Rubie/ Renee – Decommissioning Comparative Assessment

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0.0 NON-TECHNICAL SUMMARY

Endeavour Energy UK Ltd (Endeavour), undertook a Comparative Assessment (CA) of feasible decommissioning options for six redundant lines that remained trenched and buried after the cessation of operations at the Rubie/ Renee field (Blocks 15/28b and 15/27, respectively) in the central North Sea.

Initially seven methods were considered for the decommissioning of buried pipelines at the Rubie/ Renee field location. Based on technical feasibility and resource availability these methods were narrowed down to the two most feasible, namely:

- Option 1 *Leave in Place* where a relatively short offshore programme will render the pipelines overtrawlable with the pipelines remaining undisturbed below the sediment surface; and
- Option 2: *Recovery for Disposal Onshore* where a more prolonged and complex offshore programme will be undertaken to uncover and remove pipelines and associated infrastructure from the seabed for transportation to shore for recycling and/or disposal.

The CA provided a framework for assessing and assigning scores to six performance attributes and then ranking the two decommissioning options to enable a balanced comparison to be used to identify the preferred option. The six attributes were:

- Technical feasibility;
- Safety;
- Environmental impact;
- Energy usage and emissions;
- Societal impact; and
- Cost.

The results of the CA revealed a strong differentiation between the two options on the basis of the following criteria.

- Option 1: *Leave in Place* scored higher in the assessments for: Technical feasibility, Safety, and Cost.
- Option 2: *Recovery for Disposal Onshore* scored higher in the assessment of: Energy usage and emissions.

Both Environmental Impact and Societal impact provided a weak basis for differentiation.

From the CA it was concluded that Option 1: Leave in Place is Endeavour's preferred option for the decommissioning of the Rubie/ Renee trenched lines. During the decommissioning programme controlled placement of rock dump will cover the exposed cut ends of lines at trench transitions and pre-determined sections of line (estimated as 1.95 km out of a total line length of 64.9km) where surveys have found that burial depth is considered inadequate (i.e. less than 0.6m).

A suitable monitoring programme appropriate to the final strategy and mitigation procedure will be agreed with DECC in consultation with other departments. These details are specified further in the decommissioning programme.

1.0 INTRODUCTION

This report describes the Comparative Assessment (CA) of feasible decommissioning options, for six redundant lines and associated umbilicals. These trenched and buried lines formed part of the subsea infrastructure of the decommissioned Rubie/ Renee Field Development, in Blocks 15/28b and 15/27, respectively of the central North Sea.

Endeavour undertook a CA in line with DECC's 'Guidance Notes: Decommissioning of Offshore Installations under the Petroleum Act 1998' (DECC, 2011).

The Rubie/ Renee Facilities are located in UK Continental Shelf (UKCS) Blocks 15/21, 15/26, 15/27 and 15/28 of the central North Sea, approximately 115 km east of the UK coastline and approximately 60 km west of the UK/Norway median line (Figure 1). Water depth at the Rubie/ Renee Facilities ranges between 113 to 150 m. The Rubie and Renee fields are located in Blocks 15/28 and 15/27 respectively, and lie approximately six kilometres apart.

2.0 BACKGROUND

The Rubie and Renee fields were developed as subsea wells tie-backs to the Hess operated Floating Production Facility (FPF) AH001, located 21 km to the northwest of the Renee field. Hess disconnected and removed the AH001 FPF as part of the Ivanhoe, Rob Roy and Hamish (IVRRH) Decommissioning Programme in 2009.

Decommissioning preparatory work for Rubie/ Renee was completed by Hess in 2011 and involved the disconnection of the in-field pipelines and jumpers from the wells which were laid on the seabed. Endeavour had anticipated redeveloping the Rubie/ Renee fields once Endeavour's Rochelle Development became operational. However, during 2012, it was determined by Endeavour that the redevelopment of the Rubie/ Renee fields was no longer viable and as a result the decision was taken by Endeavour to decommission the facilities and fields.

At the point of the removal of the AH001 FPF, the four 21.6 km pipelines and two 5.6 km pipelines were pigged, flushed and capped, or remained connected to the closed manifold valves and then filled with inhibited seawater prior to abandonment.

The lines (pipelines and umbilicals) to be decommissioned (Figure 2) lie buried within six individual trenches containing:

- PL1616, PL1617, and PL1618 along with its piggybacked line PL1620 within three 21.6 km trenches;
- PL1619 within a single 21.6 km trench
- PL1624 and the piggybacked line PL1625 within a single 5.6 km trench; and
- PL1626 within a single 5.5 km trench.

3.0 ENVIRONMENTAL AND SOCIETAL SETTING

Appendix 1 provides an overview of the environmental and socioeconomic characteristics and sensitivities in the sea area around the Rubie/ Renee Field Development.

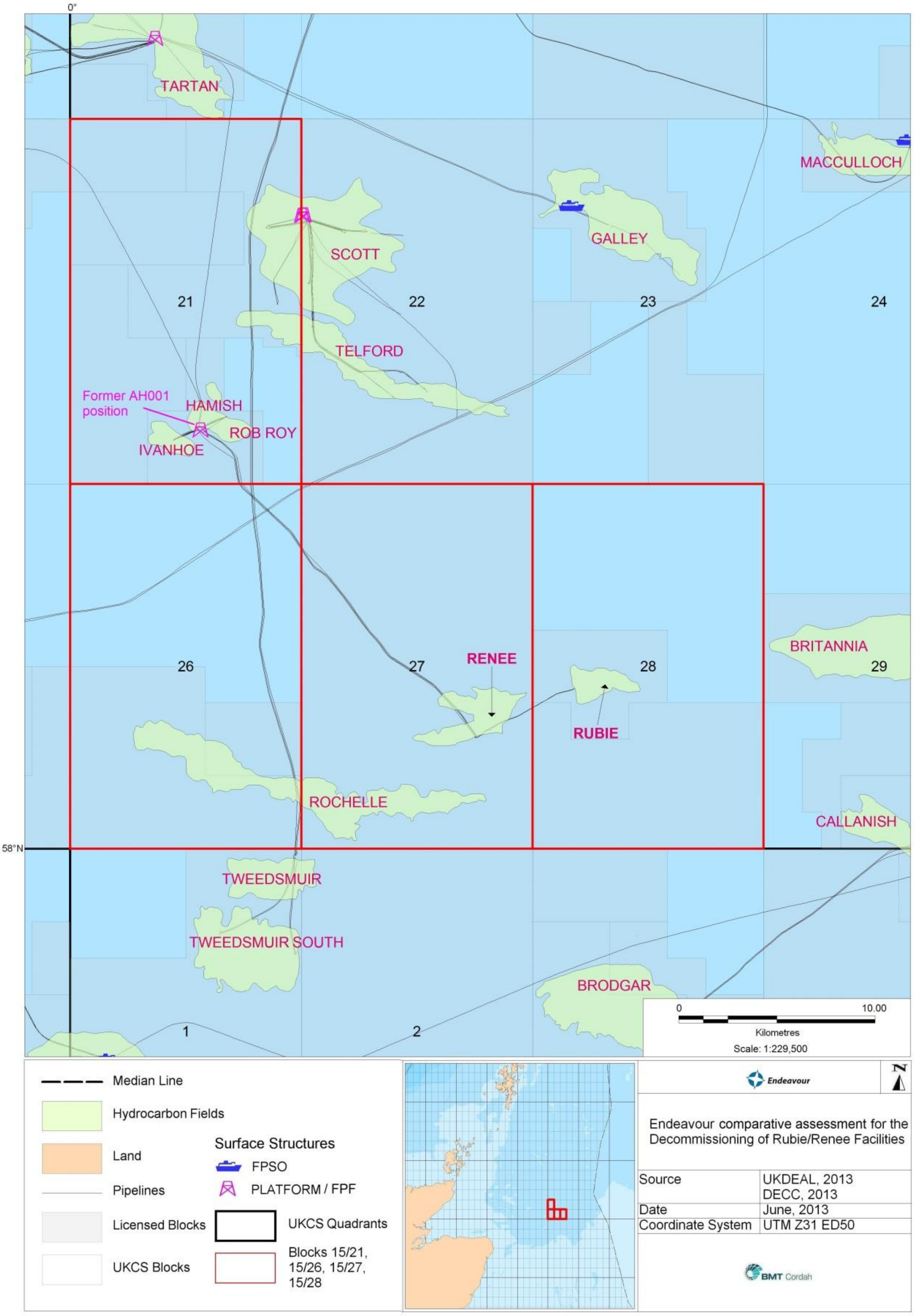

Figure 1: Location of the suspended Rubie/ Renee facilities

4.0 RUBIE/ RENEE INFRASTRUCTURE WITHIN THE CA SCOPE

In accordance with DECC's Guidance Notes (DECC, 2011), the CA scope covers the comparison of the decommissioning options for six redundant lines which are currently trenched and buried. For a description and inventory of materials see Table 1.

Lines (pipelines and umbilicals) to be decommissioned include:

- 4 x 21.6km pipelines (production (x2), gas lift and water injection) and associated 21.6 km umbilicals.
- 2 x 5.6 km pipelines (production and gas lift) and associated 5.5 km umbilicals.

4.1 Infrastructure not within scope

The CA scope does not include:

- Surface laid mattresses currently used to protect pipeline ends and crossings;
- Surface laid spool pieces, production and gas lift jumpers and hydraulic line; and
- On-seabed structures including: the Renee Manifold, Dynamic Umbilical Base, Crossover Structure, two production wellheads and one gas lift wellhead.

In line with DECC's Guidance Notes (2011) a CA is not required as these redundant structures will be decommissioned by recovery, leading to re-use, recycling or final disposal onshore.

4.2 Study parameters and considerations

The starting assumption is that the work scope for decommissioning the six lines will be discrete, and will not be combined with that for decommissioning the other Renee and Rubie infrastructure or for the adjacent Ivanhoe and Rob Roy infrastructure which is the responsibility of Hess. This simplification enables a clear boundary to be placed around the assessments to be made under the scope of the CA.

During preparatory works for decommissioning, the ends of the static lines will be exposed (excavation by jetting) and a section of the line and/or its flexible connecter will be cut out to allow access to the ends of the lines. These preparatory activities will apply to all options.

Two pre-existing characteristics of the pipelines affect decommissioning:

- Pipeline integrity: Serious corrosion was detected at one location on PL1616. This was repaired by fitting a clamp which has remained *in situ* since its installation.
- Exposure: There are areas where the lines have been uncovered due to natural movement of seabed sediments (Table 2).

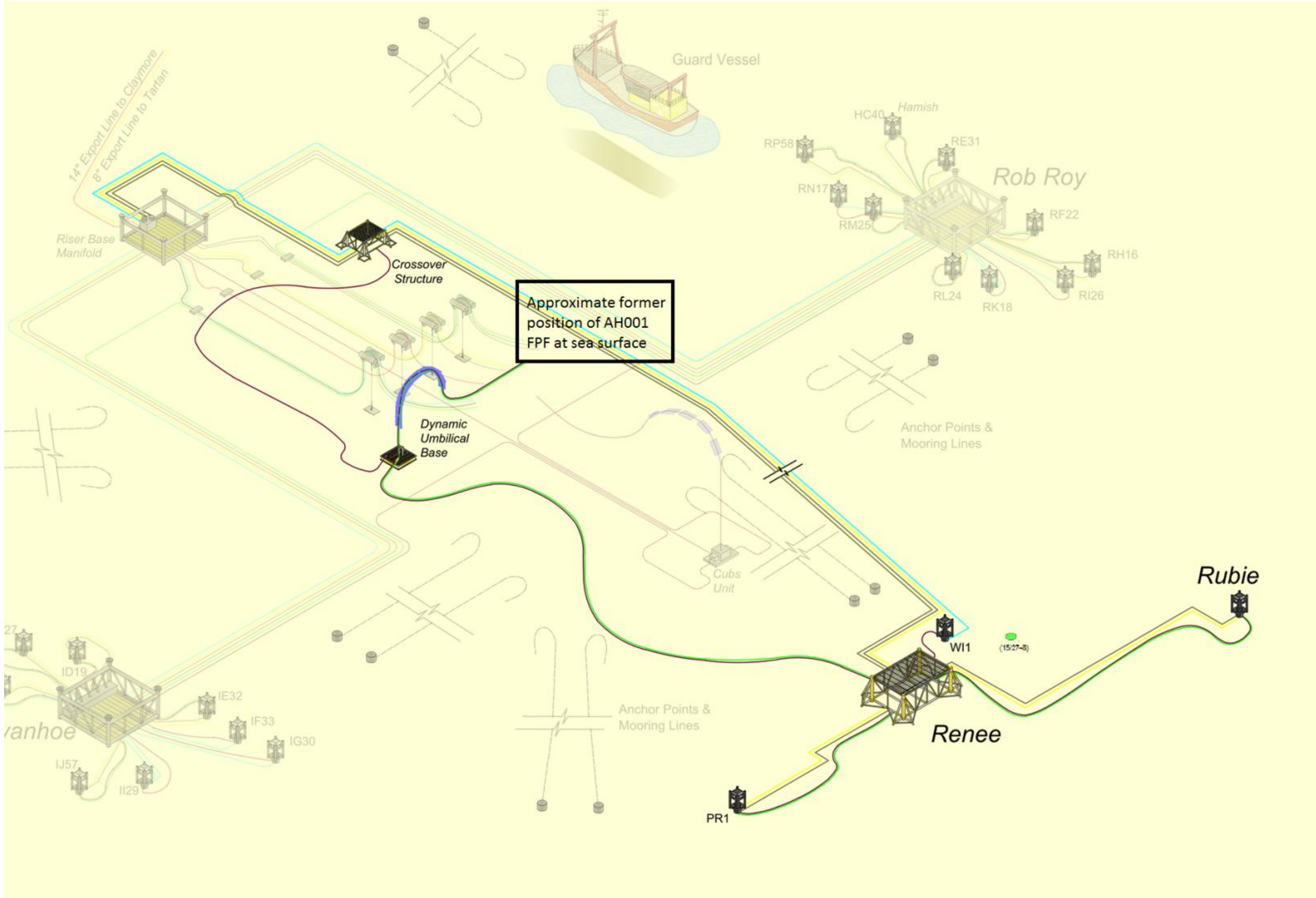

Figure 2: Schematic diagram of the Rubie/ Renee Facilities layout

Table 1: Materials Inventory for infrastructure to be decommissioned

Pipeline*	Description	Length (km)	Location/Associated with	Mass of individual metals (tonne)			Mass for all metals (tonne)	Mass for plastics (tonne)	Total mass of materials (tonne)
				Steel	Aluminium	Copper			
PL1616	8" test pipeline	21.6	from the Renee Production Manifold (RPM) to the riser base manifold.	1,383.4	22.1	0.007	1,405.5	441.8	1,847.3
PL1617	8" oil pipeline	21.6	from RPM to the riser base manifold.	1,383.4	22.1	0.000	1,405.5	441.8	1,847.3
PL1618	4" gas lift pipeline	21.6	from the RPM to the riser base manifold (piggybacked to PL1620).	342.9	3.7	0.000	346.6	15.6	362.2
PL1619	Umbilicals	21.6	from the RPM to the riser base manifold.	347.27	0	10.87	358.14	185.13	543.27
PL1620	8" water injection pipeline	21.6	from WI 1 to the riser base manifold.	1,396.3	6.8	0.014	1,403.1	29.6	1,432.7
PL1624	8" oil pipeline	5.6	connects the Rubie production well to the RPM.	358.7	0	0	358.7	114.8	473.4
PL1625	3" gas lift pipeline	5.6	connects the RPM to the Rubie production well. This pipeline was piggybacked with the 8" production pipeline (PL1624).	55.4	0	0	55.4	3.2	58.5
PL1626	Umbilicals	5.6	line containing chemical umbilicals from the RPM to the Rubie wellhead.	92.4	0	2.89	95.3	49.3	144.68
Total				**5,346.92**	**54.7**	**13.78**	**5,415.41**	**1,281.1**	**6,696.5**

* The masses of pipeline materials have been adjusted to account for the removal during the preparatory work for decommissioning of a 200m length of line from PL1616, PL1617, PL1618 and PL1619 (160 m at the crossing and 10m at each of the two trench transitions) and 40m from PL1624, PL1625 and the umbilical PL1626.1 to PL1628 (20m at each end). Because the removal of these materials applies equally to each considered option, the CA does not consider implications of removal.

Table 2: Flowline exposure status

Pipeline status (2013 survey)	Pipelines			Totals for the three pipeline routes (km)
	PL1616	PL1617	PL1618 / PL1620	
Length buried (km)	13.436	15.399	19.581	48.416
Length covered by mattresses and/or rockdump (km)	7.52	5.583	1.432	14.535
Length exposed (km)	0.654	0.651	0.648	1.953
Spanned length included within length exposed (km)	0.309	0.216	0.283	0.808
Total length (km)	**21.61**	**21.633**	**21.661**	**64.904**

Source: Summary of pipeline inspections collated by Endeavour, 2013

The occurrence of NORM is not an issue with the R-Block pipelines (Endeavour *pers. comm*, 28.06.13).

5.0 METHODOLOGY

The following section details the CA process by which the most appropriate options for decommissioning of the trenched pipelines will be assessed.

5.1 Comparative Assessment Team

This CA has been undertaken by the following personnel from both Endeavour and BMT Cordah Ltd (BMT):

- Endeavour Energy UK Ltd
  - Nick Ritchie, Director – Facilities, Engineering & New Developments,
  - Tom Milne, Asset Integrity Manager,
- BMT Cordah Ltd
  - Dr David Sell, Technical Associate,
  - Dr Joe Ferris, Associate Director,
  - Dr MacNeill Ferguson, Lead Senior Consultant, and
  - Dr Deborah McCormack, Consultant.

5.1.1 Initial screening

The following seven decommissioning methods were initially considered for the decommissioning of buried pipelines at the Rubie/ Renee field location:

1. **Leave in place;**
2. **Recovery by reverse reel;**
3. **Recovery by reverse lay;**
4. **Long section recovery;**
5. **Towed recovery;**
6. **Short section recovery (cut-and-lift); and**
7. **J-lift recovery.**

This screening exercise was undertaken to eliminate methods considered unsuitable for the decommissioning based on technical feasibility and resource availability (Appendix 2 provides a description of options not selected). On the basis of this initial screening, the CA will provide a comparison of:

- **Option 1: Leave in Place**
- **Option 2:** ***Removal by Reverse Reel*** for the majority of the lines, in combination with **Option 6:** ***Short Section Recovery*** for corroded sections unsuitable for reverse reeling. Short Section Recovery may also be used where lines have tight bends or other constrictions.

The remainder of this report focuses solely on the selected decommissioning options.

5.2 Assessment Criteria

The individual decommissioning options were assessed against the following criteria provided in DECC's Guidance Notes (DECC, 2011).

Technical Feasibility

A qualitative assessment of Technical Feasibility and Recoverability from Major Project Failure. Section 7 provides the result of the assessment.

Safety

A quantitative assessment of Potential Loss of Life of personnel working on the decommissioning options using the method given in Safetec (1995). Appendix 3 provides the methodology and detailed results.

Environmental Impact

(a) Qualitative assessment of Environmental Risks onshore and offshore using a risk assessment matrix; and

(b) Quantitative estimation of Energy Usage and CO_2 Emissions using the method given in Energy Institute (2000). Appendix 4 provides the methodology and detailed results for the environmental risk assessment. Appendix 5 provides the corresponding information on energy usage and emissions.

Societal Impact

A qualitative assessment of Societal Risks onshore and offshore using a risk assessment matrix. Appendix 4 provides the methodology and detailed results.

Cost

A quantitative estimation of Cost for each option. Appendix 6 provides the cost breakdown.

5.3 Assessment Scoring

Initially, the scores from each of the assessments were expressed in their respective quantitative and qualitative units. Justification for the scores assigned during the assessments, as well as assumptions and limitations was noted. To enable a comparison to be made of the options, the results were then collated and compared using a normalised scoring system where the results of each of the five assessments were expressed in common units of: One (1) for the top ('better') option; and Zero (0) for the bottom ('poorer') option.

An overall score was established by totalling the normalised scores of the six assessments and comparing the totals. Endeavour used the output from the CA to select its preferred decommissioning option, with the CA report documenting the justification for their choice. DECC's Guidance Notes (DECC, 2011) make provision for weightings to be assigned to the scoring for the individual assessments to reflect the priorities or policies of the operator or its stakeholders. Endeavour has weighted options as follows:

30%	20%	15 %	10%
Safety	Cost	Technical Feasibility	Energy & Emissions
		Environmental Impact	Societal Impact

6.0 DECOMMISSIONING OPTIONS ASSESSED IN THE CA

The following section details the scope of works (onshore and offshore) required for both options considered as part of the CA process.

6.1 Option 1: Leave in place

The intended decommissioning outcome is for the pipelines to remain undisturbed and adequately buried below seabed level over the long-term, thereby creating an unobstructed seabed. If on completion of the survey, the depth of burial is not found to be adequate then these materials will be recovered (as in Option 2). The following section details the proposed work scope required to decommission the lines in place.

6.1.1 Proposed work scope for Option1: Leave in place

Offshore

- A DSV with saturation dive spread and lifting equipment will be used to:
  - prepare the seabed at pipeline trench transition for rockdumping.
- A CSV or supply boat will be used for:
  - jetting/excavation carried out remotely using an ROV.
- A rockdump vessel will carry out the controlled placement of rockdump over the trench transitions and any other pre-determined vulnerable locations.
- A guard vessel will be on station throughout these operations.
- A fishing trawler with a ground beam will carry out a seabed clearance survey.
- In accordance with Section 29 of the Petroleum Act 1998, Endeavour has an indefinite liability for pipeline materials left *in situ*. Therefore, post-decommissioning monitoring will be carried out to assess the physical, chemical and ecological condition of the seabed, ensure that lines remain adequately buried and the seabed remains free from obstruction to other sea users. For the assessment purposes, the CA nominally allows for two post-decommissioning surveys.

6.2 Option 2: Recover to shore

The intended decommissioning outcome is an unobstructed seabed, the reuse or recycling of all possible pipeline materials and the long-term deposition of non-recyclable materials to landfill. The following section details the proposed work scope to decommission the lines via recovery to shore.

6.2.1 Proposed work scope for Option 2: Recover to shore

Offshore

- A DSV with saturation dive spread, cutting, jetting and lifting equipment will expose around 20m to 30m of the line, then cut and clamp on an abandonment recovery head, which will be pre-rigged for pick-up by an ROV deployed from the reel vessel.
- The recovered line will pass through the tensioner system and on to the carousel on the reel vessel, which will then commence back-reeling.
- A jetting vessel, trencher or other suitable vessel will travel along the pipeline route in advance of the reel vessel and will use remotely operated jetting equipment, trenching plough or other methods to displace seabed sediments and expose the pipeline to facilitate reel vessel recovery.
- A dynamically positioned reel vessel (fitted with one or more carousels) will continuously recover the pipeline which will be spooled onto the carousel(s). Once the carousel(s) are full, the reel vessel will return to the spool base onshore to offload the pipelines. It will then redeploy and continue the work. The CA assumes three round trips between spool base and work location.
- A DSV with saturation dive spread, cutting equipment (hydraulic bandsaw, shears or other type of equipment) and lifting equipment will cut and recover the sections of line designated for removal by the short section recovery method. These sections will be cut into manageable lengths and stored on the DSV's deck prior to return to shore or crane lift onto a supply vessel or CSV.
- A CSV and/or supply vessel will:
    - transport redundant sections of pipeline to port for recycling/disposal.
    - carry out remotely operated jetting and excavation using an ROV
- A jetting vessel, trencher or other suitable vessel will travel along the pipeline routes for a second pass using remotely operated jetting equipment, a backfill plough or other methods to fill in the trench and flatten mounds of displaced sediments created by the recovery of the 21.6 km and 5.6 km lines.
- A guard vessel will be on station throughout these operations.
- A fishing trawler with a ground beam will carry out a seabed clearance survey.
- Post-decommissioning monitoring to assess the physical, chemical and ecological condition of the seabed. For the assessment purposes, the CA nominally allows for two post-decommissioning surveys.

Onshore

- At the spool base, the lines will be unspooled on to the quayside, and then cut into lorry-load lengths for transport to the recycling and disposal facilities.

Disposal Options

The CA assumes that:

- road haulage will be used, with an estimate of 600km for metal recycling (e.g. round trip from a spool base in Northern Scotland to a recycling facility in the Central Belt), and
- all of the recovered pipeline materials will be recycled (actual figure may be around 95%).

7.0 RESULTS

The following section presents the results of the CA of the two decommissioning options. Four of the assessments displayed a strong differentiation between the options. Both environmental impact and societal impact displayed a weak differentiation. Table 3 presents the results of the CA which scored the options as follows:

- Option 1: Leave in Place scored top in the assessments of: Technical feasibility, Safety, and Cost (total weighted score of 5.4).
- Option 2: Recovery for Disposal Onshore scored top in the assessment of: Energy usage and emissions (total weighted score of 2.1).

Table 3: Results of the Comparative Assessment of the two options

Criterion	Assessment & Metric	Option 1: Leave in Place			Option 2: Recovery for Disposal Onshore			Appendix
		Assessed Result	Normalised Score	Weighted Score	Assessed Result	Normalised Score	Weighted Score	
Feasibility	Feasibility of successful completion and recoverability from project failure *Metric: Qualitative comparison*	See section 7.1.1 for differentiation	1	0.9	See section 7.1.1 for differentiation	0	0	
Safety	Safety risk offshore and onshore *Metric: Potential Loss of Life (PLL)*	1.16×10^{-2}	1	1.8	1.67×10^{-2}	0	0	3
Environmental Impact	Environmental risk offshore & onshore *Metric: Numbers of 'Medium' category environmental risks*	2	1	0.9	2	1	0.9	4
	Energy usage & emissions *Metric: Quantity of energy used (GJ) and CO_2 emitted (t)*	294,288 GJ 16,285 t	0	0	131,632 GJ 10,443 t	1	0.6	5
Societal Impact	Societal risk offshore & onshore *Metric: Numbers of 'Medium' category societal risks*	1	1	0.6	1	1	0.6	4
Cost	Cost including allowance for further surveying and remediation *Metric: Estimated project cost*	£9.5 million	1	1.2	£20.5 million	0	0	6
		Total Score	**5**	**5.4**		**3**	**2.1**	

7.1 Differentiation between options

This section highlights why the considered options were strongly or weakly differentiated and provides a more detailed justification for the scores awarded to each option.

7.1.1 Feasibility differentiation

Both options were considered technically feasible and operationally proven. Vessels with experienced crews routinely carry out pipeline repair, installation, maintenance, recovery, jetting, trenching and rock dumping operations on the UKCS which are similar to those outlined in the present CA.,

However, Option 1 is less technically complex, with a smaller vessel spread (six types of vessel) and shorter work programme (totalling 82 vessel days) than Option 2 (eight types of vessel, totalling 125 vessel days).

Option 2 requires a reel vessel which operates from a spool base; both the spool bases and reel vessels tend to have a relatively limited availability and long lead times. Option 2 also has the greater potential for schedule delays arising, for example, from complications during pipeline recovery.

For these reasons, Option 1 was assessed to have a higher degree of technical feasibility and recoverability than Option 2.

Option 1: Leave in place Differentiation Score	**0.9**	**Option 2: Recovery Differentiation Score**	**0**

7.1.2 Safety differentiation

With a less prolonged work programme involving fewer people (reduced exposure hours) working offshore, as well as less extensive onshore transport operations, the inherent safety risk for Option 1 was assessed to be 69% of that for Option 2.

Option 1: Leave in place Differentiation Score	**1.8**	**Option 2: Recovery Differentiation Score**	**0**

7.1.3 Environmental Impact differentiation

There was a weak differentiation between the two options regarding their environmental impact.

Option 1 was assessed to have two relatively benign long-term 'medium' environmental risks relating to the presence rock dump altering structure and habitats within well-defined localised areas of seabed habitat.

In contrast, Option 2 had one fairly disruptive short-term ‘medium’ impact associated with seabed excavation, retrieval and backfilling operations, and one localised short-term impact relating to emissions generated during pipeline recycling on air quality.

Option 1: Leave in place Differentiation Score	**0.9**	**Option 2: Recovery Differentiation Score**	**0.9**

7.1.4 Energy & Emissions differentiation

Energy usage and emissions from Option 2 were estimated to be lower (45% for energy and 64% for CO_2) than for Option 1. This differential was created by the relatively large component in Option 1 of energy and emissions corresponding to the hypothetical manufacture of new raw materials to replace those lost to society by leaving the decommissioned pipelines buried *in situ* in the seabed.

Option 1: Leave in place Differentiation Score	0	Option 2: Recovery Differentiation Score	0.6

7.1.5 Societal Impact differentiation

There was a weak differentiation between the options regarding their societal impact.

Option 1 was assessed to have one 'medium' long-term societal risk relating to the possibility that the buried lines may at some point in the future become uncovered to create a potential obstruction on the seabed. There is a history of the Rubie and Renee lines becoming uncovered and spans forming due to seabed sediment movement.

Notwithstanding, Endeavour's pipeline inspection programme has demonstrated that the Renee Rubie lines have remained buried below seabed level over the majority of their route length during the period since installation. These surveys have also identified where exposed sections exist (Table 3). In mitigation, further survey work would be required to confirm where burial depth is sufficient (minimum cover of 0.6m) to avoid obstruction to demersal fishing gear. Exposed or inadequately buried lines would be protected by remedial rockdump with an overtrawlable profile. Following decommissioning, an appropriate monitoring programme would be agreed with DECC and other stakeholders, with a commitment to remedial intervention should this be required in future.

Option 2 was assessed to have one short-term societal risk relating to the transportation of multiple lorry loads of pipeline on long journeys causing disruption to roads.

Option 1: Leave in place Differentiation Score	0.6	Option 2: Recovery Differentiation Score	0.6

7.1.6 Cost differentiation

Option 1's estimated cost is 59% of that of Option 2. The cost of a more extensive vessel spread with a more prolonged work programme, the recycling cost, and the higher disposal cost for Option 2 create this differential between the decommissioning options.

Option 1: Leave in place Differentiation Score	1.2	Option 2: Recovery Differentiation Score	0

8.0 CONCLUSIONS

Scoring distribution for individual assessments in the CA reflects the distinction between:

- Option 1: Leave in Place, a short-duration programme, requiring short term disturbance caused by limited intervention, but a long term physical presence; and
- Option 2: Recovery for Disposal Onshore, a more prolonged offshore programme involving divers in the uncovering and physical removal of materials from the seabed, followed by transportation and disposal onshore.

Option 1 is positively differentiated from Option 2 on the basis of 3 out of the 4 attributes assessed where differentiation was observed:

- Feasibility;
- Safety risk ; and
- Cost.

Option 2 positively differentiated only in Energy and Emissions. Both Environmental Impact and Societal impact displayed weak differentiation.

8.1 In summary

Based on the scoring criteria, the CA concludes that **Option 1: Leave in Place** is the preferred decommissioning option for the trenched lines.

The Leave in Place option meets the expectations of current DECC decommissioning guidelines (DECC, 2011), for pipelines where:

- Burial or trenching of exposed sections is undertaken to sufficient depth and is expected to be permanent.

Burial in this case will be achieved by controlled placement of rock dump to cover exposed cut ends of lines at trench transitions and pre-determined sections of line where burial depth is considered inadequate (i.e. less than 0.6m). A suitable monitoring programme appropriate to the final strategy and mitigation procedure will be agreed with DECC in consultation with other departments. These details are specified further in the decommissioning programme.

9.0 REFERENCES

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APPENDICES

APPENDIX 1: ENVIRONMENTAL & SOCIOECONOMIC SENSITIVITIES

Table A1.1: Environmental Sensitivities Summary

Environmental Sensitivities Summary

UKBAP Priority species: Priority species (highlighted in blue) are those identified as being the most threatened and requiring conservation action under the UK Biodiversity Action Plan (UK BAP).

Finfish & Shellfish

Nursery Areas

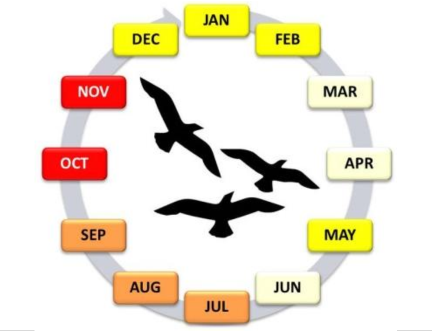
The development coincides with nursery areas for 15 species:

Norway pout	*Nephrops*	Blue whiting	Whiting	Sprat	Anglerfish	Cod	
Mackerel	Herring	*Nephrops*	Sandeel	Spotted ray	Spurdog	Ling	European hake

Spawning grounds	J	F	M	A	M	J	J	A	S	O	N	D
Cod	S	S*	S*	S								
Nephrops	S	S	S	S*	S*	S*	S	S	S	S	S	S
Norway Pout	S	S*	S*	S								

S = spawning S* = peak spawning

Seabirds

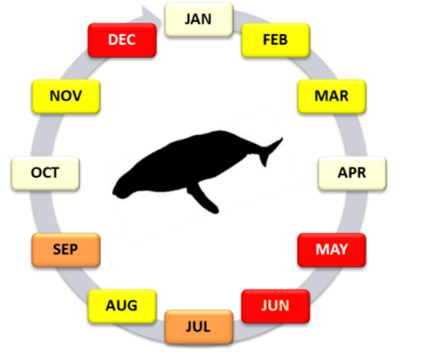


Annual peaks in seabird vulnerability in **15/27, 15/28** and surrounding blocks (left). Species recorded in Blocks **15/27, 15/28** and surrounding blocks (and their UK conservation status*):

- Red: Arctic Skua and Herring Gull
- Amber: Gannet, Puffin, Fulmar, Great and Pomarine Skua, Greater Black-backed, Lesser Black-backed Gulls, Kittiwake, Storm Petrel, Guillemot and Razorbill.
- Green: Little Auk

*UK Birds of Conservation Concern categories are informed by UK, European and Global conservation status and based on the IUCN **Red List of Threatened Species.** This informs criteria set for UK birds of conservation concern. Birds are split into three categories - **Red** is the highest conservation priority, with species needing urgent action**.** **Amber** is the next most critical group, followed by **Green**.

Marine Mammals



The following marine mammals have been recorded in Quadrant 15: killer whale, minke whale, harbour porpoise, white-beaked and white-sided dolphin. In addition, Risso's and common dolphin have been recorded in the surrounding area. Sightings were highest during April, May and July. The harbour porpoise is the only Annex II species to be sighted within Quadrant 15, with sightings recorded in every month except January and March.

Low L Medium M High H Very high VH No data

	J	F	M	A	M	J	J	A	S	O	N	D
Minke whale					L		L	L				
Killer whale											L	
White-beaked dolphin		M	M		M	L	H	L	M	L	M	L
White-sided dolphin						VH		L	H			
Common dolphin								L				
Risso's dolphin							L					
Harbour porpoise	L	M		L	VH	L	H	M	L	L		VH

Benthic Environment	Seabed Sediment / Benthic Fauna	Sediments and benthic fauna in the Rubie/ Renee area are typical of the central North Sea; therefore no specific issues are foreseen.
Pelagic Environment	Water Quality / Plankton	Plankton and water quality in the Rubie/ Renee area are likely to be typical of the central North Sea; no specific issues are foreseen.

Socioeconomic Sensitivities Summary

Commercial Fisheries

The area of the Rubie/ Renee is fished throughout the year. During 2011, fishing effort peaked in July and August and during April to May. Demersal fishing methods (such as bottom otter trawls) dominated the fishing effort.

Fishing Effort (kw/days)			Relative Value (£)		
Whitefish gears	L	20,000 – 100,000	Whitefish gears	M	100,000 – 500,000
Pelagic gears		no effort	Pelagic gears		no catch
Nephrops gears	VH	>300,000	*Nephrops* gears	VH	>1,000,000
Gillnets & Long lines		no effort	Gillnets & Long lines		no catch
Pots/Creels		no effort	Pots/Creels		no catch
Dredges		no effort	Dredges		no catch

Other Users

Receptor	Impact
Shipping Activity	DECC category: Low
Oil & Gas	The nearest infrastructure is the Nexen Scott JD production and drilling platform and the Scott JU Accommodation platform, 26 km to the N
Telecommunications	No submarine cables transect the Rubie/ Renee area.
Aggregate extraction	No designated aggregate extraction areas recorded in the vicinity.
Military Use	There are no military operation zones in the immediate vicinity.
Wrecks	There are no recorded wrecks in the immediate vicinity.
Carbon Capture	No carbon capture schemes are found within the vicinity.
Windfarms	No windfarms currently operate within the area.
Archaeology	There are no sites of archaeological importance within the vicinity.
Tourism & Recreation	None recorded.

Conservation Interests

	Receptor	Description
Annex I habitats	Sandbanks	The closest site to the Rubie/ Renee development is the Norwegian Boundary Sediment Plain proposed MPA located approximately 77 km east, near the UK/Norway median line, with offshore subtidal sands and gravel and aggregations of protected bivalve Ocean quahog (*Arctica islandica*).
	Pockmarks	Pockmarks are known to occur in this area of Central North Sea however the majority of these are inactive. The closest designated sites are South-east Fladen proposed MPA and Scanner Pockmark cSAC/SCI, located 20 km and 40 km east, respectively, of the Rubie/ Renee development.
Annex II species	Harbour porpoise	Harbour porpoise sightings have been recorded in the Rubie/ Renee area frequently throughout the year except March and November.
	Bottlenose dolphin	The Rubie/ Renee area is located 140 km from shore; therefore the presence of these species is likely to be infrequent.
	Common seal	
	Grey seal	

Designated Sites

The "South-east Fladen" and "Western Fladen" are proposed MPAs located approximately 20 km east and 28 km north west, respectively, of the Rubie/ Renee development. The South-east Fladen MPA is designated for the conservation of burrowed mud habitat and seabed fluid and gas seep pockmarks. The Western Fladen is designated for the conservation of the burrowed mud habitat and Quarternary of Scotland – subglacial tunnel valley.

Key:

Seabird vulnerability		Marine mammal sightings		Commercial Effort & Value	
VH	Very high	VH	Very high (>= 0.50 animals/km)	VH	Very High
H	High	H	High (0.20-0.49 animals/km)	H	High
M	Moderate	M	Moderate (0.10-0.19 animals/km)	M	Moderate
L	Low	L	Low (0.01-0.09 animals/km)	L	Low
	No Data		No data	VL	Very Low
					No effort/No catch

A1.2 Environmental & Socioeconomic Sensitivities References

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APPENDIX 2: OPTIONS DISMISSED AFTER INITIAL SCREENING

A2.1 Options dismissed during Initial screening

The following provides a description of the options considered along with the justification for the selection or exclusion of the particular options from further consideration in the CA. Selected Options **(1) Leave in Place** and **(2) Recovery by Reverse Reel**, are discussed in detail in Section 6 in the main body of the report.

A2.1.1 Option 3: Recovery by Reverse Lay (Rejected)

Reverse lay effectively reverses the normal pipeline construction method where standard lengths of pipe welded end to end on board the lay barge are then paid out from a hinged ramp or stinger as the barge moves forward.

Initially, the route would be surveyed and the line would be picked up by a dynamically positioned or anchored lay barge as in Option 2. The line would be winched over stinger and through tensioners on board the lay barge which will then carry out the reverse lay. These tensioners hold the weight of the suspended pipeline which takes up an "S" bend configuration between the stinger and the seabed.

The barge will travel along pipeline route recovering the pipeline, which will then be cut into manageable sections on the barge. These will be back-loaded either to a second barge or to a supply vessel, then transported to shore and to recycling and disposal facilities, as required. This method would be similar to that used for recovering a buckled pipeline.

Again, the method would be suitable for sections of the lines which are sufficiently sound to enable the lines to be recovered by reverse lay. It would not be suitable for sections which are seriously corroded.

Removal by reverse lay was rejected for further consideration in the CA because it tends to be more suited to larger diameter lines and would be less practicable for smaller diameter lines, such those in the R Block, which are usually installed by reel barge. Recovery rates could be slower and weather down time could be more significant than with Option 2.

A2.1.2 Option 4: Long Section Recovery (Rejected)

With this option, the pipe is suspended from davits mounted on the side of the recovery vessel. A jet sled, plough or other device deployed from a separate barge or vessel moving ahead of the recovery barge would be used to uncover the pipe. As the recovery vessel travels slowly along the pipeline route, the pipe would be lifted in a controlled S-bend configuration to avoid buckling. The end of the recovered pipe is fed through a cutting station near the vessel's bow, where the pipe is cut into lengths for transport to shore on a supply boat.

Long section recovery was rejected because this technique is not used in the northern North Sea (NNS) and is more suitable for shallower and sheltered waters. Appropriate vessels and experienced crews are not readily available. Relatively slow removal rates and weather down time could also be significant disincentives.

A2.1.3 Option 5: Removal by Tow Recovery (Rejected)

Following a survey of the line, a jet sled, plough or other device deployed from a separate barge or vessel would be used to uncover the pipe during removal. The pipe would then be suspended from davits aboard the recovery vessel which would carry tensioners and stingers at both ends, with a cutting station mounted in the middle of the vessel. As the pipeline is lifted and passed through to the aft stinger, a towing head and flotation buoys would be attached to the pipeline.

A tug would pick up the towing head and maintain tension on the pipeline while the recovery vessel picks up additional pipe. When the required length of pipeline is reached, the pipeline would be severed on-board the recovery vessel and the freed length of pipeline would be towed to shore. The process would then be repeated. The buoys are intended to provide sufficient buoyancy for the pipeline to be towed on or close to the seabed, close to the surface or at a mid-water level.

This method can be used to recover lengths of rigid pipeline, especially large diameter steel line and concrete covered line. However, it was rejected from further consideration in the CA because it has not been used in the NNS. Suitable vessels are readily available but experienced crews are not, and because the technique is not widely used, there would be a steep learning curve.

Navigational and handling issues to pull the pipe ashore, cut in to lengths and transport it onwards would have to be addressed. Safety relating to two or more vessels working in close proximity would also need to be addressed. Tow recovery would be expensive (i.e. cost increases in proportion to length, water depth and weather) and removal rate would be relatively slow. Fundamentally, a lot of things would have to go right every time for this technique to succeed.

A2.1.4 Option 6: Short Section Recovery (Selected for use with Option 2)

Following a survey of the line, a jet sled, plough or other device operated from a separate barge or vessel would be used to uncover the pipe during removal. The pipeline would be cut into short lengths on the seabed using divers or an ROV. Lifting slings or lines would be attached to the cut lengths of lines and the recovery vessel’s crane would lift these onto the deck. Alternatively, the vessel’s davits would lift the pipeline and it would be cut up further on the vessel.

The method is suitable for any size or type of pipeline. Technically, the method is robust, well understood and can readily be achieved. It uses established and proven techniques with minimal engineering requirement, and is undertaken frequently. Suitable vessels are readily available.

Short section recovery has been selected for further consideration in the CA because it is the only method that is suitable for the recovery of seriously corroded sections of buried lines. However, it has not been chosen for a wider application for decommissioning the R Block lines. Uncovering, cutting and removal of buried lines would be relatively slow, labour intensive and costly. High cost diving or ROV operations, subsea cutting equipment and prolonged use of vessels (more prolonged than any other option) and the high risk of schedule delays provide strong disincentives.

A2.1.5 Option 7: J-Lift Recovery (Rejected)

Following a survey of the line, a jet sled, plough or other device operated from a separate barge or vessel would be used to uncover the pipe during removal. The J-lay barge is designed primarily to lay the larger diameter pipelines in deep water. The tensioners and stinger are mounted on a nearly vertical tower extending down into the sea. This method avoids the excessive "S" bend stresses in pipelines that result from the pipeline's extra weight in very deep water. In other respects, J-lift recovery follows the same procedures as the other lay barge methods described above.

J-lift can be used to recover both rigid and flexible pipeline and is suitable for longer lengths of larger diameter pipe. However, it does require a dedicated vessel and because the method is designed for deep-water installation, it is considered technically inappropriate for the shallower water depth at R Block. In addition to technical risk and potential for schedule delays, this option would be slow and expensive.

APPENDIX 3: ASSESSMENT OF SAFETY RISKS

A3.1 Method

The calculation of Potential Loss of Life (PLL) for each option was carried out in two stages:

- Individual PLLs for each activity during the work programme were calculated by multiplying worker exposure (expressed in hours) or the numbers of lifts by cranes or the number of take-off and landing events by helicopters by the corresponding Fatal Accident Rate (FAR) (expressed as the number fatalities per 100 million hours).
- PLLs for all of the activities were summed to provide the total PLL for that option.

The report on the Joint Industry Project on the Risk Analysis of Decommissioning Activities (Safetec 1995) provides the PLL calculation methodology and FAR values.

The CA outputs are quantitative PLL tables along with stated assumptions.

A3.2 Results

A3.2.1 Option 1: Leave in Place

The purpose of this work would be to monitor rockdump operations intended to cover the pipelines and umbilicals that are being left *in situ,* and to carry out post-decommissioning surveys.

A total of six vessels (Table A3.1) will be required for the rockdumping and monitoring operations. In total, it is estimated worker expose hours will be 117,988 for Option 1.

Table A3.1: PLL calculation for Option 1: Leave in Place

Vessel or Vehicle	Activity	Number of Workers, Lifts by Crane or Helicopter Take offs & Landings	Working or Rest period	Exposure Hours Per Worker	Exposure Hours for the Activity	FAR	PLL
Dive Support Vessel	Mobilisation & demobilisation	75	Working	48	3,600	7.5	2.70x10^{-4}
			Resting	48	3,600	0.2	7.20x10^{-6}
	Transit to and from site	75	Working	12	900	7.5	6.75x10^{-5}
			Resting	12	900	0.2	1.80x10^{-6}
	Onsite: Working excluding divers	63	Working	156	9,828	7.5	7.37x10^{-4}
			Resting	156	15,876	0.2	1.97x10^{-5}
	Onsite: Divers under compression	12	Working & Resting	672	8064	97	7.82x10^{-3}
	Onsite: Lifts by Crane	35	N/A	N/A	N/A	1.10x10^{-5}	3.85x10^{-4}
CSV/ Supply Vessel (CSV used in PLL calculation)	Mobilisation & demobilisation	75	Working	48	3600	7.5	2.70x10^{-4}
			Resting	48	3600	0.2	7.20x10^{-6}
	Transit to and from site	75	Working	12	900	7.5	6.75x10^{-5}
			Resting	12	900	0.2	1.80x10^{-6}
	Onsite	75	Working	252	18,900	7.5	1.42x10^{-3}

Vessel or Vehicle	Activity	Number of Workers, Lifts by Crane or Helicopter Take offs & Landings	Working or Rest period	Exposure Hours Per Worker	Exposure Hours for the Activity	FAR	PLL
			Resting	252	18,900	0.2	$3.78x10^{-5}$
Rockdump Vessel	Mobilisation & demobilisation	30	Working	48	1440	7.5	$1.08x10^{-4}$
			Resting	48	1440	0.2	$2.88x10^{-6}$
	Transit to and from site	30	Working	12	360	7.5	$2.70x10^{-5}$
			Resting	12	360	0.2	$7.20x10^{-7}$
	Onsite	30	Working	48	1,440	7.5	$1.08x10^{-4}$
			Resting	48	1,440	0.2	$2.88x10^{-6}$
Guard Vessel	Mobilisation & demobilisation	8	Working	N/A	N/A	3.3	N/A
			Resting	N/A	N/A	0.2	N/A
	Transit to and from site	8	Working	12	96	3.3	$3.17x10^{-6}$
			Resting	12	96	0.2	$1.92x10^{-7}$
	Onsite	8	Working	252	2,016	3.3	$6.65x10^{-5}$
			Resting	252	2,016	0.2	$4.03x10^{-6}$
Fishing Trawler	Mobilisation & demobilisation	18	Working	N/A	N/A	18.1	N/A
			Resting	N/A	N/A	0.2	N/A
	Transit to and from site	18	Working	12	216	18.1	$3.91x10^{-5}$
			Resting	12	216	0.2	$4.32x10^{-7}$
	Onsite	18	Working	24	432	18.1	$7.82 x10^{-5}$
			Resting	24	432	0.2	$8.64 x10^{-7}$
Survey Vessel	Mobilisation & demobilisation	35	Working	96	3,360	5.5	$1.85x10^{-4}$
			Resting	96	3,360	0.2	$6.72x10^{-6}$
	Transit to and from site	35	Working	24	840	5.5	$4.62x10^{-5}$
			Resting	24	840	0.2	$1.68x10^{-6}$
	Onsite	35	Working	24	840	5.5	$4.62 x10^{-5}$
			Resting	24	840	0.2	$1.68 x10^{-6}$
Helicopter	Take offs & landing events*	216	N/A	N/A	N/A	32	$6.91 x10^{-5}$
	Transit to and from site	27	Travelling	8	216	97	$2.1 x10^{-4}$
PLL for Option							**$1.16 x10^{-2}$**

N/A – Not applicable

A3.2.2 Option 2: Recovery for Disposal Onshore

The purpose of this work would be to locate and recover the pipelines and umbilicals (as in Option 1) associated with the Rubie and Renee Fields. The pipelines and umbilicals would be removed from their current location on/ in the seabed and transported to shore for disposal, re-use or recycling.

A total of seven vessels (Table A3.2) will be required for operations. In total, it is estimated that worker expose hours will be 230,542 for Option 2.

The onshore transportation exposure estimate is based on 25 tonne capacity articulated lorries travelling at an average speed of 50 km per hour to make 176 x 600 km round trips for the disposal for each load of metals for recycling (e.g. a round trip from a spool base in Northern Scotland to a recycling facility in the Scottish Central Belt).

Table A3.2: PLL calculation for Option 2: Recovery for onshore disposal

Vessel or Vehicle	Activity	Number of Workers, Lifts by Crane or Helicopter Take offs and Landings	Working or Rest period	Exposure Hours Per Worker	Exposure Hours for the Activity	FAR	PLL
Dive Support Vessel	Mobilisation & demobilisation	75	Working	48	3,600	7.5	2.7×10^{-4}
			Resting	48	3,600	0.2	7.2×10^{-6}
	Transit to and from site	75	Working	12	900	7.5	6.75×10^{-5}
			Resting	12	900	0.2	1.8×10^{-6}
	Onsite: working excluding divers	63	Working	204	12,852	7.5	9.64×10^{-4}
			Resting	204	12,852	0.2	2.57×10^{-5}
	Onsite: Divers under comprsn.	12	Working & Resting	672	8,064	97	7.82×10^{-3}
	Onsite: Lifts by Crane	90	N/A	N/A	N/A	1.1×10^{-5}	9.9×10^{-4}
CSV/ Supply Vessel (CSV in PLL calculation)	Mobilisation & demobilisation	75	Working	144	10800	7.5	8.1×10^{-4}
			Resting	144	10800	0.2	2.16×10^{-5}
	Transit to and from site	75	Working	36	2700	7.5	2.03×10^{-4}
			Resting	36	2,700	0.2	5.4×10^{-6}
	Onsite	75	Working	252	18,900	7.5	1.42×10^{-3}
			Resting	252	18,900	0.2	3.78×10^{-5}
Reel Vessel	Mobilisation & demobilisation	100	Working	108	10,800	7.5	8.10×10^{-4}
			Resting	108	10,800	0.2	2.16×10^{-5}
	Transit to and from site	100	Working	48	4,800	7.5	3.6×10^{-4}
			Resting	48	4,800	0.2	9.6×10^{-6}
	Onsite	100	Working	120	12,000	7.5	9×10^{-4}
			Resting	120	12,000	0.2	2.4×10^{-5}
Jetting Vessel/ Trencher	Mobilisation & demobilisation	60	Working	48	2,880	7.5	2.16×10^{-4}
			Resting	48	2,880	0.2	5.76×10^{-6}
	Transit to and from site	60	Working	12	720	7.5	5.4×10^{-5}
			Resting	12	720	0.2	1.44×10^{-6}
	Onsite	60	Working	240	14,400	7.5	1.08×10^{-3}
			Resting	240	14,400	0.2	2.88×10^{-5}

Vessel or Vehicle	Activity	Number of Workers, Lifts by Crane or Helicopter Take offs and Landings	Working or Rest period	Exposure Hours Per Worker	Exposure Hours for the Activity	FAR	PLL
Guard Vessel	Mobilisation & demobilisation	8	Working	N/A	N/A	3.3	N/A
			Resting	N/A	N/A	0.2	N/A
	Transit to and from site	8	Working	12	96	3.3	3.17×10^{-6}
			Resting	12	96	0.2	1.92×10^{-7}
	Onsite	8	Working	300	2,400	3.3	7.92×10^{-5}
			Resting	300	2,400	0.2	4.8×10^{-6}
Fishing Trawler	Mobilisation & demobilisation	18	Working	N/A	N/A	18.1	N/A
			Resting	N/A	N/A	0.2	N/A
	Transit to and from site	18	Working	12	216	18.1	3.91×10^{-5}
			Resting	12	216	0.2	4.32×10^{-7}
	Onsite	18	Working	24	432	18.1	7.82×10^{-5}
			Resting	24	432	0.2	8.64×10^{-7}
Survey Vessel	Mobilisation & demobilisation	35	Working	96	3,360	5.5	1.85×10^{-4}
			Resting	96	3,360	0.2	6.72×10^{-6}
	Transit to and from site	35	Working	24	840	5.5	4.62×10^{-5}
			Resting	24	840	0.2	1.68×10^{-6}
	Onsite	35	Working	24	840	5.5	4.62×10^{-5}
			Resting	24	840	0.2	1.68×10^{-6}
Helicopter	Take offs and landing events*	270	N/A	N/A	N/A	32	8.64×10^{-5}
	Transit to and from site	27	Travelling	9	243	97	7.78×10^{-5}
Articulated Lorry**	Transport metals to Recycler	1	Working	2,119	2,119	12.3	2.61×10^{-4}
PLL for Option							**1.67×10^{-2}**

N/A – Not applicable

A3.3 Assumptions

It is assumed that:

- The POBs on each vessel will equally be at risk during mobilisation, transit to site, transit to shore and demobilisation.
- Time during mobilisation, transit and demobilisation will be equally divided into working and off-duty time.
- Other than for divers when working on site and the truck driver, working and resting time for each of the activities has been equally apportioned.
- The 12 saturation divers will be equally at risk during the entire time spent on site to which a FAR of 97 for saturation diving will apply.

- A FAR of 12.3 (FAR for onshore deconstruction operations; Safetec, 1995) will apply to the onshore collection and transport of the recovered metals to disposal sites.
- FAR values for the CSV and rockdump vessel are based on those of a DSV FAR of 7.5 (working) and 0.2 (off-duty) hours
- POB values for the duration of work programme and the number of helicopter journeys have been provided by Endeavour engineers.
- A FAR of 1.1×10^{-5} will apply to each of the estimated 175 (Option 2) lifting operations by crane (Safetec, 1995).

A3.4 Comparison of Options

Table A3.3 ranks the two options in terms of safety risk. Note that the PLL value for Option 1 is 74% that of Option 2. With a more prolonged work programme involving more people working offshore (twice as many worker exposure hours), Option 2 has a higher inherent safety risk than Option 1, which requires fewer vessels and a shorter work programme.

Table A3.3: Ranking of the two options. Normalised Scores: 1 = lowest PLL; 0 = highest PLL

Option	PLL	Normalised Score	Weighted Score
1. Leave in Place	**1.16×10^{-2}**	1	1.8
2. Total Removal	**1.67×10^{-2}**	0	0

A3.5 References

Safetec, 1995. Risk Analysis of Decommissioning Activities. Joint Industry Project No. P20447. Doc No. ST-20447-RA-1-Rev03. Safetec UK Ltd, Aberdeen, UK.

APPENDIX 4: ASSESSMENT OF ENVIRONMENTAL AND SOCIETAL RISKS

A4.1 Introduction

This appendix provides the methodology and results of the qualitative assessment of environmental risk and societal risk. The assessment enabled a distinction to be made between four categories of risk: High, Medium, Low and Negligible. Differentiation between options was based on the total number and characteristics of High and Medium category risks. The results of environmental and societal components of the risk assessment were compared separately.

A4.2 Method

The assessment of each option:

1. Identified the activities/operations and end-points (final outcomes from the decommissioning process, e.g. waste in landfill) occurring within each option;
2. Identified potential causes of environmental and societal impact and risk associated with each activity/operation. Include operational and accidental/emergency events;
3. Identified receptors (elements of environment or society offshore and onshore) at risk from potential operational impacts and end-point impacts;
4. Assigned an index to the likelihood of occurrence using the criteria in Tables A4.1 and A4.2. The assessment assumed that all planned and standard controls were in place.
5. Assigned an index to the potential consequences using the criteria provided in Table A4.3
6. Determined the risk rating from the intersection of the likelihood and consequence indices in the risk matrix (Table A4.4). The risk rating is expressed as an identifier (e.g. C2) which corresponds to a unique position on the matrix.
7. Documented the results on the environmental or societal risk assessment worksheets and noted the reasons for the assessment made.

A4.3 Likelihood, Consequence and Risk Assessment Tables

The tables overleaf provide:

- Likelihood criteria environmental and societal risk arising during planned (normal) operations and unplanned (accidental and emergency) events (Table A4.1 and A4.2)
- Consequence criteria for environmental and societal risk (Table A4.3); and.
- Risk Assessment Matrix to assign a risk rating on the basis of the assessed probability and consequence (Table A4.4).

Table A4.1: Guidelines for assessing likelihood of occurrence of an impact upon a particular receptor resulting from the planned activities

↓ Decreasing likelihood	Likelihood		Frequency of planned activity impacting receptors during project lifetime
	A	Definite	Impact observed every time; might occur once a year or more on site
	B	Likely	Impact often observed; could happen several times in site life
	C	Possible	Impact occasionally observed; might happen in site life
	D	Unlikely	Impact rarely observed; has occurred only several times in industry
	E	Remote	Impact almost never observed; few if any events in industry

Table A4.2: Guidelines for assessing likelihood of occurrence of an impact resulting from unplanned / accidental activities

↓ Decreasing likelihood	Likelihood		Frequency of an unplanned or accidental event occurring and impacting receptors during project lifetime
	A	Likely	Might happen once a year on site; 1 per year
	B	Unlikely	Could happen several times in site life; 1 per 10 years
	C	Very unlikely	Might happen in site life; 1 per 100 years
	D	Extremely unlikely	Has occurred several times in industry; 1 per 1,000 years
	E	Almost unheard of	Few if any events in industry; 1 per 10,000 years

Table A4.3: Guidelines for assessing the magnitude / consequence of environmental and societal impacts

↓ Decreasing consequence	Magnitude / consequence		Characteristics
	5	Catastrophic	Adverse permanent impacts on key ecosystem functions in larger natural habitats or social and economic resources/assets, uses or activities. Scale typically widespread (national or greater level).
	4	Severe	Adverse long term impact on ecologically valuable natural habitats (e.g. restitution time >10 years), or social and economic resources, uses or activities. Scale typically regional to national level.
	3	Major	Adverse medium term impacts on a significant part of habitats (e.g. restitution time 1 to 10 years) or social and economic resources, uses or activities. Scale typically local to regional level.
	2	Moderate	Adverse short term impact on natural habitats or social and economic resources, uses or activities. Scale typically localised.
	1	Minor	Very limited adverse impact on natural habitats or social and economic resources, uses or activities. No impact on population, only on individual level. Typically transient and highly localised.

Table A4.4: Environmental and societal risk assessment matrix

		Planned	Accidental	Magnitude/consequence of impact (Table 3)				
				1 Minor	2 Moderate	3 Major	4 Severe	5 Catastrophic
Likelihood of occurrence (Table 1 and 2)	A	Definite	Likely	Low A1	Medium A2	Medium A3	High A4	High A5
	B	Likely	Unlikely	Low B1	Medium B2	Medium B3	High B4	High B5
	C	Possible	Very unlikely	Low C1	Low C2	Medium C3	High C4	High C5
	D	Unlikely	Extremely unlikely	Negligible D1	Low D2	Low D3	Medium D4	Medium D5
	E	Remote	Almost unheard of	Negligible E1	Negligible E2	Low E3	Low E4	Medium E5

A4.4 Results of the Assessment

The results of the assessments are provided in:

- Table A4.5: Option 1 – Leave in Place
- Table A4.6: Option 2 - Recovery for Disposal Onshore

Table A4.5: Environmental and Societal Risk Assessment for Option 1: Leave in Place

Operation or End-Point	Potential Impact	Physical and Chemical					Biological							Societal						No of Physical, Chemical and Biological Risks				Number of Societal Risks				Justification for Risk Ratings Assigned
		Sediment structure / chemistry	Water quality	Air quality	Land	Fresh-water	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Sea mammals	Seabirds	Integrity of ecosystems/ conservation sites	Terrestrial flora & fauna	Commercial fishing	Shipping	Other users of the sea	Onshore Communities	National & local government, institutional & commercial users	Infrastructure, recreation and amenity	Negligible	Low	Medium	High	Negligible	Low	Medium	High	
Planned Operations																												
Physical presence of DSV, CSV, rockdump vessel, guard vessel and survey vessels during transit between port and the offshore site	Obstruction to fishing vessels and shipping													D1	D1					0	0	0	0	2	0	0	0	• Localised transient impact. Shipping/ fishing traffic can readily navigate round the individual vessels as they travel to and from the offshore site. • Industry standard controls involving route-planning, navigation aids, communications and good seamanship.
Physical presence of DSV, CSV, rockdump vessel, guard vessel, survey vessel, ROVs, divers, dive bell, jetting and other equipment during operations at the offshore site	Obstruction to fishing vessels and shipping													C1	C1					0	0	0	0	0	2	0	0	• Localised transient impact. Shipping/ fishing traffic can readily navigate round the vessel spread at any given stage during the work programme. • Industry standard controls involving project planning, design and operational procedures, Notices to Mariners, 500 m safety zones around the Rubie wellhead and the RPM, navigation aids, communications, good seamanship and presence onsite of a guard vessel.
Underwater noise associated with vessel's engines, DP thrusters and equipment	Injury or disturbance to marine mammals, fish and seabirds								D1	B1	D1									2	1	0	0	0	0	0	0	• Continuous (rather than impulsive) source mainly from vessel's generators and cavitation from the thrusters, with potential for localised disturbance to sea mammals (avoidance behaviour), fish and birds. • Responses of sea mammals vary sea mammal and seabird avoidance reactions and attraction to vessels can both occur (Jacques Whitford, 2007). Injury unlikely. Limited information on fish. • Also small scale contributor to background underwater noise levels from vessel traffic in the sea area. • Industry standard controls based on maintenance and power management systems.
Underwater noise associated with the use of sonar and other survey equipment	Injury or disturbance to marine mammals, fish and seabirds								D1	C1	D1									2	1	0	0	0	0	0	0	• Higher frequency emissions utilised during surveys of this type tend to be dissipated to safe levels over a relatively short distance (DEHLG, 2007)*. Additionally sound is not within frequency range of the Marine Strategy Framework Directive indicator for loud, low and mid-frequency sounds (Genesis, 2011).

Operation or End-Point	Potential Impact	Physical and Chemical					Biological							Societal						No of Physical, Chemical and Biological Risks				Number of Societal Risks				Justification for Risk Ratings Assigned
		Sediment structure / chemistry	Water quality	Air quality	Land	Fresh-water	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Sea mammals	Seabirds	Integrity of ecosystems/ conservation sites	Terrestrial flora & fauna	Commercial fishing	Shipping	Other users of the sea	Onshore Communities	National & local government, institutional & commercial users	Infrastructure, recreation and amenity	Negligible	Low	Medium	High	Negligible	Low	Medium	High	
Operational discharges of treated oily bilge	Deterioration in water quality		A1					D1	D1											2	1	0	0	0	0	0	0	• Localised transient impact from permitted discharge dissipating to background concentrations within relatively short distance. • Industry standard controls based on separation systems for oil recovery from bilge with discharges within permitted levels of 15ppm.
Sewage and grey water discharges	Deterioration in water quality		A1					D1	D1											2	1	0	0	0	0	0	0	• Localised transient impact around discharge point. • Discharged material disperses and degrades naturally. • Industry standard controls based on discharge of screened, materials as minimum requirement.
Macerated food waste discharge	Deterioration in water quality		A1					D1	D1											2	1	0	0	0	0	0	0	• Localised transient impact around the discharge point. • Discharged material disperses and degrades naturally. • Industry standard controls based on the maceration of organic food waste prior to discharge.
Ballast water uptake and discharge	Risk of transfer of non-native species (if vessels not routinely working in UK/ N. European waters)											E3								0	1	0	0	0	0	0	0	• Remote probability of introduction of non-native species as a result of ballasting of project vessels. • Project vessels will originate from northern European waters. • Ballasting operations will be managed in line with IMO guidelines.
Atmospheric emissions from generators and engines of project vessels	Deterioration in air quality and contribution to global atmospheric impacts			A1																0	1	0	0	0	0	0	0	• Small-scale contributor of GHGs and other global gases. • Localised transient impact in the vicinity of the exhausts. • Emissions disperse in exposed offshore environment. • Industry standard controls based on low sulphur diesel, power management systems, route planning and maintenance.
Atmospheric emissions from engines of helicopters for personnel transport	Deterioration in air quality and contribution to global atmospheric impacts			A1																0	1	0	0	0	0	0	0	• Small-scale contributor of GHGs and other global gases. • Localised transient impact in the vicinity of the exhausts. • Emissions disperse during flight and the exposed offshore environment. • Industry standard controls based on routine and planned maintenance.
Operational wastes from vessels	Use of waste disposal resources and landfill capacity																		A1	0	0	0	0	0	1	0	0	• Small-scale use of landfill capacity for non-reusable and non-recyclable wastes. • Industry standard controls in classification, segregation, containment, permits and traceable chain of custody for waste management, shipment, treatment and disposal.

Operation or End-Point	Potential Impact	Physical and Chemical					Biological							Societal						No of Physical, Chemical and Biological Risks				Number of Societal Risks				Justification for Risk Ratings Assigned
		Sediment structure / chemistry	Water quality	Air quality	Land	Fresh-water	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Sea mammals	Seabirds	Integrity of ecosystems/ conservation sites	Terrestrial flora & fauna	Commercial fishing	Shipping	Other users of the sea	Onshore Communities	National & local government, institutional & commercial users	Infrastructure, recreation and amenity	Negligible	Low	Medium	High	Negligible	Low	Medium	High	
Discharge of treated linefill from pipelines	Deterioration of water quality	B1	B1					B1												0	3	0	0	0	0	0	0	•Planned discharge of permitted chemicals. E.g. Oxygen scavenger, biocide and corrosion inhibitor governed by a PON15C. •Localised deterioration in water quality around the discharge plume potentially causing localised impacts to benthic and planktonic organisms.
Displacement of seabed sediments during seabed jetting/ excavation and preparation of trench transitions	Seabed and water column impacts	A1	A1				A1													0	3	0	0	0	0		0	• Sediment displacement will occur in localised area of seabed around the trench transitions which will subsequently be covered by rock dump. • It is likely that mortality of a proportion of the benthic organisms in the affected area would occur during sediment displacement. • Resuspended sediments would cause a transient, localised turbidity in the water column.
Unplanned Operations																												
Vessel-to-vessel collision causing loss mainly of diesel fuel and lubricants	Marine pollution		C2		E1				D2	D2	C2	E1		C2	D1					2	4	0	0	1	1	0	0	• Marine pollution (mainly on sea surface) caused by spilled diesel, a light refined product that would rapidly evaporate and dissipate. Impacts short-lived and unlikely to be widespread. • Industry standard controls based on vessel selection, route planning, communication, navigational aids, seamanship, maintaining condition of vessel and shipboard spill prevention and response measures. • Mitigation and response governed by Shipboard Oil Pollution Emergency Plan and Operator's Oil Pollution Emergency Plan.
Vessel-to-vessel collision causing vessel to sink	Seabed and societal impacts	D2					D2							D2	D2					0	2	0	0	0	2	0	0	• Given location and depth, it is possible that a wreck would be salvaged; other vessels would be able to replace the lost resource. • Marine pollution may occur (see above). • Industry standard controls based on vessel selection, route planning, simultaneous operations procedures, communication, navigational aids, seamanship, maintaining condition of vessel and having a guard vessel on station throughout the offshore operations.

Planned End-Points																												
Long-term presence of c.16,830 tonnes of graded rockdump (typically granite) on the seabed	Changes in seabed habitat	A2					A2					E1								0	0	2	0	1	0	0	0	• Placement of the protective cover of rock dump over the pipeline ends and other vulnerable areas will create a long-term modification of the localised area of seabed (approx. 0.113 km^2). This material will provide a habitat that will be colonised by organisms which occur in the North Sea but typically live on, around or within crevices in rocky, rather than sedimentary substrata. • The ecological impact would be limited to the relatively small (0.0113 km²) and well defined rock dumped area. The volume of rockdump will amount to a volume of approx. 9,388 m^3 and an estimated mass of 16,898 tonnes. •The profile of the rockdump is likely to flatten over the long-term (hundreds of years) as a result of natural processes of erosion and sediment deposition. • Deposition of the material will be controlled by the rock dump vessel's manoeuvrable fall-pipe and will be monitored by ROV.
Long-term presence of c.16,830 tonnes of graded rockdump (typically granite) on the seabed	Obstruction to fishing													C2						0	0	0	0	0	1	0	0	• The profile of the protective rockdump will have a 1:3 slope which will enable it to be overtrawlable and the quantity of rockdump will be consistent with the requirement for long-term protection of the pipelines. • This assessment is based on rock dump continuing to remain overtrawlable and provide effective protection, and effective monitoring and remedial intervention in the event of failure.
Long-term presence of six pipelines and two umbilicals, representing 6,709 tonnes of material	Changes in seabed chemistry and habitat	A 1	A1				A1													0	3	0	0	0	0	0	0	• The pipelines and umbilicals lie within six separate trenches, with a total length of approx. 98 km. These are buried to 0.6 m under a covering of natural seabed sediments with rockdump placed over line ends and rockdump placed over vulnerable areas. • The burial depth of the pipeline lies within an abiotic sediment zone, i.e. no infaunal species are found below *c* 30 cm burial depth. • The pipelines are likely to remain intact for a period spanning many decades (>60 years; HSE, 1997). • Structural degradation of the lines will be long-term process caused by corrosion of the steel and other metal components and break-down of plastics, leading initially to a release of residual content (line-fill and oily residues not removed during flushing). • The oil release, release of line-fill and dissolution of metals to the surrounding water column and sediment around the lines will occur so slowly that environmental impact is likely to be negligible. Corrosion of the structural steel will form ferric hydroxide (rust) which is relatively insoluble and environmentally benign. • Eventually the lines will collapse under their own weight and that of the overlying sediment and rock dump, leaving behind a residue of inert broken-up fragments and corrosion products, embedded within the seabed sediments.
Unplanned End-Points																												
Unrecoverable dropped object on seabed	Impacts to sea users benthic organisms	D1					D1							D1						2	0	0	0	1	0	0	0	• Unintentionally dropped objects will be recovered to the DSV or CSV prior to completion of the work and an as-left survey by ROV will confirm that the seabed is clear of obstructions.
Emergence of lines above seabed level	Snagging hazard for fishing gear													C3						0	0	0	0	0	0	1	0	• Unlikely to be an issue if the lines remain buried within seabed sediments and rockdump. However, pipeline exposure with significant spans has historically occurred as a result of seabed sediment movement on the Rubie/ Renee pipelines. • As-left surveys will ensure that the lines are adequately buried and protected. • Post-decommissioning monitoring programme. • Remedial intervention in the event of lines becoming exposed.
TOTAL NUMBER OF ENVIRONMENTAL AND SOCIETAL RISKS IN EACH CATEGORY																				**14**	23	2	0	**5**	7	1	0	

Table A4.6: Environmental and Societal Risk Assessment for Option 2: Recovery for Disposal Onshore

Operation or End-Point	Potential Impact	Physical and Chemical					Biological							Societal						Number of Physical, Chemical and Biological Risks				Number of Societal Risks				Justification for Risk Ratings Assigned
		Sediment structure / chemistry	Water quality	Air quality	Land	Fresh-water	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Sea mammals	Seabirds	Integrity of ecosystems/ conservation sites	Terrestrial flora & fauna	Commercial fishing	Shipping	Other users of the sea	Onshore Communities	National & local government, institutional & commercial users	Infrastructure, recreation and amenity	Negligible	Low	Medium	High	Negligible	Low	Medium	High	
Planned Operations																												
Physical presence of DSV, CSV, rockdump vessel, guard vessel and survey vessels during transit between port and the offshore site	Obstruction to fishing vessels and shipping													D1	D1					0	0	0	0	2	0	0	0	• Localised transient impact. Shipping/ fishing traffic can readily navigate round the individual vessels as they travel to and from the offshore site. • Industry standard controls involving route-planning, navigation aids, communications and good seamanship.
Physical presence of DSV, CSV, rockdump vessel, guard vessel, survey vessel, ROVs, divers, dive bell, jetting and other equipment during operations at the offshore site	Obstruction to fishing vessels and shipping													C1	C1					0	0	0	0	0	2	0	0	• Localised transient impact. Shipping/ fishing traffic can readily navigate round the vessel spread at any given stage during the work programme. • Industry standard controls involving project planning, design and operational procedures, Notices to Mariners, 500 m safety zones around the Rubie wellhead and the RPM, navigation aids, communications, good seamanship and presence onsite of a guard vessel.
Underwater noise associated with vessel's engines, DP thrusters and equipment	Injury or disturbance to marine mammals, fish and seabirds								D1	B1	D1									2	1	0	0	0	0	0	0	• Continuous (rather than impulsive) source mainly from vessel's generators and cavitation from the thrusters, with potential for localised disturbance to sea mammals (avoidance behaviour), fish and birds. • Responses of sea mammals vary. Sea mammal and seabird avoidance reactions and attraction to vessels can both occur (Jacques Whitford, 2007). Injury unlikely. Limited information on fish. • Also small scale contributor to background underwater noise levels from vessel traffic in the sea area. • Industry standard controls based on maintenance and power management systems.
Underwater noise associated with the use of sonar and other survey equipment	Injury or disturbance to marine mammals, fish and seabirds								D1	C1	D1									2	1	0	0	0	0	0	0	• Higher frequency emissions utilised during surveys of this type tend to be dissipated to safe levels over a relatively short distance (DEHLG, 2007)*. Additionally sound is not within the frequency range of the Marine Strategy Framework Directive indicator for loud, low and mid-frequency sounds (Genesis, 2011).
Operational discharges of treated oily bilge	Deterioration in water quality		A1					D1	D1											2	1	0	0	0	0	0	0	• Localised transient impact from permitted discharge dissipating to background concentrations within relatively short distance. • Industry standard controls based on separation systems for oil recovery from bilge with discharges within permitted levels of 15ppm.

Operation or End-Point	Potential Impact	Physical and Chemical					Biological							Societal						Number of Physical, Chemical and Biological Risks				Number of Societal Risks				Justification for Risk Ratings Assigned
		Sediment structure / chemistry	Water quality	Air quality	Land	Fresh-water	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Sea mammals	Seabirds	Integrity of ecosystems/ conservation sites	Terrestrial flora & fauna	Commercial fishing	Shipping	Other users of the sea	Onshore Communities	National & local government, institutional & commercial users	Infrastructure, recreation and amenity	Negligible	Low	Medium	High	Negligible	Low	Medium	High	
Sewage and grey water discharges	Deterioration in water quality		A1					D1	D1											2	1	0	0	0	0	0		• Localised transient impact around discharge point. • Discharged material disperses degrades naturally. • Industry standard controls based on discharge of screened, materials as minimum requirement.
Macerated food waste discharge	Deterioration in water quality		A1					D1	D1											2	1	0	0	0	0	0	0	• Localised transient impact around the discharge point. • Discharged material disperses and degrades naturally. • Industry standard controls based on the maceration of organic food waste prior to discharge.
Ballast water uptake and discharge	Risk of transfer of non-native species (if vessels not routinely working in UK/ N. European waters)											E3								0	1	0	0	0	0	0	0	• Remote probability of introduction of non-native species as a result of ballasting of project vessels. • Project vessels will originate from northern European waters. • Ballasting operations will be managed in line with IMO guidelines.
Atmospheric emissions from generators and engines of project vessels	Deterioration in air quality and contribution to global atmospheric impacts			A1																0	1	0	0	0	0	0	0	• Small-scale contributor of GHGs and other global gases. • Localised transient impact in the vicinity of the exhausts. • Emissions disperse in exposed offshore environment. • Industry standard controls based on low sulphur diesel, power management systems, route planning and maintenance.
Atmospheric emissions from engines of helicopters for personnel transport	Deterioration in air quality and contribution to global atmospheric impacts			A1																0	1	0	0	0	0	0	0	• Small-scale contributor of GHGs and other global gases. • Localised transient impact in the vicinity of the exhausts. • Emissions disperse during flight & the exposed offshore environment. • Industry standard controls based on routine & planned maintenance.
Operational wastes from vessels	Use of waste disposal resources and landfill capacity																		A1	0	0	0	0	0	1	0	0	• Small-scale use of landfill capacity for non-reusable and non-recyclable wastes. • Industry standard controls in classification, segregation, containment, permits and traceable chain of custody for waste management, shipment, treatment and disposal.

Operation or End-Point	Potential Impact	Physical and Chemical					Biological							Societal						Number of Physical, Chemical and Biological Risks				Number of Societal Risks				Justification for Risk Ratings Assigned
		Sediment structure / chemistry	Water quality	Air quality	Land	Fresh-water	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Sea mammals	Seabirds	Integrity of ecosystems/ conservation sites	Terrestrial flora & fauna	Commercial fishing	Shipping	Other users of the sea	Onshore Communities	National & local government, institutional & commercial users	Infrastructure, recreation and amenity	Negligible	Low	Medium	High	Negligible	Low	Medium	High	
Displacement of seabed sediments during: (a) excavation by divers or ROV using trenching or jetting methods to expose pipelines ends, (b) attachment of recovery heads by divers, (c) back-reeling of lines; (d) cut and lift operations and (e) backfilling of trenches	Seabed and water column impacts	A1	A1				A2													0	2	1	0	0	0	0	0	• Sediment displacement will occur in an area of approx. 3.904 km². Naturally occurring sediments will be displaced; although a relatively small area of seabed may be contaminated with residues from low toxicity oil based drilling muds (no OBM was used) in the immediate vicinity of the two Renee and one Rubie wells. • It is likely that mortality of a proportion of the benthic organisms would occur during sediment displacement. However, sediment structure and composition would be unaffected and natural recolonisation would occur within a relatively short timescale following backfilling (OSPAR, 2009). • Resuspended sediments would cause a transient, localised turbidity in the water column. •No Annex I habitats or other conservation features occur within the vicinity of the pipelines.
Cutting using diamond wire or hydraulic scissor snips	Seabed and water column impacts	A1	A1				A1													0	3	0	0	0	0	0	0	•Release of relatively small quantities of metal and plastic particles, which will fall to the seabed and become incorporated into the seabed sediments. The effect will be highly localised.
Unspooling pipeline and cutting at quayside	Atmospheric emissions and noise			A1													A1			0	1	0	0	0	1	0	0	• Unspooling and cutting will be done at the spool base which is managed according to the site's integrated pollution prevention and control permit. The permit includes limits and controls relating to atmospheric emissions and noise. •Oxyacetylene cutting or hydraulic shears will be used to cut the unspooled pipeline into manageable sections. • Noise will be intermittent and will contribute to the background levels at the site which will be routinely monitored. • Exhaust gases from generators or engines powering cutting equipment will cause a localised deterioration in air quality around the exhaust outlet and will be a small-scale contributor to GHGs and other global gases. • Mitigation is by adherence to permit limits and maintenance of the equipment and plant.
Transportation of recovered material from the quayside to landfill site for disposal onshore	Deterioration in air quality and contribution to global atmospheric impacts			A1																0	1	0	0	0	0	0	0	• Small-scale contributor of GHGs and other global gases. • Localised transient impact in the vicinity of the exhausts. • Emissions disperse during transit. • Industry standard controls based on routine & planned maintenance.

Operation or End-Point	Potential Impact	Physical and Chemical					Biological							Societal						Number of Physical, Chemical and Biological Risks				Number of Societal Risks				Justification for Risk Ratings Assigned
		Sediment structure / chemistry	Water quality	Air quality	Land	Fresh-water	Sediment biology (benthos)	Water column (plankton)	Finfish and shellfish	Sea mammals	Seabirds	Integrity of ecosystems/ conservation sites	Terrestrial flora & fauna	Commercial fishing	Shipping	Other users of the sea	Onshore Communities	National & local government, institutional & commercial users	Infrastructure, recreation and amenity	Negligible	Low	Medium	High	Negligible	Low	Medium	High	
Transportation of recovered material from the quayside to landfill site for disposal onshore	Contribution to congestion/ traffic nuisance																B1		B2	0	0	0	0	0	1	1	0	• An estimated 6,709 tonnes of redundant pipeline will require to be transported to suitable recycling/ waste disposal sites. • Road haulage by articulated lorries is standard practice on the UK transport network. • Wide loads are not anticipated. • Route planning is carried out and the majority of journeys. Long journeys would be required for the transport of pipeline materials between, for example, a spool base located in northern Scotland and a suitable recycling facility in the .central-belt (round trip c. 600 km). • This assessment accounts for the increased likelihood of traffic congestion and other nuisance occurring during the transportation of relatively large quantities of material over long distances on routes which pass through a few rural communities.
Unplanned Operations																												
Vessel-to-vessel collision causing loss mainly of diesel fuel and lubricants	Marine pollution		C2		E1				D2	D2	C2	E1		C2	D1					2	4	0	0	1	1	0	0	• Marine pollution (mainly on sea surface) caused by spilt diesel, a light refined product that would rapidly evaporate and dissipate. Impacts short-lived and unlikely to be widespread. • Industry standard controls based on vessel selection, route planning, communication, navigational aids, seamanship, maintaining condition of vessel and shipboard spill prevention and response measures. • Mitigation and response governed by Shipboard Oil Pollution Emergency Plan and Operator's Oil Pollution Emergency Plan.
Vessel-to-vessel collision causing vessel to sink	Seabed and societal impacts	D2					D2							D2	D2					0	2	0	0	0	2	0	0	• Given the location and depth, it is possible that the wreck would be salvaged. Other vessels would be available to replace the lost resource. • Marine pollution may occur (see above). •Industry standard controls based on vessel selection, route planning, simultaneous operations procedures, communication, navigational aids, seamanship, maintaining condition of vessel and having a guard vessel on station throughout the offshore onsite operations.

Planned End-Points																												
Recycling of pipeline components	Atmospheric emissions			A2																0	0	1	0	0	0	0	0	•Materials would be re-used or recycled where possible, thereby minimising landfill requirements. •Compliance with UK waste legislation and Duty of Care. •Use of designated licensed sites only. •Strict compliance with legislation on wastes and emissions. •Environmental limits and controls specified in the UK Pollution Prevention and Control (PPC) Permit/ Integrated Pollution Prevention and Control (IPPC). •Permit for the processes occurring at the site. Other European states have similar permitting requirements.
Unplanned End-Points																												
Unrecoverable dropped object on seabed	Obstruction to sea users and impacts to benthic organisms	D1					D1							D1						2	0	0	0	1	0	0	0	• Unintentionally dropped objects will be recovered to the DSV or CSV prior to completion of the work and an as-left survey by ROV will confirm that the seabed is clear of obstructions.
TOTAL NUMBER OF ENVIRONMENTAL AND SOCIETAL RISKS IN EACH CATEGORY																				**14**	21	2	0	**4**	8	1	0	

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A4.5 Comparison of Options

Table A4.7 lists the total numbers of each category for the two options. Table A3.8 provides a comparison of the options using the total numbers of Medium category risks. This group represents risks which are generally considered to be tolerable.

Table A4.7: Numbers of environmental and societal risks in each category

Option	Number of Environmental Risks				Number of Societal Risks			
	Negligible	Low	Medium	High	Negligible	Low	Medium	High
1. Leave in Place	14	23	2	0	5	7	1	0
2. Recovery for Disposal Onshore	14	21	2	0	4	8	1	0

No High category risks (generally considered to be unacceptable) were identified during the assessment. Negligible and Low category risks (both generally considered to be acceptable) were excluded from the comparison. The numbers of marine and onshore risks were combined.

Table A4.8 shows that Option 1 had two benign, long–term Medium environmental risks and Option 2 also had two risks, but this time short-term and more disruptive. The environmental risks associated with Option 1 (leave in place) are thought to be:

- The long term presence of rockdump and the associated impacts on sediment structure and chemistry
- The long term presence of rockdump and the associated impacts on sediment biology

The environmental risks associated with Option 2 are thought to be:

- Displacement of seabed sediments during: (a) excavation by divers or ROV using trenching or jetting methods to expose pipelines ends, (b) attachment of recovery heads by divers, (c) back-reeling of lines; (d) cut and lift operations and (e) backfilling of trenches and the associated impact on sediment biology
- Recycling of pipeline components and the associated impact on air quality

Both options had one Medium societal risk. The societal risk associated with Option 1 is:

- The potential for buried lines to become uncovered sometime in the future, creating a potential obstruction on the seabed

The societal risk associated with Option 2 is:

- The transportation of the pipeline components and the associated impact on the road network

Table A4.8: Ranking of the options in order of the total numbers of Medium category risks (Normalised score: 1 = fewest risks; 0 = most risks)

Option		Environmental Risks			Societal Risks		
		Total Number	Normalised Score	Weighted Score	Total Number	Normalised Score	Weighted Score
1	Leave in Place	2	1	0.9	1	1	0.6
2	Recovery for Disposal Onshore	2	1	0.9	1	1	0.6

A4.6 References

DEHLG, 2007. Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters. Version 1.1. August 2007. Department of the Environment, Heritage and Local Government, Dublin, Ireland. http://www.npws.ie/media/npws/publications/marine/media,5176,en.pdf

Genesis, 2011. Review and Assessment of Underwater Sound Produced from Oil and Gas Sound Activities and Potential Reporting Requirements under the Marine Strategy Framework Directive. 2011. Genesis Oil and Gas Consultants report for the Department of Energy and Climate Change. Genesis Oil and Gas Consultants, Aberdeen, UK.

HSE, 1997. The Abandonment of Offshore Pipelines. Report for the Health and Safety Executive by John Brown Engineers and Constructors Ltd. Offshore Technology Report OTH 535. HSE Books, Norwich, UK. ISBN 0-7176-1421-2.

Jacques Whitford, 2007. Sydney Basin Strategic Environmental Assessment, Report JWL 1014038 January 2007. Jacques Whitford AXYS Ltd, Sidney, British Columbia, Canada. http://www.cnlopb.nl.ca/pdfs/sea_sb/sbchap5.pdf

OSPAR, 2009. Assessment of impacts of offshore oil and gas activities in the North-East Atlantic. OSPAR Commission, London, 39 pages, Publication Number: 453/2009. ISBN 978-1-906840-93-8.

APPENDIX 5: ENERGY USAGE AND EMISSIONS ESTIMATES

A5.1 Introduction

This section presents the quantitative estimates of energy usage emissions that provide the basis for differentiating between the two options for decommissioning the Rubie/ Renee subsea infrastructure. The method follows that given in the Guidelines for Calculation of Energy Use and Gaseous Emissions in Decommissioning (IoP, 2000).

A5.2 Assessment Method

The total quantities of energy usage and CO_2 emissions were calculated by:

a) Estimating quantities of diesel fuel consumed by vessels involved in the work programmes offshore (Options 1 and 2);

b) Estimating quantities of diesel consumed during the haulage onshore of the redundant materials to landfill or recycling facilities (Option 1 and 2);

c) Estimating quantities of aviation fuel used for helicopter operations (Options 1 and 2)

d) Estimating quantities of materials required hypothetically for the manufacture of new materials equivalent to the materials lost to society by leaving material *in situ* in the seabed (Option 1 only) or by disposal to landfill (Options 1 and 2).

e) Estimating the energy required for the recycling of pipeline materials (Option 2 only)

f) Multiplying these quantities by energy content and emissions factors which are provided in tables A5.1 and A5.2:

Table A5.1: Conversion factors for fuels

Fuel type	Energy consumption (GJ/tonne)	CO_2 Emissions (tonne CO_2/ tonne)	Source*
Marine diesel fuel	43.1	3.2	IoP (2000)
Aviation fuel	46.1	3.2	IoP (2000)
DERV	44.0	3.2	DEFRA/DECC 2011

Table A5.2: Conversion factors for recycling and manufacture of replacement materials

Material	Recycling		New Manufacture		Source*
	Energy consumption (GJ/tonne)	CO_2 Emissions (tonne CO_2/tonne)	Energy consumption (GJ/tonne)	CO_2 Emissions (tonne CO_2/tonne)	
Standard steel	9	0.96	25	1.889	IoP (2000)
Aluminium	15	1.080	215	3.589	IoP (2000)
Copper	25	0.300	100	7.175	IoP (2000)
Zinc	10	0.480	65	0.024	University of Bath (2008)
Plastics*	20	0.693	105	3.179	Harvey (2010); DEFRA/DECC(2011)

* Mid-range energy consumption for 'Plastics' from Harvey (2010); CO_2 expressed as CO_2 equivalent emissions from open loop manufacture of plastics from recycled and raw materials from DEFRA/DECC 2011

A5.3 Results of the Assessment

A5.3.1 Option 1: Leave in Place

Table A5.3 provides the results of the assessment. It is assumed that:

- Energy usage and emissions would originate principally from two sources: (1) combustion of diesel fuel by the six vessels involved in rock dump and survey operations and (2) the hypothetical manufacture of new materials to replace those lost to society because the pipelines have been left in place buried in seabed sediments;
- Total time spent mobilising, transiting, onsite and demobilising by the vessels would be a maximum of 233 days;
- Fuel consumption rates have been taken from IoP (2000) guidelines

Table A5.3 provides the results to the energy usage and emissions calculations for Option 1. In line with DECC Decommissioning Guidance (DEFRA/ DECC, 2011), energy usage is expressed as GJ and gaseous emissions are expressed as tonnes of CO_2.

Table A5.3: Energy Usage and Emissions for Option 1: Leave in Place

Activity	Duration (day)	Fuel Consumption Rate (tonne/day)	Fuel Consumed (tonne)	Energy Usage (GJ)	CO_2 (tonne)
Calculation 1: DSV Operation					
Mobilisation and demobilisation	4	3	12	517	38
Transit to and from Site	1	22	22	948	70
Working on Site	13	18	234	10,085	749
Subtotal				**11,551**	**858**

Calculation 2: CSV Operation					
Mobilisation and demobilisation	4	3	12	517	38
Transit to and from Site	1	27	27	1,164	86
Working on Site	13	12	156	6,724	499
Subtotal				**8,405**	**624**
Calculation 3: Rock Dump Vessel Operation					
Mobilisation and demobilisation	4	2	8	345	26
Transit to and from Site	1	8	8	345	26
Working on Site	4	15	60	2,586	192
Subtotal				**3,276**	**243**
Calculation 4: Guard Vessel Operation					
Mobilisation and demobilisation	N/A	N/A	N/A	N/A	N/A
Transit to and from Site	1	12	12	517	38
Working on Site	21	4	84	3,620	269
Subtotal				**4,138**	**307**
Calculation 5: Fishing Trawler Operation					
Mobilisation and demobilisation	N/A	N/A	N/A	N/A	N/A
Transit to and from Site	1	5	5	216	16
Working on Site	2	5	10	431	32
Subtotal				647	48
Calculation 6: Survey Vessel Operation					
Mobilisation and demobilisation	8	2	16	690	51
Transit to and from Site	2	24	48	2,069	154
Working on Site	2	15	30	1,293	96
Subtotal				**4,051**	**301**
*Calculation 7: Helicopter Operations***					
Activity	Duration (hours)	Fuel Consumption Rate (tonne/hour	Fuel Consumed (tonne)	Energy Usage (GJ)	CO_2 (tonne)
Transport of personnel to and from the vessels at the offshore location	8	0.800	0.064	3	0.20
Subtotal				**3**	**0.20**

Calculation 8: Manufacture of Replacement Materials					
Replacement by new materials equivalent to:	Materials		Total Weight of Materials (tonne)	Energy Usage (GJ)	CO_2 (tonne)
Pipelines remaining *in situ*	Steel		5,359.8	133,996	10,125
	Aluminium		54.7	11,765	196
	Copper		13.8	1,378	98.872
	Plastics		1,096.0	115,080	3,484
Subtotal				**262,218**	**13,904**
TOTAL FOR OPTION				**294,288**	**16,285**

* The CA assumes that road haulage will be used, where a 33 tonne capacity articulated lorry with a 46 litres/100km fuel consumption (DECC/DEFRA, 2011) makes a 600km round trip for each load of pipeline materials for recycling (e.g. a round trip from a spool base in Northern Scotland to a recycling facility in the Scottish Central Belt).

** Assumes 24 (Option 1) and 28 (Option 2) flights of 150 km distance in a helicopter with a cruise speed of 250 km/hr (Eurocopter, 2013) and a fuel consumption of 0.8 tonne per hour (IoP, 2000)

A5.3.2 Option 2: Recovery for Disposal Onshore

Table A5.4 provides the results of the assessment. It is assumed that:

- Energy usage and emissions would originate principally from four sources: combustion of fuel (1) by the vessels (2) by the lorry used to transport the material to the landfill site (3) from the energy use and emissions generated during the recycling of the pipeline component materials; and (4) from the hypothetical manufacture of new materials to replace those lost to society if resources are sent to landfill.
- Total time spent mobilising, transiting, onsite and demobilising by the vessels would be a maximum of 214 days;
- Fuel consumption rates have been taken form IoP (2000) guidelines

Table A5.4 provides the results to the energy usage and emissions calculations for Option 2.

Table A5.4: Energy Usage and Emissions for Option 2: Recovery for Disposal Onshore

Activity	Duration (day)	Fuel Consumption Rate (tonne/day)	Fuel Consumed (tonne)	Energy Usage (GJ)	CO_2 (tonne)
Calculation 1: DSV Operation					
Mobilisation and demobilisation	4	3	12	517	38
Transit to and from Site	1	22	22	948	70
Working on Site	17	18	306	13,189	979
Subtotal				**14,654**	**1,088**

Calculation 2: CSV Operation					
Mobilisation and demobilisation	4	3	12	517	38
Transit to and from Site	1	27	27	1,164	86
Working on Site	13	12	156	6,724	499
Subtotal				**8,405**	**624**
Calculation 3: Reel Vessel Operation					
Mobilisation and demobilisation	9	3	27	1,164	86
Transit to and from Site	4	19	76	3,276	243
Working on Site	10	19	190	8,189	608
Subtotal				**12,628**	**938**
Calculation 4: Jetting Vessel/Trencher Operation					
Mobilisation and demobilisation	4	2	8	345	26
Transit to and from Site	1	8	8	345	26
Working on Site	20	15	300	12,930	960
Subtotal				**13,620**	**1,011**
Calculation 5: Guard Vessel Operation					
Mobilisation and demobilisation	N/A	N/A	N/A	N/A	N/A
Transit to and from Site	1	12	12	517	38
Working on Site	25	4	100	4,310	320
Subtotal				**4,827**	**358**
Calculation 6: Fishing Trawler Operation					
Mobilisation and demobilisation	N/A	N/A	N/A	N/A	N/A
Transit to and from Site	1	5	5	216	16
Working on Site	2	5	10	431	32
Subtotal				**647**	**48**
Calculation 7: Survey Vessel Operation					
Mobilisation and demobilisation	4	2	8	345	26
Transit to and from Site	2	24	48	2,069	154
Working on Site	2	15	30	1,293	96
Subtotal				**3,707**	**275**
Calculation 8: Road Haulage Vehicle Operation					
Activity	**Distance (km)**	**Fuel Consumption Rate (tonne/100km)**	**Fuel Consumed (tonne)**	**Energy Usage (GJ)**	**CO_2 (tonne)**
Transport of 6,166.2 tonne of redundant pipelines*	105,938	0.039	41.32	1,818	132
Subtotal				**1,818**	**132**

Calculation 9: Helicopter Operations					
Activity	**Duration (hours)**	**Fuel Consumption Rate (tonne/hour)**	**Fuel Consumed (tonne)**	**Energy Usage (GJ)**	**CO_2 (tonne)**
Transport of personnel to & from vessels at offshore location	10	0.800	0.08	4	0.26
Subtotal				**4**	**0.26**
Calculation 10: Recycling of Pipeline Materials					
Materials Recycled	**Total Weight of Materials (tonne)**		**Total Weight of Materials (tonne)**	**Energy Usage (GJ)**	**CO_2 (tonne)**
All of the material from the four recovered lines (100% recycling provides worst case scenario for energy usage and emissions)	Steel		5,359.8	48,239	5,145
	Aluminium		54.7	821	59
	Copper		13.8	345	4
	Plastics		1,096.0	21,920	760
Subtotal				**71,324**	**5,968**
TOTAL FOR OPTION				**131,632**	**10,443**

A5.4 Comparison of Options

Table A5.5 provides a comparison of the two options. The results indicate that energy usage for Option2 is 47% that of Option 1, and that CO_2 emissions for Option 2 represent 69% of those for Option 1.

Table A5.5 Comparison of energy usage and CO_2 emissions (Normalised Score: 1= lowest energy usage and emissions; 0 = highest values)

Option	Energy Usage (GJ)	CO_2 (tonne)	Normalised Score
1. Leave in Place	294,288	16,285	0
2. Total Removal	131,632	10,443	1

A3.5 References

DEFRA/DECC, 2011. Guidelines to DERFA/DECC's Greenhouse Gas Conversion factors for Company Reporting. Produced by AEA for the Department of Energy and Climate Change (DECC) and the Department for Environment, Food and Rural Affairs (Defra). www.gov.uk/government/uploads/system/aggachment data/file/69544/pb13773-ghg-conversion-factors-2012.pdf

Harvey, L.D.D. (2010). Energy Efficiency and Demand for Energy Services. Energy and the New Reality 1. Earthscan Ltd. Cromwell Press, London, UK. ISBN: 978-1-84971-912-5

Eurocopter (2013). Profile for Superpuma helicopter. http://www.eurocopter.com/site/en/ref/ Characteristics111.html (accessed Aug 2013)

Institute of Petroleum (2000). Guidelines for the calculation of estimates of energy use and emissions in the decommissioning of offshore structures.

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APPENDIX 6: COST ESTIMATES

Note that this appendix contains commercially sensitive, confidential data which Endeavour will only make available to DECC. Costs are therefore omitted from this version of and are submitted to DECC under cover of a separate letter.

A6.1 Introduction

This appendix provides cost estimates for the two options which were mainly based on Endeavour's knowledge for the current (August 2013) market rates for specialist vessels.

A6.2 Estimated Costs

Tables A6.1 and A6.2 respectively provide cost estimates for Options 1 and 2.

Table A6.1 Cost estimate for Option 1: Leave in Place

Item	Number	Rate	Cost
DSV: Days chartered			
CSV/supply boat: Days chartered			
Rockdump vessel: Days chartered			
Guard vessel: Days chartered			
Fishing trawler: Days chartered			
Survey vessel: Days chartered			
Helicopter: Hours chartered			
MCAA licence fee(DEFRA, 2011)			
Contingency for future surveys and seabed remediation			
TOTAL			

Table A6.2: Cost estimate for Option 2: Recovery for Disposal Onshore

Item	Number	Rate	Cost
DSV: Days chartered			
CSV/supply boat: Days chartered			
Reel vessel: Days chartered			
Jetting vessel/trencher: Days chartered			
Guard vessel: Days chartered			
Fishing trawler: Days chartered			
Survey vessel: Days chartered			
Helicopter: Hours chartered			
Spool base: Mobilisation charge			
Recycling/disposal of pipelines: tonne			
MCAA licence fee (DEFRA, 2011)			
Contingency for future surveys and seabed remediation			
TOTAL			

A6.3 Comparison of Options

Table A6.3 provides a cost comparison for the two options.

Table A6.3: Comparison of costs (Normalised Scores: 1 = lowest cost; 0 = highest cost)

Option	Estimated Cost	Normalised Score	Weighted Score
1. Leave in Place			
2. Total Removal			

A6.4 References

DEFRA, 2011. Guidance on Marine Licensing under Part 4 of the Marine and Coastal Access Act 2009. March 2011. Department for Environment, Food and Rural Affairs, London, UK. http://archive.defra.gov.uk/environment/marine /documents/interim2/mcaa-licensing-guide.pdf (Downloaded 31 March 2013).