BG GROUP

Atlantic & Cromarty Fields Decommissioning Programmes Comparative Assessment Report

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1.0 EXECUTIVE SUMMARY

This document sets out the details of the comparative assessment (CA) of feasible decommissioning options carried out for the Atlantic and Cromarty (A&C) pipelines and umbilicals. It supports the draft Decommissioning Programme for the A&C fields [1] submitted to the Department of Business, Energy and Industrial Strategy[1] (BEIS) and the statutory and public consultation which accompanies this[2].

The A&C fields, located in the outer Moray Firth, consist of three subsea production wells, two at Atlantic and one at Cromarty. The wells are suspended and isolated from the pipelines which have been flushed and are hydrocarbon free.

Control of the wells was achieved via a 32 km subsea umbilical from the Shell-operated Goldeneye platform to the Atlantic manifold. A 12 km umbilical from the Atlantic manifold controlled the Cromarty well. Both umbilicals are free of spans and, in the main, trenched and backfilled.

Production from the Cromarty well was routed to the Atlantic manifold via a 12 km, 12 inch diameter production pipeline. A 4 inch diameter piggybacked monoethylene glycol (MEG) pipeline supplied the Cromarty tree to prevent potential hydrate formation during production.

Production from the Atlantic wells was routed to the Atlantic manifold which combined fluids from the three production wells and exported directly to the Scottish Area Gas Evacuation (SAGE) terminal at St Fergus via a 79 km, 16 inch diameter export pipeline. A piggybacked 4 inch diameter pipeline carried MEG from the onshore facilities to the Atlantic manifold for onward distribution to the wells. The offshore pipelines beyond 10 km from shore are free of spans and, in the main, trenched and backfilled.

Recommendation for offshore pipelines and umbilicals: decommission in situ with minimum intervention, i.e. disconnection from the Atlantic manifold and Goldeneye platform, cut and removal of pipelines and umbilicals where they emerge from burial and with remedial rock cover to mitigate the risk of snagging to other users of the sea.

The first 10 km of the pipeline (nearshore section) features trenched, surface laid and rock covered sections according to the seabed characteristics. While there are no spans, the top of the pipeline is exposed in some locations. Recent surveys show there has been considerable natural cover of the pipelines and a reduction in exposures [19]. This trend is expected to continue.

Recommendation for nearshore pipelines: decommission in situ.

[1] In July 2016, the Department for Energy and Climate Change (DECC) was amalgamated within the new Department for Business, Energy and Industrial Strategy (BEIS). Therefore all historical correspondence and consultation prior to July 2016 refers to DECC, all planned future consultation refers to BEIS.

[2] Two further supporting documents for the draft Decommissioning Programme are available, namely the Environmental Impact Assessment (EIA) Report [21] and the Stakeholder Engagement Report [22]

During the comparative assessment workshop for the nearshore section, the Scottish Fishermen's Federation (SFF) advised that their preferred position is for total removal of all decommissioned offshore oil and gas infrastructure: if this position is adopted then there should be no oil and gas related infrastructure to snag on. As it is not technically feasible to remove all sections of the A&C pipelines given that certain sections of the lines are trenched, some are surface laid with others rock covered, rather than having potential snag hazards from a partial (segmented) cut and lift solution, SFF expressed a preference for continuous rock cover throughout the nearshore section in an attempt to avoid increasing risks to fishermen.

BG Group therefore proposes that, in conjunction with decommissioning the nearshore pipeline in situ, remedial rock cover be applied at areas of exposure, notably the area in which it can be reasonably predicted that scallop dredging may occur. The size of particle used in any new rock cover will be discussed and agreed with the relevant government departments and the SFF.

Further mitigating actions will be implemented to ensure future risk to other users of the sea is as-low-as-reasonably-practicable (ALARP). These measures are set out in the draft Decommissioning Programme [1].

All other infrastructure (outwith the scope of the comparative assessment) will be removed during the decommissioning works:

- The production wells will be plugged and abandoned; trees and protection structures will be removed and recovered to shore;
- The tie-in spools and control jumpers from the manifold to the wells, together with their concrete protection features, will be removed and recovered to shore;
- The umbilical within the J-tube at the Goldeneye platform will be removed and returned to shore for recycling;
- The A&C umbilical control equipment on the Goldeneye platform will be removed and returned to shore for recycling;
- The Atlantic manifold will be removed to shore for recycling;
- The Cromarty piping assembly, currently disconnected from the tree and the pipeline, will be removed and returned to shore for recycling;
- It is intended that all mattresses, concrete tunnels and grout bags will be removed to shore; however, in the event of practical difficulties, BEIS will be consulted.

2.0 INTRODUCTION

2.1 Purpose

This document is intended to provide a record of the comparative assessment process carried out for the Atlantic and Cromarty pipelines and umbilicals in support of the Atlantic and Cromarty (A&C) Decommissioning Programme [1].

It describes the infrastructure to be decommissioned, the options considered, the comparative assessment method used and the findings of the comparative assessment.

The Comparative Assessment Report is one of three documents submitted for consultation in support of the Draft Decommissioning Programmes [1] for the A&C Field, alongside the Stakeholder Engagement Report [21] and the Environmental Impact Assessment Report [22]. Each of these documents is available online at the BEIS website[3], on request from BG (see [21], section 4), and, during the consultation, available at its offices[4]. Other documents cited within each of the documents can also be made available to consultees for inspection by prior arrangement with BG (see the Stakeholder Engagement Report [21]).

The decommissioning options for the pipelines and main control umbilical have been subjected to a process of comparative assessment (CA) in order to determine the best method of decommissioning in compliance with DECC Guidance Notes [2].

For the purposes of the comparative assessment process, the pipelines and umbilical were grouped into five categories to be assessed separately:

- Nearshore pipelines
    - Type A: Surface laid (KP 6.4 – 8.94)
    - Type B: Surface laid with rock cover on sand with 4 inch MEG line exposures (KP 9.28 – 10.4)
    - Type C: Surface laid with rock cover with 4 inch MEG line exposures (laid on rock from KP 4.6 to KP 6.4)
- Offshore pipelines – WAGES (Western Area Gas Evacuation – Atlantic & Cromarty Pipeline System) complete with piggybacked MEG line
- Goldeneye and Cromarty umbilicals

2.2 Regulatory Context

The decommissioning of offshore oil and gas installations and pipelines on the United Kingdom Continental Shelf (UKCS) is controlled through the Petroleum Act 1998, as amended by the Energy Act 2008.

The UK's international obligations on decommissioning are governed principally by the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR

[3] See 'Table of draft decommissioning programmes under consideration' at www.gov.uk/guidance/oil-and-gas-decommissioning-of-offshore-installations-and-pipelines.
[4] BG Group, 27 Albyn Place, Aberdeen AB10 1YL

Convention). Agreement on the regime to be applied to the decommissioning of offshore installations in the Convention area was reached at a meeting of the OSPAR Commission in July 1998 (OSPAR Decision 98/3). The DECC Guidance Notes [2] align with OSPAR Decision 98/3.

Pipelines do not fall within the remit of OSPAR Decision 98/3 but BEIS requires that operators apply the OSPAR framework when assessing pipeline decommissioning options.

Because of the widely different circumstances of each case, BEIS does not predict with any certainty what decommissioning strategy may be approved in respect of any class of pipeline. Each pipeline must therefore be considered on its merits and in the light of a CA of the feasible options, taking into account the safety, environmental, technical, societal and cost impacts of the options. Cost may only be a determining factor when other criteria emerge as equal.

2.3 Overview of Field

The Atlantic and Cromarty fields are located in the outer Moray Firth in UK Continental Shelf (UKCS) Blocks 14/26a, 20/1 (north) and 13/30 respectively (see Figure 1). The fields lie approximately 79 km northeast of the St Fergus gas terminal on the north east Aberdeenshire coast and approximately 135 km from the median line with Norway. Figure 1 shows the location of the fields and their associated subsea infrastructure which tie the fields back to shore.

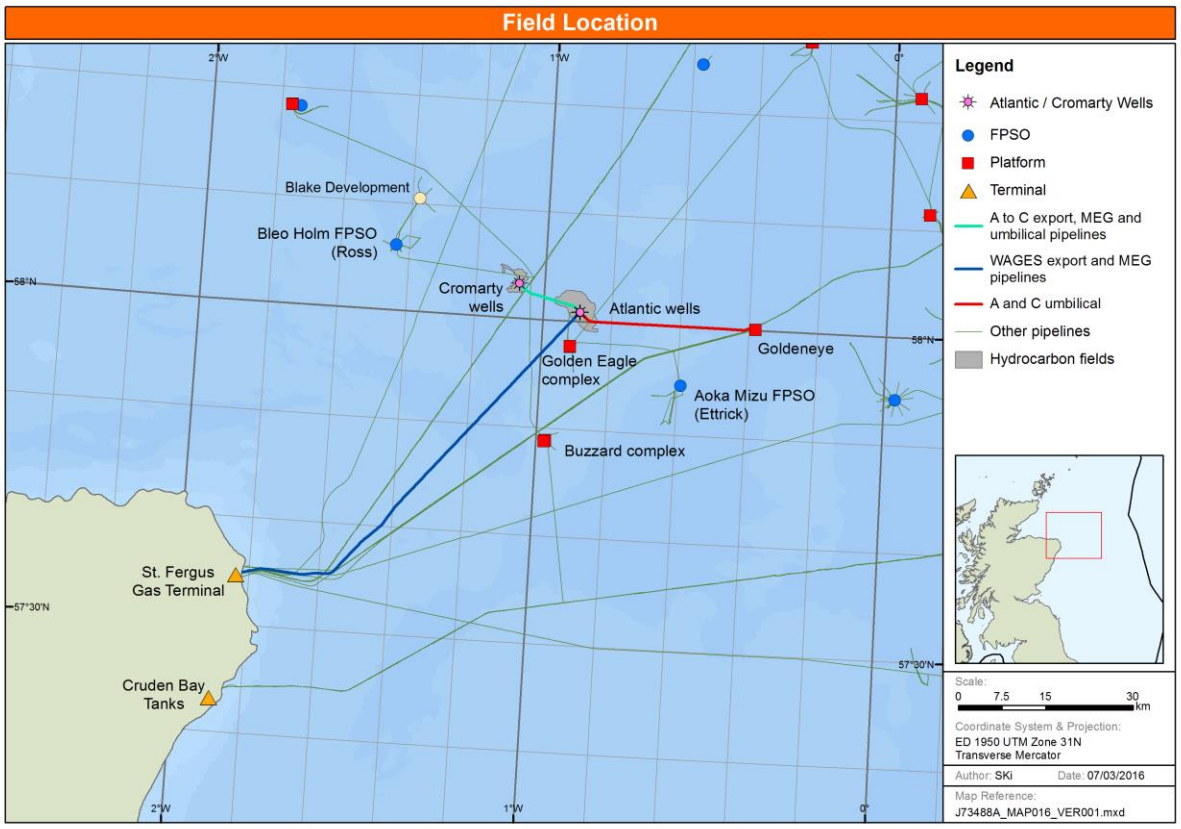

Figure 1 - Atlantic & Cromarty Field Location

BG Global Energy Limited ('BG') is the §29 Notice Holder under the Petroleum Act 1998 for the Atlantic field and Hess Limited ('Hess') is the Notice Holder for the Cromarty field. BG operates the joint facilities that serve both fields. BG is preparing the decommissioning plans for Cromarty on behalf of Hess. The field layout (as at December 2015) is shown in Figure 2.

When operational, production from the two Atlantic and one Cromarty wells was routed to the Atlantic manifold and then, via pipeline, to the Scottish Area Gas Evacuation (SAGE) terminal at St Fergus. Control of the wells was provided via an umbilical from the Goldeneye platform to the Atlantic manifold and onwards to the wells.

The fields were developed as gas and gas condensate fields and the subsea installations and pipelines were installed in 2005, with production starting in 2006. The development was designed for a field life of three years, however it was anticipated that other opportunities could tie into the infrastructure. The pipeline, subsea manifold and terminal therefore had a design life of 20 years.

Production stopped in 2009 due to high water cut and following a brief attempt to re-start in 2010 it was decided, in the absence of further production opportunities, to remove all hydrocarbons and isolate the pipelines. The pipelines and their associated piggy-backed Monoethylene Glycol (MEG) lines (PL2031 and PL2032) were cleaned and isolated from the wells and the terminal. In agreement with DECC these were put into a period of disuse under the Interim Pipeline Regime (IPR – valid until 2017) pending further investigation regarding options to extend the useful life of the pipelines. The Atlantic manifold was also left in place for this period.

Suspension of wells (mechanical plugging) was carried out during 2014 ahead of plans to fully abandon.

The export pipeline has now been disconnected from the onshore facilities and the terminal has been isolated from the SAGE terminal by the plant operators, originally ExxonMobil but now Apache. Cleaning, purging, air gapping and decommissioning of the onshore facilities will be performed by Apache at a date which remains to be confirmed.

The possible options for re-use of the export pipeline and facilities have included:

- Use of the infrastructure for gas transportation and storage;
- Use of the export pipeline and reservoirs for transporting and storing carbon dioxide;
- Sale of the facilities and infrastructure to other oil and gas companies.

To date, none of these options have yielded a specific commercial opportunity to warrant delay in decommissioning and it is now considered unlikely that there will be a feasible opportunity for re-use of the pipelines and associated subsea infrastructure.

BG notes that third-party studies on the potential for incorporating elements of the Atlantic & Cromarty facilities and the export pipeline in the context of carbon capture and storage in the Captain Aquifer are ongoing. However, advice sought from DECC's Offshore Decommissioning Unit and Environmental Management Team on three occasions (2015-2016) has confirmed that these studies in themselves do not constitute a specific proposal for an alternative use which would justify delay to decommissioning.

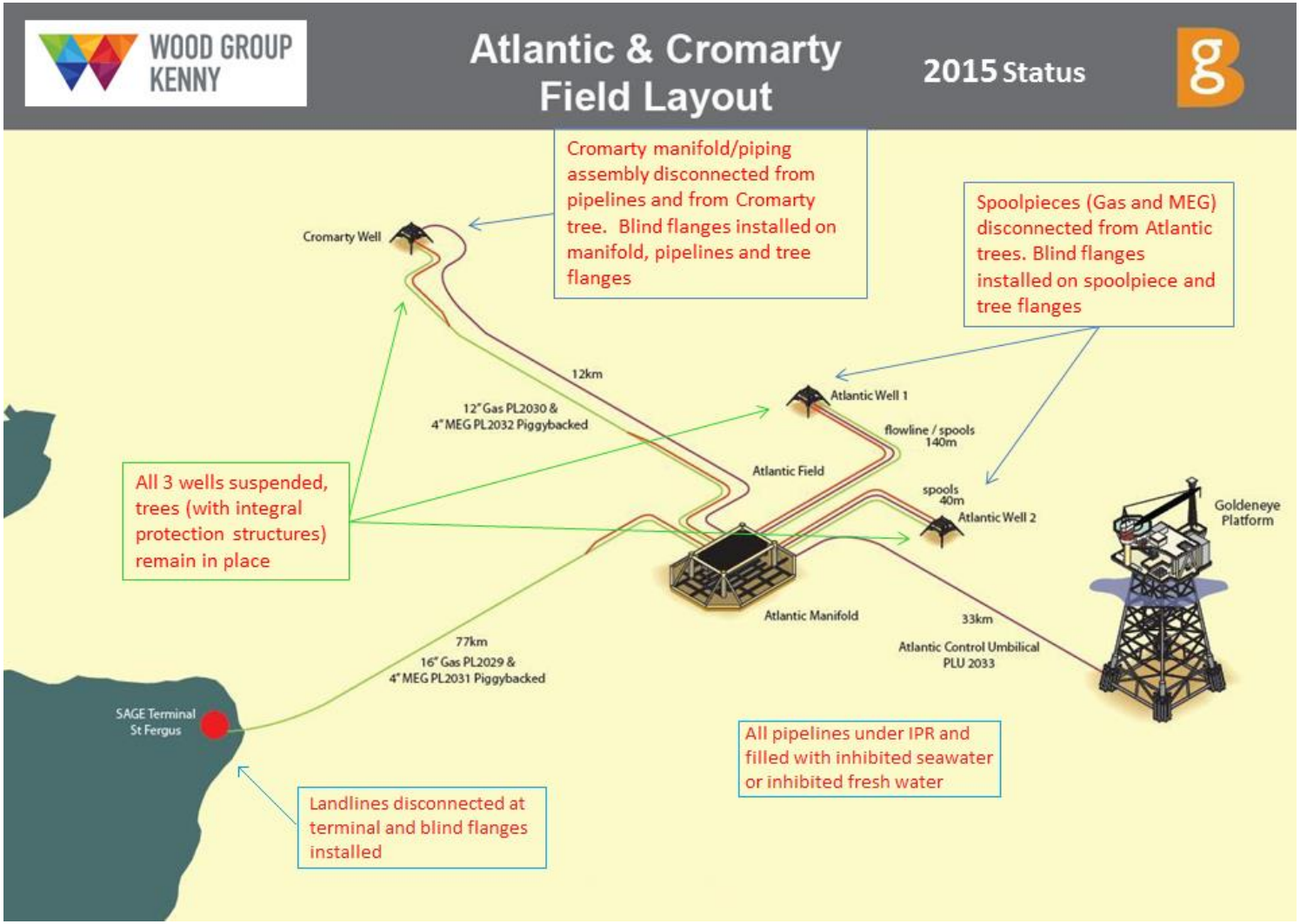

Figure 2 – Atlantic & Cromarty Field Layout

2.3.1 Infrastructure

The following infrastructure, although outwith the scope of the comparative assessment, will be removed during the decommissioning programme, with the sequence and timing of operations subject to confirmation (note: an indicative timetable is shown within the draft Decommissioning Programme [1]).

- The wells (two at Atlantic and one at Cromarty) will be plugged and abandoned; and the trees and protection structures will be removed and recovered to shore;
- The tie-in spools and control jumpers from the manifolds to the wells, together with their concrete protection features, will be removed and recovered to shore;
- The A&C umbilical control equipment on the Goldeneye platform will be removed and returned to shore for recycling;
- The section of umbilical within the Goldeneye J-Tube will be removed;
- The Atlantic manifold will be removed to shore for recycling;
- The Cromarty piping assembly, currently disconnected from the tree and the pipeline, will be removed and returned to shore for recycling;
- It is intended that all mattresses, concrete tunnels and grout bags will be removed to shore; however, in the event of practical difficulties, BEIS will be consulted.

The dedicated reception facilities at the SAGE (Scottish Area Gas Evacuation) Terminal will be dismantled and the site restored for agricultural use according to the terms of the site lease. The programme for this is outwith the scope of the A&C offshore decommissioning programme (note: an indicative timetable is shown within the draft Decommissioning Programme [1]).

2.3.2 Pipelines

Number	Description
Production System	
PL2029	16 inch pipeline from the Atlantic manifold to the SAGE terminal at St. Fergus [(1)] (79 km)
PL2030	12 inch pipeline from the Cromarty tree to the Atlantic manifold (12 km)
MEG System	
PL2031	4 inch pipeline from the Atlantic manifold to the SAGE terminal at St. Fergus [(2)] (79 km)
PL2032	4 inch pipeline from the Cromarty tree to the Atlantic manifold (12 km)
Control System	
PLU2033	Control umbilical from the Goldeneye platform to the Atlantic manifold (32 km)
PLU2034	Control umbilical from the Atlantic manifold to the Cromarty tree (12 km)

Table 1 - Pipeline Numbers and Descriptions

(1) *PL2029: the onshore section (1.6 km), and the initial 1.2 km of the offshore section of the pipeline were constructed using 18 inch diameter pipe.*
(2) *PL2031: parts of the onshore section and the initial 1.2 km of the offshore section of the pipeline were constructed using 6 inch diameter pipe.*

When operational, production from the Cromarty well was routed to the Atlantic manifold via a 12 km, 12 inch production pipeline (PL2030). MEG was supplied to the Cromarty tree through a 4 inch pipeline (PL2032) which is piggybacked to the production pipeline. Apart from the approaches to the Cromarty tree and the Atlantic manifold, and the rock covered crossings, these pipelines are trenched and buried throughout their length.

The Atlantic manifold is connected to the onshore St Fergus terminal by a 79 km production pipeline (PL2029) with a piggy-backed MEG pipeline (PL2031). The production pipeline is 16 inch diameter apart from the initial 1.2 km from the beach at St Fergus which is 18 inch diameter. The MEG pipeline is 4 inch diameter apart from the initial 1.2 km from the beach at St Fergus which is 6 inch diameter. Apart from short sections in the nearshore approach area, the approach to the Atlantic manifold and the rock covered crossings the pipelines are trenched and largely buried throughout their length.

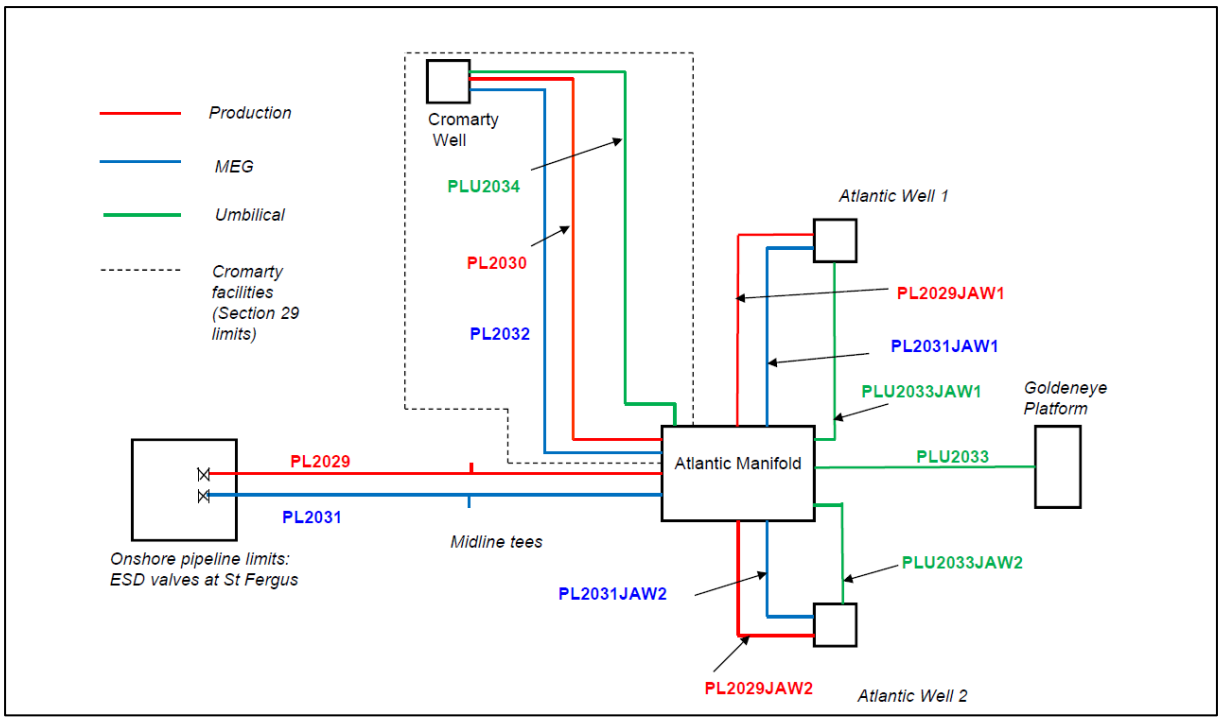

Figure 3 – Pipelines and Umbilicals Numbering Schematic

Pipeline limits and numbering are shown in the schematic at Figure 3 and listed in Table 1.

A feature of the A&C fields is the large number of crossings, protected by rock cover, where the A&C lines cross over or under third-party pipelines. The majority of these third-party lines are currently in service and not due for decommissioning for some time. It is not expected that there will be any interventions carried out at the crossing locations whilst this remains so.

Details of the crossings can be found in Section 2.3.5 of this document.

2.3.3 Characteristics

This section summarises the principal characteristics of the pipelines:

- **Nearshore Pipelines** – comprising: surface laid sections of 16 inch PL2029 and 4 inch PL2031 that are located between the beach at St. Fergus (KP0) and the crossings over the Frigg pipelines. This detail is summarised in Figure 4 below;
    - KP 0 – KP 4.6: trenched with natural infill; some rock covered areas including the Britannia crossing;
    - KP 4.6 – KP 6.4: surface laid and rock covered (Type C);
    - KP 6.4 – KP 8.94: surface laid, both 16 inch and 4 inch (Type A);
    - KP 9.28 – KP 10.4: surface laid and rock covered (including FLAGS crossing) (Type B).

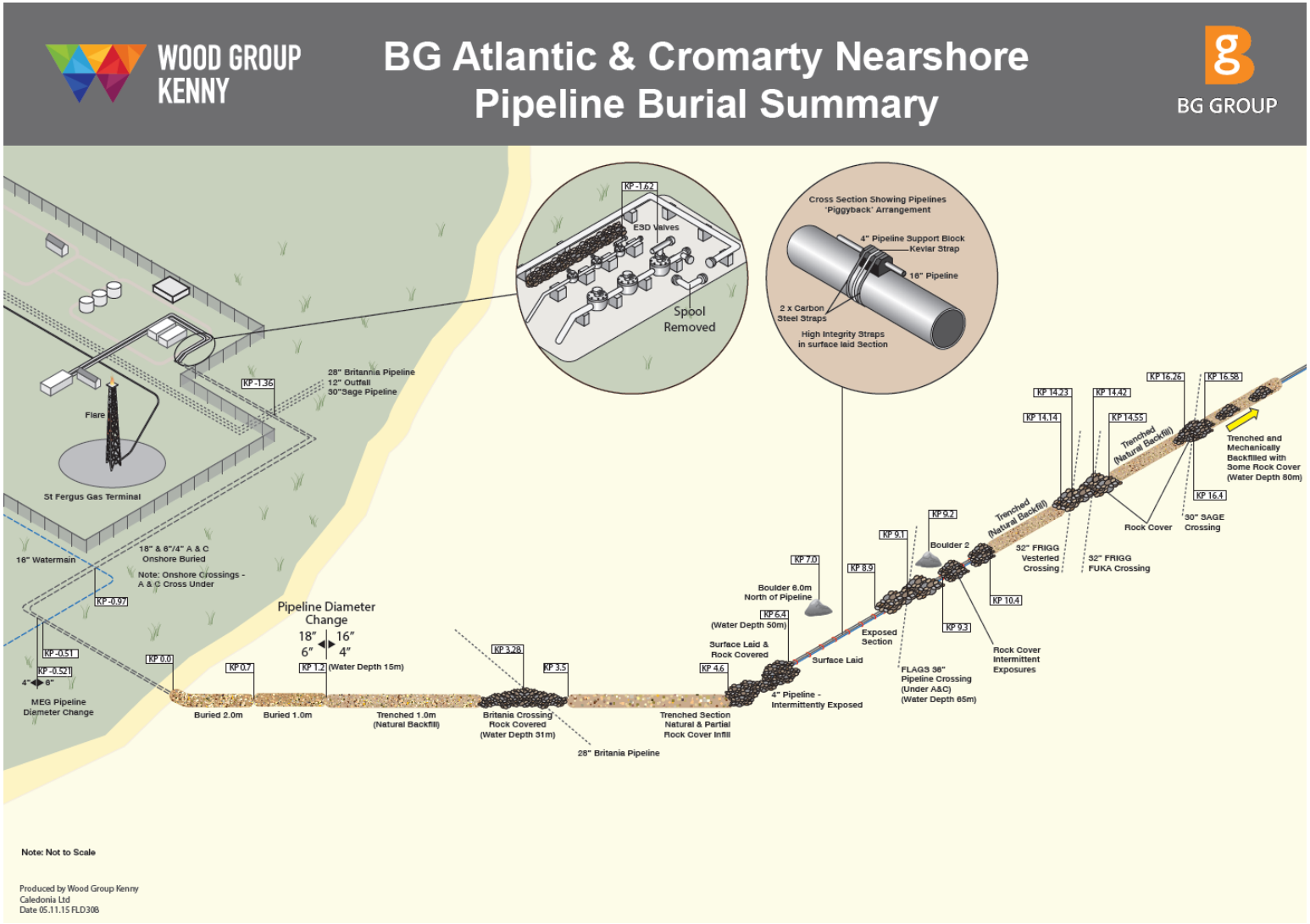

Figure 4 - Pipeline Status - Nearshore

- **Offshore Pipelines** – comprising:
  - KP 10.4 – KP 16.6: trenched with natural infill; rock covered Frigg and SAGE crossings;
  - KP 16.6 – KP 77.6: mainly trenched with ploughed backfill with some rock covered sections including a future tie-in tee at KP 42. This section extends to the tie-in to the Atlantic manifold spoolpiece (KP 77.6).
  - Cromarty to Atlantic pipelines (12 inch PL2030 and 4 inch PL2032): trenched and backfilled.

2.3.4 Umbilicals

- PLU2033 from Goldeneye to Atlantic: trenched and backfilled, with some areas of rock cover.
- PLU2034 from Atlantic to Cromarty: trenched and backfilled, with some areas with remedial rock cover.

The subsea umbilicals were installed to provide electrical power and signals, hydraulics and chemical injection capability to the A&C wells via a 32 km umbilical (PLU2033) from the Goldeneye platform to the Atlantic manifold; and a 12 km umbilical from the Atlantic manifold to Cromarty (PLU2034). A satellite link provided communication and control between the Goldeneye platform and the St Fergus gas terminal. Figure 2 shows the position of the field in relation to Goldeneye.

PLU2033 is installed in a J-tube at the (unmanned) Goldeneye platform. Both PLU2033 and PLU 2034 were trenched after installation. Rock cover was added in a number of areas where the required depth of trench was not achieved. Both umbilicals have short untrenched sections at either end that are covered by concrete mattresses.

The Atlantic well control jumpers (PLU2033JAW1 and PLU2033JAW2) are surface laid and covered by concrete mattresses. There is also a rock-covered section of approximately 500m between the trenched section of PLU2033 and the Goldeneye platform.

The umbilicals and their numbering, together with an umbilical cross-section are shown in Figures 3 and 5 respectively.

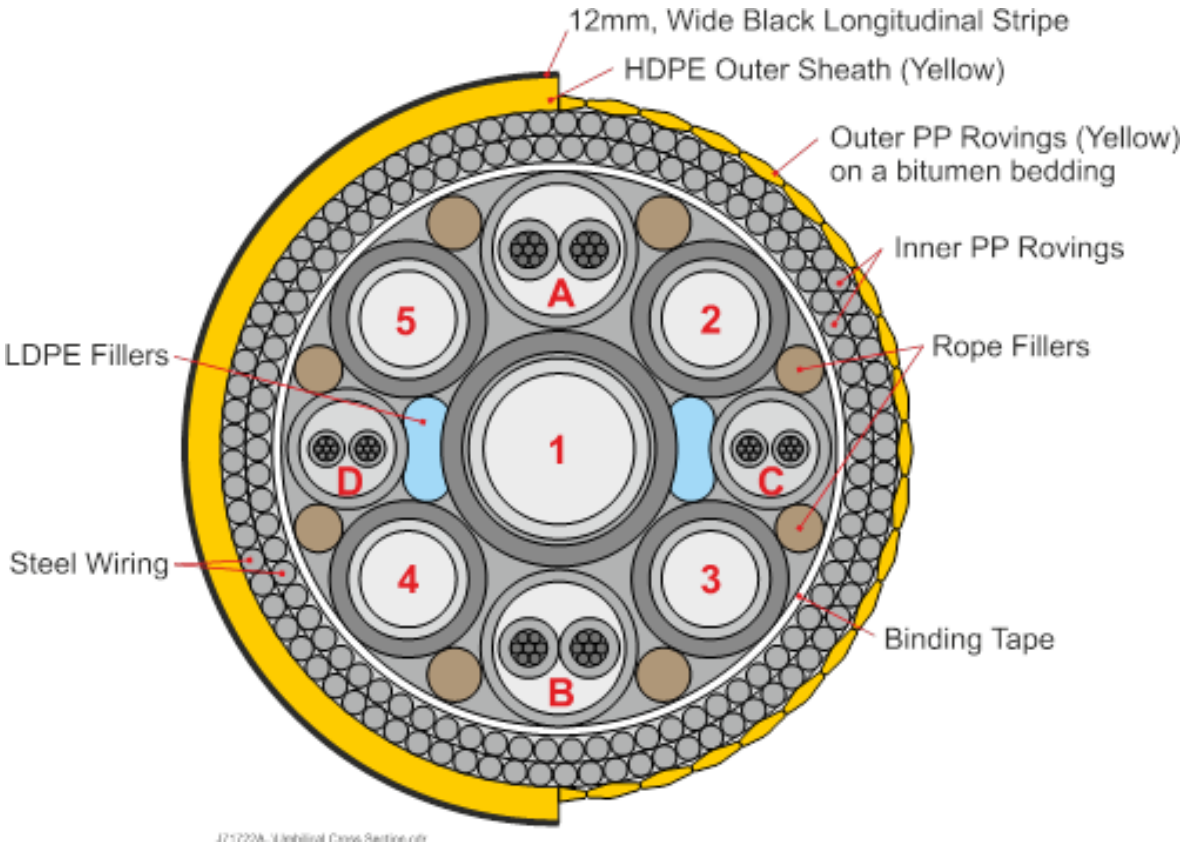

Figure 5 - Umbilicals Cross Section (PLU2033 & PLU2034)

2.3.5 Crossings

There are five third-party pipeline crossings under the Atlantic pipelines (PL2029/2031):

- 36 inch FLAGS (Far North Liquids and Associated Gas System) (PL2)
- 32 inch Frigg Vesterled (PL7S)
- 32 inch Frigg UK Pipeline (FUKA) (PL6S)
- 28 inch Britannia (PL1270)
- 30 inch SAGE (PL762)

There are four third-party crossings over the Atlantic pipelines (PL2029/2031):

- 10 inch Buzzard (PL2072)
- 8 inch Golden Eagle water injection (PL3172)
- 8 inch / 12 inch Golden Eagle Pipe-in-Pipe with 4 inch piggyback (PL3168/PL 3169)
- Golden Eagle Umbilical (PLU 3175)

There are two third-party crossings under the Cromarty pipelines (PL2030/2032):

- 32 inch Frigg Vesterled (PL7S)

- 32 inch FUKA (PL6S)

There is one third-party crossing over the Cromarty pipelines (PL2030/2032):

- 10 inch Buzzard (PL2072)

There are four third-party crossings under the Goldeneye umbilical (PLU2033):

- 20 inch Goldeneye gas export (PL1978)
- 4 inch Goldeneye service line (PL1979)
- 30 inch SAGE (PL762)
- 30 inch Miller (PL720)

There is one third-party crossing over the Goldeneye umbilical (PLU2033):

- 14 inch Golden Eagle (PL3036)

There are three third-party crossings under the Cromarty umbilical (PLU2034):

- 32 inch Frigg Vesterled (PL7S)
- 32 inch FUKA (PL6S)
- 10 inch Buzzard (PL2072)

The Cessation of Production (CoP) or decommissioning dates for each of these lines are currently unknown and will not coincide with the expected decommissioning of A&C pipelines.

The crossings will remain in situ until such time as the third-party owners are ready to decommission their pipelines. Agreements will be entered into with the owners of each pipeline. The final decommissioning method for the crossings will be determined when the crossed / crossing pipeline is to be decommissioned.

3.0 COMPARATIVE ASSESSMENT METHODOLOGY

The A&C comparative assessment has been carried out in compliance with BG Guideline BG-GL-PM-PM-040 [3] and the DECC Comparative Assessment Guidance Notes [2]. The BG Guideline provides the framework for the project's CA process and ensures that the steps are fully aligned with BG's internal Value Assurance Framework (VAF) Standard.

The BG Guideline [3] requires that a CA is conducted for each infrastructure group as identified in Section 2.2, following the process outlined in Figure 6.

The initial step is to clearly define all feasible options to be studied and the associated issues to be clarified, prior to the completion of the CA.

The CA is a process with a series of engagement points (as shown in Figure 6) and opportunities to feedback and refine the CA input data, criteria and methodology in order to ensure that options fully consider all the inputs in a balanced manner.

BG Group engaged stakeholders at every stage of the CA. Stakeholders are defined as "any party who is impacted by, contributes to or who has influence over the project". Engagement with stakeholders maximises the data input to the CA and ensures that options are assessed comprehensively.

The BG Comparative Assessment Guideline [3] provides full details of the objective, inputs and outputs from each of the stages identified in Figure 6.

Each decommissioning option was assessed against the following evaluation criteria and sub-criteria:

- Safety
  - Project risk to personnel – offshore
  - Project risk to other users of the sea
  - Project risk to personnel – onshore
  - Potential for a high-consequence event
  - Residual risk to other users of the sea
- Environment
  - Marine impact of operations
  - Energy, emissions, resource consumption
  - Impact of marine end points (legacy impact)
- Technical
  - Risk of major project failure
  - Technology demands / track record

- Societal
  - Commercial impact on fisheries
  - Socio-economic impact on communities and amenities
- Economic
  - Cost
  - Cost risk and uncertainty

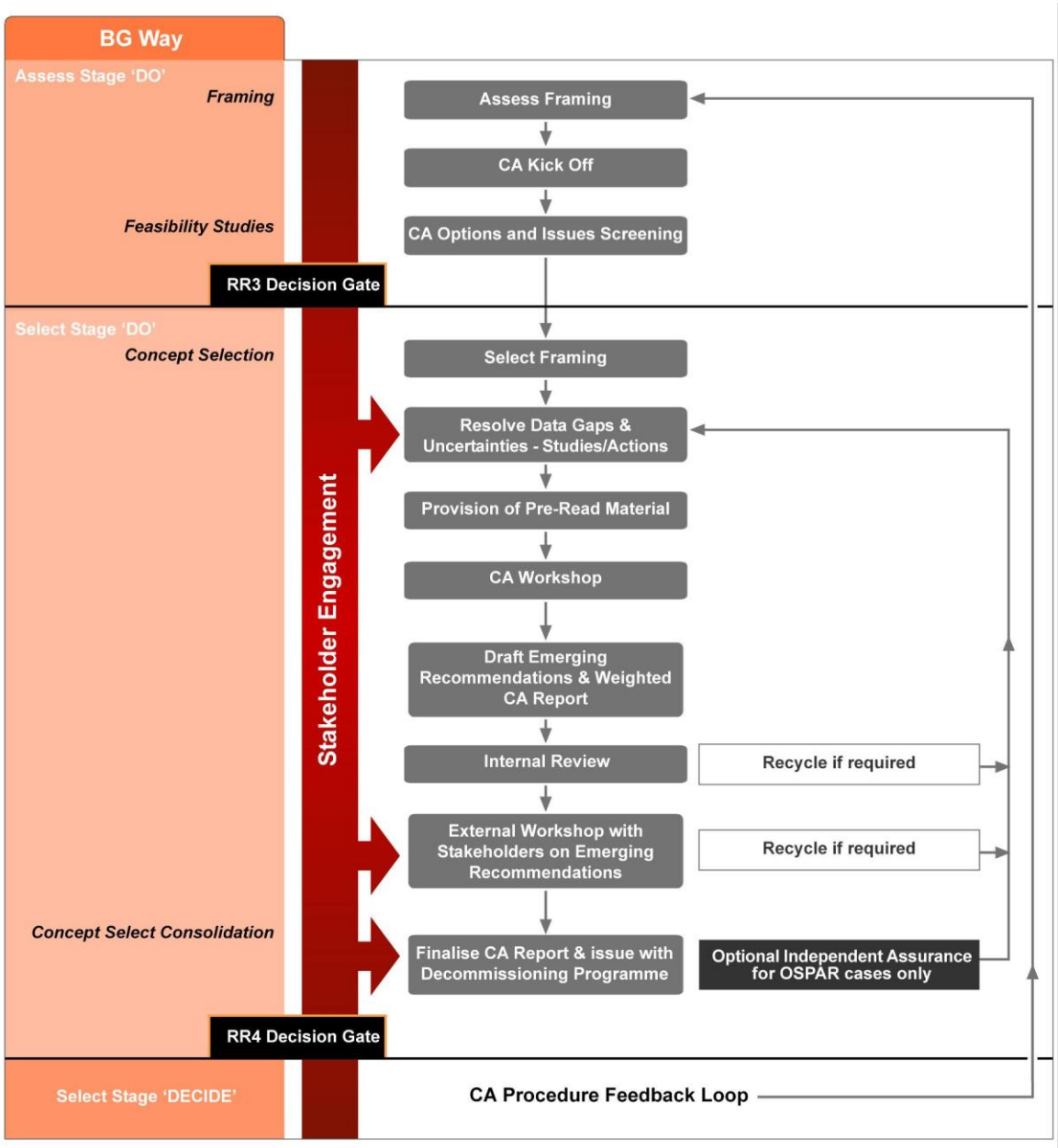

Figure 6 – Comparative Assessment Flowchart

With the exception of the assessment criteria for the "marine impact of operations" and "environmental impact on marine end-points (legacy)" sub-criteria[5], the scopes of each sub-criterion and examples which may be applied to the comparison were adopted from Table 2 in Section 6.3 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

The majority of sub-criteria were assessed qualitatively; however, as per Table 2 below, there were three sub-criteria for which quantitative data was necessary to provide clarity.

Sub-criteria	Quantative data supplied
Project risk to personnel – offshore	Potential Loss of Life (PLL) scoring for each option
Energy, emissions, resource consumption	CO_2 (tonnes) production associated with each option
Cost	Capital expenditure (£) associated with each option

Table 2 - Sub-criteria assessed by quantitative data

SCORING

A Red / Amber / Green high-level qualitative assessment was conducted for each of the CA categories to allow unrealistic and unfeasible options to be discounted at an early stage. The remaining options were then assessed using a mixture of quantitative and qualitative scoring, following the methods outlined below.

COMPARING EACH OPTION

The options were compared by relative performance against each of the other options, achieving a scoring range for each sub-criterion from 0.0, the "least best" option for that sub-criterion, to 1.0, the "best" option i.e. the higher number denotes the most preferred option.

An example of comparative scoring is illustrated below:

A NORTH SEA PIPELINE

			Option 1: Leave in situ	Option 2: Rock cover	Option 3: Trench and Bury	Option 4: Total Removal	
Attribute ranking							
Ref.	**Attribute**	**Comments**	**Best=1; Least best=0**				**Very strong preference of 1 over 0=10: Indifferent between 0 and 1=0**
2	Project risk to other users of the sea	Number of transits, interference with other sea operations (fishing, transport)	1.0	0.7	0.4	0.0	7
			Minimal intervention, hence low project risk to other users.	Operations would be expected to be completed in a matter of weeks so minor temporary impact.	Operations would be expected to be completed in 1-2 months so minor impact but greater than Option 2	Significantly longer period of operations & impact when compared to other options	

Figure 7 – Example of comparative scoring (not actual scoring)

[5] For these sub-criteria, BG assumed alternative assessment criteria which would allow for a viable comparison based on the particular circumstances of the project. The assessment criteria can be found in Appendix 2

The example depicted in Figure 7 demonstrates that for the Project Risk to Other Users of the Sea, the option with least risk was allocated a score of 1.0 and the option with greatest risk a score of 0.0. The activities with risk profiles between these two were ranked accordingly with respect to their comparative degree of risk. For qualitative sub-criteria, the exact scores of these intermediate options were agreed by the subject matter experts at the comparative assessment workshop(s); for quantitative, the highest and lowest values were used to create a scale against which the intermediate options are scored.

ADJUSTMENT TO SCALE

Each sub-criterion was given a scoring to indicate the scale of difference between the highest and lowest options; i.e. where the difference between the "least best" and "best" options is very strong, a Preference Score of up to 10 can be applied; where the difference between the "least best" and "best" options is very weak, a Preference Score of as low as 0 can be applied.

An example of this scoring is illustrated below:

A NORTH SEA PIPELINE

			Option 1: Leave in situ	Option 2: Rock cover	Option 3: Trench and Bury	Option 4: Total Removal	
Attribute ranking							
Ref.	**Attribute**	**Comments**	**Best=1; Least best=0**				**Very strong preference of 1 over 0=10: Indifferent between 0 and 1=0**
2	Project risk to other users of the sea	Number of transits, interference with other sea operations (fishing, transport)	1.0	0.7	0.4	0.0	10
			Minimal intervention, hence low project risk to other users.	Operations would be expected to be completed in a matter of weeks so minor temporary impact.	Operations would be expected to be completed in 1-2 months so minor impact but greater than Option 2	Significantly longer period of operations & impact when compared to other options	

Figure 8 – Example of preference scoring (not actual scoring)

The example depicted in Figure 8 has a preference number of 10 which can be seen in the right hand column. This indicates that there is a very great difference between the highest and lowest values and gives adjustment to the calculated scale to take account of this difference.

APPLICATION OF WEIGHTING

The comparative assessment process allows individual project teams to assign criteria weighting derived from a Pairwise Analysis. This was completed for A&C as follows:

		A	B	C	D	E		
	Assessment Criteria	Safety Risk	Environment	Technical	Societal	Economic	Geometric Mean	Weighting
A	Safety Risk	1	a2	a2	a2	a2	2.41	42%
B	Environment		1	b2	b1	b1	1.32	23%
C	Technical			1	d1	c0	0.56	10%
D	Societal				1	d0	0.80	14%
E	Economic					1	0.70	12%

Table 3 – Pairwise comparison for criteria weighting

The weightings were calculated using a pairwise comparison whereby the relative importance of each criterion is individually assessed against each of the other criteria. The assessment determines which of the two criteria is most important and by how much, using the following scale:

Letter code	Example	Definition	Numerical score
LetterCode x LetterCode	bc	Criteria are deemed of equal importance	1
LetterCode 1	b1	Moderate importance of the named criteria over the other	2
LetterCode 2	a2	Strong importance of the named criteria over the other	3
Letter Code 3	d3	Very strong importance of the named criteria over the other	4

Table 4 – Pairwise comparison scoring methodology

The codes were automatically converted into a numerical score and the inverted score assigned to the opposite comparison, e.g. A > C was given the score a2, a numerical value of 3; therefore C > A was given a numerical value of 0.33.

The scores were then normalised against the sum of the geometric mean values and rounded to the nearest 5%. Note: the weightings were determined before scoring was undertaken.

In the case of Atlantic & Cromarty Decommissioning, following normalisation the weights were thus:

- Safety – 40%
- Environment – 20%
- Technical – 10%
- Societal – 15%
- Economic – 15%

Weightings are distributed equally between each sub-criteria to produce the pairwise assessed weighting for the parent criterion, e.g. each of the five Safety sub-criteria are assigned an 8% weighting.

COMPUTATION OF SCORES

Scores for each sub-criterion are multiplied by their attribute weighting and the Preference Score, before being collated to provide an overall numerical score for each option. The most preferred option will have the highest numerical score.

An example of the overall scoring is shown below:

Attribute summary:
Best & Least best

	A North Sea Pipeline			
Block 1:	**Option 1: Leave in situ**	**Option 2: Rock cover**	**Option 3: Trench and Bury**	**Option 4: Total Removal**
Overall scoring:	D 2.85	3.08	3.89	1.58
Overall ranking:	3.0	2.0	1.0	4.0

Ref.	Attribute	A Best=1; Least best=0				B	C
						bute ghting	**ong preference of 1 0=10: Indifferent between 0 and 1=0**
1	Project risk to personnel - Offshore	1.0	0.0	0.2	0.6	8%	10
2	Project risk to other users of the sea	1.0	0.7	0.4	0.0	8%	10
3	Project risk to personnel - Onshore	0.0	0.8	1.0	0.3	8%	5
4	Potential of a high consequence even	1.0	0.9	0.8	0.0	8%	10
5	Residual risk to other users of the sea	0.0	0.0	0.6	0.3	8%	5
6	Marine impact of operations	0.0	1.0	0.1	0.1	7%	7
7	Energy, emissions, resource consumption	0.0	0.3	1.0	0.3	7%	1
8	Impact of marine end points (legacy impact)	0.0	0.9	1.0	0.0	7%	9
9	Risk of major project failure	0.0	0.1	0.0	1.0	5%	8
10	Technology demands / track record	0.0	0.1	1.0	0.0	5%	8
11	Commercial impact on fisheries	0.0	0.0	1.0	0.3	8%	2
12	Socio-economic impact on communities and amenities	0.0	0.7	1.0	0.1	8%	4
13	Cost	1.0	0.3	0.4	0.0	8%	6
14	Cost risk and uncertainty	0.0	0.1	1.0	0.9	8%	5

Figure 9 – Example of overall scoring (not actual scoring)

The example shows that the score for each sub-criterion has been computed by multiplying the comparative ranking (box A), by the attribute weighting (box B) and the Preference Score (box C). These computed scores are then added together to produce the overall score for each option (box D).

The decommissioning options described in Section 4 were identified at the Comparative Assessment Options and Screening Workshop, supported by the Pipelines Options Study [6], Nearshore Supporting Study [16] and Umbilicals Options Study [7].

NOTES ON PROCESS

The following items should be noted when considering the process undertaken during the comparative assessment of Atlantic and Cromarty decommissioning options:

- Quantitative assessment has been carried out on three sub-criteria only, with the remaining eleven sub-criteria being assessed qualitatively;
- In assessing legacy risks to the fishing industry, Brown & May [9] determined that little fishing incident data was available for the specific A&C decommissioning risk assessment therefore a mostly qualitative approach was used and included a conservative “worst case scenario” approach, as opposed to credible / most probable;
- To protect commercial confidentiality ahead of invitations to tender, a normalised relative score has been provided in this document, however detailed cost estimates are being provided to BEIS in a separate submission;
- In estimating vessel durations and costs for the partial remediation options of the offshore pipelines and umbilicals, a maximum length of 5 km has been assumed. It is likely that the area requiring remedial action would be significantly less than this;
- Decommissioning options for the crossings (both pipelines and umbilicals) have not been provided as commercial agreements will be entered into with the owners / operators of the third party pipelines and the crossings will remain in situ until the third party lines are ready to be decommissioned. The final decommissioning method for the crossings will be determined when the crossed / crossing pipeline is to be decommissioned.

4.0 DECOMMISSIONING OPTIONS

Potential options for each of the five decommissioning scopes were identified in Atlantic & Cromarty Pipelines Options [6], Nearshore Supporting Study [16] and Umbilical Options Study [7].

For each of the five scopes identified in Section 2.1, the following options were initially considered.

4.1 Pipeline Decommissioning Options

4.1.1 Remove ends and exposed pipeline sections

This option leaves the majority of the pipelines in situ, removing only the exposed pipeline ends at the Atlantic manifold from the trench transition to the pipeline end flanges, the protective mattresses, concrete protection covers and tie-in spools.

The tie-in spools would be removed either in single lift (reverse installation) or cut into manageable lengths using hydraulic pipeline shears and lifted from the seabed to the boat deck with a lifting beam and hydraulic beam clamps.

The cut end of the pipeline, at the transition to the trench, would be protected by $1m^3$ sacks of graded rock installed by Remotely Operated Vehicle (ROV).

4.1.2 Partial remediation

Partial rock cover

This option assumes the same pipeline end removal as Section 4.1.1; however, any areas of intermittently or fully exposed pipelines would be protected by additional rock cover.

Partial cut and lift

This option assumes the same pipeline end removal as Section 4.1.1; however, the exposed sections or areas lacking in sufficient protection would be cut out and recovered using the cut-and-lift method.

Partial trench

This option assumes the same pipeline end removal as Section 4.1.1; however, the exposed section and areas of incomplete protection would be trenched and the pipelines lowered under the seabed for protection.

The feasibility of the “trench and bury” option was challenged on the basis that the nearshore sections of pipeline under consideration would have been trenched during installation if it had been a practical option. Wood Group Kenny assessed the technical feasibility of this option for the nearshore sections with the report [8] concluding:

- The rock-covered pipe sections at either end of the surface laid area, i.e. at KP 6.4 and KP 8.94) would pin the pipeline in place. This would cause residual tension in the pipeline which could prevent significant lowering of the pipe into the trench;
- There would therefore be a significant transition length where the pipeline would not drop into the trench and substantial unsupported freespans would occur;

- This would also occur at the four 40m rock berms in place along the surface laid section at KPs 6.505, 7.504, 8.549 and 8.615;
- The resulting spans would then require significant rock cover to mitigate, thereby removing the benefit and original intention of the trenching;
- Further, the presence of several large boulders along the pipeline route at this location would present a significant risk to the success of the trenching activity and may result in damage to the trencher, and create unsupported spans which would also need significant rock cover to mitigate;
- In the other nearshore sections "*the length of the transition slopes [required] would negate the benefit of trenching as a solution, and would require each end of the exposed sections to be rock covered for at least 100m*".

The option to trench and bury was therefore excluded.

4.1.3 Full removal

Full removal would be carried out in two phases: the first phase would include the deburial and removal of the pipeline except the crossings; the second phase would be carried out by the third-parties at the time of decommissioning their own infrastructure.

Pipeline deburial would be carried out with mass flow excavators for rock cover dispersion and jetting sled for deburial of the main pipeline sections. Optimal deburial techniques for each area of the pipeline route would be assessed during the design phase.

The following methods were considered for performing the removal activities.

Deburial and reverse S-lay (lift and cut)

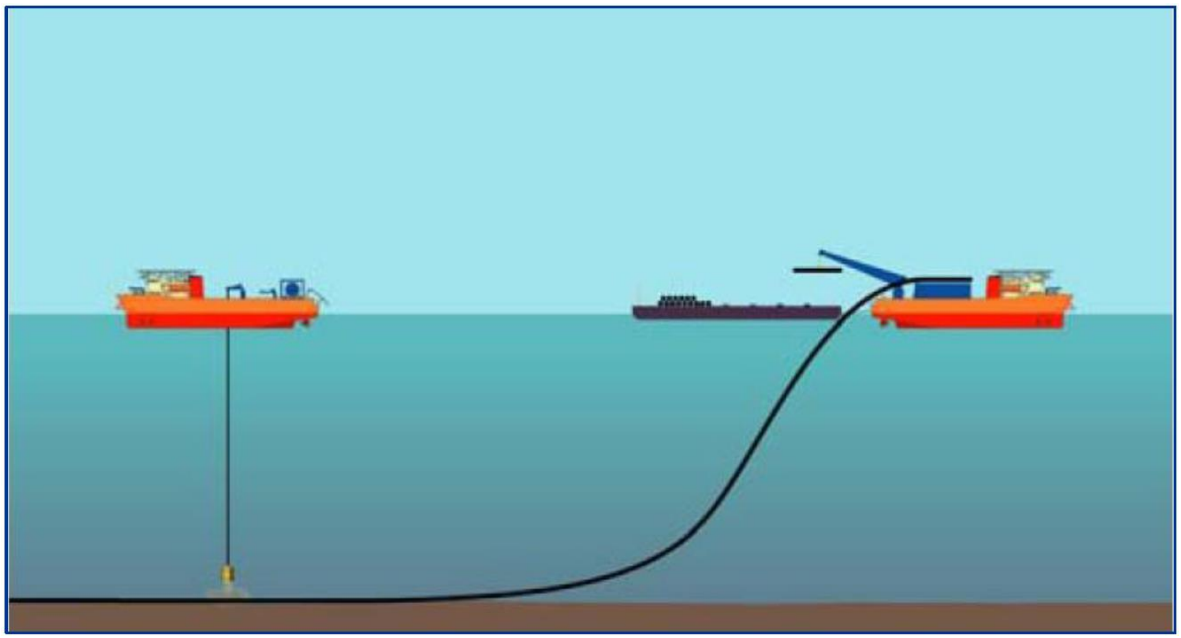

Figure 10 – S-lay illustration

When the Atlantic pipeline was installed, concrete coated pipe sections were welded together on the deck of an S-Lay barge. The pipeline had a pulling head which was deployed over

the stinger. During installation the line was air filled providing additional buoyancy, and the pipeline was maintained under a constant tension from the initiation wire connected to the initiation anchor on the seabed.

This combination of buoyancy provided by the air filled pipe, the tension applied to the pipe and the correct offset of the vessel to the touchdown point carefully maintained the correct profile of the pipe sag bend as the pipe was laid on the seabed.

During installation, the pipeline lay conditions are at their best.

To reverse this process several years later carries additional risk; i.e. the properties of the welded connections and pipeline materials, effects of internal corrosion and additional strain cycles due to pressure cycling in the pipeline during use can all increase the risk of pipe or weld failure.

With concrete coated pipelines there is also a higher potential for dropped objects due to the increased risk of cracking of the concrete coating in the sag bend while recovering the pipeline to the S-lay vessel and while cutting into manageable sections for storage.

Stopping and re-starting the pipe recovery process at pipeline crossings will be more complicated with the reverse S-Lay method.

The options for stopping pipe recovery and re-starting at crossings are:

- Laying down the pipe before the touchdown point reaches the crossing, this will leave several hundred metres of pipe laying on the seabed which will need to be removed by the cut-and-lift method with a Remote Operated Vehicle Support Vessel (ROVSV) and pipe-cutting / handling equipment.
- In a separate ROVSV preparation campaign, the crossings are prepared by pre-cutting the pipe at the required offset from the crossing point (300 to 500 metres), pulling the first 50 metres of pipe out of alignment with the crossing, installing a pulling head and initiation cable / anchor to maintain tension, or removing the section by cut-and-lift method. It is likely that a third party pipeline owner will require a minimum separation distance from the anchor to their third party pipeline being crossed. This may double the length required to the cut point – adding 300 to 500 metres and may still require an ROVSV based cut and lift campaign to recover the unprotected section from the end of burial at the crossing to the cut point.

Deburial and reverse J-lay

In reverse J-lay the pipe is recovered through the moonpool of the vessel and is held vertically in a J-Lay tower. Coating loss would be expected in the sag bend and therefore **this option was excluded** due to the greater risk of dropping the pipe and because irregularities of the pipe coating would adversely affect the ability of the pipe clamp to hold the pipeline while cutting and removing a section; and during stopping and re-starting at crossings.

Deburial and reverse reeling

Reverse reeling was excluded as concrete coated pipe will not bend sufficiently for storage on the reel without the coating cracking and falling off. Also, some coating loss would be expected on the sag bend; this would also compromise the effectiveness of the pipe clamp to

effectively hold the pipe during any stops – i.e. stopping and restarting at crossings. Further, the 16 inch pipeline was not designed for reeling and would be at risk of buckling.

Deburial and cut-and-lift

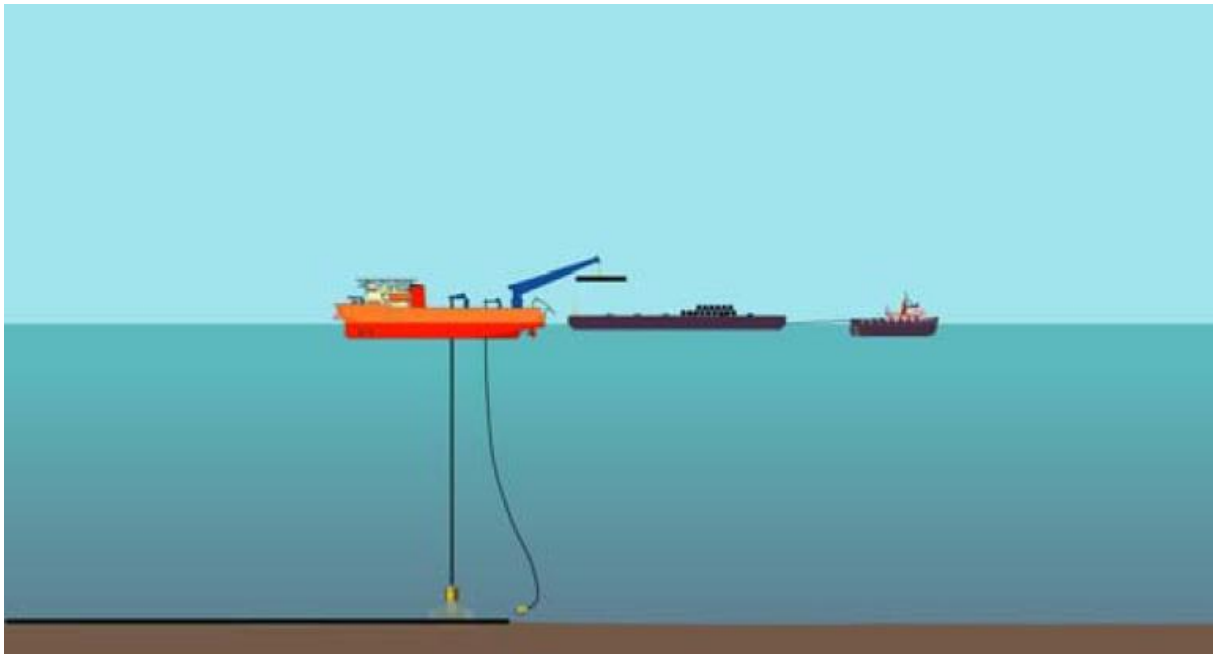

Figure 11 – Cut-and-lift illustration

The third methodology considered was the cut-and-lift method (Figure 11), with cutting carried out using hydraulic pipeline shears.

The pipeline would be cut into 24m sections and recovered using a hydraulic lifting beam. Note that this method would be able to cut both the 16 inch and 4 inch piggyback line; allowing both lines to be recovered at the same time. The hydraulic beam clamp can be profiled to hold the piggyback line in position during recovery should the piggyback straps fail during lifting.

The advantage of the cut-and-lift method is that:

- the pipe is cut into manageable lengths on the seabed
- the vessel is not connected to the pipeline
- only small sections are removed at any one time
- the hydraulic cutting shears are able to penetrate the seabed, alleviating any potential issues from poor deburial

With this in mind, the cut-and-lift method has been chosen as the base case for both partial and full removal options.

4.2 Umbilical Decommissioning Options

As the umbilical within the Goldeneye J-tube is to be removed, only the subsea sections of the umbilicals have been subjected to comparative assessment, i.e. the entire Cromarty

umbilical and the Goldeneye umbilical from the Atlantic manifold to the bottom of the J-tube at the Goldeneye platform.

4.2.1 Remove Ends Only

As per Section 4.1.1, this option will leave the vast majority of the umbilicals in situ.

The Umbilical Termination Assemblies (UTA) would be released from the Atlantic manifold by Diving Support Vessel (DSV) and removed.

All mattresses would be recovered from the seabed and removed. The surface laid sections of each umbilical would be cut subsea and recovered to the deck of a Dive Support Vessel (DSV) for removal.

At the Goldeneye platform the umbilical would be cut and removed by DSV as it enters the rock cover after exiting the J-tube.

4.2.2 Partial removal

The three options for the umbilicals are identical to those in Section 4.1.2.

4.2.3 Full removal

Reverse S-lay

Following deburial of the umbilicals and removal of all concrete mattresses, the umbilicals would be retrieved to the deck of an ROVSV.

The umbilical would be recovered to deck, held in the tensioner and cut into 18m sections using the hydraulic shears. Transport to shore for recycling will either be on the deck of the ROVSV or by means of a supply boat.

Cut-and-lift

Following deburial of the umbilicals and removal of all concrete mattresses, the umbilicals would be cut into manageable sections by a Work-Class Remotely Operated Vehicle (WROV). The cut sections would then be recovered to deck or a supply vessel using a hydraulic lifting beam.

Reverse installation by reeled-pipelay vessel

Reverse installation would be best conducted from a reeled pipelay vessel which has both the storage capacity of the main reel and the ability to pull significant loads. The pipe clamp and reel drive system would assist in the recovery of the umbilicals from their buried location, thereby removing the requirement for a separate campaign to debury the umbilicals prior to removal.

4.3 Initial Option Assessment

Two internal workshops to screen the options were held by BG in July 2015 utilising information from the 2011 survey and earlier data. The workshops enabled the project team to identify and define feasible options for each of the five pipeline categories, whilst highlighting data gaps associated with each option and defining the studies required in the next phase.

In August/September 2015 the Fugro Searcher survey vessel performed an environmental baseline survey and pipeline inspection and debris survey of A&C. The surveys indicated a continuation in the trend for backfilling of the trench and increased cover of exposed sections previously identified by the 2011 survey. More importantly, there were no spans outwith acceptable limits recorded during the 2015 survey.

Following the completion of the required studies and with some early draft survey data, the options were presented to stakeholders on 26 November 2015 [5].

Following the Stakeholder Workshop, the pipeline decommissioning options shown in Figure 12 were to be taken forward in the formal CA process. The Cromarty pipelines were assessed against the same options as the offshore pipelines shown in Figure 12.

The agreed options to be assessed for the umbilicals were:

- Minimal removal (ends only)
- Partial removal and remediation via:
    - Remedial rock-cover
    - Cut-and-lift
    - Re-trench
- Total removal via:
    - Reverse reel-lay
    - Subsea cut-and-lift

Atlantic Pipelines PL 2029/2031 Decommissioning Options for Comparative Assessment

Seabed type	Sand		Rock	Sand & sand/cobbles		Rock	Sand & sand/cobbles				Sand				
KP	0	1.2	1.3	3.067	3.509	4.6	6.4	8.94	9.28	10.4	14.136	14.545	16.255	16.575	77.569
Burial Status (Note 1)	T + I	T + R	T + I	R	T + I	R	S	R	R	T + I	R	T + I	R	T + B	
				Britannia Crossing				***Flags Crossing***			***Frigg Crossings***		***SAGE Crossing***		
Comparative Assessment Options	Leave in situ			N/A	Leave in situ	***Type 'C'*** 1. Leave in situ 2. Rock cover	***Type 'A'*** 1. Leave in situ 2. Rock cover 3. Total removal	N/A	***Type 'B'*** 1. Leave in situ 2. Add rock cover	Leave in situ	N/A	Leave in situ	N/A	***'Offshore' Pipelines*** 1. Leave in situ 2. Minimum removal (ends) 3. Partial remediation: 3a. Add rock cover 3b Cut and lift 3c Re-trench 4. Total Removal	

Note 1:
Key to burial status:

Trenched + natural infill	T + I
Trenched + backfill	T + B
Trenched + rock cover	T + R
Surface laid	S
Surface laid + rockdump	R

Figure 12 – Pipeline Decommissioning Options for Comparative Assessment

5.0 COMPARATIVE ASSESSMENT

5.1 Nearshore Pipelines: Type A – Surface Laid (from KP 6.4 to KP 8.94)

The Type A location is from KP 6.4 to KP 8.94. Here the pipeline was laid directly onto the seabed and initially installed fully exposed. Immediately following installation, four short sections of rock cover were added for mitigation of freespans at KP 6.505, 7.504, 8.549 and 8.615. Since installation, significant natural backfill has occurred in this area resulting in partial burial of the 16 inch pipeline as seen in Figures 13 and 14.

Due to the high boulder density in this area, with the installation risk of being unable to trench and backfill being high, this section of concrete coated pipeline was laid on the seabed. The piggybacked MEG line was installed at the 2 o'clock position in this area for protection. The piggyback blocks were also secured with strapping comprised of corrosion resistant alloy.

According to the most recent surveys, there are no pipeline spans in this area.

In line with Section 4.1, the initial options identified for this area were:

- Leave in situ
- Rock-cover
- Trench and bury
- Total removal by cut-and-lift

The feasibility of "trench and bury" was challenged on the basis that the pipeline would have been trenched during installation if it had been a practical option. Wood Group Kenny assessed the technical feasibility of this option with the report [8] concluding:

- The rock-covered pipe sections at either end of the surface laid area, i.e. at KP 6.4 and KP 8.94) would pin the pipeline in place. This would cause residual tension in the pipeline which could prevent significant lowering of the pipe into the trench;
- There would therefore be a significant transition length where the pipeline would not drop into the trench and substantial unsupported freespans would occur;
- This would also occur at the four 40m rock berms in place along the surface laid section at KPs 6.505, 7.504, 8.549 and 8.615;
- The resulting spans would then require significant rock cover to mitigate, thereby removing the benefit and original intention of the trenching;
- Further, the presence of several large boulders along the pipeline route at this location would present a significant risk to the success of the trenching activity and may result in damage to the pipeline and/or trencher, and create unsupported spans which would also need significant rock cover to mitigate.

The option to trench and bury was therefore excluded.

For each of the three remaining options, the project team conducted an assessment of the vessel types and durations that would be required for offshore decommissioning activities; as

well as the volume of material that would be left in situ or returned to shore for each option. For the Type A location, the results are shown in Table 5 and 6.

Option	ROVSV days	Supply Vessel Days	Rock vessel days
Leave in situ	0	0	0
Rock cover	0	0	6.6
Total removal	24.7	23.7	0

Table 5 – Vessel days for Type A nearshore pipeline options

	Tonnes to be removed			Tonnes to remain		
Option	Steel	Plastics	Concrete	Steel	Plastics	Concrete
Leave in situ	0	0	0	430.1	16.7	762.3
Rock cover	0	0	0	430.1	16.7	762.3
Total removal	430.1	16.7	762.3	0	0	0

Table 6 – Material removed / remaining for Type A nearshore pipeline options

The remaining three options were then assessed at a comparative assessment workshop as per the method outlined in Section 3.

Figure 13 – Typical "Type A" surface-laid pipeline showing partial burial (2015 survey)

Figure 14 – Same KP as Figure 13, from the 2011 survey (from opposite direction)

5.1.1 Nearshore Type A Assessment

Leave in situ is the recommendation for the Nearshore Type A pipeline, based on the scoring of the comparative assessment process.

	Type A: Surface Laid		
	Option 1: Leave in situ	**Option 2: Rock cover**	**Option 4: Total Removal (Cut and lift of both lines)**
Overall scoring:	3.23	2.51	0.19
Overall ranking:	1.0	2.0	4.0

- Leave in situ is considered to be the best option in 10 of the 14 sub-criteria
- Leave in situ is assessed as having the lowest safety risk, lowest environmental impact, lowest technical uncertainty and lowest cost
- Leave in situ is considered to be the least best option in only two sub-criteria: residual risk to other users of the sea and socio-economic impact on communities and amenities. However, in both these cases the preference scoring applied was very low, indicating that there was not considered to be a large degree of difference between the options available

When cost is removed from the comparative assessment scoring, leave in situ remains as the recommendation:

	Type A: Surface Laid		
	Option 1: Leave in situ	**Option 2: Rock cover**	**Option 4: Total Removal (Cut and lift of both lines)**
Overall scoring:	2.48	2.06	0.19
Overall ranking:	1.0	2.0	4.0

5.2 Nearshore Pipelines: Type B – Surface laid with rock cover on sand, with 4 inch MEG line exposures (from KP 9.28 to KP 10.4)

The Type B location is from KP 9.28 to KP 10.4. Here the pipeline has been laid on sand and is protected by rock cover. There are intermittent minor exposures of the pipeline, examples of which can be seen in Figures 15 to 18.

As reported in the 2011 ROV survey, no spans were evident and exposures in this section were as follows:

- 7 exposures of the 16 inch line, total length 193.9m
- 29 exposures of the 4 inch line, total length 345.8m

In line with section 4.1, the initial options identified for this section were:

- Leave in situ
- Trench exposed sections
- Remove the 4 inch exposures by cut-and-lift; and add remedial rock cover
- Total removal by cut-and-lift
- Add remedial rock cover to exposed sections

Following the Stakeholder Workshop, it was decided to exclude the option to remove the 4 inch exposures by cut-and-lift on the basis that there is no perceived benefit in comparison to additional rock cover without removing the 4 inch exposures or total removal. Removing the 4 inch line only would also be likely to leave piggyback blocks and straps exposed as an additional snagging risk, as well as disturbing the existing rock cover with the ensuing impact on the surrounding marine environment.

The feasibility of the “trench and bury” option was challenged on the basis that the pipeline would have been trenched during installation if it had been a practical option. Wood Group Kenny assessed the technical feasibility of this option with the report [8] concluding that “*the length of the transition slopes [required] would negate the benefit of trenching as a solution, and would require each end of the exposed sections to be rock covered for at least 100m*”.

Therefore the option to trench and bury was excluded.

Total removal was also excluded on the basis that the impact of removing the pipeline would exceed the benefits of addressing the minimal exposures present. Natural backfill is expected to increase in line with the current trend and thereby continue to reduce visible exposures [19]. In addition, implementation of mitigating measures will bring the residual risk to ALARP.

For each option, the project team conducted an assessment of the vessel types and durations that would be required for offshore decommissioning activities; as well as the volume of material that would be left in situ or returned to shore for each option. For the Type B location, the results are shown in Table 7 and 8.

The remaining options were then assessed at the comparative assessment workshop as per the method outlined in Section 3.

Option	ROVSV days	Supply Vessel Days	Rock vessel days
Leave in situ	0	0	0
Rock cover	0	0	6

Table 7 – Vessel days for Type B nearshore pipeline options

	Tonnes to be removed			Tonnes to remain		
Option	Steel	Plastics	Concrete	Steel	Plastics	Concrete
Leave in situ	0	0	0	185.3	7.2	267.9
Rock cover	0	0	0	185.3	7.2	267.9

Table 8 – Material removed / remaining for Type B nearshore pipeline options

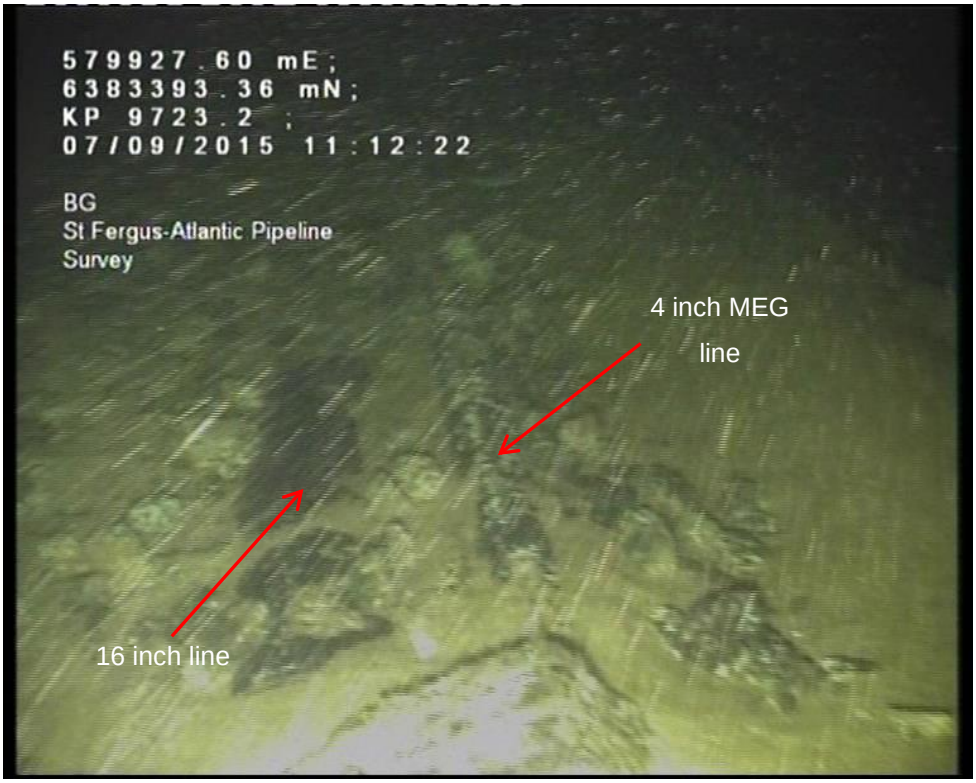

Figure 15 – Typical "Type B" rock-covered pipeline showing minor exposure (2015 survey)

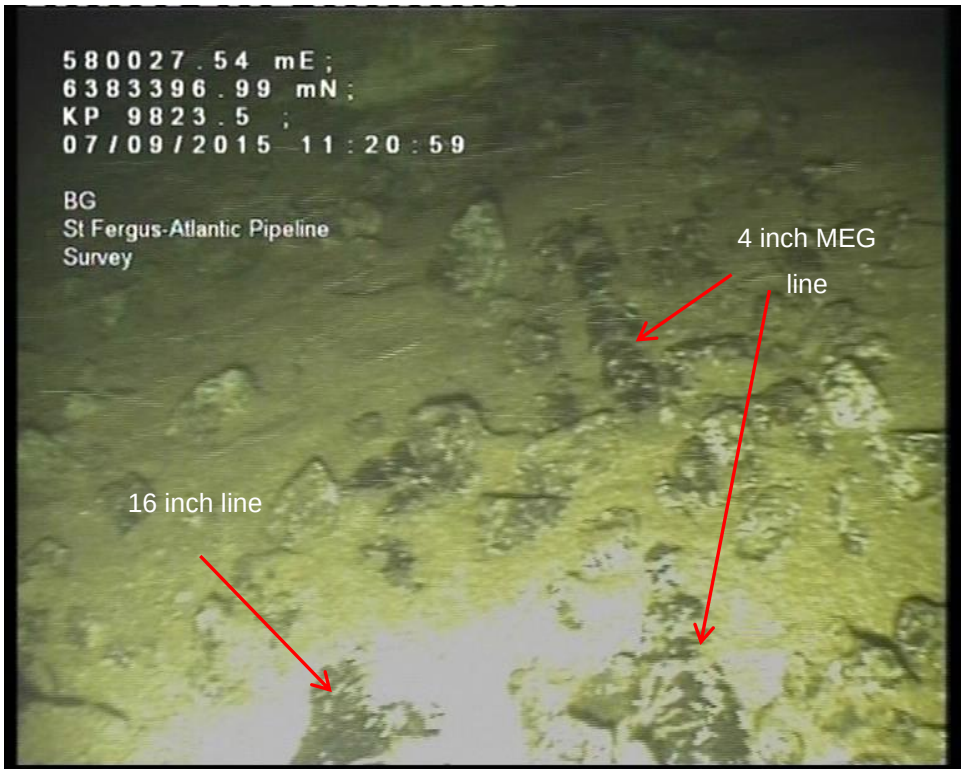

Figure 16 – Typical "Type B" rock-covered pipeline showing minor exposure (2015 survey)

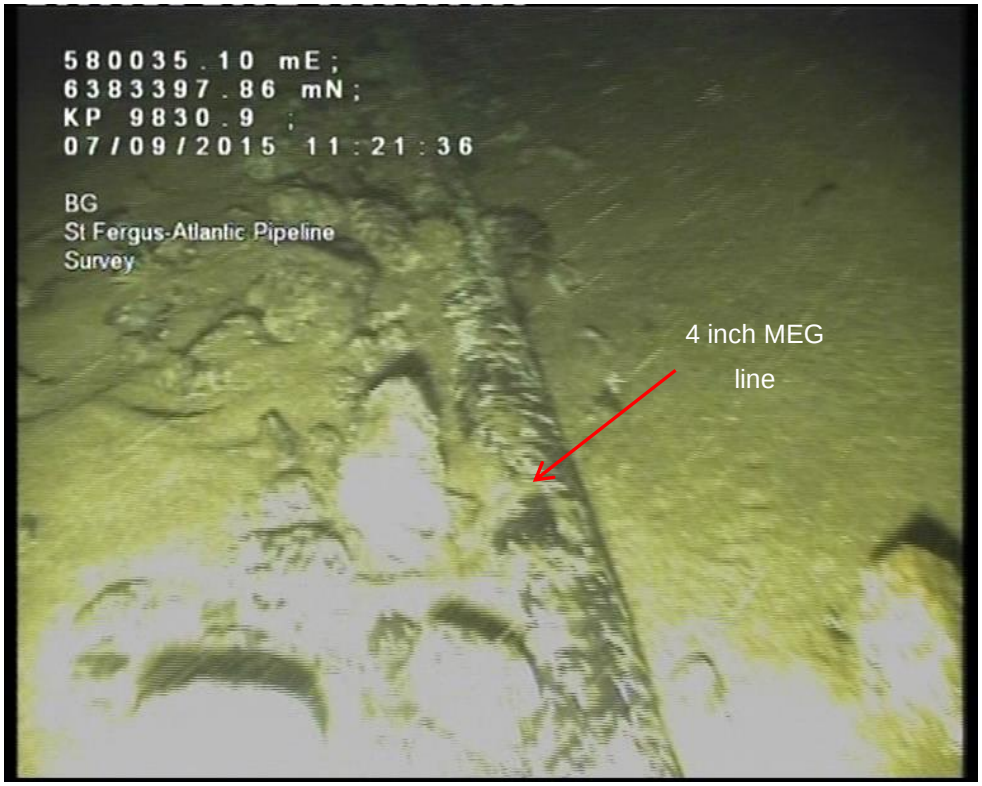

Figure 17 – Typical "Type B" rock-covered pipeline showing minor exposure (2015 survey)

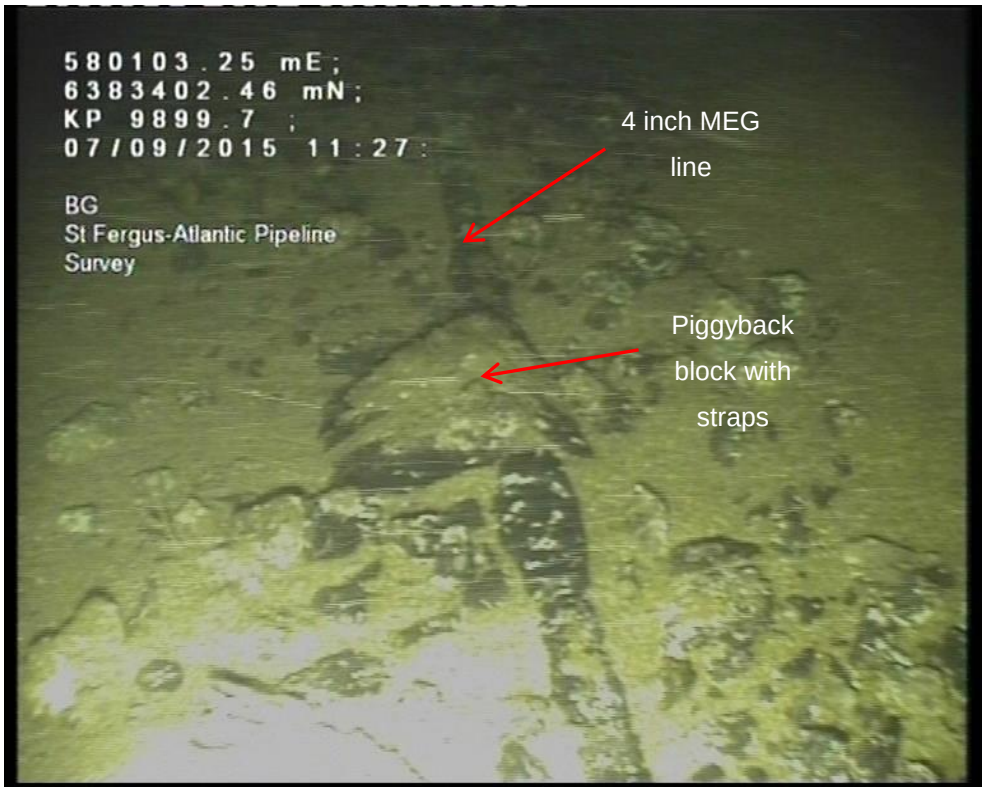

Figure 18 – Typical "Type B" rock-covered pipeline showing minor exposure (2015 survey)

5.2.1 Nearshore Type B Assessment

Leave in situ is the recommendation for the Nearshore Type B pipeline, based on the scoring of the comparative assessment process.

	Type B: Surface Laid with rock cover on sand with 4 " Meg line exposures	
	Option 1: Leave in situ	**Option 4: Remedial Rock cover**
Overall scoring:	1.56	0.39
Overall ranking:	1.0	3.0

- Leave in situ is considered to be the best option in 10 of the 14 sub-criteria
- Leave in situ is assessed as having the lowest safety risk, lowest environmental impact, lowest technical uncertainty and lowest cost
- Leave in situ is considered to be the least best option in only three sub-criteria: residual risk to other users of the sea, commercial impact on fisheries and socio-economic impact on communities and amenities. However, in all three cases the preference scoring applied was very low, indicating that there was not considered to be a large degree of difference between the options available

When cost is removed from the comparative assessment scoring, leave in situ remains as the recommendation:

	Type B: Surface Laid with rock cover on sand with 4 " Meg line exposures	
	Option 1: Leave in situ	**Option 4: Remedial Rock cover**
Overall scoring:	1.03	0.39
Overall ranking:	1.0	3.0

5.3 Nearshore Pipelines: Type C: Surface laid with rock cover with 4 inch MEG line exposures (laid on rock from KP 4.6 to KP 6.4)

The Type C location is from KP 4.6 to KP 6.4; where the pipeline was laid on rock and protected by additional rock cover.

As reported in the 2011 ROV survey, exposures in this section are as follows:

- There are no exposures of the 16 inch line
- 7 exposures of the 4 inch line, total length is 26m (1.44%)

Most of these exposures were no longer evident in the 2015 survey, with Figure 19 showing KP 5.190 where an exposure had been identified in 2011 and which now showed no evidence of exposure.

Figure 19 – "Type C" rock-covered pipeline, site of exposure identified in 2011 survey now no longer evident in 2015 survey

The 2015 survey reported that only one exposure (approximately 4m) remained evident in this area, at KP 5.2 as shown in Figure 20.

There was no evidence of other exposures which had been identified during the 2011 survey, indicating that these had been covered by natural backfill and sediment in the intervening period [19]. This provides a high level of confidence in the integrity of the existing rock berm.

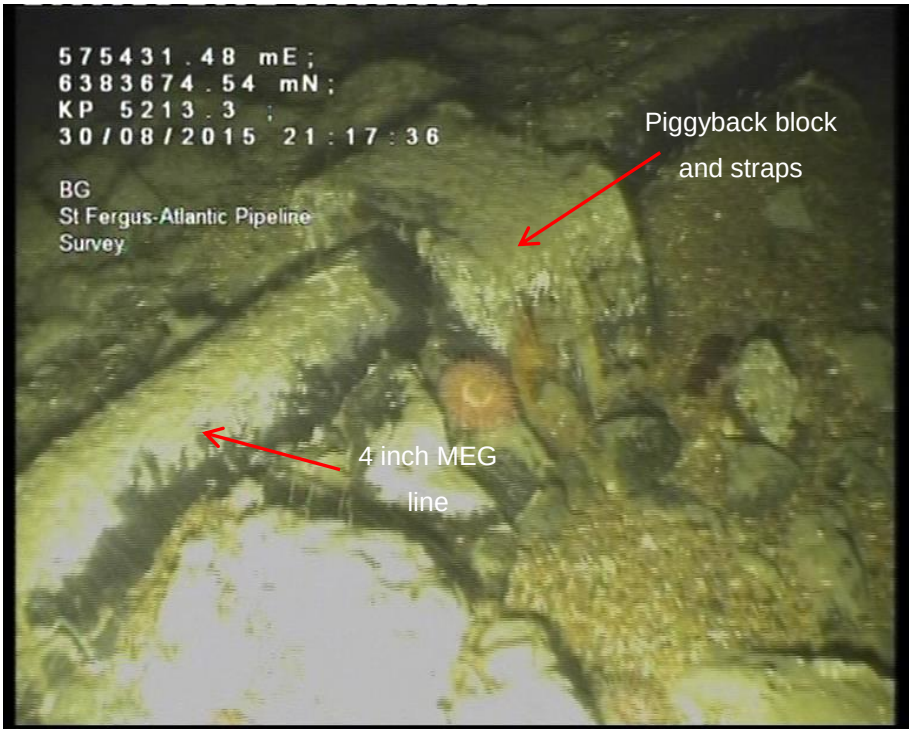

Figure 20 – "Type C" rock-covered pipeline showing minor exposure (2015 survey)

In line with section 4.1, the initial options identified for this section were:

- Leave in situ
- Add remedial rock cover to exposed sections
- Remove the 4 inch exposures by cut-and-lift; and add remedial rock cover
- Total removal by cut-and-lift

During option screening, it was agreed to exclude the option to remove the 4 inch exposures by cut-and-lift on the basis that there is no perceived benefit in comparison to additional rock cover without removing the 4 inch exposures.

Total removal was also excluded on the basis that the impact of removing the pipeline would exceed the benefits of addressing the minimal exposures present. Natural backfill is expected to increase in line with the current trend and thereby continue to reduce visible exposures [19]. In addition, implementation of mitigating measures will bring the residual risk to ALARP.

For each option, the project team conducted an assessment of the vessel types and durations that would be required for offshore decommissioning activities; as well as the volume of material that would be left in situ or returned to shore for each option. For the Type C location, the results are shown in Table 9 and 10.

Option	ROVSV days	Supply Vessel Days	Rock vessel days
Leave in situ	0	0	0
Rock cover	0	0	6.6

Table 9 – Vessel days for Type C nearshore pipeline options

	Tonnes to be removed			Tonnes to remain		
Option	Steel	Plastics	Concrete	Steel	Plastics	Concrete
Leave in situ	0	0	0	305.1	11.6	527.8
Rock cover	0	0	0	305.1	11.6	527.8

Table 10 – Material removed / remaining for Type C nearshore pipeline options

The remaining options were then assessed at comparative assessment workshops as per the method outlined in Section 3.

5.3.1 Nearshore Type C Assessment

Leave in situ is the recommendation for the Nearshore Type C pipeline, based on the scoring of the comparative assessment process.

	Type C :Surface Laid with rock cover with 4" Meg line exposures (Laid on rock from KP4.6 to 6.4)	
	Option 1: Leave in situ	**Option 2: Remedial Rock cover**
Overall scoring:	1.64	0.39
Overall ranking:	1.0	2.0

- Leave in situ is considered to be the best option in 10 of the 14 sub-criteria
- Leave in situ is assessed as having the lowest safety risk, lowest environmental impact, lowest technical uncertainty and lowest cost
- Leave in situ is considered to be the least best option in only three sub-criteria: residual risk to other users of the sea, commercial impact on fisheries and socio-economic impact on communities and amenities. However, in all three cases the preference scoring applied was very low, indicating that there was not considered to be a large degree of difference between the options available

When cost is removed from the comparative assessment scoring, leave in situ remains as the recommendation:

	Type C :Surface Laid with rock cover with 4" Meg line exposures (Laid on rock from KP4.6 to 6.4)	
	Option 1: Leave in situ	**Option 2: Remedial Rock cover**
Overall scoring:	1.19	0.39
Overall ranking:	1.0	2.0

5.4 Offshore Pipelines: Atlantic & MEG piggyback line; and Cromarty pipeline

The Offshore pipelines section consists of the Atlantic (WAGES) pipeline (PL 2029 / PL 2031) from KP 10.4 to the Atlantic manifold spoolpiece, where the pipeline exits the trench at KP 77.6 and the Cromarty to Atlantic pipeline (PL 2030 / PL 2032).

With the exception of the listed pipeline crossings and the rock-covered future Tee the Atlantic & Cromarty pipelines were designed to be trenched to 600mm Depth-of-Lowering (DOL) with back-fill to 400mm Top-of-Pipe (TOP). Where 600mm DOL was not achieved, the pipelines were rock-covered.

The 2011 pipeline survey did show some short lengths where the pipelines were exposed in the trench, however these exposures were consistent with the as-laid survey and the lengths of exposure are as follows:

- Atlantic 16 inch pipeline (PL2029):
    - KP 10.4 to KP 16 – 61.9m (1.1%)
    - KP 16 to KP 43 – none
    - KP 43 to KP 70 – 41.9m (0.1%)
- Atlantic 4 inch MEG line (PL 2031)
    - KP 10.4 to KP 16 – 411.3m (7.3%)
    - KP 16 to KP 43 – none
    - KP 43 to KP 70 – 417.7m (1.1%)
- Cromarty 12 inch pipeline (PL 2030) – none
- Cromarty 4 inch MEG line (PL2032)
    - 125.4m (1.0%)

In line with section 4.1, the initial options identified for this section were:

- Minimal removal (ends only)
- Removal of ends and partial remediation by adding additional rock cover to exposures
- Removal of ends and partial remediation by cut-and-lift of exposures
- Removal of ends and partial remediation by re-trenching exposures
- Total removal by cut-and-lift

For each option, the project team conducted an assessment of the vessel types and durations that would be required for offshore decommissioning activities; as well as the volume of material that would be left in situ or returned to shore for each option. For the offshore pipelines, the results are shown in Table 11 and 12.

Option	ROVSV days	Supply Vessel Days	Trencher vessel days	Rock vessel days
Remove ends	7.41	0	0	0
Rock cover	7.41	0	0	12
Partial cut-and-lift	38.11	29.7	0	0
Re-trench	7.41	0	10.5	1.4
Total removal	404.1	381.08	0	0

Table 11 – Vessel days for offshore pipeline options

	Tonnes to be removed			Tonnes to remain		
Option	Steel	Plastics	Concrete	Steel	Plastics	Concrete
Remove ends	33	1.2	18.7	13116.5	446.3	13482.2
Rock cover	33	1.2	18.7	13116.5	446.3	13482.2
Partial cut-and-lift	860.1	29.1	954.7	12194.8	418.4	12546.2
Re-trench	33	1.2	18.7	13116.5	446.3	13482.2
Total removal	13149.5	447.5	13500.9	0	0	0

Table 12 – Material removed / remaining for offshore pipeline options

Note – data from Tables 11 and 12 assume a conservative 5 km remediation length [6].

The remaining options were then assessed at comparative assessment workshops as per the method outlined in Section 3.

5.4.1 Offshore Pipelines Assessment

Remove ends only is the recommendation for the Offshore Pipelines section of the pipeline, based on the comparative assessment process:

	Minimal Removal	Partial Remediation	Partial Remediation	Partial Remediation	Total Removal
	2A: Remove ends of pipeline and remediate	3A (Remedial Rock Cover)	3B (Cut and Lift)	3C (Re-Trench)	Cut and Lift
Overall scoring:	4.64	3.91	3.13	3.25	0.65
Overall ranking:	1.0	2.0	4.0	3.0	5.0

- Remove ends only is considered to be the best option in 10 of the 14 sub-criteria
- Remove ends only is assessed as having the lowest safety risk, the lowest environmental impact, the lowest technical risk and the lowest cost
- Remove ends only is considered to be the least best option in only two sub-criteria: impact on marine end points and socio-economic impact on communities and amenities. However, for the former, the preference scoring applied was very low, indicating that there was not considered to be a large degree of difference between the options available.

When cost is removed from the comparative assessment scoring, remove ends remains the recommendation:

	Minimal Removal	Partial Remediation	Partial Remediation	Partial Remediation	Total Removal
	2A: Remove ends of pipeline and remediate	3A (Remedial Rock Cover)	3B (Cut and Lift)	3C (Re-Trench)	Cut and Lift
Overall scoring:	3.36	2.82	2.20	2.31	0.65
Overall ranking:	1.0	2.0	4.0	3.0	5.0

5.5 Goldeneye and Cromarty Umbilicals

For the purposes of this comparative assessment, this is defined as the entire Cromarty umbilical (PLU 2034) and the Goldeneye umbilical (PLU 2033) from the Atlantic manifold to the bottom of the J-tube at the Goldeneye platform. The remaining umbilical within the J-tube and the associated equipment on the Goldeneye topsides will be decommissioned by Shell as part of a separate commercial agreement.

The umbilicals are currently trenched and filled with hydraulic fluid (Oceanic HW 443 R) and a 50/50 MEG / water mix. Analysis of the contents and potential release rate [18] concluded that the environmental risk is acceptable for all decommissioning options.

The umbilical routes were surveyed in 2011 to confirm the effects of any seabed mobility over time. The results of this survey confirmed that the number of exposed areas of both umbilicals have decreased over time due to the natural backfill of the trenched sections, with the resulting reduction in potential snagging.

No remedial work is currently proposed along the umbilical route as the results of the 2011 survey indicate that the umbilical is continuing to backfill in line with expectations and does not present a hazard to other users of the sea [19].

A further geophysical survey carried out in 2015 as part of the A&C Pre-Decommissioning Survey [15] confirmed the location within their trenches of each umbilical. The 2015 survey did not identify any spans.

PLU 2033 – Goldeneye to Atlantic Umbilical

The 2011 survey indicates that levels of burial had increased in line with expectations. However, there was a span reported at KP 17.355 – KP 17.370 as well as five further shorter spans. None of these spans were reportable within the WAGES Pipeline System Inspection Reporting and Anomaly Criteria [20].

All exposures are located in the bottom of the trench, with sufficient Depth-of-Lowering (DOL) to protect the umbilical from snagging and therefore not considered to offer any additional threat to the environment, impact to other users of the sea or legacy costs. The 2011 survey indicated that the total length of all exposures had decreased to 155m, down from 294m in 2007, and representing 0.4% of the umbilical length, while depth of cover has increased over the rest of the line since the 2009 survey.

PLU 2034 – Atlantic to Cromarty Umbilical

The 2011 survey indicates that levels of burial are in line with expectations. The total length of exposures had decreased to 125m (down from 308m in 2007) and represent 1.0% of the umbilical length.

Umbilical decommissioning options

In line with Section 4.3, the initial options identified were:

- Minimal removal (ends only)
- Partial removal and remediation via:

- Remedial rock-cover
- Cut-and-lift
- Re-trench

- Total removal via:
  - Reverse reel-lay
  - Subsea cut-and-lift

For each option, the project team conducted an assessment of the vessel types and durations that would be required for offshore decommissioning activities, as well as the volume of material that would be left in situ or returned to shore for each option. For the umbilicals, the results are shown in Table 13 and 14.

Option	ROVSV days	Supply Vessel Days	Rock vessel days	DSV
Remove ends	15.3	0	0	7.5
Rock cover	15.3	0	13.6	7.5
Partial cut-and-lift	24.4	0	0	7.5
Re-trench	23.1	0	0	7.5
Total removal – reverse reeling	36.5	0	0	7.5
Total removal – cut-and-lift	96.7	0	0	7.5

Table 13 – Vessel days for umbilical options

	Tonnes to be removed			Tonnes to remain		
Option	Steel	Plastics	Concrete	Steel	Plastics	Concrete
Remove ends	11.6	0.8	3.6	397.1	33.3	139.3
Rock cover	11.6	0.8	3.6	397.1	33.3	139.3
Partial cut-and-lift	58.7	4.7	20.1	350	29.4	122.8
Re-trench	11.6	0.8	3.6	397.1	33.3	139.3
Total removal	408.7	34.1	142.9	0	0	0

Table 14 – Material removed / remaining for umbilical options

Note – data from Tables 13 and 14 assume a conservative 5 km remediation length [6].

The remaining options were then assessed at comparative assessment workshops as per the method outlined in Section 3.

5.5.1 Umbilicals Assessment

Minimal removal is the recommendation for the umbilicals, based on the comparative assessment process:

	Minimal Removal	Partial Remediation	Partial Remediation	Partial Remediation	Total Removal	Total Removal
		3A (Remedial Rock Cover)	3B (Cut and Lift)	3C (Re-Trench)	4A (Reverse Reel Lay (Except crossings)	4B (Subsea cut and lift)
Overall scoring:	3.87	3.29	2.75	2.87	1.64	0.37
Overall ranking:	1.0	2.0	4.0	3.0	5.0	6.0

- Minimal removal is considered to be the best option in 11 of the 14 sub-criteria
- Minimal removal is assessed as having the lowest safety risk, the lowest environmental impact, the lowest technical risk and the lowest cost
- Minimal removal is considered to be the least best option in three sub-criteria: residual risk to other users of the sea, impact of marine end points (legacy impact) and socio-economic impact on communities and amenities. However, for the latter two sub-criteria, the preference scoring applied was very low, indicating that there was not considered to be a large degree of difference between the options available.

When cost is removed from the comparative assessment scoring, minimal removal remains as the recommendation:

	Minimal Removal	Partial Remediation	Partial Remediation	Partial Remediation	Total Removal	Total Removal
		3A (Remedial Rock Cover)	3B (Cut and Lift)	3C (Re-Trench)	4A (Reverse Reel Lay (Except crossings)	4B (Subsea cut and lift)
Overall scoring:	2.74	2.39	1.94	2.07	1.22	0.37
Overall ranking:	1.0	2.0	4.0	3.0	5.0	6.0

6.0 REFERENCES

[1]	Atlantic and Cromarty Decommissioning Programme, AC-ACD-W-RE-3001
[2]	Department of Energy & Climate Change Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998, Version 6 (March 2011)
[3]	BG Decommissioning Comparative Assessment Guideline, BG-GL-PM-PM-040
[4]	Guidelines for Comparative Assessment in Decommissioning Programmes, Oil & Gas UK (Issue 1, October 2015)
[5]	Atlantic & Cromarty Field Decommissioning Stakeholder Workshop Report, 26 November 2015, AC-ACD-W-RE-3025
[6]	Atlantic & Cromarty Decommissioning: Pipelines Options Study, BG-ATCD-SU-RP-00009
[7]	Atlantic & Cromarty Decommissioning: Umbilical Options Study, BG-ATCD-SU-RP-00002
[8]	Atlantic Pipelines (Nearshore) Trenching and Rock Protection Technical Note, AC-ACD-T-SU-3004
[9]	Atlantic and Cromarty Fields: Assessment of Socioeconomic and Health & Safety Impacts on Commercial Fisheries (Brown & May Marine), AC-ACD-HS-RE-3008
[10]	Energy Institute Guidelines for the Calculation of Estimates of Energy Use and Gaseous Emissions in the Decommissioning of Offshore Structures (IoP, 2000)
[11]	BG HSSE Management System Framework, BG-ST-HSSE-HSSE-001
[12]	BG Atlantic & Cromarty Hydrocarbon Freeing Close Out Report, BG016-11-REP-003
[13]	Atlantic & Cromarty Decommissioning – Subsea Decommissioning Options Risk Assessment, AA/43-04-07/01 (DNV GL)
[14]	Atlantic & Cromarty Decommissioning – Energy and Emissions, J73488A-Y-TN-24001 (Genesis)
[15]	Atlantic & Cromarty Pre-Decommissioning Survey (Fugro), 150021V1.1
[16]	Atlantic & Cromarty Decommissioning: Nearshore Supporting Study, BG-ATCD-SU-RP-00005
[17]	Atlantic & Cromarty Decommissioning – Technical Note: Modelling Assessment of Pipeline Release (Genesis), AC-ACD-T-TN-3000
[18]	Atlantic & Cromarty Decommissioning – Osborne Adams MEG and Hydraulic Fluid Release Toxicity Calculations (Genesis), AC-ACD-T-CA-3000
[19]	Atlantic & Cromarty Decommissioning Technical Note: Depth of Burial Study for Pipelines and Umbilicals, AC-ACD-SS-TN-3000
[20]	WAGES Pipeline System Inspection Reporting and Anomaly Criteria, WB/06/450
[21]	Atlantic & Cromarty Fields Stakeholder Engagement Report, AC-ACD-W-RE-3016
[22]	Atlantic & Cromarty Environmental Impact Assessment (EIA) Report, AC-ACD-HS-RE-3002

APPENDIX 1
ABBREVIATIONS/DEFINITIONS

A&C	Atlantic and Cromarty (fields)
ALARP	As Low As Reasonably Practicable
BEIS	Department of Business, Energy and Industrial Strategy (formerly DECC)
CA	Comparative Assessment
CHARM	Chemical Hazard and Risk Management
CoP	Cessation of Production
DECC	Department of Energy and Climate Change (now BEIS)
DOL	Depth of Lowering
DSV	Dive Support Vessel
FEED	Front End Engineering Design
FLAGS	Far North Liquids and Associated Gas System
Future Tee	A branched connection designed to allow future tie-ins to a pipeline
HSSE	Health, Safety, Security and Environment
IPR	Interim Pipeline Regime
J-Tube	A structural tube housing an umbilical or flexible pipeline from seabed to platform topsides
KP	Kilometre Point
MEG	Monoethylene Glycol
OCNS	Offshore Chemical Notification Scheme
OGA	Oil and Gas Authority
PLL	Potential Loss of Life
ROV	Remote Operated Vehicle
ROVSV	Remote Operated Vehicle Support Vessel
SAGE	Scottish Area Gas Evacuation
SIMOPS	Simultaneous Operations
ToP	Top of Pipe
Tree	Assembly of valves, spools, instruments and fittings attached to the wellhead in order to control or isolate production from the well
UK	United Kingdom
UKCS	United Kingdom Continental Shelf

UTA	Umbilical Termination Assembly
VAF	Value Assurance Framework (BG internal project gate system)
WAGES	Western Area Gas Evacuation
WROV	Work-class Remote Operated Vehicle

APPENDIX 2
COMPARATIVE ASSESSMENT CRITERIA

The scopes of each sub-criterion and examples applied to the comparison assessment were adopted from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]; with the exception of the assessment criteria for the "Impact on Marine End Points (legacy impact)" and "Environmental Impact on marine end-points (legacy)" sub-criteria. For these sub-criteria, BG assumed alternative assessment criteria which would allow for a viable comparison based on the particular circumstances of the project.

The assessment criteria for these two sub-criteria are contained in the table overleaf.

Sub-Criteria	Applicable to	Applicable when	Factors	Most Preferred	Moderate	Least Preferred
Environmental - Marine Impact of Operations	Marine environmental impact caused by: Project Vessels, Supply Boats, Survey vessels	During execution phase of project including any subsequent monitoring surveys	Number and type of vessels and duration on station. Tasks vessels are fulfilling. Vessel station keeping approach. Likelihood of spills, discharges, noise.	Spill of diesel fuel <300te No incremental discharge to sea anticipated. No significant disturbance to sensitive seabed habitat / species anticipated Small vessel size and numbers anticipated and activity leading to only minor increase in noise above existing baseline. Discharge poses little environmental risk	Spill of diesel fuel >300te Minor sensitive seabed habitat / species disturbance resulting from removal operations Maximum 2 additional vessels on DP, some intermittent noise associated with vessels and helicopters for duration of project. Discharge with potential to cause harm	Spill of crude Increased risk potential vessel collisions. Increased corridor of seabed disturbance. Continuous noise from vessels (on DP) and helicopter activities. Large vessel size and noise above existing baseline. Explosive techniques adopted for cutting. Discharge of persistent or toxic material
Environmental - Impact on marine end-points (legacy)	Ongoing long term Marine environmental impact caused by materials left in place.	Following completion of the Decommissioning project and residual / ongoing impact	Extent of and composition of materials left in-situ to deteriorate into marine environment longer term. Function of extent of cleanliness of materials left in-situ. Predicted persistence of materials left in-situ.	Materials left on seabed biodegrade or exhibit low toxicity	Materials left on seabed are inert and clean	Materials left on seabed are toxic and persistent

Table 15 – CA Scoring Guidance adapted from OGUK Guidance Notes

APPENDIX 3
COMPARATIVE ASSESSMENT DETAIL – NEARSHORE PIPELINES: TYPE A – SURFACE LAID (KP 6.4 – 8.94)

Safety

The Safety criterion is split into five sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Safety criteria for Type A nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 2: Rock cover	Option 4: Total Removal (Cut and lift of both lines)
Project risk to personnel - Offshore	1.0	0.4	0.0
Project risk to other users of the sea	1.0	0.8	0.0
Project risk to personnel - Onshore	1.0	0.9	0.0
Potential of a high consequence event	1.0	0.9	0.0
Residual risk to other users of the sea	0.0	1.0	0.2

Project risk to personnel – offshore

Quantitative scoring was used to compare each option in this sub-criterion.

DNV GL conducted a high-level risk assessment utilising data derived from industry accident (occupational) rates, and project data for the anticipated man-hours and vessel days associated with each sub-criterion task. These were combined to produce a Potential Loss of Life (PLL) score for each option and allow a comparative scoring to be applied.

The results from DNV GL report, *Atlantic & Cromarty Decommissioning - Subsea Decommissioning Options Risk Assessment* [13], are thus:

- Leave in-situ – PLL 0
- Rock cover – PLL 3.77E-04
- Total removal – PLL 2.37E-03

Due to the extended duration of vessels in the field and the additional risk of cut-and-lift activities, total removal has the highest safety risk and was therefore the least best option.

With no vessel activity, leave in-situ has the lowest safety risk and is therefore the best option.

Project risk to other users of the sea

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Due to the lack of vessel activity, and therefore no risk of vessel collisions, leave in situ has the lowest risk and is therefore the best option.

Due to having the longest duration of vessels in-field, total removal has the highest risk to other users of the sea and is therefore the least best option.

Project risk to personnel onshore

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With no material returned to shore, leave in situ has the lowest risk and is therefore the best option. No material is returned to shore for the partial remediation option of using additional rock cover, however a small risk is associated with the production and loading of rock to the vessel.

Due to the volume of material to be returned and the associated risks of offloading, transport and disposal of such material, total removal has the highest risk to personnel onshore and therefore is the least best option.

Potential of a high consequence event

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Due to the lack of vessel activity, leave in situ has the lowest risk of a high consequence event and is therefore the best option.

Due to having the longest duration of vessels in-field; multiple mobilisations and de-mobilisations for offloading of material; and multiple lifting operations as part of the cut-and-lift activities, total removal has the highest risk of a high consequence event and is therefore the least best option.

Residual risk to other users of the sea

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Leave in situ is considered the highest risk option due to the uncertain impact of corrosion and pipeline collapse over time, which would present a potential hazard such as snagging for fishing vessels. Although it is likely that the pipeline will silt over, and therefore cover, before corrosion occurs, this is deemed to be the highest residual risk and therefore leave in situ is the least best option.

Total removal would require significant amount of rock cover at the cut ends to ensure there was no residual risk of snagging from the remaining pipe at either end of the removed section. The rock berm itself could present an additional risk to other users of the sea.

Full rock cover, if profiled correctly and proven by overtrawl-ability trials, would present less of a risk to other users of the sea as the berm required would be lower and of shallower dimensions, presenting a consistent known-quantity to fishermen and other vessels. Therefore, rock cover is the best option.

Due to the low level of scallop dredging in the area, considered the most likely type of fishing to encounter challenges from rock cover, and taking the relatively small length of pipeline considered, a low preference scoring (3) was applied.

Environmental

The Environment criterion is split into three sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Environmental criteria for Type A nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 2: Rock cover	Option 4: Total Removal (Cut and lift of both lines)
Marine impact of operations	1.0	0.3	0.0
Energy, emissions, resource consumption	1.0	0.7	0.0
Impact of marine end points (legacy impact)	0.1	0.0	1.0

Marine impact of operations

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are amended from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]. To ensure relevancy to the specific project circumstances, alternative criteria were used as detailed in Appendix 3.

Neither leave in situ or remedial rock cover will incur any planned release of pipeline contents during decommissioning activities. Total removal will release fluids from the pipeline into the marine environment; however, the pipeline is hydrocarbon free. It contains the chemicals MEG (which poses little or no risk to the environment) and the corrosion inhibition chemical RX 5227, assessed as Gold under the Chemical Hazard and Risk Management (CHARM) guidance. An Osborne-Adams calculation [17 & 18] has concluded that release of these chemicals would result in an acceptable environmental impact.

This area is in a sandeel and herring spawning area. The presence of *Sabellaria spinulosa* was confirmed by the pre-decommissioning Environmental Survey [15] but the 'Habitat Assessment' carried out as part of that survey concluded that the nearshore areas exhibit low-moderate 'reefiness'.

Leave in situ will result in no further disturbance to the habitat and is therefore the best option.

Rock cover will result in some seabed disturbance, along a 5m corridor, and incur some temporary noise disturbance from in-field activities.

Total removal will incur the greatest level of noise disturbance, albeit a relatively low level, and the greatest level of seabed disturbance, along a 10m corridor, and is therefore the least best option.

Although the area in question is relatively small, a moderate Preference Score (5) has been maintained to reflect the consideration of cumulative impacts.

Energy, emissions, resource consumption

Quantitative scoring was used to compare each option in this sub-criterion.

Genesis conducted an energy and emissions assessment [14] of the potential options for decommissioning the PL2029 and PL2031 pipelines. This analysis was conducted in accordance with the Energy Institute Guidelines [10].

The analysis includes CO_2 emissions during operations, primarily from vessels, and "endpoint" emissions, those associated with production of rock cover; recycling of recovered steel and copper; and the production of steel and copper to replace that decommissioned in situ.

The results are thus:

- Leave in situ – 812te CO_2
- Partial remediation by rock cover – 1380te CO_2
- Total removal – 1633te CO_2

Due to having the lowest associated emissions, leave in situ is the best option.

Due to having the largest associated emissions, total removal is the least best option.

Impact of marine end points (legacy impact)

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are adapted from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]. To ensure relevancy to the specific project circumstances, alternative criteria were used as detailed in Appendix 3.

The pipelines are hydrocarbon free and were flushed and cleaned in accordance with the Hydrocarbon Freeing Close Out Report [12].

Total removal will see the smallest volume of material left on the seabed and is therefore the best option.

Both rock cover and leave in situ will see the largest volume of pipeline material left on the seabed, whilst rock cover will introduce additional material and is therefore the least best option.

As none of the material to be left on the seabed is toxic and the volumes are relatively very low, a low Preference Score (1) has been applied.

Technical

The Technical criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Technical criteria for Type A nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 2: Rock cover	Option 4: Total Removal (Cut and lift of both lines)
Risk of major project failure	1.0	1.0	0.0
Technology demands / track record	1.0	0.9	0.0

Risk of major project failure

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With no vessel activity to be undertaken, leave in situ presents the lowest risk of major project failure and so is the best option.

With the greatest duration of vessel activity, the total removal options inherit the highest level of weather risk.

However, there is a high degree of confidence in each option and taking into account the relatively short section of pipeline to be considered, there is very little difference between the three options and so a low Preference Score has been applied.

Technological demands and track record

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With no remedial activity to be undertaken, there are clearly no technological demands or considerations of track record for the leave in situ option.

Both partial remediation by additional rock cover and total removal by cut-and-lift are considered to be routine operations with a proven track record of the methods to be employed; however total removal is considered to have the greater risk as there is no known history of removing a directly comparable concrete-coated trunkline with piggyback.

However, there is a high degree of confidence in each option and taking into account the relatively short section of pipeline to be considered, there is very little difference between the three options and so a low Preference Score has been applied.

Societal

The Societal criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Societal criteria for Type A nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 2: Rock cover	Option 4: Total Removal (Cut and lift of both lines)
Commercial impact on fisheries	0.9	1.0	0.0
Socio-economic impact on communities and amenities	0.0	0.5	1.0

Commercial impact on fisheries

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Total removal may inadvertently result in some fishing grounds being lost as vessels avoid the area due to the risk of snagging from the cut ends at KP 6.4 and KP 8.94. Although mitigating rock cover will be added at the cut points, it was advised by the Scottish Fishermen's Federation (SFF) at the Comparative Assessment Workshop that the presence of a cut end and potential snagging risk would be more likely to deter fishing activity in the area than if the pipeline were left uncut in its present condition. Therefore total removal is the least best option.

Leave in situ and rock cover are very unlikely to result in loss of fishing grounds, with rock cover deemed to have the lowest risk due to the additional protection from snagging on corroded pipe in the long term. Therefore rock cover is the best option.

Due to the low level of scallop dredging in the nearshore area, considered the most likely type of fishing to encounter challenges from rock cover, and taking the relatively small length of pipeline considered, a low preference scoring (2) was applied.

Socio-economic impact on communities and amenities

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Total removal would result in the largest volume of material returned to shore, thereby offering economic opportunities to communities, and is the best option.

Leave in situ and rock cover will result in no material returned to shore; while rock cover assumes some onshore material handling (quarrying rock, etc) and will result in minimal economic benefit from pre-existing supply chains. Therefore leave in situ is the least best option.

Due to the relatively low volumes of material considered, the positive economic impacts from onshore employment opportunities are considered to be minimal and will be handled by existing facilities. Therefore a low preference scoring (1) has been applied.

Economic

The Economic criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Economic criteria for Type A nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 2: Rock cover	Option 4: Total Removal (Cut and lift of both lines)
Cost	1.0	0.3	0.0
Cost risk and uncertainty	1.0	0.9	0.0

Cost

Quantitative scoring was used to compare each option in this sub-criterion.

A cost estimate was produced using projected vessel types and durations, disposal costs and project management costs for each option.

Full cost estimate figures are being provided to BEIS in a separate submission and will not be provided here. To maintain commercial confidentiality ahead of invitations to tender for the work involved, the costs have been normalised where the lowest cost option has been set as 0 and the highest cost option as 1.

The estimates for each option are thus:

- Leave in situ - 0
- Partial remediation with additional rock cover – 0.77
- Total removal by cut-and-lift – 1

By virtue of having the lowest cost, leave in situ is the best option.

Due to having the highest cost, total removal is the least best option.

Cost risk and uncertainty

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

As there are no vessel activities associated with the leave in situ option, there is no cost risk or uncertainty during the project phase. There will be ongoing survey costs for infrastructure that is left in situ; but this is not considered to be an additional risk when compared to the other options as legacy survey obligations will remain for the rest of the pipeline which is left in situ. As such, leave in situ is the best option.

With the longest duration of vessels in-field and the associated additional exposure to weather risk, particularly if divers are required for the cut-and-lift activities, the total removal option is the least best option.

APPENDIX 4
COMPARATIVE ASSESSMENT DETAIL – NEARSHORE PIPELINES: TYPE B – SURFACE LAID WITH ROCK COVER ON SAND, WITH 4 INCH MEG LINE EXPOSURES (KP 9.28 – 10.4)

Safety

The Safety criterion is split into five sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Safety criteria for Type B nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 4: Remedial Rock cover
Project risk to personnel - Offshore	1.0	0.0
Project risk to other users of the sea	1.0	0.0
Project risk to personnel - Onshore	1.0	0.0
Potential of a high consequence event	1.0	0.0
Residual risk to other users of the sea	0.0	1.0

Project risk to personnel – offshore

Quantitative scoring was used to compare each option in this sub-criterion.

DNV GL conducted a high-level risk assessment utilising data derived from industry accident (occupational) rates, and project data for the anticipated man-hours and vessel days associated with each sub-criterion task. These were combined to produce a Potential Loss of Life (PLL) score for each option and allow a comparative scoring to be applied.

The results from DNV GL report, *Atlantic & Cromarty Decommissioning - Subsea Decommissioning Options Risk Assessment* [13], are thus:

- Leave in-situ – PLL 0
- Rock cover – PLL 3.60E-04

Due to the operational risk of vessels at sea, rock cover has the highest safety risk and was therefore the least best option.

With no vessel activity, leave in situ has the lowest safety risk and is therefore the best option.

Project risk to other users of the sea

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Due to the lack of vessel activity, and therefore no risk of vessel collisions, leave in situ has the lowest risk and is therefore the best option.

Due to the operational risk of vessels at sea, rock cover has the highest safety risk and was therefore the least best option.

However, the short duration of activities and the routine nature of the scope to be undertaken indicate that a low level of risk exists for both options and so a low Preference Score (2) was applied.

Project risk to personnel onshore

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With no material returned to shore, leave in situ has the lowest safety risk to personnel onshore and is therefore the best option.

No material is returned to shore for the partial remediation option of using additional rock cover, however a small risk is associated with the production and loading of rock to the vessel and therefore this is the least best option.

The levels of risk for each option are perceived to be minimal and no clear differentiator exists, therefore a low Preference Score (1) has been applied.

Potential of a high consequence event

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Due to the lack of vessel activity, leave in situ is perceived to have the lowest likelihood and associated risk of a high consequence event and is therefore the best option.

Due to the operational risk of vessels at sea, rock cover has the highest safety risk and was therefore the least best option.

The levels of risk for each option are perceived to be minimal and no clear differentiator exists, therefore a low Preference Score (2) has been applied.

Residual risk to other users of the sea

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

The residual risk arises from snagging on any exposures within this section.

Rock cover provides further mitigation to this risk and so is considered the best option; with leave in situ applying no mitigation and the least best option.

However, due to the small exposures that are present and the low residual risk, a small Preference Score (3) between each option has been applied.

Environmental

The Environment criterion is split into three sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Environmental criteria for Type B nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 4: Remedial Rock cover
Marine impact of operations	1.0	0.0
Energy, emissions, resource consumption	1.0	0.0
Impact of marine end points (legacy impact)	-	-

Marine impact of operations

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are amended from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]. To ensure relevancy to the specific project circumstances, alternative criteria were used as detailed in Appendix 3.

Neither option includes planned discharge of pipeline contents to sea and no explosives will be used.

With no vessels operations to be undertaken, leave in situ constitutes the option with the lowest impact on the marine environment and so is the best option.

With a vessel in the field and some minor seabed disturbance and noise pollution, rock dump is the least best option.

However, due to the very short vessel duration and minimal impact of the rock cover activities, a very small Preference Score (1) has been applied.

Energy, emissions, resource consumption

Quantitative scoring was used to compare each option in this sub-criterion.

Genesis conducted an energy and emissions assessment [14] of the potential options for decommissioning the PL2029 and PL2031 pipelines. This analysis was conducted in accordance with the Energy Institute Guidelines [10].

The analysis includes CO_2 emissions during operations, primarily from vessels, and “endpoint” emissions, those associated with production of rock cover; recycling of recovered steel and copper; and the production of steel and copper to replace that decommissioned in situ.

The results are thus:

- Leave in situ – 350te CO_2
- Partial remediation by rock cover – 641te CO_2

Due to having the lowest associated emissions, leave in situ is the best option.

Due to having the largest associated emissions, rock cover is the least best option.

As the emissions for both options are relatively low, a “Preference Score” of 1 was assigned to this sub-criterion, indicating that it is not a strong differentiating factor between the options.

Impact of marine end points (legacy impact)

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are amended from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]. To ensure relevancy to the specific project circumstances, alternative criteria were used as detailed in Appendix 3.

As neither option includes the removal of any material, there is no perceived difference between leave in situ or rock cover. Therefore a Preference Score of 0 (zero) has been applied to indicate that this sub-criterion is not a measurable differentiator between the options.

Technical

The Technical criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative analysis, the Technical criteria for Type B nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 4: Remedial Rock cover
Risk of major project failure	1.0	0.0
Technology demands / track record	1.0	0.0

Risk of major project failure

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With no vessel activity to be undertaken, leave in situ presents the lowest risk of major project failure and so is the best option.

Due to the comparatively higher risk of operational vessels at sea, rock cover has the highest safety risk and was therefore the least best option.

However, there is a high degree of confidence in the rock cover technique and taking into account the relatively short section of pipeline to be considered, there is very little difference between the three options. Therefore a low Preference Score (1) has been applied.

Technological demands and track record

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With no remedial activity to be undertaken, there are clearly no technological demands or considerations of track record for the leave in situ option.

Partial remediation by additional rock cover is considered to be a routine operation with a proven track record. Although it is the least best option of the two, there is a high degree of confidence in the technique and, taking into account the relatively short section of pipeline to be considered, there is very little difference between the two options. Therefore a low Preference Score (1) has been applied.

Societal

The Societal criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Societal criteria for Type B nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 4: Remedial Rock cover
Commercial impact on fisheries	0.0	1.0
Socio-economic impact on communities and amenities	0.0	1.0

Commercial impact on fisheries

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Brown & May conducted an analysis of fishing activity in the vicinity of the Atlantic and Cromarty pipelines, to assess the impact of each decommissioning option on the legacy risk to other users of the sea.

The Brown & May report [9] identifies residual safety risk levels as follows:

Option	Creel vessels	Scallop dredgers	Demersal trawlers
Leave in situ	L2	L2	L2
Rock cover	L1	L2	L2

Table 16 – Risk associated with snagging on infrastructure left in situ

The risk level is assessed in accordance with BG's HSSE Management System Framework [11]. An L2 risk level is defined as "risk lies within the risk tolerability threshold, requiring active management to drive the risk to ALARP"; L1 is defined as "risk lies within the acceptable risk level".

With additional mitigation to reduce the snagging risk to creel vessels, rock cover is the best option.

With no mitigation applied, leave in situ is the least best option.

However, due to the low level of fishing currently in the area and the low level of residual risk from the leave in situ option, a low Preference Score (1) has been applied.

Socio-economic impact on communities and amenities

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Leave in situ and rock cover will result in no material returned to shore; while rock cover assumes some onshore material handling (quarrying rock, etc) and will result in minimal economic benefit from pre-existing supply chains. Therefore leave in situ is the least best option.

Due to the relatively low volumes of material considered, the positive economic impacts from onshore employment opportunities are considered to be minimal and will be handled by existing facilities. Therefore a low preference scoring (1) has been applied.

Economic

The Economic criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Economic criteria for Type B nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 4: Remedial Rock cover
Cost	1.0	0.0
Cost risk and uncertainty	1.0	0.0

Cost

Quantitative scoring was used to compare each option in this sub-criterion.

A cost estimate was produced using projected vessel types and durations, disposal costs and project management costs for each option.

Full cost estimate figures are being provided to BEIS in a separate submission and will not be provided here. To maintain commercial confidentiality ahead of invitations to tender for the work involved, the costs have been normalised where the lowest cost option has been set as 0 and the highest cost option as 1.

The estimates for each option are thus:

- Leave in situ – 0
- Partial remediation with additional rock cover – 1

By virtue of having the lowest cost, leave in situ is the best option.

Due to having the highest cost, rock cover is the least best option.

Cost risk and uncertainty

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

As there are no vessel activities associated with the leave in situ option, there is no cost risk or uncertainty during the project phase. There will be ongoing survey costs for infrastructure that is left in situ; but this is not considered to be an additional risk when compared to the other options as legacy survey obligations will remain for the rest of the pipeline which is left in situ. As such, leave in situ is the best option.

Due to the inherent risk of vessels at sea, rock cover has the highest safety risk and was therefore the least best option.

Due to the small level of risk associated with even the least best option, a low preference score (2) has been applied.

APPENDIX 5
COMPARATIVE ASSESSMENT DETAIL – NEARSHORE PIPELINES: TYPE C – SURFACE LAID WITH ROCK COVER WITH 4 INCH MEG LINE EXPOSURES (LAID ON ROCK FROM KP 4.6 – 6.4)

Safety

The Safety criterion is split into five sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Safety criteria for Type C nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 2: Remedial Rock cover
Project risk to personnel - Offshore	1.0	0.0
Project risk to other users of the sea	1.0	0.0
Project risk to personnel - Onshore	1.0	0.0
Potential of a high consequence event	1.0	0.0
Residual risk to other users of the sea	0.0	1.0

Project risk to personnel – offshore

Quantitative scoring was used to compare each option in this sub-criterion.

DNV GL conducted a high-level risk assessment utilising data derived from industry accident (occupational) rates, and project data for the anticipated man-hours and vessel days associated with each sub-criterion task. These were combined to produce a Potential Loss of Life (PLL) score for each option and allow a comparative scoring to be applied.

The results from DNV GL report, *Atlantic & Cromarty Decommissioning - Subsea Decommissioning Options Risk Assessment* [13], are thus:

- Leave in-situ – PLL 0
- Rock cover – PLL 3.77E-04

Having the highest PLL, rock cover is the least best option.

With no vessel activity, leave in-situ has the lowest safety risk and is therefore the best option.

With the vessel activity being of a very short duration and considered to be a routine, low risk operation, a low Preference Score (3) has been applied.

Project risk to other users of the sea

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Due to the lack of vessel activity, and therefore no risk of vessel collisions, leave in situ has the lowest risk and is therefore the best option.

Due to having the longest duration of vessels in-field, rock cover has the highest risk to other users of the sea and is therefore the least best option.

With the vessel activity being of a very short duration and considered to be a routine, low risk operation, a low Preference Score (3) has been applied.

Project risk to personnel onshore

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With no material returned to shore, leave in situ has the lowest risk and is therefore the best option.

No material is returned to shore for the partial remediation option of using additional rock cover, however a small risk is associated with the production and loading of rock to the vessel and this is therefore the least best option.

With the onshore activity being of a very short duration and considered to be a routine, low risk operation, a low Preference Score (3) has been applied.

Potential of a high consequence event

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

No vessel or occupational project risk is associated with leave in situ option and this is therefore considered the best option.

By comparison, rock cover is the least best option due to the operational risk of vessel activity.

With the vessel activity being of a very short duration and considered to be a routine, low risk operation, a low Preference Score (3) has been applied.

Residual risk to other users of the sea

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

The residual risk arises from snagging on any exposures within this section.

Rock cover applies mitigation to this risk and so is considered the best option; with leave in situ applying no mitigation and the least best option.

However, due to the small exposures that are present and the low residual risk, a small Preference Score (3) has been applied.

Environmental

The Environment criterion is split into three sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Environmental criteria for Type C nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 2: Remedial Rock cover
Marine impact of operations	1.0	0.0
Energy, emissions, resource consumption	1.0	0.0
Impact of marine end points (legacy impact)	-	-

Marine impact of operations

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are amended from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]. To ensure relevancy to the specific project circumstances, alternative criteria were used as detailed in Appendix 3.

Neither option includes planned discharge of pipeline contents to sea during decommissioning operations and no explosives will be used.

With no vessels operations to be undertaken, leave in situ constitutes the lowest impact on the marine environment and so is the best option.

With a vessel in the field and some minor seabed disturbance and noise pollution, rock dump is the least best option.

However, due to the very short vessel duration and minimal impact of the rock cover activities, a very small Preference Score (1) has been applied.

Energy, emissions, resource consumption

Quantitative scoring was used to compare each option in this sub-criterion.

Genesis conducted an energy and emissions assessment [14] of the potential options for decommissioning the PL2029 and PL2031 pipelines. This analysis was conducted in accordance with the Energy Institute Guidelines [10].

The analysis includes CO_2 emissions during operations, primarily from vessels, and "endpoint" emissions, those associated with production of rock cover; recycling of recovered steel and copper; and the production of steel and copper to replace that decommissioned in situ.

The results are thus:

- Leave in situ – 576te CO_2
- Partial remediation by rock cover – 894te CO_2

Due to having the lowest associated emissions, leave in situ is the best option.

Due to having the largest associated emissions, remedial rock cover is the least best option.

As the emissions for both options are very low, a “Preference Score” of 1 was assigned to this sub-criterion, indicating that it is not a strong differentiating factor between the options.

Impact of marine end points (legacy impact)

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are amended from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]. To ensure relevancy to the specific project circumstances, alternative criteria were used as detailed in Appendix 3.

As neither option includes the removal of any material, there is no perceived difference between leave in situ or rock cover. Therefore a Preference Score of 0 (zero) has been applied to indicate that this sub-criterion is not a measurable differentiator between the options.

Technical

The Technical criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative analysis, the Technical criteria for Type C nearshore pipeline were scored thus:

Ref.	Attribute	Option 1: Leave in situ	Option 2: Remedial Rock cover
9	Risk of major project failure	1.0	0.0
10	Technology demands / track record	1.0	1.0

Risk of major project failure

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With no vessel activity to be undertaken, leave in situ presents the lowest risk of major project failure and so is the best option.

With the greatest duration of vessel activity, the remedial rock cover option inherits the highest level of weather risk.

However, there is a high degree of confidence in each option and taking into account the relatively short section of pipeline to be considered, there is very little difference between the three options and so a very low Preference Score (1) has been applied.

Technological demands and track record

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With no remedial activity to be undertaken, there are clearly no technological demands or considerations of track record for the leave in situ option.

Partial remediation by additional rock cover is considered to be a routine operation with a proven track record.

As there is a high degree of confidence in each option and taking into account the relatively short section of pipeline to be considered, a Preference Score of 0 (zero) has been applied to indicate that this sub-criterion is not considered to be a differentiating factor between the options available.

Societal

The Societal criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative analysis, the Societal criteria for Type C nearshore pipeline were scored thus:

Attribute	Option 1: Leave in situ	Option 2: Remedial Rock cover
Commercial impact on fisheries	0.0	1.0
Socio-economic impact on communities and amenities	0.0	1.0

Commercial impact on fisheries

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Brown & May conducted an analysis of fishing activity in the vicinity of the Atlantic and Cromarty pipelines, to assess the impact of each decommissioning option on the legacy risk to other users of the sea.

The Brown & May report [9] identifies residual safety risk levels as follows:

Option	Creel vessels	Demersal trawlers
Leave in situ	L2	L1
Rock cover	L1	L1

Table 17 – Risk associated with snagging on infrastructure left in situ

The risk level is assessed in accordance with BG's HSSE Management System Framework [11]. An L2 risk level is defined as "risk lies within the risk tolerability threshold, requiring active management to drive the risk to ALARP"; L1 is defined as "risk lies within the acceptable risk level".

With additional mitigation to reduce the snagging risk to creel vessels, rock cover is the best option.

With no mitigation applied, leave in situ is the least best option.

However, due to the low level of fishing currently in the area and the low level of residual risk from the leave in situ option, a low Preference Score (1) has been applied.

Socio-economic impact on communities and amenities

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Leave in situ and rock cover will result in no material returned to shore; while rock cover assumes some onshore material handling (quarrying rock, etc) and will result in minimal economic benefit from pre-existing supply chains. Therefore leave in situ is the least best option.

Due to the relatively low volumes of material considered, the positive economic impacts from onshore employment opportunities are considered to be minimal and will be handled by existing facilities. Therefore a low preference scoring (1) has been applied.

Economic

The Economic criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Economic criteria for Type C nearshore pipeline were scored thus:

Ref.	Attribute	Option 1: Leave in situ	Option 2: Remedial Rock cover
13	Cost	1.0	0.0
14	Cost risk and uncertainty	1.0	0.0

Cost

Quantitative scoring was used to compare each option in this sub-criterion.

A cost estimate was produced using projected vessel types and durations, disposal costs and project management costs for each option.

Full cost estimate figures are being provided to BEIS in a separate submission and will not be provided here. To maintain commercial confidentiality ahead of invitations to tender for the work involved, the costs have been normalised where the lowest cost option has been set as 0 and the highest cost option as 1.

The estimates for each option are thus:

- Leave in situ – 0
- Partial remediation with additional rock cover – 1

By virtue of having the lowest cost, leave in situ is the best option.

Due to having the highest cost, total removal is the least best option.

Cost risk and uncertainty

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

As there are no vessel activities associated with the leave in situ option, there is no cost risk or uncertainty during the project phase. There will be ongoing survey costs for infrastructure that is left in situ, but this is not considered to be an additional risk when compared to the other options as legacy survey obligations will remain for the rest of the pipeline left in situ. As such, leave in situ is the best option.

With the longest duration of vessels in-field and the associated additional exposure to weather risk, remedial rock cover is the least best option.

However, taking into account the relatively short duration of operations for rock cover and the high degree of confidence in a well understood method with a long and successful track record in the North Sea, a very low Preference Score (1) has been applied to indicate that this is not a strong differentiating factor between the options available.

APPENDIX 6
COMPARATIVE ASSESSMENT DETAIL – OFFSHORE PIPELINES: ATLANTIC AND MEG PIGGYBACK LINE; CROMARTY TRUNKLINE

Safety

The Safety criterion is split into five sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Safety criteria for the offshore pipelines were scored thus:

	Minimal Removal	Partial Remediation			Total Removal
Attribute	**2A: Remove ends of pipeline and remediate**	**3A (Remedial Rock Cover)**	**3B (Cut and Lift)**	**3C (Re-Trench)**	**Cut and Lift**
Project risk to personnel - Offshore	1.0	0.6	0.4	0.2	0.0
Project risk to other users of the sea	1.0	0.8	0.7	0.8	0.0
Project risk to personnel - Onshore	1.0	0.6	0.3	1.0	0.0
Potential of a high consequence event	1.0	0.8	0.3	0.8	0.0
Residual risk to other users of the sea	0.3	0.7	0.0	0.5	1.0

Project risk to personnel – offshore

Quantitative scoring was used to compare each option in this sub-criterion.

DNV GL conducted a high-level risk assessment based on accident rates and the anticipated man-hours and vessel days associated with each option. These were combined to produce a Potential Loss of Life (PLL) score for each option and allow a comparative scoring to be applied.

The results from DNV GL report, *Atlantic & Cromarty Decommissioning - Subsea Decommissioning Options Risk Assessment* [13], are thus:

- Minimal removal - remove ends – 3.88E-04
- Remedial rock cover – 9.16E-04
- Partial cut-and-lift – 3.30E-03
- Partial re-trench – 1.00E-03
- Total removal – 3.63E-02

Due to the extended duration of vessels in the field and the additional risk of cut-and-lift activities, total removal has the highest safety risk and was therefore the least best option.

All the options for partial remediation (rock cover, cut-and-lift and re-trench) also include the activities included in the minimal removal option. Each of these additional scopes necessarily increases the level of risk to project personnel, albeit marginally.

Therefore, minimal removal has the lowest safety risk and is the best option.

Project risk to other users of the sea

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With minimal vessel operations limiting interaction and interference with other users of the sea, minimal removal has the lowest risk and is the best option.

Each of the partial remediation options include slightly increased levels of risk when compared with the minimal removal option by virtue of their extended vessel durations; with cut-and-lift having a slightly higher risk level due to the lifting activities which are not involved in remedial rock cover and re-trench.

With the longest duration in-field by a large margin and with a significant number of lifts (more than 3000), the total removal option has the highest risk to other users of the sea and is therefore the least best option.

Project risk to personnel onshore

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

The minimal removal, remedial rock cover and partial re-trench options all result in a small volume of material being returned to shore; however the latter two also incur a small risk associated with the production and loading of rock to the vessel and mobilisation of the trencher, respectively. Therefore minimal removal has the lowest risk to personnel onshore and is therefore the best option.

This is considered to be lower risk than the partial cut-and-lift option which will see ~1800te of steel, concrete and plastic returned to shore for disposal which is ranked worse than minimal removal but better than the total removal option.

Due to the significant volumes of material to be returned to shore for disposal (~27000te of steel, concrete and plastic), the total removal option has the highest risk to personnel onshore and therefore is the least best option.

Potential of a high consequence event

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With minimal vessel operations, minimal removal has the lowest risk of a high consequence event and is therefore the best option.

Both remedial rock cover and re-trenching are considered to have slightly higher likelihood of a high consequence event by virtue of their additional activities in-field; however both are considered to be routine operations with relatively small scopes that are well understood.

Due to having the longest duration of vessels in-field; multiple mobilisations and de-mobilisations for offloading of material; and a significant number of lifting operations (3000+) as part of the cut-and-lift activities, total removal has the highest risk of a high consequence event and is therefore the least best option.

Residual risk to other users of the sea

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Brown & May conducted an analysis of fishing activity in the vicinity of the Atlantic and Cromarty pipelines, to assess the impact of each decommissioning option on the legacy risk to other users of the sea.

Partial cut-and-lift is considered to have the highest residual risk of snagging due to the number of cut ends created. It is likely that rock cover would be applied to the cut ends to minimise the risk but this remains the least best option.

Removing the pipeline ends only would create no additional snagging risks to other users of the sea but retains potential risk from pipeline corrosion creating new snagging hazards in the long term and is therefore considered the next least best option.

This risk could be removed by remedial rock cover, partial re-trench or total removal of the pipeline; with the latter removing all infrastructure from the seabed and considered to be the best option.

However, it should be noted that the Brown & May report concludes “all of the impacts assessed above principally relate to the presence of fastening risks as a result of infrastructure decommissioned in situ. Therefore, taking these factors into consideration, the risk of occurrence would be minimised to as low as reasonably practicable (ALARP) following the application of the mitigation described.” [Section 4.7.2, 9]

The report also notes the residual risk from the minimal removal option would apply only across a very short section of pipeline (60-100m) and that “at locations where the pipeline is currently buried to adequate depth to negate the risk of future exposure, leave in situ represents the best option in terms of minimising risks to fishing activity. No disturbance to the ground would occur and future snagging risks are unlikely, therefore no further mitigation would be required at these locations.” [Section 1.4, 9]

It is therefore considered that there is no significant difference in risk between each of the options and a low Preference Score (1) has been applied to this sub-criterion.

Environmental

The Environment criterion is split into three sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Environmental criteria for the offshore pipelines were scored thus:

	Minimal Removal	Partial Remediation			Total Removal
Attribute	**2A: Remove ends of pipeline and remediate**	**3A (Remedial Rock Cover)**	**3B (Cut and Lift)**	**3C (Re-Trench)**	**Cut and Lift**
Marine impact of operations on Environment	1.0	0.9	0.8	0.7	0.0
Energy, emissions, resource consumption	1.0	0.9	0.9	0.9	0.0
Impact on marine end points (legacy impact)	0.0	0.7	0.6	0.5	1.0

Marine impact of operations

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are amended from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]. To ensure relevancy to the specific project circumstances, alternative criteria were used as detailed in Appendix 3.

The pipelines have been left in a hydrocarbon free condition following cleaning, pigging and preservation in accordance with the Hydrocarbon Freeing Close Out Report [12]. Therefore, there is no risk of hydrocarbon release from any of the decommissioning options.

With the shortest duration of vessel activities, no requirement for SIMOPS (simultaneous operations) and the lowest level of seabed disturbance, minimal removal is the best option.

The three partial remediation options (rock cover, cut-and-lift and re-trench) all result in a higher level of seabed disturbance than removing the ends only. Of these three, the re-trench option is considered to have the greatest impact due to the wider corridor of disturbance caused by the mechanical plough. Cut-and-lift is considered the next largest impact due to additional vessel duration and potential for SIMOPS with a supply vessel alongside the ROVSV. Rock cover is considered to have the lowest impact of the three partial remediation options due to comparatively shorter vessel durations than cut-and-lift and comparatively less seabed disturbance than re-trench.

With vessels in the field for over a year and significant seabed disturbance from removing the entire length of pipeline, total removal is considered to have the most significant marine impact and is therefore the least best option.

Energy, emissions, resource consumption

Quantitative scoring was used to compare each option in this sub-criterion.

Genesis conducted an energy and emissions assessment [14] of the potential options for decommissioning the PL2029 and PL2031 pipelines. This analysis was conducted in accordance with the Energy Institute Guidelines [10].

The analysis includes CO_2 emissions during operations, primarily from vessels, and "endpoint" emissions, those associated with production of rock cover; recycling of recovered steel and copper; and the production of steel and copper to replace that decommissioned in situ.

The results are thus:

- Remove ends only – 25,243te CO_2
- Remedial rock cover – 25,617te CO_2
- Partial cut-and-lift – 26,358te CO_2
- Partial re-trench – 25,329te CO_2
- Total removal – 43,898te CO_2

Due to having the lowest associated emissions, remove ends only is the best option.

Due to having the largest associated emissions, total removal is the least best option.

As the highest emissions, for total removal, are almost double the lowest emissions, a high Preference Score (10) has been applied to this sub-criterion.

Impact of marine end points (legacy impact)

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are amended from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]. To ensure relevancy to the specific project circumstances, alternative criteria were used as detailed in Appendix 3.

Total removal is the option that leaves no material on the seabed and is therefore scored as the best option.

Conversely, while recognising that the material left on the seabed is inert and clean (steel, concrete and plastic), minimal removal is the option that leaves the most material on the seabed and is consequently scored as the least best option.

Where sections of the hydrocarbon-freed offshore pipeline have come out of burial, none of the options for remediation would leave persistent toxic materials on the seabed. All options leave materials that are inert and clean. Additional considerations are that:

- Cut-and-lift would release small quantities of chemical inhibitor. Modelling has shown this will cause only localised temporary impact on water quality.
- Re-trenching involves temporary suspension and redistribution of seabed sediments. This is relatively benign but if contaminants are present in the seabed they may be released and recovery of the marine environment may take time
- Remedial rock cover introduces additional material. Where it introduces hard substrate to a soft-seabed habitat, it may take some time for the seabed to recover.

Of these remedial options, re-trenching may be considered preferable to cut-and-lift or adding rock cover.

Technical

The Technical criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative analysis, the Technical criteria for the offshore pipelines were scored thus:

		Minimal Removal	Partial Remediation			Total Removal
Ref.	**Attribute**	**2A: Remove ends of pipeline and remediate**	**3A (Remedial Rock Cover)**	**3B (Cut and Lift)**	**3C (Re-Trench)**	**Cut and Lift**
9	Risk of major project failure	1.0	0.9	0.6	0.5	0.0
10	Technology demands / track record	1.0	1.0	0.4	0.0	0.2

Risk of major project failure

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With the shortest duration of vessel activity to be undertaken, minimal removal presents the lowest risk of major project failure and so is the best option.

Rock cover is a routine operation with a comparatively short duration and is therefore considered to be the next best option.

With cut-and-lift subject to more stringent weather constraints due to the lifting activities involved, and re-trenching subject to uncertainty of the soil conditions, both options are considered to have higher risk of major project failure than minimal removal or rock cover.

With the greatest duration of vessel activity, the total removal option has the highest inherent weather risk and is considered to be the least best option.

Technological demands and track record

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

The methods and techniques involved in minimal removal and rock cover are both considered to be well understood, routine workscopes with proven track records in the North Sea and are therefore the best options.

Whilst the techniques for cut-and-lift are considered to be well understood and generally have a proven track record, there is no known precedent of removing a comparable buried concrete-coated trunkline with a piggyback line. Therefore, both the partial remediation and total removal options by cut-and-lift are considered to be technologically less certain than minimal removal and rock cover.

Partial remediation by re-trenching is considered to be the most technologically challenging option due to potentially problematic soil conditions at locations which require re-trenching.

There is also no known precedent of re-trenching a comparable buried concrete-coated trunkline with piggyback line. Therefore, re-trenching is the least best option.

Societal

The Societal criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative analysis, the Societal criteria for the offshore pipelines were scored thus:

	Minimal Removal	Partial Remediation			Total Removal
Attribute	**2A: Remove ends of pipeline and remediate**	**3A (Remedial Rock Cover)**	**3B (Cut and Lift)**	**3C (Re-Trench)**	**Cut and Lift**
Commercial impact on fisheries	0.0	0.0	1.0	1.0	1.0
Socio-economic impact on communities and amenities	0.0	0.2	0.5	0.1	1.0

Commercial impact on fisheries

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Brown & May conducted an analysis of fishing activity in the vicinity of the Atlantic and Cromarty pipelines, to assess the impact of each decommissioning option on loss or restricted access to fishing grounds.

Partial cut-and-lift, partial re-trench and total removal all result in no loss of fishing area, indeed a small increase in fishable area will be realised when decommissioning has been completed.

Removing the ends only and providing a small quantity of remedial rock cover to mitigate the potential snagging risk may result in the loss of fishing ground but the area under consideration is very small and the potential impact was assessed by Brown & May as “negligible loss of earnings due to little or no fishing history around area of Atlantic & Cromarty where decommissioning occurring”.

It is therefore considered that there is no significant difference in risk between each of the options and a low Preference Score (1) has been applied to this sub-criterion.

Socio-economic impact on communities and amenities

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Minimal removal, remedial rock cover and partial re-trenching were all considered to have no negative impact on communities and amenities by virtue of having no material returned to shore with the associated noise and odour pollution. By contrast, there would be no positive economic benefit to the communities from the employment arising from disposal activities.

Remedial rock cover was considered to have a marginal positive economic benefit from sourcing rock, accommodated by existing business and infrastructure.

Partial cut-and-lift will have a small positive impact from ~1800te of concrete, steel and plastic being returned to shore for disposal; with total removal having a far greater positive economic impact with ~27000te material returned for disposal. Both options would have proportional negative impacts from the noise and odour pollution arising from the disposal activities.

Due to the economic benefits, total removal is the best option.

With no economic benefit to communities, minimal removal is the least best option.

Economic

The Economic criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Economic criteria for the offshore pipelines were scored thus:

		Minimal Removal	Partial Remediation			Total Removal
Ref.	**Attribute**	**2A: Remove ends of pipeline and remediate**	**3A (Remedial Rock Cover)**	**3B (Cut and Lift)**	**3C (Re-Trench)**	**Cut and Lift**
13	Cost	1.0	0.9	0.9	0.9	0.0
14	Cost risk and uncertainty	1.0	0.8	0.5	0.5	0.0

Cost

Quantitative scoring was used to compare each option in this sub-criterion.

A cost estimate was produced using projected vessel types and durations, disposal costs and project management costs for each option.

Full cost estimate figures have been provided to BEIS in a separate submission and will not be provided here. To maintain commercial confidentiality ahead of invitations to tender for the work involved, the costs have been normalised where the lowest cost option has been set as 0 and the highest cost option as 1.

The estimates for each option are thus:

- Minimal removal (ends only) – 0
- Remedial rock cover – 0.02
- Partial cut-and-lift – 0.08
- Partial re-trench – 0.03
- Total removal - 1

By virtue of having the lowest cost, minimal removal is the best option.

Due to having the highest cost, total removal is the least best option.

With total removal being nearly eleven times greater than the next most expensive option, a high Preference Score (10) has been assigned to indicate the scale of difference between the options.

Cost risk and uncertainty

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With a relatively short campaign consisting of standard offshore construction activities which are well understood and routinely undertaken in the North Sea, minimal removal has the lowest cost risk and is the best option.

Remedial rock cover is also considered to be a routine operation that is well understood and so has a low level of cost risk, although with comparatively more than minimal removal due to the involvement of an additional vessel and more time in-field.

Partial cut-and-lift and partial re-trench have a higher cost risk than both minimal removal and rock cover due to comparatively more complex operations and, for partial cut-and-lift, some periods of simultaneous operations (SIMOPS).

With by far the longest duration of vessels in the field (at least eleven times longer than the next longest option) and the associated additional exposure to weather risk the total removal option is the least best option.

Due to the scale of difference between total removal and the other options, a high Preference Score (10) has been assigned to this sub-criterion.

APPENDIX 7
COMPARATIVE ASSESSMENT DETAIL – GOLDENEYE AND CROMARTY UMBILICALS

Safety

The Safety criterion is split into five sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Safety criteria for the offshore umbilicals were scored thus:

	Minimal Removal	Partial Remediation	Partial Remediation	Partial Remediation	Total Removal	Total Removal
Attribute		**3A (Remedial Rock Cover)**	**3B (Cut and Lift)**	**3C (Re-Trench)**	**4A (Reverse Reel Lay (Except crossings)**	**4B (Subsea cut and lift)**
Project risk to personnel - Offshore	1.0	0.8	0.9	0.9	0.8	0.0
Project risk to other users of the sea	1.0	0.9	0.7	0.8	0.3	0.0
Project risk to personnel - Onshore	1.0	0.6	0.3	1.0	0.0	0.0
Potential of a high consequence event	1.0	0.8	0.3	0.8	0.0	0.0
Residual risk to other users of the sea	0.5	0.7	0.0	0.6	1.0	1.0

Project risk to personnel – offshore

Quantitative scoring was used to compare each option in this sub-criterion.

DNV GL conducted a high-level risk assessment utilising data derived from industry accident (occupational) rates and the anticipated man-hours and vessel days associated with each option. These were combined to produce a Potential Loss of Life (PLL) score for each option and allow a comparative scoring to be applied.

The results from DNV GL report, *Atlantic & Cromarty Decommissioning - Subsea Decommissioning Options Risk Assessment* [13], are thus:

- Minimal removal - remove ends – 4.02E-03
- Remedial rock cover – 4.75E-03
- Partial cut-and-lift – 4.40E-03
- Partial re-trench – 4.35E-03
- Total Removal by reverse reel-lay – 4.74E-03
- Total Removal by cut-and-lift – 7.19E-03

Due to the extended duration of vessels in the field and the additional risk of cut-and-lift activities, total removal has the highest occupational risk and was therefore the least best option.

All the options for partial remediation (rock cover, cut-and-lift and re-trench) also include the activities included in the minimal removal option. Each of these additional scopes have

marginally increased risk when compared to minimal removal but much less than the total removal options and are ranked accordingly.

Therefore, minimal removal has the lowest safety risk and is the best option.

Project risk to other users of the sea

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With minimal vessel operations limiting interaction and interference with other users of the sea, minimal removal has the lowest risk and is the best option.

Each of the partial remediation options assume slightly increased levels of risk by virtue of their extended vessel durations; with cut-and-lift having a slightly higher risk level due to the lifting activities which are not involved in remedial rock cover and re-trench.

With the longest duration in the field by a large margin, total removal has the highest risk to other users of the sea, with total removal by cut-and-lift having a higher risk than removal by reverse relay due to vessel duration in-field. The former is therefore the least best option.

Project risk to personnel onshore

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

The minimal removal, remedial rock cover and partial re-trench options all result in a small volume of material being returned to shore, however the latter two also incur a small risk associated with the production and loading of rock to the vessel and mobilisation of the trencher, respectively. Therefore minimal removal has the lowest risk to personnel onshore and is therefore the best option in terms of having the lowest onshore personnel risk.

This is considered to be lower risk than the partial cut-and-lift option which will see ~85te of steel, concrete and plastic returned to shore for disposal.

Due to the significant volumes of material to be returned to shore for disposal (~580te of steel, concrete and plastic) and increased occupational risk associated with this, the total removal option has the highest risk to personnel onshore and therefore is the least best option.

Potential of a high consequence event

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With minimal vessel operations and likelihood for incident, minimal removal has the lowest risk of a high consequence event and is therefore the best option.

Both remedial rock cover and re-trenching are considered to have slightly higher risks of a high consequence event by virtue of their additional activities in-field, however both are considered to be routine operations with relatively small scopes that are well understood.

Due to having the longest duration of vessels in-field; multiple mobilisations and de-mobilisations for offloading of material, and a significant number of lifting operations (more than 1800) as part of the cut-and-lift activities, total removal has the highest risk of a high consequence event and is therefore the least best option.

Residual risk to other users of the sea

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Brown & May conducted an analysis of fishing activity in the vicinity of the Atlantic and Cromarty pipelines, to assess the impact of each decommissioning option on the legacy risk to other users of the sea.

Removal of the umbilical ends only is considered to have risk of snagging due to the exposed ends potential to protrude from the seabed. This is considered to be a small risk to other users of the sea taking into account the size and mass of the umbilical. This risk would be further mitigated by the addition of rock cover or burying the cut end.

By virtue of having several cut ends, compared to just one cut end with the minimal removal option, partial cut-and-lift is considered to have the highest residual risk to other users of the sea.

The residual snagging risk of cut ends for partial re-trench is broadly similar to that for minimal removal whilst total removal of the umbilical removes all infrastructure from the seabed and is considered to be the best option.

However, it should be noted that the report concludes “all of the impacts assessed above principally relate to the presence of fastening risks as a result of infrastructure decommissioned in situ. Therefore, taking these factors into consideration, the risk of occurrence would be minimised to as low as reasonably practicable (ALARP) following the application of the mitigation described.” [Section 4.7.2, 9]

It is therefore considered that there is no significant difference in risk between each of the options and a low Preference Score (1) has been applied to this sub-criterion.

Environmental

The Environment criterion is split into three sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Environmental criteria for the offshore umbilicals were scored thus:

		Minimal Removal	Partial Remediation	Partial Remediation	Partial Remediation	Total Removal	Total Removal
Ref.	Attribute		3A (Remedial Rock Cover)	3B (Cut and Lift)	3C (Re-Trench)	4A (Reverse Reel Lay (Except crossings)	4B (Subsea cut and lift)
6	Marine impact of operations	1.0	0.9	0.8	0.7	0.0	0.0
7	Energy, emissions, resource consumption	1.0	0.9	0.9	0.9	0.8	0.0
8	Impact of marine end points (legacy impact)	0.0	0.4	0.4	0.6	1.0	1.0

Marine impact of operations

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are amended from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]. To ensure relevancy to the specific project circumstances, alternative criteria were used as detailed in Appendix 3.

The Goldeneye to Atlantic (PLU 2033) and Atlantic to Cromarty (PLU 2034) umbilicals have hydraulic cores filled with MacDermid Oceanic HW443R hydraulic fluid. HW443 is in OCNS (Offshore Chemical Notification Scheme) Class D. An Osborne Adams calculation [18] was carried out on the basis that the worst case release rate from these lines is $3m^3$/hr. At this rate, it was concluded that the environmental risk is acceptable for all options.

With the shortest vessel durations of any of the options and lowest level of noise from decommissioning activities, minimal removal is the best option.

Partial remediation activities would all require additional vessel time in the field resulting in higher risk of vessel collision, although the risk is still considered to be very low.

- Remedial rock dump would result in the lowest level of seabed disturbance of the three partial remediation options
- Partial removal by cut-and-lift would have the longest vessel duration and highest associated noise levels of the three partial remediation options
- Partial re-trench would result in the greatest disturbance to the seabed of the three partial remediation options with a comparatively wide corridor of disturbance.

Due to extended vessel durations and significant seabed disturbance along the entire length of each umbilical, both total removal options have the greatest marine impact and are therefore the least best options.

Energy, emissions, resource consumption

Quantitative scoring was used to compare each option in this sub-criterion.

Genesis conducted an energy and emissions assessment [14] of the potential options for decommissioning the PL2029 and PL2031 pipelines. This analysis was conducted in accordance with the Energy Institute Guidelines [10].

The analysis includes CO_2 emissions during operations, primarily from vessels, and "endpoint" emissions, those associated with production of rock cover; recycling of recovered steel and copper; and the production of steel and copper to replace that decommissioned in situ.

The results are thus:

- Remove ends only – 1,868te CO_2
- Remedial rock cover – 2,448te CO_2
- Partial cut-and-lift – 2,419te CO_2
- Partial re-trench – 2,407te CO_2
- Total removal (reverse reel-lay) – 3,003te CO_2
- Total removal (cut-and-lift) – 5,402te CO_2

Due to having the lowest associated emissions, remove ends only is the best option.

Due to having the largest associated emissions, total removal by cut-and-lift is the least best option.

As the highest emissions, for total removal, are more than double the lowest emissions, a high Preference Score (10) has been applied to this sub-criterion.

Impact of marine end points (legacy impact)

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are amended from Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]. To ensure relevancy to the specific project circumstances, alternative criteria were used as detailed in Appendix 3.

Total removal is the option that leaves no material on the seabed and is therefore scored as the best option.

Conversely, while recognising that the material left on the seabed is inert and clean (steel, concrete and plastic), minimal removal is the option that leaves the most material on the seabed and is consequently scored as the least best option.

Where sections of the hydrocarbon-freed umbilical have come out of burial, none of the options for remediation would leave persistent toxic materials on the seabed. All options leave materials that are inert and clean. Additional considerations are that:

- Cut-and-lift would release small quantities of hydraulic fluid. Modelling has shown this will cause only localised temporary impact on water quality.

- Re-trenching involves temporary suspension and redistribution of seabed sediments. This is relatively benign but if contaminants are present in the seabed they may be released and recovery of the marine environment may take time
- Remedial rock cover introduces additional material, in this location introducing hard substrate to a soft-seabed habitat and it may take some time for the seabed to recover.

Of these remedial options, re-trenching may be considered preferable to cut-and-lift or adding rock cover.

Technical

The Technical criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative analysis, the Technical criteria for the offshore umbilicals were scored thus:

		Minimal Removal	Partial Remediation	Partial Remediation	Partial Remediation	Total Removal	Total Removal
Ref.	Attribute		3A (Remedial Rock Cover)	3B (Cut and Lift)	3C (Re-Trench)	4A (Reverse Reel Lay (Except crossings)	4B (Subsea cut and lift)
9	Risk of major project failure	1.0	0.9	0.6	0.0	0.1	0.1
10	Technology demands / track record	1.0	1.0	0.5	0.0	0.2	0.2

Risk of major project failure

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

With the shortest duration of vessel activity and high degree of confidence in the activities to be undertaken, minimal removal presents the lowest risk of major project failure and so is the best option.

Rock cover is a routine operation with a comparatively short duration and is therefore considered to be the next best option.

With cut-and-lift subject to more stringent weather constraints due to the lifting activities involved and requirement for two vessels to work alongside each other this is considered to have higher risk than rock cover.

Due to the extended duration of vessel activities, both total removal options assume a much higher level of weather risk to schedule than partial remediation or minimal removal.

The initial trenching of both umbilicals during installation encountered technical difficulties due to the seabed condition, requiring the umbilicals to be surface-laid and buried by Technip's FlexJet system during a separate vessel campaign. Consequently, it is considered that the technical feasibility of re-trenching remains uncertain and would require significant engineering during FEED. Therefore, re-trenching is the least best option.

Technological demands and track record

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

The methods and techniques involved in minimal removal and rock cover are both considered to be well understood, routine workscopes with proven track records in the North Sea and are therefore the best options.

Whilst the techniques for cut-and-lift are considered to be well understood and generally have a proven track record, there is no known precedent of removing a comparable buried umbilical of this length. Therefore, both the partial remediation and total removal options by cut-and-lift are considered to be technologically less certain than minimal removal and rock cover.

Partial remediation by re-trenching is considered to be the most technologically challenging option due to potentially problematic soil conditions. Therefore, re-trenching is the least best option.

Societal

The Societal criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative analysis, the Societal criteria for the offshore umbilicals were scored thus:

	Minimal Removal	Partial Remediation	Partial Remediation	Partial Remediation	Total Removal	Total Removal
Attribute		3A (Remedial Rock Cover)	3B (Cut and Lift)	3C (Re-Trench)	4A (Reverse Reel Lay (Except crossings)	4B (Subsea cut and lift)
Commercial impact on fisheries	0.0	0.0	1.0	1.0	1.0	1.0
Socio-economic impact on communities and amenities	0.0	0.2	0.5	0.1	1.0	1.0

Commercial impact on fisheries

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Brown & May conducted an analysis of fishing activity in the vicinity of the Atlantic and Cromarty pipelines, to assess the impact of each decommissioning option on loss or restricted access to fishing grounds.

Partial cut-and-lift, partial re-trench and total removal all result in no loss of fishing area, indeed a small increase in fishable area will be realised when decommissioning has been completed.

Removal of the pipeline ends only and remedial rock cover may result in the loss of fishing ground but the area under consideration is very small and the potential impact was assessed by Brown & May as “negligible loss of earnings due to little or no fishing history around area of Atlantic & Cromarty where decommissioning occurring”.

It is therefore considered that there is no significant difference in risk between each of the options and a low Preference Score (1) has been applied to this sub-criterion.

Socio-economic impact on communities and amenities

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4].

Minimal removal, remedial rock cover and partial re-trenching were all considered to have no negative impact on communities and amenities by virtue of having no or negligible volumes of material returned to shore with the associated noise and odour pollution. Similarly, there would be no positive economic benefit to the communities from the employment arising from disposal activities.

Remedial rock cover was considered to have a marginal positive economic benefit from sourcing rock, accommodated by existing business and infrastructure.

Partial cut-and-lift will have a small positive impact from ~85te of concrete, steel and plastic being returned to shore for disposal; with total removal having a far greater positive economic impact with ~580te material returned for disposal. Both options would have proportional negative impacts from the noise and odour pollution arising from the disposal activities.

Due to the significant economic benefits, total removal is the best option.

With no economic benefit to communities, minimal removal is the least best option.

Economic

The Economic criterion is split into two sub-criteria which were individually assessed and scored relative to the other options.

Summary

Based on the below qualitative and quantitative analysis, the Economic criteria for the offshore umbilicals were scored thus:

	Minimal Removal	Partial Remediation	Partial Remediation	Partial Remediation	Total Removal	Total Removal
Attribute		**3A (Remedial Rock Cover)**	**3B (Cut and Lift)**	**3C (Re-Trench)**	**4A (Reverse Reel Lay (Except crossings)**	**4B (Subsea cut and lift)**
Cost	1.0	0.8	0.9	0.9	0.7	0.0
Cost risk and uncertainty	1.0	0.8	0.5	0.5	0.0	0.0

Cost

Quantitative scoring was used to compare each option in this sub-criterion.

A cost estimate was produced using projected vessel types and durations, disposal costs and project management costs for each option.

Full cost estimate figures have been provided to BEIS in a separate submission and will not be provided here. To maintain commercial confidentiality ahead of invitations to tender for the work involved, the costs have been normalised where the lowest cost option has been set as 0 and the highest cost option as 1.

The estimates for each option are thus:

- Minimal removal (ends only) – 0
- Remedial rock cover – 0.17
- Partial cut-and-lift – 0.11
- Partial re-trench – 0.09
- Total removal by re-reeling – 0.26
- Total removal by cut-and-lift - 1

By virtue of having the lowest cost, minimal removal is the best option.

Due to having the highest cost, total removal by cut-and-lift is the least best option.

With total removal more than double the next most expensive option, a high Preference Score (8) has been assigned to indicate the scale of difference between the options.

Cost risk and uncertainty

Qualitative scoring was used to compare each option in this sub-criterion.

The factors and assessment criteria used are as per Table 2 of the Oil and Gas UK *Guidelines for Comparative Assessment in Decommissioning Programmes* [4]

With a relatively short campaign consisting of standard offshore construction activities which are well understood and routinely undertaken in the North Sea, minimal removal has the lowest cost risk and is the best option.

Remedial rock cover is also considered to be a routine operation that is well understood and so has a low level of cost risk, although with comparatively more than minimal removal due to the involvement of an additional vessel and more time in-field.

Partial cut-and-lift and partial re-trench have a higher cost risk than both minimal removal and rock cover due to comparatively more complex operations and, for partial cut-and-lift, some periods of SIMOPS.

With the longest duration of vessels in-field (approximately double the next longest option) and the associated additional exposure to weather risk the total removal by cut-and-lift is the least best option.

Due to the scale of difference between total removal and the other options, a high Preference Score (7) has been assigned to this sub-criterion.