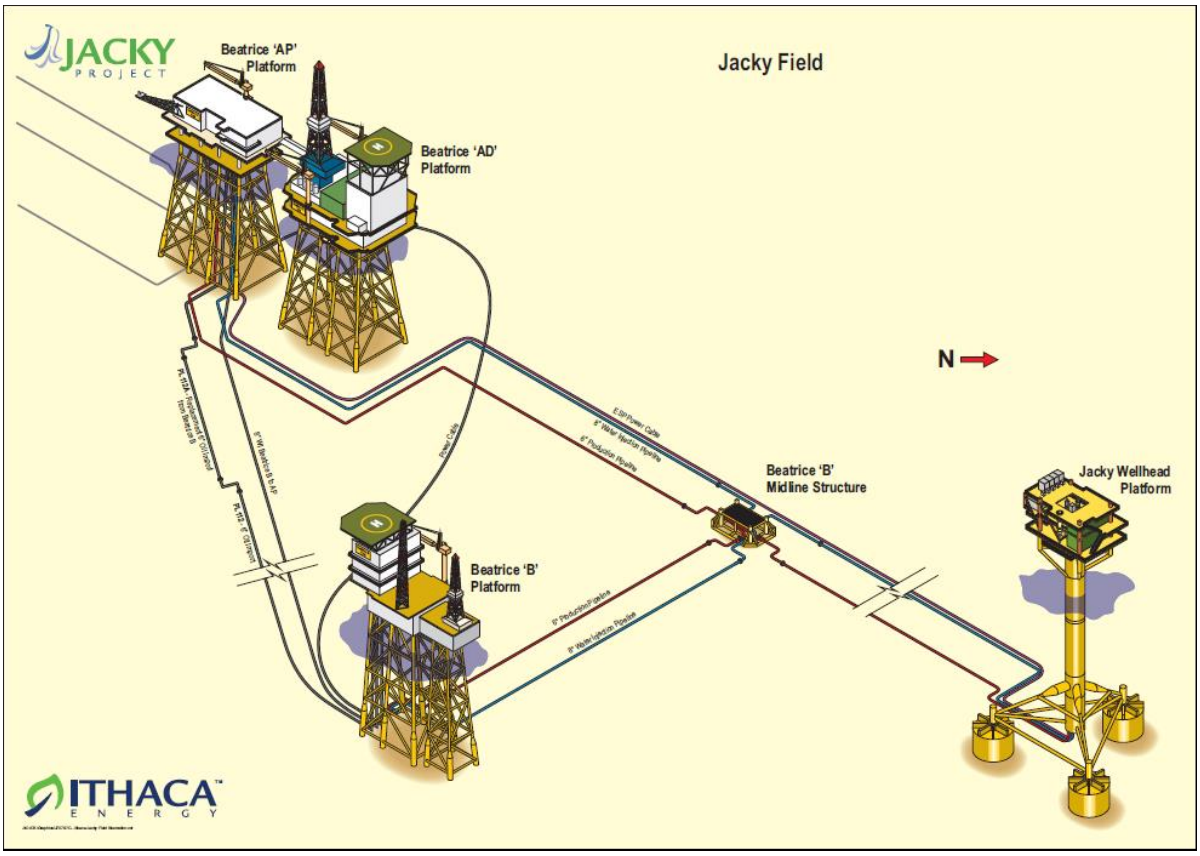
Ithaca Energy (UK) Limited



Jacky Decommissioning
Pipelines and Power Cable
Comparative Assessment

February 2018

CONTENTS

1 INTRODUCTION AND BACKGROUND

Ithaca Energy (UK) Limited (Ithaca) is planning for the decommissioning of the Jacky Field which commenced production in April 2009 and has now ceased production.

Ithaca is updating and revising their Decommissioning Programmes for those Jacky facilities for which they have liability, namely:

1. The normally unattended Jacky Wellhead Platform (WHP)
2. Three Jacky wells (1 x production, 1 x water injection and 1 x suspended)
3. All subsea infrastructure associated with the Jacky WHP, including production and water injection flowlines, power cable, gravity based midline tee structure and protective material (mattresses, grout bags and rock)

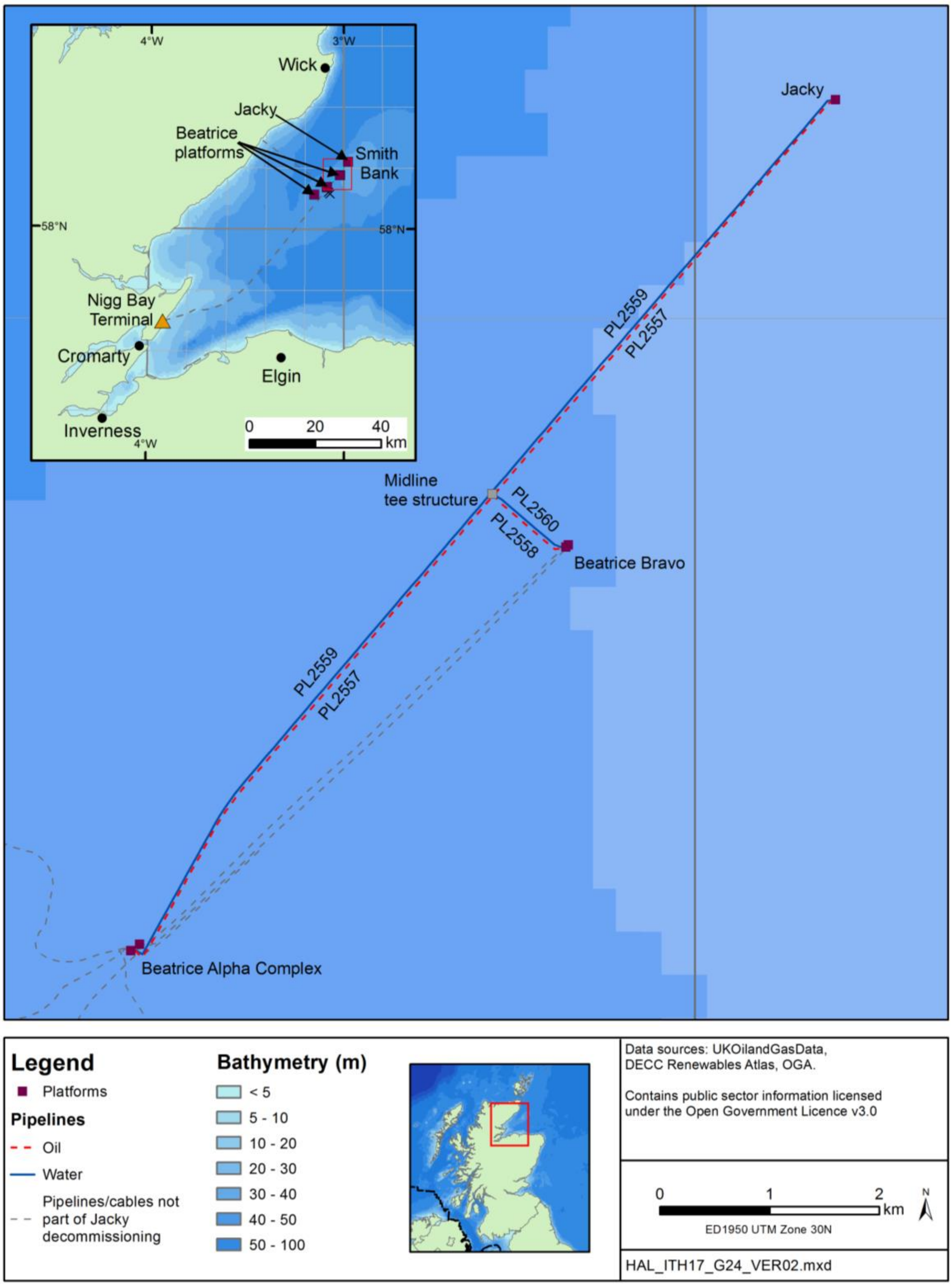
To fulfil Ithaca's HS&E policy and in line with regulator (DECC 2011 and BEIS 2017 (draft guidance)) and industry guidance (OGUK 2015) and in keeping with Annex 2 of OSPAR Decision 98/3, the Decommissioning Programmes for the Jacky Field offshore facilities are supported by a Comparative Assessment (CA) of the feasible options for the decommissioning of the Jacky pipelines and power cable. The CA is a systematic process by which the various options are examined leading to the identification of a preferred option for decommissioning of the infrastructure.

1.1 Location of the Jacky Facilities

The Jacky Field is located on the Smith Bank in the outer Moray Firth (UKCS Block 12/21c), approximately 19km southeast of the Caithness coast and 10.5km northeast of the Beatrice AP (see Figures 1.1 and 3.1). Jacky is tied-back to the Beatrice AP by flowlines and a power cable, via a midline (manifold) tee structure. The midline tee structure also connects Beatrice AP to Beatrice B, via two short spur pipelines (production and water injection).

Crude oil is exported from Beatrice AP through a 67km submarine pipeline which makes landfall at Shandwick, and a buried 9km onshore section of pipeline carries the crude to the Nigg Oil Terminal. Power is supplied to the Beatrice facilities from the onshore electricity grid by a 25km submarine cable from Dunbeath. The Beatrice Complex platforms, export pipeline from Beatrice AP, the onshore pipeline to the Nigg Terminal and the submarine power cable are not part of the Jacky Decommissioning Programmes.

Figure 1.1 – Jacky location



1.2 Purpose, Regulatory Context and Approach

The OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations sets out OSPAR Contracting Parties obligations on the decommissioning of offshore installations. Pipelines are not covered by this OSPAR Decision and there are no international guidelines on the decommissioning of disused pipelines.

In the UK, the principal legislation for the decommissioning of disused offshore installations and pipelines is the Petroleum Act 1998 (as amended) ("the 1998 Act"). Under Part IV of the 1998 Act and amendments to it through the Energy Act 2008 (as amended), operators proposing to decommission an offshore installation or submarine pipeline must submit a Decommissioning Programme. Where the programmes includes the decommissioning of pipelines (and cables), the Department for Business, Energy and Industrial Strategy (BEIS), (previously the Department of Energy and Climate Change (DECC)) guidance ("the guidance") indicates a CA must be carried out to examine all feasible options for decommissioning to inform decisions relating to the decommissioning of those pipelines. Oil and Gas UK (OGUK 2015) published further guidance, expanding on that provided in the guidance, with the aim of encouraging a consistent approach to the CA process in the UK; the CA for the Jacky Field facilities has been drafted taking account of this guidance.

The options considered are also the subject of an Environmental Impact Assessment (EIA), information and conclusions from which support the CA process. Both the EIA report and the CA support the final Decommissioning Programmes, and BEIS take these into consideration when assessing the final Programmes for approval.

The decommissioning options considered in the CA for the Jacky pipelines, cable and protective material, primarily relate to whether these are wholly or partially to be left *in situ*, or fully retrieved, the methods used and their potential effects, and any proposed remediation. Consistent with the guidance, the CA considers these options for the Jacky pipelines and power cable, based on the following 5 criteria: Safety, Environmental, Technical, Societal and Economic (see Section 5).

This document describes the CA process, the outcomes and the recommended options for the decommissioning of the Jacky pipelines and power cable.

2 SUMMARY OF ENVIRONMENTAL CONDITIONS

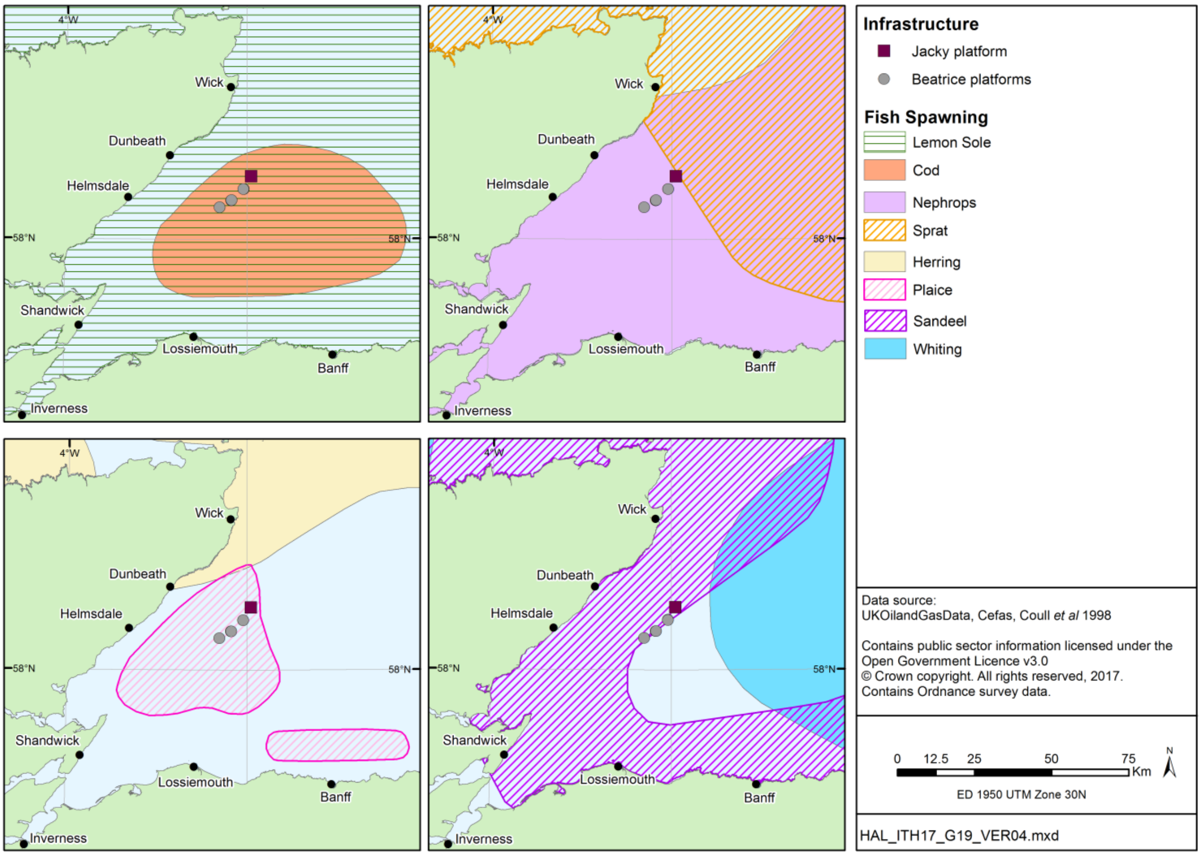
The Jacky pipelines and other facilities lie on the north-west edge of Smith Bank, where the seabed is generally flat with a water depth of approximately 35-45m. The seabed comprises medium to coarse sands with shell fragments, with some patches of coarser material present.

Waters in the area are influenced by a combination of oceanic Atlantic water and coastal waters of the inner Moray Firth. The water currents are dominated by tides moving on a north to south axis. The area has a mild maritime climate, with strongest winds and largest waves occurring during winter months.

The area has well mixed shelf water (salinity is 34-35ppt) for the majority of the year and some thermal stratification occurs in summer, although this is typically weak over Smith Bank. There is a spring bloom of phytoplankton, initially dominated by diatoms, then followed by flagellates and dinoflagellates. Peak zooplankton abundance generally occurs shortly after the phytoplankton bloom. Primary productivity slows in summer, although zooplankton abundance may remain high. Autumnal breakdown of stratification initiates a second, smaller bloom of dinoflagellates.

Jacky overlaps or abuts reported spawning grounds (see Figure 2.1) of eight commercially important fish and shellfish species (cod, herring, lemon sole, plaice, sandeel, sprat, whiting and *Nephrops*) as well as nursery grounds for these eight species and a further ten species (mackerel, blue whiting, haddock, saithe, European hake, ling, monkfish, spurdog, thornback ray and spotted ray). No herring spawning habitat was identified in the Jacky site or pipeline route surveys.

Figure 2.1 – Fish spawning areas



The Moray Firth region contains important populations of Atlantic salmon; adult fish may be more abundant in coastal waters during spring and summer. There have also been several sightings of basking shark during summer months, predominantly in the south of the Moray Firth area.

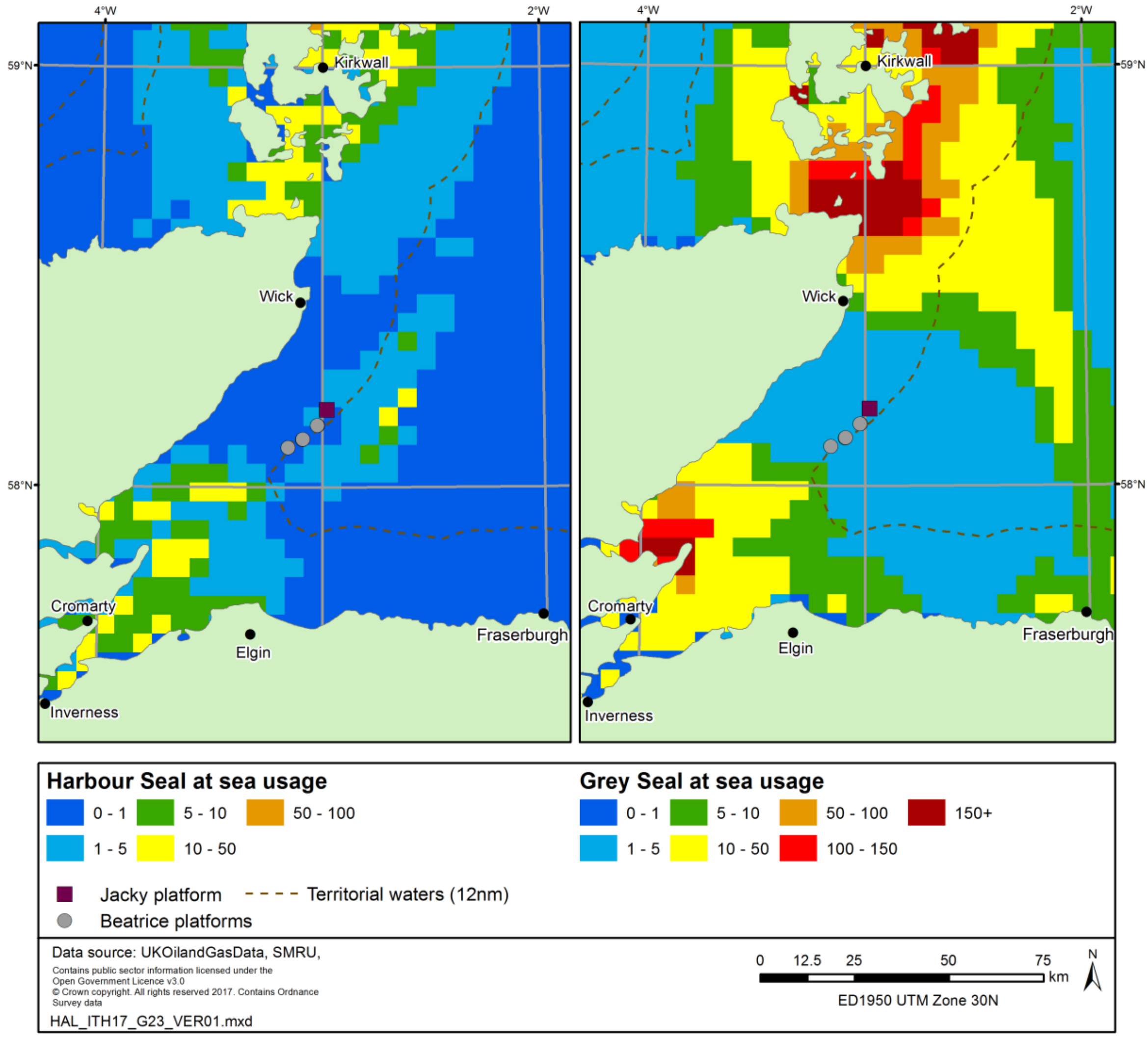
The adjacent east Caithness coast is of conservation importance for breeding seabirds, while the waters of the inner Moray Firth to the west are of considerable importance for bottlenose dolphins, seabirds, seals and otters. There are many other habitats, species and bird populations of conservation importance around the Moray Firth coastline.

The Jacky area and surrounding region are of very high importance for seabirds; the new Seabird Oil Sensitivity Index (SOSI) indicates their vulnerability to surface pollution is high, very high, or extremely high for at least eight months of the year (but it should be noted that low data availability is indicated for a number of months (Webb *et al*. 2016)). The region is important for breeding, wintering and migratory birds and contains important feeding areas and the Moray Firth coasts support a number of designated sites for their bird assemblages (breeding and wintering).

The Moray Firth is important for bottlenose dolphin and harbour porpoise, with the former having a resident population in the area (this species is a primary feature for a designated marine Special Area of Conservation) and the latter likely to be regularly present throughout the whole area. An area of persistent high density of harbour porpoise in summer has been identified on Smith Bank (Heinänen & Skov 2015) and may be proposed as a conservation site in the future.

White-beaked dolphin and minke whale are likely to be occasionally present in the Moray Firth, particularly during summer. The Moray Firth area supports important breeding colonies for grey and harbour seals; both species forage offshore and are likely to traverse the Jacky area (Figure 2.2).

Figure 2.2 – Habitat usage by harbour and grey seals in the Moray Firth



The importance of the area for breeding seabirds, wintering and migratory waterbirds, marine mammals and other features is reflected in the number and variety of designated sites, protected under a variety of national, international and non-statutory provisions.

Fisheries in the wider area provide valuable landings of shellfish and demersal fish, and are primarily exploited by demersal trawls, dredges and pots. Fishing effort is generally greatest during summer months, and appears to be concentrated both closer to the adjacent coast and east of Jacky. There are also a number of important fishing ports in the area.

The closest oil and gas infrastructure in the area consists of a series of four installations in the Beatrice oilfield; Beatrice AD and AP (Jacky is tied back to the latter), Beatrice B (which is connected by production and water injection spur lines to the Jacky midline tee structure) and Beatrice Charlie (to the SW of Beatrice AD and AP). The Beatrice Demonstrator Project (two offshore wind turbines) also lies to the south of the Jacky infrastructure and supplies power to Beatrice AP. Jacky lies adjacent to areas consented for offshore wind farm developments; the Jacky WHP is near (~3km) the Moray Firth Round 3 wind farm zone, with the tie-in at Beatrice Alpha just overlapping the zone, while the Beatrice Scottish territorial waters wind farm leasing zone borders the Jacky WHP 500m safety zone. The Beatrice Offshore Wind Farm was granted consent in March 2014, and offshore construction began in April 2017. The windfarm is being constructed in phases and is expected to be fully operational in 2019. The

Round 3 Moray Offshore East Development was also granted consent in 2014, but it is uncertain when construction will commence.

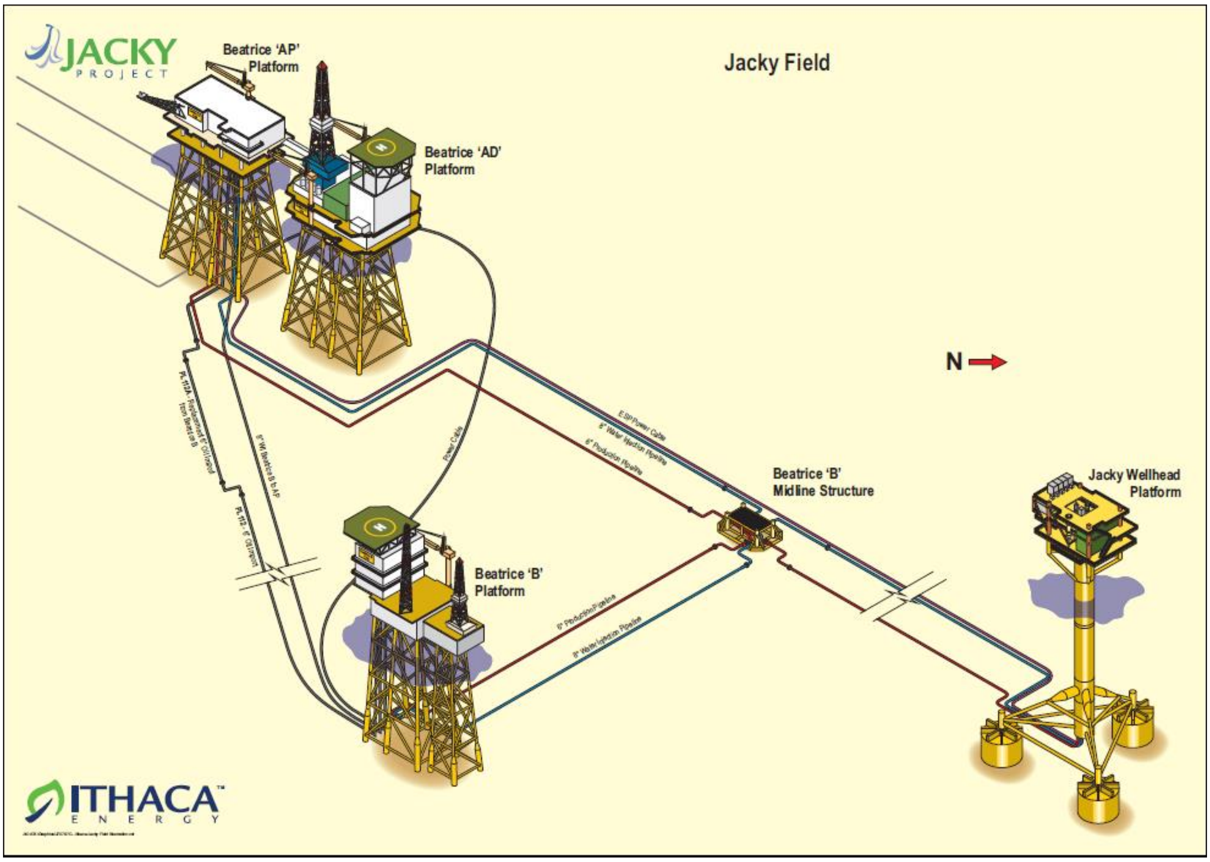
Several shipping routes pass within 10nm of Jacky, although overall traffic density is low. There are no designated protected wrecks in the area and no telecommunication cables present.

More detail on the environmental conditions of the Jacky area is given in the decommissioning EIA.

3 JACKY PIPELINE FACILITIES FOR DECOMMISSIONING

At commencement of the CA process, Ithaca identified those infrastructures and their boundaries to be considered in the assessment, and identified all reasonable options for their decommissioning. After initial review, only those feasible decommissioning options were taken forward for assessment. The following section provides an overview of the pipelines and power cable relevant to the Jacky Field Decommissioning Programmes covered by the CA (Figure 3.1 and Table 3.1), and the feasible options under consideration for their removal.

Figure 3.1 – Jacky infrastructure



All Jacky pipelines and the power cable were installed over a period between Q4 2008/Q1 2009.

- **Jacky production pipelines (PL2557 and PL2558)**: the 10.5km, 6″ diameter infield production pipeline (PL2557) connects Beatrice AP to Jacky, via the midline tee structure and the 6″, 0.8km spur production line connects the midline tee structure to Beatrice B (PL2558). Both production lines and all tie-in spools are of rigid carbon steel. The production pipelines are buried to 1m along the majority of their length and both are no longer in use. They have been cleaned and are currently filled with inhibited seawater.

- **Jacky water injection pipelines (PL2559 and PL2560)**: the 10.5km, 8″ diameter infield water injection pipeline (PL2559) connects Beatrice AP to Jacky WHP and the 8″, 0.8km spur water injection line connects the midline tee structure to Beatrice B (PL2560). As for the production lines, both water injection lines and the tie-in spools are of rigid carbon steel. Both water injection lines are buried to 0.6m along the majority of their lengths, are no longer in use, and are filled with inhibited seawater.
- **Jacky power cable (PLU2561)**: the 10.5km power cable was trenched and buried next to the Jacky water injection line and is also buried for the majority of its length. It has a dynamic section free hanging/tethered to a clump weight and tether clamp at the Beatrice AP platform, and a static section within the J-tube at the Jacky WHP. The power cable is buried to 0.6m along the majority of its length.

At the approach to Beatrice AP, and within the platform 500m safety zone, the Jacky lines PL2557, PL2559 and PLU2561 cross over the original water injection and production infield lines installed in 1980 (PL111 8″ water injection line, PL112 6″ production line) and 2004 (replacement section PL112A 6″ production line). The spur lines to Beatrice B (PL2558 and PL2560) also cross pre-existing lines in the approach to the platform, specifically PL111 8″ water injection line and PL112 6″ production line.

Each of the pipelines has a series of rigid spool tie-ins, connecting the main sections of the pipelines to the Platform risers. All spool pieces are protected by mattresses/grout bags (see Table 3.1 for numbers and weights), which abut the rock protected (transition) sections of the pipelines, after which the lines are trenched and buried.

Seabed deposits

- **Mattresses**: flexible concrete mattresses with polypropylene rope are located at a number of strategic locations along the production, water injection pipelines and power cable, including at trench transitions (where the lines exit the seabed prior to connection at the platforms), at pipeline and cable crossing locations, at spool tie-in locations (Beatrice AP, Jacky WHP and midline tee structure) and spot deposits where required.
- **Rock**: there is a quantity of rock cover overlaying the water injection and production lines at strategic locations including trench transitions and crossings of disused lines at approaches to Beatrice AP and Beatrice B, in addition to various spot locations along both pipelines. Decommissioning liability for rock cover deposited for pipeline crossings over disused lines as part of the Jacky Development, is retained by Ithaca. The power cable also has rock cover at the Jacky WHP location from the trench transition to ~5m from the J-tube.
- **Grout bags**: a number of grout bags were deposited as infill between mattresses at various tie-in locations

Two gabion bags were also used to support the midline tee structure and 28 frond mats were deployed around the suction piles at the Jacky WHP location; these will be recovered.

The mattresses used at Jacky are the most commonly used in the North Sea. These are best at retaining their structural integrity, compared to for e.g. armorflex and bitumen style mattresses and have the largest potential scope for reuse (Jee Ltd 2015). A small number of mattresses at the Jacky WHP (8), midline tee structure (4) and the Beatrice AP approaches (35), were placed and then covered in rock at time of installation. Given that the rock profile covering these mattresses is overtrawlable, the fisheries snagging potential is considered low. Therefore, it is proposed to decommission these 47 mattresses *in situ*, and as such, these have not been considered further here. If during decommissioning activities any part of these are found to have become exposed, it is proposed to rebury with natural backfill and/or redistribute existing rock cover. The current plan is to recover the remaining exposed mattresses (~98) using a subsea grab, thus minimizing exposure of and safety risk to divers; however, using a grab does have the potential to damage the mattress during recovery. Following the waste hierarchy, Ithaca will look to identify options to reuse these, using specialist contractors, when returned to shore, such as coastal defences, road construction or as gabion walls, or their recycling as concrete aggregate (once crushed and the rope removed) only disposing to landfill if alternative options cannot be identified. The potential for reuse as stabilising material for the nearby windfarm development(s) will also be explored.

Where rock has been used to protect a pipeline/cable, following the guidance, the assumption is if the pipeline is to remain *in situ*, then the rock will remain in place, undisturbed. If the pipeline is to be removed, partially or entirely, then the assumption is minimum disturbance of the rock would be expected, to allow safe access to the pipeline/cable, as well as the elimination of any seabed obstruction that may result from the presence of the rock (DECC 2011, BEIS 2017 (draft guidance)). This has been taken into account when assessing the different decommissioning options for the Jacky pipelines and power cable.

The Jacky CA process was informed by information contained in a range of survey and technical reports (see Section 9, References).

Table 3.1 – Pipeline and ancillary equipment information

Pipeline No. Materials	Diam (″)	Length (m)	Current contents Use/Disused	Installation Method	Depth trenched (m)	Mattress and grout bags installed	Rock cover
PL2557 Production Pipeline Jacky Wellhead Platform Riser To Beatrice 'AP' Production Riser Carbon steel, polyurethane coating	6"	10307	Inhibited seawater Disused (notified to BEIS)	Trenched and natural backfill	1	Five areas of mattresses, ranging in length from 8m to 23m giving a total length on 91m. 28 Mattresses (total mass 139 tonnes) and 5 grout bags (0.1 tonnes) were used on the pipeline. In addition, there were 14 mattresses (69 tonnes) and 21 grout bags (0.53 tonnes) covering the spool pieces. A total of 42 mattresses (208 tonnes) and 26 grout bags (0.6 tonnes) were used.	Twenty five areas of rock cover, ranging in length from 6.3m to 484.6m giving a total length on 2122m
PL2558 Production Pipeline Beatrice 'B' Production Riser To Midline tee Structure Carbon steel, polyurethane coating	6"	901	Inhibited seawater Disused (notified to BEIS)	Trenched and natural backfill	1	One area of mattresses, with length of 13m. 3 mattresses (15 tonnes) and 4 grout bags (0.1 tonnes) were used on the pipeline. An additional 14 mattresses (69 tonnes) and 47 grout bags (1.18 tonnes) were located at the spool pieces. A total of 17 mattresses (84 tonnes) and 51 grout bags (1.28 tonnes) were used.	Four areas of rock cover, ranging in length from 18m to 70m giving a total length on 176m
PL2559 Water Injection Pipeline Jacky Wellhead Platform Riser To Beatrice 'AP' Production Riser Carbon steel, polypropylene coating	8"	10266	Inhibited seawater Disused (notified to BEIS)	Trenched and natural backfill	0.6	Two areas of mattresses, ranging in length from 12m to 23m giving a total length on 35m. Stabilisation in the form of concrete mats was present over the approach and spool areas to the Beatrice A Platform and continued up to the tube bend at the riser. A total of 33 mattresses (163 tonnes) and 6 grout bags (0.2 tonnes) were used on this pipeline.	Ten areas of rock cover, ranging in length from 3m to 372m giving a total length on 717m.

Pipeline No. Materials	Diam (″)	Length (m)	Current contents Use/Disused	Installation Method	Depth trenched (m)	Mattress and grout bags installed	Rock cover
PL2560 Water Injection Pipeline Beatrice 'B' Production Riser To Midline tee Structure Carbon steel, polypropylene coating	8"	842	Inhibited seawater Disused (notified to BEIS)	Trenched and natural backfill	0.6	Three areas of mattresses, ranging in length from 36m to 50m giving a total length on 126m A total of 11 mattresses (54 tonnes) were used on this pipeline (no grout bags).	Three areas of rock cover, ranging in length from 2m to 55m giving a total length on 100m.
PLU2561 Power Cable Beatrice 'AP' Platform To Jacky Wellhead Platform Polypropylene, bitumen, steel armour wire, copper wire, fibre optic cable, hard polyvinyl chloride filler	6"	10330	-	Trenched and natural backfill	0.6	A total of 12 mattresses (59 tonnes) and 30 grout bags (0.8 tonnes) were used on this line.	Much of the cable is buried adjacent to PL2559 and the rock quantities are included with that (see above). A bight of the cable near Beatrice A and one near Jacky are rock covered with an average height of 0.92m and width of 6.5m containing an estimated 278 and 389 tonnes of rock respectively
Midline tee Structure (MLT) Note, this will be removed in accordance with OSPAR Decision 98/3 Carbon steel	-	-	-	Gravity based, with four steel ballast weights	-	Stabilisation in the form of concrete mats were present on the spool areas before and after the mid line structure. A total of 30 mattresses (149 tonnes) protect the tie-ins at MLT.	None.

4 JACKY PIPELINE DECOMMISSIONING OPTIONS

This CA has been undertaken to inform decisions relating to the decommissioning of the pipelines and cable described in Section 3 above and shown in Figures 1.1 and 3.1. As the Jacky Field infrastructure lies on the 12 nautical mile (nm) territorial waters boundary, Ithaca entered into a lease agreement with The Crown Estate (TCE) in 2008 for the Jacky WHP and the connecting pipelines. At the time this lease agreement was entered into, a decommissioning summary (the Summary) was also supplied to TCE. In this, the pipelines were described as trenched and buried (as is the case) and that decisions on the abandonment plans for these will be based on relevant legislation at that time and that a CA would be carried out. Assumptions were made to estimate project decommissioning costs for the Summary, including for the decommissioning of the pipelines; no allowance was made for removal of rock cover, and all pipelines were assumed to be left *in situ*. Ithaca followed the Regulator and Industry guidance, and the assumptions of the Summary, when identifying and considering the options for decommissioning the Jacky pipelines and cable. Therefore, the options being considered by Ithaca are:

1. Partial removal of spool pieces, midline tee structure, section of power cable umbilical, clump weight and tether clamp and some mattresses/grout bags
2. Removal of all spool pieces, midline tee structure, section of power cable umbilical, clump weight and tether clamp and all exposed and recoverable mattresses/grout bags
3. Removal of all spool pieces, midline tee structure, power cable clump weight and tether clamp, selective removal of pipeline and power cable sections and all exposed and recoverable mattresses/grout bags
4. Removal of all Jacky development pipelines and power cable using reverse lay and removal of midline tee structure, power cable clump weight and tether clamp and removal/displacement of all mattresses/grout bags/rock
5. Removal of all Jacky development pipelines and power cables using cut and lift and removal of midline tee structure, power cable clump weight and tether clamp and removal/displacement of all mattresses/grout bags/rock

After initial review of all possible options, the option to "Leave *in situ*" with no additional work was not considered feasible since the isolation of the Jacky pipeline and power cable from the Beatrice Complex is required (through removal of tie-in spool pieces). This was the only option from all identified as potentially possible for the Jacky facilities that was not taken forward for assessment. Ithaca intends to completely remove the midline tee structure and power cable clump weight, in line with guidance (DECC 2011, BEIS 2017, OGUK 2015) and TCE Lease and Summary. These have been included in option titles for completeness, but were not included in the CA.

Options 1 and 2 would be the minimum work scopes, with only the removal of some or all of the tie-in spool connections and protective material covering these, leaving the pipelines and power cable in their original configuration. Both options would utilise rock placement, where necessary, to reduce potential snagging risks.

Option 3 involves the removal of all of the tie-in spool connections and partial removal of the selected lengths of pipeline and cable. This option would use proven technology to cut sections of the pipeline, using either hydraulic shears, diamond wire cutting or abrasive water jet cutting; with the preferred option for the Jacky decommissioning being diamond wire cutting for the pipelines and hydraulic tools for the power cable. Cutting tools would require the pipeline to be lifted, or cutting an excavation trench to access the pipeline.

Where all or any part of the pipeline is proposed to be left *in situ*, consideration would be given to the effects of continued degradation of the pipeline materials, and whether this could result in possible future environmental effects, including in relation to other users of the sea. The possibility of future pipeline exposure informed by past inspection survey data would also be considered.

Option 4 and 5 are similar, with the displacement/removal of existing protective material and backfill and complete removal of all Jacky pipelines and the power cable (including all of the tie-in spool connections and the protective material covering them), the difference being the method of removal either by reverse lay or cut and lift. Both options would require the displacement/removal of rock and mattresses in order to gain access to and remove the pipelines and power cable and both options would require sediment to be excavated to expose the lines as well as seabed remediation once all infrastructure has been removed.

5 COMPARATIVE ASSESSMENT PROCESS

Ithaca developed a framework for conducting a CA using qualitative and quantitative data to evaluate the alternative decommissioning options outlined in Section 4. This framework draws from OSPAR 98/3 and Regulator and industry guidance (DECC 2011, BEIS 2017, OGUK 2015). A methodology and scoring system was used to assess the relative performance of each of the potential decommissioning options for the pipelines and power cable, with results presented in the Matrix in Appendix A and discussed in Section 6.

Ithaca has a risk management process as part of their verified management system. This provides a consistent and systematic approach to (not exhaustive):

- Identifying hazards associated with specific operations including all environmental aspects
- Assessing and understanding the risks associated with these hazards and
- Identifying where further risk controls may be required

Following a review, it was felt the CA process was consistent Ithaca's approach to risk assessment and that an additional risk assessment on the recommended decommissioning option would not be required.

5.1 Comparative Assessment Criteria and Scoring

Criteria for evaluating the relative potential impact/risk of the options were developed (listed below) with reference to the OSPAR Decision 98/3, Regulator guidance, industry guidance and Ithaca's HS&E policy and Mission Statement:

1. Safety
2. Environmental
3. Technical
4. Societal
5. Economic

Sub-criteria were then derived (see Table 5.1) to cover:

- The potential risk to life of offshore and onshore personnel of each option considered
- All potential impacts (including cumulative effects) on the marine environment, including exposure of biota to contaminants, other biological impacts arising from physical effects, impacts on mariculture, and interference with other legitimate uses of the sea
- All potential impacts on other environmental receptors, including emissions to the atmosphere, leaching to groundwater, discharges to surface fresh water and effects on the soil
- Consumption of natural resources and energy associated with reuse and recycling
- Other consequential effects on the physical environment which may be expected to result from the selected option

- Potential risk of project failure and technical challenge
- Potential impacts on amenities, the activities of communities and on future uses of the environment
- Costs of each option

The sub-criteria were scored on a five point scale ranging from 1 (Very Low) through to 5 (Very High), where 1 represents best performance/least significant impact/lowest risk and 5 worst performance/largest significant impact/highest risk. Scores for the sub-criteria were then weighted on a three point scale (see Table 5.2) according to the level of definition and understanding of methods, equipment and hazards ("uncertainty"), ranging from Low Uncertainty – high definition and understanding of methods, equipment and hazards (weighting x 1), to High Uncertainty – low level of definition and understanding of methods, equipment and hazards (weighting x 2). Final scores for each criterion were recorded in matrix format (see Appendix A) with relative ranking for each option derived from the weighted scores using the matrix in Table 5.3.

Where quantitative data are used, these have been based on measurable data from supporting decommissioning studies, i.e. quantitative estimate total of PLL (Potential for Loss of Life) of offshore personnel, CO_2 emissions (tonnes) and cost estimates. Qualitative assessment is based on a range of sources including regional and site specific data, supporting studies including the Jacky Decommissioning EIA, and conducted by experts with wide experience in the strategic and project level assessment of oil and gas activities and developments in the Moray Firth and wider North Sea, including the EIA for the Jacky development and its tie-back to the Beatrice facilities in 2008.

Table 5.1 – Relative Risk and Impact Criteria and Scoring

Criteria	Sub criteria	Very Low 1	Low 2	Medium 3	High 4	Very High 5
Safety	Risk to personnel offshore during decommissioning operations	No risk	Minor/first aid	Medical aid/ lost time injury	Permanent disability/ fatality	Multiple fatalities
Safety	Risk to personnel onshore during decommissioning operations	No risk	Minor/first aid	Medical aid/ lost time injury	Permanent disability/ fatality	Multiple fatalities
Safety	Risk to divers during decommissioning operations	No risk	Minor/first aid	Medical aid/ lost time injury	Permanent disability/ fatality	Multiple fatalities
Safety	Risk to 3rd parties and assets during decommissioning operations	No risk	Loss of access to operational area	Interference with 3rd party operations altering safety risk	Damage to 3rd party asset/damage to vessel	Damage to 3rd party asset requiring remediation/ loss of vessel
Safety	Residual risk to 3rd parties	No risk	Potential snagging risk	Damage/loss of fishing gear	Damage to vessel	Loss of vessel
Environment	Chemical discharge	None	PLONOR chemicals only	No warnings or substitution labels RQ<1	Warning labels RQ>1	Warnings and substitution labels RQ>1
Environment	Hydrocarbon release from pipelines	None	<50 litres	50 litres - 500 litres	501 litres - 1000 litres	>1000 litres
Environment	Seabed disturbance and/or habitat alteration including cumulative impact	None	<10% of existing footprint	10% - 50% of existing footprint	>50% - 100% of existing footprint	>100% of existing footprint
Environment	Total energy consumption and GHG emissions	<10,000Gj	10,000-100,000Gj	>100,000-200,000Gj	>200,000-400,000Gj	>400,000Gj

Criteria	Sub criteria	Very Low 1	Low 2	Medium 3	High 4	Very High 5
Environment	Proportion of material recycled	>80%	50% - 80%	30% - <50%	10% - <30%	<10%
Environment	Proportion of material landfilled	0%	<10%	10% - 30%	>30% - 50%	>50%
Environment	Conservation sites and species (including noise effects)	No impact	Potential effects but unlikely to be detectable as within normal variability	Minor detectable effects with rapid recovery	Effects detectable, not affecting site integrity or species population	Significant effects on site integrity or population
Technical	Technical feasibility	Routine operations with high confidence of outcomes Very low risk of failure	Routine operations with good confidence of outcomes Low risk of failure	Non-routine operations but with good experience base Low risk of failure	Non-routine operations with limited experience base Moderate risk of failure	Untried technique Higher risk of failure
Technical	Weather sensitivity	Operations not weather sensitive	Operations are little affected by weather	Requires good weather window	Requires typical summer good weather window	Requires long good weather window
Societal	Residual effect on fishing, navigation or other access (including cumulative)	No effect	Access to area unrestricted	Access to area with charted obstructions	Access to area with uncharted debris and obstructions	Closed access to area

Criteria	Sub criteria	Very Low 1	Low 2	Medium 3	High 4	Very High 5
Societal	Coastal communities	No impact	Impacts within normal variability of onshore operations	Short term nuisance during onshore operations	Medium term nuisance during onshore operations	Long term nuisance during onshore operations
Economic	Total cost	<£2m	£2-5m	£5-10m	£10-15m	>£15m
Economic	Residual liability including monitoring and remediation if necessary	No residual liability	Surveys and remediation unlikely to be required	Surveys and remediation requirement anticipated but at declining frequency	Surveys and remediation likely to be required in each 5 year period	Annual survey and potential for remedial work

Table 5.2 – Levels of uncertainty weighting

Increasing uncertainty →		
x 1 (Low)	**x 1.5 (Medium)**	**x 2 (High)**
High level of definition and understanding of methods, equipment and hazards	Moderate level of definition and understanding of methods, equipment and hazards	Low level of definition and understanding of methods, equipment and hazards

Table 5.3 – Ranking of weighted scores

	Uncertainty		
Impact/ Consequence	**1 (Low)**	**1.5 (Medium)**	**2 (High)**
5 (Very High)	5	7.5	10
4 (High)	4	6	8
3 (Medium)	3	4.5	6
2 (Low)	2	3	4
1 (Very Low)	1	1.5	2

Options

Low **Medium** **High**

Best → **Worst**

5.2 Comparative Assessment Workshop

Ithaca held a workshop to assess the different options for pipeline decommissioning. The workshop involved a multi-disciplinary team (the team) including:

- Janet Ogilvie (HSE Manager – Ithaca Energy)
- David Watts (Decommissioning Manager – Petrex)
- Ian Pithie (Business Development Manager – Petrex)
- John Hartley (Director - Hartley Anderson)
- Suzanne Lumsden (Environmental Advisor – Hartley Anderson)

Wider stakeholder engagement for the proposed decommissioning project was considered more appropriate for the Jacky Field facilities, rather than consulting a small number of stakeholders on the CA methodology and evaluation. An EIA scoping document was issued, which included a summary overview of the CA options considered and the infrastructure to be included, with stakeholders invited to respond.

The workshop included a round table discussion with the team focusing on several key areas:

- Reach agreement on scoring criteria and methodology
- The current status of all the Jacky pipelines and cables, including mattresses and rock cover
- Identify all potential options for their decommissioning
- Identify potential equipment and vessels needed to achieve decommissioning
- Estimate duration of removal/burial operations
- Identify potential fate of materials recovered and taken to shore
- Examine comparative safety of the different options
- Examine comparative costs of the different options
- Examine comparative environmental implications of the different options (for the natural environment and other users of the area
- Examine comparative ongoing liability implications

The workshop commenced with a brief presentation re-affirming the requirement for a CA to be carried out and Regulator's expectations that all feasible options for pipeline decommissioning must be considered on their merit, supported by a robust evidence base.

A pipeline inspection survey was conducted on the Jacky pipelines in 2013 and information from this, along with information from the approved Pipeline Works Authorisation (PWA), was used to compile a table of pipeline (and power cable) information (Table 3.1). This table of pipeline number, length, depth of cover and type and estimated area of protection, was circulated to the decommissioning team for discussion and agreement the information was accurate. From these discussions an action was raised to compile an inventory of mattress number and condition (see further studies/technical notes below). Prior to the 2013 survey, an ROV survey in 2009 captured sidescan sonar data of the pipelines.

The team reviewed the feasible decommissioning options for the pipeline and power cable to ensure all options had been identified and captured for assessment. The options considered are shown in Sections 4 and 6. While considering each option in turn, the adequacy of the information base was also reviewed and any key gaps identified (see further studies/technical notes).

The criteria and methodology drafted to assess each option were then reviewed, modified where necessary and agreed upon (see Section 5.1 and Tables 5.1-5.3), before progressing with the CA. Using the agreed criteria and methodology, the team then considered each option in turn, within their area of expertise, assigning impact values and level of uncertainty values to generate an overall assessment of the option.

Further studies/technical notes

A small number of further studies/technical notes were identified to address information gaps. These were:

- An inventory of mattress number and condition
- Estimate of vessel time and fuel usage

The information from these was incorporated into the final scoring for the different options and any initial scoring updated where relevant.

The outcome of the CA process and the resulting recommended decommissioning option for the pipelines and power cable is described in Section 6 below.

6 RESULTS AND RECOMMENDED OPTIONS FOR JACKY PIPELINES AND POWER CABLE DECOMMISSIONING

The five options considered for the decommissioning of the Jacky pipelines and power cable were:

1. Partial removal of spool pieces, midline tee structure, section of power cable umbilical, clump weight and tether clamp and some mattresses/grout bags
2. Removal of all spool pieces, midline tee structure, section of power cable umbilical, clump weight and tether clamp and all exposed and recoverable mattresses/grout bags
3. Removal of all spool pieces, midline tee structure, power cable clump weight and tether clamp, selective removal of pipeline and power cable sections and all exposed and recoverable mattresses/grout bags
4. Removal of all Jacky development pipelines and power cable using reverse lay and removal of midline tee structure, power cable clump weight and tether clamp and removal/displacement of all mattresses/grout bags/rock
5. Removal of all Jacky development pipelines and power cables using cut and lift and removal of midline tee structure, power cable clump weight and tether clamp and removal/displacement of all mattresses/grout bags/rock

The Option scores, derived by the Jacky Decommissioning Team, are shown in Appendix A, with a summary of each Option and final recommendation described below.

Option 1: Partial removal of spool pieces, midline tee structure, a section of power cable umbilical, clump weight and tether clamp and some mattresses/grout bags

Options 1 and 2 (below) are very similar, leaving the pipelines and power cable *in situ*, removing the midline tee structure and power cable clump weight and tether; the difference being Option 1 proposes to remove only some of the spool pieces and mattresses/grout bags, and Option 2 removes all spool pieces and all exposed and recoverable mattress/grout bags.

The overall assessment for Option 1 was low risk.

Safety Risk to personnel offshore and onshore would be minimal: diver time would be of short duration, with only removal of some of the tie-in spools requiring diver intervention, with no pipeline material being brought onshore for processing.

Release of hydrocarbon contaminants from the disused production pipelines is not considered to be a significant concern, as these lines were cleaned and flushed and left with inhibited seawater; the final pig from the Bravo to Alpha production line (PL2558) recorded an Oil in Water (OIW) content of 7.3mg/l and the pig from Jacky to Alpha (PL2557) recorded an OIW content of 8.1mg/l.

The inhibited seawater in the production and water injection pipelines contains a combination of oxygen scavengers and biocides, in relatively low quantities (ranging from 50kg to 650kg). Of the four chemicals used, only one has been identified as containing components for substitution, an oxygen scavenger, the total use of which was 50kg, with the remaining chemicals being either Gold, ranked an E, and PLONOR (Pose Little or No Risk to the Environment). Assuming a full discharge of these chemicals and any residual hydrocarbons, the assessment was deemed to be of low to medium risk (medium due to the presence of one chemical with a substitution warning, despite this being in small quantities). However, given the tidal currents in the area, these chemicals and small quantities of oil are expected to rapidly disperse from the area.

After removing some of the protective material and spool pieces, the exposed ends are then lowered into the seabed following sediment excavation using mass flow excavation and then back filled with the natural sediment. For pipeline infrastructure being removed that is covered by rock, e.g. spools/flanges, the rock will first be moved (by grab) to enable access to the relevant infrastructure, then replaced once the spools/flanges are removed to protect the pipeline ends.

Mass flow excavation is where a flow of water is directed at the seabed to displace the sediment. This equipment can be deployed from a dive support vessel (DSV) using proven technology and methods, with time on site expected to be of short duration. It is proposed that a DSV would be used to complete most operations (e.g. removal of spool pieces and midline tee structure), over a period of approximately 21 days. Estimated vessel emissions (~1,100 tonnes CO_2 equivalent, t CO_2eq.) include transit and contingency and are low in relation to UKCS and wider UK greenhouse gas emissions and total estimated energy use including from the recycling of recovered steel components is in the range 10-100,000Gj. It has been assumed that all recovered steel will be reused/recycled, along with the mattresses recovered (see Section 3). Seabed remediation after this operation is expected to be minimal.

To expose the spool pieces for removal requires moving the mattress/grout bag protection covering them. The intention is to either do an initial programme of peeling back the mattresses to one side, completing the spool removal and burial of ends and then removing the mattresses, with an alternative being removing the mattresses initially and then proceeding with the spool piece removal/burial of ends; the final sequence of work will depend on vessel availability and weather. Displacing/removing the protective mattresses/grout bags and burying the exposed ends will result in some disturbance to seabed sediments and communities. This disturbance would be localised to areas where protective material is removed and sediment displaced to lower the exposed ends into the seabed.

An ROV survey conducted in 2012 (Andrews Survey 2013) showed the presence of mobile and sessile epifauna, including the plumose anemone *Metridium senile* and the urchin *Echinus esculentus* on the mattresses/grout bags covering the spool pieces; with most observed along the PL2558 and PL2560 pipelines at their approach to Beatrice B. The survey also indicated that the spool pieces and protective mattresses have not been smothered by sediment in the period since they were laid. Disturbance during removal and burial operations would be limited to those benthic communities colonising the hard surfaces of the mattresses to be lifted and those immediately adjacent to the pipelines and power cable. Some superficial displacement of sediment from the peeling back (if this happens initially) of the mattresses may occur.

The closest Natura 2000 site, the East Caithness Cliffs Special Protection Area is some 19km from Jacky and interactions with the site, including impacting the integrity of the site and the species it is designated to protect are not predicted. The location, scale and duration of the potential operations from

Option 1 are such that effects on the integrity of this and other Natura 2000 sites in the Moray Firth area, including any noise impact on marine mammals, are not predicted.

Disturbance of historic cuttings deposits at the Beatrice platforms is not expected, since the pipelines and power cable were surface laid at the platform approaches and, due to the relative distance of potential cuttings piles (beneath and immediately adjacent to Beatrice AD and Beatrice B) from the spool pieces. An ROV survey of the Beatrice AD drilling template in 2012 did not show an appreciable depth of cuttings and a much smaller accumulation than was recorded by BRITOIL in 1989 which indicated a mound 9m in height. Between these surveys, it is likely that the pile was subject to redistribution and degradation by natural hydrographic and biological processes. An ROV survey conducted at Beatrice B in 2008 showed no substantial variation in sediment topography, suggesting a cuttings pile was not evident.

Given the seabed sediments types, burying the exposed ends is not anticipated to present technical difficulties and existing rock (which has been displaced to allow access to the pipeline ends) would be reused, if required, to provide cover. The existing rock cover has a profile designed to be over-trawlable by fishing gear and after burial of exposed ends, any reuse of rock would be replaced in a controlled manner and an over-trawl verification would be undertaken of the final rock profile.

Energy use and associated emissions are largely comparable to Option 2, though are estimated to be slightly less (~820 tonnes CO_2 eq.) using a rock placement vessel compared to trenching and burying the pipeline and cable ends.

Upon completion of Option 1 (and the remainder of the Jacky decommissioning work scope), access to the area for other users of the marine environment, particularly for commercial fisheries will not be restricted and any material remaining on the seabed will be marked on charts. The potential for those mattresses left on the seabed to break up over time cannot be discounted; the fragmented material would be in the form of single or several concrete segments linked by short sections of polypropylene rope. Most of such material is expected to remain over-trawlable (and analogous to the naturally occurring cobbles and small boulders in the area). If mattress fragments are picked up by fishing nets there is the potential for some damage to the catch although again this can be considered analogous to naturally occurring rock on the area.

The vessels and techniques involved in Option 1 are considered well proven and there is high confidence in the expected outcomes.

By removing only some of the spool pieces and protective material covering them Option 1 reduces the dive time required, vessel time on site, resulting in additional atmospheric emissions, the total seabed disturbance as well as processing onshore of returned material.

The cost of Option 1 is the lowest but not significantly different to the cost of Option 2.

Option 2: Removal of all spool pieces, midline tee structure, a section of power cable umbilical, clump weight and tether clamp and all exposed and recoverable mattresses/grout bags

This option is similar to Option 1, with Option 2 removing all spool pieces and all exposed and recoverable protective material covering them. Where the considerations of Options 1 and 2 are essentially the same, they are not repeated here.

The overall assessment for Option 2 was low risk.

Although not reflected by a significant difference in the matrix scores, Option 2 is considered preferable to Option 1 since the residual long term risk of fragmentation of those mattresses left exposed is obviated through their removal.

The cost of Option 2 is more than that for Option 1 but the difference is not considered significant.

Option 3: Removal of all spool pieces, midline tee structure, power cable clump weight and tether clamp, selective removal of pipeline and power cable sections and all exposed and recoverable mattresses/grout bags

This option uses proven technology and methods. However, this Option requires an increased time offshore for vessels and personnel using specialist equipment. The overall assessment for this Option was a moderate risk.

There is an increased operational safety risk for divers, as this Option is time consuming and exposes the divers to increased risk if multiple cuts are undertaken subsea.

To remove the Jacky pipeline and power cable in 15m sections, approximately 12 subsea cuts are required. To make each cut, the pipeline has to be exposed, by displacing or removing the protective rock or removing protective mattresses and excavating a trench to allow tool access. Approximately 90 tonnes of rock would have to be displaced/removed. The power cable would require 2 cuts at the exit from the risers and trench areas. While specialist equipment is used for lifting the cut sections, diver support is usually required for this operation, extending the diver time subsea.

It is proposed that a dive support vessel would be used to complete most operations (e.g. removal of spool pieces, midline tee structure and selected pipeline components), over a period of approximately 22 days. Estimated vessel emissions (~1,150 tonnes CO_2 eq.) are low in relation to UKCS and wider UK greenhouse gas emissions and total estimated energy use including from the recycling of recovered steel components is in the range 10,000-100,000Gj.

This Option requires disturbance of the seabed in order to cut and prepare the sections for removal and if hydraulic cuttings tools are used, this increases the potential for chemical discharges into the marine environment. Although disturbance would be localised to areas where sections are being removed compared to full removal (Option 5), the exposed ends would still have to be buried or covered by rock to reduce snagging potential.

The discharge to sea of chemicals and any residual hydrocarbons for Option 3 has been considered the same as that for Options 1 and 2, i.e. a full discharge of the production and water injection lines, with the risk assessment being the same.

The vessels and techniques involved in Option 3 are considered well proven and there is high confidence in the expected outcomes.

The total cost of Option 3 is significantly more than those for Options 1 and 2, but much less than for Options 4 and 5.

Option 4: Removal of all Jacky development pipelines and power cable, using reverse lay and removal of midline tee structure, power cable clump weight and tether clamp and removal/displacement of all mattresses/grout bags/rock

The overall assessment for this Option was a high risk. In order to prepare the pipelines and cable for removal, an increased time offshore for vessels and personnel is required, as is the use of specialist vessels and equipment and work onshore to receive and process the recovered material.

Additional time is required by divers to cut and prepare the pipelines and power cable for removal, increasing the dive time and potential exposure to harm. Operational risk is also increased for personnel onshore, for receiving and processing the recovered material at the yard.

There are a limited number of specialist vessels which can/have been adapted for rigid pipe reverse reeling and although also requiring specialist equipment, there are more vessels available for reverse reeling of flexible lines/umbilicals. Due to high forces the pipelines are subjected to during recovery, technical issues of reverse reeling arise when there are problems with the integrity of the pipeline. Usually a problem associated with older pipelines, the Jacky water injection line has experienced significant corrosion during its lifetime. There is also limited reuse for the rigid steel production pipeline recovered by reverse reeling as the pipelines long term integrity may be compromised due to being subjected to multiple cycles of deformation through the reeling and unreeling process.

Although not commonly undertaken, reverse reeling is a proven technology in the UKCS. However, due to the equipment required and the uncommon nature of the activity, this scored a medium for the level of uncertainty of methods, equipment and hazards.

It is proposed that dive support vessels, and additional support vessel would be used to complete most operations (e.g. removal of spool pieces, midline tee structure and pipeline removal and recovery to shore), over a period of approximately 39 days. Estimated vessel emissions (~2,030 tonnes CO_2 eq.) are low in relation to UKCS and wider UK greenhouse gas emissions and total estimated energy use including from the recycling of recovered steel components is in the range 10,0000-100,000Gj.

Following the assumption for the fate of rock cover when the pipeline is removed (see Section 3) the majority of the 11,884 tonnes of rock used would either have to be displaced or removed for this Option to enable safe removal of the pipelines and power cable. Depending on the method of rock displacement, the rock may be jetted away and scattered. The resulting scattered rock is not considered to be of significant concern as there is already (pre-existing) natural hard substrate in the area, as identified in previous site and pipeline surveys (see Option 1/2). However, the current disposition of the rock is in over-trawlable mounds, and the scattering of rocks over an area of seabed surface may result in some interference with trawl fishing in the immediate area. A trench would have to be excavated along the entire length of the pipelines, using mass flow excavation, prior to spooling back onto a reel; this would require an additional vessel on site.

The discharge to sea of chemicals and any residual hydrocarbons for Option 4 has been considered the same as that for Options 1 and 2, i.e. a full discharge of the production and water injection lines, with the risk assessment being the same.

The vessels and techniques involved in Option 4 are generally considered well proven but uncertainty about the likely behaviour of the pipelines and cable during manipulation means there is low confidence in the expected outcomes.

The costs of Option 4 are substantially greater than those for Options 1-3, and are similar in magnitude to those for Option 5.

Option 5: Removal of all jacky development pipelines and power cable using cut and lift and removal of midline tee structure, power cable clump weight and tether clamp and removal/displacement of all mattresses/grout bags/rock

Option 5 requires the longest time offshore for vessels and significant numbers of personnel. This Option had an overall assessment of high risk.

Additional time is required by divers to cut and prepare the pipelines and power cable for removal, increasing the dive time and potential exposure to harm. Operational risk is also increased for personnel onshore, for receiving and processing the recovered material at the yard.

Risks involved for divers cutting sections and supporting lifting operations are as described in Option 3, with time increased for complete removal; an estimated 1,300 cuts required for Option 5 compared to 12 for Option 3. And, as for Option 3, Option 5 would result in extensive seabed disturbance, exposing sections of the pipelines/cable for cutting and removing. As for Option 4, a trench would have to excavated along the length of the pipelines, requiring an additional vessel on site, in order to gain access prior to cut and lift. Reuse of the pipelines from this Option, is also not available.

It is proposed that dive support vessels, a transport barge and tugs, additional support vessel would be used to complete most operations (e.g. removal of spool pieces, midline tee structure and pipeline removal and recovery to shore), over a period of about 60 days. Estimated vessel emissions (~3,120 tonnes CO_2 eq.) are low in relation to UKCS and wider UK greenhouse gas emissions and total estimated energy use including from the recycling of recovered steel components is in the range 10-100,000Gj.

The discharge to sea of chemicals and any residual hydrocarbons for Option 5 has been considered the same as that for Options 1 and 2, i.e. a full discharge of the production and water injection lines, with the risk assessment being the same.

The vessels and techniques involved in Option 5 are generally considered well proven but uncertainty about the likely behaviour of the pipelines and cable during manipulation means there is low confidence in the expected outcomes.

The costs of Option 5 are substantially greater those for Options 1-3, and are similar in magnitude to those for Option 4.

Recommendation for the decommissioning of theJacky pipelines and power cable

Options 3, 4 and 5 have increased risk to diver safety with the time and work required to prepare the pipeline and power cable for removal. Although Option 3 and 5 use proven technology and methods, all use specialist vessels and equipment and Option 4 also relies on modified vessels for reverse reeling. Option 4 and 5 by removing the pipelines and power cable completely, removes any future snagging potential for fishermen from exposed ends/sections; with any potential snagging potential on remaining protective material (rock/mattresses) having to also be eliminated. Option 3, while having an increased operational safety risk, also retains a potential snagging risk by only partially removing the pipelines and power cable.

All three of these Options have a medium to high environmental impact, with the seabed disturbance required to access the pipelines/cable for removal and potential for discharges to the marine environment if hydraulic cutting equipment is used. However, all three were unlikely to have a significant (negative) impact on communities, and commercial fishing in the area was not expected to be impacted (i.e. through exclusion/lack of access to fishing grounds).

Options 1 and 2 were considered the most favourable and were recommended as the Options going forward for decommissioning.

Both Options use proven technology and methods and given the pipelines and power cable were trenched and buried at installation and have remained so for the majority of their lengths and not developed spans, with only remedial additional protective material being required, either of these Options represent minimal/minor intervention for decommissioning.

Due to the small amount of offshore work required, leaving the pipelines and power cable *in situ* is the safest option. Environmentally, although there would be disturbance of the seabed trenching and burying the ends or covering the ends with rock, and remedial covering of exposed sections, this would be minimal and localised. Hard substrates were already present in the area, along with organisms associated with this habitat type therefore additional rock is not expected to introduce new organisms not already present.

By leaving the pipelines and power cable *in situ*, there is the future potential of snagging, if any ends/sections become exposed. The burial of any exposed ends/sections will minimise this potential.

7 CONCLUSIONS AND KEY POINTS

The Jacky Decommissioning Team identified all available decommissioning options for the Jacky pipelines and power cable. The team had good knowledge and experience of the development as several members were involved in the original Environmental Impact Assessment, design and installation of the infrastructure. For the Jacky CA a bespoke set of criteria and a scoring system was developed to assess each of the available options in turn. From this, several key points were identified:

- The three options for removal (partial, complete using reverse reeling and complete using cut and lift), involved significant equipment and personnel spreads and increased operational safety risk, compared to the leave *in situ* options.
- Leaving the trenched and buried pipeline/cable *in situ* aligned with Industry guidance, whereby pipelines under these circumstances, (adequately trenched and buried and not subject to developing spans) can be candidates for *in situ* decommissioning. Leaving the pipeline/cables *in situ*, also aligned with the original assumptions in the Jacky Facilities Decommissioning Summary (2008) provided to The Crown Estate in support of a lease agreement for the facilities.
- Snagging risk for leaving the pipeline *in situ* options was higher than removal. However, where there is existing rock covering the pipelines/cables and a relatively small number of mattresses, the current profile is over-trawlable and an over-trawlable verification will be carried out for any additional rock placement. A monitoring programme will also be agreed with the Regulator and established to identify future exposure/debris if the pipeline/cable and rock covered mattresses become exposed, degrade and break up.
- As the production line has been cleaned and flushed, with both the production and water injection lines currently left filled with inhibited seawater, the potential for leakage of contaminants from degrading pipelines if left *in situ*, was considered low to medium. Seabed disturbance would also be minimised as only the exposed ends where tie-in spools have been removed and any other sections which are exposed, would be trenched/buried/protected by rock, compared to excavating trenches to expose sections of the pipelines/cable for tool access (removal options).
- Hard substrate and species associated with this habitat type were already naturally present in the area, prior to the infrastructure being installed, as identified through site and pipeline route surveys. The additional of minimal (controlled, well placed) rock protection for exposed ends/sections for the *in situ* options would not significantly modify the habitat or introduce new species as a result.
- All options, with the exception of complete removal using reverse reeling, use proven technology and methods and are considered technically feasible. Reverse reeling, is relatively uncommon and requires specialist, modified vessels.
- None of the options were found to have significant differences in terms of societal criteria. No options appeared to exclude/significantly limit access commercial fisheries from exploiting the area; with any additional rock placement being verified as over-trawlable, to match existing, safely over-trawlable rock profiles.

- The costs of the various options can be grouped into Options 1 and 2 relatively low cost, Option 3 intermediate scale of cost, and Options 4 and 5 are the most expensive by a significant margin.

Assessment of all available options for the decommissioning of the Jacky pipelines and power cable, indicates there is a significant increase in operational safety risk for each of the removal options, compared to leaving the infrastructure *in situ*.

Therefore, the recommended decommissioning option is Option 2:

- Removal of all spool pieces, midline tee structure, section of power cable umbilical, clump weight and tether clamp and all exposed and recoverable mattresses/grout bags.

8 ABBREVIATIONS AND GLOSSARY

Term	Explanation
BEIS	Department for Business, Energy and Industrial Strategy
Beatrice AD	Beatrice Alpha Drilling Platform
Beatrice AP	Beatrice Alpha Production Platform
Beatrice B	Beatrice Bravo Platform
DECC	Department of Energy and Climate Change
DSV	Dive Support vessel
Decommissioning Programmes	Costed programmes submitted to BEIS, detailing the measures the Licensee proposes to take in connection with the decommissioning of oil and gas infrastructure (installations and pipelines)
Diatoms	Microscopic algae, with cell walls of silica consisting of two interlocking symmetrical valves
Dinoflagellates	Minute single-celled organisms, primarily marine plankton, with one or more whip-like organelles (flagella) generally used for locomotion. Approximately half are photosynthetic, and some species may produce toxins
EIA	Environmental Impact Assessment
Flagellates	A cell or organism with one or more whip-like organelles called flagella
Gj	Gigajoule. 1 gigajoule is equal to 1 billion (10^9) joules
HS&E	Health, Safety and Environment
Mariculture	The cultivation of marine organisms for food/other products in the open ocean, an enclosed section of the ocean, or in tanks filled with seawater
OSPAR	Oslo and Paris Convention
Phytoplankton	Free-floating microscopic plants
PLONOR	OSPAR list of substances used and discharged offshore which are considered to Pose Little or No Risk to the Environment
Ppt	Parts per thousand, a measure of relative salinity
Zooplankton	Free-floating small animals

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APPENDIX A - PIPELINES AND CABLES COMPARATIVE ASSESSMENT SCORED OPTIONS MATRIX

Criteria	Sub criteria	Option 1 Leave in situ - some spool pieces / protective material removed			Option 2 Leave in situ - all spool pieces / protective material removed			Option 3 Removal of all spool pieces/protective material and partial removal of pipelines/PC			Option 4 Complete removal reverse lay			Option 5 Complete removal cut and lift		
		Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score	Risk/ Impact	Relative Uncertainty	Weighted Score
Safety	Risk to personnel offshore during decommissioning operations	2	1	2	2	1.5	3	3	1.5	4.5	4	1.5	6	4	1.5	6
Safety	Risk to personnel onshore during decommissioning operations	2	1	2	1	2	2	3	1	3	3	1	3	4	1.5	6
Safety	Risk to divers during decommissioning operations	3	1	3	3	1.5	4.5	4	1.5	6	4	1.5	6	4	1.5	6
Safety	Risk to 3rd parties and assets during decommissioning operations	2	1	2	2	1	2	3	1.5	4.5	2	1	2	2	1	2
Safety	Residual risk to 3rd parties	3	1	3	2	1	2	2	1	2	1	1	1	1	1	1
			Total	12		Total	13.5		Total	20		Total	18		Total	21
			Average	2.4		Average	2.7		Average	4.0		Average	3.6		Average	4.2
Environment	Chemical discharge	4	1	4	4	1	4	4	1	4	4	1	4	4	1	4
Environment	Hydrocarbon release from pipelines	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2
Environment	Seabed disturbance and/or habitat alteration including cumulative impact	3	1	3	3	1	3	4	1.5	6	4	2	8	4	2	8
Environment	Total energy consumption and GHG emissions	2	1	2	2	1	2	2	1.5	3	2	2	4	2	2	4
Environment	Proportion of material reused/recycled	4	1	4	3	1	3	3	1	3	1	2	2	1	2	2
Environment	Proportion of material landfilled	2	1	2	2	1	2	2	1	2	3	1	3	3	1	3
Environment	Conservation sites and species (including noise effects)	3	1	3	4	1	4	4	1.5	6	4	2	8	4	2	8
			Total	20		Total	20		Total	26		Total	31		Total	31
			Average	2.9		Average	2.9		Average	3.7		Average	4.4		Average	4.4
Technical	Technical feasibility	2	1	2	2	1	2	2	1.5	3	4	2	8	5	2	10
Technical	Weather sensitivity	2	1	2	2	1	2	2	1.5	3	4	1.5	6	4	2	8
			Total	4		Total	4		Total	6		Total	14		Total	18
			Average	2.0		Average	2.0		Average	3.0		Average	7.0		Average	9.0
Societal	Residual effect on fishing, navigation or other access (including cumulative)	3	1.5	4.5	3	1	3	3	1.5	4.5	2	2	4	2	2	4
Societal	Coastal communities	3	1	3	3	1	3	4	1	4	4	1.5	6	4	1.5	6
			Total	7.5		Total	6		Total	8.5		Total	10		Total	10
			Average	3.8		Average	3.0		Average	4.3		Average	5.0		Average	5.0
Economic	Total cost	3	1	3	3	1	3	4	1	4	5	2	10	5	2	10
Economic	Residual liability including monitoring and remediation if necessary	3	1	3	3	1	3	3	1.5	4.5	2	1.5	3	2	1.5	3
			Total	6		Total	6		Total	8.5		Total	13		Total	13
			Average	3.0		Average	3.0		Average	4.3		Average	6.5		Average	6.5
				14.0			13.56			19.21			26.53			29.13
				2.8			2.7			3.8			5.3			5.8