes Tables & Pairwise Comparison (Exc. Costs)
- Appendix G – Decision Output Charts
- Appendix H – Data Sheets (Inc. Costs)
- Appendix I – CA Attributes Tables & Pairwise Comparison (Inc. Costs)

2. Comparative Assessment Methodology

2.1. Overview

CA is a process by which decisions are made on the most appropriate approach to decommissioning. As such it is a core part of the overall decommissioning planning process being undertaken by Fairfield for the subsea infrastructure at Osprey, Merlin and Dunlin.

Guidelines for CA were prepared in 2015 by Oil and Gas UK where seven steps to the CA process were recommended. Table 2.1 provides commentary on each of these steps to demonstrate the Fairfield position.

Title	Scope	Status	Commentary
Scoping	Decide on appropriate CA method, confirm criteria, identify boundaries of CA (physical and phase), and identify and map stakeholders	✓	Scoping Reports prepared for Osprey, Merlin and Dunlin subsea infrastructure in advance of Screening (see below). Stakeholders identified and mapped and Stakeholder Engagement Plan prepared. CA methodology and criteria established for screening by early 2016.
Screening	Consider alternative uses and deselect unfeasible options.	✓	Screening workshops held Q1 2016 with external stakeholders for Osprey, Merlin and Dunlin. Specific studies identified and agreed that would help with the evaluation of options. CA methodology and criteria also revisited following screening to support option selection.
Preparation	Undertake technical, safety, environmental studies plus stakeholder engagement	✓	Studies undertaken alongside continued stakeholder engagement. Section 4 lists the relevant study reports.
Evaluation	Evaluate the options using the chosen CA methodology	✓	Fairfield conducted two internal CA workshops as part of the evaluation phase. The first, in August 2016, identified areas where further information was needed in order to make a recommendation (effectively recycling to the preparation phase). A second internal workshop was held in November where the results of recent study work were used to discuss and update the decision tool. An additional study (fisheries QRA) was commissioned to run in parallel and be used to either amend or validate the decision tool.
Recommendation	Create recommendation in the form of narrative	✓	The two workshops described above under the Evaluation stage produced a set of emerging recommendations which Fairfield presented as emerging

Title	Scope	Status	Commentary
	supported by charts explaining key trade-offs.		recommendations to external stakeholders. A Briefing Session was held in December 2016 to review these and provide additional data to stakeholders.
Review	Review the recommendation with internal and/or external stakeholders	✓	Workshop held with external stakeholders (JNCC, SFF, Marine Scotland, BEIS, OGA) on Tuesday 10 January 2017.
Submit	Submit to BEIS as part of/alongside Decommissioning Programme	✓	This report is available alongside the Decommissioning Programme for the Merlin subsea infrastructure.

Table 2.1 CA Process Overview

2.2. CA Methodology

Fairfield has selected a Multi Criteria Decision Analysis (MCDA) methodology for the evaluation phase of the CA. This methodology uses a pairwise comparison system based on the methodologies of the Analytical Hierarchy Process (AHP) by T.L. Saaty, described in various publications, such as Analytical Hierarchy Process ref. [9]. This allows the relative importance of each differentiating criteria to be judged against each other in a qualitative way, supported by quantification where appropriate. The key steps for the evaluation phase of the CA are as follows:

- Define Differentiating Criteria – this was completed in July 2016;
- Define Options – this was initially completed as part of CA Screening, but a trial run internal CA workshop validated or amended the options where appropriate;
- Pre-populate worksheets for internal CA workshops – based on all the studies undertaken the worksheets were pre-populated in advance of the internal CA workshops;
- Perform internal CA workshop:
    - Discuss attributes of each option against each differentiating criteria – the discussion was recorded 'live' during the workshop in order that informed opinion and experience is factored into the decision-making process;
    - Perform scoring (see Appendix A.3);
    - Perform sensitivity analyses to test the decision outcomes;
- Export CA worksheets as a formal record of the workshop attendees' combined opinion on the current preferred options, the 'Emerging Recommendations';
- Evaluate whether the CA needs to 'recycle' to the Preparation phase to obtain any further information to help inform decision making (this occurred following the first internal CA workshop in August 2016);
- Discuss Emerging Recommendations with stakeholders (January 2017); and
- Recycle process as required prior to decision on the selected options which will be presented in the Decommissioning Programme and assessed in the Environmental Impact Assessment.

The sections below describe how the MCDA methodology has been applied. Appendix A contains a more detailed explanation of the workings behind the MCDA tool.

2.3. Differentiating Criteria & Approach to Assessment

A key step in setting up the CA was agreeing and defining the appropriate criteria that differentiates between each of the tabled options. As a starting point, the criteria considered for this CA were taken from the DECC (now BEIS) Guidelines for Decommissioning of Offshore Oil and Gas Installations and Pipelines which are as follows (in no particular order):

- Safety
- Environmental
- Economic
- Technical
- Societal

These differentiating criteria were found to be appropriate for the decommissioning options tabled and were largely aligned with Fairfield's Guiding Principles, Ref [1] and were taken forward as the primary differentiating criteria for the CA. Additional sub-criteria and definitions were added for clarity and are shown in Table 2.2 alongside the approach used for assessment under each criteria or sub-criteria.

Appendix C provides some additional information on the calculations/assumptions used for assessing the environmental criteria.

Differentiating Criteria	Sub-Criteria	Description	Approach to Assessment
1. Safety	1.1 Personnel Offshore	This sub-criterion considers elements that impact risk to offshore personnel and 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.	Summed PLL numbers allow a quantified direct comparison between options. See section 4.3 for information on study work undertaken.
	1.2 Personnel Onshore	This sub-criterion considers elements that impact risk to onshore personnel. Factors such as any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel.	
	1.3 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.	
	1.4 High Consequence Events	This sub-criterion relates to any inherent potential for high consequence events i.e. major accident hazard, major environmental hazard type events. It applies to all onshore and offshore personnel involved in the project. Considerations such as dropped object concerns, support vessel risks, are considered.	Assessment made based on summed PLL numbers and narrative around other factors such as high consequence events or residual risk where there was a differentiator.
	1.5 Residual Risk	This sub-criterion addresses and residual risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, that is provided by the option. Issues such as residual snag risk, collision risk, etc. may be considered.	
2. Environmental	2.1 Marine Impacts	This sub-criterion covers elements such as underwater noise generated by vessels, cutting operations, explosives etc. It also covers any damaging discharges to sea from vessels and / or activities performed.	Assessment based on quantifying underwater noise generated by decommissioning activities in the short term. Potential discharges to sea also

Differentiating Criteria	Sub-Criteria	Description	Approach to Assessment
			captured where appropriate, but assumed not to be a differentiating factor for flushed and cleaned pipelines.
	2.2 Emissions	This sub-criterion relates to the amount of damaging atmospheric emissions associated with a particular option.	A life-cycle emissions assessment has been carried out capturing: • Transport emissions from vessels or trucks; • Rock excavation; • Reuse of materials; • Production of new materials; • Disposal of marine growth; and • Material left *in situ.* The output CO2 figures allow a direct, quantitative comparison between options.
	2.3 Consumption	This sub-criterion relates to the amount of Energy / Resource consumption such as fuel use, recycling of materials, use of quarried rock, production of replacement materials.	Assessment based on quantifying the volume of fuel and new material used.
	2.4 Disturbance	This sub-criterion relates to both direct and indirect seabed disturbance. Both short and long term impacts are considered.	Assessment based on quantifying the area of disturbance by type of disturbance (dredging, rock dump, trenching, backfilling), in combination with an understanding of the baseline

Differentiating Criteria	Sub-Criteria	Description	Approach to Assessment
			environment in the area as shown by the outputs from the environmental surveys.
	2.5 Protections	This sub-criterion relates to the impact of the options on any protected sites and species.	The Dunlin Area as a whole (including Merlin and Osprey) does not overlap with any protected areas or zones. The habitat type is mud with sea pens and burrowing megafauna which is a priority marine feature, however impacts on this habitat type (and associated recovery) is via the mechanism of seabed disturbance which is covered in sub-criteria 2.4 above. Therefore, 'Protections' on its own is not considered to be a differentiator.
3. Technical	3.1 Technical Risk	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. Technical Feasibility and Technical Maturity is also considered.	Assessment based on engineering studies (see section 4.2) and captures: • Feasibility; • Concept Maturity; • Availability of Technology; • Track Record; • Risk of Failure; • Consequence of Failure; and • Emerging Technology.

Differentiating Criteria	Sub-Criteria	Description	Approach to Assessment
4. Societal	4.1 Fishing	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.	Commercial Fisheries Baseline Study provides a base level of understanding for the importance of the area for fisheries. This is combined with narrative (rather than quantification) regarding the influence of each decommissioning option on the availability of the area of seabed for fisheries. A fisheries QRA (see section 4.3) has been used to provide some context for the risk of loss of equipment due to snagging risk.
	4.2 Other Users	This sub-criterion addresses any socio-economic impacts on other users both onshore where the impact may be from dismantling, transporting, 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	Assessment of impacts on other users is a qualitative narrative considering both positive and negative impacts on waste disposal, recycling, business interruption

Differentiating Criteria	Sub-Criteria	Description	Approach to Assessment
		communities or amenities are considered here e.g. business or jobs creation/retention, increase in noise, dust or odour pollution during the process which has a negative impact on communities, increased traffic disruption due to extra-large transport loads, etc. Includes the FEL Guiding Principle of 'Minimal business interruption to others'.	and general community impacts. Potential employment benefits have been considered but at the scale of any individual option and in context with the wider full removal scopes for each field area the potential employment benefits are not deemed to be a differentiator.
5. Economic	5.1 Short-term Costs	This sub-criterion addresses the cost of delivering the option as described. No long-term cost element is considered here. Cost uncertainty (a function of activity maturity) is also recorded.	See engineering studies, section 4.2.
	5.2 Long-term Costs	This sub-criterion addresses the costs associated with any long-term liabilities such as on-going monitoring and any potential future remediation costs.	See engineering studies, section 4.2. Timeframe assumed for the purposes of the CA is 50 years.

Table 2.2 Differentiating Criteria and Sub-Criteria

2.4. Differentiator Weightings

The 5 differentiating criteria all carry a 20% weighting. That is, all criteria are neutral to each other. Figure 2.1 shows the pairwise comparison matrix. Fairfield decided that equal weightings offered the most transparency and a balanced view from all perspectives.

Differentiating Criteria	1. Safety	2. Environmental	3. Technical	4. Societal	5. Economic	Weighting
1. Safety	N	N	N	N	N	20%
2. Environmental	N	N	N	N	N	20%
3. Technical	N	N	N	N	N	20%
4. Societal	N	N	N	N	N	20%
5. Economic	N	N	N	N	N	20%

Figure 2.1 Example Pairwise Comparison Matrix (N = Neutral)

2.5. Option Attributes

The next step in the CA process was to describe and discuss the attributes of each option with respect to each of the differentiating criteria. In preparation, all relevant data and information developed during the preparation phase were pre-populated into the attributes table for each option. Appendix F contains the completed Merlin Attributes Tables.

Any additional discussion around the relative merits of the options was also recorded in the attributes matrix. A summary discussion of why options are considered more or less attractive with respect to each of the differentiating criteria was also recorded. An easy-to-read version of this matrix was supplied to stakeholders as part of the recommendation review process.

2.6. Option Pair-Wise Comparison

Once the option attributes were compiled and discussed, a pair-wise comparison was performed for each of the differentiating criteria where the proposed options were compared against each other. The pairwise comparison adopted in this case used phrases such as stronger, much stronger, weaker, much weaker, etc. to make qualitative judgements (often based on quantitative data) of the options against each other. Adopting these phrases rather than the more common numerical 'importance scale' from the Analytical Hierarchy Process (AHP) is often more intuitive and representative of the sentiment of a workshop.

One of the challenges of applying the numerical importance scale historically, is that often when scoring a pair of options against each other as a score of 3, delegates implied the comparison was 3 times better, etc. rather than 'slightly better' as the importance scale suggests.

To manage this, Fairfield chose to apply the principles of the AHP by replacing numbers in the pairwise comparison matrix with a narrative or descriptive approach. This is already programmed into the AHP in the importance scale explanations (see Appendix A, Table A.1). It was agreed that three positions from equal (and their reciprocals) would be sufficient for this CA. These positions were:

Phrase	Meaning
Neutral	Equal Importance, equivalent to 1 in the importance scale from Table A.1.
Stronger (S) / Weaker (W)	Moderate importance of one criteria / option over the other, equivalent to 3 in the importance scale from Table A.1.
Much Stronger (MS) / Much Weaker (MW)	Essential / strong importance of one criteria / option over the other equivalent to 5 or 6 in the importance scale from Table A.1.
Very Much Stronger (VMS) / Very Much Weaker (VMW)	Extreme importance of one criteria / option over the other equivalent to 8 or 9 in the importance scale from Table A.1.

Table 2.3 Explanation of Phrasing Adopted for Pairwise Comparison

Using this transposed scoring system made it simpler and, more importantly, more effective at capturing the mind-set and feeling of the attendees at the workshops. Phrases such as 'what are the relative merits of pipeline removal on a project versus rock dumping from a safety perspective? Are these Neutral to each other? Are they stronger? If so, how much stronger? If you had to prioritise one over the other, which would it be?'. This promoted a collaborative dynamic in the workshop and enabled the collective mind-set of the attendees to be captured. Where there was quantitative data to provide back-up and evidence to support the collective assertions, so much the better.

Largely, these qualitative judgements were driven by the quantitative parameters captured in the previous step (as described in Table 2.2 above). This allowed qualitative and quantitative judgment criteria to be combined. A summary example of the completed pair-wise comparisons for differentiating criteria versus options are shown in Figure 2.2 with a full worked example in Appendix A.4.

1. Safety	Option 1	Option 2	Option 3
Option 1	N	S	N
Option 2	W	N	W
Option 3	N	S	N

3. Technical	Option 1	Option 2	Option 3
Option 1	N	N	S
Option 2	N	N	S
Option 3	W	W	N

5. Economic	Option 1	Option 2	Option 3
Option 1	N	MS	MW
Option 2	MW	N	VMW
Option 3	MS	VMS	N

Figure 2.2 Example Option Pair-Wise Comparison

2.7. Visual Output and Sensitivities

The decision-making tool used the above judgements to automatically generate a visual output indicating the highest scoring option i.e. the option which represents the most ‘successful’ solution in terms of its overall contribution to the set of differentiating criteria. At this stage, opportunity was provided to fine tune the judgements provided to ensure that all attendees were happy to endorse the outcome. The visual outputs from each decision point are included in section 5.

The CA output could then easily be stress tested by the workshop attendees by undertaking a sensitivity analysis such as by modifying the pair-wise comparison of the options against each other within the differentiating criteria where appropriate. These sensitivities helped inform workshop attendees as to whether a particular aspect was driving a preferred option, or indeed if the preferred option remained the same when the sensitivities were applied the preferred option was effectively reinforced. Where sensitivities were performed, these are described in section 5.

3. Comparative Assessment Decisions

3.1. Overview

Table 3.1 lists all infrastructure groups from the Merlin field. Early CA scoping and screening activities identified where full removal would be the immediately recommended approach, and where the remainder of the CA process needed to be undertaken in order to conclude on a recommended approach (groups 7, 8 and 9). The options for these groups are provided in Table 3.1.

Group	Infrastructure Type	Decommissioning Recommendation
1	Pipeline and Umbilical Components	Full Removal
2a	Deposits	Full Removal
2b	Structures	Full Removal
3	Structures and Deposits (Pipeline Route)	Full Removal
4	Surface Laid Flexible Jumpers	Full Removal
5	Surface Laid Rigid Spools	Full Removal
6	Surface Laid Umbilicals	Full Removal
7	Trenched and Rock Dumped Pipelines and Umbilicals	Subject to Comparative Assessment
8	Trenched and Buried Pipelines	Subject to Comparative Assessment
9	Umbilical Riser	Subject to Comparative Assessment

Table 3.1 Merlin Infrastructure Groups

3.2. Options Carried Forward to Full Comparative Assessment (Option Recommendation)

Screening was conducted in March 2016. Section 5 of this CA report demonstrates which options were screened in and screened out at that stage, and detailed information on the decisions made at screening are available in the Merlin CA Screening Report Ref [2].

Table 3.2 identifies the options included within the CA process for the Merlin subsea infrastructure. Table 3.3 identifies the battery limits for Merlin subsea infrastructure. Figures 3.1 and 3.2 show the locations of these infrastructure groups in relation to the remaining infrastructure which is proposed for full removal.

Decision	Group	Description	Option 1	Option 2	Option 3
1	7	Trenched and Rock Dumped Pipelines and Umbilicals	End removal, local rock dump of cut ends and areas of low burial depth, periodic monitoring and remediation as required.	End, span and exposure removal, local rock dump of cut ends, periodic monitoring and remediation as required.	End removal, local rock dump of cut ends and backfill along length using MFE, periodic monitoring and remediation as required.
2	8	Trenched and Buried Pipelines	End removal, local rock dump of cut ends and areas of low burial depth, periodic monitoring and remediation as required.	End, span and exposure removal, local rock dump of cut ends, periodic monitoring and remediation as required.	Full removal using reverse reeling technique, no monitoring required.
3	9	Umbilical Riser	Cut outboard of j-tube subsea and recover, remainder to remain in-situ.	Cut outboard of j-tube subsea and recover, remainder to be removed by topside pull.	

Table 3.2 Merlin Decision Points

Field	System	Battery Limits
Merlin	Water Injection	From the flowbase on water injection tree W11 to the 8" flange on the 10" / 8" Wye on pipeline PL735A. Upstream of the flowbases belong to well plug and abandonment scopes.
	Production	From the flowbase on production well P13 to Osprey Towhead 6. Upstream of the flowbases belong to well plug and abandonment scopes.
	Controls	The battery limits for the umbilicals are from the topside umbilical termination unit on the Dunlin Alpha platform to the Merlin Xmas tree SCM's (production and water injection) and manifold valves.

Table 3.3 Merlin Battery Limits

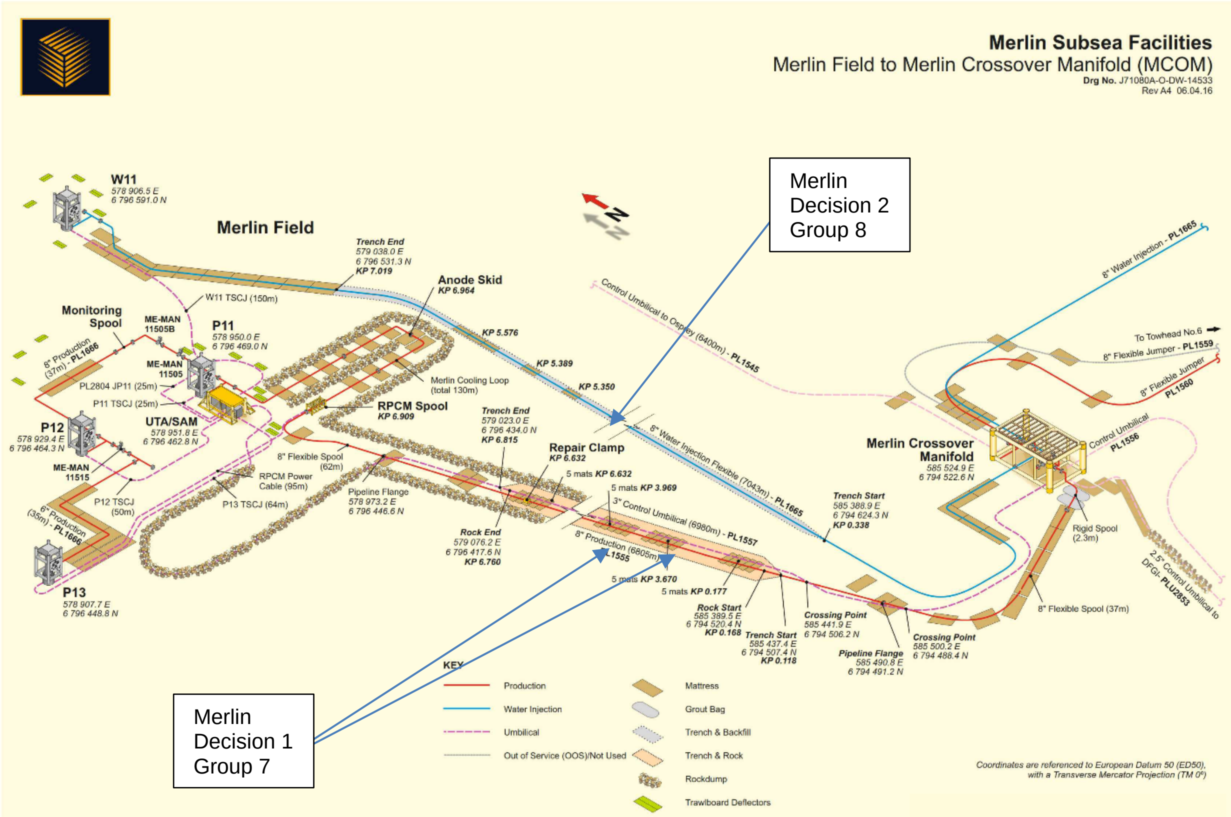


Figure 3.1 Merlin Decision Points (1 & 2)

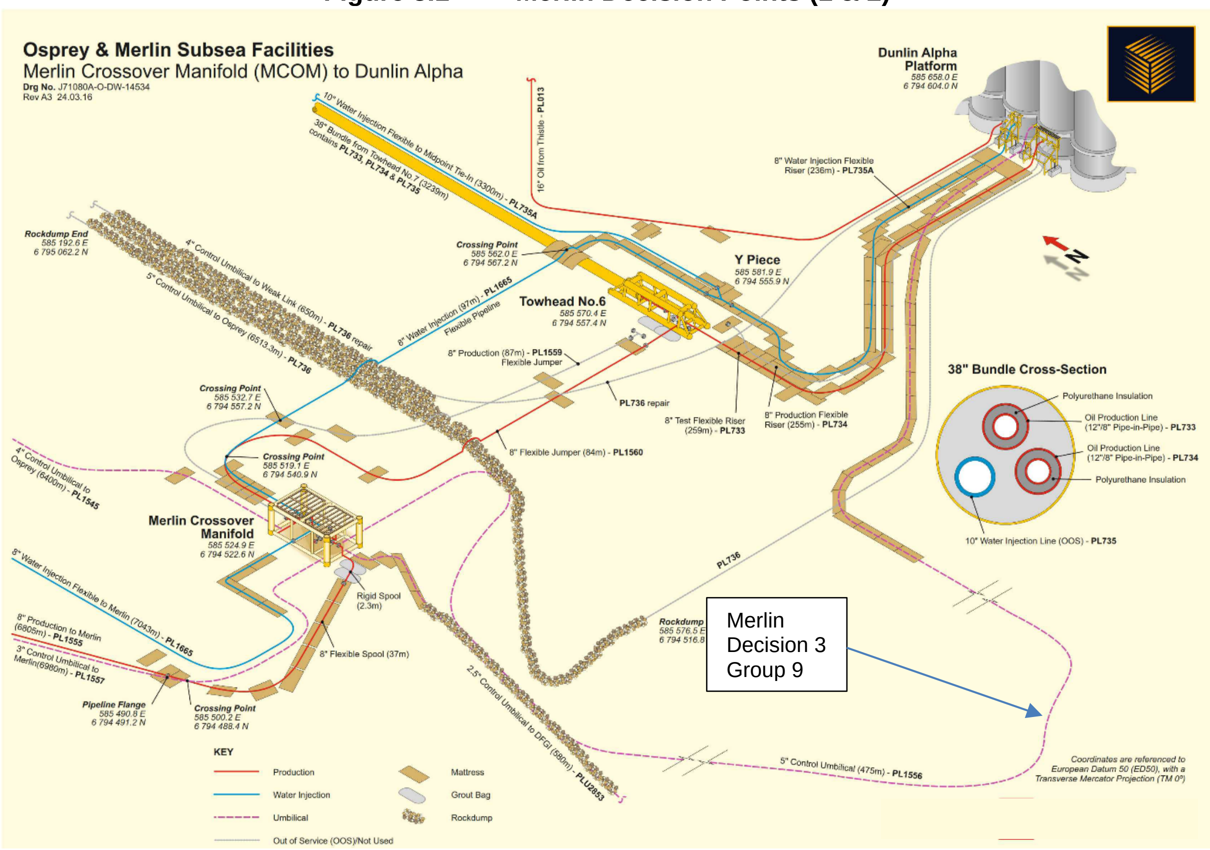


Figure 3.2 Merlin Decision Points (3)

4. Comparative Assessment Preparation

4.1. Introduction

In advance of the internal CA workshops the preparation phase output was consolidated into a data sheet (Appendix E) for each option and the decision tool was pre-populated. Additional narrative was added during the internal CA workshops.

This section presents the work carried out following the CA Screening session held with stakeholders in Q1 2016. Note that the CA Scoping and Screening reports, and the reports of all other CA preparation activities, are available on request so information within them is not presented here.

For clarity of presentation, in advance of the external CA workshops, the decision tool and emerging recommendations were provided to stakeholders with a consolidated narrative and key data points only. A Briefing Session was held a month in advance of the external CA workshop where stakeholders were provided with an opportunity to discuss any supplementary information that they would like to receive.

Studies and activities during the Preparation phase were conducted under four broad themes:

- Engineering;
- Safety;
- Environmental and Societal; and
- Consultation / Engagement with Stakeholders and Supply Chain.

This work was conducted alongside regular continued engagement with the Regulator, BEIS.

4.2. Engineering Studies

Merlin Common Scope Report ref. [3]. This report provided the following information on each option:

- Execution Method Statement, including:
    - Sequence of operations;
    - List of vessels and equipment specifications and durations;
    - Materials requirements;
    - Environmental impacts (i.e. area of disturbance, vessel emissions, noise outputs);
    - Onshore disposal requirements;
    - Execution Schedule;
    - Cost estimate;
    - Long term liability estimation (considering material remaining in situ, material degradation, seabed mobility);
    - Risk review (see section 4.3 below).

This information was summarised into the datasheets made available during the CA workshop. Additionally, the following studies were also completed and informed the above report:

- Merlin specific scopes:
    - Merlin Long-term Materials Degradation Study ref. [4];

    - Merlin Trench and Backfill Feasibility Study ref. [5];
    - Merlin Removal / Recovery Feasibility Study ref. [6];
    - Merlin Effect of Riser Remaining ref. [7];

4.3. Safety Studies

Fairfield conducted two specific safety studies:

- Personnel risk review (contained within the Common Scope Report referenced in 4.2), which considered:
    - General working occupational risk for the suite of activities associated with each option. This included offshore exposure (e.g. diver activity, vessel based activity and topsides activity), onshore activities (up to the final disposal/recycling point) and legacy activities (e.g. future surveys and remediation activities). A set of Fatal Accident Rates (FAR) were used to provide a consistent approach to assessing Potential Loss of Life (PLL); and
    - Unique high consequence events from major accident hazards. Major accident hazards were defined as those events with the potential for serious injury or fatality to more than 4 personnel.
- Fisheries Quantified Risk Assessment (QRA) ref [19] which:
    - Determined fishing activity in the vicinity of the Dunlin, Merlin and Osprey pipelines, umbilicals and bundles;
    - Calculated frequency of interaction (probability of occurrence) of vessels fishing across the subsea infrastructure; and
    - Calculated PLL for the decommissioning options specified above.

The personnel risk review was based on the Risk Analysis of Decommissioning Activities ref. [8] which provided the PLL calculation methodology and FAR values. The CA outputs are quantitative PLL tables and are included in the relevant sections of the Common Scope Report.

4.4. Environmental Societal Studies

The following studies, surveys and activities were used to support the evaluation process:

- Environmental surveys:
    - Habitat Assessment Reports ref. [11];
    - Environmental Baseline Survey Reports ref. [12];
    - Drill Cuttings Analysis ref. [13];
- Pipeline Cleanliness Study ref. [14];
- Lifecycle Emissions Assessment ref. [16];
- Noise Emissions Calculations (contained within the Common Scope Report) ref. [3];
- Drill Cuttings Screening (against OSPAR 2006/5) ref. [15];
- Commercial Fisheries Baseline (including SFF Services Limited questionnaire survey) ref. [17];
- Internal Environmental Issues Identification Workshop detailed in the ENVID Report ref. [18].

4.5. Consultation & Engagement

4.5.1. Engagement Strategy

Fairfield recognised that early and ongoing engagement with stakeholders is a critical part of the development of robust, respectful programmes for the decommissioning of North Sea installations. To ensure the efficacy of stakeholder engagement, Fairfield developed a Stakeholder Engagement Strategy and Action Plan. This Plan outlined how and why stakeholder engagement should occur. It assisted in driving engagement through the CA, and was supported by a continually updated Stakeholder Engagement Workbook and Stakeholder Alignment Plan / Matrix, through which stakeholder engagement could be tracked.

4.5.2. Consultation

As a demonstration of Fairfield's execution of its stakeholder strategy and the extent to which external stakeholders have had the opportunity to influence the decommissioning project, a summary of the key engagement activities is given in Table 4.1. As well as working with key regulatory and environmental stakeholders, Fairfield has sought to understand the lessons that other UKCS Operators have learned during their decommissioning activities to date. In addition, Fairfield makes information available to the general public via a dedicated decommissioning website at http://www.fairfield-energy.com/.

Activity	Date	Stakeholders
Introduction to the Greater Dunlin Area Decommissioning Project	January 2010	Aberdeenshire Council, BEIS, Cefas, Decom North Sea, HSE, JNCC, Marine Scotland, Maritime and Coastguard Agency, Greenpeace, Scottish Enterprise, SEPA (Radioactive waste), SEPA (Marine), SFF, University of Aberdeen
Between 2010 and 2015, Fairfield continued engagement with stakeholders, including OSPAR and those outlined above, to guide the development of Fairfield's decommissioning strategy for the Greater Dunlin Area.		
Meet with statutory stakeholders to discuss progress	December 2015/January 2016	JNCC, Marine Scotland, SFF
Subsea CA Screening Workshop	March 2016	BEIS, JNCC, Marine Scotland, SFF
Update on Greater Dunlin Area decommissioning	April 2016	BEIS
Fisheries update on Greater Dunlin Area decommissioning	May 2016	UK Fisheries Offshore Oil and Gas Legacy Trust Fund (FLTC) National Federation of Fishermen's Organisations (NFFO), Northern Ireland Fish Producers' Organisation Limited (NIFPO)
Issue of note to advise on progress	June 2016	BEIS, JNCC, OGA, SFF
Update on Greater Dunlin Area decommissioning	July 2016	OGA

Activity	Date	Stakeholders
Workshop on decommissioning of concrete mattresses	September 2016	SEPA, Decom North Sea
Update meetings on Greater Dunlin Area decommissioning	September 2016	SFF, JNCC
Update on Greater Dunlin Area decommissioning	October 2016	SEPA
Briefing session for Subsea CA	December 2016	BEIS, JNCC, Marine Scotland, OGA, SFF
Subsea CA workshop	January 2017	BEIS, JNCC, Marine Scotland, OGA, SFF

Table 4.1 Summary of Key Stakeholder Engagement Activities

4.5.3. Supply Chain Engagement

In addition to its stakeholders, Fairfield has also informed its decommissioning projects (including the CA) through discussions with supply chain. The following organisations have been met:

- Bibby Offshore
- Jee
- PDi
- ROVOP
- Zenocean
- Subsea7
- Technip
- Ardent Global
- ASCO (disposal facilities)
- EMAS Chiyoda Subsea
- Halliburton
- Forth Ports
- CSub (GRP Subsea Protection Structures)
- Boskalis

5. Comparative Assessment Results

5.1. Decision 1: Group 7 – Trenched and Rock Dumped Pipelines and Umbilicals

5.1.1. Characteristics

This group comprises two pipelines, PL1555 and PL1557, within the same trench as described in Table 5.1.

Item	Characteristics
PL1555	8″ Oil Pipeline, installed 1997, 6,805 m long, 219 mm outside diameter (OD) Carbon steel with a PUF coating Trenched and rock dumped
PL1557	3″ Umbilical, installed 1997, 6,980 m long, 66 mm OD Material comprises polymers, super duplex and copper Trenched and rock dumped

Table 5.1 Decision 1 Characteristics

The routes of these lines are shown in Figure 5.1.

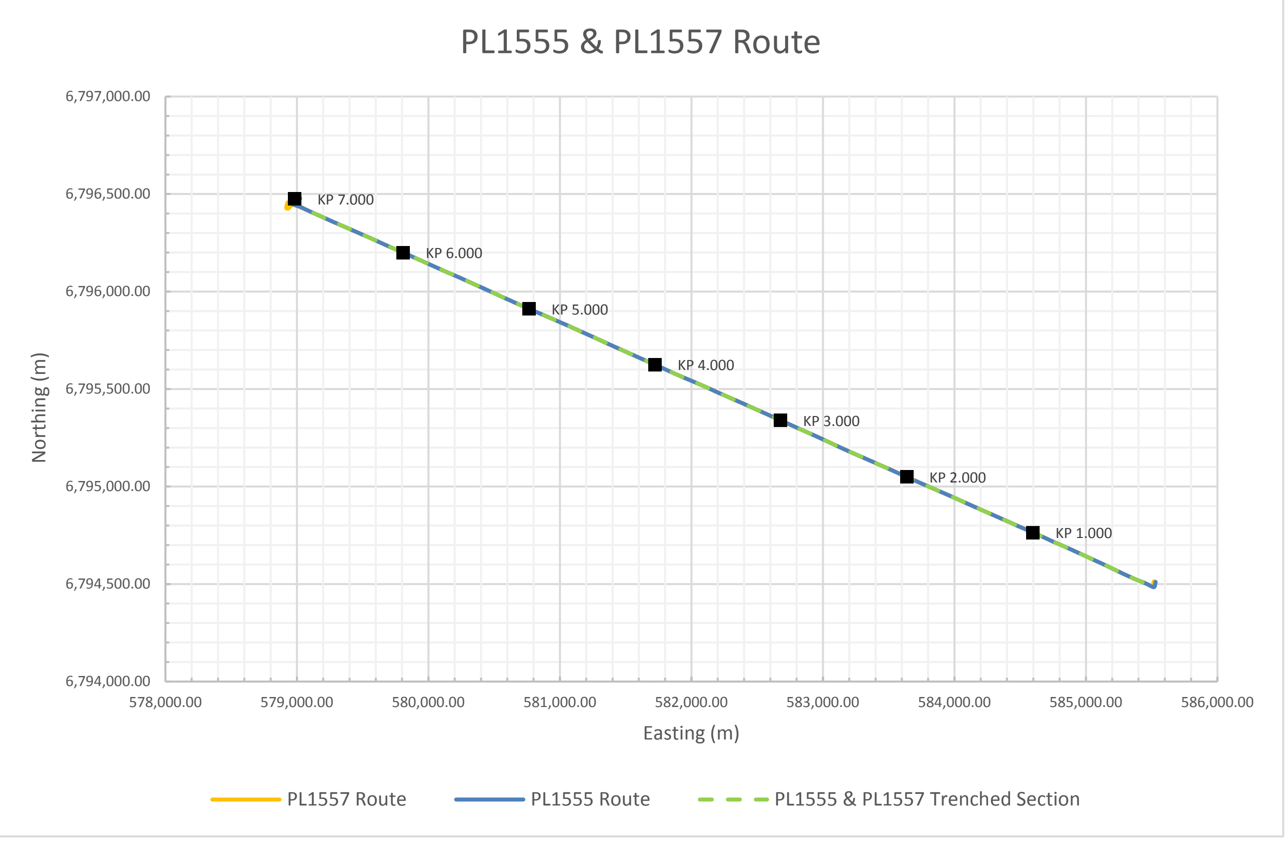


Figure 5.1 PL1555 & PL1557 Route

5.1.2. Options

Eight options were presented at screening stage with five of those screened out. The options assessed during the CA were:

- Option 1: Leave *in situ* – Minimal Intervention (Rock Placement) - Removal of exposed ends, rock placement over snag hazards and areas of low cover (i.e. those revealed on removal of mattresses/grout).
- Option 2: Leave *in situ* – Minor Intervention (Rock Placement) - Removal of all exposures, rock placement over snag hazards and areas of low cover (i.e. those revealed on removal of mattresses/grout).
- Option 3: Leave *in situ* – Major Intervention (Backfill).

Note that full removal options (reverse reeling and cut and lift) were removed at screening stage. More information is provided in the Screening Report Ref [2] but it was found that the configuration of these lines and known defects present, and associated safety and environmental impacts, meant that neither full removal option would be worth considering further in the CA process.

The process undertaken for this decision point, the judgement made against each of the five criteria, and the chart which demonstrates which option is recommended to be taken forward from the CA are presented on the following pages.

5.1.3. Sensitivity Analysis

A sensitivity analysis was performed on this decision point relating to economics. Removing the economics criteria (shown in blue on the chart) from the decision making process had no impact on the preferred option nor the order of the remaining options.

Additionally, the workshop attendees discussed the potential to remove the monitoring element associated with option 3 (with a noticeable impact on both safety and economics). This sensitivity improved the performance of option 3, but was not enough to change the overall outcome.

5.1.4. Recommendation

The outcome of the CA workshops is summarised on the next page.

In reality Options 1 and 2 are very similar, with Option 2 being differentiated by having more diving hours to undertake cutting works to remove the exposed pipeline or umbilical once mattresses and grout have been removed. As with all operations, Fairfield will look to minimise safety exposure (to all) and the introduction of new material, to the lowest amount required to ensure confidence in the long term future of the decommissioning solution.

The outcome of this decision point is therefore to decommission Group 7 *in situ.* This infrastructure will be decommissioned by removing all areas of exposure and placing local rockdump at the cut ends and areas of low burial depth. Periodic monitoring and remediation will be carried out at this location as required.

Group 7 – Trenched and Rock Dumped Pipelines and Umbilicals

Option Screening

(for narrative see Merlin Screening Report)

Leave in Situ – Minimal Intervention (Rock Placement) **Screened In**	Leave in Situ – Minor Intervention (Rock Placement) **Screened In**	Leave in Situ – Minor Intervention (Local Trench) **Screened Out**	Leave in Situ – Major Intervention (Full Re-Trench) **Screened Out**
Leave in Situ – Major Intervention (Rock Placement) **Screened Out**	Full Removal – Reverse Reeling **Screened Out**	Full Removal – Cut and Lift **Screened Out**	Leave in Situ - Major Intervention (Backfill) **Screened In**

Comparative Assessment

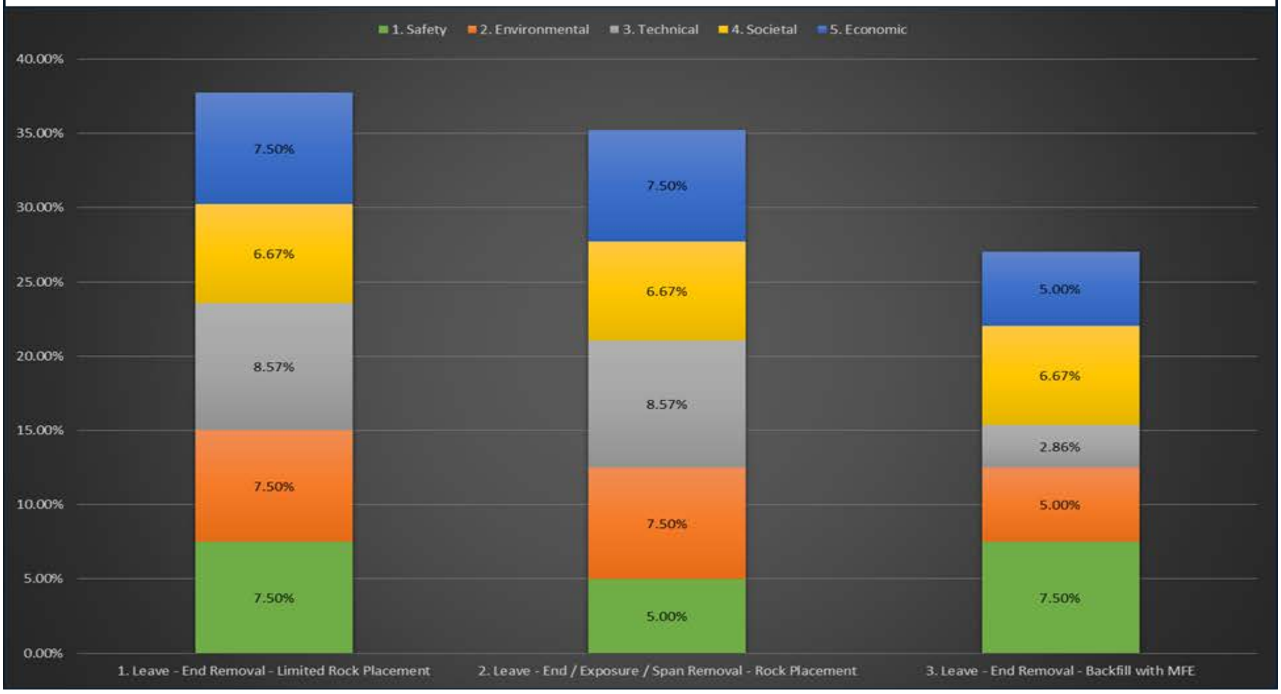
(for full attributes tables and pairwise comparisons see Appendix F)

Option 1	**Option 2**	**Option 3**
Leave in Situ – End Removal, Limited Rock Placement	Leave in Situ – End, Exposure & Span Removal, Rock Placement	Leave in Situ – End Removal, Backfill with Mass Flow Excavator

Safety	**Environment**	**Technical**	**Societal**	**Economic**
Summed PLL figures for options 1, 2 and 3 indicate that the risk exposure associated with options 1 and 3 are largely similar and slightly lower than option 2. Overall option 1 and 3 are **Neutral** against each other and both are **Stronger** than option 2 from a safety perspective.	Options 1, 2 and 3 are largely similar in terms of sound exposure, emissions and fuel use. Option 3 has a significantly larger seabed disturbance impact. Overall, options 1 and 2 are **Neutral** to each other and both are **Stronger** than option 3.	Option 1 and 2 are similar, and considered **Neutral** to each other from a technical perspective. They are also **Much Stronger** than option 3 due to the uncertainty of whether backfilling over those distances and to the level required is achievable.	Option 1, 2 and 3 largely similar from a Societal perspective so scored **Neutral** against each other.	The differential in cost between options 1, 2 and 3 is relatively limited. However, there is a significant cost risk related to potential overruns for option 3. Therefore option 1 and 2 are **Neutral** to each other whilst both being **Stronger** than option 3.

Summary

The workshops considered Option 1 to be **Neutral** with Option 2 in the areas of environmental, technical, societal and Economic, but with Option 1 **Stronger** than Option 2 for safety. Other than safety and societal, both Options 1 and 2 were at least **Stronger** than Option 3 in all other areas, **Much Stronger** from a technical perspective. Overall, Option 1 is marginally preferred and is therefore recommended to be taken forward from the CA process.



5.2. Decision 2: Group 8 – Trenched and Buried Pipelines

5.2.1. Characteristics

Item	Characteristics
PL1665	8″ Water Injection Line, installed 1999 7,043 m long, 267 mm outside diamteter (OD) Flexible pipeline comprising steel and polymer Trenched and buried.

Table 5.2 Decision 2 Characteristics

The route of this line is shown in Figure 5.2.

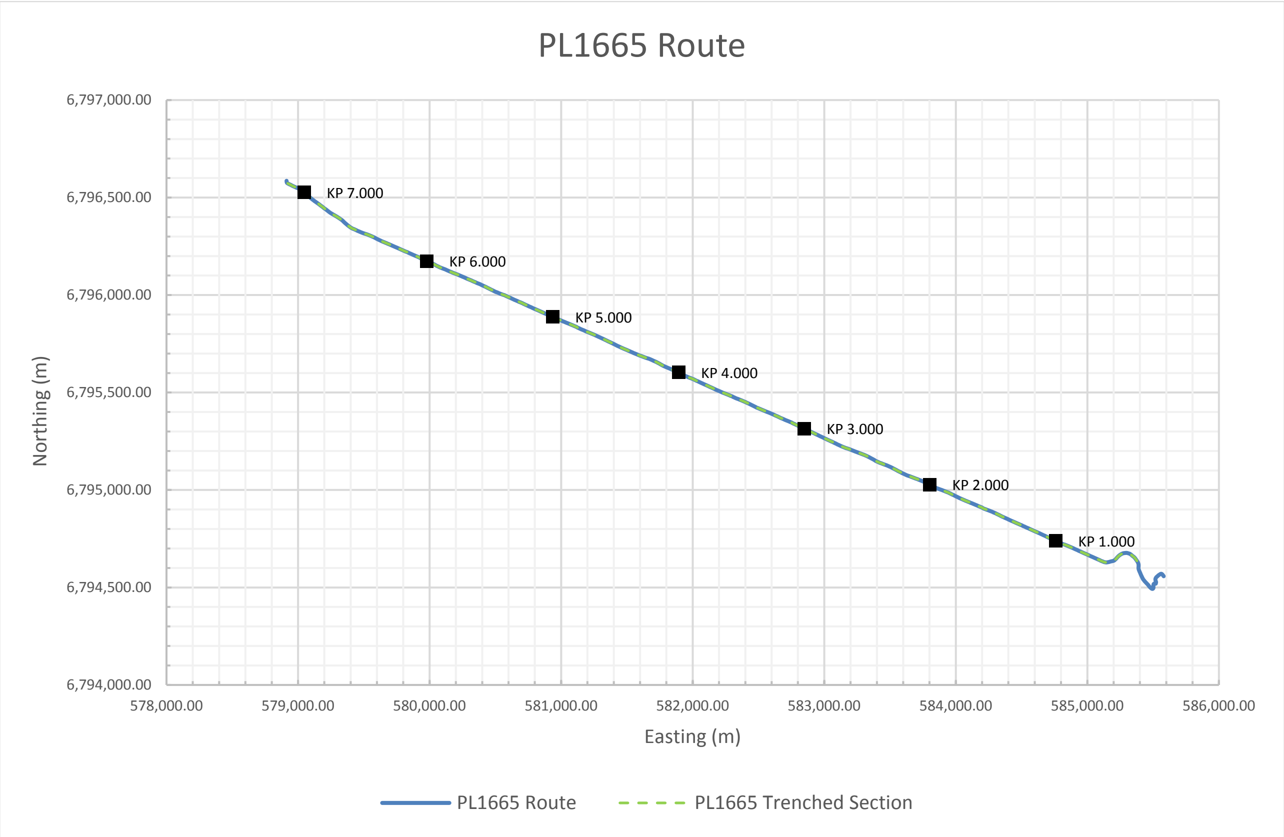


Figure 5.2 PL1665 Route

5.2.2. Options

Seven options were presented at screening stage with four of those screened out. The options assessed during the CA were:

- Option 1: Leave *in situ* – Minimal Intervention - Removal of exposed ends, rock placement over snag hazards and areas of low cover (i.e. those revealed on removal of mattresses/grout).
- Option 2: Leave *in situ* – Minor Intervention - Removal of all exposures, rock placement over snag hazards and areas of low cover (i.e. those revealed on removal of mattresses/grout).
- Option 3: Full Removal – Reverse Reel.

The process undertaken for this decision point, the judgement made against each of the five criteria, and the chart which demonstrates which option is recommended to be taken forward from the CA are presented on the following page.

5.2.3. Sensitivity Analysis

A sensitivity analysis was performed on this decision point relating to economics. Removing the economics criteria (shown in blue on the chart) from the decision making process had no impact on the preferred option nor the order of the remaining options. No further sensitivity analysis was performed for this decision point.

5.2.4. Recommendation

Unlike Group 7, the integrity of the water injection line and its configuration are such that reverse reeling, according to desk-top engineering studies, is deemed to be feasible although it still carries some technical risk. In all other areas Option 3 was either preferred or neutral with Options 1 and 2. The outcome of this decision point is therefore to fully remove Group 8 and ship it onshore for processing.

Group 8 – Trenched and Buried Pipelines

Option Screening

(for narrative see Merlin Screening Report)

Leave in Situ – Minimal Intervention (Rock Placement) **Screened In**	Leave in Situ – Minor Intervention (Rock Placement) **Screened In**	Leave in Situ – Minor Intervention (Local Trench) **Screened Out**	Leave in Situ – Major Intervention (Full Re-Trench) **Screened Out**
Leave in Situ – Major Intervention (Rock Placement) **Screened Out**	Full Removal – Reverse Reeling **Screened In**	Full Removal – Cut and Lift **Screened Out**	

Comparative Assessment

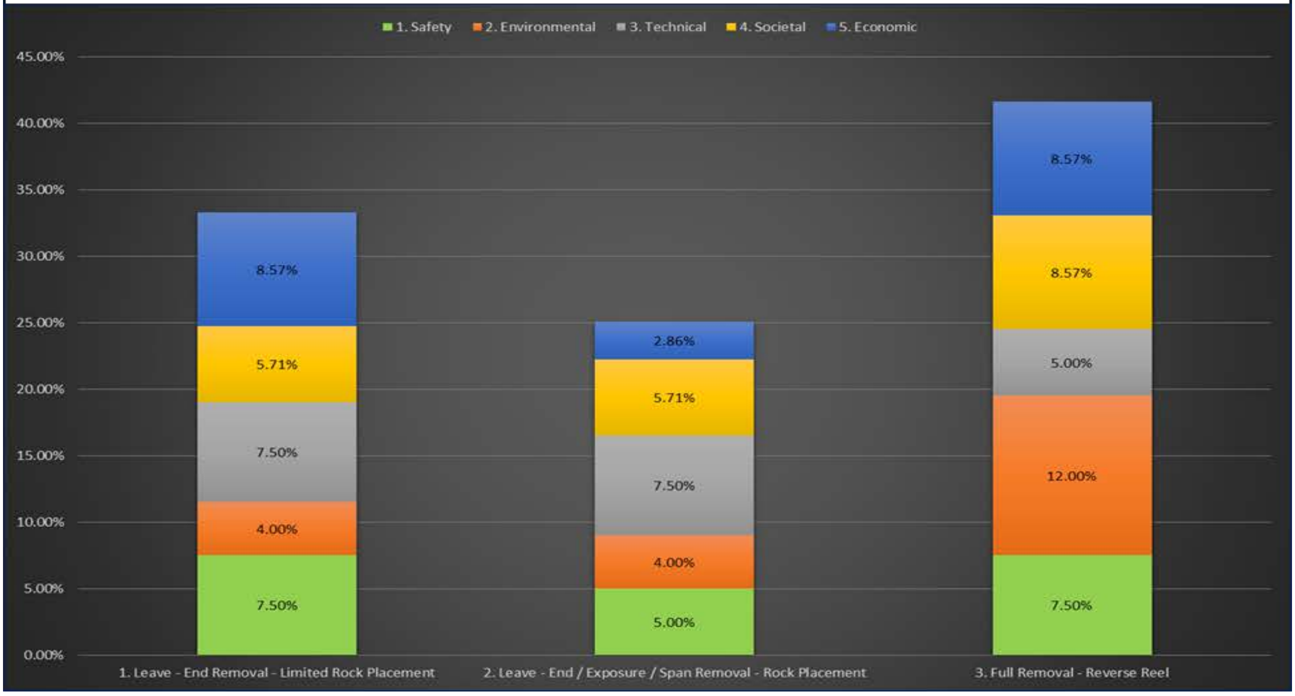
(for full attributes tables and pairwise comparisons see Appendix F)

Option 1	Option 2	Option 3
Leave in Situ – End Removal, Limited Rock Placement	Leave in Situ – End, Exposure & Span Removal, Rock Placement	Full Removal – Reverse Reeling

Safety	Environment	Technical	Societal	Economic
Whilst Option 3 has the lowest risk exposure this is offset by the potential for high consequence events, preventing a much stronger preference. Option 1 is therefore **Neutral** to Option 3 and **Stronger** than Option 2. Option 2 is **Weaker** than Option 3.	Option 3 is the most attractive in terms of noise exposure, emissions, fuel use and seabed disturbance. It introduces no new material and has short term impacts only. Overall, Options 1 and 2 are **Neutral**. They are both **Much Weaker** than option 3.	Options 1 and 2 are comparable and therefore **Neutral** from a technical perspective. Option 1 and 2 are **Stronger** than Option 3 due to the uncertainty surround the ability to reverse reel a flexible pipeline through soil cover.	Option 1, 2 and 3 largely similar from a Societal perspective, however Option 3 returns 7km of pipeline to shore which has a positive recycling potential. Options 1 and 2 are **Neutral** to each other, and both **Weaker** than Option 3.	Overall, Option 1 is **Much Stronger** than Option 2 due to the large cost differential. Option 1 is **Neutral** to Option 3 as, whilst Option 3 has a lower cost, there is significant cost risk. Finally, Option 2 is **Weaker** than option 3 due to the high cost differential.

Summary

The workshops considered Option 3 to be preferred over Options 1 and 2 in the areas of environmental and societal, and similar to one or both of the other options in safety and economic. The only area where Option 3 was ranked less preferred was in technical. Therefore the overall stack up for Option 3 shows it is preferred and is therefore recommended to be taken forward from the CA process.



5.3. Decision 3: Group 9 – Umbilical Risers

5.3.1. Characteristics

Item	Characteristics
PL1556	4″ Control Umbilical, installed 1998 475 m long, 132 mm outside diamteter (OD) 180 m contained within J-Tube (part of the Dunlin Alpha Concrete Gravity Base), 295 m is surface laid and exposed apart from approximately 60 m of rock dump (overspill).

Table 5.3 Decision 3 Characteristics

5.3.2. Options

Four options were presented at screening stage with two of those screened out. The options assessed during the CA were:

- Option 1: Leave *in situ* – Minor Intervention (Outboard Cut and Recovery)
- Option 2: Full Removal -Topside Pull

The process undertaken for this decision point, the judgement made against each of the five criteria, and the chart which demonstrates which option is recommended to be taken forward from the CA are presented on the following page.

5.3.3. Sensitivity Analysis

A sensitivity analysis was performed on this decision point relating to economics. Removing the economics criteria (shown in blue on the chart) from the decision making process had no impact on the preferred option nor the order of the remaining options.

The environmental and societal criteria were discussed in the workshops because there could be justification made to rank them differently. For the environmental criteria the workshop agreed to rank Option 1 as Stronger than Option 2. In absolute terms the difference between the two is negligible, but Option 1 is still slightly better than Option 2. For societal, the workshop agreed to rank Options 1 and 2 as Neutral to each other. Option 2 could be argued as slightly stronger due to more material being returned to shore (with positives such as recycling or employment) but the workshop felt the benefits were not enough to move away from Neutral. However, a sensitivity was undertaken for both environmental and societal in favour of Option 2, but the overall outcome with all five criteria combined did not change.

5.3.4. Recommendation

The outcome of the CA workshops is summarised on the next page. Option 1, removal of the outboard section and leaving the remainder in the J-Tube, was assessed as being the preferred option in all criteria apart from societal (in which it was considered Neutral to option 2). The outcome of this decision point is therefore to decommission Group 9 *in situ* having recovered the surface laid section. The fate of the section within the J-Tube will ultimately be determined by the CA covering the fate of the Dunlin Alpha CGB. The Merlin – Effect of Riser Remaining Study, Ref [7] has been conducted examining the effects of decommissioning the riser in the J-Tube and found the consequence on other activities to be negligible.

Group 9 – Umbilical Risers

Option Screening

(for narrative see Merlin Screening Report)

Leave in Situ – Minimal Intervention (Local Rock Placement)	Leave in Situ – Minor Intervention (Outboard Cut and Recovery)	Full Removal - Reverse J-Tube Pull	Full Removal - Topside Pull
Screened Out	**Screened In**	**Screened Out**	**Screened In**

Comparative Assessment

(for full attributes tables and pairwise comparisons see Appendix F)

Option 1 Leave in Situ – Minor Intervention (Outboard Cut and Recovery)	**Option 2** Full Removal - Topside Pull

Safety	Environment	Technical	Societal	Economic
Summed PLL figures for options 1 and 2 indicate that the risk exposure for option 1 is slightly lower than option 2 driven by a higher exposure to offshore and topsides worker groups for option 2. Option 1 is also a slightly shorter duration and carries a lower risk of high consequence events. Overall, option 1 is **Stronger** than option 2 from a safety perspective.	Option 1 is either equal to or marginally better than option 2 in all areas. As such, option 1 is considered **Stronger** than option 2 from an environmental perspective. It is noted that the difference here in absolute terms is likely to be negligible, but given a choice on environmental grounds alone, option 1 would be preferred.	Option 1 carries less technical risk than option 2 due to the potential / consequence of failure associated with the uncertainty of the j-tube integrity. Overall option 1 is considered **Stronger** than option 2 from a Technical Feasibility perspective.	Options 1 and 2 largely similar from a Societal perspective so scored **Neutral** against each other. Whilst there is more material returned to shore under option 2, the workshops did not consider this enough to warrant a change to the scoring from Neutral.	Option 1 has a lower cost and cost risk than option 2. Therefore option 1 is considered **Stronger** than option 2.

Summary

The workshops considered Option 1 to be **Stronger** than Option 2 in the areas of safety, environmental, technical and Economic, but **Neutral** to each other in societal. Whilst there was not a much stronger or very much stronger preference against any criteria, Option 1 was consistently the preferred option and is therefore recommended to be taken forward from the CA process. The workshop attendees also noted that altering the scoring for the environmental and societal criteria away from a stronger or neutral position, respectively, would not change the overall outcome.

6. Summary of Final Recommendations

The CA for the Merlin Subsea Infrastructure Decommissioning Programme has focussed on three groups (Trenched and Rock Dumped Pipelines and Umbilicals, Trenched and Buried Pipelines, and Umbilical Riser). All other groups of Merlin subsea infrastructure were confirmed at the CA Scoping and Screening stage to be fully removed from the field. The outcome of the CA process has made the following recommendations:

Group	Infrastructure Type	Decommissioning Recommendation
1	Pipeline and Umbilical Components	Full Removal
2a	Deposits	Full Removal
2b	Structures	Full Removal
3	Structures and Deposits (Pipeline Route)	Full Removal
4	Surface Laid Flexible Jumpers	Full Removal
5	Surface Laid Rigid Spools	Full Removal
6	Surface Laid Umbilicals	Full Removal
7	Trenched and Rock Dumped Pipelines and Umbilicals	Leave in Situ – Minimal Intervention (Rock Placement)
8	Trenched and Buried Pipelines	Full Removal - Reverse Reeling
9	Umbilical Riser	Leave in Situ – Minor Intervention (Outboard Cut and Recovery)

Table 6.1 Final Merlin Recommendations

The three decisions (7, 8 and 9) were found, on completion of an appropriate amount of preparatory study work, to have clear decision outcomes. Justifications are summarised below.

Group 7: With the exception of the end sections, PL1555 & PL1557 are trenched to 0.6m or greater along the majority of the route. Backfill is provided by 35,000t of rock located within the trench. The lines are stable and there is no significant seabed mobility within the vicinity of the lines.

All options considered at the CA were similar however; partial removal has lower levels of personnel exposure. As with all operations, Fairfield will look to minimise safety exposure (to all) and the introduction of new material, to the lowest amount required to ensure confidence in the long term future of the decommissioning solution.

The outcome of this decision point is therefore to decommission Group 7 in situ by partial removal. This infrastructure will be decommissioned by removing exposures outside of the defined trench and placing local rock cover at the cut ends and areas of low burial depth.

Periodic monitoring and remediation will be carried out at this location as required.

Group 8: With the exception of the end sections, PL1665 is trenched and buried along the majority of the route. However; there are a number of exposures, spans and areas of low cover along the route that may present hazards to other users of the sea.

The physical properties of the flexible line and its installed configuration are such that reverse reeling, according to desk-top engineering studies, is deemed to be feasible, although it still carries some technical risk.

Against all other CA criteria, removal by revers reeling was either preferred or neutral with the other options considered. The outcome of this decision point is therefore to fully remove Group 8 and ship it onshore for processing.

Group 9: Partial removal of the riser, where the outboard and exposed section of the riser is removed, leaving the remainder in the J-tube, was assessed as being the preferred option in all criteria apart from societal (in which it was considered neutral to the other CA options).

The outcome of this decision point is therefore to decommission Group 9 in situ by partial removal, having recovered the surface laid/exposed sections. The fate of the section within the J-tube will ultimately be determined by the CA covering the fate of the Dunlin Alpha CGBS. The Merlin – Effect of Riser Remaining Study has been conducted examining the effects of decommissioning the risers in the J-tube and found the consequence on other activities to be negligible.

Sensitivities were performed where appropriate (e.g. relating to economics, or relating to uncertainty for some rankings) and found that these did not alter the overall decision outcome.

The only infrastructure remaining from the Merlin field following decommissioning is proposed to be the already trenched and rock dumped pipelines and umbilicals, and the section of the umbilical riser which is within the J-Tube integral to the Dunlin Alpha CGB. As shown in Table 6.1, all other infrastructure will be fully removed.

Figure 6.1 shows the Merlin post decommissioning situation, whilst Figure 6.2 shows the overall Dunlin area context post decommissioning.

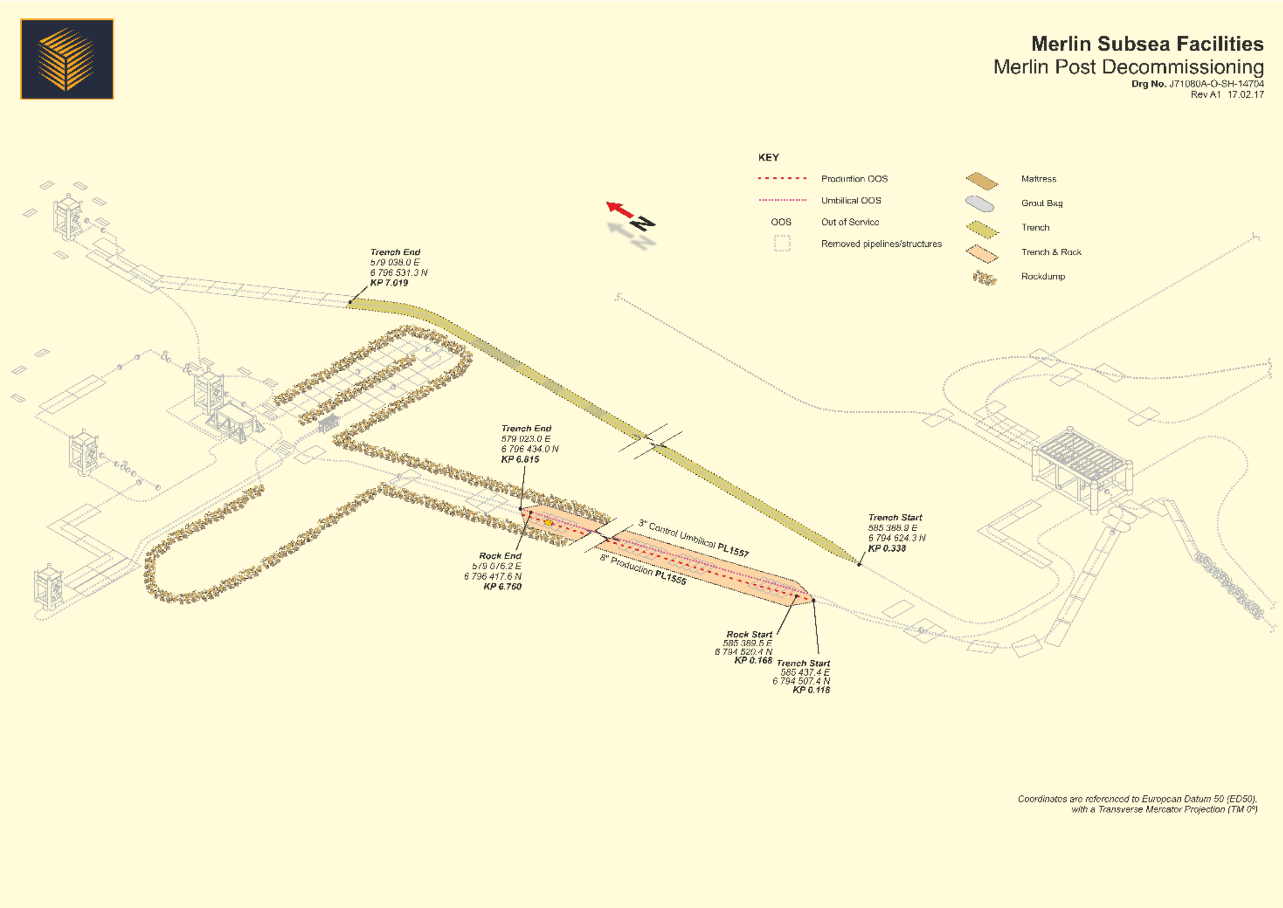


Figure 6.1 Merlin Post Decommissioning

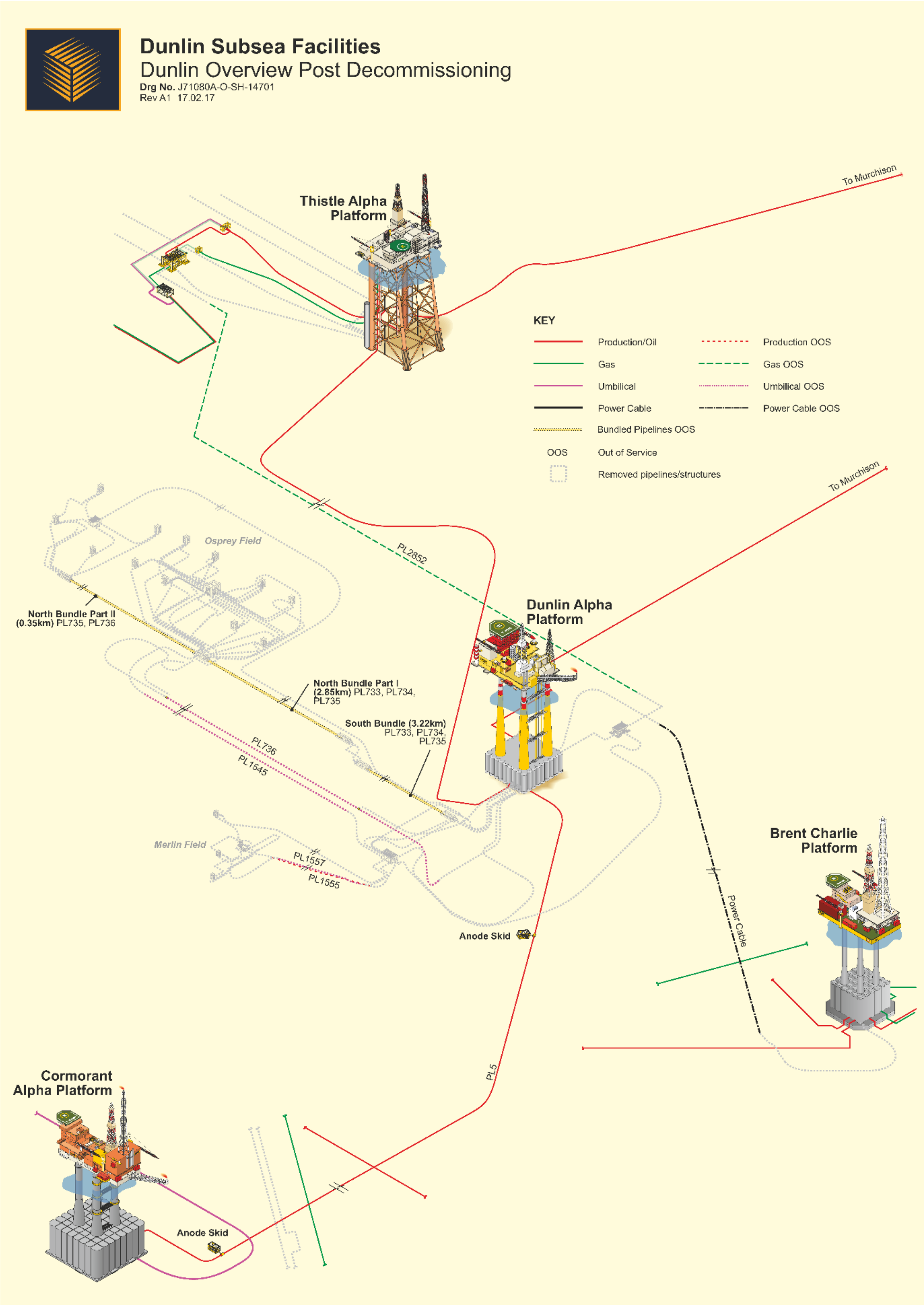


Figure 6.2 Overall Project Context

7. References

1. Comparative Assessment Strategy	FBL-DUN-HSE-STR-00002, Comparative Assessment Strategy, Dated 09/01/2017.
2. Merlin Screening Report	FBL-DUN-MER-SSP-01-RPT-00002 A1, Merlin CA Screening, Dated 31/05/2016.
3. Merlin Common Scope Report	A301649-S01-REPT-002, Common Scope Preparation Report – Merlin, Rev. A02, Dated 12/10/2016.
4. Merlin Long-term Materials Degradation Study	A301649-S01-TECH-005, Merlin – Long-term Materials Degradation Study, Rev. A01, Dated 21/09/2016.
5. Merlin Trench and Backfill Feasibility Study	A301649-S01-TECH-006, Merlin – Trench and Backfill Feasibility Study, Rev. A02, Dated 13/09/2016.
6. Merlin Removal / Recovery Feasibility Study	A301649-S01-TECH-007, Merlin – Merlin Removal / Recovery Feasibility Study, Rev. A01, Dated 13/09/2016.
7. Merlin Effect of Riser Remaining	A301649-S01-TECH-013, Merlin – Effect of Leaving Riser Section within J-tube, Rev. A01, Dated 16/08/2016.
8. Risk Analysis of Decommissioning Activities	Joint Industry Project Report “Risk Analysis of Decommissioning Activities” (Safetec 2005) [http://www.hse.gov.uk/research/misc/safetec.pdf]
9. Analytical Hierarchy Process	The Analytical Hierarchy Process by T.L. Saaty, McGraw Hill, 1980.
10. Guidelines for Decommissioning of Offshore Oil & Gas Installations and Pipelines	Guidance Notes Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998, Version 6, Dated: March 2011, Issued by: Department of Energy & Climate Change.
11. Habitat Assessment Report	160120-3_Fairfield Habitat Survey Osprey, 160120-4_Fairfield Habitat Survey Dunlin A to Brent C, 160120-5 Fairfield Habitat Survey Dunlin Fuel Gas Import Pipeline, 160120-6 Fairfield Habitat Survey Dunlin Field, 160120-7 Draft Fairfield Habitat Survey Merlin
12. Environmental Baseline Survey Reports	160120_08rev1 Merlin Report, 160120_09rev1 Osprey Report, 160120_10rev1 Dunlin Alpha Report, 160120_11rev1 Dunlin DPI Report, 160120_12rev1 Dunlin DGI Report
13. Drill Cuttings Analysis	Merlin Pre-decommissioning Cuttings Assessment Survey (Fugro Emu Limited, 2017)
14. Pipeline Cleanliness Study	A301524-S04-TECH-001, Pipelines Cleanliness Study – Dunlin Infield Oil Pipelines, Rev. A01, Dated 04/05/2016.
15. Drill Cuttings Screening	A301524-S00-TECH-005, Dunlin, Merlin and Osprey Drill Cuttings Screening, Rev. A02, Dated 22/09/2016.
16. Lifecycle Emissions Assessment	A301524-S00-REPT-007, Lifecycle Emissions Assessment Report

17. Commercial Fisheries Baseline	A301524-S00-REPT-003, Dunlin Area Decommissioning – Commercial Fisheries Baseline, Rev. A01, Dated 01/09/2016.
18. ENVID Report	A301524-S00-TECH-003, Environmental Issues Identification (ENVID) Report
19. Fishing Risk Assessment	A3910-XG-RA-1, Dunlin, Merlin and Osprey Subsea Infrastructure Decommissioning Fishing Risk Assessment

8. Abbreviations and glossary

AHP	Analytical Hierarchy Process
BEIS	Business, Energy and Industrial Strategy
CA	Comparative Assessment
DAD	Dunlin Area Decommissioning
dB	Decibels
EIA	Environmental Impact Assessment
ESDVs	Emergency Shutdown Valves
FAR	Fatal Accident Rate
FEL	Fairfield Energy Limited
KP	Kilometre Post
MCDA	Multi-criteria Decision Analysis
MFE	Mass Flow Excavator
OSPAR	Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)
PLL	Potential for Loss of Life
QRA	Quantitative Risk Assessment
SCMs	Subsea Control Modules
SEL	Sound Energy Level
SFF	Scottish Fisheries Federation
SID	Subsea Infrastructure Decommissioning
TPa^2S	Tera-pascal Squared Second – Total Noise Emission metric
TUTU	Topside Umbilical Termination Unit

Appendix A Pairwise Methodology Explanation

A1 Introduction

In order to support the decision making process for the remaining Subsea Infrastructure Decommissioning (SID) decision points, Fairfield has adopted the use of Xodus' Multiple Criteria Decision Analysis (MCDA) tool for delivering the required Comparative Assessment.

Whilst the key attributes and steps taken in the use of this tool are discussed in the main body of this report, an elaboration of the calculation methods used has been deemed appropriate.

A2 The Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is a general theory of measurement used to derive ratio scales or priorities which reflect the relative strength of comparisons. It was developed during the 1970s by Thomas L. Saaty, a mathematician at University of Pennsylvania and is considered a fundamental approach to multi-criteria decision making. It has been used extensively in a wide variety of applications and industries and is the subject of many books, papers and other publications.

Whilst a detailed discussion of the AHP is beyond the scope of this document it is however, worth discussing a number of the key mathematical elements of the process and how these are implemented.

A2.1 Initial Setup

One of the key concepts of AHP is the hierarchical nature of the decision making process. This is demonstrated by the need for any decision to have the following elements:

- Objective – the primary goal or objective for the decision.
- Decision criteria – the primary criteria by which the decision will be measured.
- Sub-criteria – the second tier (and potentially other tiers) of criteria that primary criteria may be split into
- The proposed alternatives (options) which may satisfy the objective.

In the context of the SID, the above elements are:

- Objective – to select the optimum decommissioning strategy, for each decision point, given the prevailing legislation and the Fairfield Guiding Principles.
- Criteria – Safety | Environment | Technical | Societal | Economic
- Sub-criteria:
  - Safety – Personnel Offshore | Personnel Onshore | Other Users | High Consequence Events | Residual Risk
  - Environmental – Marine Impacts | Emissions | Consumption | Disturbance | Protections
  - Societal – Fishing | Other Users
  - Economic – Short-term Costs | Long-term Costs

- Options (For this Worked Example - Osprey Group 3, Bundle)
  - 1a – Initial towhead removal and local rock dump with only minor remediation required in the future
  - 1b – Initial towhead removal and local rock dump with full rock dump in the future
  - 1c – Initial towhead removal and local rock dump with full removal in the future
  - 2 – Towhead removal and full rock dump
  - 3 – Towhead removal and trench and bury
  - 4 – Full removal

A2.2 Pairwise Comparison Matrix

The focal point of multi-criteria decision making and AHP is the construction of matrices by performing pairwise comparisons where the relative merits of pairs of criteria are considered against each other. AHP uses a hierarchical system of these matrices to allow the relative merits of options against the defined criteria and objective to be calculated.

These pairwise comparison matrices are constructed by listing the parameters being considered in rows and columns and considering what the relevant importance of each versus the others is. Most applications of the AHP use a 1 to 9 numeric scale as defined in Table A.1.

Importance Value	Definition	Explanation
1	Equal Importance	The criteria / options are considered equally important to each other.
3	Moderate importance	Experience and judgement moderately favour one criteria / option over the other.
5	Essential or strong importance	Experience and judgement strongly favour one criteria / option over the other.
7	Very Strong importance	A criteria / option is strongly favoured over the other and can be demonstrated in practice.
9	Extreme importance	The evidence favouring one criteria / option over the other is of the highest possible order.
2 / 4 / 6 / 8	Intermediate values between the two adjacent judgements	Can be used where compromise is needed.

Table A.1 Standard AHP Importance Scale

It should be noted that finer judgements can be made by applying further intermediate ranges such as 1.1, 1.2. etc. to add fidelity as required. Equally, the 1 to 9 numerical scale could be extended to say 1 to 100 as well if required. However, caution is advised in departing significantly from the widely accepted 1 to 9 numerical scale with the descriptions as detailed in Table A.1 as these have been shown over many applications to reflect the appropriate decision.

It should be further noted that only the upper triangle of the pairwise comparison matrix is completed as this represents the row versus column judgement, with the reciprocal being automatically inserted in the lower triangle of the pairwise comparison matrix.

An example is shown in Table A.2 of the standard AHP importance scale applied to decision relating to the relevant importance of criteria in the decision making process of buying a personal vehicle. In this example the first pairwise comparison we make is Cost versus Style. Here, we make the decision that Cost is a much stronger consideration than Style, and so, from Table A.1 an importance metric of 7 may be selected (with a reciprocal of 1/7 automatically inserted in the corresponding Style versus Cost cell).

The next comparison is Cost versus Fuel Economy. In this case, the use of the personal vehicle could be over limited mileage and thus Cost could be considered vastly more important than Fuel Economy. Again, using the importance scale from Table A.1 a 9 is inserted with 1/9 as the reciprocal.

The remaining comparisons are made with the final pairwise comparison matrix shown in Table A.2.

	Cost	Style	Fuel Economy	Reliability
Cost	1	7	9	3
Style	1/7	1	1/3	1
Fuel Economy	1/9	3	1	1/3
Reliability	1/3	1	3	1

Table A.2 Example Pairwise Comparison

The scale of priorities or relative weighting of the criteria from Table A.2 has been shown by the AHP to be derived by calculating the primary eigenvector of the above matrix and normalising the result. Again, detailed discussion of how this calculation is performed and the associated priorities arrived at is beyond the scope of this discussion. In this example this derives the following priorities:

- Cost – 0.6445
- Style – 0.0812
- Fuel Economy – 0.1001
- Reliability – 0.1742

A3 Xodus Application of the AHP

Section Appendix A2 details a standard application of the AHP and can be found described in many public domain papers and publications. Over the years, Xodus has applied these principles of the standard AHP in many applications, ranging from prioritising the order of competing work scopes by comparing their relative benefits, to identifying the most attractive option during the concept select phase of many projects.

In delivering these decision support activities, our consultants have gathered a breadth of experience that has enabled them to identify and implement improvements to the application of the standard AHP. In terms of Xodus' implementation of the AHP for this SID, on behalf of Fairfield, and as engineered into our tool, there are two departures from the standard AHP. These are:

- Using phrases rather than numbers in the importance scale.
- Tuning of the importance scale.

A3.1 Words v Numbers

One of the challenges that has faced Xodus when asking assembled audiences to apply the importance scale to a particular comparison, was to encourage them to apply the scale according to the descriptions and explanations (see Table A.1) rather than implying that adopting a 3 in the matrix meant the comparison was 3 times better, etc.

To manage this, Xodus changed the way we apply the principles of the AHP by replacing numbers in the pairwise comparison matrix with a narrative or descriptive approach. This is already programmed into the AHP in the importance scale explanations in Table A.1. Whilst implementing this change, Xodus also decided that three positions from equal (and their reciprocals) would be sufficient for most applications. These positions are:

Neutral	Equal Importance, equivalent to 1 in the importance scale from Table A.1.
Stronger (S) / Weaker (W)	Moderate importance of one criteria / option over the other, equivalent to 3 in the importance scale from Table A.1.
Much Stronger (MS) / Much Weaker (MW)	Essential / strong importance of one criteria / option over the other equivalent to 5 or 6 in the importance scale from Table A.1.
Very Much Stronger (VMS) / Very Much Weaker (VMW)	Extreme importance of one criteria / option over the other equivalent to 8 or 9 in the importance scale from Table A.1.

Table A.3 Definitions of positions from equal

Using this transposed scoring system makes it, in our experience, simpler and more importantly, more effective at capturing the mind-set and feeling of the attendees at the workshops. Phrases such as 'what are the relative merits of pipeline removal on a project versus rock dumping from a safety perspective? Are these Neutral to each other? Are they stronger? If so, how much stronger? If you had to prioritise one over the other, which would it be?'. This promotes a collaborative dynamic in the workshop and enables the collective mind-set of the attendees to be captured. Where there is quantitative data to provide back-up and evidence for the collective assertions, so much the better.

Once the matrix is complete, deriving the priority scale is performed in exactly the same manner as for the standard AHP i.e. the primary eigenvector of the matrix is solved (with Stronger replaced with 3, Much Stronger replaced with 6 and Very Much Stronger replaced with 9 (and similarly for the reciprocals)).

A3.2 Tuning Importance Scale

A further adjustment from the standard AHP has been implemented by Xodus in the last few years of applying AHP for decision making. This takes the form of tuning the importance scale to reflect the sentiment of the workshops. This is best illustrated by a 2 option decision matrix.

Let us take two options, option 1 and option 2 and apply the standard AHP importance scale to them with the Xodus Stronger / Much Stronger / Very Much Stronger wording relating to that standard scoring. This provides the derived priorities as shown in Table A.4.

Original AHP Importance Scale		Derived Priority	
Option 1	**Option 2**	**Option 1**	**Option 2**
1 (Neutral)	**1 (Neutral)**	**0.5000**	**0.5000**
2	1/2	0.6667	0.3333
3 (Stronger)	**1/3 (Weaker)**	**0.7500**	**0.2500**
4	1/4	0.8000	0.2000
5	1/5	0.8333	0.1667
6 (Much Stronger)	**1/6 (Much Weaker)**	**0.8571**	**0.1429**
7	1/7	0.8750	0.1250
8	1/8	0.8889	0.1111
9 (Very Much Stronger)	**1/9 (Very Much Weaker)**	**0.9000**	**0.1000**

Table A.3 Standard AHP Importance Scale and Derived Priorities

As can be seen, criteria / options that are scored as Neutral to each other have a relative priority of 0.500 each, which reflects what we would expect. If we then look at priority derived from considering criteria / options Stronger / Weaker to each other, we get a (0.7500, 0.2500) split. Following this through, for Much Stronger / Much Weaker we get priorities of (0.8571, 0.1429) and finally for Very Much Stronger / Very Much Weaker we get priorities of (0.9000, 0.1000).

When delivering comparison sessions, Xodus felt that the Stronger / Weaker sentiment in the room did not reflect a 75 / 25 split between the options and that this resulted in a contribution which was too dominant in these areas. It was felt that the Much Stronger / Much Weaker providing an 86 / 14 split was also more dominant than was intended by the workshop attendees. Finally, Very Much Stronger / Very Much Weaker with a 90 / 10 split seemed about right for the intentions of the workshops.

As such, Xodus decided to tune the relative importance scale to ensure that the sentiment of the workshop attended was reflected correctly when selecting the Stronger / Much Stronger / Very Much Stronger assessment. The outcome of that tuning process is shown in Table A.5.

Revised Xodus Importance Scale		Derived Priority	
Option 1	Option 2	Option 1	Option 2
1 (Neutral)	**1 (Neutral)**	**0.5000**	**0.5000**
1.5 (Stronger)	**1/1.5 (Weaker**	**0.6000**	**0.4000**
2	1/2	0.6667	0.3333
3 (Much Stronger)	**1/3 (Much Weaker)**	**0.7500**	**0.2500**
4	1/4	0.8000	0.2000
5	1/5	0.8333	0.1667
6	1/6	0.8571	0.1429
7	1/7	0.8750	0.1250
8	1/8	0.8889	0.1111
9 (Very Much Stronger)	**1/9 (Very Much Weaker)**	**0.9000**	**0.1000**

Table A.4 Xodus Tuned AHP Importance Scale and Derived Priorities

In this revised system the following splits are obtained:

- Stronger / Weaker provides a 60 / 40 split
- Much Stronger / Much Weaker provides a 75 / 25 split
- Very Much Stronger / Very Much Weaker provides a 90 / 10 split

Xodus believes this importance scale more accurately reflects what workshop attendees actually mean when they assess a criteria / option as stronger, much stronger or very much stronger than another.

A4 Worked Example

A key question when considering the Xodus application of AHP to our multi-criteria decision making activities is, what is the impact of Xodus modifications to the standard importance scale? Xodus believes the modifications to have been identified and implemented for valid reasons as described in Appendix A3. To illustrate the impact of these changes, one of the SID decision points has been calculated using both the standard AHP importance scale and the tuned Xodus version and the derived priorities from these are illustrated in Figures A.1 to A.5.

1. Safety	1. Leave - End Removal - Limited Rock Placement	2. Leave - End Removal - Full Rock Placement	3. Full Removal - Reverse Reel	Standard AHP Priorities	Xodus AHP Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	MS	46.15%	42.86%
2. Leave - End Removal - Full Rock Placement	N	N	MS	46.15%	42.86%
3. Full Removal - Reverse Reel	MW	MW	N	7.69%	14.29%

Figure A.1 Safety Pair-wise Comparison Matrix

2. Environmental	1. Leave - End Removal - Limited Rock Placement	2. Leave - End Removal - Full Rock Placement	3. Full Removal - Reverse Reel	Standard AHP Priorities	Xodus AHP Priorities
1. Leave - End Removal - Limited Rock Placement	N	S	S	58.42%	42.63%
2. Leave - End Removal - Full Rock Placement	W	N	W	13.50%	24.83%
3. Full Removal - Reverse Reel	W	S	N	28.08%	32.54%

Figure A.2 Environmental Pair-wise Comparison Matrix

3. Technical	1. Leave - End Removal - Limited Rock Placement	2. Leave - End Removal - Full Rock Placement	3. Full Removal - Reverse Reel	Standard AHP Priorities	Xodus AHP Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	MS	46.15%	42.86%
2. Leave - End Removal - Full Rock Placement	N	N	MS	46.15%	42.86%
3. Full Removal - Reverse Reel	MW	MW	N	7.69%	14.29%

Figure A.3 Technical Pair-wise Comparison Matrix

4. Societal	1. Leave - End Removal - Limited Rock Placement	2. Leave - End Removal - Full Rock Placement	3. Full Removal - Reverse Reel	Standard AHP Priorities	Xodus AHP Priorities
1. Leave - End Removal - Limited Rock Placement	N	W	S	28.08%	32.54%
2. Leave - End Removal - Full Rock Placement	S	N	S	58.42%	42.63%
3. Full Removal - Reverse Reel	W	W	N	13.50%	24.83%

Figure A.4 Societal Pair-wise Comparison Matrix

5. Economic	1. Leave - End Removal - Limited Rock Placement	2. Leave - End Removal - Full Rock Placement	3. Full Removal - Reverse Reel	Standard AHP Priorities	Xodus AHP Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	S	42.86%	37.50%
2. Leave - End Removal - Full Rock Placement	N	N	S	42.86%	37.50%
3. Full Removal - Reverse Reel	W	W	N	14.29%	25.00%

Figure A.5 Economic Pair-wise Comparison Matrix

A5 Final Priorities

As the name Analytical Hierarchical Process suggests, there is a strong hierarchical component to the process. This was introduced in Appendix A2.1 where the relationship between the objectives / goals, the success criteria, and associated sub-criteria and finally the proposed options was introduced.

The priorities derived for each of the proposed options, with respect to the identified criteria from the example detailed in Section Appendix A4 (using Xodus importance scale only) are summarised in Table A.6.

	Safety	Environment	Technical	Societal	Economic
Option 1	0.4286	0.4263	0.4286	0.3254	0.3750
Option 2	0.4286	0.2483	0.4286	0.4263	0.3750
Option 3	0.1429	0.3254	0.1429	0.2483	0.2500

Table A.5 Priority Matrix – Options w.r.t. Criteria

Similarly, the priorities derived by performing a pairwise comparison of the criteria themselves are summarised in Table A.7. At this stage, the criteria have been considered as having equal priority. As such the derived priorities are 0.2000 for all criteria.

	Priority
Safety	0.2000
Environment	0.2000
Technical	0.2000
Societal	0.2000
Economic	0.2000

Table A.6 Priority Matrix – Criteria

In order to obtain the final priorities, each row of the 3 x 5 matrix (i.e. a 1 x 5 matrix) is multiplied by the 5 x 1, which provides priority values which relate to the contributions of the benefits associated with each option for each criteria, weighted by that criteria.

In this example, the overall priorities derived are shown in Table A.8.

	Safety	Environment	Technical	Societal	Economic	Total
Option 1	0.0857	0.0853	0.0857	0.0651	0.0750	**0.3968**
Option 2	0.0857	0.0497	0.0857	0.0853	0.0750	**0.3814**
Option 3	0.0286	0.0651	0.0286	0.0497	0.0500	**0.2219**

Table A.7 Final Priorities

A6 Discussion

Combining the priorities derived in the example presented in Appendix A4 and the method for deriving the final priorities described in Appendix A5, we obtain the final priorities as shown in Table A.9 and Table A.10 and depicted graphically in Figure A.6.

Option	1. Saf.	2. Env.	3. Tech.	4. Soc.	5. Eco.	Total
1. Leave - End Removal - Limited Rock Placement	9.23%	11.68%	9.23%	5.62%	8.57%	**44.33%**
2. Leave - End Removal - Full Rock Placement	9.23%	2.70%	9.23%	11.68%	8.57%	**41.42%**
3. Full Removal - Reverse Reel	1.54%	5.62%	1.54%	2.70%	2.86%	**14.25%**

Table A.8 Outcome with Standard AHP Importance Scale

Option	1. Saf.	2. Env.	3. Tech.	4. Soc.	5. Eco.	Total
1. Leave - End Removal - Limited Rock Placement	8.57%	8.53%	8.57%	6.51%	7.50%	**39.68%**
2. Leave - End Removal - Full Rock Placement	8.57%	4.97%	8.57%	8.53%	7.50%	**38.14%**
3. Full Removal - Reverse Reel	2.86%	6.51%	2.86%	4.97%	5.00%	**22.19%**

Table A.9 Outcome with Xodus Tuned AHP Importance Scale

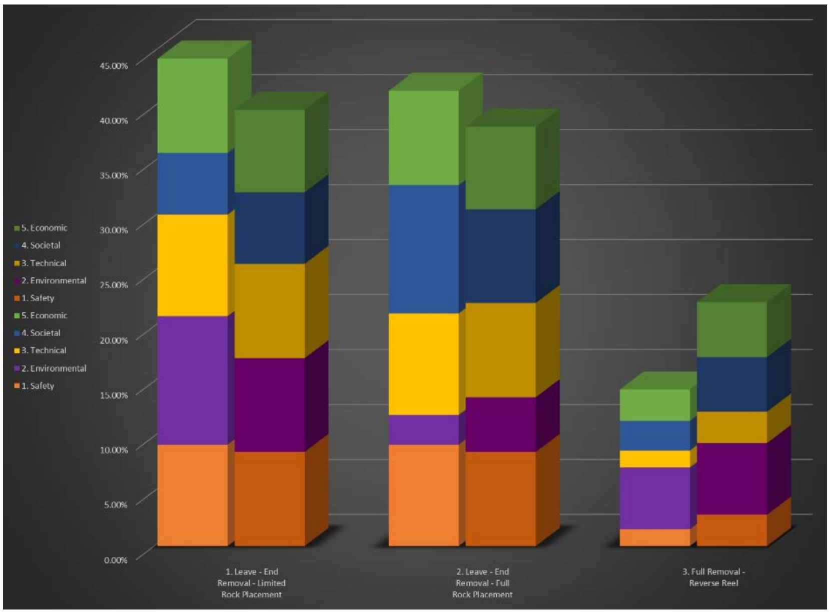


Figure A.6 CA Visual Output showing Standard v Xodus Tuned Importance Scale

In the graph shown in Figure A.6, the first column of each option shows the colour coded individual criteria priorities, whilst the stack-up shows the overall or final priority for the option under the standard AHP importance scale. The second column shows the equivalent using the Xodus tuned AHP importance scale.

As can be seen, and as would be expected given that Xodus tuning of the AHP importance scale reduces the impact of the Stronger and Much Stronger judgements (and their reciprocals), overall the priorities of the stronger options are a little lower and this has the associated impact of increasing the priority of the less attractive options. In effect, this Xodus tuning compresses priorities together – an outcome Xodus believes more accurately reflects the sentiment associated with comparisons of options that are considered close to each other.

Overall, the outcome for this example decision point is not altered by adopting standard versus Xodus tuned AHP importance scale.

Appendix B CA Criteria

Differentiator	Sub-Criteria	Description
1. Safety	1.1 Personnel Offshore	This sub-criterion considers elements that impact risk to offshore personnel and 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.
	1.2 Personnel Onshore	This sub-criterion considers elements that impact risk to onshore personnel. Factors such as any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel.
	1.3 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.
	1.4 High Consequence Events	This sub-criterion relates to any inherent potential for high consequence events i.e. major accident hazard, major environmental hazard type events. It applies to all onshore and offshore personnel involved in the project. Considerations such as dropped object concerns, support vessel risks, are considered.
	1.5 Residual Risk	This sub-criterion addresses any residual risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, that is provided by the option. Issues such as residual snag risk, collision risk, etc. may be considered.
2. Environmental	2.1 Marine Impacts	This sub-criterion covers elements such as noise generated by vessels, cutting operations, explosives etc. It also covers any damaging discharges to sea from vessels and / or activities performed.
	2.2 Emissions	This sub-criterion relates to the amount of damaging atmospheric emissions associated with a particular option.
	2.3 Consumption	This sub-criterion relates to the amount of Energy / Resource consumption such as fuel use, recycling of materials, use of quarried rock, production of replacement materials.
	2.4 Disturbance	This sub-criterion relates to both direct and indirect seabed disturbance. Both short and long term impacts are considered.
	2.5 Protections	This sub-criterion relates to the impact of the options on any protected sites and species.
3. Technical	3.1 Technical Risk	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. Technical Feasibility and Technical Maturity is also considered.
4. Societal	4.1 Fishing	This sub-criterion addresses the impact of the option on commercial fishing operations. It includes consideration of impacts from both the decommissioning activities and residual impacts post decommissioning such as reinstatement of access to area.
	4.2 Other Users	This sub-criterion addresses any socio-economic impacts on other users both onshore where the impact may be from dismantling, transporting, 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 negative impact on communities, increased traffic disruption due to extra-large transport loads, etc. Includes the FEL Guiding Principle of 'Minimal business interruption to others'.
5. Economic	5.1 Short-term Costs	This sub-criterion addresses the cost of delivering the option as described. No long-term cost element is considered here. Cost uncertainty (a function of activity maturity) is also recorded.
	5.2 Long-term Costs	This sub-criterion addresses the costs associated with any long-term liabilities such as on-going monitoring and any potential future remediation costs.

Appendix C Environment Criteria Assessment Methodologies

C1 Introduction

This appendix provides further information on environment criteria assessment methodologies. Assessment methodologies for safety (e.g. Potential Loss of Life calculations), technical and economics are available within the Common Scope Report.

C2 Noise Emissions Assessment

A range of offshore activities generate airborne and underwater noise. Fish, whales and dolphins, and even diving seabirds, may be able to detect this noise and, if it is sufficiently loud, it can damage the hearing of these animals. Where noise is not loud enough to cause injury, it might still be loud enough to disturb the animals from normal behaviour. As part of this assessment, the activities that create noise in the marine environment have been identified and a representation of how loud the emissions are has been considered. It has been concluded that the possible noise emissions are either sufficiently quiet that injury isn't considered likely, or that mitigation measures could be adopted so that injury can be avoided. Examples of noise levels from decommissioning activities are given in the following table, alongside the levels required to cause injury:

Activity	Source Noise Level (dB re 1 mP @ 1 m rms)	Threshold of injury to marine mammals
Dive support vessel	178	233
Rock dumping	188	233
Mass flow excavation	162	233
Underwater cutting	195	233
Survey vessel	184	233

Table C.1 Comparison of Decommissioning Noise Sources and Injury Thresholds

On this basis, the activities are not likely to injure any marine animals. As such, it is the possibility of disturbing animals that required further consideration. Disturbance is not simply a function of cumulative noise exposure but also of absolute levels; habituation is important, where animals may become tolerant of a noise over time, but disturbance will also be related to the extent to which interference with communication and echolocation systems occurs. To investigate the measure of risk of disturbance posed by the decommissioning options, a risk score was developed that allowed Fairfield to compare the multi-activity events with each other in order to demonstrate the different total energy of each overall option. Taking the amount of noise emitted on each day and summing it for all days that the activities will occur on provided an estimate of the total noise from each decommissioning option. This number is not a measure of how loud the option is, but how much noise overall is emitted. If an option emits a lot of noise for a long time then it is, crudely for the purposes of comparison, considered as having a higher risk of disturbance to animals.

Calculations are given for two numbers:

- Total noise energy emitted in terms of cumulative SEL in decibels. The decibel scale is logarithmic (i.e. a 3 dB change represents a doubling or halving of acoustic energy and a 6 dB change represents a quadrupling or quartering of acoustic energy).

- Total noise energy emitted in TPa2s; this metric is a linear scale so comparing between two numbers is easier than using the decibel scale (i.e. a doubling of this metric means a doubling in noise emissions).

Note: Care must be taken in interpreting these abstract figures in terms of impact on marine wildlife because, as noted above, there is not necessarily a direct relationship between the cumulative sound exposure and marine mammal response. Nevertheless, this gave a relatively simple method of comparing the options in terms of acoustic emissions.

The two metrics were calculated to compare between the different decommissioning options. To set these values in context of existing offshore activities, a standby vessel on site for a year would result in the following values for the two metrics:

- Cumulative SEL = 263 dB re 1 P @ 1 m; and Total Noise Energy = 199 TeraPa2s.

C3 Disturbance Assessment

The disturbance assessment considered dredging, backfilling, trenching and rock dumping as the four key differentiating mechanisms for seabed disturbance. The seabed habitat in the region is mud with sea pens and burrowing megafauna. This is a priority marine feature and mud is relatively limited on the UK Continental Shelf compared to other sediment habitats. However, this habitat does have a reasonable recovery potential.

Whilst the area of disturbance is an important factor, the type of disturbance is also important. Dredging, backfilling and trenching are all activities which cause a temporary disturbance. Recovery from these, specifically for a pipeline or umbilical, will be via migration of species from bordering undisturbed areas, resulting in a community similar to what was there before. Rock dump, however, represents a permanent change and a new or different habitat type. In broad terms, the following hierarchy is applied:

Grading	**Best** →			**Worst**
Type of disturbance	**Dredge**	**Backfill**	**Trench**	**Rockdump**

When combining this with area of disturbance the general scale and context is also important:

- An area of approximately 1,000,000 m2 is effectively a large area equivalent to or larger than the largest habitat features thought to be of conservation significance.
- One tenth of this area, 100,000 m2 would be generally only be significant from a cumulative perspective (i.e. multiple areas of this size).
- Anything smaller is considered to be a relatively small area of disturbance.

When comparing options the project team in the workshop combined the quantified disturbance areas with this approximate hierarchy of disturbance types through discussion and narrative.

C4 Emissions

In order to provide a comparative assessment of the energy and emissions produced during each of the proposed decommissioning options being considered within this report, primarily the Institute of Petroleum (IP) guidelines for the calculations of estimates of energy use and gaseous emissions in the decommissioning of offshore structures (IP, 2000) methodology has been used. The IP document provides a standardised set of guidelines, allowing oil and gas operators to make predictions of the potential energy use and gaseous emissions during the process of decommissioning, when assessing the options for removal.

End points are defined as the final states of the materials following the decommissioning operations, i.e. secondary raw materials. If the end-point is a useful material then it is assumed that the material is recycled, with any consequent onshore reprocessing energy use and emissions also taken into account, including dismantling of materials and their subsequent transport to recycling yards. At this stage the recycling location has not as yet been identified, however, an assumption has been made in this assessment that the materials will be transported by lorry to a recycling plant 150 km from the quayside for dismantling and for recycling.

The weights for each material were extracted from the Materials Inventory, whilst the energy and emissions values were extracted from the IP guidelines values per tonne of new and recycled materials as well as the dismantling and onshore transportation data.

Xodus provided the anticipated vessel activity data for each of the proposed decommissioning methods (from the Common Scope Reports). This activity data (including the type of vessel(s) as well as the expected transit and field activity data) was used in the assessment in conjunction with the vessel operations energy and fuel consumption values (tonnes/day, based on fuel consumption figures provided by the IP Guidelines; IP, 2000). This assessment followed the internationally agreed principles for full life cycle assessments, as per DECC (2011) guidance notes for the Decommissioning of Offshore Oil and Gas Installations and Pipelines.

Energy consumption for both new materials manufactured or recycled uses the following calculation:

Tonnes of material to be processed x IP Factor for Energy used for processing (new manufacture or recycling) material(GJ/t) = Total energy consumption (GJ)

- Example: 450 tonnes of aluminium is designated to be recycled, requiring 6,750 GJ (450 t (to be processed) x 15 GJ/t (IP Factor for recycling Aluminium)) of energy to undergo the recycling process alone (this does not account for the energy requirement needed to dismantle the material and any transportation required onshore).

The gaseous emissions produced for both new material manufacturing and recycling uses the following calculation:

Tonnes of material to be processed x IP Emission factor (kg/t) = Gaseous emissions from the manufacture of new material (kg)

- Example: 450 tonnes of aluminium designated to be recycled is estimated to produce 486,000 kg (450 t x CO_2 emissions factor (1,080 of CO_2 kg emitted/t) of CO_2 gaseous emissions.

The Energy consumption from onshore transportation of materials from the quay side to a recycling facility have been calculated using IP guidelines (IP, 2000). The Energy consumption for both new materials manufactured or recycled uses the following calculation:

Total fuel use (t) x IP Emission factor (kg/t) = Gaseous emission from vessel activities (kg)

- Example: If 66.9 tonnes of fuel is need to complete the transfer of recycling materials to a designated recycling facility the vehicle(s) are estimated to produce 212,800 kg (66.9 x CO_2 emissions factor (3180 of CO_2 kg emitted/t)) of CO_2 gaseous emissions.

C5 Scale and Context

The base case for all options, following the extensive preparation works to date, was that all options are tolerable in terms of safety, environmental impact, and societal impact. However, to understand whether one option is ‘stronger’, ‘much stronger’, or ‘very much stronger’ than another sometimes required an understanding of how close the options were on a given scale. For example, in terms of CO_2 emissions whilst the numbers for two options may appear an order of magnitude different, in terms of percentage contribution to UK annual emissions both might still be relatively similar and could feasibly still be neutral or ‘stronger’ rather than ‘very much stronger’.

Appendix D Stakeholder CA Workshop Agenda and Minutes

Fairfield Energy Limited

(Registered No. 5562373)

Minutes

Meeting Name:	Dunlin Area Subsea Infrastructure Removal – Comparative Assessment Workshop
Date:	10th January 2017
Venue:	Fairfield, Westhill

Present:		
	Louise Pell-Walpole	JNCC
	John Watt, Steven Alexander	Scottish Fishermen's Federation
	Dr Peter Hayes	Marine Scotland
	Debbie Taylor, Amy Stubbs	BEIS - ODU
	Ian Fozdar	Oil and Gas Authority
	Gary Farquhar, Peter Lee	FEL
	James Clarkson, Andrew Corse,	FEL
	Jonathan Bird, Harry Yorston	FEL
	Jiro Mukai	MCX
	Peter Tipler, John Foreman,	Xodus
	Kenneth Couston	Xodus

Actions

1. PURPOSE OF THE MEETING

The purpose of the workshop was to engage stakeholders in a comparative assessment (CA) workshop of the options to decommission subsea infrastructure associated with the Dunlin, Osprey and Merlin Fields. The outputs from the meeting were recommended methodologies for inclusion in the relevant Decommissioning Programmes for public consultation.

2. INTRODUCTIONS

FEL thanked stakeholders for taking time to attend the workshop and reading the CA recommendations and supporting analysis which had been issued in advance. Each participant was introduced.

3. COMPARATIVE ASSESSMENT PROCESS

Xodus described the CA process undertaken and confirmed that it is aligned to the CA guidelines issued by Oil and Gas UK. It was explained that six key CA recommendations would be made during the workshop. The recommendations will then also be applied to any analogous subsea infrastructure. The limits for the workshop were confirmed as subsea infrastructure only, the Dunlin CGBS will the subject of a separate CA.

The evaluation criteria are aligned to the BEIS ODU and OGUK Guidelines, namely Safety, Environmental, Technical, Societal and Economics. The criteria have been assessed using the Xodus "Pairwise" methodology and weighted equally.

For each decision a sensitivity analysis excluding the Economics criterion, has also been prepared. It was noted that removing Economics did not change the recommendation for any removal decision.

Xodus also advised that a Quantitative Risk Analysis (QRA) workshop in relation to the impact on fishing for each option is to be held week commencing 16th January 2017. Stakeholders will be advised of the QRA output and any impact on the CA recommendations.

3.1 Merlin Field

3.1.1 Merlin Trenched and Rock-Dumped Pipelines and Umbilicals

FEL described the scope and status of the Merlin Trenched and Rock-Dumped Pipeline (PL1555) and Umbilical (PL1557) and reminded attendees that full removal had previously been recommended for most of the other Merlin infrastructure groupings. FEL explained that three options were assessed for Merlin Trenched and Rock-Dumped Pipelines and Umbilicals which had not been not previously identified for full removal.

The options are:

> **Option 1** - Leave in situ, remove ends, rock placement over snag hazards and areas of low cover.
> **Option 2** - Leave in situ, remove all exposures, rock placement over snag hazards and areas of low cover.
> **Option 3**- Leave in situ, back-fill trench using existing berm.

Xodus presented the assessment of the options against the five criteria.

JNCC asked if the CA takes into consideration impacts of future monitoring requirements and impacts to future users of the sea if infrastructure is left in situ. Xodus confirmed that the assessments include future impacts for up to 50 years for the purposes of comparative assessment.

SFF stated that option 3 would improve future fishing risk exposure, whereas options 1 and 2 have a neutral effect. Xodus updated the assessment accordingly.

Marine Scotland (MS) observed that the Oil Pipeline contains around 5 tonnes of LSA scale. **FEL committed to verify any relevant regulatory requirements in relation to the LSA scale.** **FEL**

FEL explained that the trench berms have a typical gradient of 1 in 8 and a height of less than 0.6m which is within over-trawl parameters. **FEL committed to issuing the berm analysis data to stakeholders.** **FEL**

The overall result of the CA is that Option 1 is the recommended decision. Merlin Trenched and Rock-Dumped Pipeline and Umbilical (PL1555 and PL

1557) should be left in situ, ends removed, rock placed over snag hazards and areas of low burial followed by a sea-bed survey and trawl sweep.

3.1.2 Merlin Trenched and Buried Pipelines

FEL described the scope and status of the Merlin Trenched and Buried Pipeline (PL1665). FEL explained that three options were assessed for PL1665 which that had not been previously identified for full removal.

The options are:

Option 1 - Leave in situ, remove ends, rock placement over snag hazards and areas of low cover.
Option 2 - Leave in situ, remove all exposures, rock placement on snag hazards and areas of low cover.
Option 3 - Full removal, reverse reel.

Xodus presented the assessment of the options against the five criteria.

JNCC asked why there were free spans and areas of low burial, was it due to the target burial depth not being achieved during laying or due to subsequent sediment movement. FEL advised that it was not certain and that this had happened prior to FEL taking Operatorship and further confirmed there had been no change in the nine years since. MS observed that these pipelines had not had rock placement which may be a contributory factor.

In response to a question from MS, SFF and FEL confirmed that if the pipeline is removed then an over-trawl check will be required.

The overall result of the CA is that Option 3 is the recommended decision. Merlin Trenched and Buried Pipeline PL1665 should be removed by reverse reeling followed by a sea-bed survey.

3.2 Osprey Field

3.2.1 Osprey Bundles

FEL described the scope and status of the Osprey North and South Bundles and reminded attendees that full removal had previously been recommended for most other Osprey infrastructure groupings. FEL explained that six options were assessed for the Bundles which had not been previously identified for full removal.

The options are:

Option 1 - Leave in situ, remove towheads, rock placement over snag hazards and areas of potential span growth.
Option 1A - Leave in situ, remove towheads, rock placement over snag hazards and areas of potential span growth. Return after 30 years and place rock over entire length.
Option 1B - Leave in situ, remove towheads, rock placement over snag hazards and areas of potential span growth. Return after 30 years, cut bundle into 20m lengths and recover to shore.

Option 2 - Leave in situ, remove towheads, rock placement over entire length.
Option 3 - Leave in situ, remove towheads, cut bundle into 350m lengths, pull bundles into pre-cut trench and backfill with spoil.
Option 4 - Full removal, cut into 20m lengths and lift, recover to shore.

Xodus presented the assessment of the options against the five criteria.

FEL confirmed that for the options where the bundle remains in situ there will be regular future monitoring. FEL confirmed that their current understanding is that in around 30 years time the bundle would begin to lose structural integrity and therefore could become a safety risk for fishermen.

Xodus observed that safety exposure and technological feasibility and maturity were the key drivers impacting the CA. A discussion followed on the likelihood of safety exposure and technology changing over the next 30 years. FEL said that they would monitor industry progress.

SFF stated that they did not want option 1 to be the final outcome as it presents a future risk to fishermen. SFF asked if a removal trial could be undertaken on the smaller section of the North Bundle. FEL responded that such a trial would not prove the concept for the entirety of the two bundles and that research and development funds are not available, given the industry challenge of reducing decommissioning cost. SFF observed that the height of rock placement over the entire length would be substantial but still could be over-trawled. Xodus commented that the upcoming fishing impact QRA would provide a more detailed assessment.

SFF asked if the bundle could be refloated. FEL commented that refloating had been ruled out at the screening workshop in March 2016 due to the integrity of the bundle internals and lack of onshore landing facilities.

MS commented that there needs to be industry wide research into bundle removal and that technology would not improve unless there was a driver to do so.

JNCC also stated that industry leadership is required and that rock placement is a sub-optimal solution. JNCC further commented that leaving the bundle in situ, without significant rock placement allows more time for the Regulator and the wider industry to find better solutions. MS questioned how BEIS are considering the removal of old bundles across Operators.

OGA asked how long the bundle will last prior to decomposition commencing. FEL responded approximately 30 years based on the results of an Xodus material degradation study.

BEIS confirmed that subsequent to the Osprey Bundle installation, subsea bundles must be designed with a recovery methodology.

The overall result of the CA is that Option 1 is the recommended decision. The Osprey Bundles should be left in situ, towheads removed and rock placed over snag hazards and areas of potential span growth, followed by a sea-bed survey and trawl sweep.

3.2.2 Osprey Trenched and Rock Dumped Umbilicals

FEL described the scope and status of the Osprey Trenched and Rock-Dumped Umbilicals (PL736 and PL1545). FEL explained that three options were assessed for PL736 and PL1545 which had not been previously identified for full removal.

The options are:

> **Option 1** - Leave in situ, remove exposed ends, rock placement over snag hazards and areas of low cover.
> **Option 2** - Leave in situ, remove all exposed ends, rock placement over entire length.
> **Option 3** - Full removal, reverse reel.

Xodus presented the assessment of the options against the five criteria.

OGA asked if PL736 would have to be de-buried to allow for reverse reeling. FEL confirmed that de-burial would be required.

MS asked if BEIS Guidelines required pipelines to be buried. It was confirmed that BEIS Guidelines require pipelines to be trenched or buried to a depth of 0.6m below the sea-bed.

SFF asked about the profile of the PL1545 trench. FEL responded that the data is available and will be included in the fishing impact QRA.

The overall result of the CA is that Option 1 is the recommended decision. Osprey Trenched and Rock-Dumped Umbilicals (PL736 and PL1545) should be left in situ, the exposed ends removed and rock placed over snag hazards and areas of low cover followed by a sea-bed survey and trawl sweep.

3.3 Dunlin Field

3.3.1 Dunlin Rigid Risers

FEL described the scope and status of the Dunlin Rigid Risers. FEL explained that two options were assessed for the Risers.

The options are:

> **Option 1** - Leave in situ, riser cut at J-tube exit, outboard section recovered and J-tube sealed.
> **Option 2** - Full removal, outboard section cut and recovered, remaining section removed via topside.

Xodus presented the assessment of the options against the five criteria.

The overall result of the CA is that Option 1 is the recommended decision. The Dunlin Rigid Risers will be left in situ within the J-tube, the riser will be cut at the J-tube exit by a DSV, the J-tube will be sealed and the outboard section recovered to shore.

3.3.2 – Trenched and Buried Cable

FEL described the scope and status of the Dunlin Power Import Cable. FEL explained that three options were assessed for the Cable Risers.

The options are:

Option 1 - Leave in situ, remove all cable transitions, rock placement over snag hazards and areas of low cover.
Option 2 - Leave in situ, remove all cable transitions and exposures, rock placement over snag hazards and areas of low cover.
Option 3 - Full removal, reverse reel

Xodus presented the assessment of the options against the five criteria.

The overall result of the CA is that Option 1 is the recommended decision.
The Dunlin Power import Cable should be left in situ, cable transitions removed and rock placed over snag hazards and areas of low burial depth followed by a sea-bed survey and trawl sweep.

4 Next Steps

FEL thanked meeting attendees for their participation in the CA Workshop and reviewing the extensive pre-read materials. The fishing impact QRA will be undertaken week commencing 16th January and FEL will re-engage with the stakeholders should the QRA change the CA recommendations. Decommissioning Programmes will be updated with the CA recommendations in preparation for Public Consultation.

5 Post-Meeting Notes

On reviewing the minutes the SFF made three observations:

The SFF would like to highlight that for a number of the CAs considered, the overall option recommended was not the SFF's preference.

The SFF noted that removing the evaluation criteria of Economics did not change the recommendation for any removal decision, however the SFF also note that for the six separate Comparative Assessments reviewed, the chosen decommissioning option was the least expensive option on each occasion.

The SFF has concerns re the statement made in Section 3.2.2. (Osprey Trenched and Rock Dumped Umbilicals), that 'BEIS Guidelines require pipelines to be trenched or buried to a depth of 0.6m below the sea-bed' and will be seeking clarification with BEIS on this matter – it is felt that leaving pipelines or umbilicals uncovered in an open trench would pose a significant safety risk to fishermen.

Appendix E Data Sheets (Exc. Costs)

Area	Merlin
Decision/Group	Decision 1 Group 7 – Trenched and Rock Dumped Pipelines and Umbilicals
Option	1 – Leave in Situ – Minimal Intervention (Rock Placement)
Description	Pipeline and umbilical end removal by DSV Rock placement over snag hazards and areas of low burial depth by DPFPV Survey by ROVSV Trawl sweep using trawler
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 Subsea Decommissioning Inventory FBL-DUN-MER-SSP-01-RPT-00002 Subsea Decommissioning Screening – Merlin A-301649-S01-TECH-005 Merlin – Long Term Materials Degradation Study A-301649-S01-REPT-002 Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1555 8" Oil	Rigid	Steel	6805	6550	1.1-1.5	0	0	6610	0.7
PL1557 3" Umb.	Umbilical	Polymer / SD Steel / Copper	6980	6550	1.1-15	0	0	6610	0.7

SAFETY				
Offshore Personnel	Number	157	Man Hours	13766
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	1037
Onshore Personnel	Number	20	Man Hours	3903
Legacy Personnel	Number	35	Man Hours	21420
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	4	Duration of Operations	24.6
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	1	Duration of Operations	50.8
Potential for High Consequence Event	Low	Comments	Routine operations	

Operational Risk Diver	PLL	1.01E-03
Operational Risk Offshore	PLL	1.03E-03
Operational Risk Topsides	PLL	N/A
Operational Risk Onshore	PLL	4.80E-04
Legacy Risk (out to 50yrs)	PLL	1.18E-03
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)
Overall Risk	∑PLL	3.70E-03

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	10.0	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	1	Duration	4.5	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	5.1	Activity	Survey
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	1	Duration	5.0	Activity	Trawl Sweep
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	1	Duration	50.8	Activity	Survey
Noise (Total = Ops + Legacy)	Sound Exposure Level	252 dB re 1mP		17.5 TPa^2s				
Energy Use (Total = Ops + Legacy)	Fuel	883.0 Te	CO_2	2799.2 Te	NOx	52.1 Te	SO_2	10.6 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2	3905.91 Te	CO_2 (Credit)	N/A				

Marine Impact (Seabed)	Activity	Dredging	Area	100 m^2	Resources	N/A
	Activity	Rock Dump	Area	833 m^2	Resources	940 Te (Rock)
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	213 m PL1555 (21.3 Te) 388 m PL1557 (1.9 Te)			
	Remaining	6592 m PL1555 6592 m PL1557 35940 Te Rock (35000 Te Existing + 940 Te New)			
	Persistence	PL1555 100-500 years where fully covered PL1557 >100 years (no long term data/experience of polymers in seawater/buried)			
Residuals	LSA Scale	In-Situ	5099 kg Approx. PL1555 Only	Returned	165 kg Approx. PL1555 Only
	Hydrocarbon	In-Situ	3.4 kg Approx. PL1555 Only	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history		
	Risk of Failure	Low		
	Consequence of Failure	Alternate cutting technique / additional rock / limited schedule impacts		
	Emerging Technology	Diverless cutting maybe an option		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational	XX M		
	Comparative Cost Legacy - Monitoring	XX M		
	Comparative Cost Legacy - Remedial	XX M		
Economic Risk	Cost Risk	Low	Factors	High degree of achievability; Low likelihood of future remediation required due to existing burial depth, rock cover and absence of spans.

Area	Merlin	
Decision/Group	Decision 1 Group 7 – Trenched and Rock Dumped Pipelines and Umbilicals	
Option	2 – Leave in Situ – Minor Intervention (Cut and Rock Placement)	
Description	Pipeline and umbilical exposure, span and end removal by DSV Rock placement over snag hazards and cut ends by DPFPV Survey by ROVSV Trawl sweep using trawler	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-005 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Long Term Materials Degradation Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1555 8" Oil	Rigid	Steel	6805	6550	1.1-1.5	0	0	6610	0.7
PL1557 3" Umb.	Umbilical	Polymer / SD Steel / Copper	6980	6550	1.1-15	0	0	6610	0.7

SAFETY				
Offshore Personnel	Number	157	Man Hours	15965
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	1534
Onshore Personnel	Number	20	Man Hours	4209
Legacy Personnel	Number	35	Man Hours	21420
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	4	Duration of Operations	27
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	1	Duration of Operations	50.8
Potential for High Consequence Event	Low	Comments	Routine operations	

Operational Risk Diver	PLL	1.49E-03
Operational Risk Offshore	PLL	1.20E-03
Operational Risk Topsides	PLL	N/A
Operational Risk Onshore	PLL	5.18E-04
Legacy Risk (out to 50yrs)	PLL	1.18E-03
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)
Overall Risk	∑PLL	4.38E-03

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	12.4	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	1	Duration	4.5	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	5.1	Activity	Survey
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	1	Duration	5.0	Activity	Trawl Sweep
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	1	Duration	50.8	Activity	Survey
Noise (Total = Ops + Legacy)	Sound Exposure Level		253 dB re 1mP			21.3 TPa²s		
Energy Use (Total = Ops + Legacy)	Fuel	934.1 Te	CO_2	2961.0 Te	NOx	55.1 Te	SO_2	11.2 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		4058.08 Te		CO_2 (Credit)		4.61 Te	

Marine Impact (Seabed)	Activity	Dredging	Area	100 m²	Resources	N/A
	Activity	Rock Dump	Area	700 m²	Resources	790 Te (Rock)
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	273 m PL1555 (27.3 Te) 448 m PL1557 (2.1 Te)
	Remaining	6532 m PL1555 6532 m PL1557 35790 Te Rock (35000 Te Existing + 790 Te New)
	Persistence	PL1555 100-500 years where fully covered PL1557 >100 years (no long term data/experience of polymers in seawater/buried)

Residuals	LSA Scale	In-Situ	5052 kg Approx. PL1555 Only	Returned	211 kg Approx. PL1555 Only
	Hydrocarbon	In-Situ	3.4 kg Approx. PL1555 Only	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history		
	Risk of Failure	Low		
	Consequence of Failure	Alternate cutting technique / additional rock / limited schedule impacts		
	Emerging Technology	Diverless cutting maybe an option		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Limited material returned to shore

Economic		
Economic Considerations	Comparative Cost Operational	XX M
	Comparative Cost Legacy - Monitoring	XX M
	Comparative Cost Legacy - Remedial	XX M

Economic Risk	Cost Risk	Low	Factors	High degree of achievability; Low likelihood of future remediation required due to existing burial depth, rock cover and absence of spans.

Area	Merlin	
Decision/Group	Decision 1 Group 7 – Trenched and Rock Dumped Pipelines and Umbilicals	
Option	3 – Leave in Situ – Major Intervention (Backfill)	
Description	Pipeline and umbilical end removal by DSV Spoil backfilling using a mass flow excavator deployed from CSV Survey by ROVSV Trawl sweep using trawler	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-005 A-301649-S01-TECH-006 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Long Term Materials Degradation Study Merlin – Trenching and Backfill Feasibility Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1555 8” Oil	Rigid	Steel	6805	6550	1.1-1.5	0	0	6610	0.7
PL1557 3” Umb.	Umbilical	Polymer / SD Steel / Copper	6980	6550	1.1-15	0	0	6610	0.7

SAFETY				
Offshore Personnel	Number	157	Man Hours	15006
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	1037
Onshore Personnel	Number	20	Man Hours	4303
Legacy Personnel	Number	76	Man Hours	23880
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	4	Duration of Operations	27.4
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	2	Duration of Operations	55.8
Potential for High Consequence Event	Low	Comments	Routine operations	
Operational Risk Diver	PLL	1.01E-03		
Operational Risk Offshore	PLL	1.13E-03		
Operational Risk Topsides	PLL	N/A		
Operational Risk Onshore	PLL	5.29E-04		
Legacy Risk (out to 50yrs)	PLL	1.36E-03		
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)		
Overall Risk	∑PLL	4.02E-03		

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	10.0	Activity	Destruct
	Type	CSV	Number	1	Duration	7.0	Activity	Backfill
	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	1	Duration	5.1	Activity	Survey
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	1	Duration	5.0	Activity	Trawl Sweep
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	1	Duration	5	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	50.8	Activity	Survey
Noise (Total = Ops + Legacy)	Sound Exposure Level		253 dB re 1mP			18.9 TPa²s		
Energy Use (Total = Ops + Legacy)	Fuel	1047.8 Te	CO_2	3321.6 Te	NOx	61.8 Te	SO_2	12.6 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		4396.35 Te		CO_2 (Credit)		N/A	

Marine Impact (Seabed)	Activity	Dredging	Area	100 m²	Resources	N/A
	Activity	Rock Dump	Area	N/A	Resources	N/A
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	56400 m²	Resources	N/A

Materials	Recovered	213 m PL1555 (21.3 Te) 388 m PL1557 (1.9 Te)			
	Remaining	6592 m PL1555 6592 m PL1557 35000 Te Rock (Existing)			
	Persistence	PL1555 100-500 years where fully covered PL1557 >100 years (no long term data/experience of polymers in seawater/buried)			
Residuals	LSA Scale	In-Situ	5099 kg Approx. PL1555 Only	Returned	165 kg Approx. PL1555 Only
	Hydrocarbon	In-Situ	3.4 kg Approx. PL1555 Only	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	Low	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	Low – Little history of use over such distances		
	Risk of Failure	High		
	Consequence of Failure	Destruction of local seabed due to MFE removing material/ Removal of the existing rock cover leading to exposures and spans/ additional rock required to remediate areas of high removal/ large schedule impacts		
	Emerging Technology	N/A		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational	XX M		
	Comparative Cost Legacy - Monitoring	XX M		
	Comparative Cost Legacy - Remedial	XX M		
Economic Risk	Cost Risk	High	Factors	High risk of failure requiring additional works to be carried out; High likelihood of future remediation required due to a removal of existing burial material whilst attempting to utilise the spoil heaps.

Area	Merlin	
Decision/Group	Decision 2 Group 8 – Trenched and Buried Pipelines	
Option	1 – Leave in Situ – Minimal Intervention (Rock Placement)	
Description	Pipeline end removal by DSV Rock placement over snag hazards and areas of low burial depth by DPFPV Survey by ROVSV Trawl sweep using trawler	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-005 A-301649-S01-TECH-007 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Long Term Materials Degradation Study Merlin – Removal/Recovery Feasibility Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1665 8" WI	Flexible	Polymer / Steel	7043	6680	0.6	6660	0.6	0	0

SAFETY				
Offshore Personnel	Number	157	Man Hours	12556
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	368
Onshore Personnel	Number	20	Man Hours	3567
Legacy Personnel	Number	76	Man Hours	26340
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	4	Duration of Operations	23.4
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	2	Duration of Operations	60.9
Potential for High Consequence Event	Low	Comments	Routine operations	
Operational Risk Diver	PLL	3.57E-04		
Operational Risk Offshore	PLL	9.42E-04		
Operational Risk Topsides	PLL	N/A		
Operational Risk Onshore	PLL	4.39E-04		
Legacy Risk (out to 50yrs)	PLL	1.55E-03		
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)		
Overall Risk	∑PLL	3.28E-03		

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	8.5	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	1	Duration	4.8	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	5.1	Activity	Survey
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	1	Duration	5.0	Activity	Trawl Sweep
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	1	Duration	10	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	50.9	Activity	Survey
Noise (Total = Ops + Legacy)	Sound Exposure Level		253 dB re 1mP			21.2 TPa²s		
Energy Use (Total = Ops + Legacy)	Fuel	1076.0 Te	CO_2	3410.9 Te	NOx	63.5 Te	SO_2	12.9 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		4965.87 Te		CO_2 (Credit)		N/A	

Marine Impact (Seabed)	Activity	Dredging	Area	20 m²	Resources	N/A
	Activity	Rock Dump	Area	5500 m²	Resources	6000 Te (Rock)
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	402 m PL1665 (37.3 Te)			
	Remaining	6641 m PL1665 6000 Te Rock (New)			
	Persistence	Steel - PL1665 >150 years where fully covered Polymer – PL1665 >100 years (no long term data/experience of polymers in seawater/buried)			
Residuals	LSA Scale	In-Situ	N/A	Returned	N/A
	Hydrocarbon	In-Situ	N/A	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history		
	Risk of Failure	Low		
	Consequence of Failure	Alternate cutting technique / additional rock / limited schedule impacts		
	Emerging Technology	Diverless cutting maybe an option		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational	XX M		
	Comparative Cost Legacy - Monitoring	XX M		
	Comparative Cost Legacy - Remedial	XX M		
Economic Risk	Cost Risk	Low	Factors	High degree of achievability; Low likelihood of future remediation required due to existing burial depth and span prediction.

Area	Merlin	
Decision/Group	Decision 2 Group 8 – Trenched and Buried Pipelines	
Option	2 – Leave in Situ – Minor Intervention (Cut and Rock Placement)	
Description	Pipeline exposure, span and end removal by DSV Rock placement over snag hazards and cut ends by DPFPV Survey by ROVSV Trawl sweep using trawler	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-005 A-301649-S01-TECH-007 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Long Term Materials Degradation Study Merlin – Removal/Recovery Feasibility Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1665 8" WI	Flexible	Polymer / Steel	7043	6680	0.6	6660	0.6	0	0

SAFETY				
Offshore Personnel	Number	157	Man Hours	26187
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	3608
Onshore Personnel	Number	20	Man Hours	5409
Legacy Personnel	Number	76	Man Hours	26340
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	4	Duration of Operations	38.3
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	2	Duration of Operations	60.9

Potential for High Consequence Event	Low	Comments	Routine operations

Operational Risk Diver	PLL	3.50E-03
Operational Risk Offshore	PLL	1.96E-03
Operational Risk Topsides	PLL	N/A
Operational Risk Onshore	PLL	6.65E-04
Legacy Risk (out to 50yrs)	PLL	1.55E-03
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)
Overall Risk	∑PLL	7.68E-03

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	23.5	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	1	Duration	4.7	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	5.1	Activity	Survey
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	1	Duration	5.0	Activity	Trawl Sweep
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	1	Duration	10	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	50.9	Activity	Survey

Noise (Total = Ops + Legacy)	Sound Exposure Level	256 dB re 1mP	35.7 TPa²s

Energy Use (Total = Ops + Legacy)	Fuel	1404.0 Te	CO_2	4450.7 Te	NOx	82.8 Te	SO_2	16.8 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		5872.16 Te		CO_2 (Credit)		N/A	

Marine Impact (Seabed)	Activity	Dredging	Area	620 m²	Resources	N/A
	Activity	Rock Dump	Area	3560 m²	Resources	3900 Te (Rock)
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	1002 m PL1665			
	Remaining	6041 m PL1665 3900 Te Rock (New)			
	Persistence	Steel - PL1665 >150 years where fully covered Polymer – PL1665 >100 years (no long term data/experience of polymers in seawater/buried)			
Residuals	LSA Scale	In-Situ	N/A	Returned	N/A
	Hydrocarbon	In-Situ	N/A	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history		
	Risk of Failure	Low		
	Consequence of Failure	Alternate cutting technique / additional rock / limited schedule impacts		
	Emerging Technology	Diverless cutting maybe an option		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational	XX M		
	Comparative Cost Legacy - Monitoring	XX M		
	Comparative Cost Legacy - Remedial	XX M		
Economic Risk	Cost Risk	Low	Factors	High degree of achievability; Low likelihood of future remediation required due to existing burial depth and span prediction.

Area	Merlin	
Decision/Group	Decision 2 Group 8 – Trenched and Buried Pipelines	
Option	3 – Full Removal – (Reverse Reel)	
Description	Pipeline disconnect and recovery head installation by DSV Recover pipeline and reverse reel by DSV with reel spread Survey by DSV	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-006 A-301649-S01-TECH-007 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Trenching and Backfill Feasibility Study Merlin – Removal/Recovery Feasibility Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1665 8" WI	Flexible	Polymer / Steel	7043	6680	0.6	6660	0.6	0	0

SAFETY				
Offshore Personnel	Number	76	Man Hours	12860
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	281
Onshore Personnel	Number	20	Man Hours	7028
Legacy Personnel	Number	N/A	Man Hours	N/A
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	1	Duration of Operations	14.1
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	N/A	Duration of Operations	N/A
Potential for High Consequence Event	Medium	Comments	Non Routine Operation; Integrity assumed by engineering only.	
Operational Risk Diver	PLL	2.73E-04		
Operational Risk Offshore	PLL	9.65E-04		
Operational Risk Topsides	PLL	N/A		
Operational Risk Onshore	PLL	8.64E-04		
Legacy Risk (out to 50yrs)	PLL	N/A		
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)		
Overall Risk	∑PLL	2.10E-03		

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	14.1	Activity	Reverse Reel
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	N/A	Duration	N/A	Activity	N/A
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
Noise (Total = Ops + Legacy)	Sound Exposure Level		239 dB re 1mP			0.8 TPa^2s		
Energy Use (Total = Ops + Legacy)	Fuel	309.8 Te	CO_2	981.9 Te	NOx	18.3 Te	SO_2	3.7 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		1651.93 Te		CO_2 (Credit)		481.89 Te	

Marine Impact (Seabed)	Activity	Dredging	Area	N/A	Resources	N/A
	Activity	Rock Dump	Area	N/A	Resources	N/A
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	7043 m PL1665 (653.7 Te)			
	Remaining	0 m			
	Persistence	N/A			
Residuals	LSA Scale	In-Situ	N/A	Returned	N/A
	Hydrocarbon	In-Situ	N/A	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	Medium
	Availability of Technology	High – Off the shelf		
	Track Record	Low – Limited history of recovering flexibles through soil cover		
	Risk of Failure	Low – Initial engineering shows low utilisation values during recovery		
	Consequence of Failure	Pipeline deburial may be required in local areas / limited schedule impacts		
	Emerging Technology	N/A		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Material returned to shore will generate a small amount of recycling work.

Economic				
Economic Considerations	Comparative Cost Operational	XX M		
	Comparative Cost Legacy - Monitoring	XX M		
	Comparative Cost Legacy - Remedial	XX M		
Economic Risk	Cost Risk	Low	Factors	Whilst initial engineering indicates a high degree of achievability, maturity of the concept is not sufficiently detailed to enable certainty of success without some deburial operations that could increase schedule and cost.

Area	Merlin	
Decision/Group	Decision 3 Group 9 – Umbilical Riser	
Option	1 – Leave in Situ – Minor Intervention (Outboard Cut and Recovery)	
Description	Umbilical cut at J-tube exit by DSV Seal J-tube and recover outboard section of umbilical back to the DSV Survey by DSV	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-007 A-301649-S01-TECH-013 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Removal/Recovery Feasibility Study Merlin – Effect of Leaving Riser Section within J-Tube Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1556 4" Umb.	Umbilical	Polymer / Steel / Copper	475	0	0	0	0	60	0.5

SAFETY				
Offshore Personnel	Number	76	Man Hours	6020
Topsides Personnel	Number	10	Man Hours	240
Divers Required	Number	9	Man Hours	389
Onshore Personnel	Number	20	Man Hours	2350
Legacy Personnel	Number	N/A	Man Hours	N/A
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	1	Duration of Operations	6.6
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	N/A	Duration of Operations	N/A
Potential for High Consequence Event	Low	Comments	Routine operations	
Operational Risk Diver	PLL	3.77E-04		
Operational Risk Offshore	PLL	4.52E-04		
Operational Risk Topsides	PLL	9.84E-06		
Operational Risk Onshore	PLL	2.89E-04		
Legacy Risk (out to 50yrs)	PLL	N/A (in line with CGB)		
Fishing Risk	PLL	N/A		
Overall Risk	∑PLL	1.13E-03		

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	6.6	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	N/A	Duration	N/A	Activity	N/A
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
Noise (Total = Ops + Legacy)	Sound Exposure Level	236 dB re 1mP		0.4 TPa^2s				
Energy Use (Total = Ops + Legacy)	Fuel	145.4 Te	CO_2	461.0 Te	NOx	8.6 Te	SO_2	1.7 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2	681.51 Te	CO_2 (Credit)	N/A				
Marine Impact (Seabed)	Activity	Dredging	Area	N/A	Resources	N/A		
	Activity	Rock Dump	Area	N/A	Resources	N/A		
	Activity	Trenching	Area	N/A	Resources	N/A		
	Activity	Backfilling	Area	N/A	Resources	N/A		

Materials	Recovered	295 m (6 Te)			
	Remaining	180 m within J-tube			
	Persistence	In-line with CGB & J-tubes >250 years			
Residuals	LSA Scale	In-Situ	N/A	Returned	N/A
	Hydrocarbon	In-Situ	N/A	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history		
	Risk of Failure	Low		
	Consequence of Failure	Limited schedule impacts		
	Emerging Technology	N/A		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – Area where umbilical is removed will potentially remain within a safety zone
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational	XX M		
	Comparative Cost Legacy - Monitoring	XX M – (Monitoring is assumed to be done as part of any CGB monitoring)		
	Comparative Cost Legacy - Remedial	XX M		
Economic Risk	Cost Risk	Low	Factors	High degree of achievability.

Area	Merlin
Decision/Group	Decision 3 Group 9 – Umbilical Riser
Option	2 – Full Removal – Topsides Pull
Description	Mobilise winch spread to platform, install and test Remove topside hang-off and transfer umbilical to winch Remove J-tube seal by DSV (part reverse pull as required) Umbilical cut at J-tube exit by DSV Seal J-tube and recover outboard section of umbilical back to the DSV Pull-in umbilical using the topside winch (pull, secure, cut, repeat) Backload umbilical sections and winch equipment Survey by DSV

Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-007 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Removal/Recovery Feasibility Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1556 4" Umb.	Umbilical	Polymer / Steel / Copper	475	0	0	0	0	60	0.5

SAFETY				
Offshore Personnel	Number	126	Man Hours	12111
Topsides Personnel	Number	6	Man Hours	2693
Divers Required	Number	9	Man Hours	346
Onshore Personnel	Number	20	Man Hours	4162
Legacy Personnel	Number	N/A	Man Hours	N/A
Impact to Other Users of the Sea(Operational)	Number of Vessels Used	2	Duration of Operations	16.7
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	N/A	Duration of Operations	N/A
Potential for High Consequence Event	Medium	Comments	Non-routine operations but not unusual. Limited SIMOPS.	
Operational Risk Diver	PLL	3.36E-04		
Operational Risk Offshore	PLL	9.08E-04		
Operational Risk Topsides	PLL	1.10E-03		
Operational Risk Onshore	PLL	5.12E-04		
Legacy Risk (out to 50yrs)	PLL	N/A		
Fishing Risk	PLL	N/A		
Overall Risk	∑PLL	1.87E-03		

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	6.7	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	PSV	Number	1	Duration	10	Activity	Supply
	Type	Trawler	Number	N/A	Duration	N/A	Activity	N/A
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
Noise (Total = Ops + Legacy)	Sound Exposure Level		244 dB re 1mP			2.8 TPa²s		
Energy Use (Total = Ops + Legacy)	Fuel	247.4 Te	CO_2	784.3 Te	NOx	14.6 Te	SO_2	3.0 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		906.5 Te		CO_2 (Credit)		1.87 Te	

Marine Impact (Seabed)	Activity	Dredging	Area	N/A	Resources	N/A
	Activity	Rock Dump	Area	N/A	Resources	N/A
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	475 m (9.7 Te)			
	Remaining	0 m			
	Persistence	N/A			
Residuals	LSA Scale	In-Situ	N/A	Returned	N/A
	Hydrocarbon	In-Situ	N/A	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	Medium
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history in North Sea and recent history on Dunlin.		
	Risk of Failure	Medium – Unknown integrity of J-tube / umbilical and inability to inspect.		
	Consequence of Failure	Umbilical would remain within J-tube / schedule over runs		
	Emerging Technology	N/A		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – Area where umbilical is removed will potentially remain within a safety zone
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational	XX M		
	Comparative Cost Legacy - Monitoring	XX M		
	Comparative Cost Legacy - Remedial	XX M		
Economic Risk	Cost Risk	Medium	Factors	Topside engineering for winch locating is not fully defined; Inspection to confirm integrity of J-tube and Umbilical is not possible; Previous pull-in operations have suffered delays and cost over runs.

Appendix F CA Attributes Tables & Pairwise Comparison (Exc. Costs)

Project Differentiator Attributes

Differentiator	Sub-Criteria	Description	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE
1. Safety	1.1 Personnel Offshore	This sub-criterion considers elements that impact risk to offshore personnel and 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.	Total PLL (incl. Legacy): 3.70E-03 Vessels located on site for Operations: 24.6 days Legacy: 50.8 days	Total PLL (incl. Legacy): 4.38E-03 Vessels located on site for Operations: 27 days Legacy: 50.8 days	Total PLL (incl. Legacy): 4.02E-03 Vessels located on site for Operations: 27.4 days Legacy: 55.8 days
	1.2 Personnel Onshore	This sub-criterion considers elements that impact risk to onshore personnel. Factors such as any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel.			
	1.3 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.			
	1.4 High Consequence Events	This sub-criterion relates to any inherent potential for high consequence events i.e. major accident hazard, major environmental hazard type events. It applies to all onshore and offshore personnel involved in the project. Considerations such as dropped object concerns, support vessel risks, are considered.	Low risk of high consequence - routine.	Low risk of high consequence - routine. A little higher than option 1 as more lifting operations.	Low risk of high consequence - routine.
	1.5 Residual Risk	This sub-criterion addresses and residual risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, that is provided by the option. Issues such as residual snag risk, collision risk, etc. may be considered.	Residual Risk Legacy: 35 / 21420 / 1.18E-03 (monitoring) Fishing: Negligible additional risk presented to fisherman from spot rock dumped pipeline / umbilical.	Residual Risk Legacy: 35 / 21420 / 1.18E-03 (monitoring) Fishing: Negligible additional risk presented to fisherman from fully rock dumped pipeline / umbilical.	Residual Risk Legacy: 76 / 23880 / 1.36E-03 (monitoring) Fishing: Future risk to fishing operations eliminated by this option.
		Summary	The summed PLL figures for options 1, 2 and 3 (all worker groups and including legacy component where present) are 3.70E-03, 4.38E-03 and 4.02E-03 respectively. This indicates that the risk exposure associated with options 1 and 3 are largely similar and slightly lower than option 2. This is driven by the marginally higher exposure associated with most worker groups. Overall option 1 and 3 are Neutral against each other and both are Stronger than option 2 from a safety perspective. The workshop discussed and conducted a sensitivity relating to reduction in monitoring requirements for option 3 (whereby option 1 became Weaker than option 3, and option 2 became Much Weaker than option 3) but this had no affect on the overall outcome.		
2. Environmental	2.1 Marine Impacts	This sub-criterion covers elements such as noise generated by vessels, cutting operations, explosives etc. It also covers any damaging discharges to sea from vessels and / or activities performed.	Sound Exposure 252 dB re 1mP / 17.5 TPa2s	Sound Exposure 253 dB re 1mP / 21.3 TPa2s	Sound Exposure 253 dB re 1mP / 18.9 TPa2s
	2.2 Emissions	This sub-criterion relates to the amount of damaging atmospheric emissions associated with a particular option.	CO2: 2799.2 Te NOx: 52.1 Te SO2: 10.6 Te Lifecycle CO2: 3905.91 Te CO2 Credit for Steel: N/A	CO2: 2961.0 Te NOx: 55.1 Te SO2: 11.2 Te Lifecycle CO2: 4058.08 Te CO2 Credit for Steel: 4.61 Te	CO2: 3321.6 Te NOx: 61.8 Te SO2: 12.6 Te Lifecycle CO2: 4396.35 Te CO2 Credit for Steel: N/A
	2.3 Consumption	This sub-criterion relates to the amount of Energy / Resource consumption such as fuel use, recycling of materials, use of quarried rock, production of replacement materials.	Fuel: 883.0 Te Rock: 940 Te	Fuel: 934.1 Te Rock: 790 Te	Fuel: 1047.8 Te Rock: N/A
	2.4 Disturbance	This sub-criterion relates to both direct and indirect seabed disturbance. Both short and long term impacts are considered.	Disturbance Dredging: 100 m2 Rock Dump: 833 m2	Disturbance Dredging: 100 m2 Rock Dump: 700 m2	Disturbance Dredging: 100 m2 Backfilling: 56400 m2
	2.5 Protections	This sub-criterion relates to the impact of the options on any protected sites and species.	This option has no impact on protected sites or species.	This option has no impact on protected sites or species.	This option has no impact on protected sites or species.
		Summary	Options 1, 2 and 3 are largely similar in terms of sound exposure, emissions and fuel use. The only real environmental differentiator relates to Option 3 which has a significantly larger seabed disturbance impact than options 1 and 2. Overall, options 1 and 2 are Neutral to each other and both are Stronger than option 3 from an environmental perspective (even though the seabed disturbance associated with options 1 and 2 will have no recovery potential, they are both small areas compared to that for option 3).		

Project Differentiator Attributes

Differentiator	Sub-Criteria	Description	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE
3. Technical	3.1 Technical Risk	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. Technical Feasibility and Technical Maturity is also considered.	Feasibility: High. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: High – Extensive history. Risk of Failure: Low. Consequence of Failure: Alternate cutting technique / additional rock / limited schedule impacts. Emerging Technology: Diverless cutting may be an option.	Feasibility: High. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: High – Extensive history. Risk of Failure: Low. Consequence of Failure: Alternate cutting technique / additional rock / limited schedule impacts. Emerging Technology: Diverless cutting may be an option.	Feasibility: Low. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: Low – Little history of use over such distances. Risk of Failure: High. Consequence of Failure: Destruction of local seabed due to MFE removing material / Removal of the existing rock cover leading to exposures and spans / additional rock required to remediate areas of high removal / large schedule impacts. Emerging Technology: N/A
		Summary	Option 1 and 2 are similar from a technical perspective. They are also Much Stronger than option 3 due to the uncertainty that backfilling over those distances and to the level required is achievable.		
4. Societal	4.1 Fishing	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.	Can fish over so long term OK. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either.	Can fish over so long term OK. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either.	Can fish over so long term ok. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either.
	4.2 Other Users	This sub-criterion addresses any socio-economic impacts on other users both onshore where the impact may be from dismantling, transporting, 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 negative impact on communities, increased traffic disruption due to extra-large transport loads, etc. Includes the FEL Guiding Principle of 'Minimal business interruption to others'.	Material returned to shore Recovered: 213 m PL1555 (21.3 Te) 388 m PL1557 (1.9 Te) 165 kg LSA Scale (PL1555) Remaining: 6592 m PL1555 6592 m PL1557 35940 Te Rock (35000 Te Existing + 940 Te New). 5099 kg LSA Scale (PL1555) 3.4 kg Hydrocarbon (PL1555) Persistence: PL1555 100-500 years where fully covered / PL1557 >100 years (no long term data / experience of polymers in seawater / buried).	Material returned to shore Recovered: 273 m PL1555 (27.3 Te) 448 m PL1557 (2.1 Te) 211 kg LSA Scale (PL1555) Remaining: 6532 m PL1555 6532 m PL1557 35790 Te Rock (35000 Te Existing + 790 Te New). 5052 kg LSA Scale (PL1555) 3.4 kg Hydrocarbon (PL1555) Persistence: PL1555 100-500 years where fully covered / PL1557 >100 years (no long term data / experience of polymers in seawater / buried).	Material returned to shore Recovered: 213 m PL1555 (21.3 Te) 388 m PL1557 (1.9 Te) 165 kg LSA Scale (PL1555) Remaining: 6592 m PL1555 6592 m PL1557 35500 Te (Existing) 5099 kg LSA Scale (PL1555) 3.4 kg Hydrocarbon (PL1555) Persistence: PL1555 100-500 years where fully covered / PL1557 >100 years (no long term data / experience of polymers in seawater / buried).
		Summary	Option 1, 2 and 3 largely similar from a Societal perspective so scored Neutral against each other.		
5. Economic	5.1 Short-term Costs	This sub-criterion addresses the cost of delivering the option as described. No long-term cost element is considered here. Cost uncertainty (a function of activity maturity) is also recorded.	Cost: XXM Cost Risk: Low Risk Factors: High degree of achievability.	Cost: XXM Cost Risk: Low Risk Factors: High degree of achievability.	Cost: XXM Cost Risk: High Risk Factors: High risk of failure requiring additional works to be carried out.
	5.2 Long-term Costs	This sub-criterion addresses the costs associated with any long-term liabilities such as on-going monitoring and any potential future remediation costs.	Monitoring Cost: XXM Remedial Cost: XXM Cost Risk: Low Risk Factors: Low likelihood of future remediation required due to existing burial depth.	Monitoring Cost: XXM Remedial Cost: XXM Cost Risk: Low Risk Factors: Low likelihood of future remediation required due to existing burial depth.	Monitoring Cost: XXM Remedial Cost: XXM Cost Risk: High Risk Factors: High likelihood of future remediation required due to a removal of existing burial material whilst attempting to utilise the spoil heaps.
		Summary	The differential in cost between options 1, 2 and 3 is relatively limited at XXM, XXM and XX M respectively. However, there is a significant cost risk associated with the risk of overruns associated with option 3. The workshop agreed that options 1 and 2 are Neutral to each other whilst being Stronger than option 3. The workshop discussed and conducted a sensitivity relating to reduction in monitoring requirements for option 3 (whereby option 1 became Neutral to option 3, and option 2 became Neutral to option 3) but this had no affect on the overall outcome.		

Merlin Decision 1 – Trenched and Rock Dumped Pipelines and Umbilicals

Pairwise Comparison

1. Safety

1. Safety	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE	Priorities
1. Leave - End Removal - Limited Rock Placement	N	S	N	37.50%
2. Leave - End / Exposure / Span Removal - Rock Placement	W	N	W	25.00%
3. Leave - End Removal - Backfill with MFE	N	S	N	37.50%

2. Environmental

2. Environmental	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	S	37.50%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	S	37.50%
3. Leave - End Removal - Backfill with MFE	W	W	N	25.00%

3. Technical

3. Technical	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	MS	42.86%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	MS	42.86%
3. Leave - End Removal - Backfill with MFE	MW	MW	N	14.29%

4. Societal

4. Societal	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	N	33.33%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	N	33.33%
3. Leave - End Removal - Backfill with MFE	N	N	N	33.33%

5. Economic

5. Economic	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	S	37.50%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	S	37.50%
3. Leave - End Removal - Backfill with MFE	W	W	N	25.00%

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Project Differentiator Attributes

Differentiator	Sub-Criteria	Description	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel
1. Safety	1.1 Personnel Offshore	This sub-criterion considers elements that impact risk to offshore personnel and 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.	Total PLL: 3.28E-03 Vessels located on site for Operations: 23.4 days Legacy: 60.9 days	Total PLL: 7.68E-03 Vessels located on site for Operations: 38.3 days Legacy: 60.9 days	Total PLL: 2.10E-03 Vessels located on site for 14.1 days.
	1.2 Personnel Onshore	This sub-criterion considers elements that impact risk to onshore personnel. Factors such as any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel.			
	1.3 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.			
	1.4 High Consequence Events	This sub-criterion relates to any inherent potential for high consequence events i.e. major accident hazard, major environmental hazard type events. It applies to all onshore and offshore personnel involved in the project. Considerations such as dropped object concerns, support vessel risks, are considered.	Low risk of high consequence - routine.	Low risk of high consequence - routine. A little higher than option 1 as more lifting operations.	Medium risk of high consequence events - non-routine operations. The integrity of the pipeline is assumed by engineering only. Potential for pipeline integrity failure during these operations.
	1.5 Residual Risk	This sub-criterion addresses and residual risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, that is provided by the option. Issues such as residual snag risk, collision risk, etc. may be considered.	Residual Risk Legacy: 76 / 26340 / 1.55E-03 (monitoring) Fishing: Negligible additional risk presented to fisherman from spot rock dumped pipeline.	Residual Risk Legacy: 76 / 26340 / 1.55E-03 (monitoring) Fishing: Negligible additional risk presented to fisherman from rock dumped / trenched and buried pipeline.	Residual Risk There is no residual legacy risk or risk to fishing operations associated with this option as it is a full removal option.
		Summary	The summed PLL figures for options 1, 2 and 3 (all worker groups and including legacy component where present) are 3.28E-03, 7.68E-03 and 2.10E-03 respectively. This indicates that option 3 is the lowest risk exposure, driven by the lowest exposure for the high risk divers worker group and the lack of a legacy risk component. This is followed by option 1 which has a higher risk exposure from the increased exposure to the divers worker group and the inclusion of the legacy risk associated with the on-going monitoring. Option 2 has the highest risk exposure, again driven by the significant increased exposure to the high risk diver worker group. The other differential between the options is the potential for a high consequence event. Option 1 is slightly lower than option 2 in this respect due to increased lifting operations. Option 3 is worse again, due to the risk associated with reverse reeling operations. Overall, option 1 is Stronger than option 2 due the lower risk exposure and the slightly lower potential for high consequence events. It is Neutral to option 3 as, whilst option 1 has higher risk exposure than option 3, this offset by the increased potential for high consequence events posed by reverse reeling operations. Option 2 is Weaker than option 3 due to the large differential in risk exposure being offset slightly by the increased potential for high consequence events posed by reverse reeling operations.		
2. Environmental	2.1 Marine Impacts	This sub-criterion covers elements such as noise generated by vessels, cutting operations, explosives etc. It also covers any damaging discharges to sea from vessels and / or activities performed.	Sound Exposure 253 dB re 1mP / 21.2 TPa2s	Sound Exposure 256 dB re 1mP / 35.7 TPa2s	Sound Exposure 239 dB re 1mP / 0.8 TPa2s
	2.2 Emissions	This sub-criterion relates to the amount of damaging atmospheric emissions associated with a particular option.	CO_2: 3410.9 Te NOx: 63.5 Te SO_2: 12.9 Te Lifecycle CO_2: 4965.87 Te CO_2 Credit for Steel: N/A	CO_2: 4450.7 Te NOx: 82.8 Te SO_2: 16.8 Te Lifecycle CO_2: 5872.16 Te CO_2 Credit for Steel: N/A	CO_2: 981.9 Te NOx: 18.3 Te SO_2: 3.7 Te Lifecycle CO_2: 1651.93 Te CO_2 Credit for Steel: 481.89 Te
	2.3 Consumption	This sub-criterion relates to the amount of Energy / Resource consumption such as fuel use, recycling of materials, use of quarried rock, production of replacement materials.	Fuel: 1076.0 Te Rock: 6000 Te	Fuel: 1404.0 Te Rock: 3900 Te	Fuel: 309.8 Te Rock: N/A
	2.4 Disturbance	This sub-criterion relates to both direct and indirect seabed disturbance. Both short and long term impacts are considered.	Disturbance Dredging: 20 m2 Rock Dump: 5500 m2	Disturbance Dredging: 620 m2 Rock Dump: 3560 m2	This option has no associated seabed disturbance.
	2.5 Protections	This sub-criterion relates to the impact of the options on any protected sites and species.	This option has no impact on protected sites or species.	This option has no impact on protected sites or species.	This option has no impact on protected sites or species.
		Summary	Option 3 is the most attractive in terms of noise exposure, emissions and fuel use with options 1 and 2 being less attractive in each area. Options 1 and 2 are however, considered largely similar. In terms of seabed disturbance, options 1 and 2 are broadly similar, with option 1 impacting a larger area. Option 1 also introduces the highest amount of new material, resulting in permanent seabed change. *** Option 3 has low permanent seabed impact when compared to Options 1 and 2. *** Overall, option 1 and 2 are Neutral. They are both Much Weaker than option 3.		

Project Differentiator Attributes

Differentiator	Sub-Criteria	Description	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel
3. Technical	3.1 Technical Risk	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. Technical Feasibility and Technical Maturity is also considered.	Feasibility: High. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: High – Extensive history. Risk of Failure: Low. Consequence of Failure: Alternate cutting technique / additional rock / limited schedule impacts. Emerging Technology: Diverless cutting may be an option.	Feasibility: High. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: High – Extensive history. Risk of Failure: Low. Consequence of Failure: Alternate cutting technique / additional rock / limited schedule impacts. Emerging Technology: Diverless cutting may be an option.	Feasibility: High. Concept Maturity: Medium. Availability of Technology: High – Off the shelf. Track Record: Low – Limited history of recovering flexibles through soil cover. Risk of Failure: Low – Initial engineering shows low utilisation values during recovery. Consequence of Failure: Pipeline deburial may be required in local areas / limited schedule impacts. Emerging Technology: N/A.
		Summary	Options 1 and 2 are comparable and therefore Neutral from a technical perspective. Option 1 and 2 are Stronger than option 3 due to the uncertainty surround the ability to reverse reel a flexible pipeline through soil cover.		
4. Societal	4.1 Fishing	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.	Can fish over so long term OK. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either.	Can fish over so long term ok. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either. Less rock in place but considered marginal contribution.	Can fish over so long term ok. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either.
	4.2 Other Users	This sub-criterion addresses any socio-economic impacts on other users both onshore where the impact may be from dismantling, transporting, 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 negative impact on communities, increased traffic disruption due to extra-large transport loads, etc. Includes the FEL Guiding Principle of 'Minimal business interruption to others'.	Material returned to shore Recovered: 402 m PL1665 (37.3 Te) Remaining: 6641 m PL1665 6000 Te Rock (New) Persistence: Steel - PL1665 >150 years where fully covered / Polymer – PL1665 >100 years (no long term data / experience of polymers in seawater / buried). Less material returned to shore than other options but offset by the highest requirement for new rock.	Material returned to shore Recovered: 1002 m PL1665 Remaining: 6041 m PL1665 3900 Te Rock (New) Persistence: Steel - PL1665 >150 years where fully covered / Polymer – PL1665 >100 years (no long term data / experience of polymers in seawater / buried). A little more material returned to shore than option 1 but lower new rock requirement.	Material returned to shore Recovered: 7043 m PL1665 (653.7 Te) Remaining: 0 m Persistence: N/A All material returned to shore. Recycling of material is positive.
		Summary	Options all Neutral from a fishing perspective. In terms of the wider societal impact, option 1 returns less material but requires more rock, whereas option 2 returns a little more material to shore but requires less rock. Option 3 returns more material to shore provides a positive from a recycling perspective, makes option 3 marginally more attractive than options 1 and 2 from a societal perspective. Overall, option 1 and 2 are Neutral from a Societal perspective. Option 1 and 2 are both slightly Weaker than option 3.		
5. Economic	5.1 Short-term Costs	This sub-criterion addresses the cost of delivering the option as described. No long-term cost element is considered here. Cost uncertainty (a function of activity maturity) is also recorded.	Cost: XXM Cost Risk: Low Risk Factors: High degree of achievability.	Cost: XXM Cost Risk: Low Risk Factors: High degree of achievability.	Cost: XXM Cost Risk: Medium Cost Risk Factors: Initial engineering indicates a high degree of achievability as residual integrity of pipeline is high.
	5.2 Long-term Costs	This sub-criterion addresses the costs associated with any long-term liabilities such as on-going monitoring and any potential future remediation costs.	Monitoring Cost: XXM Remedial Cost: XXM Cost Risk: Low Risk Factors: Low likelihood of future remediation required due to existing burial depth and span prediction.	Monitoring Cost: XXM Remedial Cost: XXM Cost Risk: Low Risk Factors: Low likelihood of future remediation required due to existing burial depth and span prediction.	There are no long-term cost liabilities associated with this full removal option.
		Summary	Option 1 has a total cost of XX M associated with it and has a high degree of success. Option 2 is more expensive at XX M and also has a high degree of success. Option 3 is the lowest total cost at XXM, it does carry a medium risk associated with completing the umbilical reverse reel without deburial operations where an overspend of up to 2 M is not considered impossible. Overall, option 1 is Much Stronger than option 2 due to the large cost differential. Option 1 is Neutral to option 3 as, whilst option 3 has a lower cost, there is significant cost risk. Finally, option 2 is Weaker than option 3 due to the high cost differential.		

Merlin Decision 2 – Trenched and Buried Pipeline

Pairwise Comparison

1. Safety	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel	Priorities
1. Leave - End Removal - Limited Rock Placement	N	S	N	37.50%
2. Leave - End / Exposure / Span Removal - Rock Placement	W	N	W	25.00%
3. Full Removal - Reverse Reel	N	S	N	37.50%

2. Environmental	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	MW	20.00%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	MW	20.00%
3. Full Removal - Reverse Reel	MS	MS	N	60.00%

3. Technical	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	S	37.50%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	S	37.50%
3. Full Removal - Reverse Reel	W	W	N	25.00%

4. Societal	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	W	28.57%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	W	28.57%
3. Full Removal - Reverse Reel	S	S	N	42.86%

5. Economic	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel	Priorities
1. Leave - End Removal - Limited Rock Placement	N	MS	N	42.86%
2. Leave - End / Exposure / Span Removal - Rock Placement	MW	N	MW	14.29%
3. Full Removal - Reverse Reel	N	MS	N	42.86%

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Project Differentiator Attributes

Differentiator	Sub-Criteria	Description	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull
1. Safety	1.1 Personnel Offshore	This sub-criterion considers elements that impact risk to offshore personnel and 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.	Total PLL: 1.13E-03 Vessels located on site for 6.6 days.	Total PLL: 1.87E-03 Vessels located on site for 16.7 days. This includes shuttling with PSV which results in increased exposure of vessels in area.
	1.2 Personnel Onshore	This sub-criterion considers elements that impact risk to onshore personnel. Factors such as any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel.		
	1.3 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.		
	1.4 High Consequence Events	This sub-criterion relates to any inherent potential for high consequence events i.e. major accident hazard, major environmental hazard type events. It applies to all onshore and offshore personnel involved in the project. Considerations such as dropped object concerns, support vessel risks, are considered.	Low risk of high consequence events - routine.	Medium risk of high consequence events - non-routine, although not unusual, possible limited SIMOPS.
	1.5 Residual Risk	This sub-criterion addresses and residual risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, that is provided by the option. Issues such as residual snag risk, collision risk, etc. may be considered.	No residual risk as it is wholly within the 500m exclusion zone and all outboard elements are fully removed.	There is no residual risk associated with this full removal option.
		Summary	The summed PLL figures for options 1 and 2 (all worker groups and including legacy component where present) are 1.13E-03 and 1.87E-03 respectively. This indicates that, whilst the risk exposure is similar for the two options, option 1 is lower than option 2. This is driven by the higher exposure associated with the offshore and topsides worker groups for option 2. Option 1 is also slightly shorter duration and caries a lower risk of high consequence events. Overall, option 1 is Stronger than option 2 from a safety perspective.	
2. Environmental	2.1 Marine Impacts	This sub-criterion covers elements such as noise generated by vessels, cutting operations, explosives etc. It also covers any damaging discharges to sea from vessels and / or activities performed.	Sound Exposure 236 dB re 1mP / 0.4 TPa2s	Sound Exposure 244 dB re 1mP / 2.8 TPa2s
	2.2 Emissions	This sub-criterion relates to the amount of damaging atmospheric emissions associated with a particular option.	CO_2: 461.0 Te NOx: 8.6 Te SO_2: 1.7 Te Lifecycle CO_2: 681.51 Te CO_2 Credit for Steel: N/A	CO_2: 784.3 Te NOx: 14.6 Te SO_2: 3.0 Te Lifecycle CO_2: 906.50 Te CO_2 Credit for Steel: 1.87 Te
	2.3 Consumption	This sub-criterion relates to the amount of Energy / Resource consumption such as fuel use, recycling of materials, use of quarried rock, production of replacement materials.	Fuel: 145.4 Te Rock: None	Fuel: 247.4 Te Rock: None
	2.4 Disturbance	This sub-criterion relates to both direct and indirect seabed disturbance. Both short and long term impacts are considered.	This option has no associated seabed disturbance.	This option has no associated seabed disturbance.
	2.5 Protections	This sub-criterion relates to the impact of the options on any protected sites and species.	This option has no impact on protected sites or species.	This option has no impact on protected sites or species.
		Summary	Option 1 is either equal to or marginally better than option 2 in all areas. As such, option 1 is Stronger than option 2 from an environmental perspective due to the cumulative effect of these marginal improvements.	

3. Technical	3.1 Technical Risk	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. Technical Feasibility and Technical Maturity is also considered.	Feasibility: High. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: High – Recent history of cutting umbilicals and flexibles. Risk of Failure: Low. Consequence of Failure: Limited schedule impacts. Emerging Technology: Diverless cutting may be an option.	Feasibility: High. Concept Maturity: Medium - final details for performing task are yet to be defined, platform crane, winch placement and operations, etc. Availability of Technology: High – Off the shelf. Track Record: High – Extensive history in North Sea and recent history on Dunlin. Risk of Failure: Medium – Unknown integrity of J-tube / umbilical and inability to inspect. Consequence of Failure: Umbilical would remain within J-tube / schedule overruns - extremely minor potential of flooding leg performing these operations. Emerging Technology: N/A.
		Summary	Option 1 carries less technical risk than option 2 due to the potential / consequence of failure associated with the uncertainty of the j-tube integrity. Overall option 1 is considered Stronger than option 2 from a Technical Feasibility perspective.	
4. Societal	4.1 Fishing	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.	Will not remain on seabed - no long term exposure.	Will not remain on seabed - no long term exposure.
	4.2 Other Users	This sub-criterion addresses any socio-economic impacts on other users both onshore where the impact may be from dismantling, transporting, 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 negative impact on communities, increased traffic disruption due to extra-large transport loads, etc. Includes the FEL Guiding Principle of 'Minimal business interruption to others'.	Material returned to shore Recovered: 295 m Umbilical (6 Te) Remaining: 180 m Umbilical (within J-tube) Persistence: In-line with CGB & J-tubes >250 years.	Material returned to shore Recovered: 475 m Umbilical (9.7 Te) Remaining: 0 m Persistence: N/A
		Summary	Options 1 and 2 are largely similar from a societal perspective. There is more material returned to shore under option 2, however this was not considered significant enough to change the scoring from Neutral.	
5. Economic	5.1 Short-term Costs	This sub-criterion addresses the cost of delivering the option as described. No long-term cost element is considered here. Cost uncertainty (a function of activity maturity) is also recorded.	Cost: XX M Cost Risk: Low Risk Factors: High degree of achievability.	Cost: XX M Cost Risk: Medium Risk Factors: Topside engineering for winch locating is not mature / inspection to confirm integrity of J-tube and contained products is not possible / previous pull-in operations have suffered delays and cost overruns. Historical overruns have been pull-in rather than removal operations.
	5.2 Long-term Costs	This sub-criterion addresses the costs associated with any long-term liabilities such as on-going monitoring and any potential future remediation costs.	No long-term costs, any Monitoring is assumed to be done as part of any CGB monitoring.	No long-term costs associated with this full removal option.
		Summary	Option 1 has a lower cost and cost risk than option 2. Therefore option 1 is Stronger than option 2.	

Merlin Decision 3 – Umbilical Riser

Pairwise Comparison

1. Safety	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull	Priorities
1. Leave - Outboard Cut and Recover	N	S	60.00%
2. Full Removal - Topsides Pull	W	N	40.00%

2. Environmental	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull	Priorities
1. Leave - Outboard Cut and Recover	N	S	60.00%
2. Full Removal - Topsides Pull	W	N	40.00%

3. Technical	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull	Priorities
1. Leave - Outboard Cut and Recover	N	S	60.00%
2. Full Removal - Topsides Pull	W	N	40.00%

4. Societal	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull	Priorities
1. Leave - Outboard Cut and Recover	N	N	50.00%
2. Full Removal - Topsides Pull	N	N	50.00%

5. Economic	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull	Priorities
1. Leave - Outboard Cut and Recover	N	S	60.00%
2. Full Removal - Topsides Pull	W	N	40.00%

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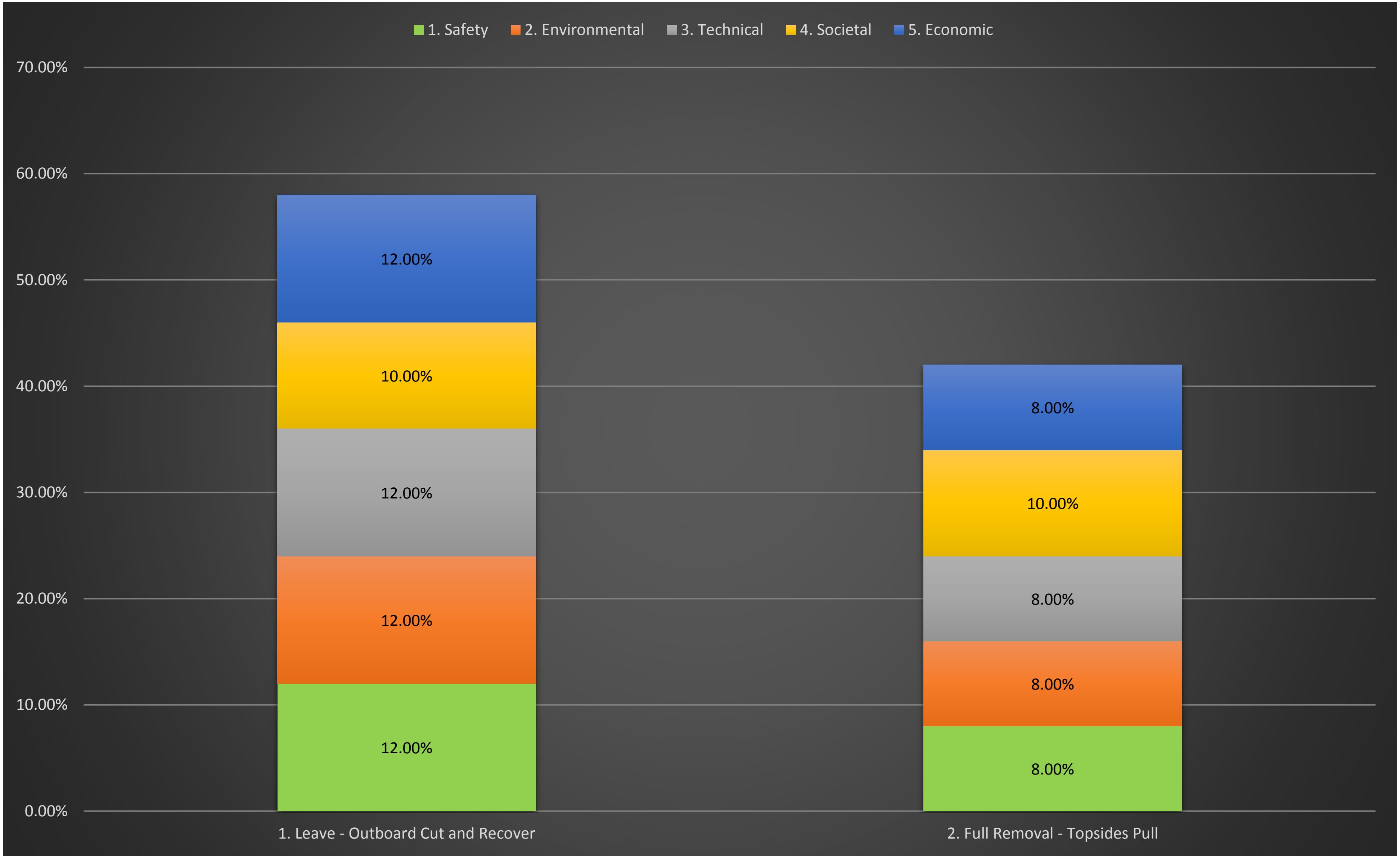
Appendix G Output Charts

Merlin Group 7 - Trenched and Rock Dumped Pipelines and Umbilicals - Results (5 Criteria)

Merlin Group 8 - Trenched and Buried Pipeline - Results (5 Criteria)

Merlin Group 9 - Umbilical Riser - Results (5 Criteria)



Appendix H Data Sheets (Inc. Costs)

Area	Merlin	
Decision/Group	Decision 1 Group 7 – Trenched and Rock Dumped Pipelines and Umbilicals	
Option	1 – Leave in Situ – Minimal Intervention (Rock Placement)	
Description	Pipeline and umbilical end removal by DSV Rock placement over snag hazards and areas of low burial depth by DPFPV Survey by ROVSV Trawl sweep using trawler	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-005 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Long Term Materials Degradation Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1555 8" Oil	Rigid	Steel	6805	6550	1.1-1.5	0	0	6610	0.7
PL1557 3" Umb.	Umbilical	Polymer / SD Steel / Copper	6980	6550	1.1-15	0	0	6610	0.7

SAFETY				
Offshore Personnel	Number	157	Man Hours	13766
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	1037
Onshore Personnel	Number	20	Man Hours	3903
Legacy Personnel	Number	35	Man Hours	21420
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	4	Duration of Operations	24.6
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	1	Duration of Operations	50.8
Potential for High Consequence Event	Low	Comments	Routine operations	
Operational Risk Diver	PLL	1.01E-03		
Operational Risk Offshore	PLL	1.03E-03		
Operational Risk Topsides	PLL	N/A		
Operational Risk Onshore	PLL	4.80E-04		
Legacy Risk (out to 50yrs)	PLL	1.18E-03		
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)		
Overall Risk	∑PLL	3.70E-03		

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	10.0	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	1	Duration	4.5	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	5.1	Activity	Survey
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	1	Duration	5.0	Activity	Trawl Sweep
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	1	Duration	50.8	Activity	Survey
Noise (Total = Ops + Legacy)	Sound Exposure Level		252 dB re 1mP			17.5 TPa²s		
Energy Use (Total = Ops + Legacy)	Fuel	883.0 Te	CO_2	2799.2 Te	NOx	52.1 Te	SO_2	10.6 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		3905.91 Te		CO_2 (Credit)		N/A	

Marine Impact (Seabed)	Activity	Dredging	Area	100 m²	Resources	N/A
	Activity	Rock Dump	Area	833 m²	Resources	940 Te (Rock)
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	213 m PL1555 (21.3 Te) 388 m PL1557 (1.9 Te)			
	Remaining	6592 m PL1555 6592 m PL1557 35940 Te Rock (35000 Te Existing + 940 Te New)			
	Persistence	PL1555 100-500 years where fully covered PL1557 >100 years (no long term data/experience of polymers in seawater/buried)			
Residuals	LSA Scale	In-Situ	5099 kg Approx. PL1555 Only	Returned	165 kg Approx. PL1555 Only
	Hydrocarbon	In-Situ	3.4 kg Approx. PL1555 Only	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history		
	Risk of Failure	Low		
	Consequence of Failure	Alternate cutting technique / additional rock / limited schedule impacts		
	Emerging Technology	Diverless cutting maybe an option		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Limited material returned to shore

Economic		
Economic Considerations	Comparative Cost Operational	3.8M
	Comparative Cost Legacy - Monitoring	2.0M
	Comparative Cost Legacy - Remedial	0.0M

Economic Risk	Cost Risk	Low	Factors	High degree of achievability; Low likelihood of future remediation required due to existing burial depth, rock cover and absence of spans.

Area	Merlin	
Decision/Group	Decision 1 Group 7 – Trenched and Rock Dumped Pipelines and Umbilicals	
Option	2 – Leave in Situ – Minor Intervention (Cut and Rock Placement)	
Description	Pipeline and umbilical exposure, span and end removal by DSV Rock placement over snag hazards and cut ends by DPFPV Survey by ROVSV Trawl sweep using trawler	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-005 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Long Term Materials Degradation Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1555 8" Oil	Rigid	Steel	6805	6550	1.1-1.5	0	0	6610	0.7
PL1557 3" Umb.	Umbilical	Polymer / SD Steel / Copper	6980	6550	1.1-15	0	0	6610	0.7

SAFETY				
Offshore Personnel	Number	157	Man Hours	15965
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	1534
Onshore Personnel	Number	20	Man Hours	4209
Legacy Personnel	Number	35	Man Hours	21420
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	4	Duration of Operations	27
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	1	Duration of Operations	50.8
Potential for High Consequence Event	Low	Comments	Routine operations	
Operational Risk Diver	PLL	1.49E-03		
Operational Risk Offshore	PLL	1.20E-03		
Operational Risk Topsides	PLL	N/A		
Operational Risk Onshore	PLL	5.18E-04		
Legacy Risk (out to 50yrs)	PLL	1.18E-03		
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)		
Overall Risk	∑PLL	4.38E-03		

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	12.4	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	1	Duration	4.5	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	5.1	Activity	Survey
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	1	Duration	5.0	Activity	Trawl Sweep
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	1	Duration	50.8	Activity	Survey
Noise (Total = Ops + Legacy)	Sound Exposure Level		253 dB re 1mP			21.3 TPa²s		
Energy Use (Total = Ops + Legacy)	Fuel	934.1 Te	CO_2	2961.0 Te	NOx	55.1 Te	SO_2	11.2 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		4058.08 Te		CO_2 (Credit)		4.61 Te	
Marine Impact (Seabed)	Activity	Dredging	Area	100 m²	Resources	N/A		
	Activity	Rock Dump	Area	700 m²	Resources	790 Te (Rock)		
	Activity	Trenching	Area	N/A	Resources	N/A		
	Activity	Backfilling	Area	N/A	Resources	N/A		

Materials	Recovered	273 m PL1555 (27.3 Te) 448 m PL1557 (2.1 Te)			
	Remaining	6532 m PL1555 6532 m PL1557 35790 Te Rock (35000 Te Existing + 790 Te New)			
	Persistence	PL1555 100-500 years where fully covered PL1557 >100 years (no long term data/experience of polymers in seawater/buried)			
Residuals	LSA Scale	In-Situ	5052 kg Approx. PL1555 Only	Returned	211 kg Approx. PL1555 Only
	Hydrocarbon	In-Situ	3.4 kg Approx. PL1555 Only	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history		
	Risk of Failure	Low		
	Consequence of Failure	Alternate cutting technique / additional rock / limited schedule impacts		
	Emerging Technology	Diverless cutting maybe an option		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational	4.5M		
	Comparative Cost Legacy - Monitoring	2.0M		
	Comparative Cost Legacy - Remedial	0.0M		
Economic Risk	Cost Risk	Low	Factors	High degree of achievability; Low likelihood of future remediation required due to existing burial depth, rock cover and absence of spans.

Area	Merlin	
Decision/Group	Decision 1 Group 7 – Trenched and Rock Dumped Pipelines and Umbilicals	
Option	3 – Leave in Situ – Major Intervention (Backfill)	
Description	Pipeline and umbilical end removal by DSV Spoil backfilling using a mass flow excavator deployed from CSV Survey by ROVSV Trawl sweep using trawler	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-005 A-301649-S01-TECH-006 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Long Term Materials Degradation Study Merlin – Trenching and Backfill Feasibility Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1555 8” Oil	Rigid	Steel	6805	6550	1.1-1.5	0	0	6610	0.7
PL1557 3” Umb.	Umbilical	Polymer / SD Steel / Copper	6980	6550	1.1-15	0	0	6610	0.7

SAFETY				
Offshore Personnel	Number	157	Man Hours	15006
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	1037
Onshore Personnel	Number	20	Man Hours	4303
Legacy Personnel	Number	76	Man Hours	23880
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	4	Duration of Operations	27.4
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	2	Duration of Operations	55.8

Potential for High Consequence Event	Low	Comments	Routine operations

Operational Risk Diver	PLL	1.01E-03
Operational Risk Offshore	PLL	1.13E-03
Operational Risk Topsides	PLL	N/A
Operational Risk Onshore	PLL	5.29E-04
Legacy Risk (out to 50yrs)	PLL	1.36E-03
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)
Overall Risk	∑PLL	4.02E-03

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	10.0	Activity	Destruct
	Type	CSV	Number	1	Duration	7.0	Activity	Backfill
	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	1	Duration	5.1	Activity	Survey
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	1	Duration	5.0	Activity	Trawl Sweep
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	1	Duration	5	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	50.8	Activity	Survey

Noise (Total = Ops + Legacy)	Sound Exposure Level	253 dB re 1mP	18.9 TPa^{2}s

Energy Use (Total = Ops + Legacy)	Fuel	1047.8 Te	CO_2	3321.6 Te	NOx	61.8 Te	SO_2	12.6 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		4396.35 Te		CO_2 (Credit)		N/A	

Marine Impact (Seabed)	Activity	Dredging	Area	100 m^2	Resources	N/A
	Activity	Rock Dump	Area	N/A	Resources	N/A
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	56400 m^2	Resources	N/A

Materials	Recovered	213 m PL1555 (21.3 Te) 388 m PL1557 (1.9 Te)			
	Remaining	6592 m PL1555 6592 m PL1557 35000 Te Rock (Existing)			
	Persistence	PL1555 100-500 years where fully covered PL1557 >100 years (no long term data/experience of polymers in seawater/buried)			
Residuals	LSA Scale	In-Situ	5099 kg Approx. PL1555 Only	Returned	165 kg Approx. PL1555 Only
	Hydrocarbon	In-Situ	3.4 kg Approx. PL1555 Only	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	Low	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	Low – Little history of use over such distances		
	Risk of Failure	High		
	Consequence of Failure	Destruction of local seabed due to MFE removing material/ Removal of the existing rock cover leading to exposures and spans/ additional rock required to remediate areas of high removal/ large schedule impacts		
	Emerging Technology	N/A		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational	4.5M		
	Comparative Cost Legacy - Monitoring	2.0M		
	Comparative Cost Legacy - Remedial	0.5M		
Economic Risk	Cost Risk	High	Factors	High risk of failure requiring additional works to be carried out; High likelihood of future remediation required due to a removal of existing burial material whilst attempting to utilise the spoil heaps.

Area	Merlin	
Decision/Group	Decision 2 Group 8 – Trenched and Buried Pipelines	
Option	1 – Leave in Situ – Minimal Intervention (Rock Placement)	
Description	Pipeline end removal by DSV Rock placement over snag hazards and areas of low burial depth by DPFPV Survey by ROVSV Trawl sweep using trawler	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-005 A-301649-S01-TECH-007 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Long Term Materials Degradation Study Merlin – Removal/Recovery Feasibility Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1665 8" WI	Flexible	Polymer / Steel	7043	6680	0.6	6660	0.6	0	0

SAFETY				
Offshore Personnel	Number	157	Man Hours	12556
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	368
Onshore Personnel	Number	20	Man Hours	3567
Legacy Personnel	Number	76	Man Hours	26340
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	4	Duration of Operations	23.4
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	2	Duration of Operations	60.9
Potential for High Consequence Event	Low	Comments	Routine operations	

Operational Risk Diver	PLL	3.57E-04
Operational Risk Offshore	PLL	9.42E-04
Operational Risk Topsides	PLL	N/A
Operational Risk Onshore	PLL	4.39E-04
Legacy Risk (out to 50yrs)	PLL	1.55E-03
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)
Overall Risk	∑PLL	3.28E-03

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	8.5	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	1	Duration	4.8	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	5.1	Activity	Survey
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	1	Duration	5.0	Activity	Trawl Sweep
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	1	Duration	10	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	50.9	Activity	Survey
Noise (Total = Ops + Legacy)	Sound Exposure Level		253 dB re 1mP			21.2 TPa²s		
Energy Use (Total = Ops + Legacy)	Fuel	1076.0 Te	CO_2	3410.9 Te	NOx	63.5 Te	SO_2	12.9 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		4965.87 Te		CO_2 (Credit)		N/A	

Marine Impact (Seabed)	Activity	Dredging	Area	20 m²	Resources	N/A
	Activity	Rock Dump	Area	5500 m²	Resources	6000 Te (Rock)
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	402 m PL1665 (37.3 Te)			
	Remaining	6641 m PL1665 6000 Te Rock (New)			
	Persistence	Steel - PL1665 >150 years where fully covered Polymer – PL1665 >100 years (no long term data/experience of polymers in seawater/buried)			
Residuals	LSA Scale	In-Situ	N/A	Returned	N/A
	Hydrocarbon	In-Situ	N/A	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history		
	Risk of Failure	Low		
	Consequence of Failure	Alternate cutting technique / additional rock / limited schedule impacts		
	Emerging Technology	Diverless cutting maybe an option		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational	3.7M		
	Comparative Cost Legacy - Monitoring	2.0M		
	Comparative Cost Legacy - Remedial	1.0M		
Economic Risk	Cost Risk	Low	Factors	High degree of achievability; Low likelihood of future remediation required due to existing burial depth and span prediction.

Area	Merlin	
Decision/Group	Decision 2 Group 8 – Trenched and Buried Pipelines	
Option	2 – Leave in Situ – Minor Intervention (Cut and Rock Placement)	
Description	Pipeline exposure, span and end removal by DSV Rock placement over snag hazards and cut ends by DPFPV Survey by ROVSV Trawl sweep using trawler	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-005 A-301649-S01-TECH-007 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Long Term Materials Degradation Study Merlin – Removal/Recovery Feasibility Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1665 8" WI	Flexible	Polymer / Steel	7043	6680	0.6	6660	0.6	0	0

SAFETY				
Offshore Personnel	Number	157	Man Hours	26187
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	3608
Onshore Personnel	Number	20	Man Hours	5409
Legacy Personnel	Number	76	Man Hours	26340
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	4	Duration of Operations	38.3
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	2	Duration of Operations	60.9
Potential for High Consequence Event	Low	Comments	Routine operations	
Operational Risk Diver	PLL	3.50E-03		
Operational Risk Offshore	PLL	1.96E-03		
Operational Risk Topsides	PLL	N/A		
Operational Risk Onshore	PLL	6.65E-04		
Legacy Risk (out to 50yrs)	PLL	1.55E-03		
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)		
Overall Risk	∑PLL	7.68E-03		

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	23.5	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	1	Duration	4.7	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	5.1	Activity	Survey
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	1	Duration	5.0	Activity	Trawl Sweep
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	1	Duration	10	Activity	Rock Dump
	Type	ROVSV	Number	1	Duration	50.9	Activity	Survey
Noise (Total = Ops + Legacy)	Sound Exposure Level		256 dB re 1mP			35.7 TPa²s		
Energy Use (Total = Ops + Legacy)	Fuel	1404.0 Te	CO_2	4450.7 Te	NOx	82.8 Te	SO_2	16.8 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		5872.16 Te		CO_2 (Credit)		N/A	

Marine Impact (Seabed)	Activity	Dredging	Area	620 m²	Resources	N/A
	Activity	Rock Dump	Area	3560 m²	Resources	3900 Te (Rock)
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	1002 m PL1665			
	Remaining	6041 m PL1665 3900 Te Rock (New)			
	Persistence	Steel - PL1665 >150 years where fully covered Polymer – PL1665 >100 years (no long term data/experience of polymers in seawater/buried)			
Residuals	LSA Scale	In-Situ	N/A	Returned	N/A
	Hydrocarbon	In-Situ	N/A	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history		
	Risk of Failure	Low		
	Consequence of Failure	Alternate cutting technique / additional rock / limited schedule impacts		
	Emerging Technology	Diverless cutting maybe an option		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational		8.0M	
	Comparative Cost Legacy - Monitoring		2.0M	
	Comparative Cost Legacy - Remedial		1.0M	
Economic Risk	Cost Risk	Low	Factors	High degree of achievability; Low likelihood of future remediation required due to existing burial depth and span prediction.

Area	Merlin	
Decision/Group	Decision 2 Group 8 – Trenched and Buried Pipelines	
Option	3 – Full Removal – (Reverse Reel)	
Description	Pipeline disconnect and recovery head installation by DSV Recover pipeline and reverse reel by DSV with reel spread Survey by DSV	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-006 A-301649-S01-TECH-007 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Trenching and Backfill Feasibility Study Merlin – Removal/Recovery Feasibility Study Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1665 8” WI	Flexible	Polymer / Steel	7043	6680	0.6	6660	0.6	0	0

SAFETY				
Offshore Personnel	Number	76	Man Hours	12860
Topsides Personnel	Number	N/A	Man Hours	N/A
Divers Required	Number	9	Man Hours	281
Onshore Personnel	Number	20	Man Hours	7028
Legacy Personnel	Number	N/A	Man Hours	N/A
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	1	Duration of Operations	14.1
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	N/A	Duration of Operations	N/A

Potential for High Consequence Event	Medium	Comments	Non Routine Operation; Integrity assumed by engineering only.

Operational Risk Diver	PLL	2.73E-04
Operational Risk Offshore	PLL	9.65E-04
Operational Risk Topsides	PLL	N/A
Operational Risk Onshore	PLL	8.64E-04
Legacy Risk (out to 50yrs)	PLL	N/A
Fishing Risk	PLL	N/A (No increase in risk over and above what currently exists for fishing)
Overall Risk	∑PLL	2.10E-03

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	14.1	Activity	Reverse Reel
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	N/A	Duration	N/A	Activity	N/A
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A

Noise (Total = Ops + Legacy)	Sound Exposure Level	239 dB re 1mP	0.8 TPa^2s

Energy Use (Total = Ops + Legacy)	Fuel	309.8 Te	CO_2	981.9 Te	NOx	18.3 Te	SO_2	3.7 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		1651.93 Te		CO_2 (Credit)		481.89 Te	

Marine Impact (Seabed)	Activity	Dredging	Area	N/A	Resources	N/A
	Activity	Rock Dump	Area	N/A	Resources	N/A
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	7043 m PL1665 (653.7 Te)			
	Remaining	0 m			
	Persistence	N/A			
Residuals	LSA Scale	In-Situ	N/A	Returned	N/A
	Hydrocarbon	In-Situ	N/A	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	Medium
	Availability of Technology	High – Off the shelf		
	Track Record	Low – Limited history of recovering flexibles through soil cover		
	Risk of Failure	Low – Initial engineering shows low utilisation values during recovery		
	Consequence of Failure	Pipeline deburial may be required in local areas / limited schedule impacts		
	Emerging Technology	N/A		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – No change as area is currently available for fishing
	Socio Economic	Low – Material returned to shore will generate a small amount of recycling work.

Economic				
Economic Considerations	Comparative Cost Operational	4.7M		
	Comparative Cost Legacy - Monitoring	0.0M		
	Comparative Cost Legacy - Remedial	0.0M		
Economic Risk	Cost Risk	Low	Factors	Whilst initial engineering indicates a high degree of achievability, maturity of the concept is not sufficiently detailed to enable certainty of success without some deburial operations that could increase schedule and cost.

Area	Merlin	
Decision/Group	Decision 3 Group 9 – Umbilical Riser	
Option	1 – Leave in Situ – Minor Intervention (Outboard Cut and Recovery)	
Description	Umbilical cut at J-tube exit by DSV Seal J-tube and recover outboard section of umbilical back to the DSV Survey by DSV	
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 FBL-DUN-MER-SSP-01-RPT-00002 A-301649-S01-TECH-007 A-301649-S01-TECH-013 A-301649-S01-REPT-002	Subsea Decommissioning Inventory Subsea Decommissioning Screening – Merlin Merlin – Removal/Recovery Feasibility Study Merlin – Effect of Leaving Riser Section within J-Tube Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1556 4" Umb.	Umbilical	Polymer / Steel / Copper	475	0	0	0	0	60	0.5

SAFETY				
Offshore Personnel	Number	76	Man Hours	6020
Topsides Personnel	Number	10	Man Hours	240
Divers Required	Number	9	Man Hours	389
Onshore Personnel	Number	20	Man Hours	2350
Legacy Personnel	Number	N/A	Man Hours	N/A
Impact to Other Users of the Sea (Operational)	Number of Vessels Used	1	Duration of Operations	6.6
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	N/A	Duration of Operations	N/A
Potential for High Consequence Event	Low	Comments	Routine operations	
Operational Risk Diver	PLL	3.77E-04		
Operational Risk Offshore	PLL	4.52E-04		
Operational Risk Topsides	PLL	9.84E-06		
Operational Risk Onshore	PLL	2.89E-04		
Legacy Risk (out to 50yrs)	PLL	N/A (in line with CGB)		
Fishing Risk	PLL	N/A		
Overall Risk	∑PLL	1.13E-03		

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	6.6	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	PSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	Trawler	Number	N/A	Duration	N/A	Activity	N/A
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
Noise (Total = Ops + Legacy)	Sound Exposure Level		236 dB re 1mP			0.4 TPa²s		
Energy Use (Total = Ops + Legacy)	Fuel	145.4 Te	CO_2	461.0 Te	NOx	8.6 Te	SO_2	1.7 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		681.51 Te		CO_2 (Credit)		N/A	

Marine Impact (Seabed)	Activity	Dredging	Area	N/A	Resources	N/A
	Activity	Rock Dump	Area	N/A	Resources	N/A
	Activity	Trenching	Area	N/A	Resources	N/A
	Activity	Backfilling	Area	N/A	Resources	N/A

Materials	Recovered	295 m (6 Te)			
	Remaining	180 m within J-tube			
	Persistence	In-line with CGB & J-tubes >250 years			
Residuals	LSA Scale	In-Situ	N/A	Returned	N/A
	Hydrocarbon	In-Situ	N/A	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	High
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history		
	Risk of Failure	Low		
	Consequence of Failure	Limited schedule impacts		
	Emerging Technology	N/A		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – Area where umbilical is removed will potentially remain within a safety zone
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational		2.3 M	
	Comparative Cost Legacy - Monitoring		0.0 M – (Monitoring is assumed to be done as part of any CGB monitoring)	
	Comparative Cost Legacy - Remedial		0.0 M	
Economic Risk	Cost Risk	Low	Factors	High degree of achievability.

Area	Merlin
Decision/Group	Decision 3 Group 9 – Umbilical Riser
Option	2 – Full Removal – Topsides Pull
Description	Mobilise winch spread to platform, install and test Remove topside hang-off and transfer umbilical to winch Remove J-tube seal by DSV (part reverse pull as required) Umbilical cut at J-tube exit by DSV Seal J-tube and recover outboard section of umbilical back to the DSV Pull-in umbilical using the topside winch (pull, secure, cut, repeat) Backload umbilical sections and winch equipment Survey by DSV
Ref. Documents	FBL-DUN-DAOM-SSP-01-RPT-00001 – Subsea Decommissioning Inventory FBL-DUN-MER-SSP-01-RPT-00002 – Subsea Decommissioning Screening – Merlin A-301649-S01-TECH-007 – Merlin – Removal/Recovery Feasibility Study A-301649-S01-REPT-002 – Merlin – Common Scope Report

ID No.	Type	Material	Length (m)	Trenched		Buried		Rock Dumped	
				Length (m)	Depth (m)	Length (m)	Depth (m)	Length (m)	Height (m)
PL1556 4" Umb.	Umbilical	Polymer / Steel / Copper	475	0	0	0	0	60	0.5

SAFETY				
Offshore Personnel	Number	126	Man Hours	12111
Topsides Personnel	Number	6	Man Hours	2693
Divers Required	Number	9	Man Hours	346
Onshore Personnel	Number	20	Man Hours	4162
Legacy Personnel	Number	N/A	Man Hours	N/A
Impact to Other Users of the Sea(Operational)	Number of Vessels Used	2	Duration of Operations	16.7
Impact to Other Users of the Sea (Legacy)	Number of Vessels Used	N/A	Duration of Operations	N/A
Potential for High Consequence Event	Medium	Comments	Non-routine operations but not unusual. Limited SIMOPS.	
Operational Risk Diver	PLL	3.36E-04		
Operational Risk Offshore	PLL	9.08E-04		
Operational Risk Topsides	PLL	1.10E-03		
Operational Risk Onshore	PLL	5.12E-04		
Legacy Risk (out to 50yrs)	PLL	N/A		
Fishing Risk	PLL	N/A		
Overall Risk	∑PLL	1.87E-03		

ENVIRONMENTAL								
Marine Impact (Vessels Operational)	Type	DSV	Number	1	Duration	6.7	Activity	Destruct
	Type	CSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
	Type	PSV	Number	1	Duration	10	Activity	Supply
	Type	Trawler	Number	N/A	Duration	N/A	Activity	N/A
Marine Impact (Vessels Legacy)	Type	DPFPV	Number	N/A	Duration	N/A	Activity	N/A
	Type	ROVSV	Number	N/A	Duration	N/A	Activity	N/A
Noise (Total = Ops + Legacy)	Sound Exposure Level		244 dB re 1mP			2.8 TPa²s		
Energy Use (Total = Ops + Legacy)	Fuel	247.4 Te	CO_2	784.3 Te	NOx	14.6 Te	SO_2	3.0 Te
Life Cycle Emissions (Total = Ops + Legacy)	CO_2		906.5 Te		CO_2 (Credit)		1.87 Te	
Marine Impact (Seabed)	Activity	Dredging	Area	N/A	Resources	N/A		
	Activity	Rock Dump	Area	N/A	Resources	N/A		
	Activity	Trenching	Area	N/A	Resources	N/A		
	Activity	Backfilling	Area	N/A	Resources	N/A		

Materials	Recovered	475 m (9.7 Te)			
	Remaining	0 m			
	Persistence	N/A			
Residuals	LSA Scale	In-Situ	N/A	Returned	N/A
	Hydrocarbon	In-Situ	N/A	Returned	N/A
	Control Fluids	In-Situ	N/A	Returned	N/A

Technical				
Technical Considerations	Feasibility	High	Concept Maturity	Medium
	Availability of Technology	High – Off the shelf		
	Track Record	High – Extensive history in North Sea and recent history on Dunlin.		
	Risk of Failure	Medium – Unknown integrity of J-tube / umbilical and inability to inspect.		
	Consequence of Failure	Umbilical would remain within J-tube / schedule over runs		
	Emerging Technology	N/A		

Societal		
Societal Factors	Commercial Fisheries Impact	Low – Area where umbilical is removed will potentially remain within a safety zone
	Socio Economic	Low – Limited material returned to shore

Economic				
Economic Considerations	Comparative Cost Operational	3.5 M		
	Comparative Cost Legacy - Monitoring	0.0 M		
	Comparative Cost Legacy - Remedial	0.0 M		
Economic Risk	Cost Risk	Medium	Factors	Topside engineering for winch locating is not fully defined; Inspection to confirm integrity of J-tube and Umbilical is not possible; Previous pull-in operations have suffered delays and cost over runs.

Appendix I CA Attributes Tables & Pairwise Comparison (Inc. Costs)

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Project Differentiator Attributes

Differentiator	Sub-Criteria	Description	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE
1. Safety	1.1 Personnel Offshore	This sub-criterion considers elements that impact risk to offshore personnel and 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.	Total PLL (incl. Legacy): 3.70E-03 Vessels located on site for Operations: 24.6 days Legacy: 50.8 days	Total PLL (incl. Legacy): 4.38E-03 Vessels located on site for Operations: 27 days Legacy: 50.8 days	Total PLL (incl. Legacy): 4.02E-03 Vessels located on site for Operations: 27.4 days Legacy: 55.8 days
	1.2 Personnel Onshore	This sub-criterion considers elements that impact risk to onshore personnel. Factors such as any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel.			
	1.3 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.			
	1.4 High Consequence Events	This sub-criterion relates to any inherent potential for high consequence events i.e. major accident hazard, major environmental hazard type events. It applies to all onshore and offshore personnel involved in the project. Considerations such as dropped object concerns, support vessel risks, are considered.	Low risk of high consequence - routine.	Low risk of high consequence - routine. A little higher than option 1 as more lifting operations.	Low risk of high consequence - routine.
	1.5 Residual Risk	This sub-criterion addresses and residual risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, that is provided by the option. Issues such as residual snag risk, collision risk, etc. may be considered.	Residual Risk Legacy: 35 / 21420 / 1.18E-03 (monitoring) Fishing: Negligible additional risk presented to fisherman from spot rock dumped pipeline / umbilical.	Residual Risk Legacy: 35 / 21420 / 1.18E-03 (monitoring) Fishing: Negligible additional risk presented to fisherman from fully rock dumped pipeline / umbilical.	Residual Risk Legacy: 76 / 23880 / 1.36E-03 (monitoring) Fishing: Future risk to fishing operations eliminated by this option.
		Summary	The summed PLL figures for options 1, 2 and 3 (all worker groups and including legacy component where present) are 3.70E-03, 4.38E-03 and 4.02E-03 respectively. This indicates that the risk exposure associated with options 1 and 3 are largely similar and slightly lower than option 2. This is driven by the marginally higher exposure associated with most worker groups. Overall option 1 and 3 are Neutral against each other and both are Stronger than option 2 from a safety perspective. The workshop discussed and conducted a sensitivity relating to reduction in monitoring requirements for option 3 (whereby option 1 became Weaker than option 3, and option 2 became Much Weaker than option 3) but this had no affect on the overall outcome.		
2. Environmental	2.1 Marine Impacts	This sub-criterion covers elements such as noise generated by vessels, cutting operations, explosives etc. It also covers any damaging discharges to sea from vessels and / or activities performed.	Sound Exposure 252 dB re 1mP / 17.5 TPa2s	Sound Exposure 253 dB re 1mP / 21.3 TPa2s	Sound Exposure 253 dB re 1mP / 18.9 TPa2s
	2.2 Emissions	This sub-criterion relates to the amount of damaging atmospheric emissions associated with a particular option.	CO_2: 2799.2 Te NOx: 52.1 Te SO_2: 10.6 Te Lifecycle CO_2: 3905.91 Te CO_2 Credit for Steel: N/A	CO_2: 2961.0 Te NOx: 55.1 Te SO_2: 11.2 Te Lifecycle CO_2: 4058.08 Te CO_2 Credit for Steel: 4.61 Te	CO_2: 3321.6 Te NOx: 61.8 Te SO_2: 12.6 Te Lifecycle CO_2: 4396.35 Te CO_2 Credit for Steel: N/A
	2.3 Consumption	This sub-criterion relates to the amount of Energy / Resource consumption such as fuel use, recycling of materials, use of quarried rock, production of replacement materials.	Fuel: 883.0 Te Rock: 940 Te	Fuel: 934.1 Te Rock: 790 Te	Fuel: 1047.8 Te Rock: N/A
	2.4 Disturbance	This sub-criterion relates to both direct and indirect seabed disturbance. Both short and long term impacts are considered.	Disturbance Dredging: 100 m2 Rock Dump: 833 m2	Disturbance Dredging: 100 m2 Rock Dump: 700 m2	Disturbance Dredging: 100 m2 Backfilling: 56400 m2
	2.5 Protections	This sub-criterion relates to the impact of the options on any protected sites and species.	This option has no impact on protected sites or species.	This option has no impact on protected sites or species.	This option has no impact on protected sites or species.
		Summary	Options 1, 2 and 3 are largely similar in terms of sound exposure, emissions and fuel use. The only real environmental differentiator relates to Option 3 which has a significantly larger seabed disturbance impact than options 1 and 2. Overall, options 1 and 2 are Neutral to each other and both are Stronger than option 3 from an environmental perspective (even though the seabed disturbance associated with options 1 and 2 will have no recovery potential, they are both small areas compared to that for option 3).		

Project Differentiator Attributes

Differentiator	Sub-Criteria	Description	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE
3. Technical	3.1 Technical Risk	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. Technical Feasibility and Technical Maturity is also considered.	Feasibility: High. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: High – Extensive history. Risk of Failure: Low. Consequence of Failure: Alternate cutting technique / additional rock / limited schedule impacts. Emerging Technology: Diverless cutting may be an option.	Feasibility: High. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: High – Extensive history. Risk of Failure: Low. Consequence of Failure: Alternate cutting technique / additional rock / limited schedule impacts. Emerging Technology: Diverless cutting may be an option.	Feasibility: Low. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: Low – Little history of use over such distances. Risk of Failure: High. Consequence of Failure: Destruction of local seabed due to MFE removing material / Removal of the existing rock cover leading to exposures and spans / additional rock required to remediate areas of high removal / large schedule impacts. Emerging Technology: N/A
		Summary	Option 1 and 2 are similar from a technical perspective. They are also Much Stronger than option 3 due to the uncertainty that backfilling over those distances and to the level required is achievable.		
4. Societal	4.1 Fishing	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.	Can fish over so long term OK. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either.	Can fish over so long term OK. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either.	Can fish over so long term ok. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either.
	4.2 Other Users	This sub-criterion addresses any socio-economic impacts on other users both onshore where the impact may be from dismantling, transporting, 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 negative impact on communities, increased traffic disruption due to extra-large transport loads, etc. Includes the FEL Guiding Principle of 'Minimal business interruption to others'.	Material returned to shore Recovered: 213 m PL1555 (21.3 Te) 388 m PL1557 (1.9 Te) 165 kg LSA Scale (PL1555) Remaining: 6592 m PL1555 6592 m PL1557 35940 Te Rock (35000 Te Existing + 940 Te New). 5099 kg LSA Scale (PL1555) 3.4 kg Hydrocarbon (PL1555) Persistence: PL1555 100-500 years where fully covered / PL1557 >100 years (no long term data / experience of polymers in seawater / buried).	Material returned to shore Recovered: 273 m PL1555 (27.3 Te) 448 m PL1557 (2.1 Te) 211 kg LSA Scale (PL1555) Remaining: 6532 m PL1555 6532 m PL1557 35790 Te Rock (35000 Te Existing + 790 Te New). 5052 kg LSA Scale (PL1555) 3.4 kg Hydrocarbon (PL1555) Persistence: PL1555 100-500 years where fully covered / PL1557 >100 years (no long term data / experience of polymers in seawater / buried).	Material returned to shore Recovered: 213 m PL1555 (21.3 Te) 388 m PL1557 (1.9 Te) 165 kg LSA Scale (PL1555) Remaining: 6592 m PL1555 6592 m PL1557 35500 Te (Existing) 5099 kg LSA Scale (PL1555) 3.4 kg Hydrocarbon (PL1555) Persistence: PL1555 100-500 years where fully covered / PL1557 >100 years (no long term data / experience of polymers in seawater / buried).
		Summary	Option 1, 2 and 3 largely similar from a Societal perspective so scored Neutral against each other.		
5. Economic	5.1 Short-term Costs	This sub-criterion addresses the cost of delivering the option as described. No long-term cost element is considered here. Cost uncertainty (a function of activity maturity) is also recorded.	Cost: 3.8M Cost Risk: Low Risk Factors: High degree of achievability.	Cost: 4.5M Cost Risk: Low Risk Factors: High degree of achievability.	Cost: 4.5M Cost Risk: High Risk Factors: High risk of failure requiring additional works to be carried out.
	5.2 Long-term Costs	This sub-criterion addresses the costs associated with any long-term liabilities such as on-going monitoring and any potential future remediation costs.	Monitoring Cost: 2.0M Remedial Cost: 0.0M Cost Risk: Low Risk Factors: Low likelihood of future remediation required due to existing burial depth.	Monitoring Cost: 2.0M Remedial Cost: 0.0M Cost Risk: Low Risk Factors: Low likelihood of future remediation required due to existing burial depth.	Monitoring Cost: 2.0M Remedial Cost: 0.5M Cost Risk: High Risk Factors: High likelihood of future remediation required due to a removal of existing burial material whilst attempting to utilise the spoil heaps.
		Summary	The differential in cost between options 1, 2 and 3 is relatively limited at 5.8M, 6.5M and 7.0 M respectively. However, there is a significant cost risk associated with the risk of overruns associated with option 3. The workshop agreed that options 1 and 2 are Neutral to each other whilst being Stronger than option 3. The workshop discussed and conducted a sensitivity relating to reduction in monitoring requirements for option 3 (whereby option 1 became Neutral to option 3, and option 2 became Neutral to option 3) but this had no affect on the overall outcome.		

Merlin Decision 1 – Trenched and Rock Dumped Pipelines and Umbilicals

Pairwise Comparison

1. Safety	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE	Priorities
1. Leave - End Removal - Limited Rock Placement	N	S	N	37.50%
2. Leave - End / Exposure / Span Removal - Rock Placement	W	N	W	25.00%
3. Leave - End Removal - Backfill with MFE	N	S	N	37.50%

2. Environmental	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	S	37.50%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	S	37.50%
3. Leave - End Removal - Backfill with MFE	W	W	N	25.00%

3. Technical	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	MS	42.86%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	MS	42.86%
3. Leave - End Removal - Backfill with MFE	MW	MW	N	14.29%

4. Societal	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	N	33.33%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	N	33.33%
3. Leave - End Removal - Backfill with MFE	N	N	N	33.33%

5. Economic	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Leave - End Removal - Backfill with MFE	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	S	37.50%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	S	37.50%
3. Leave - End Removal - Backfill with MFE	W	W	N	25.00%

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Project Differentiator Attributes

Differentiator	Sub-Criteria	Description	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel
1. Safety	1.1 Personnel Offshore	This sub-criterion considers elements that impact risk to offshore personnel and 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.	Total PLL: 3.28E-03 Vessels located on site for Operations: 23.4 days Legacy: 60.9 days	Total PLL: 7.68E-03 Vessels located on site for Operations: 38.3 days Legacy: 60.9 days	Total PLL: 2.10E-03 Vessels located on site for 14.1 days.
	1.2 Personnel Onshore	This sub-criterion considers elements that impact risk to onshore personnel. Factors such as any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel.			
	1.3 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.			
	1.4 High Consequence Events	This sub-criterion relates to any inherent potential for high consequence events i.e. major accident hazard, major environmental hazard type events. It applies to all onshore and offshore personnel involved in the project. Considerations such as dropped object concerns, support vessel risks, are considered.	Low risk of high consequence - routine.	Low risk of high consequence - routine. A little higher than option 1 as more lifting operations.	Medium risk of high consequence events - non-routine operations. The integrity of the pipeline is assumed by engineering only. Potential for pipeline integrity failure during these operations.
	1.5 Residual Risk	This sub-criterion addresses and residual risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, that is provided by the option. Issues such as residual snag risk, collision risk, etc. may be considered.	Residual Risk Legacy: 76 / 26340 / 1.55E-03 (monitoring) Fishing: Negligible additional risk presented to fisherman from spot rock dumped pipeline.	Residual Risk Legacy: 76 / 26340 / 1.55E-03 (monitoring) Fishing: Negligible additional risk presented to fisherman from rock dumped / trenched and buried pipeline.	Residual Risk There is no residual legacy risk or risk to fishing operations associated with this option as it is a full removal option.
		Summary	The summed PLL figures for options 1, 2 and 3 (all worker groups and including legacy component where present) are 3.28E-03, 7.68E-03 and 2.10E-03 respectively. This indicates that option 3 is the lowest risk exposure, driven by the lowest exposure for the high risk divers worker group and the lack of a legacy risk component. This is followed by option 1 which has a higher risk exposure from the increased exposure to the divers worker group and the inclusion of the legacy risk associated with the on-going monitoring. Option 2 has the highest risk exposure, again driven by the significant increased exposure to the high risk diver worker group. The other differential between the options is the potential for a high consequence event. Option 1 is slightly lower than option 2 in this respect due to increased lifting operations. Option 3 is worse again, due to the risk associated with reverse reeling operations. Overall, option 1 is Stronger than option 2 due the lower risk exposure and the slightly lower potential for high consequence events. It is Neutral to option 3 as, whilst option 1 has higher risk exposure than option 3, this offset by the increased potential for high consequence events posed by reverse reeling operations. Option 2 is Weaker than option 3 due to the large differential in risk exposure being offset slightly by the increased potential for high consequence events posed by reverse reeling operations.		
2. Environmental	2.1 Marine Impacts	This sub-criterion covers elements such as noise generated by vessels, cutting operations, explosives etc. It also covers any damaging discharges to sea from vessels and / or activities performed.	Sound Exposure 253 dB re 1mP / 21.2 TPa2s	Sound Exposure 256 dB re 1mP / 35.7 TPa2s	Sound Exposure 239 dB re 1mP / 0.8 TPa2s
	2.2 Emissions	This sub-criterion relates to the amount of damaging atmospheric emissions associated with a particular option.	CO_2: 3410.9 Te NO_x: 63.5 Te SO_2: 12.9 Te Lifecycle CO_2: 4965.87 Te CO_2 Credit for Steel: N/A	CO_2: 4450.7 Te NO_x: 82.8 Te SO_2: 16.8 Te Lifecycle CO_2: 5872.16 Te CO_2 Credit for Steel: N/A	CO_2: 981.9 Te NO_x: 18.3 Te SO_2: 3.7 Te Lifecycle CO_2: 1651.93 Te CO_2 Credit for Steel: 481.89 Te
	2.3 Consumption	This sub-criterion relates to the amount of Energy / Resource consumption such as fuel use, recycling of materials, use of quarried rock, production of replacement materials.	Fuel: 1076.0 Te Rock: 6000 Te	Fuel: 1404.0 Te Rock: 3900 Te	Fuel: 309.8 Te Rock: N/A
	2.4 Disturbance	This sub-criterion relates to both direct and indirect seabed disturbance. Both short and long term impacts are considered.	Disturbance Dredging: 20 m2 Rock Dump: 5500 m2	Disturbance Dredging: 620 m2 Rock Dump: 3560 m2	This option has no associated seabed disturbance.
	2.5 Protections	This sub-criterion relates to the impact of the options on any protected sites and species.	This option has no impact on protected sites or species.	This option has no impact on protected sites or species.	This option has no impact on protected sites or species.
		Summary	Option 3 is the most attractive in terms of noise exposure, emissions and fuel use with options 1 and 2 being less attractive in each area. Options 1 and 2 are however, considered largely similar. In terms of seabed disturbance, options 1 and 2 are broadly similar, with option 1 impacting a larger area. Option 1 also introduces the highest amount of new material, resulting in permanent seabed change. Overall, option 1 and 2 are Neutral. They are both Much Weaker than option 3.		

Project Differentiator Attributes

Differentiator	Sub-Criteria	Description	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel
3. Technical	3.1 Technical Risk	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. Technical Feasibility and Technical Maturity is also considered.	Feasibility: High. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: High – Extensive history. Risk of Failure: Low. Consequence of Failure: Alternate cutting technique / additional rock / limited schedule impacts. Emerging Technology: Diverless cutting may be an option.	Feasibility: High. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: High – Extensive history. Risk of Failure: Low. Consequence of Failure: Alternate cutting technique / additional rock / limited schedule impacts. Emerging Technology: Diverless cutting may be an option.	Feasibility: High. Concept Maturity: Medium. Availability of Technology: High – Off the shelf. Track Record: Low – Limited history of recovering flexibles through soil cover. Risk of Failure: Low – Initial engineering shows low utilisation values during recovery. Consequence of Failure: Pipeline deburial may be required in local areas / limited schedule impacts. Emerging Technology: N/A.
		Summary	Options 1 and 2 are comparable and therefore Neutral from a technical perspective. Option 1 and 2 are Stronger than option 3 due to the uncertainty surround the ability to reverse reel a flexible pipeline through soil cover.		
4. Societal	4.1 Fishing	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.	Can fish over so long term OK. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either.	Can fish over so long term ok. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either. Less rock in place but considered marginal contribution.	Can fish over so long term ok. Whilst durations of programme are different, fishing activity low in area so no differentiation in short term either.
	4.2 Other Users	This sub-criterion addresses any socio-economic impacts on other users both onshore where the impact may be from dismantling, transporting, 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 negative impact on communities, increased traffic disruption due to extra-large transport loads, etc. Includes the FEL Guiding Principle of 'Minimal business interruption to others'.	Material returned to shore Recovered: 402 m PL1665 (37.3 Te) Remaining: 6641 m PL1665 6000 Te Rock (New) Persistence: Steel - PL1665 >150 years where fully covered / Polymer – PL1665 >100 years (no long term data / experience of polymers in seawater / buried). Less material returned to shore than other options but offset by the highest requirement for new rock.	Material returned to shore Recovered: 1002 m PL1665 Remaining: 6041 m PL1665 3900 Te Rock (New) Persistence: Steel - PL1665 >150 years where fully covered / Polymer – PL1665 >100 years (no long term data / experience of polymers in seawater / buried). A little more material returned to shore than option 1 but lower new rock requirement.	Material returned to shore Recovered: 7043 m PL1665 (653.7 Te) Remaining: 0 m Persistence: N/A All material returned to shore. Recycling of material is positive.
		Summary	Options all Neutral from a fishing perspective. In terms of the wider societal impact, option 1 returns less material but requires more rock, whereas option 2 returns a little more material to shore but requires less rock. Option 3 returns more material to shore provides a positive from a recycling perspective, makes option 3 marginally more attractive than options 1 and 2 from a societal perspective. Overall, option 1 and 2 are Neutral from a Societal perspective. Option 1 and 2 are both slightly Weaker than option 3.		
5. Economic	5.1 Short-term Costs	This sub-criterion addresses the cost of delivering the option as described. No long-term cost element is considered here. Cost uncertainty (a function of activity maturity) is also recorded.	Cost: 3.7M Cost Risk: Low Risk Factors: High degree of achievability.	Cost: 8.0M Cost Risk: Low Risk Factors: High degree of achievability.	Cost: 4.7M Cost Risk: Medium Cost Risk Factors: Initial engineering indicates a high degree of achievability as residual integrity of pipeline is high.
	5.2 Long-term Costs	This sub-criterion addresses the costs associated with any long-term liabilities such as on-going monitoring and any potential future remediation costs.	Monitoring Cost: 2.0M Remedial Cost: 1.0M Cost Risk: Low Risk Factors: Low likelihood of future remediation required due to existing burial depth and span prediction.	Monitoring Cost: 2.0M Remedial Cost: 1.0M Cost Risk: Low Risk Factors: Low likelihood of future remediation required due to existing burial depth and span prediction.	There are no long-term cost liabilities associated with this full removal option.
		Summary	Option 1 has a total cost of 6.7 M associated with it and has a high degree of success. Option 2 is more expensive at 11.0 M and also has a high degree of success. Option 3 is the lowest total cost at 4.7M, it does carry a medium risk associated with completing the umbilical reverse reel without deburial operations where an overspend of up to 2 M is not considered impossible. Overall, option 1 is Much Stronger than option 2 due to the large cost differential. Option 1 is Neutral to option 3 as, whilst option 3 has a lower cost, there is significant cost risk. Finally, option 2 is Weaker than option 3 due to the high cost differential.		

Merlin Decision 2 – Trenched and Buried Pipeline

Pairwise Comparison

1. Safety	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel	Priorities
1. Leave - End Removal - Limited Rock Placement	N	S	N	37.50%
2. Leave - End / Exposure / Span Removal - Rock Placement	W	N	W	25.00%
3. Full Removal - Reverse Reel	N	S	N	37.50%

2. Environmental	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	MW	20.00%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	MW	20.00%
3. Full Removal - Reverse Reel	MS	MS	N	60.00%

3. Technical	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	S	37.50%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	S	37.50%
3. Full Removal - Reverse Reel	W	W	N	25.00%

4. Societal	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel	Priorities
1. Leave - End Removal - Limited Rock Placement	N	N	W	28.57%
2. Leave - End / Exposure / Span Removal - Rock Placement	N	N	W	28.57%
3. Full Removal - Reverse Reel	S	S	N	42.86%

5. Economic	1. Leave - End Removal - Limited Rock Placement	2. Leave - End / Exposure / Span Removal - Rock Placement	3. Full Removal - Reverse Reel	Priorities
1. Leave - End Removal - Limited Rock Placement	N	MS	N	42.86%
2. Leave - End / Exposure / Span Removal - Rock Placement	MW	N	MW	14.29%
3. Full Removal - Reverse Reel	N	MS	N	42.86%

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Project Differentiator Attributes

Differentiator	Sub-Criteria	Description	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull
1. Safety	1.1 Personnel Offshore	This sub-criterion considers elements that impact risk to offshore personnel and 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.	Total PLL: 1.13E-03 Vessels located on site for 6.6 days.	Total PLL: 1.87E-03 Vessels located on site for 16.7 days. This includes shuttling with PSV which results in increased exposure of vessels in area.
	1.2 Personnel Onshore	This sub-criterion considers elements that impact risk to onshore personnel. Factors such as any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel.		
	1.3 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.		
	1.4 High Consequence Events	This sub-criterion relates to any inherent potential for high consequence events i.e. major accident hazard, major environmental hazard type events. It applies to all onshore and offshore personnel involved in the project. Considerations such as dropped object concerns, support vessel risks, are considered.	Low risk of high consequence events - routine.	Medium risk of high consequence events - non-routine, although not unusual, possible limited SIMOPS.
	1.5 Residual Risk	This sub-criterion addresses and residual risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, that is provided by the option. Issues such as residual snag risk, collision risk, etc. may be considered.	No residual risk as it is wholly within the 500m exclusion zone and all outboard elements are fully removed.	There is no residual risk associated with this full removal option.
		Summary	The summed PLL figures for options 1 and 2 (all worker groups and including legacy component where present) are 1.13E-03 and 1.87E-03 respectively. This indicates that, whilst the risk exposure is similar for the two options, option 1 is lower than option 2. This is driven by the higher exposure associated with the offshore and topsides worker groups for option 2. Option 1 is also slightly shorter duration and caries a lower risk of high consequence events. Overall, option 1 is Stronger than option 2 from a safety perspective.	
2. Environmental	2.1 Marine Impacts	This sub-criterion covers elements such as noise generated by vessels, cutting operations, explosives etc. It also covers any damaging discharges to sea from vessels and / or activities performed.	Sound Exposure 236 dB re 1mP / 0.4 TPa2s	Sound Exposure 244 dB re 1mP / 2.8 TPa2s
	2.2 Emissions	This sub-criterion relates to the amount of damaging atmospheric emissions associated with a particular option.	CO_2: 461.0 Te NO_x: 8.6 Te SO_2: 1.7 Te Lifecycle CO_2: 681.51 Te CO_2 Credit for Steel: N/A	CO_2: 784.3 Te NO_x: 14.6 Te SO_2: 3.0 Te Lifecycle CO_2: 906.50 Te CO_2 Credit for Steel: 1.87 Te
	2.3 Consumption	This sub-criterion relates to the amount of Energy / Resource consumption such as fuel use, recycling of materials, use of quarried rock, production of replacement materials.	Fuel: 145.4 Te Rock: None	Fuel: 247.4 Te Rock: None
	2.4 Disturbance	This sub-criterion relates to both direct and indirect seabed disturbance. Both short and long term impacts are considered.	This option has no associated seabed disturbance.	This option has no associated seabed disturbance.
	2.5 Protections	This sub-criterion relates to the impact of the options on any protected sites and species.	This option has no impact on protected sites or species.	This option has no impact on protected sites or species.
		Summary	Option 1 is either equal to or marginally better than option 2 in all areas. As such, option 1 is Stronger than option 2 from an environmental perspective due to the cumulative effect of these marginal improvements.	

3. Technical	3.1 Technical Risk	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. Technical Feasibility and Technical Maturity is also considered.	Feasibility: High. Concept Maturity: High. Availability of Technology: High – Off the shelf. Track Record: High – Recent history of cutting umbilicals and flexibles. Risk of Failure: Low. Consequence of Failure: Limited schedule impacts. Emerging Technology: Diverless cutting may be an option.	Feasibility: High. Concept Maturity: Medium - final details for performing task are yet to be defined, platform crane, winch placement and operations, etc. Availability of Technology: High – Off the shelf. Track Record: High – Extensive history in North Sea and recent history on Dunlin. Risk of Failure: Medium – Unknown integrity of J-tube / umbilical and inability to inspect. Consequence of Failure: Umbilical would remain within J-tube / schedule overruns - extremely minor potential of flooding leg performing these operations. Emerging Technology: N/A.
		Summary	Option 1 carries less technical risk than option 2 due to the potential / consequence of failure associated with the uncertainty of the j-tube integrity. Overall option 1 is considered Stronger than option 2 from a Technical Feasibility perspective.	
4. Societal	4.1 Fishing	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.	Will not remain on seabed - no long term exposure.	Will not remain on seabed - no long term exposure.
	4.2 Other Users	This sub-criterion addresses any socio-economic impacts on other users both onshore where the impact may be from dismantling, transporting, 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 negative impact on communities, increased traffic disruption due to extra-large transport loads, etc. Includes the FEL Guiding Principle of 'Minimal business interruption to others'.	Material returned to shore Recovered: 295 m Umbilical (6 Te) Remaining: 180 m Umbilical (within J-tube) Persistence: In-line with CGB & J-tubes >250 years.	Material returned to shore Recovered: 475 m Umbilical (9.7 Te) Remaining: 0 m Persistence: N/A
		Summary	Options 1 and 2 are largely similar from a societal perspective. There is more material returned to shore under option 2, however this was not considered significant enough to change the scoring from Neutral.	
5. Economic	5.1 Short-term Costs	This sub-criterion addresses the cost of delivering the option as described. No long-term cost element is considered here. Cost uncertainty (a function of activity maturity) is also recorded.	Cost: 2.3 M Cost Risk: Low Risk Factors: High degree of achievability.	Cost: 3.5 M Cost Risk: Medium Risk Factors: Topside engineering for winch locating is not mature / inspection to confirm integrity of J-tube and contained products is not possible / previous pull-in operations have suffered delays and cost overruns. Historical overruns have been pull-in rather than removal operations.
	5.2 Long-term Costs	This sub-criterion addresses the costs associated with any long-term liabilities such as on-going monitoring and any potential future remediation costs.	No long-term costs, any Monitoring is assumed to be done as part of any CGB monitoring.	No long-term costs associated with this full removal option.
		Summary	Option 1 has a lower cost and cost risk than option 2. Therefore option 1 is Stronger than option 2.	

Merlin Decision 3 – Umbilical Riser

Pairwise Comparison

1. Safety

1. Safety	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull	Priorities
1. Leave - Outboard Cut and Recover	N	S	60.00%
2. Full Removal - Topsides Pull	W	N	40.00%

2. Environmental

2. Environmental	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull	Priorities
1. Leave - Outboard Cut and Recover	N	S	60.00%
2. Full Removal - Topsides Pull	W	N	40.00%

3. Technical

3. Technical	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull	Priorities
1. Leave - Outboard Cut and Recover	N	S	60.00%
2. Full Removal - Topsides Pull	W	N	40.00%

4. Societal

4. Societal	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull	Priorities
1. Leave - Outboard Cut and Recover	N	N	50.00%
2. Full Removal - Topsides Pull	N	N	50.00%

5. Economic

5. Economic	1. Leave - Outboard Cut and Recover	2. Full Removal - Topsides Pull	Priorities
1. Leave - Outboard Cut and Recover	N	S	60.00%
2. Full Removal - Topsides Pull	W	N	40.00%

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