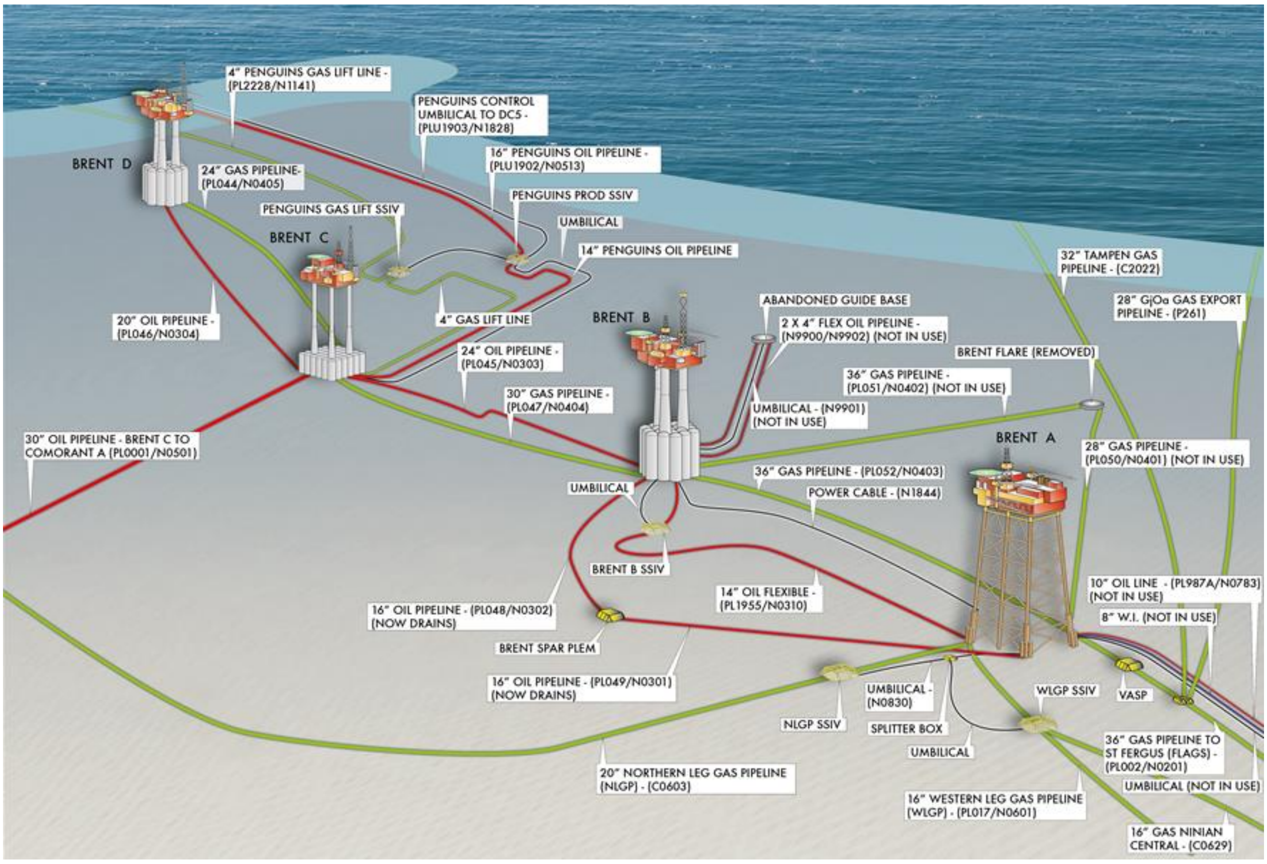
Shell U.K. Limited

BRENT FIELD PIPELINES DECOMMISSIONING PROGRAMME



Submitted to the UK Department for Business, Energy and Industrial Strategy

Shell Report Number BDE-F-PIP-AA-5880-00002

February 2020

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Contents

1 EXECUTIVE SUMMARY

Introduction

This document presents the Decommissioning Programme (DP) for the Brent Field pipelines, associated subsea structures and debris. The Brent installations are subject to separate DPs. The owners of the infrastructure are Shell U.K. Limited (registered number 0140141) (Shell, the operator) 50%, and Esso Exploration and Production UK Limited (registered number 00207426) (Esso) 50%. Shell has prepared this Programme in accordance with Section 29 of the *Petroleum Act* 1998 [1], and Esso confirms that it supports the proposals described in them. A letter of support from Esso is presented at the end of this Executive Summary. Throughout this document therefore, the terms 'owners', 'we', 'us', and 'our' refer to 'Shell and Esso'.

Decommissioning in the UK sector of the North Sea takes place under a mature regulatory process that is stipulated in the UK's Petroleum Act and regulated by the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), which is a department within the Department for Business, Energy and Industrial Strategy (BEIS)[1]. The decommissioning of pipelines is governed by Part IV of the Petroleum Act 1998 and the Pipeline Safety Regulations 1996. The *BEIS Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998*[2] [3] provide guidance and advice in the preparation of DPs.

Background

At the time of its discovery the expected lifespan of the Brent Field was 25 years. Through continuous improvement and significant investment in the 1990s, we have extended the life of the Field well beyond original expectations. After many years of service to the UK, however, the Brent Field is now reaching the stage where all the economically recoverable reserves of oil and gas have been extracted. The next step is to decommission the Field's four platforms and their related infrastructure. Before considering decommissioning options, and as part of our Final Field Development Plan (FFPD), we examined possible re-use options for the platforms and the pipeline system, particularly for further oil and gas production offshore, and carbon capture and storage. In addition, as part of our Comparative Assessment process, we reviewed a range of possible re-use options such as wind-farms, marine research stations, energy hubs, and artificial reefs. After a thorough review, we were not able to identify any further oil and gas uses for any part of the Field infrastructure, and concluded that all the alternative non-oil and gas uses were either not feasible, or not economically viable because of the age of the infrastructure, its distance from shore, the lack of demand for reuse and the cost of converting the facilities. We have therefore concluded that the Field, including its pipeline system, must be decommissioned.

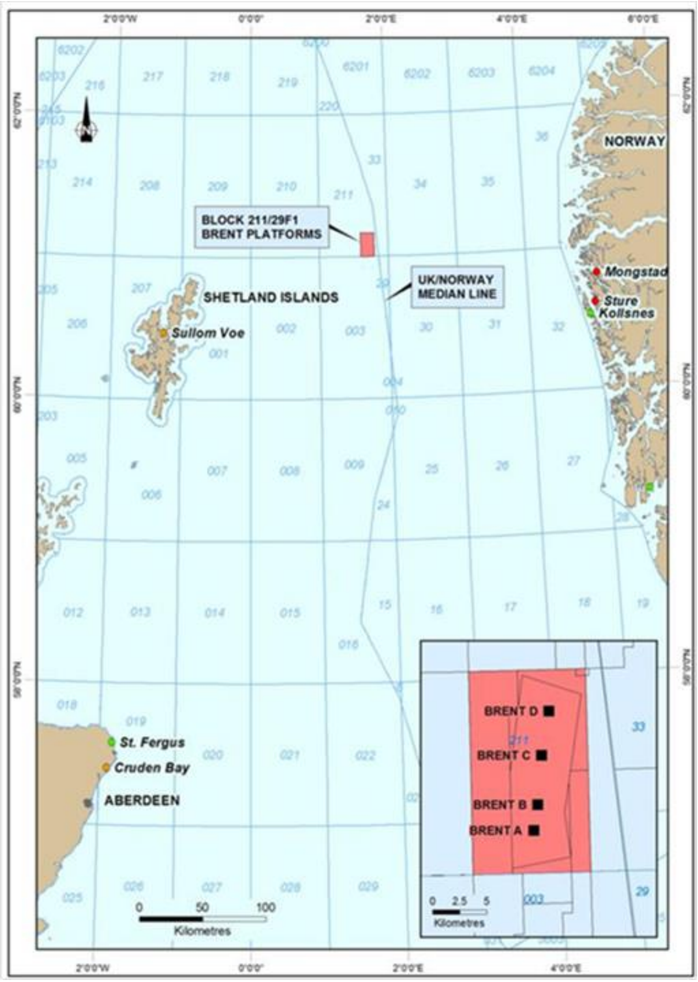
[1] In July 2016 the Department of Energy and Climate Change (DECC) was replaced by BEIS. At this time, a number of DECC regulatory responsibilities also transferred to the new Oil and Gas Authority (OGA). Any further references to DECC should be taken as BEIS.

[2] The Brent Decommissioning Programmes were prepared in accordance with the Guidance Notes available at the time,-*Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998*. Version V6, DECC, March 2011. The Guidance Notes have since been superceded by the BEIS Guidance Notes November 2018. This does not change any of the decommissioning outcomes.

Layout and Adjacent Facilities

The Brent Field is located in the East Shetland Basin in Block 211/29 (Figure 1), midway between the Shetland Islands and Norway. The nearest oil and gas installation is the Statfjord B platform operated by Statoil Petroleum (9.6 km) (Figure 3). Shipping activity is low and dominated at present by oil industry support vessels, and there are no Ministry of Defence (MOD) exercise areas near the Field. The nearest third-party, non-oil and gas submarine cable is the CANTAT 3 operated by BT located approximately 60 km away. There are no renewable energy developments or dredging or aggregate extraction operations in the area.

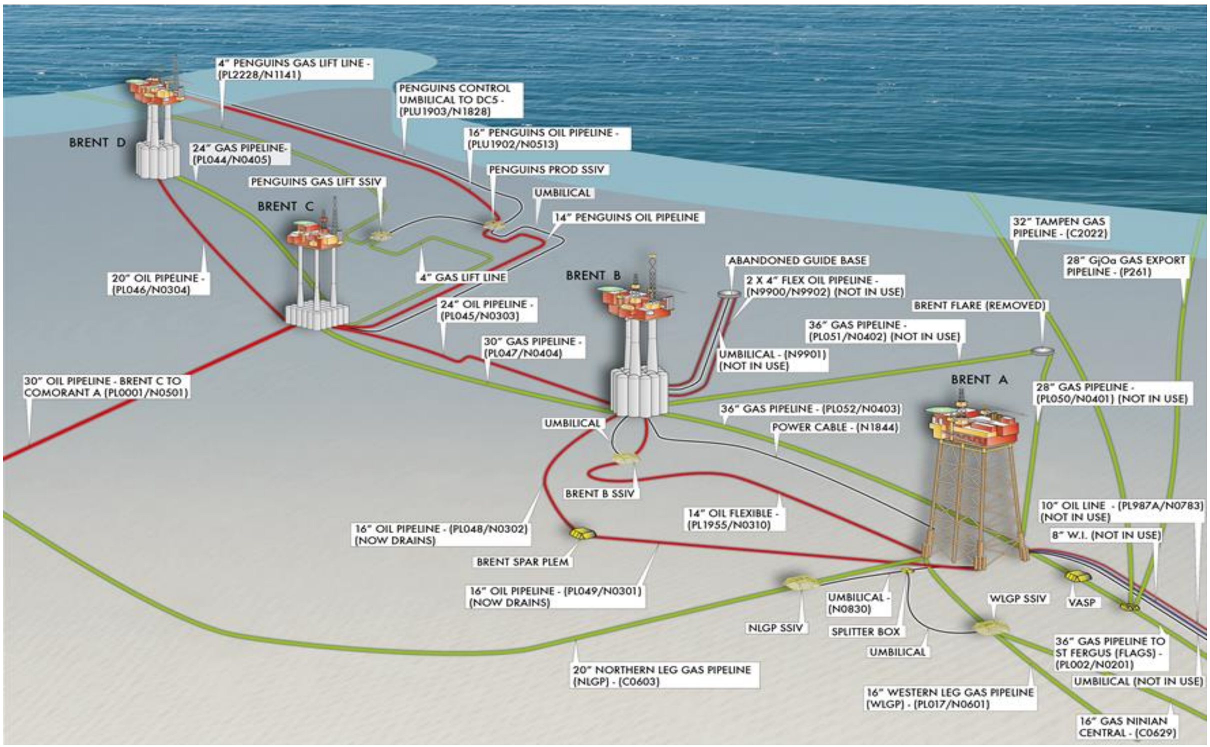
Figure 1 Location of the Brent Field



Several species of fish and shellfish are present in the area, but none is protected or of conservation importance. The Brent area is subject to commercial fishing operations, and although bottom trawling is the predominant vessel activity, the weight and value of landings from this area are dominated by mid-water (pelagic) species. Fishing intensity is low to moderate in comparison with other areas of the North Sea and is classified by Marine Scotland as being of 'low' value. The main species landed by UK vessels are mackerel, herring and haddock.

Many species of seabirds are found in the area and their abundances vary seasonally. The most frequently sighted species of marine mammal in the Field is the bottlenose dolphin. With the exception of marine mammals, there are no species or habitats in the area which have been designated for their conservation importance. The nearest Special Area of Conservation is the Braemar Pockmark, approximately 225 km from the Field.

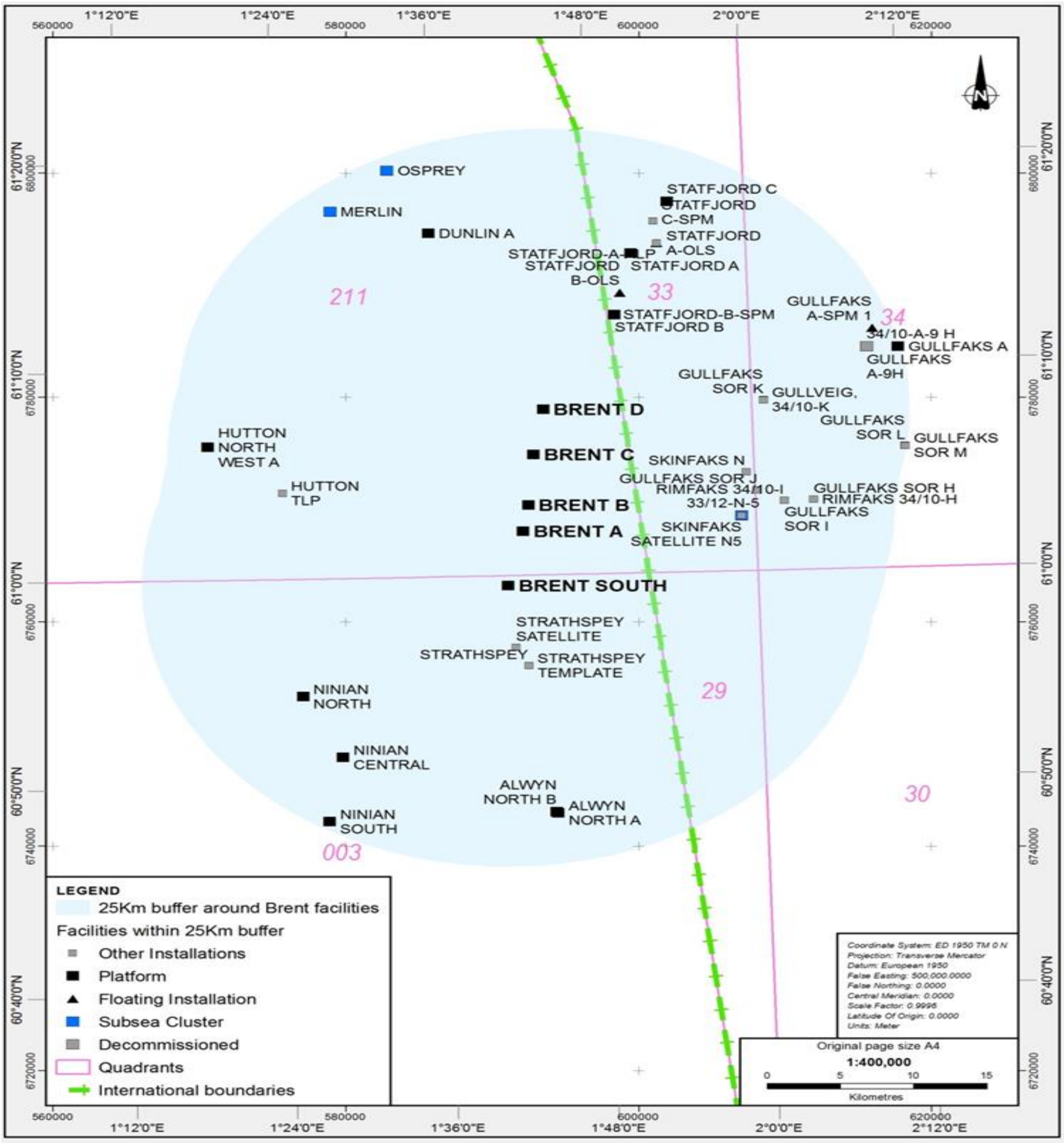
Figure 2 Layout of Facilities in the Brent Field



The Field is served by approximately 103 km of pipeline and 4 small subsea structures which are part of the pipeline system. Overall, the material covered in this Pipeline DP includes approximately 26,000 tonnes of steel, 22,000 tonnes of concrete, and 16,000 tonnes of rock-dump.

Table 1 provides an overview of the pipelines system being decommissioned.

Figure 3 Location of Adjacent Facilities



Stakeholder Engagement

Since 2007 we have been working on the long-term planning necessary to stop production and decommission the Brent Field. This has involved in-depth work with third-party experts, academics and other interested stakeholders.

Stakeholder engagement has played a significant role in the development of the Brent Decommissioning Programmes. For more than ten years we have carried out a thorough and transparent process of stakeholder engagement with interested parties. This has involved discussing and informing stakeholders of the different risks, challenges and benefits associated with decommissioning. More than 180 organisations across Europe have been engaged including non-governmental organisations such as environmental groups, government representatives and bodies, academics and professional institutes, fisheries organisations, oil and gas industry bodies, and media and community groups. Our stakeholder engagement activities have included individual visits to stakeholders, hosting larger stakeholder events (facilitated by independent third-party facilitators The Environment Council and then latterly Resources for Change), publishing an online newsletter and maintaining a dedicated Brent Decommissioning website.

These discussions have enabled stakeholders to share their views and concerns, which we have taken into account when assessing the different decommissioning options. Their expertise and input have made a valuable contribution to the project.

Public Consultation

The Brent Delta Topsides DP was approved in July 2015. A consultation draft of the *Brent Field Decommissioning Programmes* document [4] was submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) in January 2017. It described our proposals for decommissioning the remaining facilities in the Brent Field, including proposals for the decommissioning of the Brent Field pipeline systems. The Programmes were subject to a sixty day public and statutory consultation between 8 February and 10 April 2017, and OPRED carried out simultaneous consultation with other government departments.

The consultations provided the opportunity for consultees to raise comments on our pipelines proposals. In accordance with UK decommissioning procedures, OPRED has had sight of our response to the comments raised by consultees in relation to the pipelines and have informed us that they are satisfied that these have been addressed appropriately and that no further consideration of proposals for the pipelines is required. As the pipeline decommissioning proposals have no bearing on the decommissioning options for the Brent Alpha jacket or the Brent Bravo, Charlie and Delta Gravity Based Structures (GBS), OPRED has agreed that our Pipelines Decommissioning Programme can be decoupled from the original document and separately approved.

Since the public consultation of the Brent Decommissioning Programmes, a production pipeline and a control umbilical were installed to allow continued production from the Brent Charlie platform. When production ends, they will become redundant and responsibility of decommissioning them falls within the Brent Decommissioning Project (BDP). Information on the construction, installation, comparative assessment and proposed decommissioning option have been included in this document and in the updated *Brent Pipelines Technical Document* [5].

Independent Review

To inform decision-making, we completed a wide range of engineering and technical studies, using either our own expertise or external companies and consultancies. The important supporting studies associated with the decommissioning of the pipelines have been scrutinised by an independent review group (IRG).

Comparative Assessments

The BEIS Guidance Notes provide clarification on how the necessary Comparative Assessment (CA) of options for each pipeline should be carried out. For the Brent Field Decommissioning Programme covering the four Brent installations, we developed a robust CA process that met the requirements of OSPAR Decision 98/3. Since the pipeline system is part of the Brent Field, we have applied the same formal CA process to the pipelines.

Decommissioning the Brent Field – Our Recommendations

Table 1 and Table 2 present our proposed decommissioning programmes for the pipelines, subsea structures and debris in the Brent Field.

Table 1 Summary of Proposed Decommissioning Programmes of Work for Brent Field Pipeline System

Field	BRENT	Blocks	211/29, 211/28, and 211/26 UKCS	Depth	140-42 m
Owners	Shell U.K. Limited 50% Operator				
	Esso Exploration and Production UK Limited 50%				
Min. distance to UK	136 km, Shetland Islands	Min. distance to median line	11 km Norway		
ICES rectangles 45F1 and 45F2	Fishing intensity	'Low' to 'Moderate'	Fishing value	'Low' to 'Moderate'	

Line number	Diameter (inches)	Present status	Length (km)	Recommended option for whole length
PL001/N0501	30	Part trenched	35.9	Partial trench and rock-dump
PL002B/N0201	36	Surface-laid	1.25	Trench and back-fill
PL017A-D/N0601	16	Surface-laid	0.4	Remove by cut and lift
PL044/N0405	24	Surface-laid	4.2	Trench and back-fill
PL045/N0303	24	Surface-laid	4.6	Trench and back-fill
PL046/N0304	20	Surface-laid	4	Trench and back-fill
PL047/N0404	30	Surface-laid	4.4	Trench and back-fill
PL048/N0302	16	Surface-laid	2.3	Trench and back-fill
PL049/N0301	16	Surface-laid	2.8	Trench and back-fill
PL050/N0401	28	Surface-laid	3	Trench and back-fill
PL050/N0952	8	Rock-dumped	0.03	Leave in existing rock-dump
PL051/N0402	36	Surface-laid	2.6	Trench and backfill
PL051/N0402A	36	Surface-laid	0.15	Remove by cut and lift
PL052/N0403	36	Surface-laid	2.3	Trench and back-fill
PL987A/N0738	10	Trenched & rock-dumped	5	Leave in trench
PL987A/N0739	10	Trenched & rock-dumped	1.8	Leave in trench
PL987A1-3/N0841	4.5	Trenched & rock-dumped	5.3	Leave in trench
PL988A/N0913	8	Trenched & rock-dumped	5	Leave in trench
PL1955/N0310	16/19	Surface-laid	2.7	Remove by reverse reeling
PL1955/N0311	16	Surface-laid	0.27	Remove by reverse reeling
PL4493/N0610	16/24	Surface-laid	0.117	Remove by cut and lift
PLU4494/N4870	1	Surface-laid	0.06	Remove by reverse reeling
PLU4560/N2801	4	Surface-laid	0.423	Remove by reverse reeling
-PLU4561/N1844	5	Surface-laid	2.9	Remove by reverse reeling
PLU4562/N0830	4	Trenched and back-filled	0.5	Remove by reverse reeling
PL4730/N9903A	24	Surface-laid	1.7	Trench and back-fill
PL4730/N9903B	24	Surface-laid	2.9	Trench and back-fill
PL4731/N9900	4	Surface-laid	2.1	Remove by cut and lift
PL4732/N9902	4	Surface-laid	2.3	Remove by cut and lift
PLU4733/N9901	4	Surface-laid	2.2	Remove by cut and lift

Table 1, continued Summary of Proposed Decommissioning Programmes of Work for Brent Field Pipeline System

GENERIC EXPLANATION OF SELECTIONS FOR PIPELINES	
Cut and Lift	Removes the whole line. Provides a clear seabed and removes a snagging risk for fishermen.
Reverse Reeling	Removes the whole line. Provides a clear seabed and removes a snagging risk for fishermen.
Partial Trench and Rock-dump	Lowers an already partially trenched line so that adequate cover over the top of pipe (at least 0.6 m) is obtained. Rock-dump on selected sections that cannot be adequately buried provides additional cover and stability, and minimises future snagging risk.
Leave in Existing Rock-dump	Line lies under existing and stable rock-dump, in area where incidence of spanning is low.
Leave in Existing Trench	Line lies in existing trench where the trench depth is >0,6m above top of pipe.in areas where incidence of spanning is low Surface laid pipeline ends will be remediated. If necessary, the trench may be backfilled with natural sediment to prevent fishing gear from snagging on the trench itself.
Trench and backfill	End sections of the surface lengths of the pipeline e.g. tie-in spools will be removed by cut and lift to allow trenching equipment appropriate to the pipeline diameter and seabed sediment conditions to be deployed. The main length of the pipeline will be trenched and buried to a minimum depth of 0.6 m above the pipeline. Where necessary, existing rock dump may be extended over short lengths of pipeline that cannot be fully trenched and buried.
ADDITIONAL INFORMATION on PIPELINE DECOMMISSIONING	
Mattresses	All mattresses which are associated with subsea structures and pipelines that are to be removed, will be removed if safe to do so.
Grout Bags	All grout bags will be removed if safe to do so, unless needed to protect *in situ* pipelines.
Rock-dumps	Existing stable rock-dumps will be left in place and extended as necessary (where rock dump already exists).

Table 2 Proposed Decommissioning Programmes of Work for Brent Field Subsea Infrastructure and Debris

SUBSEA STUCTURESS: PLEM, SSIV, SPLITTER BOX and VASP
Selected Option: Complete removal to shore. Reason for Selection: Meets regulatory requirements. Proposed Decommissioning Solution: Subsea structures will be cut from lines, with anchoring piles (if present) cut a minimum of 3 m below the seabed. All material will be returned to shore for recycling.
SEABED DEBRIS
Selected Option: Complete removal to shore. Reason for Selection: Meets regulatory requirements. Proposed Decommissioning Solution: All seabed debris relating to oil and gas operations in the Field that is present within a 100 m wide corridor centred on each pipeline, will be removed and taken to shore for recycling. Should any item be partly buried in existing drill cuttings, it will be cut as close to the drill cuttings as possible without significantly disturbing them, and the visible portion of the item recovered.

Supporting Studies

We engaged with a wide range of engineering, safety and environmental experts to examine all the pipelines options subject to CA. Their reports are listed in this DP and in the supporting *Brent Field Pipelines Decommissioning Technical Document* (TD) [5].

Conclusion

Through this Brent Field Pipelines DP the owners seek approval to decommission the Brent Field Pipelines and four subsea structures in a phased programme of work, planned to be completed by about 2024. The final recommendations contained in this document are the result of ten years of exhaustive studies, the completion of the detailed CA process and extensive stakeholder engagements. In order to understand the environmental impact of the recommendations, an EIA has been performed by DNV GL for the owners and is presented in the *Brent Field Decommissioning Environmental Statement* (ES) [6]. The EIA shows that decommissioning operations offshore and onshore, including those for the pipelines, subsea structures and debris, can be undertaken without causing any significant environmental or societal impacts, provided the proposed mitigation and measurement measures are implemented.

On completion of all the Brent offshore decommissioning operations for the pipelines, subsea structures and debris, we propose a detailed survey of each pipeline route and former location of the subsea structures would be undertaken to assess and record either the 'as-left' condition of the pipeline or the former route of any pipeline that is removed. Once all offshore decommissioning activities within the Brent Field have been completed, we propose that two environmental surveys would be undertaken to determine if the decommissioning programme has had any measurable effect on the adjacent seabed. The scopes of these surveys will replicate the scopes performed in the 2007 and 2015 seabed environmental surveys. The first survey would be shortly after decommissioning, and the second about five years later. The timing, frequency and scope of subsequent environmental and or visual surveys will be discussed and agreed with BEIS.

In accordance with the Petroleum Act 1998, the responsibility for the subsequent management of on-going residual liabilities, including managing and reporting the results of the agreed post-decommissioning monitoring, evaluation and any remedial programme, will remain with the present owners. All the pipelines which are proposed to be left in place remain the property and responsibility of the Brent Field licensees.

PARTNER LETTER OF SUPPORT FROM
ESSO EXPLORATION AND PRODUCTION UK LIMITED

Esso Exploration and Production UK Ltd
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John Gillies
Technical Manager

ExxonMobil

Department for Business, Energy and Industrial Strategy
Offshore Decommissioning Unit
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Aberdeen
AB10 1BJ

20th February 2020

Dear Sir or Madam,

PETROLEUM ACT 1998
BRENT FIELD PIPELINES DECOMMISSIONING PROGRAMME

We acknowledge receipt of your letter dated 23rd January 2014 regarding the abandonment programme for the Brent Field Pipelines.

We, Esso Exploration and Production UK Limited, confirm that we authorise Shell U.K. Limited to submit on our behalf an abandonment programme relating to the Brent Field pipelines as directed by the Secretary of State on the above date.

We confirm that we support the proposals detailed in the Brent Field Pipelines Decommissioning Programme, which has been submitted for approval in 2020 by Shell U.K. Limited.

Yours faithfully

John Gillies

For and on behalf of Esso Exploration and Production UK Limited

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An ExxonMobil Subsidiary

2 INTRODUCTION

This document presents the Decommissioning Programme (DP) for the Brent Field pipelines (Figure 2). Shell U.K. Limited (the operator of the Brent Field) and Esso Exploration and Production UK Limited are the owners in equal shares of the Brent Field.

The Brent Field pipeline system comprises 30 pipelines[3] and 4 small subsea structures, with a total mass of about 68,000 tonnes. We started planning our complex decommissioning programmes in 2006, and as a result of this extensive period of study, evaluation and assessment there is a substantial body of work which:

- Describes the pipelines and seabed infrastructure, and their environmental settings
- Provides information on the technical and engineering aspects of a range of decommissioning options, and the ways in which those options could be undertaken; and
- Examines the advantages and disadvantages of technically feasible options.

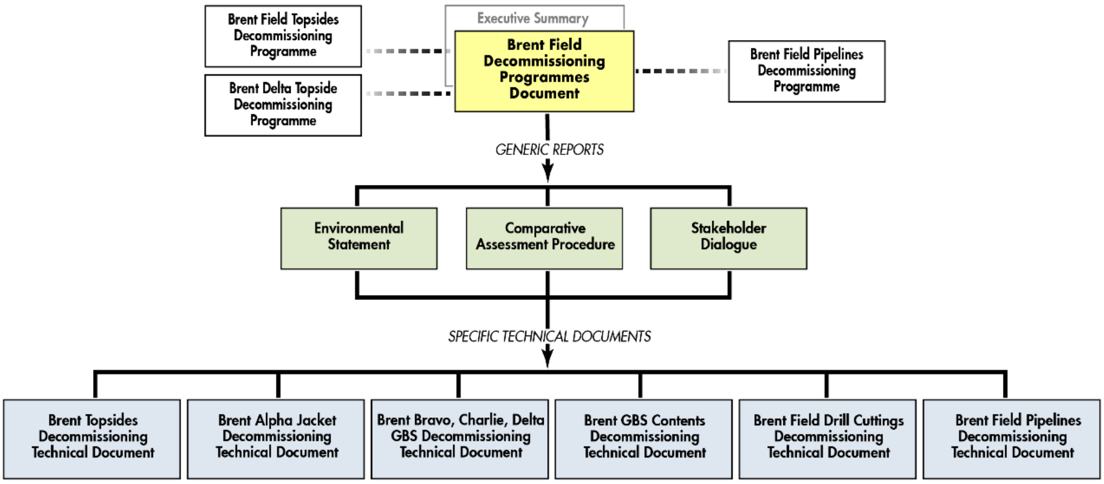
After discussion with BEIS we have chosen to present essential, detailed descriptive and factual information, and where necessary full Comparative Assessments (CA), in the Brent Field Pipelines Decommissioning TD which supports and informs this DP. This DP therefore focuses on describing:

- The process we followed to identify technically feasible options.
- The safety, technical, environmental, economic and societal implications of different options.
- The important differences between options.
- The recommended options for each of the Brent Field pipelines.
- The proposed programmes of work for decommissioning the Brent Field pipelines.
- The proposed programmes of work for decommissioning the subsea infrastructure and seabed debris.
- The continuing responsibilities that we will have for pipelines remaining in the Brent Field.
- The monitoring programme that we would undertake to assess the environmental impacts of any pipelines left in the Brent Field.

Figure 4 shows the suite of documentation for all the DPs prepared for the overall Brent project. The TDs are designed to be read after the DP document, supplementing it and providing detail to the facts, assessments and conclusions presented in the DPs. The full title of each reference is given when first cited, and thereafter by the document's number in brackets [ ] as listed in Section 17.

[3] Since the public consultation of the Brent Field Decommissioning Programmes ended in 2017, two newly installed pipelines have been added to the Brent Section 29 Notice and are now included in the Brent Decommissioning Project. Further information is presented in Section 4.3.3, Section 9.6.1 and Annex 1 of this document.

Figure 4 Brent Field Decommissioning Programmes and their Supporting Documentation.



Under the Petroleum Act 1998 [1] and the Section 29 Notices that have been served on the co-venturers, Shell and Esso have a joint and several obligation for the decommissioning of the Brent Field. Esso confirms that it fully supports and endorses the proposed programme, and that it authorises Shell to submit the DP as directed by the UK Secretary of State.

In accordance with the Notices that have been issued to the owners, and as required by the Petroleum Act 1998, the pipelines DP is presented in this document (Table 3).

Table 3 The Brent Pipelines covered in this Document.

Decommissioning Programme	Section 29 Notice Date	Facilities Covered
Brent Pipelines	24th October 2019	The Brent Field pipeline system, and associated seabed infrastructure, namely: PL001/N0501 PL002B/N0201[1] PL017A-D/N0601 PL044/N0405[2] PL045/N0303 PL046/N0304 PL047/N0404 PL048/N0302 PL049/N0301 PL050/N0401 PL050/N0952 PL051/N0402 PL051/N0402A PL052/N0403 PL987A/N0738 PL987A/N0739 PL987A.1-3/N0841 PL988A/N0913 PL1955N0310 PL1955/N0311 PL4664/N0201 PL4493/N0610 PLU4494/N4870 PLU4560/N2801 PLU4561/N1844 PLU4562/N0830 PL4730/N9903A PL4730/N9903B PL4731/N9900 PL4732/N9902 PL4733/N9901 It is noted that some of these PWA[4] numbers cover several of Shell's pipelines number prefix 'N'.
Brent Field Subsea Structures	23rd January 2014	Brent Bravo SSIV Brent Spar PLEM Brent Alpha Splitter Box Valve Assembly Spool Piece

Notes: 1. Includes the redundant section PL4664
2. Includes the cut out spool PL44A

[4] PWA, Pipeline Works Authorisation

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3 BACKGROUND INFORMATION

3.1 Introduction

The Brent Field and its pipeline system are located in Block 211/29, Block 211/28, Block 211/27, Block 211/26 and Block 3/4a of the UK sector of the North Sea, approximately 136 km northeast of the Shetland Islands (Figure 1). The Field is part of the extensive oil and gas infrastructure which has been established over the last 40 years in the East Shetland Basin; there are 11 platforms, 3 floating installations, 17 templates and 4 subsea clusters within 25 km of the Brent locations covered in this DP document (Figure 3).

3.2 Development History

Brent was discovered in 1971, and during 40 years of operations (Table 4) has produced approximately 2 billion barrels of oil and 6.0 trillion cubic feet of gas, together amounting to some 3 billion barrels of oil equivalent. At its peak in the late 1980s to early 1990s, the Brent Field alone provided approximately 8% of the UK's total gas consumption. To date, about 99.5% of the economically recoverable reserves in the Brent Field have been recovered, a historically high value for North Sea fields. The Brent Field has also created and sustained thousands of jobs, contributed more than £20 billion[5] in tax revenue, and provided the UK with a substantial amount of its oil and gas.

Table 4 History of the Development of the Brent Field.

Date	Event	Date	Event
1971	Brent Field discovered	1995	Brent Spar removed from the Field
1975	First platform, Brent B, installed	1995	Brent upgraded for major gas export
1976	Development drilling begins	1996	Brent South decommissioned
1976	First oil produced, from Brent Bravo	1998	Discharge of oil-based mud cuttings ceases
1976	Brent A and D installed	2004	Well plug and abandonment begins (at Brent South)
1978	Brent C installed	2009	Dates for Cessation of Production (CoP) agreed with DECC (now BEIS)
1978	Production from Brent A begins	2011	Brent D ceases production
1978	Pipeline to Sullom Voe installed	2014	Brent A and Brent B cease production
1981	First gas exported	2017	Brent D topside removed to shore

3.3 Environmental Setting

The Brent Field: The environmental setting of the Brent Field is summarised below. A full description of the environmental settings can be found in our Brent Field Decommissioning ES [6] which has been prepared for us by DNV GL. Table 5 summarises the physical, biological and socio-economic environments in the Brent Field.

The character of the benthos, and in particular the changes that have occurred as a result of the permitted discharge of drill cuttings and the recovery that has begun since those discharges ceased, are well documented by a series of seabed surveys, the most recent of which was in 2015. With the exception of work along the export pipeline PL001/N0501, the vast majority of offshore work in the Field will occur within the 500 m safety zones around the four installations, areas which have been covered by all the benthic surveys.

[5] In today's money

Table 5 Summary of the Physical, Biological and Socio-economic Environments in the Brent Field.

Aspect	Summary Data			
Water column	Water depth	140.2 m-142.1 m	Tidal range	1.83 m
100 year return wave	Amplitude	26.2 m	Period	15.5 seconds
Maximum current speeds	Surface	0.86 $m.s^{-1}$	Seabed	0.46 $m.s^{-1}$
Water temperature	Maximum	13°C	Minimum	6°C
Seabed sediments	Muddy sand, with holes and mounds created by burrowing fauna especially Norway lobster *Nephrops*.			
Benthos	Characterised as 'North British Coastal zone' and 'offshore Northern North Sea', dominated by polychaetes, crustaceans, bivalves and echinoderms.			
Fish	Demersal and pelagic species, predominantly cod, haddock, whiting and herring. Platform located within spawning areas for herring, whiting, lemon sole, Norway pout, sandeels, sprat and *Nephrops*.			
Shellfish	Norway lobster *Nephrops*.			
Marine mammals	Low densities of cetaceans; most commonly occurring species are harbour porpoise and white-beaked dolphin. White-sided dolphin, Risso's dolphin, bottlenose dolphin, fin whale and minke whale have also been recorded.			
Seabirds	Important area for seabirds, particularly in summer, especially guillemot, fulmar, kittiwake and razorbill. Other species include puffin, herring gull, little auk, arctic tern, gannet, great skua, arctic skua, sooty shearwater, cormorant and common tern.			
Conservation interests	Marine mammals are designated species. There are numerous colonies of coral *Lophelia pertusa* on all four platforms. The nearest offshore SAC[6] is Braemar Pockmark, 225 km away.			
Commercial fishing	The relative value of commercial fisheries in ICES[7] rectangle 51F1, in the Brent Field area, is 'Moderate' to 'Low'. Fishing effort in 51F1 is 'Low' and dominated by demersal gear types.			
Shipping	Within 50 km there are 14 recognised shipping lanes, used by 8,430 vessels each year. Shipping density in the Brent Field ranges from 'low' to 'very low'.			
Nearest oil and gas activities	Statfjord Field, 9.6 km to the northeast.			
Commercial activity	With the exception of oil and gas activity, and commercial fishing, there is no other commercial activity at the site.			
MOD activity	None			
Wrecks	Nearest marked wrecks are 9 km away from Brent Alpha and Brent Bravo.			

Transportation route to shore and onshore dismantling, treatment and disposal sites: Material that is removed from the seabed (pipelines, umbilicals, subsea structures, concrete mattresses and grout bags), will be returned to shore for reuse, recycling and/or disposal.

[6] SAC, Special Area of Conservation.

[7] ICES, International Council for the Exploration of the Sea.

4 END OF FIELD LIFE MANAGEMENT

4.1 Managing Declining Production

The Brent Field was discovered in 1971 and production started in 1976. In total, 146 wells and side-tracks have been drilled, accessing all parts of the extensive Brent reservoir.

We completed a major restructuring programme (called the Long-Term Field Development project, LTFD) in 1996 and this changed the Field from producing predominantly oil to producing predominantly gas. This boosted production and extended field life by approximately ten years. Further upgrades, reconfigurations and management of the provision and distribution of fuel gas from Brent Charlie have all contributed to maximising production and minimising costs. In recent years, Brent Alpha has produced oil and some gas, Brent Bravo and Charlie have produced mostly gas, and Brent Delta has produced mostly oil.

Up to 1991 oil was exported from Alpha and Bravo by shuttle tanker, loading oil from the Brent Spar buoy. When the Spar was decommissioned this oil was exported via the existing Brent Charlie-Cormorant Alpha oil export line (PL001/N0501), along with crude from Charlie and Delta. The three GBSs have storage cells that allowed oil production to be stored for several days, but they were also designed to help process and separate the crude oil.

We have continually evaluated the Field's performance and the state of its reservoir and producing wells, and updated our forecasts of future production and remaining reserves. The challenge faced in managing end-of-field life is to maximize production from the reservoir safely and cost-effectively. End-of-life management, and determining a date for cessation of production (CoP), need careful consideration because the Brent Field is a complex set of facilities and processes.

4.2 Timing of Cessation of Production

Plateau production levels were achieved in 1985 for oil and in 2002 for gas, and since these dates production of both oil and gas have declined significantly. Despite detailed investigations since 2006, no viable or economically sustainable programmes or measures can be put in place to extend production.

In 2006 we initiated detailed discussions with DECC (now BEIS) about possible dates for CoP which examined fiscal, economic, technical and safety implications both for ourselves as owners and the UK Government. As these progressed it became clear that, despite earlier hopes that it would be economically viable to continue production on some platforms and thus carry out a phased cessation of production, all four platforms were rapidly coming to the end of production.

Three of the four Brent platforms have now ceased production (Table 6) and we have reached agreement with DECC (now BEIS) that Brent Charlie will cease production in the near future.

Table 6 CoP Dates for Three Brent Platforms.

Platform	Date of CoP
Alpha	1st November 2014
Bravo	1st November 2014
Delta	31st December 2011

4.3 Reconfiguration of the Gas Export Pipelines

4.3.1 Introduction

This section summarises three other programmes of work – the Brent Bypass Project, the Brent Charlie Gas Export Project, and the Penguins Redevelopment Project - that are not part of the BDP but which will affect the general configuration of the pipelines in the wider Brent area and will have a bearing on the detailed programme of work that is carried out on the pipelines covered in this DP.

The Brent Alpha and Brent Charlie platforms are key installations for the export of hydrocarbon gas to the FLAGS pipeline to St. Fergus. In order to decommission the Brent Alpha platform, a project called Brent Bypass (BBY) was completed to disconnect the Alpha platform from the gas transmission network. As Brent Charlie is the only Brent platform still in operation and receives production from the Penguins Field, a second project, the Brent Gas Export Project, was completed to continue to transport the Brent Charlie and Penguins gas to the FLAGS pipeline. Finally, the Penguins Field will continue to produce after the Brent Charlie Platform reaches CoP and preparation was required to allow the future transmission of the Penguins gas to FLAGS, without the use of the Brent Charlie platform. A summary of the work that has been completed to achieve the transmission of gas to FLAGS and the effect on the Brent pipelines is given below. A full description of these two projects and the changes that have been made to the pipelines in the Brent Field, is presented in the Pipelines TD [5].

During both the BBY and GEP projects, some of the mattresses and grout bags that were deployed to the seabed were never used to protect or support the pipelines. The BDP will recover these items as part of the debris clearance work. However, as BBY and GEP were executed after the public consultation version of the DP, the estimated mass of these items are not included in the material inventories presented in this document or the Environmental Statement.

4.3.2 The Brent Bypass Project

The BBY was executed in two phases. In Phase 1, the Northern Leg Gas Pipeline (NLGP), from the Magnus platform) and WLGP (from the Ninian Central and Cormorant Alpha platforms) gas flows were disconnected from the Brent Alpha platform. Historically, NLGP gas had been transported from the Magnus platform via pipeline PL164/C0603 and the Magnus SSIV to the Brent Alpha platform. WLGP gas was transported from the contributing gas fields (e.g. Ninian Central, Cormorant Alpha) and co-mingled at the WLGP SSIV before arriving at the Brent Alpha platform via PL017A-D/N0601. The gas from NLGP and WLGP was then comingled at the Brent Alpha platform with the produced gas from the Brent platforms and transported into the FLAGS pipeline via PL002/N0201 and the VASP structure located to the south of the Brent Alpha platform.

Gas from the WLGP contributing fields still comingle at the WLGP SSIV but the section of PL17/N0601 between the WLGP SSIV and the Brent Alpha platform has been disconnected. Instead, the gas from the NLGP and WLGP are now commingled at a new subsea Northern Leg-Western Leg (NL- WL) PLEM structure installed on the seabed to the west of the Brent Alpha platform, within the platform 500 m safety zone. A new 1.6 km pipeline (PL4103/N0611) has been installed to transport gas from the NL-WL PLEM into a new subsea Tee Connection Structure (TCS). From there, via PL4103/N0615, the gas is transported through existing infrastructure into the FLAGS pipeline (PL002/N0201) via the Knarr Tee and FLAGS Hot Tap Tee (HTT), located to the south of the existing VASP structure. The new NL- WL PLEM and TCS subsea structures, and PL4103/N0611 and PL4103/N0615 were successfully installed in 2017.

In Phase 2, which was completed in February 2019, a new FLAGS PLEM, together with a section of pipeline connecting it to the existing FLAGS HTT, was installed to replace the existing VASP allowing the FLAGS pipeline to be disconnected from the Brent Alpha platform and the existing VASP. The FLAGS PLEM will allow future pigging of the main length of PL002/N0201 between the FLAGS PLEM and St. Fergus.. Gas from the NL-WL PLEM continues to flow via the TCS and Knarr Tee and on to the main FLAGS pipeline to shore.

4.3.3 The Brent Charlie Gas Export Project

With the disconnection of Brent Alpha from the FLAGS pipeline, a new export route for the gas from Brent Charlie and the Penguins Field was required. This was the purpose of the Brent Charlie Gas Export Project (GEP), which was completed in 2018.

At Brent Charlie, a new Brent Charlie Gas Export SSIV was installed within the Brent Charlie 500 m safety zone. The current Brent Charlie to Brent Delta 24 inch gas export riser (PL044/N0405) was re-purposed and renumbered (by means of a PWA application) and now forms part of pipeline PL4493/N0610[8] which connects the Brent Charlie platform to the Gas Export SSIV. In order to connect the new section of pipeline PL4493/N0610 with the re-purposed riser, the original tie-in spool was disconnected and renumbered as PL044A and is wet-stored on the seabed. This spool (PL044A) and the main length of PL044/N0405 will be decommissioned by the BDP.

At Brent Charlie, the control lines for the Brent Charlie Gas Export SSIV from the Penguins Production SSIV (PLU4494/N4870[7]) cross the Penguins lines PLU1903/N1845, close to the existing Penguin Gas SSIV. The new pipeline (PL4493/N0610) between the Brent Charlie platform and the Brent Charlie Gas Export SSIV crosses the Penguins 4 inch gas flexible riser PL2228/N1141, the 14 inch oil flexible riser section of the 16 inch PL1902/N0513 and the control umbilical PLU1903/N1845, serving the existing Penguins Gas SSIV. The responsibility for the decommissioning of the Penguins lines remains with Shell.

The Brent Charlie Gas Export SSIV is connected to the NL-WL PLEM (installed during BBY Phase 1) via the new 7 km GEP pipeline PL4492/N0610. From the NL-WL PLEM, the gas is transported into the FLAGS pipeline. PL4492/N0610 crosses five pipelines which are within scope of the BDP: at the Brent Charlie end, PL4492/N0610 crosses over the Brent Bravo to Brent Charlie gas and oil export lines PL047/N0404 and PL045/N0303; as the new pipeline passes the Brent Bravo and Brent Alpha platforms, it crosses the Brent Bravo to Brent Spar PLEM pipeline PL048/N0302 and the Brent Alpha to Brent Spar PLEM pipeline PL049/N0301 and it also crosses the Brent Alpha to WLGP SSIV control umbilical PLU4562/N0830. At the Brent Alpha end of the pipeline, PL4492/N0610 also crosses three lines owned by BP (PL164/C0603, C0801, C0815) but these are outwith the scope of the BDP.

The whole length of pipeline PL4492/N0610 was rock-dumped for fishing protection, with some mattresses installed at the Brent Alpha end for further protection. Consequently, it will not be possible for the BDP to trench and bury the full length of PL047/N0404, PL045/N0303, PL048/N0302 and PL049/N0301. Responsibility for the ultimate decommissioning of the sections underneath the rock-dumped crossings will be handed over to the Penguins decommissioning team.

Due to the proximity of live lines associated with Penguins export in the congested area close to the Brent Charlie platform, the removal of sections of PL045/N0303 and PL047/N0404 on the platform side of the GEP crossings that are outwith rock cover and not covered by the drill cuttings at Brent Charlie will be executed by the future Penguins decommissioning project team.

Because the umbilical PLU4562/N0830 was out of use before PL4492/N0610 was installed, the new pipeline was laid directly over the umbilical, without a crossing. The crossing over PLU4562/N0830 was placed over a trenched section of this umbilical; it should therefore remain possible to completely remove this umbilical from its trench using reverse reeling.

[8] The two newly laid pipelines from the Brent Charlie platform to the GEP SSIV – PL4493/N0610 and PLU4494/N4870 - became part of the BDP after the public consultation of the Brent Field Decommissioning Programmes had ended in 2017. We have subsequently performed CAs of these two lines and the results are summarised in Section 9.6.1; the full CAs are presented in [5] and in Annex 1 of this document.

4.3.4 The Penguins Redevelopment Project

Production from the Penguins Field is currently tied-back to the Brent Charlie platform; however, the lifetime of the current and planned Penguins production facilities are expected to exceed the Brent Charlie production lifetime. In January 2018, Shell announced a final investment decision on the redevelopment of the Penguins Field; the Penguins Redevelopment Project plans to install new infrastructure to allow production from the Penguins Field to be disconnected from the Brent Charlie platform and instead occur via a new Floating, Production, Storage and Offloading (FPSO) vessel. The existing 16 inch oil production pipeline PL1902/N0513 from Penguins will be disconnected from the existing Penguin Production SSIV and re-purposed to transport Penguin gas to the Brent Charlie Gas Export SSIV, installed during the Brent Charlie GEP), and on through the 7 km pipeline PL4492/N0610 to the FLAGS pipeline (PL002/N0201). In this way, the Penguins Redevelopment Project will successfully disconnect the Brent Charlie platform from the export operations, allowing the platform to be decommissioned. When the new pipelines and infrastructure are installed as proposed, three pipelines which currently connect the Penguin Production and Gas Lift SSIVs to the Brent Charlie platform will become redundant (the umbilical PLU2232/N1845, the 14 inch oil production flexible riser PL1902/N0513 and the 4 inch gas lift flexible riser PL2228/N1141). The Penguins Redevelopment team will flush and clean these lines ready for future decommissioning by Shell.

At this time, the recently-installed pipelines PL4493/N0610 (including the repurposed riser section of PL044/N0405) between Brent Charlie and the Gas Export SSIV and the control umbilical between the Gas Export SSIV and the Penguins production SSIV (PLU4494/N4870) will become redundant.

5 FACILITIES TO BE DECOMMISSIONED

5.1 Overview

The Brent platforms are connected to each other and to other platforms by approximately 103 km of subsea pipelines, umbilicals and power cables that fall within the scope of this Brent Field Pipelines DP. These lines range in diameter from 2.5 inches (control umbilical) to 36 inches (gas export pipeline). The lines are a mixture of surface-laid and trenched with sections of rock-dump and mattress protection and have areas where natural burial has occurred.

Four small subsea structures are included in this DP; the Brent Bravo Sub-Sea Isolation Valve (SSIV), the Brent Spar PipeLine End Manifold (PLEM), the Valve Assembly Spool-Piece (VASP) and the Brent Alpha umbilical splitter box.

With the exception of one pipeline, all of the pipelines and seabed infrastructure covered in this Pipelines DP lie in the Brent Field within approximately 6 km of one of the Brent installations. The exception is the 36 km long oil export line that runs from Brent Charlie to Cormorant Alpha.

Overall, the materials covered in this Brent Field Pipelines DP document comprise approximately 26,000 tonnes of steel, 24,000 tonnes of concrete, and 16,000 tonnes of rock-dump. Table 7 summarises our best estimates of the material in the DP.

Table 7 Summary of Brent Field Pipeline System and Subsea Structures.

- 30 lines, approximately 103 km; approximately 25,129 tonnes of steel, 21,896 tonnes of concrete and 16,000 tonnes of rock-dump
- 4 subsea structures, approximately 617 tonnes of steel and grout
- Concrete mattresses, approximately 491 mattresses, approximately 1,762 tonnes
- Grout bags, approximately 4,156 grout bags, approximately 104 tonnes
- Associated seabed debris, approximately 630 tonnes

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6 METHOD USED TO ASSESS ENVIRONMENTAL IMPACTS

6.1 Introduction

DNV GL completed a comprehensive Environmental Impact Assessment (EIA) for the Brent Decommissioning Project and this included assessments of the potential impacts of technically-feasible options and the proposed programme of work to decommission the Brent pipelines, subsea structures and debris. DNV GL reported the results of the EIA in the *Brent Field Decommissioning Environmental Statement* (ES) [6], prepared on behalf of and as endorsed by Shell U.K. Limited and Esso Exploration and Production UK Limited, the Brent Field owners. The environmental impact assessment was completed in accordance with the requirements of the BEIS Guidance Notes [3] and the UK *Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) (Amendment) Regulations* [13].

The EIA conducted by DNV GL is primarily based upon the 2007 pre-decommissioning seabed surveys by Gardline. During the preparation of the ES and the completion of our CAs, a further pre-decommissioning survey was completed in 2015 by Fugro EMU and is presented in a series of *Pre-Decommissioning Environmental Survey Data Reports* [14], [15], [16], [17], [18], [19] and a *Brent Field Temporal Report Block 211/29* [20] which examines changes in the extent of perturbation and effects on the benthos over time across the whole Field. The 2015 survey endeavoured to re-sample all the grab sample and reference stations from the 2007 surveys although this was not always possible. The 2015 survey also sampled new areas of the seabed to fill in identified data gaps and sampled new reference stations for the Field.

The results from the 2015 seabed environmental survey were not available in time for the completion of our CAs. Since the submission of the consultation draft of the Brent Field DP document, however, DNV GL have reviewed the results of this survey and presented the following statement:

> "DNV GL believe that the 2015 Brent Field survey data indicates that the Brent Field is, in general, recovering over time (which is to be expected given biodegradation processes and bioturbation). As such, DNV GL consider that the environmental impact assessment (and thus the CA scores), which are based on the 2007 Brent Field survey data, do not require amendment or updating to reflect the 2015 Brent field survey data."

Information on the spatial and temporal changes and trends in the physical, chemical and biological characteristics of the seabed adjacent to each of the five Brent sites is presented in more detail in the ES [6].

This section presents a summary of the methods that were used to assess and compare the potential impacts of short-listed options, and the way they presented their results.

6.2 Summary of Method Used to Assess Environmental Impacts

To complete the EIA and prepare the ES, DNV GL:

1. Described the possible programmes of work that would be undertaken to complete each of the short-listed options. This was done with reference to reports, studies and data supplied by the BDP and through numerous interviews and meetings with each of the lead engineers on the BDP.
2. Described the environmental settings, at all the locations and sites offshore, nearshore and onshore, where project-related activities or operations may be carried out. This was done with reference to site-specific offshore surveys gathered by the BDP, project-specific baseline descriptions provided in other studies, and published data.
3. Identified the types, number and possible severity of all potential impacts from the BDP in these settings. This was done by means of a scoping report that was undertaken following the international guidance given in the EU document *'European Commission (EC) Guidance in EIA Scoping'* [21] and the EU *'Guidance Checklist of Criteria for Evaluating the Significance of Environmental Effects'* [22]. The *'Brent Decommissioning Environmental Assessment Scoping Report'* prepared by DNV [23] was published in June 2011, and stakeholders were invited to comment on its findings.
4. Calculated the total energy use and the total gaseous emissions of the proposed programmes of work. To prepare these estimates DNV GL used the widely-accepted method, reference data and factors in the Institute of Petroleum's (IoP) '*Guidelines for the calculation of estimates of energy use and gaseous emissions in the removal and disposal of offshore structures'* [24].
5. Identified those potential impacts that were considered significant, and assessed their effects in greater detail. This was achieved by scrutinising the results of the scoping report, and the comments and concerns expressed by stakeholders either in our programme of stakeholder engagement or as a result of the scoping report. Particularly significant or important issues were examined in greater depth by the BDP, often by means of specialist third-party studies, reports or modelling.
6. Assessed the potential cumulative effects of decommissioning the Brent pipelines, subsea structures and debris and of executing the Brent Decommissioning Project as a whole. This was done by examining the phasing of the offshore and onshore work, the numbers and magnitudes of impacts, and the ways in which these impacts might overlap or interact spatially and temporally. Specialist studies and modelling by third-party experts were again used as necessary.

6.3 Assessment of Impacts and Presentation of Results

Following the EU guidance [22], potential impacts were assessed in terms of 12 criteria (Table 8).

Table 8 Criteria Selected to Examine Potential Environmental Effects.

Onshore Impacts: Effects of operations on local nearshore and onshore communities	Accidents: Effects of possible accidental events on the marine environment
Resource Use: Effects of the use of resources, such as fuel and raw materials	Employment: Assessment of possible employment effects from the option
Hazardous Substances: Effects of the presence, handling, treatment of hazardous substances	Legacy: Long-term physical and chemical impacts from both operations and end-points
Waste: Effects of the handling and treatment of other wastes	Fisheries: The effects of offshore *operations* on fisheries. Long-term effects assessed in *legacy*
Physical: Physical effects of offshore operations on the marine environment	Shipping: Effects of *operations* on navigation; long-term effects assessed in *legacy*
Marine: Ecological effects of operations on the marine environment, including underwater noise	Energy and Emissions: Estimate of energy use and gaseous emissions from the complete option.

(Derived from [21])

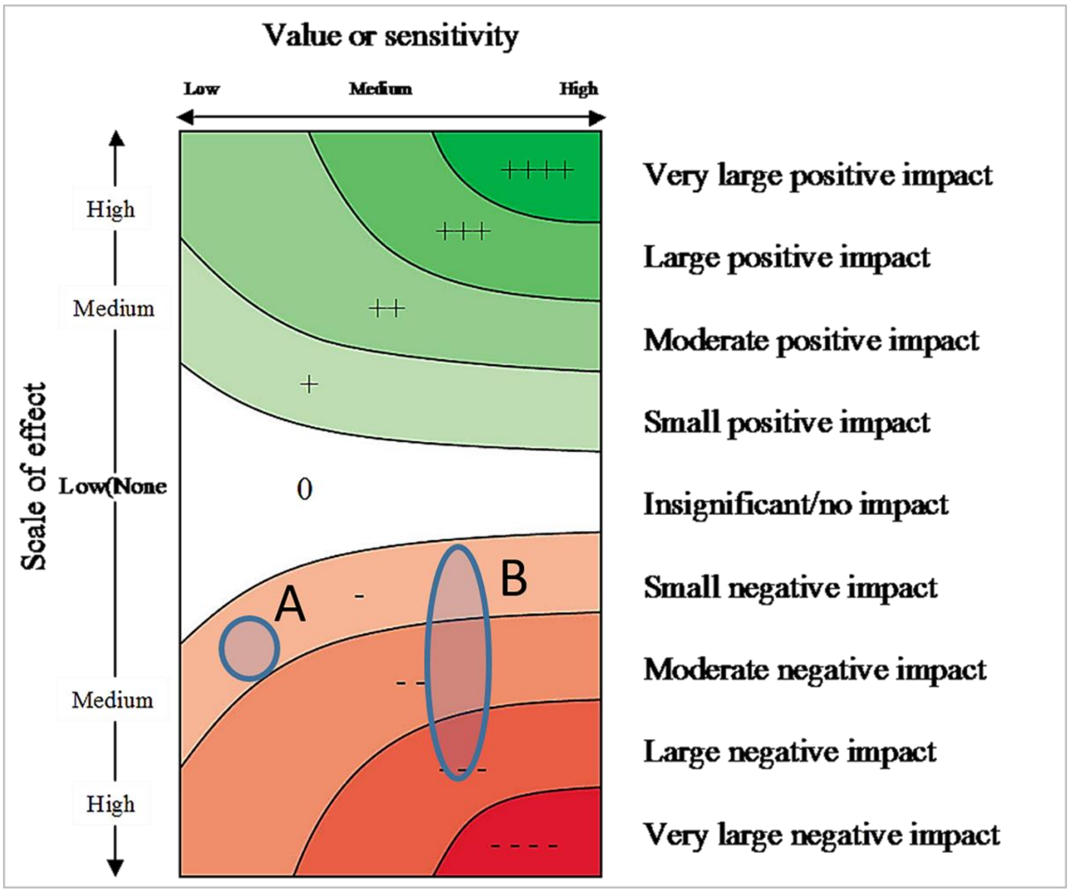
For each potential impact, DNV GL assessed the likely scale of effect, taking into consideration standard mitigation measures commonly applied by the offshore industry

The likely overall **severity** of the effect was determined by considering the **sensitivity** of the receptor or the environment and the **scale or magnitude** of the potential impact. For every facility, the severity of the overall effect of the option on each receptor is shown on a single diagram, as shown in Figure 5.

In these diagrams, the four curved bands shaded green indicate positive impacts of increasing effect, and the four curved bands shaded red indicate negative impacts of increasing effect. The white zone indicates where the combination of sensitivity and severity would result in no impact or an insignificant impact. The labels on the right of the diagram indicate the severities of each band. The position of the circular or elliptical area within a band or straddling a band indicates the degree of certainty or uncertainty in the assessment. For example, Point A has a small negative impact and a relatively small degree of uncertainty, as indicated by the small circle. The value or sensitivity (horizontal axis) is well defined, and the assessment of effect (vertical axis) has been determined with confidence. By contrast, Point B represents a relatively larger degree of uncertainty, because although the value or sensitivity is well defined, there is a high uncertainty about the scale of effect, and this translates into an impact ranging from 'small negative' to 'large negative'. DNV GL noted that detailed planning of activities, substantial knowledge, and robust methodologies and procedures can contribute to a reduction in the uncertainty of the assessment.

As a result of applying this methodology, the same scale of effect may give a different impact depending on the value or sensitivity of the receptor or environment. DNV GL note that a 'moderate negative' or 'large negative' impact does not necessarily mean that the impact is unacceptable, but that further consideration should be given to it.

Figure 5 An Example of the Diagrams Used to Portray the Severity of an Impact.



6.4 Estimation of Energy Use and Emissions

Decommissioning options will use energy and emit gases as a result of several different types of activity, including the use of vessels offshore, the transportation of material at sea, and the dismantling, treatment, recycling or disposal of material onshore.

All these activities are 'direct' sources of energy use. To properly account for any energy 'savings' that may be made when material is removed and taken to shore for recycling, options in which no such removal is undertaken must be 'debited' with the energy and emissions that would be associated with the new manufacture of replacement materials [24].

The total net energy use and the total masses of gaseous emissions for the options for the Brent pipelines, subsea structures and debris were estimated by following the IoP guidelines [24]. DNV GL took the IoP factors for the amounts of energy used and gases emitted during the combustion of different fuels and during the recycling or new manufacture of different types of materials, and applied these to our estimates of the durations of operations, the sizes of the vessel spreads for each option, and inventories of the masses of materials in structures and of the material that would be removed or left in the sea under different options.

7 STAKEHOLDER ENGAGEMENT

7.1 Introduction

Throughout the development of the Brent Decommissioning Programmes we have carried out a programme of engagement with both formal and informal consultees and stakeholders. This included the statutory consultees: The National Federation of Fishermen's Organisations, The Scottish Fishermen's Federation, the Northern Ireland Fish Producers Organisation Ltd and Global Marine Systems Limited.

The issues raised by our stakeholders, and the views and concerns they expressed throughout the programme of stakeholder engagement, have informed the way in which we have carried out our CAs and framed our recommended decommissioning options.

A full description of our overall Brent project stakeholder engagement programme including our stakeholders, and the concerns and issues they raised is given in our *Brent Decommissioning Stakeholder Engagement Report* [25].

7.2 Consultation with Statutory Consultees and Public Notification

In accordance with the BEIS Guidance Notes, we undertook a programme of formal statutory consultation on the Consultation draft of the overall Brent Field DP document and its supporting documentation from February to April 2017. This document described our proposals for decommissioning all of the facilities in the Brent Field, including proposals for the decommissioning of the Brent Field pipelines.

Public notifications were published in local and national newspapers to provide the opportunity for representations to be made regarding the programmes. The Consultation Draft Field DP Document and its supporting documentation, including the ES, were available for a period of 60 days through the Brent Decommissioning website www.shell.co.uk/brentdecomm. All the referenced supporting material (technical studies and reports) were also available upon request. The Consultation Draft DP Document and the ES were available on the BEIS website (https://www.gov.uk/guidance/oil-and-gas-decommissioning-of-offshore-installations-and-pipelines).

7.3 Comments from Public Consultation

The Consultation Draft DP was submitted for Public Consultation on 7th February 2017, and the Consultation closed on 10th April 2017. We received a number of comments during this 60-day period of public consultation concerning pipelines, subsea structures and debris from the following organisations:

- Scottish Fishermens' Federation
- World Wildlife Fund UK, on behalf of itself and seven other organisations..

Where comments were made regarding specific facilities, they are presented along with our responses in the relevant sub-section within this DP under the heading 'Issues and Concerns Raised by Stakeholders', 'Questions raised by stakeholders during Public Consultation' or 'Questions on the Proposed Programme of Work raised by stakeholders during Public Consultation'.

We considered these comments, and where appropriate corrected or updated this DP.

We did not receive any comments from three of the four statutory consultees, namely the National Federation of Fishermen's Organisations, Northern Ireland Fish Producers' Organisation and Global Marine Systems Limited. A full copy of the comments from the Scottish Fishermens' Federation, and our response, is presented in the Stakeholder Engagement Report [25] alongside all the comments and questions received on this DP during Consultation and our responses.

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8 DECOMMISSIONING OPTIONS AND THE COMPARATIVE ASSESSMENT PROCESS

8.1 Regulatory Framework

8.1.1 Introduction

This Section summarises the regulatory framework that governs the decommissioning of offshore infrastructure on the UKCS.

The decommissioning of oil and gas facilities on the UKCS is regulated by the Petroleum Act 1998, as amended by the Energy Acts. We have performed CAs for the pipelines as required by the BEIS Guidance Notes. For some of the pipelines, we have used the same quantitative Comparative Assessment procedure that we established for the Brent installations (see Section 8.2.2).

8.1.2 Decommissioning Options

Decommissioning options comprise logical combinations of:

- The 'operations' that may be carried out offshore and onshore to decommission, dismantle, remove, recycle or treat components and materials from offshore facilities.
- The legacies or consequences that may be achieved by the successful completion of operations.

This distinction between operations and legacies is useful when considering the relative advantages and disadvantages of options. It reflects the fact that operational effects may be more or less immediate, local and possibly short-lived, whereas end-point effects may be slow-acting and diffuse.

Table 11 lists the pipelines subjected to CA, and the technically feasible options that were assessed. All the options are summarised in Section 9, and the detailed CAs for each of these facilities are presented in the Brent Field Pipelines Decommissioning TD [5].

8.2 Brent Decommissioning Comparative Assessment Process

8.2.1 Introduction

For each of the pipelines, we completed CAs in accordance with the requirements of the BEIS Guidance Notes [3].

This section:

- Describes the categorisation of the pipelines into 'Qualitative' and 'Quantitative' pipelines and the reasons for doing this
- Describes the method used to complete the Qualitative Comparative Assessment process
- Summarises the method that we used to complete the later, "numerical" stage of the Quantitative Comparative Assessment process

The results of the Comparative Assessments are presented in Section 9.6.1 to Section 9.6.6 which:

- Describe the important aspects of the options for each pipeline
- Identify the recommended option for each pipeline, and the reasons for that recommendation

A comprehensive description of the numerical stage of our CA procedure, with some discussion of sensitivity to changes in weightings, is presented in our document *Brent Field Decommissioning Comparative Assessment Procedure* [7].

8.2.2 Categorisation of the Pipelines

The BEIS Guidance Notes provide generic advice on the types of pipelines that would normally be expected to be removed, such as small diameter pipelines and flexible pipelines and umbilicals that have been neither trenched nor buried. A comparative assessment of the options for such pipelines is required but it may not have to be as complex as that for larger lines because there may be fewer viable options, or because the advantages and disadvantages of each option are very obvious and clear.

From the narrative of the BEIS Guidance Notes we therefore created a decision tree (Figure 6) which identified the types of pipeline for which there is an *a priori* presumption that they can either be left in place, or must be completely removed. The decision tree included an outcome in which no option could be recommended, and where, consequently, a quantitative comparative assessment would have to be carried out.

When we reviewed the thirty Brent pipelines using this decision tree, we concluded that for sixteen of the lines the recommended or preferred options were clearly indicated by the BEIS Guidance Notes. These pipelines had fewer, simpler options for decommissioning and we compared their options by a qualitative or narrative-based assessment. These pipelines are called ‘Qualitative Lines’ (Table 9).

For the remaining fourteen lines, this initial screening using the decision tree indicated that a more detailed comparative assessment was required. The technically feasible options were often numerous, varied and complex, and no clear preferred option was immediately apparent. We therefore compared the options for these pipelines using largely numerical data, and these pipelines are called ‘Quantitative Lines’ (Table 10).

Figure 6 Decision Tree for the Division of the Pipelines Subject to Qualitative and Quantitative Assessment.

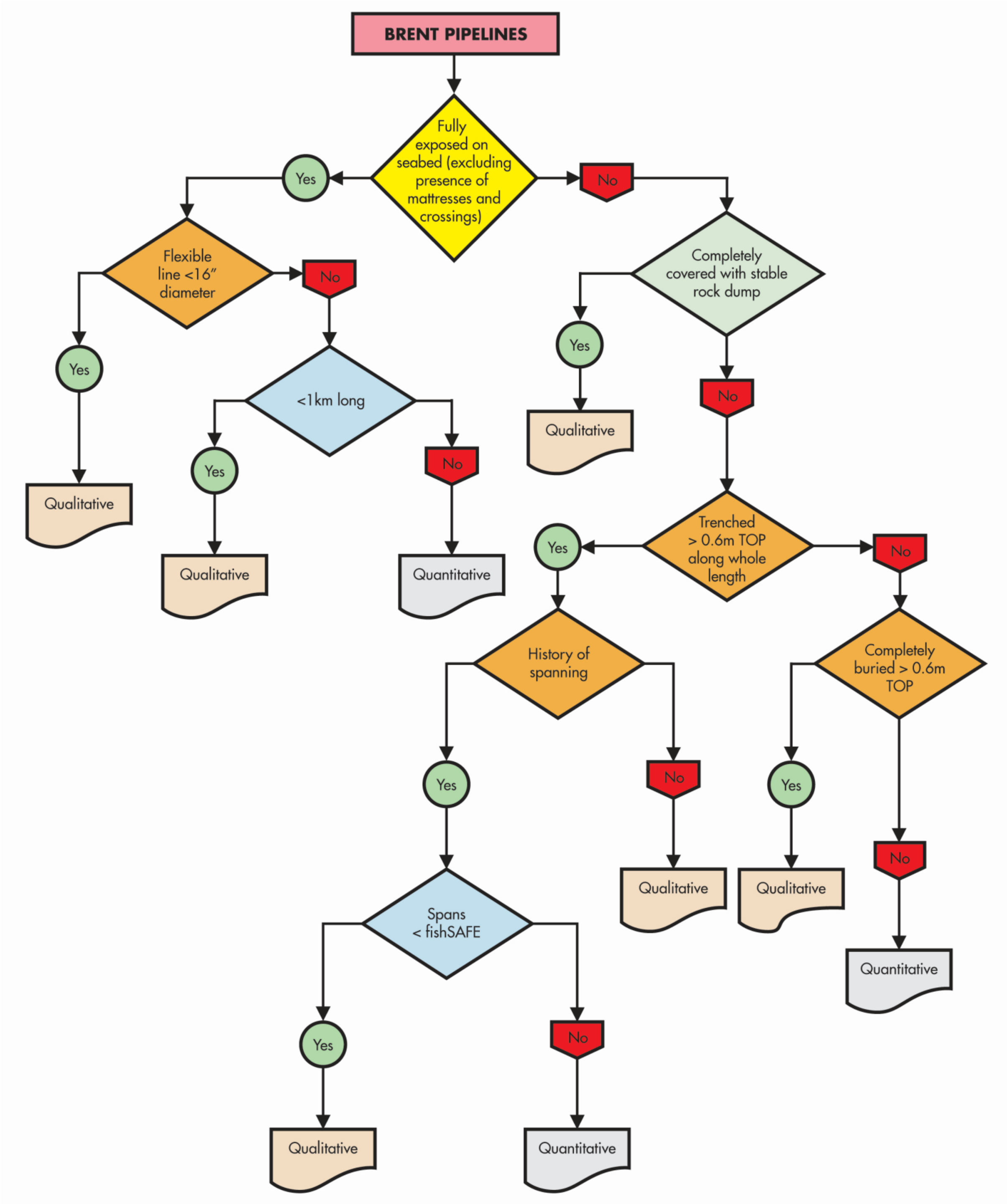


Table 9 The Qualitative Brent Pipelines.

	Pipeline Number	Pipeline Type	From	To	Diameter (")	Length (km)	Status
Qualitative Pipelines	PL050/N0952	Flexible	Brent Flare system	Brent Flare system	8	0.03	Rock-dumped
	PL051/N0402a	Rigid	Brent Bravo	Brent Flare system	36	0.147	Surface
	PL987A/N0738	Rigid	Brent South	Brent Alpha	10	5	Trenched
	PL987A/N0739	Rigid	Brent South	Statfjord DC	10	1.8	Trenched
	PL987A.1-3/N0841	Umbilical	Brent Alpha	Brent South	4.5	5.3	Trenched
	PL988A/N0913	Rigid	Brent Alpha	Brent South	8	5	Trenched
	PL1955/N0310[1]	Flexible	Brent Alpha topsides	Brent Alpha seabed	16	0.36	Riser
			Brent Alpha	Brent Bravo SSIV	19	2.3	Surface
	PL1955/N0311	Flexible	Brent Bravo SSIV	Brent Bravo	16	0.27	Surface
	PL4493/N0610	Rigid	Brent Charlie	GEP Export SSIV	16/24	0.117	Surface
	PLU4494/N4870	Umbilical	Penguins Production SSIV	GEP Export SSIV	1	0.06	Surface
	PLU4560/N2801	Umbilical	Brent Bravo	Brent Bravo SSIV	4	0.423	Surface
	PLU4561/N1844	Power cable	Brent Bravo	Brent Alpha	5	2.9	Surface
	PLU4562/N0830	Umbilical	Brent Alpha	WLGP SSIV	4	0.5	Surface
	PL4731/N9900	Flexible	Well 211/29-7	Brent Bravo	4	2.1	Surface
	PL4732/N9902	Flexible	Well 211/29-7	Brent Bravo	4	2.3	Surface
	PLU4733/N9901	Umbilical	Brent Bravo	Well 211/29-7	4	2.2	Surface

Notes: 1. Although the external diameter of this pipeline is greater than 16 inches, the protective coating is also flexible and thus the pipeline has been considered as a Qualitative pipeline.

Table 10 The Quantitative Brent Pipelines.

	Pipeline Number	Pipeline Type	From	To	Diameter (")	Length (km)	Status
Quantitative Pipelines	PL001/N0501	Rigid	Brent Charlie	Cormorant Alpha	30	35.9	Partially trenched
	PL002B/N0201	Rigid	Brent Alpha	VASP	36	1.25	Surface
	PL017A-D/N0601	Rigid	WLGP SSIV	Brent Alpha	16	0.4	Surface
	PL044/N0405	Rigid	Brent Delta	Brent Charlie	24	4.2	Surface
	PL045/N0303	Rigid	Brent Bravo	Brent Charlie	24	4.6	Surface
	PL046/N0304	Rigid	Brent Delta	Brent Charlie	20	4	Surface
	PL047/N0404	Rigid	Brent Charlie	Brent Bravo	30	4.4	Surface
	PL048/N0302	Rigid	Brent Bravo	Brent Spar PLEM	16	2.3	Surface
	PL049/N0301	Rigid	Brent Alpha	Brent SPLEM	16	2.8	Surface
	PL050/N0401	Rigid	Brent Alpha	Brent Flare system	28	3	Surface
	PL051/N0402	Rigid	Brent Bravo	Brent Flare system	36	2.6	Surface
	PL052/N0403	Rigid	Brent Bravo	Brent Alpha	36	2.3	Surface
	PL4730/N9903A	Rigid	PL044/N0405 midline tie-in	PL1902/N0513 pipeline crossing	24	1.7	Surface
	PL4730/N9903B	Rigid	PL1902/N0513 pipeline crossing	PL045/N0303 midline tie-in	24	2.9	Surface

8.3 Comparative Assessment Process for Qualitative Pipelines

For the Qualitative lines, we examined the option that was indicated by the decision tree and reviewed its advantages and disadvantages in terms of the BEIS 5 Main Criteria (described in Section 8.5.2) in a narrative.

We then performed the same assessment on the alternative option(s), to satisfy ourselves that no other option provided a better balance of performance across the criteria.

8.4 Overview of the Brent Decommissioning Comparative Assessment Process for the Quantitative Pipelines

The Brent Decommissioning numerical CA process, which was used for the Quantitative pipelines, comprises the following six stages:

1. Preparation of a description of the pipeline.
2. Identification and consideration of a long list of potential options for re-use and alternative uses.
3. Identification of a short list of practically-available options for the pipelines
4. Description of Programmes of Work to undertake practically-available options for the pipelines.
5. Completion of studies necessary to inform the final numerical stage of the CA process.
6. Completion of the numerical stage of the Brent Decommissioning CA process.

8.4.1 Stakeholder Engagement in the CA Process

Stakeholder engagement played an important part in all the phases of the CA process for the pipelines. Through the multi-faceted programme of stakeholder engagement described in Section 7, stakeholders were involved at the following key stages:

i. The initial work undertaken to describe the installations and pipelines, the environment of the Brent Field, and the technical, safety and environmental issues that would have to be considered and stakeholders' concerns on these.

ii. The reviews of alternative uses and the range of possible decommissioning options, and the technical and safety reasons why some options were not considered to be practically-available.

iii. The reviews of the technically feasible options and detailed assessments of technical feasibility, safety risk and environmental impacts of those options.

iv. Presentations of our CA process (e.g. criteria, global scales and weightings) during a number of engagements including: public talks (in association with the IMechE); and as part of a number of one-to-one meetings ahead of public consultation.

v. The detailed review of the results of the CAs and the examination of our "emerging recommendations" for each of the pipelines.

8.4.2 Practically-Available Options

Table 11 lists the practically-available options for each of the Brent pipelines that were subject to CAs. Summary descriptions of all the options are presented in Section 9, and the detailed CAs for each of these facilities are presented in the Brent Field Pipelines Decommissioning TD [5].

Table 11 The Practically-Available Decommissioning Options for the Brent Pipelines were Subjected to CA.

Item	Feasible Options Identified for Comparative Assessment
Qualitative pipelines, umbilicals and power cables	1. Leave *in situ* 2. Leave *in situ* with remediation 3. Remove whole length by appropriate method
Quantitative pipelines, umbilicals and power cables Note: This is a list of all the technically feasible options for the pipelines. Not all of these options apply to every pipeline, umbilical or power cable, because of their size, characteristics or present status.	1. Leave *in situ* with no further remediation required
	2. Leave tied-in at platforms; remote end trenched
	3. Leave tied-in at platforms; rock-dump remote ends.
	4. Disconnect from platforms/infrastructure and trench and backfill whole length.
	5. Disconnect from platforms/infrastructure and rock-dump whole length.
	6. Recover whole length by cut and lift.
	7. Recover whole length by reverse S-lay (single joint).
	8. Partial trench and backfill with isolated rock-dump on all shallow trenched sections (PL001/N0501 only).
	9. Partial rock-dump all shallow trenched sections (PL001/N0501 only).

8.5 Method Used to Complete the Numerical Stage of Comparative Assessments

8.5.1 Introduction

This section describes the method that we used to perform the numerical, stage of CAs on the practically available options for those facilities that were subject to CA (Table 11). A description and discussion of the full procedure is presented in the Brent Decommissioning Project's (BDP) CA Procedure [7].

8.5.2 Comparative Assessment Criteria

All the CAs were performed following the BEIS Guidance Notes [3] and the Shell BDP CA Procedure [7], with appropriate modification for the materials and the options under consideration. Technically feasible options were assessed using the five main criteria, namely:

- Safety
- Environmental
- Technical
- Societal
- Economic

We used the advice provided in the BEIS Guidance Notes which lists those matters which are to be considered during a CA of feasible management options. These include but are not restricted to:

- Technical and engineering aspects
- Timing
- Safety
- Impacts on the marine environment
- Impacts on other environmental compartments
- Consumption of natural resources and energy (and climate change)
- Other consequences to the physical environment
- Impacts on amenities and the activities of communities
- Economic aspects

In line with this guidance, therefore, we assessed each option's performance by dividing that criterion into more specific sub-criteria. For example, the main criterion 'Environmental' encompasses both the potential environmental impacts arising during the work programme (which is likely to be on a timescale of a few months) and the potential environmental impact arising from the long-term presence and degradation of the pipelines. By evaluating these different risks as separate sub-criteria, we were able properly to record the performance of options in these two measures and examine how environmental impacts changed with different options. We decided that 'Safety' should be assessed using three sub-criteria, 'Environment' using four sub-criteria and 'Societal' using three sub-criteria; the criteria 'Technical' and 'Economic' were each assessed by one sub-criterion (Table 12).

We examined the impacts of each option in each sub-criterion. Throughout this document and the narratives of the CAs the term 'performance' is used for simplicity to described the ability of an option to result in desirable effects when expressed in terms of the raw data or weighted score for a particular sub-criterion, or the total weighted score of the option.

Table 12 The BEIS 5 Main Criteria and the Selected Sub-criteria used in all Brent CAs.

Main Criterion	Sub-criterion	Description
Safety	Safety risk to offshore project personnel	An estimate of the safety risk to offshore personnel as a result of completing the proposed offshore programme of work.
	Safety risk to other users of the sea	An estimate of the safety risk to other users of the sea from the long-term legacy of the structure after completion of the proposed programme of work.
	Safety risk to onshore project personnel	An estimate of the safety risk to onshore personnel as a result of completing the proposed onshore programme of work.
Environmental	Operational environmental impacts	An assessment of the environmental impacts that could arise as a result of the planned operations offshore and onshore.
	Legacy environmental impacts	An assessment of the environmental impacts that could arise as a result of the long-term legacy effects of the structure or facility after completion of the proposed programme of work.
	Energy use	An estimate of the total net energy use of the proposed programme of work, including an allowance for energy saved by recycling and energy used in the manufacture of new material to replace otherwise recyclable material left at sea.
	Emissions	An estimate of the total net emissions of CO_2 from the proposed programme of work, including an allowance for emissions from the manufacture of new material to replace otherwise recyclable material left at sea.
Technical	Technical feasibility	An assessment of the technical feasibility of being able to complete the proposed programme of work as planned.
Societal	Effects on commercial fisheries	An estimate of the financial gain or loss compared with the current situation that might be experienced by commercial fishermen as a result of the successful completion of the planned programme of work.
	Employment	An estimate of the man-years of employment that might be supported or created by the option.
	Impact on communities	An assessment of the effects of the option on communities and onshore infrastructure.
Economic	Cost	An estimate of the total likely cost of the option, including an allowance for long-term monitoring.

8.5.3 Comparative Assessment Data

We elected to use a method of assessment that uses 'global scales' as a way of i) providing a unit-less scale on which to compare different sub-criteria (e.g. safety risk to other users of the sea and environmental impact of operations) and ii) providing a way to compare the performance of the options across all of facilities within the BDP. The procedure for generating the global scales involved the following three steps:

1. For each sub-criterion the data for each option for each facility were generated using the same method of calculation. For example, if the cost estimate for a Brent pipeline option had been generated using current vessel day rate estimates and ignoring any effect of inflation that might be expected to occur between now and the execution of the work.
2. Considering each sub-criterion in turn, the 'best' and 'worst' data from any option and for any facility was used to fix the top and bottom of the scale for that sub-criterion. For example, the option with the highest Potential Loss of Life (PLL) is the least desirable and therefore marks the bottom of the scale and is therefore '0' on the scale. The option with the lowest PLL is the most desirable and is therefore '1' on the scale. This resulted in a 'global scale' spanning the whole data range for each sub-criterion.
3. We then arithmetically transformed the data for all other options onto these global scales. Thus, a single global scale for each sub-criterion could be used and applied consistently in all of the CAs for all of the facilities. This process of transformation converted the different sub-criteria into a common measure which then allowed us more easily and robustly to examine and compare the overall performances of the options.

For the majority of the sub-criteria listed in Table 12 we generated numerical data such as values for PLL, energy use (in gigajoules, GJ) and cost (£); the methods used to obtain these data are described in the CA Procedure [7].

The estimation of safety risk was an important aspect of this work, and the following description of the derivation and application of PLLs is taken from our CA procedure [7]:

> 'PLL is one of the prime outputs of a quantitative risk assessment (QRA). It provides a measure of cumulative risk which is directly dependent on the number of people exposed to the risk and the duration of the activity. In this context it therefore provides a simple measure of the relative safety risk between project personnel who may be engaged in operations to complete an option, and third-parties who may be exposed to the long-term risk from the planned end-point of the option. PLLs can and are therefore used in the overall decision-making process (such as in a CA) along with considerations of the environmental impacts, costs and other criteria.
>
> There are absolute values of risk tolerability used by authorities such as the Health and Safety Executive (HSE). For example, risks between 1×10^{-1} and 1×10^{-3} are considered intolerable and risks between 1×10^{-3} and 1×10^{-6} are in the region where it has to be shown that the risks are tolerable and are ALARP. Within a decision-making process such as a CA, however, it should be stressed that PLL figures should not be used as an absolute measure of risk because the total PLLs here represent the cumulative predicted risk for different groups of people and activities, and there is no analysis of the options to determine the effects of any risk-reduction measures that would or could be applied. Such detailed analysis occurs once an option has been selected, and it is at this point that the specific PLLs for a given activity could be compared with the HSE thresholds above'.

The assessment of four of the sub-criteria - 'operational environmental impacts', 'legacy environmental impacts', 'technical feasibility' and 'impact on communities' - required the use of expert judgements on the performance of the options, and therefore had no fixed numerical scale against which to score the options. Following advice from the independent consultancy Catalyze, who are Multi-Criteria Decision Analysis (MCDA) experts, we established a methodology for ensuring that the scores provided by the experts could be used to create a global scale that maintained the mathematical accuracy of the performances of the options relative to each other on the global scale.

For the sub-criterion 'Technical Feasibility' (TF), the owners' technical experts attended a series of facility-based workshops to discuss and score each of the options under consideration. An aid to scoring was developed, which listed factors which would affect the likelihood of successfully executing the option and included considerations such as the novelty of the equipment required and the susceptibility of the workscope to unplanned events. This resulted in a score on a 'local scale' (which was out of 45) and an understanding of the reasons behind this score. The engineers then assessed whether the initial scores gave a realistic and justifiable measure of the relative technical feasibility of the options, and ranked the options from best to worst. The engineers then examined the differences between each of the scores to satisfy themselves that the relative position of each option was consistent and justifiable. For example, if Option A scored 30, Option B scored 15 and Option C scored 45, then the technical feasibility of Option B was half that of Option A and the difference in technical feasibility between Option B and Option C was twice that of the difference between Option A and Option B. The engineers discussed and agreed any adjustments to the scores that they deemed necessary to ensure that the scores of the options on the local scale were correct relative to each other, and the reasons for any adjustments were recorded.

A plenary TF workshop was then held at which the technical feasibilities of the options across the facilities were discussed and compared, with the objective of agreeing an assessment for each option which was relative to and consistent with all options across all facilities. This plenary workshop was facilitated by Catalyze and observed by the IRG. In summary, using the judgement of the Plenary TF Team, the best option with respect to of technical feasibility across all of the BDP facilities was defined as '1' on the global scale. Similarly, the worst option for TF across all facilities was defined as '0' on the global scale. The best and worst options for each facility were then placed on the global scale, referring to the record of the facility-based workshops as necessary. The intermediate options (those between 'best' and 'worst') were placed onto the global scale by simple arithmetic mapping from the local scale position for each facility onto the global scale, using the 'best' and 'worst' options for each facility as reference points. The resulting option placements on the global scale were then reviewed and any further changes documented.

DNV GL assessed the potential environmental impacts that could arise from each of the options under consideration in the CA as part of their work to complete the EIA. We therefore asked DNV GL to provide their expert judgement for the scoring of the two environmental impact sub-criteria and the 'impact on communities' sub-criterion. As an initial step, DNV GL reviewed the type and degree of impact for each of the options under consideration. They then discounted any impact which duplicated any other sub-criterion that had been separately assessed for the purpose of the CAs; for example, the impact under the EIA category 'Fisheries' was removed because the commercial effect on fisheries was the subject of a separate sub-criterion in the CA. This resulted in a judgement of the overall impacts arising from the execution of the different options and the reasons for each judgement, similar to the process used in the facility-based workshops held by Shell to generate scores for TF. The DNV GL scores for the environmental impacts of each option were therefore informed by the EIA, but do not necessarily directly correspond to the impact assessments presented in the ES because the EIA assessments consider each facility in turn and do not assess the magnitude of impacts across the different facilities. DNV GL then attended a plenary workshop, again facilitated by the MCDA experts and observed by both the IRG and Shell representatives. The same process as described for TF was followed for operational environmental impacts, legacy environmental impacts and impacts on communities, producing scores on a global scale for each of the three sub-criteria which reflected each option's relative position.

Ultimately the work described here resulted in a suite of data appropriate for use in the BDP CA (Table 13), and a set of global scales for each sub-criterion (Table 14).

Table 13 The Source and Type of Data used to Assess the Performance in each Sub-criterion.

Sub-criterion	Source of Information	Type of Data	Unit
Safety risk to offshore project personnel	Internal study by Shell	Numerical	PLL
Safety risk to other users of the sea	Studies by Anatec [1, 2, 3]	Numerical	PLL
Safety risk to onshore project personnel	Internal study by Shell	Numerical	PLL
Operational environmental impacts	Score provided by DNV GL	Score	
Legacy environmental impacts	Score provided by DNV GL	Score	
Energy use	Environmental Statement	Numerical	Gigajoules
Emissions	Environmental Statement	Numerical	Tonnes
Technical feasibility	Score provided by Shell	Score	
Effects on commercial fisheries	Study by McKay Consultants [4]	Numerical	GBP
Employment	Study by McKay Consultants [5]	Numerical	Man-years
Impact on communities	Score provided by DNV GL	Score	
Cost	Internal study by Shell	Numerical	GBP

Notes:
1. Anatec, 2011. Assessment of the safety risk to fishermen from derogated footings of the Brent Alpha steel jacket [8]
2. Anatec, 2016. Assessment of safety risk to mariners from derogated GBSs in the Brent Field [9]
3. Anatec, 2014. Assessment of safety risk to fishermen from decommissioned pipelines in the Brent Field [10]
4. Mackay Consultants, 2014. Brent Decommissioning: Assessment of socio-economic effects on commercial fisheries [11]
5. Mackay Consultants, 2014. Brent Decommissioning: Likely economic and employment impacts [12]

Table 14 Global Scales for each Sub-criterion used in Brent Decommissioning CAs.

Sub-criterion	Units	Best Value	Worst Value
Safety risk to offshore project personnel	PLL	0.0000	0.2640
Safety risk to other users of the sea	PLL	0.0000	0.2640
Safety risk to onshore project personnel	PLL	0.0000	0.2640
Operational environmental impacts [1]	Score	1.00	0.00
Legacy environmental impacts [1]	Score	1.00	0.00
Energy use	GJ	0	1,738,959
Emissions (CO_2)	Tonnes	1	156,726
Technical feasibility [1]	Score	1.00	0.00
Effects on commercial fisheries [2]	GBP	2,318,040	0.00
Employment	Man years	2,128	0.00
Impact on communities [1]	Score	1.00	0.00
Cost	GBP (million)	0.00	534.14

Notes:
1. The maximum possible score for these sub-criteria is 1.0
2. Effects on commercial fisheries measured by how much the value of landings might change from the present situation. A positive value denotes an increase and a negative value a decrease from present.

8.5.4 Assessing the Performance of each Option

To begin our assessment and comparison of options, we decided to weight each of the BEIS 5 Main Criteria equally. Where a main criterion was represented by more than one sub-criterion, we decided that these too should be weighted equally. Table 15 shows the weightings for the criteria and sub-criteria, in a weighting scenario we have called the 'standard weighting'.

Table 15 'Standard Weights' for the BEIS Main Criteria and Sub-criteria.

Selected Sub-criteria		BEIS Main Criteria	
Description	Weight	Weight	Description
Safety risk to offshore project personnel	6.7%	20%	Safety
Safety risk to other users of the sea	6.7%		
Safety risk to onshore project personnel	6.7%		
Operational environmental impacts	5.0%	20%	Environmental
Legacy environmental impacts	5.0%		
Energy use	5.0%		
Emissions (CO_2)	5.0%		
Technical feasibility	20.0%	20%	Technical
Effects on commercial fisheries	6.7%	20%	Societal
Employment	6.7%		
Impact on communities	6.7%		
Cost	20.0%	20%	Economic

The scores from the global scales for each sub-criterion were multiplied by the standard weights and then summed to derive a total weighted score for each option. The option with the highest total weighted score was identified as the 'CA-recommended option'.

8.5.5 Examining the Sensitivity of the CA-recommended Option

The OSPAR Framework for CAs state that the CA shall be *'sufficiently comprehensive to enable a reasoned judgement on the practicability of each disposal option'*, and that *'the conclusion shall be based on scientific principles…….and linked back to the supporting evidence and arguments'* [2]. The BEIS Guidance Notes state that operators must robustly assess decommissioning options based on evidence and data and also state *'it is unlikely that cost will be accepted as the main driver unless all other matters show no significant difference'* [3].

To examine the sensitivity of the CA recommended option, therefore, we applied five 'selected weighting scenarios' to the transformed scores, to generate new total weighted scores for each option. The selected weighting scenarios were derived after a consideration of the relative values in the global scales, and reflect our view, informed by feedback from meetings and dialogue, of the importance of the various criteria and sub-criteria to all our Stakeholders. Table 16 lists the five scenarios we used, and Table 17 lists the resultant weights for each of the sub-criteria in each of the selected weighting scenarios as well as the 'standard weights'.

We then examined the total weighted scores in each scenario, and assessed how the scores changed, and determined if the order of the options changed in some scenarios. This resulted in the identification of the option that was the 'Emerging recommendation'. It should be noted that this option may have been so identified because, although not necessarily always the best option in every scenario, overall it performed well in a number of the scenarios.

Table 16 The Five Weighting Scenarios used to Assess the Sensitivity of the CA-recommended Decommissioning Option.

Scenario	Description
2	Weighted to Safety: Safety criterion weighted 40%.
3	Weighted to Environment: Environmental criterion weighted 40%.
4	Weighted to Technical: Technical Feasibility criterion weighted 40%
5	Weighted to Societal: Societal criterion weighted 40%.
6	Standard weighting without Economic.

Table 17 Weighting Applied to Sub-criteria in Selected Weighting Scenarios.

Sub-criteria	Weighting Scenario					
	1	2	3	4	5	6
Safety risk to offshore project personnel	6.7%	13.3%	5.0%	5.0%	5.0%	6.7%
Safety risk to fishermen	6.7%	13.3%	5.0%	5.0%	5.0%	6.7%
Safety risk to onshore project personnel	6.7%	13.3%	5.0%	5.0%	5.0%	6.7%
Operational environmental impacts	5.0%	3.8%	10.0%	3.8%	3.8%	5.0%
Legacy environmental impacts	5.0%	3.8%	10.0%	3.8%	3.8%	5.0%
Energy use	5.0%	3.8%	10.0%	3.8%	3.8%	5.0%
Emissions (CO_2)	5.0%	3.8%	10.0%	3.8%	3.8%	5.0%
Technical feasibility	20%	15.0%	15.0%	40.0%	15.0%	20.0%
Effects on commercial fisheries	6.7%	5.0%	5.0%	5.0%	13.3%	6.7%
Employment	6.7%	5.0%	5.0%	5.0%	13.3%	6.7%
Impact on communities	6.7%	5.0%	5.0%	5.0%	13.3%	6.7%
Cost	20%	15.0%	15.0%	15.0%	15.0%	20.0% (Note)

Note: .In this weighting scenario, to preserve the spread of the weightings across the other sub-criteria, the sub-criterion 'cost' retains a weighting of 20% but all the options are accorded a cost of 'nil'; this means that cost does not contribute to the overall weighted score of an option.

Key to Weighting Scenarios

Scenario	Description
1	Standard weighting; equal weight to the BEIS 5 Main Criteria
2	Weighted to Safety
3	Weighted to Environmental
4	Weighted to Technical
5	Weighted to Societal
6	Standard weighting without Economic

8.5.6 Identifying the Recommended Option

We used all the above assessments and sensitivity analyses to compare and contrast the performances of the options being assessed by means of CAs, in order to identify our 'Recommended option'. The results of our comparison and the reasons for our recommendations were then presented in a narrative and in two types of diagram. Firstly, the total weighted scores of the options are presented in coloured charts such as the example in Figure 7. These show the relative contributions of each of the sub-criteria to the overall performance of the option; the larger the coloured segment, the greater the contribution that sub-criterion has made. Secondly, to aid our examination of the important sub-criteria (the 'drivers') and enable our assessment of the trade-offs between sub-criteria, we prepared 'difference charts', as shown in Figure 8. The bars show the difference in the total weighted score between the options in each of the sub-criteria; the longer the bar, the greater the difference. In this example, green bars show where Option 2 is better than Option 1 and red bars show where Option 1 is better than Option 2. The dotted line bars show the *maximum* size of the difference that there could be between any two options in each sub-criterion.

Figure 7 Example of a Bar Chart Showing the Total Weighted Scores of Three Options.

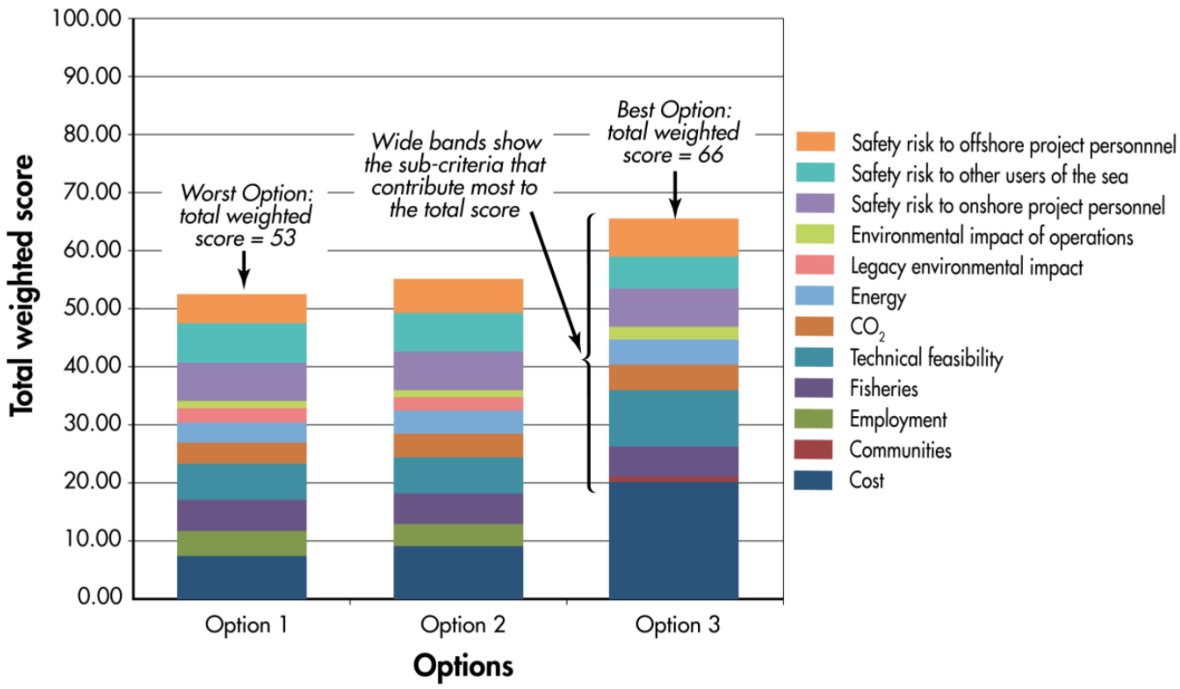
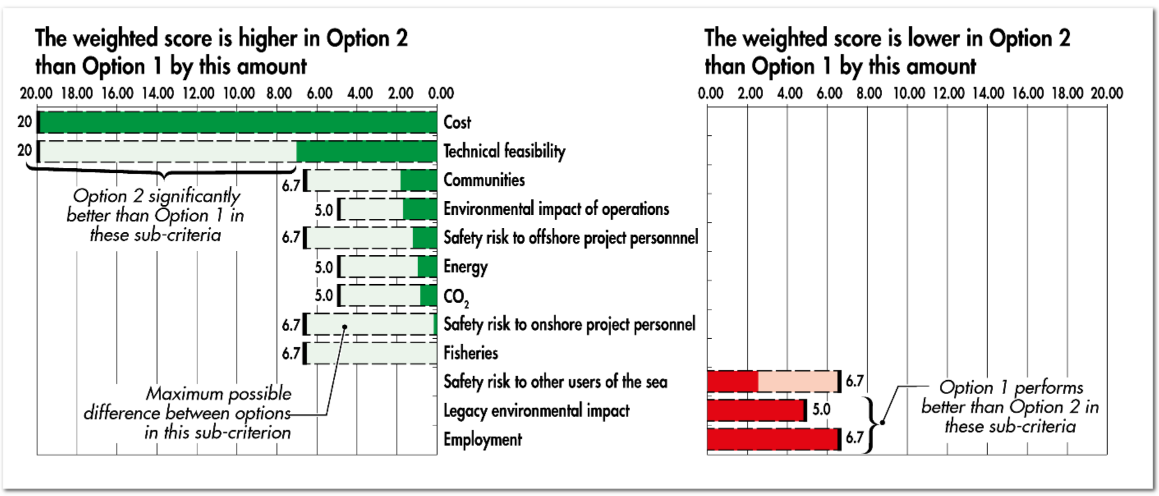


Figure 8 Example of a Difference Chart Showing the Difference between Two Options in each of the Sub-criteria.



9 DECOMMISSIONING THE BRENT PIPELINE SYSTEM

9.1 Introduction

The Brent Field pipeline system comprises approximately 103 km of rigid and flexible pipelines for the transportation of oil or gas, umbilicals for controlling subsea infrastructure or for chemical injection and power cables. These run between the Brent platforms, the former sites of the Brent Spar and Brent Flare, and the various host platforms that link the Brent Field to both Sullom Voe and St Fergus.

Prior to decommissioning, the subsea pipeline system will be depressurised and flushed to remove remaining inventory; the oil lines will also be pigged to remove any residual solid hydrocarbons adhering to the walls of the pipes. Pipeline cleaning operations are described in Section 9.7.2. All the lines will then be left filled with inhibited seawater, pending the approval of this DP. This will ensure that if we are later directed to remove a pipeline which we had proposed to decommission *in situ*, the integrity of the pipeline will have been maintained.

Detailed descriptions of every line, including the locations of any areas of rock-dump and mattressing and of four items of subsea infrastructure and debris items, are provided in the Pipelines TD [5]. Figure 9 shows an example of the schematic diagrams we have prepared for every line (in this case PL049/N0301). Detailed information on the current status and extent of spanning on each line is presented in the Pipelines TD [5] and Figure 10 shows an example of such a 'spanogram', again for line PL049/N0301. In general, there is no significant spanning on any line. The Field is in deep water and the seabed currents are weak, so apart from very localised eddies caused by topography or the presence of obstructions on the seabed there are few forces that would cause extensive erosion of seabed sediments. A 'FishSAFE' span is defined as a span more than 0.8 m high and more than 10 m long which represents a potential snagging risk to bottom-towed fishing gear and so should be included in the FishSAFE system to provide an early warning to fishermen as they approach it. Latest information indicates that with the exception of the closing spans – where lines rise from the seabed to attach to platforms – there are only two FishSAFE spans in the Brent Field. These are both found on the 30 inch export line N0501/PL001 at around KP[9]34; one is 0.9 m high and 17.9 m long and the other 1.2 m high and 15 m long.

[9] KP= kilometre point, the distance along the pipeline from the platform measured in kilometres

Figure 9 Example of Schematic Layout Drawn for each Pipeline.

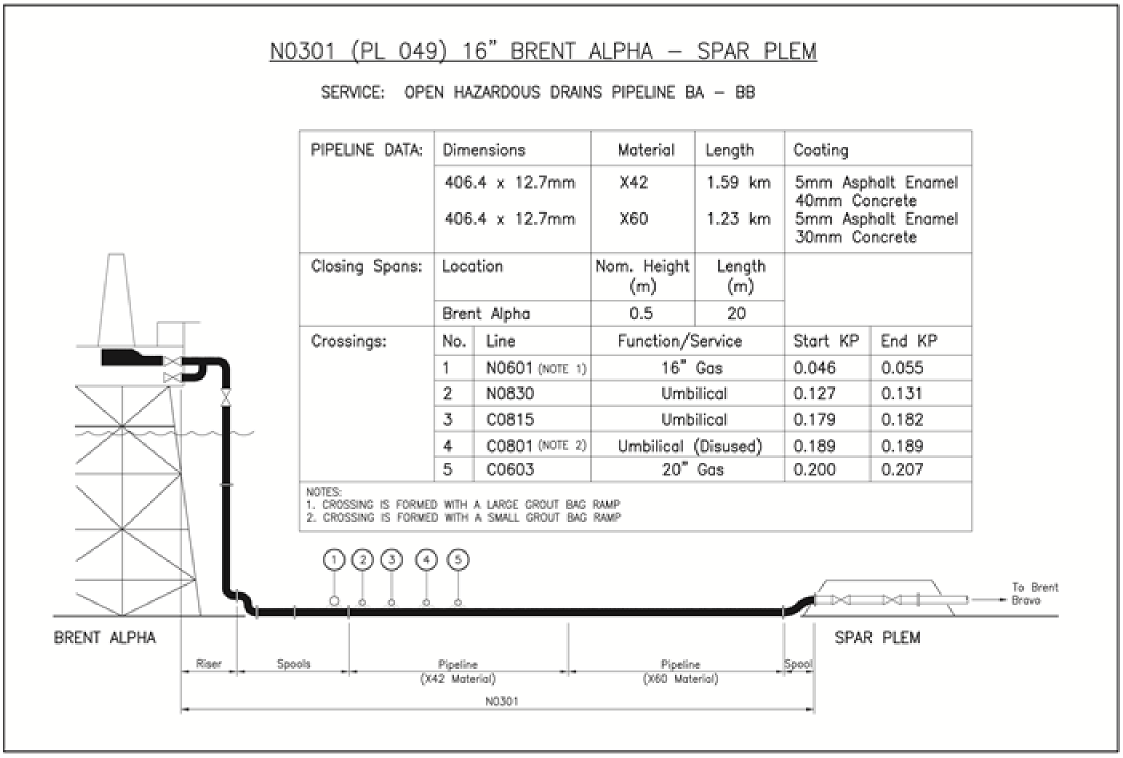
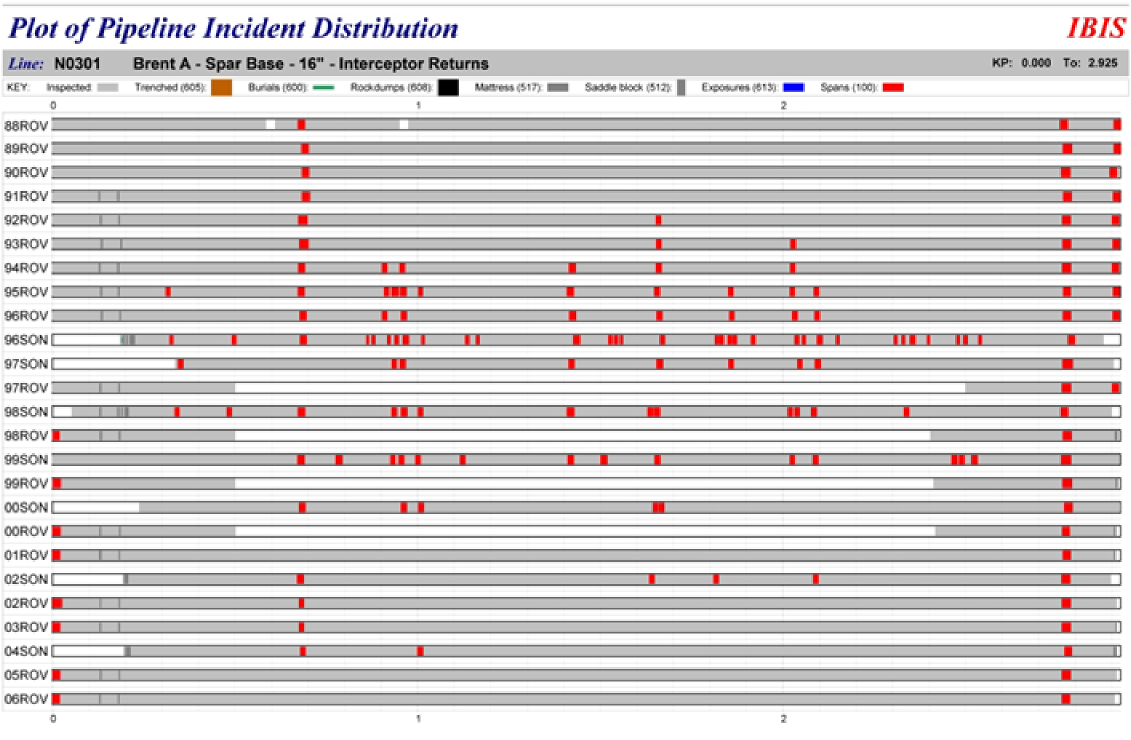


Figure 10 Example of a Spanogram Recording Results of Pipeline Survey.[10]



[10] In Figure 10 each line represents a survey of the whole line in a particular year. The grey zones show the lengths of the line that were covered by the survey. The red bands show the location and lengths of spans.

9.2 Description of the Brent Pipelines, Umbilicals and Power Cables and Material Inventory

Figure 11 shows the arrangement of pipelines in the Brent Field that are included in this decommissioning programme, and Table 18 and Table 20 provide factual data on the system and an inventory of materials. These are based primarily on the original plans for the pipelines and the records of modifications and additions that have been made over the years. The condition and status of the whole pipeline system has been regularly monitored and surveyed. Table 19 summarises the inventories of each pipeline. We have prepared inventories of the Brent pipelines (Table 19).

Figure 11 Schematic Showing the Present Layout of the Brent Field Pipeline System.

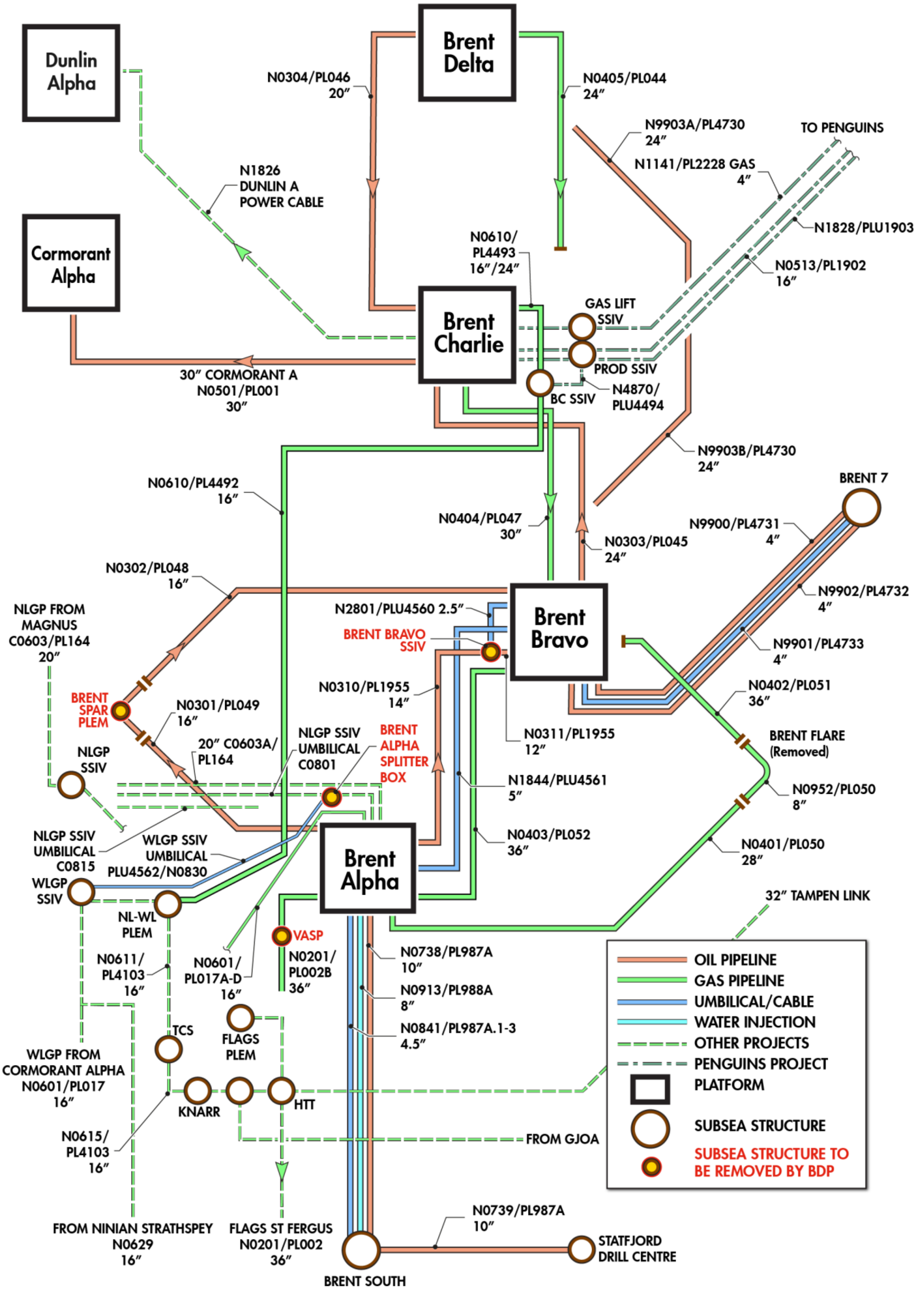


Table 18 Data on the Brent Pipeline System.

PWA Number	Shell Number	Diameter (inches)	Length (km)	Service
PL001	N0501	30	35.9	Oil export Brent C to Cormorant Alpha
PL002B	N0201	36	1.25	Gas export Brent A to VASP
PL017A-D	N0601	16	0.4	Gas import WGLP SSIV to Brent A
PL044	N0405	24	4.2	Gas export Brent D to Brent C
PL045	N0303	24	4.6	Oil production Brent B to Brent C
PL046	N0304	20	4	Oil production Brent D to Brent C
PL047	N0404	30	4.4	Gas export Brent C to Brent B
PL048	N0302	16	2.3	Oil export, now drains fluids from Brent B to PLEM
PL049	N0301	16	2.8	Oil export, now drains fluids from Brent A to PLEM
PL050	N0401	28	3	Flare gas Brent A to Brent Flare (Note 1)
PL050	N0952	8	0.03	Brent flare system (Note 5)
PL051	N0402	36	2.6	Flare gas Brent B to Brent Flare (Note 2)
PL051	N0402A	36	0.147	Brent B 500 m zone (Note 3)
PL052	N0403	36	2.3	Gas export Brent B to Brent A
PL987A	N0738	10	5	Oil export Brent South to Brent A (Note 4)
PL987A	N0739	10	1.8	Oil export Brent South to Statfjord drill centre (Note 5)
PL987A.1-3	N0841	4.5	5.3	Control and chemical umbilical Brent A to Brent South (Note 6)
PL988A	N0913	8	5	Water injection Brent A to Brent South (Note 6)
PL1955	N0310	16	0.36	Oil production Brent A to Brent B SSIV
		19	2.3	Oil production Brent A topside to Brent A seabed
PL1955	N0311	16	0.27	Oil production Brent B SSIV to Brent B
PL4493	N0610	16/24	0.117	Brent C to GEP SSIV
PLU4494	N4870	1	0.06	Control umbilical Penguins SSIV to Gas Export SSIV
PLU4560	N2801	4	0.423	Control umbilical Brent B to Brent B SSIV
PLU4561	N1844	5	2.9	Power cable Brent B to Brent A
PLU4562	N0830	4	0.5	Control umbilical Brent A to WLGP SSIV
PL4730	N9903A	24	1.7	Oil production Brent D to Brent B (Note 6)
PL4730	N9903B	24	2.9	
PL4731	N9900	4	2.1	Well 211/29-7 to Brent B (Note 6)
PL4732	N9902	4	2.3	Oil production Well 211/29-7 to Brent B (Note 6)
PLU4733	N9901	4	2.2	Control and chemical umbilical Brent B to Well 211/29-7 (Note 6)

Notes:
1. Currently suspended and subject to Interim Pipeline Regime (IPR).
2. Currently suspended and subject to IPR.
3. Disused.
4. Disused and subject to IPR.
5. Never commissioned and subject to IPR.
6. Disused and subject to IPR.

Table 19 Inventories for each Brent Field Pipeline.

PWA Number	Shell Number	Length (km)	Mass of Materials (tonnes)			
			Steel	Concrete	Coatings	Total
PL001	N0501	35.9	12,819	11,983	728	25,529
PL002B	N0201	1.25	629	600	16	1,246
PL017A-D	N0601	0.4	49	68	4	121
PL044	N0405	4.2	978	991	57	2,025
PL045	N0303	4.6	1,071	1,085	62	2,218
PL046	N0304	4.0	703	658	46	1,407
PL047	N0404	4.4	1,571	1,465	74	3,110
PL048	N0302	2.3	284	296	21	600
PL049	N0301	2.8	384	321	25	730
PL050	N0401	3.0	1,132	1,075	60	2,267
PL050	N0952	0.03	6	0	0.2	6
PL051	N0402	2.6	1,259	1,171	53	2,483
PL051	N0402A	0.147	71	66	3	140
PL052	N0403	2.3	1,114	1,032	18	2,164
PL987A	N0738	5	776	0	107	883
PL987A	N0739	1.8	279	0	38	317
PL987A.1-3	N0841	5.3	ND	0	ND	133
PL988A	N0913	5.0	361	0	0	361
PL1955	N0310 (16")	0.36	527	0	130	657
PL1955	N0310 (19")	2.3				
PL1955	N0311	0.27	51	0	9	60
PL4493	N0610	0.117	ND	ND	ND	ND
PLU4494	N4870	0.06	ND	0	ND	ND
PLU4560	N2801	0.423	ND	0	ND	3
PLU4561	N1844	2.9	55	0	15	96
PLU4562	N0830	0.5	ND	0	ND	13
PL4730	N9903A	1.7	396	401	23	820
PL4730	N9903B	2.9	675	684	39	1,398
PL4731	N9900	2.1	ND	0	ND	63
PL4732	N9902	2.3	ND	0	ND	69
PLU4733	N9901	2.2	ND	0	ND	55

ND = No data

Table 20 Mattresses and Grout Bags on the Brent Pipeline System.

Location	Number of Items	
	Mattresses	Grout Bags
Brent Alpha	187	375
Brent Bravo	78	1,071
Brent Charlie	62	743
Brent Delta	0	1,647
Brent South	125	0
Brent Spar PLEM	19	120
VASP	20	200
Totals	491	4,156
Estimated Total Mass (tonnes)	1,762	104(Note)

Note: Assuming a grout bag weighs 25 kg.

9.3 Further Use or Re-use of the Pipelines, Umbilicals and Power Cables

There are no other uses for these lines; they are not of use to others in adjacent fields and as far as is known are not likely to be of use in the development of future fields. It is not feasible to consider re-using lines in other locations even though it may be technically possible to retrieve them in one piece. Consequently, all the lines listed in Table 18 will have to be decommissioned.

9.4 Options for the Decommissioning of the Pipelines, Umbilicals and Power Cables

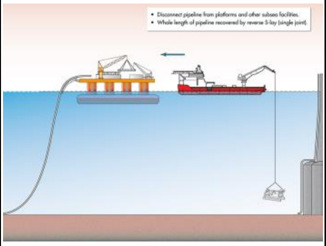
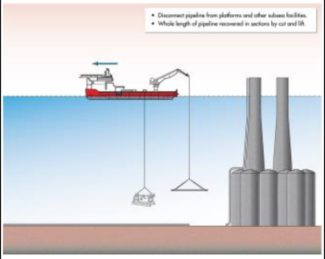
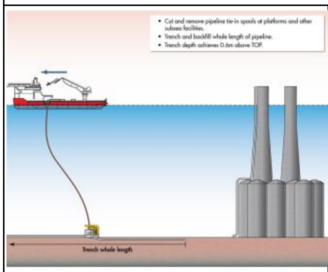
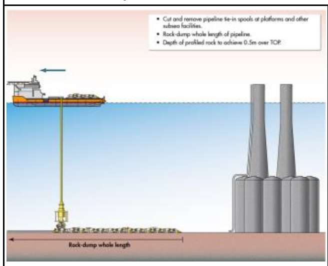
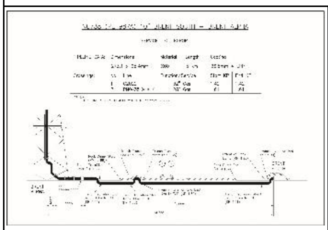
In accordance with the BEIS Guidance Notes [3] we have completed CAs of feasible options for each of the 30 Brent Field pipelines that fall within the scope of this DP (Section 9.1). The CAs were informed by our own extensive data on the condition and burial status of each line (described in detail in Pipelines TD [5]), engineering studies on removal or burial techniques, the ES [6], Field-specific studies on pipeline degradation and longevity [5], the report on commercial impacts on fisheries [11], and the Anatec study Assessment of safety risk to fishermen [10].

To permit the continuing export of gas through the Western Leg Gas Pipeline (WLGP) and FLAGS export routes after the decommissioning of the Brent Field, we are reconfiguring the pipeline network in a separate project called the Brent Bypass Project (BBY) (Section 4.3). Our assessment of options for the decommissioning of the Brent Field pipelines has taken into account the changes that will be made as a result of the Bypass Project.

For the purpose of assessing options, we assumed that all oil and gas lines had been successfully flushed under permit (see Section 9.7.2) to an acceptable standard that would be agreed with BEIS. The main options, and the various techniques or operations that could be performed to complete each type of option for decommissioning pipelines, are summarised in Table 21 and described more fully in the Pipelines TD [5].

One of our main objectives was to examine ways of reducing or eliminating the potential for a long-term snagging risk to fishermen. This risk arises from the presence of exposed sections of pipeline with or without spans. The presumed higher snagging risk on these sections could be reduced by complete removal, selective partial removal, rock-dumping or trenching. Consequently, we developed various permutations of removal activities and this resulted in the identification of up to nine different options for each of the lines.

Table 21 Main Options for Decommissioning Pipelines.

Option	Methods
Complete or Partial Removal[11]	
	*Reverse S-lay (illustrated):* One end of the line is picked up by a vessel and progressively pulled on board over a 'stinger'. On board the vessel it is cut into sections for recycling onshore. *Reverse reeling:* One end of the line is picked up by a vessel and progressively wound onto a very large reel on board. The line is recycled onshore.
	*Cut and Lift:* After suitable de-burial the line is cut into 12 m long sections on the seabed by ROVs. The sections are lifted by the vessel and taken to shore for recycling.
Trench[16]	
	*Mechanical trenching (illustrated):* A large plough is fitted over one end of the line and pulled or driven along the line to create a trench. A separate backfilling operation is then performed by a specialist backfill plough, to achieve the required depth of burial (usually >0.6 m to top of pipe). *Jet trench:* Jet trenchers work by fluidising the seabed using a combination of high flow/low pressure and low flow/high pressure water jets to cut into sands and gravels and low to medium strength clays. In sands, the pipeline sinks through the slurry that this operation creates, whereas in clay, the jetting process cuts through the material which is carried away by the flow of water.
Rock-dump	
	*Rock-dump:* A specialised vessel deploys a long controllable 'fall pipe' and delivers controlled amounts of graded rock onto and over the line. The rock-dump is carefully designed to provide the required protection and stability to the line.
Leave in Place	
	*Leave in place:* The line would be left in place as it is but there may be operations (such as local trenching or local rock-dumping) to stabilise or protect any exposed ends.

[11] With the exception of any sections of pipeline already protected by stable, over-trawlable rock-dump

9.5 Issues and Concerns Raised by Stakeholders

For the technically feasible options for the pipelines the main issues and concerns raised by stakeholders during the programme of stakeholder engagement were:

- The long-term snagging risks for towed fishing gear from any lines left exposed on the surface of the seabed.
- Pipelines lying in an open trench 0.6 m below the surrounding/mean seabed level would not necessarily be safe in relation to fishing activity.
- Regaining access to grounds for demersal fishing.
- Creation of debris.
- How the lines will be cleaned before decommissioning.
- Release of residual hydrocarbons during removal or from lines left in place.
- Long-term impacts on benthos from the lines and especially from any additional rock-dump.
- Impacts to local communities at onshore dismantling sites caused by noise, dust and odour.

9.6 Comparative Assessment of Options

9.6.1 Results of Comparative Assessments for Qualitative Pipelines

The results of the assessments for the qualitative lines are presented in Table 22 and discussed in Section 9.6.2. Work at any pipeline crossing is described in Section 9.7.3, and Section 9.7.5 describes how mattresses and grout bags would be dealt with. Individual CAs for each of the lines are presented in the Pipelines TD [5].

Table 22 Recommended Decommissioning Option for Brent Field Pipelines Subject to Qualitative Comparative Assessment.

Pipeline Number		Diam. (inches)	Length (km)	Service	Status	Recommended Option	Justification
PL050	N0952	8	0.03	Flushing jumper	Lying beneath profiled rock-dump	Leave under rock-dump	Fully covered by stable, profiled rock-dump
PL051	N0402A	36	0.147	Never used	Laid on the seabed	Remove by cut-and-lift	Short exposed rigid line
PL987A	N0738	10	5.0	Oil production (disused and in IPR)	Trenched and partially end rock-dumped	Leave in trench, remediate exposed flange with rock-dump	Whole line is trenched. Approx. 3.2km under adequate and stable rock dump; 1.8km covered by natural backfill.
PL987A	N0739	10	1.8	Never used, now in IPR	Trenched, both ends rock-dumped	Leave in trench, remediate one exposed flange with rock-dump	Stable in trench, and under profiled rock-dumps and natural backfill
PL987A 1-3	N0841	4.5	5.3	Control umbilical	Trenched (with N0913), one end rock-dumped	Leave in trench, remediate exposed flushing head with rock-dump	Stable in trench, and under profiled rock-dump and natural backfill
PL988A	N0913	8	5.0	Water injection	Trenched (with N0841), one end rock-dumped	Leave in trench, remediate exposed flange with rock-dump	Stable in trench and covered by natural backfill
PL1955	N0310	16/19	2.66	Oil production	Laid on the seabed with mattresses at each end	Remove by reverse reeling	Flexible line, lying on the seabed
PL1955	N0311	16	0.27	Oil production	Laid on the seabed + catenary riser	Remove by reverse reeling	Flexible line, lying on the seabed
PL4493	N0610	16/24	0.117	Gas Export Pipeline	Laid on seabed largely protected by mattresses.	Remove by cut and lift	Short rigid pipeline, unprotected when mattresses removed.
PLU4494	N4870	1	0.06	Control umbilical	Laid on seabed protected by grout bags	Remove by reverse reeling	Short section of flexible umbilical, unprotected when grout bags removed.
-PLU4560	N2801	4	0.423	Control umbilical	Laid on the seabed, largely protected by mattresses	Remove by reverse reeling	Umbilical, lying on the seabed, unprotected when mattresses removed
PLU4561	N1844	5	2.9	Power cable	Laid on the seabed with mattresses at each end	Remove by reverse reeling	Umbilical, lying on the seabed
PLU4562	N0830	4 (Est)	0.5	Control umbilical	Part of length trenched and part mattressed	Remove by reverse reeling	Short section of umbilical which would be partly exposed on seabed once mattresses removed
PL4731	N9900	4	2.1	Oil production	Exposed on seabed, with some natural burial	Remove by cut-and-lift	Small diameter flexible mainly exposed. Lying open to sea for many years. Integrity likely to be compromised
PL4732	N9902	4	2.3	Oil production	Exposed on seabed, with some natural burial. Cut into sections	Remove by cut-and-lift	Small diameter flexible mainly exposed. Lying open to sea for many years. Integrity likely to be compromised
PLU4733	N9901	4 (Est)	2.2	Control umbilical	Mostly exposed on seabed, 14% buried. Cut into sections	Remove by cut-and-lift	Small diameter umbilical mainly exposed and in sections on seabed

9.6.2 Discussion of the Recommended Options for the Qualitative Pipelines

Pipelines to be Removed by Reverse Reeling

Lines PL1955/N0310[12], PL1955/N0311, PLU4494/N4870, PLU4560/N2801, PLU4561/N1844, and PLU4562/N0830 are all flexible lines less than 16 inches in diameter. They are therefore ideal candidates for removal by reverse reeling. The lines PL1955/N0310, PLU4562/N0830, PLU4561/N1844 and PLU4560/N2801 have some mattress protection, and for the purposes of the CA it was assumed that all these mattresses had been successfully removed.

Reverse reeling is a standard operation which has been successfully undertaken many times in the North Sea. It has well understood risks and mitigations to manage these risks and therefore does not represent a significant risk to offshore personnel. The remaining risk, which might only become apparent once decommissioning work begins, is the structural capacity of the lines to withstand the process of reverse reeling or, for PLU4562/N0830, the loads imposed by the potential over-burden of seabed sediment.

This option will leave a clean seabed and eliminate a potential snagging risk for fishermen and a source of litter and potential environmental impact. Any minor impact to the marine environment as a result of reverse reeling these lines is expected to be localised and reversible. Removal will result in a 'small positive' effect in terms of long-term environmental impacts. Only a relatively small mass of material would be returned to shore from these lines and the materials can be processed in accordance with waste management practices at suitably licensed onshore sites.

Pipelines to be Removed by Cut-and-lift

Line PL051/N0402a is a very short (147 m) section of 36 inch line lying on the seabed open to the sea after being abandoned in 1976, and the best option is to remove it by cut-and-lift. Because of concerns about its strength and the fact that the concrete coating would probably fall off during removal, we do not believe that this line is suitable for reverse reeling.

Line PL4493/N0610 is a very short (117 m) section of rigid pipeline. When the mattresses covering the whole length of this section are removed, it will be unprotected on the seabed. It is constructed of a series of spool pieces, so the preferred method is to remove by cut and lift.

Lines PL4731/N9900, PL4732/N9902 and PLU4733/N9901are of very small diameter and lie exposed on the seabed open to the sea; all three have some degree of natural burial over them. As small diameter flexible pipelines they are ideal candidates for reverse reeling but there are concerns over their structural integrity after such a long period lying unprotected on the seabed. On safety and technical grounds it is therefore inadvisable to attempt to remove them by reverse reeling.

The best option is remove these five lines by cut-and-lift. For all these lines the operational safety risk to project personnel is low, and a long-term safety risk to fishermen would be removed. There may be some 'small negative' impacts offshore during operations and onshore during dismantling and recycling, but these will be limited in extent and duration and will be reversible. In all cases removal will result in 'small positive' effects in terms of 'legacy'. None of the alternative options (trenching or rock-dump) offers better performances in terms of either the negative effects of operations or the positive effects of outcomes.

Through this procedure the potential future risk to fishermen can be eliminated without incurring unmanageable levels of risk to offshore personnel. Cutting and lifting operations are likely to disturb only the upper layer of the seabed.

[12] The seabed section of PL1955/N0310 between the Brent Alpha platform and the Brent Bravo SSIV has a total external diameter of 19 inches; however, as the protective coating is flexible it has been considered as a qualitative pipeline.

Pipelines to be Left in Trench

Lines PL987A/N0738, PL987A/N0739, PL987A1-3/N0841 and PL988A/N0913 are all associated with the now decommissioned Brent South development. They were all laid in trenches and have some degree of natural burial, and all have some mattress and rock cover. When Brent South was decommissioned the mattresses at the ends of these lines were buried beneath over-trawlable rock-dump. The rock-dump and the trenches have remained stable since that time. These lines are thus likely to remain in their trenches as they gradually degrade and collapse, and so would not be likely to become a snagging risk to fishing or a source of seabed litter. There is only a small safety risk to offshore project personnel during the remediation of the pipeline ends. The impact on commercial fisheries is judged to be 'small negative' because of the long-term presence of a trenched line, but the marine impacts of operations and the legacy environmental impacts are both 'insignificant'.

Pipelines to be Left Under Rock-dump

Line PL050/N0952 is a very short section (30 m) of small diameter line associated with the decommissioned Brent Flare. Profiled rock-dump was deposited during decommissioning of the entire Brent Flare site and this has completely buried PL050/N0952. The line therefore lies under an existing stable rock-dump and is not likely to interfere with fishing or create seabed litter as it degrades and collapses; there have been no reported incidents on this line to date. The rock-dump will serve to contain any degradation products and stop or severely restrict the migration of degradation products onto the adjacent seabed. Safety risks to operational personnel would be very low (only from monitoring programmes), as would the long-term risks for fishermen associated with the presence of the over-trawlable rock-dump.

The alternative option would be to displace the rock-dump onto the adjacent seabed and remove this line by cut-and-lift. Although technically feasible, displacement of the rock-dump would cause further disturbance to the adjacent seabed and may increase the risk of snagging demersal fishing gear. This alternative option would have some additional negative operational impacts (to the seabed and benthos) while not resulting in any better long-term outcome for other users or the environment.

9.6.3 Results of Comparative Assessments for Quantitative Pipelines

We identified a total of nine different options that could be applied to the quantitative lines (Table 23), with 3 to 6 options being applicable to any one line (Table 24).

Although the presumption of full removal, does not currently apply to pipelines, the BDP has chosen to apply this presumption to the evaluation of the decommissioning options for the Quantitative pipelines. Whilst acknowledging that no intervention (Option 1 Leave *in situ* with no further remediation required) or minimal intervention to remediate the pipeline ends (Option 2 Leave tied in; remote end trenched or Option 3 Leave tied in; remote end rock-dumped) are technically feasible decommissioning options, representatives of the Scottish Fishermen's Federation (SFF) have, during informal discussions, expressed reservations regarding the long-term implications of leaving the majority of the pipelines lying unprotected on the seabed with little or no further mitigation.

On the basis of this feedback and the application of the presumption of full removal, the assessment of the performance of the options considers the best performing full removal option against the next best performing option (excluding Options 1 to 3), to establish whether there are any strong drivers to recommend anything other than full removal.

The results of the assessments for the quantitative lines are presented in Table 25 and discussed in Section 9.6.4, to Section 9.6.6 and illustrated with examples of data and results from specific pipelines.. Work at any pipeline crossing is described in Section 9.7.3, and Section 9.7.5 describes how mattresses and grout bags would be dealt with. Individual CAs for each of the lines are presented in the Pipelines TD [5].

Table 23 Decommissioning Options for the Quantitative Pipelines.

Option Number	Description
1	Leave *in situ* with no further remediation required
2	Leave tied-in at platform; remote end trenched
3	Leave tied-in at platform; remote end rock-dumped
4	Disconnect from platforms/infrastructure and trench and backfill the whole length
5	Disconnect from the platforms/infrastructure and rock-dump the whole length
6	Recover whole length by cut and lift
7	Recover whole length by reverse S-lay (single joint)
8	Partial trench and backfill with isolated rock-dump
9	Partial rock-dump of pipeline

Table 24 Decommissioning Options Applicable to each Quantitative Pipeline.

Pipeline Number	Applicable Options								
	1	2	3	4	5	6	7	8	9
PL001/N0501	✓					✓	✓	✓	✓
PL002B/N0201		✓	✓	✓	✓	✓	✓		
PL017A-D/N0601		✓	✓		✓	✓			
PL044/N0405	✓			✓	✓	✓	✓		
PL045/N0303	✓			✓	✓	✓	✓		
PL046/N0304	✓			✓	✓	✓	✓		
PL047/N0404	✓			✓	✓	✓	✓		
PL048/N0302		✓	✓	✓	✓	✓	✓		
PL049/N0301		✓	✓	✓	✓	✓	✓		
PL050/N0401	✓			✓	✓	✓	✓		
PL051/N0402	✓			✓	✓	✓	✓		
PL052/N0403	✓			✓	✓	✓	✓		
PL4730/N9903A				✓	✓	✓			
PL4730/N9903B				✓	✓	✓			

Option 1	Leave *in situ* with no further remediation required
Option 2	Leave tied-in at platform; remote end trenched
Option 3	Leave tied-in at platform; remote end rock-dumped
Option 4	Disconnect from the installation, trench and backfill the whole length
Option 5	Disconnect from platforms/infrastructure, rock-dump the whole length
Option 6	Recover whole length by cut and lift
Option 7	Recover whole length by reverse S-lay (single joint)
Option 8	Partially trench and backfill, with isolated rock-dump
Option 9	Partially rock-dump

Table 25 Recommended Decommissioning Option for Brent Lines Subject to Quantitative Comparative Assessment.

Pipeline Number		Diam. (inches)	Length (km)	Status	Recommended Option	Justification	Final Percentage Trenched, and Material to be added
PL001	N0501	30	35.9	Trenched along majority of length	Partially trench and backfill with isolated rock-dump.	The majority of the line lies in a stable trench with the top of the pipe lower than the mean seabed level. Shallower sections of the line will be retrenched or rock-dumped.	Estimate of 70% trenched resulting in the remaining 30% of the pipeline length requiring remediation, i.e. approximately 146,800 tonnes of rockdump to be added
PL002B	N0201	36	1.25	Laid on the seabed with some mattresses and 71 m of rock-dump	Disconnect, remove the tie-in spools, grout bags and mattresses if present, then trench and backfill to provide at least 0.6 m seabed cover over the top of the pipe. If there is existing rock-dump, trenching will stop just short of the rock-dump and where necessary the existing rock-dump will be extended to cover the cut end(s).	This option provides a clear seabed and reduces the snagging risk for fishermen. It offers most of the benefits of the option 'Complete removal by cut and lift', including lower legacy environmental impacts and lower safety risk to project personnel, but at a significantly lower cost than full removal.	Predominantly trenched with approximately 510 tonnes of rockdump added
PL017A-D	N0601	16	0.4	Laid on the seabed with some burial and rock-dump	Remove completely by cut and lift.	This is a short line and the differences between the options are small. It is too short to trench, and a section will have been previously removed by the Brent Bypass Project.	Removed completely

Table 25, Concluded. Recommended Decommission Option for Brent Lines Subject to Quantitative Comparative Assessment.

Pipeline Number		Diam. (inches)	Length (km)	Status	Recommended Option	Justification	Final Percentage Trenched, and Material to be Added
PL044	N0405	24	4.2	Laid on the seabed	Disconnect, remove the tie-in spools, grout bags and mattresses if present, then trench and backfill to provide at least 0.6 m seabed cover over the top of the pipe. If there is existing rock-dump, trenching will stop just short of the rock-dump and where necessary the existing rock-dump will be extended to cover the cut end(s).	This option provides a clear seabed and reduces the snagging risk for fishermen. It offers most of the benefits of the option 'Complete removal by cut and lift', including lower legacy environmental impacts and lower safety risk to project personnel, but at a significantly lower cost than full removal.	100% trenched
PL045	N0303	24	4.6	Laid on the seabed with some mattress at BB end			100% trenched
PL046	N0304	20	4.0	Laid on the seabed			100% trenched
PL047	N0404	30	4.4	Laid on the seabed with mattresses at BC end			100% trenched
PL048	N0302	16	2.3	Laid on the seabed.			Predominantly trenched 510 tonnes of rockdump added
PL049	N0301	16	2.8	Laid on the seabed with occasional mattresses			Predominantly trenched 510 tonnes of rockdump added
PL050	N0401	28	3.0	Laid on the seabed, rock-dump at flare end			Predominantly trenched 255 tonnes of rockdump added
PL051	N0402	36	2.6	Laid on the seabed, rock-dump at flare end			100% trenched
PL052	N0403	36	2.3	Laid on the seabed with mattresses at BA and 112 m of rock-dump and supported by grout bags			Predominantly trenched 510 tonnes of rockdump added
PL4730	N9903 A	24	1.7	Laid on the seabed, some buried sections			100% trenched
PL4730	N9903 B	24	2.9	Laid on the seabed, with some buried sections			100% trenched

9.6.4 Discussion of the Recommended Option for the Quantitative Pipelines to be Decommissioned by Trench and Backfill

Introduction

The recommended option for twelve of the fourteen quantitative lines (Table 25) is 'Disconnect, remove tie-in spools, trench and backfill'. Three to six options were assessed in the CAs for these lines (Table 26). The results of the CAs for each of the twelve lines to be decommissioned by Option 4 'Disconnect, trench and backfill' are shown in Table 26.

Table 26 Total Weighted Scores of Options for the 12 Quantitative Lines to be Decommissioned by Option 4 'Disconnect, Trench and Backfill'.

Pipeline Number	Total Weighted Score in Options								
	1	2	3	4	5	6	7	8	9
PL002B/N0201		82.61	83.83	82.66	85.75	83.07	73.34		
PL044/N0405	82.11			82.37	83.98	83.32	72.82		
PL045/N0303	84.10			82.27	83.86	82.55	72.50		
PL046/N0304	81.41			82.42	84.07	83.42	72.89		
PL047/N0404	83.97			82.27	83.88	83.04	72.58		
PL048/N0302		83.55	84.80	82.33	85.07	83.13	73.23		
PL049/N0301		82.54	83.97	82.24	84.53	83.11	73.21		
PL050/N0401	79.53			81.78	84.01	82.60	72.73		
PL051/N0402	84.11			82.06	84.80	82.35	72.47		
PL052/N0403	82.54			82.77	85.50	83.64	73.17		
PL4730/N9903A				82.45	85.36	82.47			
PL4730/N9903B				82.40	84.72	82.44			

Option 1	Leave *in situ* with no further remediation required
Option 2	Leave tied-in at platform; remote end trenched
Option 3	Leave tied-in at platform; remote end rock-dumped
Option 4	Disconnect from platforms/infrastructure, trench and backfill the whole length
Option 5	Disconnect from platforms/infrastructure, rock-dump the whole length
Option 6	Recover whole length by cut and lift
Option 7	Recover whole length by reverse S-lay (single joint)
Option 8	Partially trench and backfill, with isolated rock-dump
Option 9	Partially rock-dump

Option 7 'Recover whole line by reverse S-lay (single joint)' is a feasible option for ten of these twelve lines, but in every case it clearly had the lowest total weighted score and was never a candidate for the 'CA-recommended option'.

For all of these lines except PL045/N0303 and PL047/N0404 the option with the highest total weighted score (and thus the presumptive CA-recommended option) was Option 5 'Disconnect and rock-dump whole length'. In all cases, however, we have proposed Option 4 'Disconnect, and trench and backfill whole length' as the Recommended Option, an option which for seven of the lines had the lowest total weighted score. Our recommendation is based on a consideration of the relative performances of the options, the raw data and the views of our stakeholders including commercial fishermen..

Results: Pipeline PL050/N0401, the 28 inch, 3 km long flare gas line from Brent Alpha to the site of the former Brent Flare, has been selected as an example of the CA results for those lines where the recommended decommissioning option is Option 4 'Disconnect, trench and backfill'.

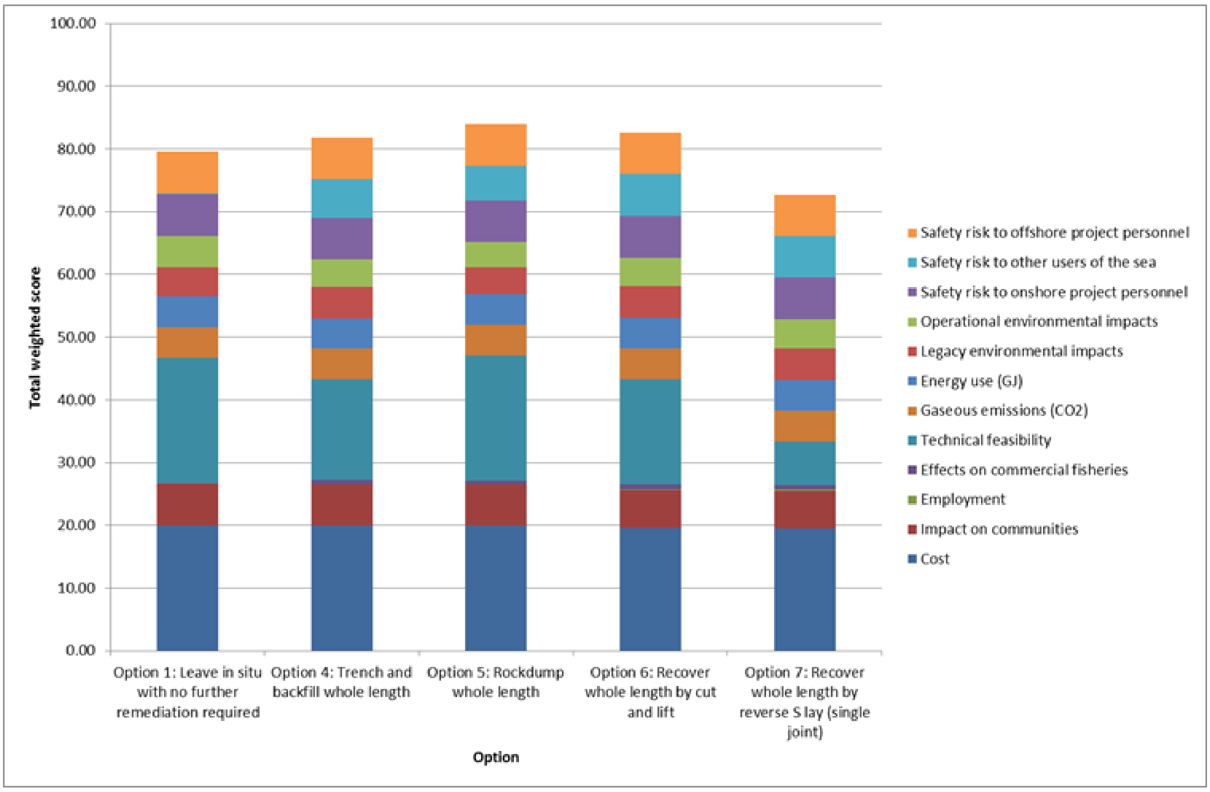
Table 27 shows the total weighted scores of the options for PL050/N0401 and Figure 12 illustrates the results. On the basis of this assessment the 'CA-recommended' option for PL050/N0401 is Option 5 'Disconnect and rock-dump whole length'. It has a total weighted score of 84.01 in contrast to the next best score which is 82.60 for Option 6 'Recover whole length by cut and lift'. The narrative below, however, explains why Option 4 was recommended in preference to either Option 5 or Option 6.

Table 27 Transformed and Weighted Sub-criteria Scores for Pipeline PL050/N0401.

Sub-criterion	Option 1	Option 4	Option 5	Option 6	Option 7
Safety risk to offshore project personnel	6.66	6.65	6.66	6.59	6.54
Safety risk to other users of the sea	0.10	6.13	5.59	6.67	6.67
Safety risk to onshore project personnel	6.67	6.67	6.67	6.66	6.66
Operational environmental impacts	5.00	4.30	3.95	4.60	4.65
Legacy environmental impacts	4.65	5.00	4.25	5.00	5.00
Energy use	4.89	4.88	4.87	4.88	4.88
Emissions	4.90	4.89	4.89	4.91	4.91
Technical feasibility	20.00	16.00	20.00	16.80	7.00
Effects on commercial fisheries	0.00	0.71	0.57	0.71	0.71
Employment	0.01	0.02	0.02	0.12	0.15
Impact on communities	6.67	6.60	6.60	6.00	6.00
Cost	19.97	19.93	19.94	19.65	19.54
Total weighted score	79.53	81.78	84.01	82.60	72.73

Option 1	Leave *in situ* with no further remediation required
Option 4	Disconnect from platforms/infrastructure, trench and backfill the whole length
Option 5	Disconnect from platforms/infrastructure, rock-dump the whole length
Option 6	Recover whole length by cut and lift
Option 7	Recover whole length by reverse S-lay (single joint)

Figure 12 The Total Weighted Scores for Options for Pipeline PL050/N0401, and the Contributions of the Sub-criteria.



No strong driver has been identified as the reason for the differences in the total weighted scores under the different weighting scenarios. Option 5 'Rock-dump whole length' is usually ranked first in the sensitivity scenarios though it never scores significantly higher than Option 6 'Recover whole length by cut and lift' or most of the other options. The determination of the recommended option for this pipeline has been based on the comparison between the best full removal option Option 6 'Recover whole length by cut and lift', and the CA-recommended option Option 5 'Rock-dump whole length'. The differences between Option 5 and Option 6 are illustrated in Figure 13. The green bars indicate sub-criteria where Option 5 has the better performance and the red bars indicate sub-criteria where Option 6 has the better performance.

Figure 13 Difference Chart Comparing the Weighted Scores for Each Sub-criterion of Option 5 'Rock-dump Whole Length' with Option 6 'Recover Whole Length by Cut and Lift', under the Standard Weighting, for Pipeline PL050/N0401.

Green bars: Option 5 'Rock-dump whole length' is better than Option 6 'Recover whole length by cut and lift'

Red bars: Option 6 'Recover whole length by cut and lift' is better than Option 5 'Rock-dump whole length'

Option 6 'Recover whole length by cut and lift' is preferable to Option 5 'Rock-dump whole length' in seven sub-criteria: safety risk to other users of the sea, legacy and operational environmental impacts, effects on commercial fisheries, employment and gaseous emissions and energy use. It should be noted that some of these differences are so small that the bars do not appear in Figure 13. Option 5 is preferable to Option 6 in the five remaining sub-criteria: safety risk to onshore and offshore project personnel, cost, impact on communities and technical feasibility; again some of the differences are so small that the bars do not appear on the difference chart.

It is important to examine these differences to see if the differing performance of the options is related to significant and material differences in the raw data in the various sub-criteria. The following sections discuss the performances of the options in each of the sub-criteria in turn as ordered in Figure 13, and determine the extent to which the differences could assist us in reaching a recommendation for PL050/N0401.

Technical Feasibility: The rock-dumping in Option 5 was assessed to be one of the most feasible operations considered by the project (hence the score of 1.0) and to be more feasible than the cut and lift operations in Option 6 (a score of 0.84). Rock-dumping is a routine operation in the industry and there are no concerns about our ability to successfully execute the option. The cutting and lifting of pipeline sections required in Option 6 is a relatively common operation in the industry, but the score was reduced because of the age of the pipeline and some concerns over whether the concrete coating would have sufficient strength to be recovered without spalling off the steel pipeline. Option 6 may require some development of existing technologies and although not insurmountable this will add complexity to the execution of the option. Any problems encountered with the removal of the pipeline in Option 6 are therefore more likely to result in extended operations and hence increased overall cost. As a result, technical feasibility does not, in our view, act as a strong differentiator of the options.

Impact on Communities: In Option 5 and in Option 6 respectively approximately 38 tonnes and 2,180 tonnes of material would be returned to shore. These are relatively small amounts of material and would not be expected to cause any significant onshore impacts, particularly when compared with the amounts of material that will be returned to shore from other scopes of work in the project. Accordingly, both options were scored highly on global scale (0.99 for Option 5 and 0.90 for Option 6). With no significant difference in their scores and relatively small amounts of material being returned to shore, we have concluded that the sub-criterion 'impact on communities' is not a strong differentiator between these options.

Cost: With an estimated cost of approximately £1.6 million, Option 5 'Rock-dump whole length' is approximately 17% of the £9.28 million cost of Option 6 'Recover whole length by cut and lift'. Option 6 therefore represents almost a six-fold increase in the expenditure of Option 5. Cost should therefore be considered further in this assessment.

Safety Risk to Project Personnel: Option 5 has the lowest combined safety risk for project personnel (a PLL of 0.0005) whereas Option 6 has a combined project personnel PLL of 0.0034. The majority of the risk in both options is attributable to offshore project personnel. This means that if Option 5 were performed 2,000 times there might be one fatality among the project personnel and if Option 6 were performed 294 times there might be one fatality among the project personnel.

When compared with the PLL thresholds used in the first step of evaluating E&P projects (an annual PLL of1 $\times 10^{-3}$), the total PLL for Option 5 (0.5 $\times 10^{-3}$) falls within the ALARP range. Option 6 is three times higher (3.4 $\times 10^{-3}$) than the threshold and would require some degree of mitigation prior to execution to confirm it was ALARP.

In all cases the assessments of safety risks are unmitigated assessments made in the absence of any site- or project-specific safety measures. We would not knowingly embark on any activity that was unsafe and we always work to reduce all safety risks to a level that is ALARP. Given the conservative (unmitigated) PLLs presented here we are confident that both options could be executed safely and have therefore concluded that the sub-criterion 'safety risk to project personnel' does not act as a differentiator between Option 5 and Option 6.

Energy Use and Emissions: Option 5 'Rock-dump whole length' would use more energy (45,171 GJ) than Option 6 (41,386 GJ)(an increase of about 9%) as a result of the vessels used and the penalty for not recycling the steel contained within the pipeline. Even though the steel would be recycled in Option 6 this option would still require 92% of the energy required for Option 5. On the basis of these estimates we have concluded that the sub-criterion 'energy use' does not act as a differentiator between the two options.

Option 5 would also generate about 25% more gaseous emissions (a total of 3,430 tonnes CO_2) than Option 6 (2,742 CO_2 tonnes). Both these values are low when compared to the emissions from operating platforms. The total CO_2 emissions from all four Brent platforms in 2011 was 396,000 tonnes, which is approximately 115 times higher than the estimated total CO_2 emissions of Option 5 or approximately 144 times higher than those of Option 6. The estimated emissions from each option are also very low when compared with the total CO_2 emissions from all UKCS oil and gas platforms (which, as reported in the Oil & Gas UK *Environment Report 2013* [26] was 14.22 million tonnes in 2011) and when compared with the UK commitment under the *Climate Change Act* [27] (which implies an average annual reduction of 47.6 million tonnes CO_2 each year from 2013 to 2017). Given the small amounts of emissions associated with Option 5 and Option 6 we have concluded that the sub-criterion 'emissions' is not a strong differentiator between the options.

Employment: Option 6 is more expensive than Option 5 and therefore supports a higher level of employment (37 man-years as opposed to 6 man-years). The employment supported in Option 5 would only be in offshore roles during the rock-dumping operations; the employment in Option 6 would be split between offshore (cut and lift operations) and onshore (recycling of the material). In absolute terms these levels of employment are not significant; the employment would not be continuous and would not support roles full-time. The level of employment supported by Option 5 and Option 6 is equivalent to less than 1 % of the estimated 3,800 man-years of employment Brent Decommissioning well abandonment programme. Consequently, we have concluded that the sub-criterion 'employment' is not a strong differentiator between the options.

Effects on Commercial Fisheries: If the lines were covered with rock-dump (Option 5) or removed completely (Option 6) a small additional area of seabed would be available for demersal fishing. Based on information in [11] this would amount to a net benefit over the 280 year predicted lifetime of the pipeline of £197,230 and £246,538 for Option 5 and Option 6 respectively. On an annual basis this represents a very small increase (£704 and £880 each year respectively) so in absolute terms of benefit to commercial fishermen and in relative terms between the options, this is a small benefit. This sub-criterion is therefore not considered to be a strong differentiator between Option 5 and Option 6.

Operational Environmental Impacts: Option 6 would result in the minor disturbance of seabed sediments as the pipeline is cut into sections and removed. It is expected that the short and limited nature of the disturbance would allow the rapid recovery of the seabed and benthic fauna, hence Option 6 scored highly on the global scale (0.92). The seabed would also be disturbed in Option 5 by the deposition of the new rock-dump. This would probably result in a larger area of disturbance in order to create the over-trawlable profile of the deposited rock and so for pipeline PL050/N0401 this option had the lowest score of all the options in this sub-criterion (0.79). Neither option is expected to result in significant environmental impacts nor is the difference in the assessment of such impacts for the options very great, so this sub-criterion is not considered to act as a strong differentiator between the options.

Legacy Environmental Impacts: The full removal of the pipeline in Option 6 will completely eliminate the legacy environmental impacts which might occur as the pipeline degrades and disintegrates. It was therefore accorded the highest score on the global scale (1.00). In Option 5 the pipeline and any disintegration products and hence environment impacts, including seabed litter, would be contained within the rock-dump and the effects would therefore be limited. The addition of the rock in Option 5 would have the potential to cause environmental changes as a result of the local change in habitat and colonisation by different species more typical of rocky substrates. DNV GL did not consider this impact to be significant, however, because areas of hard substrate are already present in the Field; the Brent seabed is known to be littered with rocks and boulders in various places. The score for Option 5 has been reduced to 0.85 because of the amount of rock to be used in this option (51,000 tonnes). Overall, no significant environmental impacts are expected to occur and we have concluded that the sub-criterion 'legacy environmental impacts' is not a strong differentiator between the options.

Safety Risks to Other Users of the Sea: The other users of the sea who would be exposed to safety risks from the pipelines are fishermen who might trawl over the pipelines and snag their fishing gear. We commissioned Anatec to assess the potential safety risks to fishermen for the decommissioning options [10]). These assessments assumed that all the safety zones around subsea infrastructure had been removed and as such were a worst-case assessment. In Option 6, the pipeline would be removed and any risk to the fishermen would be eliminated. The total PLL for fishermen in Option 5 was calculated to be 0.0428 which means that if pipeline PL050/N0401 were to be decommissioned 23 times by covering in rock-dump, there might be one fisherman fatality over the predicted lifetime of the pipeline (280 years). Anatec estimated that the annual PLL in Option 5 for this pipeline was 7.14×10^{-5} which, when compared to the annualised PLL threshold for oil and gas industry E&P projects (1×10^{-3}), is well within the tolerable range.

There have been no reported incidents of fishing gear interactions or accidents during the time this pipeline has been in place. We will remain responsible for any section pipeline which remains *in situ* and we will ensure that any section of any pipeline which remains above the mean seabed level is marked on navigational charts and is registered in the FishSAFE database used by commercial fishing vessels. Although the sub-criterion 'safety risks to other users of the sea' is a differentiator between Option 5 and Option 6, the potential risk to fishermen in Option 5 is considered to be acceptable.

Conclusion: Following the assessment of the weighted scores for each sub-criterion and an examination of the data informing those scores we have concluded that there are no strong drivers that differentiate the two best-performing options, Option 5 and Option 6. The supporting data do show differences, however, particularly in the sub-criterion 'safety risk to other users of the sea' (fishermen), although the risk to fishermen in both options is low or eliminated. Estimating the long-term safety risk for fishermen is complex and uncertain. In addition, the assessment of safety risk used in the CA assumed that the 500 m safety zone around the Brent Alpha platform would no longer be in place. In reality, if derogation from the OSPAR 98/3 Decision were granted for the Brent Alpha jacket footings, we would apply to the HSE for the 500 m safety zone to remain in place. Overwhelmingly, the assumptions used in the calculations of safety risk to other users of the sea have been conservative, and we believe that their individual and combined effects have been to over-estimate the likelihood that fishing gear will snag on degrading pipelines on the seabed and that snaggings will lead to accidents and that accidents will lead to fatalities. The risks to fishermen are, however, less amenable to mitigation than those to project personnel. They are not under the control of the project and would be reduced mainly by the application of good navigation practice and seamanship, by the use of present and future aids to navigation and by the use and maintenance of systems such as FishSAFE.

Option 6 would completely eliminate any future safety risk to fishermen but this would require an expenditure of £9.28 million which is a significant increase in expenditure when compared with either Option 5 'Rock-dump whole length' or Option 4 'Trench and backfill whole length', which is the remaining affordable option that would significantly reduce the long-term safety risk to other users of the sea. When the performances in all other sub-criteria show no significant differences, cost can be considered to be a driver. Mindful of the views expressed by the SFF during informal discussions, however, we wished to investigate if a more cost-efficient compromise could be achieved between reducing safety risk to other users (fishermen) and project expenditure. To this end, the data for Option 4 'Trench and backfill whole length' were re-examined because this option would result in a halving of the potential safety risk to fishermen

In Option 4 the potential safety risk to fishermen over the predicted lifetime of the pipeline is half that estimated for Option 5 (PLLs of 0.0214 and 0.0428 respectively). This reduction in the PLL would be accompanied by a slight increase in the safety risk to project personnel (from a PLL of 0.0005 in Option 5 to a PLL of 0.0009 in Option 4, but this is not a significant increase and we are confident that the risk to project personnel in Option 4 could be demonstrated to be ALARP. Trenching and backfilling the pipeline would have an increased operational environmental impact when compared to Option 6because there would be greater disturbance of the seabed sediments, but Option 4 would have less of an operational impact compared with Option 5. Once operations were completed the pipeline would be entirely buried and this would minimise the legacy impacts of the degrading pipeline (as rock-dumping would in Option 5) but without the potential for altering the seabed habitat by the use of a large volume of additional rock. Option 4 therefore performs better than Option 5 in the sub-criterion 'legacy environmental impact', achieving the highest possible score (1.0) on the global scale. This is the same score as Option 6 'Recover whole length by cut and lift', but it is noted that there is a difference between a negligible impact in Option 4 and the absence of an impact in Option 6.

In Option 4 the trenching of the pipeline would use slightly more energy and generate slightly more gaseous emissions than Option 6 because the pipeline material would not be returned to shore, but it would use less energy and generate less gaseous emissions than Option 5. These differences in the calculated values are, however, small.

Because of the changeable and difficult seabed conditions known to exist in the Brent Field, trenching the pipeline is thought to be slightly more difficult than removing it by cut and lift or rock-dumping the whole length. The difference in feasibility is not great, however, and Option 4 still scores relatively highly on the global scale in this sub-criterion (0.80).

Recommendation for Pipeline PL050/N0401: Option 4 presents what we believe to be a balanced recommendation in which the concerns of our stakeholders can be addressed with only a minimal increase in the safety risk to our own project personnel, which remains at a level within the tolerable range. Although Option 4 would not completely remove the legacy environmental impact as in Option 6, it would result in less of an impact than Option 5. This more desirable outcome can be achieved with a marginally greater operational environmental impact than Option 6 and a smaller operational impact than Option 5. Once the pipeline is trenched, the additional area available for fishing would be the same as would be available if the pipeline had been removed. These benefits can be achieved with a very minor increase in project expenditure when compared with Option 5 (approximately £15,000) as opposed to the significant cost required to remove the pipeline completely. We have therefore concluded that the recommended decommissioning option for PL050/N0401 is Option 4 'Trench and backfill whole length'.

9.6.5 Discussion of the Recommended Option for the Quantitative Pipeline to be Left Partially Trenched and Backfilled with Isolated Rock-dump.

Results: This is the recommended option for one line PL001/N0501, the 30 inch 35.9 km export line. Five options were considered for this line (Table 24). Table 28 shows the total weighted scores of the options for this line and Figure 14 illustrates the results. On the basis of this assessment the 'CA-recommended' option for PL001/N0501 is Option 8 'Partially trench and backfill, with isolated rock-dump'. It has a total weighted score of 81.42 in contrast to the next best score which is 80.89 for Option 6 'Recover whole length by cut and lift'.

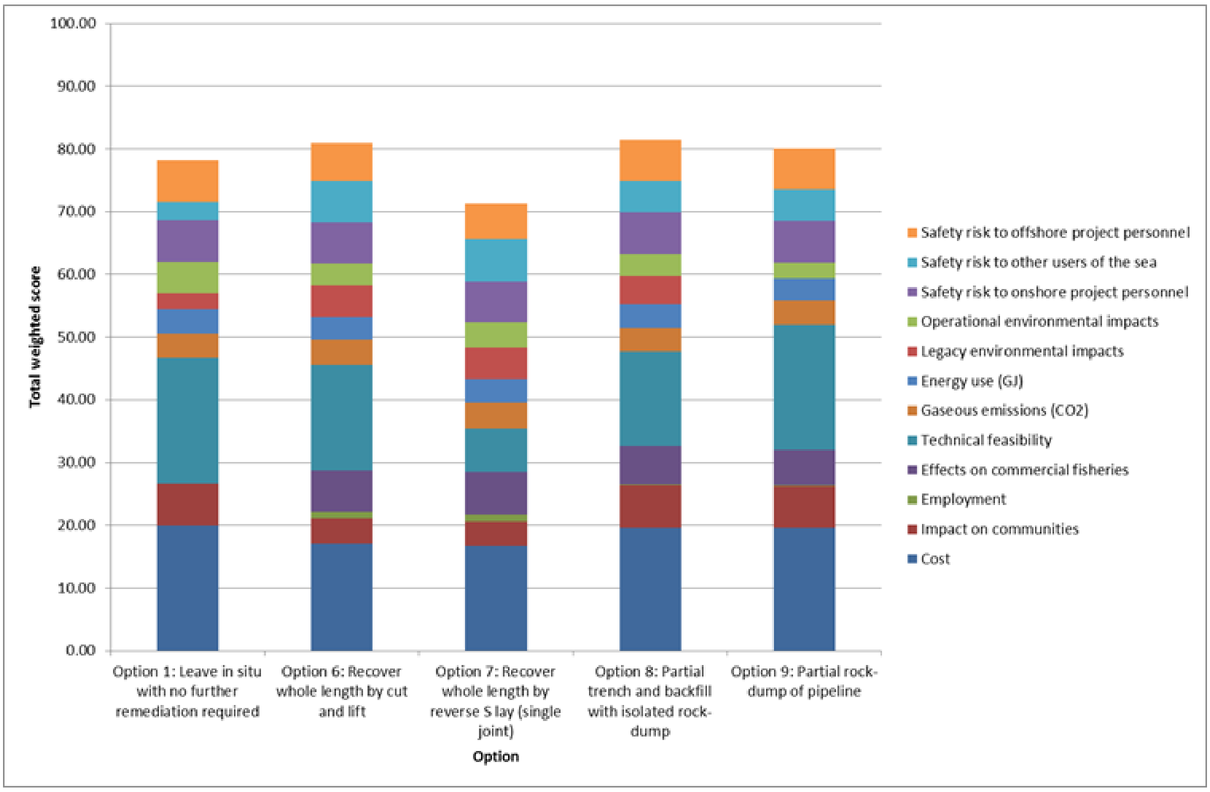
It should be noted that Shell and Esso own this pipeline from the Brent Charlie platform to the 30 "riser tie-in spool piece near the base of the Cormorant Alpha platform. Decommissioning of the vertical risers between this point and the Cormorant Alpha topsides is not the responsibility of Shell and Esso. The vertical section of PL001/N0501 from the subsea tie-in spool at the base of Brent Charlie to the topsides is contained within the Brent Charlie GBS; the vertical section of the pipeline will be decommissioned in situ.

Table 28 Transformed and Weighted Sub-criteria Scores for Pipeline PL001/N0501.

Sub-criterion	Option 1	Option 6	Option 7	Option 8	Option 9
Safety risk to offshore project personnel	6.64	5.91	5.64	6.54	6.56
Safety risk to other users of the sea	2.88	6.67	6.67	5.02	4.94
Safety risk to onshore project personnel	6.67	6.61	6.61	6.67	6.67
Operational environmental impacts	5.00	3.50	4.00	3.50	2.50
Legacy environmental impacts	2.50	5.00	5.00	4.50	0.00
Energy use	3.82	3.66	3.79	3.67	3.59
Emissions	3.97	3.98	4.08	3.86	3.81
Technical feasibility	20.00	16.80	7.00	15.00	20.00
Effects on commercial fisheries	0.00	6.67	6.67	6.23	5.60
Employment	0.01	0.96	1.12	0.12	0.15
Impact on communities	6.67	4.00	4.00	6.67	6.67
Cost	19.97	17.13	16.65	19.64	19.56
Total weighted score	78.13	80.89	71.22	81.42	80.04

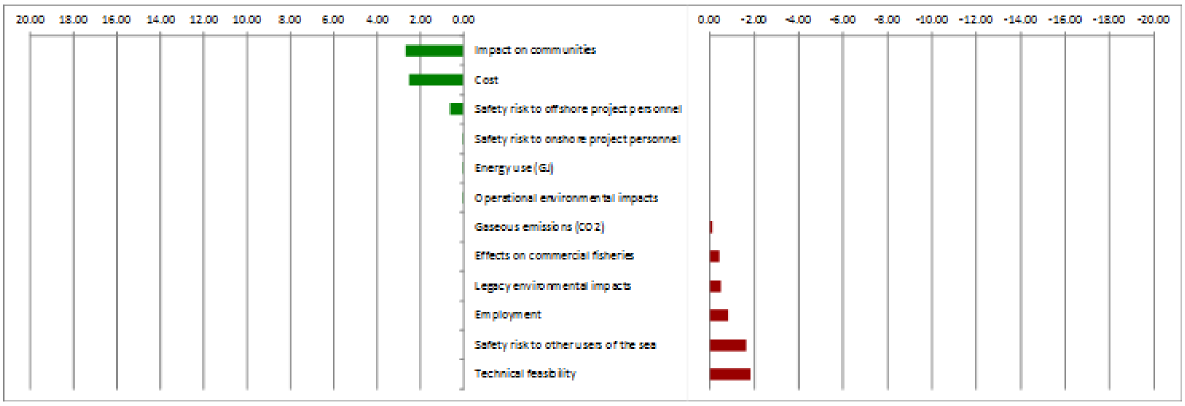
Option 1	Leave *in situ* with no further remediation required
Option 6	Recover whole length by cut and lift
Option 7	Recover whole length by reverse S-lay (single joint)
Option 8	Partial trench and backfill, with isolated rock-dump
Option 9	Partial rock-dump of pipeline

Figure 14 The Total Weighted Scores for Options for Pipeline PL001/N0501, and the Contributions of the Sub-criteria.



No strong drivers have been identified under any of the weighting scenarios. Option 6 'Recover whole length by cut and lift' is often ranked first under the six weighting scenarios but it never scores significantly higher than Option 8 'Partial trench and backfill with isolated rock-dump'. This is illustrated in Figure 15 which shows that Option 6 performs marginally better than Option 8 across a number of sub-criteria rather than there being any strong drivers for the performance of either option. The green bars indicate sub-criteria where Option 8 has the better performance and the red bars indicate sub-criteria where Option 6 has the better performance.

Figure 15 Difference Chart Comparing the Weighted Scores for Each Sub-criterion of Option 6 'Recover Whole Length by Cut and Lift' with Option 8 'Partial Trench and Backfill with Isolated Rock-dump', under the Standard Weighting, for Pipeline PL001/N0501.



Green bars: Option 8 'Partial trench and backfill with isolated rock-dump' is better than Option 6 'Recover whole length by cut and lift'

Red bars: Option 6 'Recover whole length by cut and lift' is better than Option 8'Partial trench and backfill with isolated rock-dump'

Conclusion: Following the assessment of the weighted scores for each sub-criterion and an examination of the data informing those scores we have concluded that there are no strong drivers that differentiate Option 6 and Option 8. PL001/N0501 is the longest pipeline in the Brent Field, however, and the implications of the pipeline to commercial fishermen must be considered. Estimating the long-term safety risk for fishermen is complex and uncertain. Particularly in respect to commercial fishing activity and pipeline degradation, several important assumptions had to be accepted, and forecasts made going hundreds of years into the future. These assumptions have been intended to be conservative, and we believe that their individual and combined effects have been to over-estimate the likelihood that fishing gear will snag on degrading pipelines on the seabed and that snaggings will lead to accidents and that accidents will lead to fatalities. The risks to fishermen, however, are less amenable to mitigation than those to project personnel. They are not under the control of the project and would be reduced mainly by the application of good navigation practice and seamanship, by the use of present and future aids to navigation, and by the use and maintenance of systems such as FishSAFE. Despite the fact that there have been no incidents involving this pipeline during its lifetime we would prefer to take steps to reduce even a theoretical risk to third-parties, and by trenching and rock-dumping the pipeline we would reduce the risk currently associated with this pipeline. Although the risks could be completely eliminated by removing the pipeline by, for example, cut and lift, this would incur an increase in cost of £67 million which is a disproportionate expenditure to reduce a theoretical risk.

Recommendation for pipeline PL001/N0501: There have been no incidents involving this pipeline in its current configuration, but we have limited influence on the future activities in the vicinity of the pipeline. The cost of completely removing this pipeline is, however, substantial. We therefore intend to complete extensive operations to reduce the theoretical future risk to fishermen by trenching and rock-dumping the shallow-trenched sections of this pipeline. The recommended decommissioning option for PL001/N0501 is Option 8 'Partial trench and backfill with isolated rock-dump'.

9.6.6 Discussion of the Recommended Option for the Quantitative Pipeline to be Removed Completely by Cut and Lift.

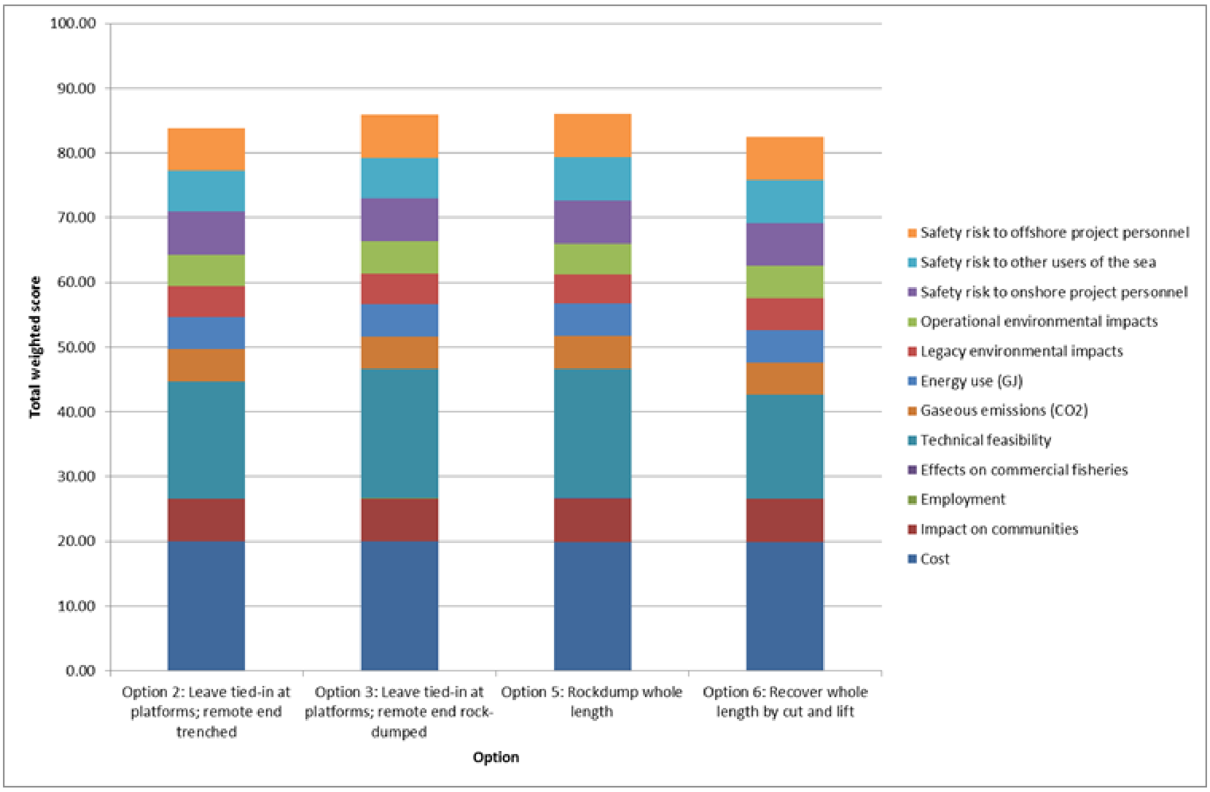
Results: This is the recommended option for PL017A-D/N0601 the short length (0.4 km) of 16 inch gas export lying exposed on the seabed at Brent Bravo. Four options were considered for this line (Table 24). Table 29 shows the total weighted scores of the options for this line and Figure 16 illustrates the results. On the basis of this assessment the 'CA-recommended option' for PL017A-D/N0601 is Option 5 'Rock-dump whole length'. The total weighted score for this option is 86.03. The next best performing option is Option 3 'Leave tied-in at platform, remote end rock-dumped' with a total weighted score of 85.89.

Table 29 Transformed and Weighted Sub-criteria Scores for Pipeline PL017A-D/N0601.

Sub-criterion	Option 2	Option 3	Option 5	Option 6
Safety risk to offshore project personnel	6.66	6.66	6.66	6.66
Safety risk to other users of the sea	6.23	6.23	6.67	6.67
Safety risk to onshore project personnel	6.67	6.67	6.67	6.67
Operational environmental impacts	4.95	4.95	4.75	4.90
Legacy environmental impacts	4.75	4.75	4.60	5.00
Energy use	4.98	4.98	4.98	4.98
Emissions	4.99	4.99	4.99	4.99
Technical feasibility	18.00	20.00	20.00	16.00
Effects on commercial fisheries	0.00	0.00	0.06	0.08
Employment	0.01	0.01	0.01	0.02
Impact on communities	6.67	6.67	6.67	6.60
Cost	19.97	19.97	19.96	19.94
Total weighted score	83.89	85.89	86.03	82.51

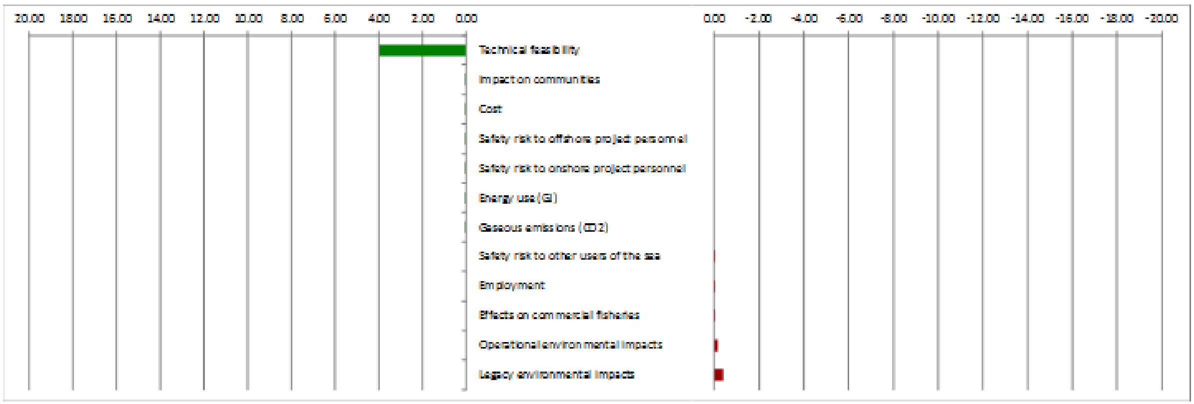
Option 2	Leave tied-in at platform; remote end trenched
Option 3	Leave tied-in at platform; remote end rock-dumped
Option 5	Disconnect from platforms/infrastructure, rock-dump the whole length
Option 6	Recover whole length by cut and lift

Figure 16 The Total Weighted Scores for Options for Pipeline PL017A-D/N0601, and the Contributions of the Sub-criteria.



No strong driver has been identified as the cause of the difference in the total weighted scores under the different weighting scenarios. Option 5 'Rock-dump whole length' is usually ranked first, though it never scores significantly higher than Option 3 'Leave tied-in at platform; remote end rock-dumped' or the other options. The determination of the recommended option for PL017A-D/N0601 has been based on the comparison of the best full removal option (Option 6 'Recover whole length by cut and lift' which is the only full removal option for this line) and the best-performing option based on the CA data (Option 5 'Rock-dump whole length'). The differences between Option 5 and Option 6 are illustrated in Figure 17. The green bars indicate sub-criteria where Option 5 has the better performance and the red bars indicate sub-criteria where Option 6 has the better performance. The difference chart shows that there are hardly any differences between the options except in terms of Technical Feasibility, where Option 5 'Rockdump whole length' has a better performance than Option 6 'Recover whole length by cut and lift'.

Figure 17 Difference Chart Comparing the Weighted Scores for Each Sub-criterion of Option 5 'Rock-dump Whole Length' with Option 6 'Recover Whole Length by Cut and Lift', under the Standard Weighting, for Pipeline PL017A-D/N0601



Green bars: Option 5 'Rock-dump whole length' is better than Option 6 'Recover whole length by cut and lift'

Red bars: Option 6 'Recover whole length by cut and lift' is better than Option 5 'Rock-dump whole length'

Conclusion: Following the assessment of the weighted scores for each sub-criterion and an examination of the data informing those scores, we have concluded that there are no strong drivers that differentiate Option 5 the best-performing option, and Option 6 the best full removal option. Bearing in mind the preference of the Scottish Fishermens' Federation (SFF) and the small difference in cost between Option 5 and Option 6 (approximately £500,000), we propose that this pipeline should be completely removed from the seabed.

Recommendation for pipeline PL017A-D/N0601: The recommended decommissioning option for PL017A-D/N0601 is Option 6 'Recover whole length by cut and lift'.

9.7 Recommended Programme of Work for Decommissioning the Brent Field Pipeline System

9.7.1 Introduction

The decommissioning of the Brent Field lines comprises the completion of seven different options across the Field (Table 22 and Table 25), which between them involve one or more of the following activities:

- Reverse reeling
- Cutting and lifting
- Trenching and backfilling
- Rock-dumping

This section describes, in general terms, the operations that would be carried out and the results that would be achieved on successful completion of each type of decommissioning activity. The operations that would be performed during these activities are likely to be broadly similar regardless of whether we categorised the line as 'qualitative' or 'quantitative'. Detailed programmes of work for each pipeline and for each pipeline crossing are presented in the Pipelines TD [5].

9.7.2 Subsea Cleaning and Preparatory Work

The Brent pipeline system will be decommissioned in a programme of work extending over several years. Initial phases will be carried out before the topsides are decommissioned with fluids and residues flushed from the pipes with waxy contents transported to shore for disposal. Once flushed, however, some lines may be left on the seabed for a time until they can be decommissioned in a cost-effective 'campaign'. As a result, the project will leave the pipelines filled with inhibited seawater to protect against corrosion. The projected schedule for completing the decommissioning of the Brent Field subsea infrastructure (pipelines, subsea structures and debris) is presented in Section 14.

Each of the Brent pipelines will be cleaned prior to decommissioning. The cleaning operations will be completed under the appropriate permits and reporting requirements. For those pipelines already submitted to the Interim Pipeline Regime (IPR), which have already been cleaned, we will confirm that the previous cleaning is sufficient under the present legislation. If so, no further cleaning will be undertaken.

Cleaning operations will include pigging operations, and chemical and seawater flushing, as determined by the content and configuration of the pipeline. Some pipelines are not connected to any pigging facilities and would require temporary pipework to be fitted or alternative arrangements to be made.

The intention is to clean the pipelines from one platform to another using the existing connections to push the pipeline contents through the system. Depending on the function of the pipeline and the nature of the contaminants found within the cleaning fluids, the waste at the receiving platform will either be stored in tanks and transported to shore for treatment and disposal, or discharged to sea under permit.

In cleaning the pipelines, we are required to demonstrate that BAT has been employed, and to this end we will de-oil or de-gas the pipeline before commencing cleaning operations. In 2016 we had the opportunity to trial our cleaning methodology with PL046/N0304 (the oil export line from Brent Delta to Brent Charlie) and PL044/N0405 (the gas export line from Brent Delta to Brent Charlie). Cleaning of these pipelines was required so that we could sever the pipelines at Brent Delta to allow the Brent Delta topside to be lifted away. At the time of the cleaning operation the final decommissioning recommendation for these pipelines had not been confirmed; we therefore intended to leave both these pipelines in such a condition that either a leave in place or full removal option was possible.

Full details of the proposed flushing operations on each Brent Field pipeline are presented in the Pipelines TD [5]. In summary, our proposed programmes for the three types of line are as follows:

- Oil pipelines will be treated using a mixture of seawater flushes and mechanical pigging runs. If flushing operations are insufficient we may consider using chemicals to assist in the removal of waxy deposits. When repeated sampling of the flush water indicates that a plateau in the concentration of oil-in-water (OIW) has been reached we will confirm with BEIS that flushing operations can stop. Any solids will be collected and returned to shore for treatment and disposal.
- Gas pipelines will be flushed. No heavy deposits are expected in these pipelines and so it is likely that flushing will successfully remove any free hydrocarbons from the pipeline. As with the oil pipelines, samples will be taken and when no further improvement in OIW concentrations are found a report will be sent to BEIS to confirm that flushing operations can be stopped.
- Umbilicals will flushed before being severed, capped and removed.

9.7.3 Pipeline Crossings

The recommended decommissioning option takes account of the presence of pipeline crossings, where one of our lines goes over or under one of our lines or a line belonging to another operator. Eighteen of the Brent Field pipelines cross or are crossed by pipelines or umbilicals owned by Shell or third-parties.

PL051/N0402 is crossed by PL4731/N9900, PLU4733/N9901 and PL4732/N9902. We propose to trench and backfill PL051/N0402 and to recover PL4731/N9900, PLU4733/N9901 and PL4732/N9902 by cut and lift. During these operations the two small metal bridges supporting PL4731/N9900 and PL4732/N9902 will also be recovered.

PL987A/N0738, PL987A.1-3/N0841 and PL988A/N0913 are all situated within trenches to a depth of burial of 0.6 m or more and are all crossed by third-party pipelines. The recommendation from our CAs is to leave our pipelines in place. The crossings therefore do not need to be dismantled.

The new GEP pipeline PL4493/N0610, which connects the new Brent Charlie GEP SSIV and the Brent Charlie platform, crosses three Penguin lines: PLU1903/N1845, PL1902/N0513 and PL2228/N1141. As PL4493/N0610 will be fully recovered, its presence will not impede the decommissioning of the Penguin pipelines. The GEP SSIV control umbilical PLU4494/N4870, between the GEP SSIV and the Penguins Production SSIV, crosses PLU1903/N1845 at the connection point at the Penguins Production SSIV. As PLU4494/N4870 will be fully removed, its presence will not impede the decommissioning of the Penguin pipelines.

The crossings of the seven remaining Shell pipelines are more complex and the details and proposed programmes of are presented in Table 30.

Where a pipeline crossing cannot be dismantled by the BDP and we intend to completely remove the pipeline section at the crossing, we will sever the pipeline a minimum of 25 m either side of the pipeline crossing which will ensure that we do not disturb the crossing or risk adversely affecting the live pipelines. If the owners of the third-party pipelines were permitted to remove the pipelines which cross over the Brent pipelines, we would return at a later date to collect the severed section of each pipeline for recycling or disposal onshore. If the owners of the third-party pipelines were permitted to leave their pipelines in place, we would consult with BEIS on the best course of action regarding the decommissioning of the lengths of Brent pipelines remaining in place.

Table 30 Pipeline Crossings to be Decommissioned after the Brent Field Pipelines Programme of Work.

Proposed Decommissioning Option	Pipeline Crossings						
	Crossing 1	Crossing 2	Crossing 3	Crossing 4	Crossing 5	Crossing 6	Crossing 7
PIPELINE PL001/N0501							
Partial trench and backfill	Crosses under Fairfield Energy power cable N1826 from Brent Charlie to Dunlin at KP 0.15. Crossing is mattressed (Note 1).	Crosses under Enquest 20 inch NLGP gas pipeline PL164/C0603 from Magnus to Brent Alpha at KP 5.46. Crossing is rock-dumped (Note 1).	Crosses under EnQuest 24 inch oil line PL139/C0503 from Magnus to Ninian Central at KP 8.56. Crossing is rock-dumped (Note 1).	Crosses under TAQA Bratani Ltd.10 inch gas line PL114/N0602 from North Cormorant to Welgas Junction at KP 30.98. Crossing is rock-dumped (Note 1).	Crosses under TAQA Bratani Ltd. umbilical PL118/N0801B from Cormorant A to Satellite well P1 at KP 34.42. Crossing is rock-dumped. (PL118/N0801B is listed in Shell imaps[13] as abandoned). (Note 1).	Crosses under TAQA Bratani Ltd. 2 x 3" flexible flowlines N0701A and B from Cormorant Alpha to Cormorant Satellite well P1 at KP34.6. Crossing is rock-dumped. (Both lines are listed in Shell imaps as abandoned). (Note 1).	Crosses under TAQA Bratani Ltd. umbilical PL169/N0803 from Cormorant A to Cormorant UMC at KP 35.9. (PL169/N0803 is listed in Shell imaps as abandoned and as being with line N0802). (Note 1).

Notes: 1. These Brent pipelines run underneath these third-party pipelines; the third-party pipelines must be taken out of use or removed before the Brent pipelines can be fully decommissioned.

[13] Imaps is Shell's Geographical Information System (GIS) for recording the status of all of its facilities

Table 30, continued Pipeline Crossings to be Decommissioned after the Brent Field Pipelines Programme of Work

Proposed Decommissioning Option	Pipeline Crossings		
	Crossing 1	Crossing 2	Crossing 3
PIPELINE PL017A-D/N0601			
Recover whole length by cut and lift	Crosses under BP 20 inch NLGP gas pipeline PL164/C0603A, from Magnus to Brent A at KP 41.2. Decommissioning of PL164/C0603A is the responsibility of BP. Before PL017A-D/N0601 can be removed, PL164/C0603A and the associated crossing must be removed (Note 1).	Crosses under Shell umbilical PLU4562/N0830 from Brent A to SSIV at KP 41.15. The crossing is formed of a concrete saddle and mattresses. The BDP will recover the concrete saddle and mattresses which form the crossing during the reverse-reeling of PLU4562/N0830 (Note 2).	Crosses over Shell hazardous drains line PL049/N0301 from Brent A to Brent Spar PLEM at KP 41.10. The crossing is formed by a large grout bag ramp. PL049/N0301 will be trenched and backfilled, therefore the crossing will be removed during the recovery of PL017/N0601 (Note 2).

Notes:
1. These Brent pipelines run underneath these third-party pipelines; the third-party pipelines must be taken out of use or removed before the Brent pipelines can be fully decommissioned
2. This work is the responsibility of the Brent Decommissioning Project (BDP).

Table 30, continued Pipeline Crossings to be Decommissioned after the Brent Field Pipelines Programme of Work

Proposed Decommissioning Option	Pipeline Crossings					
	Crossing 1	Crossing 2	Crossing 3	Crossing 4	Crossing 5	Crossing 6
PIPELINE PL045/N0303						
Trench and backfill whole length	Crosses under Shell 4 inch gas lift line PL2228/N1141 at KP 4.48. Decommissioning of PL2228/N1141 is the responsibility of Shell but not the BDP. Before PL045/N0303 can be decommissioned, PL2228/N1141 and the crossing must be removed (Note 3).	Crosses under Shell 30 inch gas line PL047/N0404 at KP 4.56. The lengths of PL045/N0303 and PL047/N0404 between the GEP export line PL4492/N0610 and the Brent Charlie platform are too short to trench; these sections will be recovered by cut and lift (Note 4).	Crosses under Shell umbilical PLU2232/N1845 at KP 4.55. The crossing is mattressed. Decommissioning of PLU2232/N1845 is the responsibility of Shell but not the BDP. Before PL045/N0303 can be decommissioned, PLU2232/N1845 and the crossing must be removed (Note 4).	Crosses under Shell 4 inch gas lift line PL2228/N1141 at KP 4.52. The crossing is mattressed. Decommissioning of PL2228/N1141 is the responsibility of Shell but not the BDP. Before PL045/N0303 can be decommissioned, PL2228/N1141 and the crossing must be removed (Note 4).	Crosses under Shell umbilical N1845 at KP 4.48. The crossing is mattressed. Decommissioning of PLU2232/N1845 is the responsibility of Shell but not the BDP. Before PL045/N0303 can be decommissioned, PLU2232/N1845 and the crossing must be removed (Note 4).	Crosses under 7 km GEP pipeline, PL4492/N0601 (KP 0.196). Decommissioning of PL4492/N0610 is the responsibility of the Shell Penguins asset and not the BDP. Responsibility for decommissioning the section of PL045/N0303 which will remain under the rock-dumped crossing will transfer to the Penguins decommissioning team (Note 3).

Notes: 3. This crossing is the responsibility of Shell U.K. Limited but not the Brent Decommissioning Project.

4. The crossings of these pipelines may be covered by a significant amount of drill cuttings. Should this be the case the crossings and the associated lengths of pipeline will remain in place to prevent disturbance of the drill cuttings. Full details are presented in the programme of work descriptions for these pipelines.

Table 30, continued Pipeline Crossings to be Decommissioned after the Brent Field Pipelines Programme of Work

Proposed Decommissioning Option	Pipeline Crossings		
	Crossing 1	Crossing 2	Crossing 3
PIPELINE PL047/N0404			
Trench and backfill whole length	Crosses over PL045/N0303 at KP 0.010 between the GEP line PL4492/N0610 and the Brent Charlie platform. These sections of PL045/N0303 and PL047/N0404 are too short to trench; both pipeline sections will be recovered by cut and lift.(Note 4).	Crosses under PL2228/N1141 at KP 0.050 between the GEP line PL4492/N0610 and the Brent Charlie platform. Decommissioning of PL2228/N1141 is the responsibility of Shell but not the BDP. Before this section of PL047/N0404 can be recovered by cut and lift, PL2228/N1141 and the mattresses at the crossing must be removed (Note 3).	Crosses under 7 km GEP pipeline PL4492/N0610 (KP 0.148). Decommissioning of PL4492/ N0610 is the responsibility of the Shell Penguins asset and not the BDP. Responsibility for decommissioning the section of PL047/N0404 which will remain under the rock-dumped crossing will transfer to the Penguins decommissioning team (Note 3).

Notes: 3. This crossing is the responsibility of Shell U.K. Limited but not the Brent Decommissioning Project.

4. The crossings of these pipelines may be covered by a significant amount of drill cuttings. Should this be the case the crossings and the associated lengths of pipeline will remain in place to prevent disturbance of the drill cuttings. Full details are presented in the programme of work descriptions for these pipelines.

Table 30, continued Pipeline Crossings to be Decommissioned after the Brent Field Pipelines Programme of Work

Proposed Decommissioning Option	Pipeline Crossings
	Crossing 1
PIPELINE PL048/N0302	
Trench and backfill whole length	Crosses under 7 km GEP pipeline PL4492/N0610(KP 0.491). Decommissioning of PL4492/ N0610 is the responsibility of the Shell Penguins asset and not the BDP. Responsibility for decommissioning the section of PL048/N0302 which will remain under the rock-dumped crossing will transfer to the Penguins decommissioning team (Note 3).

Notes: 3. This crossing is the responsibility of Shell U.K. Limited but not the Brent Decommissioning Project.

Table 30, continued Pipeline Crossings to be Decommissioned after the Brent Field Pipelines Programme of Work

Proposed Decommissioning Option	Pipeline Crossings					
	Crossing 1	Crossing 2	Crossing 3	Crossing 4	Crossing 5	Crossing 6
PIPELINE PL049/N0301						
Trench and backfill whole length	Crosses under Shell 16 inch gas line PL017A-D/N0601 at KP 0.046 to KP 0.055. The crossing is formed with a large grout bag ramp. PL017A-D/N0601 will be removed by cut and lift, so the crossing will be dismantled and the material removed (Note 2).	Crosses under Shell umbilical PLU4562/N0830 at KP 0.127 to KP 0.131. The crossing is mattressed. During the reverse reeling of PLU4562/N0830 the four mattresses at the crossing will be recovered. The length of PL049/N0301 between the GEP export line PL4492/N0610 and the Brent Alpha platform is too short to trench; this section will be recovered by cut and lift (Note 2, 3).	Crosses under BP umbilical C0815 at KP 0.179 to KP 0.182. The crossing comprises two mattresses. Decommissioning of C0815 is the responsibility of BP. Before PL049/N0301 can be decommissioned, the crossing and C0815 must be removed (Note 1).	Crosses under disused BP umbilical C0801 at KP 0.189. The crossing is formed by a small grout bag ramp. Decommissioning of C0801 is the responsibility of BP. Before PL049/N0301 can be trenched, the crossing and C0801 must be removed; however, the 7 km GEP pipeline PL4492/N0610 was installed over this crossing. Whilst the decommissioning of the section of PL049/N0301 under the GEP pipeline will transfer to the Penguins decommissioning team, the ultimate fate of this crossing and the associated sections of pipelines will have to be agreed with BP. (Note 1, 3).	Crosses under 20 inch BP NLGP pipeline PL164/C0603A at KP 0.200 to KP 0.207. The crossing comprises eight mattresses. Decommissioning of C0603A is the responsibility of BP. Before PL049/N0301 can be trenched, the crossing and PL164/C0603A must be removed; however, the 7 km GEP pipeline PL4492/N0610 was installed over this crossing. Whilst the decommissioning of the section of PL049/N0301 under the GEP pipeline will transfer to the Penguins decommissioning team, the ultimate fate of this crossing and the associated sections of pipelines will have to be agreed with BP. (Note 1, 3).	Crosses under the 7 km GEP pipeline PL4492/N0610 (KP 0.207). Decommissioning of PL4492/N0610 is the responsibility of the Shell Penguins asset and not the BDP. Responsibility for decommissioning the section of PL049/N0301 which will remain under the rock-dumped crossing will transfer to the Penguins decommissioning team (Note 3).

Notes:
1. These Brent pipelines run underneath these third-party pipelines; the third-party pipelines must be taken out of use or removed before the Brent pipelines can be fully decommissioned.
2. This work is the responsibility of the Brent Decommissioning Project (BDP).
3. This crossing is the responsibility of Shell U.K. Limited but not the Brent Decommissioning Project.

Table 30, continued Pipeline Crossings to be Decommissioned after the Brent Field Pipelines Programme of Work

Proposed Decommissioning Option	Pipeline Crossings		
	Crossing 1	Crossing 2	Crossing 3
PIPELINE PLU4562/N0830			
Recover by reverse-reeling	Crosses under Shell 20 inch gas line PL4104/N0614 approximately 100 m north of the WLGP SSIV. PL4104/N0614 crosses PLU4562/N0830 at a point where PLU4562/N0830 is trenched and buried. PL4104/N0614 has been rock-dumped; therefore the crossing is rock-dumped. Decommissioning of PL4104/N0614 is the responsibility of Shell but not the BDP. Responsibility for decommissioning the rock-dumped section of PLU4562/N0830 will remain with Shell (Note 3).	Crosses under Shell 16 inch gas line PL4492/N0610 approximately 130 m north-east of the WLGP SSIV. PL4492/N0610 crosses PLU4562/N0830 at a point where PLU4562/N0830 is trenched and buried. PL4492/N0610 has been rock-dumped; therefore the crossing is rock-dumped. Decommissioning of PL4492/N0610 is the responsibility of Shell but not the BDP. Responsibility for decommissioning the rock-dumped section of PLU4562/N0830 will remain with Shell (Note 3).	Crosses over PL049/N0301. The removal of PLU4562/N0830 will allow the mattressed crossing to be dismantled and recovered and will allow the section of PL049/N0301 between the GEP pipeline PL4492/N0610 and the Brent Alpha platform to be recovered.

Notes: 3. This crossing is the responsibility of Shell U.K. Limited but not the Brent Decommissioning Project.

9.7.4 Span Remediation

Twelve of the thirty Brent Field pipelines will be completely removed, thus removing any spans that are present. One pipeline is completely buried under rock-dump and therefore is not expected to span. Ten pipelines will be trenched and backfilled. Four of the pipelines will remain in their existing trenches. The shallow trenched sections of PL001/N0501 will be remediated with trenching and rock-dump, and the FishSAFE spans thought to be present on PL001/N0501 will be removed by cut and lift if they still exist. If any spans are found on the eighteen pipelines that remain in the Field after the decommissioning operations, we will discuss possible remediation options with BEIS and agree the most appropriate action on a case-by-case basis.

9.7.5 Removal of Subsea Mattresses and Grout Bags

The contract for the removal of pipelines, grout bags, mattresses and subsea infrastructure has not yet been tendered or awarded, and so the final destination of these materials is not yet known. If the material is to be brought ashore in England or Scotland, we will inform the EA or SEPA respectively as required.

This programme of work will be carried out by experienced contractors under all necessary permits and licences, and the materials returned to shore will be dealt with by experienced companies according to the waste hierarchy. Although it may be possible to re-use some items it is likely that, because of their age and long period of exposure on the seabed, most of the materials will be recycled.

Mattresses and grout bags will be removed from the seabed to effect the decommissioning of the structures and pipelines, as determined by their proposed programmes of work. Should any problems be encountered with the removal of the mattresses we will consult with BEIS on the most appropriate course of action. Some mattresses will be intentionally left in place on the seabed if this is required by the recommended decommissioning option for the pipeline. All retrieved mattresses will be taken to shore for recycling or disposal.

The mattresses at Brent South which are already covered with rock-dump will remain in place. All concrete mattresses and grout bags associated with subsea structures and pipelines which are to be removed will also be removed. If any problems are encountered with these operations we will contact BEIS for guidance.

The intention is to recover the mattresses using speed-loaders or lifting baskets because it is likely that the ropes which form the lifting points have degraded, and may not be strong enough to bear the full weight of the mattresses when lifted. On the seabed, the mattresses will be loaded into the speed-loader or basket using a lifting frame (which would require divers) or a mattress grab. The mechanical mattress grab is unlikely to be able to lift those mattresses that are closely associated with seabed structures, and these mattresses will either have to be dragged clear or lifted clear using a frame. Five mattresses can be lifted at a time in a lifting basket; speed-loaders can recover up to six mattresses in each load and use less deck space than lifting baskets.

Grout bags set and harden when immersed in water, and when packed close together they may adhere to each other, forming large heavy masses on the seabed. In such circumstances the grout bags cannot be removed by ROV and the safest and most efficient method is to use a mattress grab. Once lifted from the seafloor the grout bags will be recovered to the vessels in debris baskets and disposed of onshore.

The removal of concrete mattresses and grout bags will cause very minor, localised and short-lived disturbances to the seabed and benthic communities in the immediate vicinity. Recovery of the seabed should begin as soon as the seabed activities have been completed.

9.7.6 Operations for Reverse Reeling

These operations will be performed on PL1955/N0310, PL1955/N0311, PLU4494/N4870, PLU4560/N2801, PLU4561/N1844 and PLU4562/N0830, a total of approximately 7.0 km of line. It is likely that the removal and recovery operations will be conducted from an MSV with a carousel. After the line has been cut or detached from any platform or subsea structure an anchor 'head' will be fitted at one end to fix it to the seabed. A lifting head will be fitted at the other end of the line, which will then be pulled up to the MSV. The line will then be wound under tension onto a large reel and transported to shore where it will be unspooled for treatment and recycling or disposal.

9.7.7 Operations for Removal by Cut-and-lift

These operations would be performed on PL017A-D/N0601, PL051/N0402a, PL4493/N0610, PL4731/N9900, PLU4733/N9901, N9002 and, a total of approximately 7.2 km of line. The pipelines will be cut into sections approximately 25m long using an ROV fitted with a cold-cutting tool such as a diamond wire system or shear cutters. It is likely that the operations will be conducted from an ROV Support Vessel (ROVSV) or DSV. The sections will be lifted to the vessel and transported to shore for dismantling and recycling. Some excavation may be required for those lines which are partially covered or in a trench and this would probably be carried out by water-jetting.

Cut-and-lift is a standard operation in the North Sea and can be completed without excessive safety risks to offshore personnel. The cuts would be made using an ROV, which reduces the need for divers. Should the lines be so weak that the 'standard' lengths of cut lines could not be lifted safely the lines would either be cut into shorter lengths or recovered to the surface in a debris basket.

The redundant pipeline sections PL4664/N0201 and PL044A/N0405 will also be recovered.

9.7.8 Operations to Disconnect, Trench and Backfill

This operation will be performed on PL002B/N0201, PL044/N0405, PL045/N0303, PL046/N0304, PL047/N0404, PL048/N0302, PL049/N0301, PL050/N0401, PL051/N0402, PL052/N0403, PL4730/N9903A and PL4730/N9903B, a total of approximately 36.1km of pipeline.

The pipelines would be disconnected from the platform or subsea structures at each end, and the tie-in spools removed by cut and lift for onshore recycling or disposal. The main section of the pipeline would be trenched and back-filled over the whole length to a depth of 0.6m to top of pipe (TOP). On pipelines with a diameter greater than 24 inches, a mechanical trenching tool would be used followed by back-filling by another tool. For lines with a diameter of less than 24 inches, trenching and back-filling would be achieved simultaneously using a water-jet trenching tool. Should any problems be encountered with achieving a 0.6m depth of trench to TOP we would consult with BEIS regarding the options for appropriate remediation. Such options might include re-trenching the pipeline such that the TOP was at least below the mean seabed level, removal of the section of the pipeline, or the addition of material to the seabed to mitigate any snagging risk to fishing gear.

Four pipelines (PL045/N0303, PL047/N0404, PL048/N0302 and PL049/N0301) are now crossed by the new GEP pipeline PL4492/N0610, which is rock-dumped along its entire length. If it is not feasible to deploy a trencher on the "platform side" of the GEP pipeline, these sections of line will be decommissioned by cut and lift. The short sections of PL048/N0302 and PL049/N0301 will be decommissioned as part of the BDP, and the short sections of PL045/N0303 and PL047/N0404 will be decommissioned as part of the future Penguins decommissioning project.

9.7.9 Operations to Partial Trench and Backfill with Isolated Rock-dump

This operation would be performed on the 35.9 km long line PL001/N0501. An ROVSV will perform preparatory works including spool piece recovery, recovery of the 62 mattresses already over the pipeline, and boulder clearance in the areas to be trenched. The trenching and backfilling operations will probably require the use of a mechanical trencher and separate backfilling tool. As with all rock-dumping operations in the Brent decommissioning programme of work, the rock-dump will be deposited by a flexible fallpipe vessel (FFPV).

All shallow-trenched sections (<0.6 m below mean seabed level) will be remediated. Where possible, we will trench all the sections that are long enough to allow the deployment of the trenching and backfilling equipment. Where the sections are too short or where trenching does not reach the required depth of 0.6 m to TOP rock will be used to provide sufficient cover over the pipeline to mitigate the snagging risks to fishermen. Trenching will not be possible at the seven crossings over this pipeline if they remain in place. As necessary at these locations, we will stop trenching operations and may add more rock cover on either side of the crossings to prevent snagging. All of the seven pipelines are operated by third-parties; four of them are still in operation and three are disused. We will liaise with the owners of these pipelines to coordinate the decommissioning works. Details of how we will deal with each crossing on this line are presented in the Pipelines TD [5].

9.7.10 Operations for Pipelines to be Left in Trench

Four pipelines, PL987A/N0738, PL987A/N0739, PL987A 1-3/N0841 and PL988A/N0913, a total of approximately 17.1km of line, will be remediated by the placement of approximately 30m of rock-dump at the cut ends (total length of rock-dump approximately 120m). This will ensure that the cut ends are covered by at least 0.5m to TOP. The general procedure for rock-dumping operations was summarised in Section 9.7.9.

In response to stakeholder concerns, the depth of burial by natural infill of these particular pipelines within the trenches will be confirmed as over-trawlable during decommissioning operations. Should the depth of burial be insufficient, we will discuss and agree the appropriate course of action with Regulator.

9.7.11 Onshore Dismantling, Treatment and Disposal of Retrieved Material

The contract for the removal of pipelines, grout bags, mattresses and subsea infrastructure has yet to be awarded, and so the final destination of these materials is not yet known. If the material is to be brought ashore in England or Scotland, we will inform the EA or SEPA respectively as required.

This programme of work will be carried out by experienced contractors under all necessary permits and licences, and the materials returned to shore will be dealt with by experienced companies according to the waste hierarchy. Although it may be possible to re-use some items it is likely that, because of their age and long period of exposure on the seabed, most of the materials will be recycled or responsibly disposed of.

Retrieved pipelines may have to be cut into shorter sections for handling and treatment onshore, and this could be done using hot or cold cutting techniques. Further internal cleaning of lines may be required either before or after this operation, depending on the diameter, length and cleanliness of the retrieved line.

Sections of line will then be separated into their component materials for recycling or disposal as appropriate. Concrete-coated lines will, if practicable, be treated by a concrete-crushing machine to shatter and remove the concrete coating; the steel would then be recycled and the concrete would probably have to be disposed of to landfill. As much material as possible will be recovered and recycled from the umbilical and flexible lines, but in reality, a small proportion of these recovered lines may also have to be disposed of to landfill.

9.8 Environmental Impacts of Decommissioning the Pipeline System

9.8.1 Stakeholder Environmental Concerns

For the suite of recommended options for the Brent Field pipelines, the specific environmental concerns or issues raised by our stakeholders were:

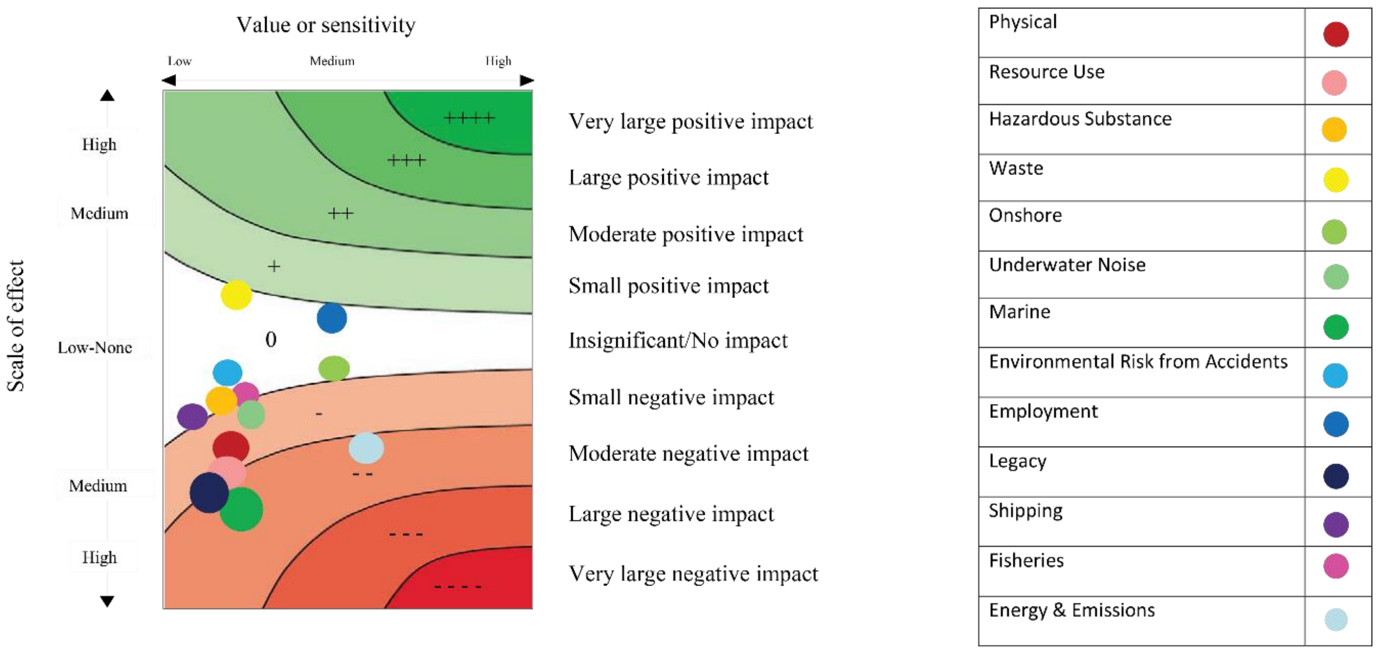
- Continued loss of access to fishing grounds.
- Potential for presence of long-term snagging risk for bottom-towed fishing gear.
- Accidental discharges or releases of hydrocarbons or chemicals to sea.
- Disturbance to seabed and benthic fauna, especially from additional rock-dump.
- Impacts to local communities at onshore dismantling sites caused by noise, dust and odour.

9.8.2 Potentially Significant Impacts in the ES

DNV GL have undertaken a detailed assessment of the potential environmental impacts of the proposed decommissioning options for the Brent pipelines and umbilicals and this is reported in the ES [6] [14]. This section summarises their findings, concentrating only on those impacts that were worse than 'small negative' or better than 'small positive'.

Figure 18 presents DNV GL's assessment of the impacts of the whole pipeline decommissioning programme. The most significant negative impacts are in the 'marine' category which was assessed as 'moderate negative, and in the 'resource use', 'legacy' and 'energy and emissions' categories which were all assessed as being 'small-moderate negative'.

Figure 18 Environmental Impacts of Completing the Whole Proposed Programme of Work for the Brent Field Pipeline System.



[14] It should be noted that the EIA was completed prior to the installation of the GEP-related pipeline and umbilical PL4493/N0610 and PLU4494/N4870; however the full removal of the short, surface laid lines are not expected to significantly alter the EIA findings documented in the ES.

Marine Impacts from operations

Decommissioning the pipelines would result in marine impacts associated with the disturbance of benthic fauna and habitats caused by operations such as cut and lift, reverse reeling and trenching and rock-dumping, and with disturbance caused by noise generated by vessels and operations such as underwater cutting. When viewed in isolation these impacts are generally small for the individual pipelines (except PL001/N0501) because:

- The total rock-dump for the programme (excluding PL001/N0501) is only approximately 2,000 tonnes.
- Removal by cut and lift will cause only very local, transient and fully-reversible impacts on benthic communities within a few metres along the 13.9 km of line to be removed, as a result of the disturbance of sediments and/or smothering by sediments. Locally, noise levels may be elevated for a time during the offshore operations. The combined impact to the marine environment would, however, be small, because the impacts are temporary and reversible.
- With the exception of PL001/N0501, only short lengths of new rock-dump will be created, impacting a very small proportion of the ICES rectangle, and all new rock-dumps will be verified as being over-trawlable. Although areas of rock-dump can be a concern for demersal trawlers, DNV GL estimated that the long-term effect of these short sections would be small.

The main contribution to the assessment of impacts in the category "marine" is the decommissioning of the 35.9 km long 30 inch export line PL001/N0501, which will involve both trenching and rock dumping. We estimate that the isolated areas of rock-dump on this line would require a total of approximately 147,000 tonnes of rock-dump. As well as causing a permanent change to the seabed (see "legacy" below) rock-dumping on such a scale will cause direct impacts by smothering the benthic fauna under and adjacent to the areas of rock-dump.

We have carefully assessed the amount of rock-dump that would be required on the 36 km export line PL001/N0501. Approximately 28 km (80 %) of the 36 km line is not sufficiently trenched to a depth of greater than 0.6 m. The mass of rock dump required for this long export pipeline was calculated on the assumption that of the 28 km requiring remediation, approximately 20 km (70%) could be effectively remediated using a trenching tool. Consequently, we assumed that the remaining 30 % (9 km) would have to be remediated using rock dump. In reality, the amount of rock required may be more or less than this figure. As reported in the Pipelines TD [5], we have some data from the MBES survey on the depth of cover over the pipeline, regardless of whether the pipeline is sufficiently trenched or not, but we have not calculated the volume of cover from these data.

The Brent Field surface sediments are largely sandy mud, although there are numerous cobbles and boulders on the surface of the seabed and at shallow depth in the sub-surface sediment. We recognise that the deposition of rock dump material will change the nature of the seabed substratum in these areas. Accordingly, we will minimise the total mass of rock-dump necessary to provide the required stable, profiled over-trawlable rock cover on those lines where rock-dumping is the permitted decommissioning option. This will be achieved by the careful design of the rock-dump profile, and the use of a rock-dump vessel with controllable fall pipe to carefully place graded rock in the specified location.

Viewed together, the various proposed operational activities in the whole pipelines programme of work would result in impacts in the "marine" category that were assessed by DNV GL as being "moderate negative". This was primarily based upon the impacts arising from the decommissioning of pipeline N0501 owing to the combination of rock-dumping and trenching, in combination with the cumulative effects from trenching the other 11 pipelines.

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Legacy impacts from pipelines left in place

On completion of the proposed programme of work no pipeline, umbilical or cable will remain uncovered on the surface of the seabed; The main legacy impacts of the proposed programme therefore arise from the rock-dumping of the pipelines and the long-term degradation of pipelines left in situ. In particular, we have assumed that of the estimated 28 km of PL001/N0501 that requires remediation (because the top of the pipe is less than 0.6 m below the level of the seabed), approximately 9 km) will require rock-dumping because further trenching will not be completely successful. The creation of new areas of rock-dump along a total of approximately 9 km of line will result in a permanent change to the nature of the seabed, although it is noted that the areas of rock-dump, including on PL001/N0501, are not necessarily continuous. If the rock-dump is 10 m wide on either side of the line the total area of seabed covered would be approximately 0.2 km^2, about 0.007 % of the ICES rectangle. The new rock-dump will permanently change the character of the seabed and provide a new and different type of surface and habitat for marine life.

Overall, DNV GL assessed the potential legacy impacts from the proposed programme of work as being "small-moderate negative", primarily as a result of the extensive new rock-dumping that may be required on PL001/N0501.

We estimate that the trenched or rock-dumped lines on the seabed will remain extant for many centuries (depending on the line) before they degrade and are incorporated into the seabed sediment. On concrete-coated lines the light steel reinforcing mesh will corrode and expand, causing the spalling of the outer shell of the coating. Seawater will then penetrate to the steel below and surface corrosion will begin. At the same time seawater inside the line will initiate corrosion of the inner face, although this will be very slow to begin with because of the lack of oxygen within stretches of intact line that are distant from holes and openings to the sea. Pinhole corrosion of the outer face of the line and corrosion of the inner face by sulphate reducing bacteria will eventually create holes which will allow oxygenated seawater inside the line. Double-sided corrosion may then take place, and this will accelerate the rate of degradation. Within the trench or under the rock-dump, the remains of the concrete coating will spall and the line may begin to break into shorter lengths. In the final stages of degradation the steel line will corrode completely and crumble, and the remains of the concrete coating will collapse. The degraded remains of the line will lie within the trench or under the rock-dump.

9.8.3 Energy Use and Emissions

We estimate that the whole proposed programme of work for the Brent Field pipeline system would use about 1,003,500 GJ of energy and have total emissions of about 78,000 tonnes CO_2 (Table 31). These estimates include the energy and emissions associated with the 'replacement' by new manufacture of otherwise recyclable material that was left in the sea. For the recommended programme this accounts for some 94% of the total estimated energy use and gaseous emissions. The total estimated 'direct' use of energy and 'direct' CO_2 emissions would be approximately 62,000 GJ and 5,000 tonnes respectively.

Table 31 Total Energy Use and Emissions from Programme of Work to Decommission Brent Pipeline System.

Operations	Energy (GJ)	Emissions to Atmosphere (tonnes)		
		CO_2	NO_X	SO_2
Direct				
In marine operations, onshore dismantling, and recycling	62,016	4,761	83	63
Recycling				
Replacement of material left at sea	941,495	72,870	310	125
Total	1,003,511	77,631	393	188

9.9 Mitigation Measures for Pipelines Programme of Work

- All oil and gas lines will be depressurised, de-oiled and flushed with seawater to reduce the amounts of residual hydrocarbons they contain.
- Umbilicals will be flushed clean. If this is not technically possible, then the umbilicals will be capped immediately after being cut to contain the contents.
- The campaign(s) to remove or treat offshore pipelines and umbilicals will be conducted under all necessary permits.
- Appropriate Notices to Mariners will be issued to alert other users of the sea to proposed offshore operations.
- The size, extent and profile of each area of rock-dump will be carefully planned. Suitably graded rock will be accurately placed around the line(s) using a dedicated specialist rock-dump vessel with a fall pipe.
- Where pipelines or umbilicals have been removed we will verify that the area is free of debris.
- On completion of offshore operations other users of the sea will be advised of the changed status or condition of each line and the information will be entered into the FishSAFE system.
- Pipelines and umbilicals retrieved to shore will be treated, recycled or disposed of through suitably-licensed onshore sites.
- As far as practicable all the different materials in the lines and umbilicals will be segregated into different waste streams to maximise the amount of recycling. It is impracticable, however, to strip down some composite umbilicals and a small proportion of the mass of lines removed will have to be disposed of to landfill, as will some proportion of the removed concrete coating.

9.10 Questions on the Proposed Programme of Work Raised by Stakeholders during Public Consultation

The following comments were made by the Scottish Fishermens' Federation:

- In relation to the offshore pipelines and umbilicals, the SFF is also appreciative of the approach that Shell is looking to take with the majority of these; specifically the trench and backfill approach to some of the larger diameter surface laid lines. As you will be aware, any pipelines left on the seabed represent a legacy issue and will require on-going monitoring – we are pleased to note Shell's rolling programme of risk assessment in this regard.

  We would wish to highlight that in relation to a pipeline lying in an open trench 0.6 m below the surrounding/mean seabed level, the SFF would not deem this as necessarily 'safe' in relation to fishing activity. We view any area insufficiently covered/buried as a potential risk to fishermen. We would be more than willing to work with Shell in relation to such scenarios by, for example, using a purpose-built chain mat to spread existing soil berms, created at the time of installation, to aid the necessary backfill. Where rock cover is deployed, we would look for the size and profile of the rock to follow normal industry standards and would recommend that such rock dump berms are incorporated into the post decommissioning debris clearance trawl sweeps to verify that, at the time of deposit, they did not pose a risk to fishing operations.

Our response to this comment is:

Although it is not our intention to leave any of the thirty pipelines in an "open" trench, four lines, N0738, N0739, N0841 and N0913 are already in trenches. Most of N0738 is covered by an adequate and stable rockdump, and the remaining 1.8 km of this pipeline and the whole lengths of the other three pipelines are buried by natural infill. We appreciate that the information in our Pipelines Technical Document (TD) [5] and Decommissioning Program (DP) is not absolutely clear on this point. We will re-check the survey data and update the documents with the necessary clarifications. For the avoidance of doubt, if we propose to decommission by trench and backfill some pipelines we will ensure adequate depth of burial as detailed within the Decommissioning Programme. Any rock dump profile will be over-trawlable, and verified by over trawl survey or alternative seabed verification methods as determined by OPRED, as required.

Finally, after decommissioning we plan to carry out an "as left" survey of any facilities permitted to be left in or on the seabed and two environmental seabed surveys. The rolling programme of risk assessment is only for the GBS. The nature and frequency of any subsequent structural or environmental surveys is still to be discussed and agreed with BEIS.

The questions and issues from stakeholders during the period of Public Consultation were:

- Concern about the Brent infrastructure being taken to an English yard for decommissioning and not a Scottish Yard.

Our response to this comment is:

We appreciate and understand the many differing views around the decommissioning industry. The decision to decommission the Brent Field, and remove infrastructure for recycling and disposal in Teesside, was taken following a full competitive tendering process with bids received from UK and European companies ahead of awarding the contract to Able UK.

We would point out that over the 40+ year lifecycle of the Brent Field numerous Scottish businesses have been intricately involved with varying aspects, activities and operations. In addition, and as the Field has entered its decommissioning phase, the majority of business has, in fact, been awarded to Scottish businesses. In June 2016 this figure was calculated to be approximately 90%.

All Operators are expected to deliver safe and efficient decommissioning programmes (under the Petroleum Act 1998) and the Oil and Gas Authority monitors delivery of this. We aim to do this for the Brent Field.

It should be noted that the final dismantling and disposal site for recovered pipelines, umbilicals, subsea structures and debris is not known. Onshore facilities will be suggested by contractors during the tendering process. The co-venturers confirm that only suitably equipped and fully licensed onshore sites will be used for the dismantling, treatment and disposal of all materials recovered during the pipeline decommissioning programme of work.

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10 DECOMMISSIONING THE SEABED INFRASTRUCTURE

10.1 Introduction

Four discrete subsea structures are included in this DP, the Brent Bravo SSIV, The Brent Spar PLEM and protection structure, the Brent Alpha splitter box and the VASP, located near the Brent Alpha platform. We will remove all four structures as part of the BDP.

Information about the numbers and masses of grout bags and mattresses associated with the sub-sea structures (where available) is presented in the Pipelines TD [5] and summarised in the description of the Brent Field pipeline system (Section 9.1). Programmes of work for mattresses, grout bags and third-party crossings are fully described in the Pipelines TD and summarised in the programme of work to decommission the pipelines (Section 9.7).

10.2 Description of Subsea Structures and Material Inventory

The locations of the four subsea structures are presented in Table 32 and shown in Figure 11. Table 33 and Table 34 present the material inventory and a summary description of the four subsea structures, respectively. A full description of these structures is given in the Pipelines TD [5].

Table 32 Locations of the Sub-Sea Structures in the Brent Field.

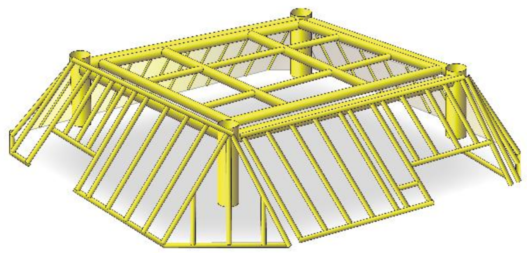
Sub-Sea Structure	Location Decimal Minute WGS84	Location Decimal (WGS84)
Spar PLEM	01°39.973'W 61°03.205'N	01.6662°W 61.0534°N
SSIV	01°42.465'W 61°03.272'N	01.7077°W 61.0545°N
BA Splitter Box	01°39.972'W 61°03.205'N	01.6662°W 61.0534°N
VASP	01°41.874'W 61°01.412'N	01.6979°W 61.0235°N

Table 33 Seabed Structures Materials Inventory.

Subsea Structure	Steel (Tonnes)	Grout (Tonnes)
Brent Bravo SSIV	99	2
Spar PLEM	164[1]	189
Valve Assembly Spool Piece (VASP)	133	-
Splitter box	30	-

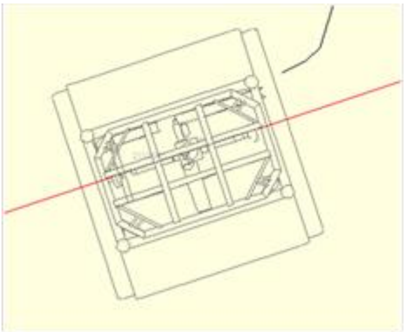
[1]Approximately 100 tonnes of this weight is attributed to the Spar PLEM protection structure and is an estimate only.

Table 34 Summary Descriptions of Subsea Structures.



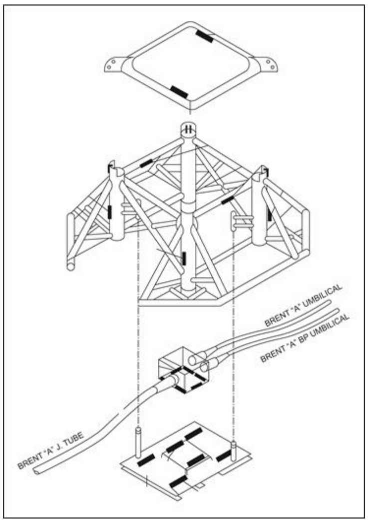
The Spar PLEM was the base connection manifold for the Spar offloading system, which has been removed. The PLEM is made of steel and is 10 m x 6 m x 2.35 m high, with associated pipework and valves. After placement, the structure was filled with grout to increase its submerged weight to approximately 134 tonnes. Following the removal of Brent Spar, a rectangular steel protection structure was installed over the PLEM.

Pipeline End Manifold (PLEM)



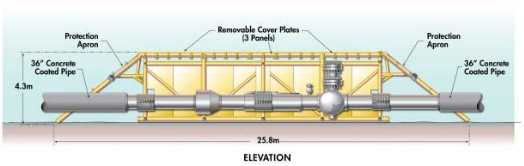
The SSIV consists of steel tubing and valves within a skirted steel frame incorporating a base frame with mud-mats. It is not piled and is held in place on the seabed by ballast "chests" inside the frame. Each ballast chest weighs 19.5 tonnes and there is no evidence of the ballast chests being attached to the main structure. The SSIV is approximately 7.5 m x 7.5 m x 3 m high and weighs approximately 103 tonnes. The structure is protected by mattresses and grout bags.

Subsea Isolation Valve (SSIV)



This structure was installed to house and protect the Brent Alpha SSIV umbilical splitter assembly and consists of three sections; the base, the main structure and the roof panel. The whole structure is approximately 4 m x 4 m x 3 m high and weighs at least 30 tonnes.

Splitter Box



The VASP is a subsea structure forming part of the FLAGS pipeline. It consists of a rectangular structure of steel tubes and sections, and measures approximately 16.4 m x 4.3 m x 3.4 m high and weighs up to 200 tonnes.

Valve Assembly Spool-piece (VASP)

10.3 Programmes of Work for Removing Subsea Structures

Once brought to shore, the subsea structures will be examined to determine the type and level of residual contamination and the appropriate methods to further clean and handle the structures.

The four seabed structures will be removed by the vessel's crane after cutting any steel piles at a depth of 3 m below the seabed by AWJ and likely using specially designed subsea baskets, cradles or grillages for lifting to the vessel deck. Wherever possible, the work will be completed by a Work-class ROV (WROV), although disconnection of flowlines from some structures will have to be undertaken by divers. Cutting and lifting will cause some disturbance of the natural seabed sediment (no structure is within or under a drill cuttings pile) but the impact on the seabed will be very small, localised and fully reversible.

Any grout bags and mattresses associated with these structures will also be removed and returned to shore for reuse, recycling or disposal as appropriate.

The contract for the removal of pipelines, grout bags, mattresses and subsea infrastructure has not yet been awarded, and so the final destination of these materials is not yet known. If the material is to be brought ashore in England or Scotland, we will inform the Environment Agency (EA) or Scottish Environment Protection Agency (SEPA), respectively, as required.

This programme of work will be carried out by experienced contractors under all necessary permits and licences, and the materials returned to shore will be dealt with by experienced companies according to the waste hierarchy. Although it may be possible to re-use some items it is likely that, because of their age and long period of exposure on the seabed, most of the materials will be recycled or disposed of.

10.4 Environmental Impacts of Decommissioning the Subsea Infrastructure

10.4.1 Stakeholder Environmental Concerns

Stakeholders did not express any concerns regarding the decommissioning of the subsea infrastructure but from their comments on the decommissioning of the Brent Field, it is likely that their main concerns would be:

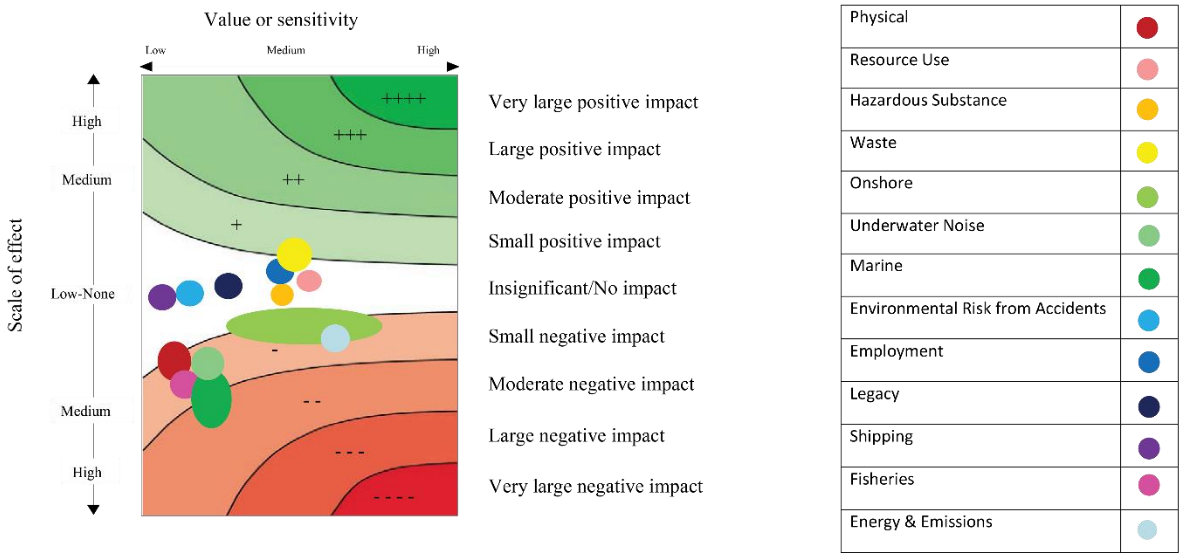
- Disturbance to seabed cuttings piles.
- Accidental loss of large components to sea.
- Impacts to the benthos.
- Creation of debris.

10.4.2 Potentially Significant Impacts in the ES

Figure 19 presents DNV GL's summary of the assessment of the environmental impacts of the programme of work that would be carried out to remove all the subsea structures and dismantle, recycle or dispose of them onshore. The ES found that the most significant negative impact from this activity was in the marine category, which was estimated to be "small-moderate negative". All the other categories of impacts were estimated to be 'small negative' or 'insignificant-no impact'.

It should be noted that the ES assessed the removal of the subsea infrastructure and the Brent Field debris from the pipeline corridors, previous locations of the subsea structures and the 500 m zones around the platforms collectively. The environmental impact detailed below therefore represents a conservative estimate in terms of the impacts of removal of debris from pipeline corridors and the previous locations of the subsea structures included in this DP.

Figure 19 Environmental Impacts from the Removal and Onshore Disposal of all Subsea Infrastructure, including Debris.



The identified impact to the marine environment is primarily a result of disturbances or impact to benthic communities from the removal activities that disturb marine sediment and/or drill cuttings piles. The impact will be localised and temporary but will occur in a number of locations. It is noted that the benthic fauna impacted are diverse and abundant and typical of the region, and do not appear to contain any species of particular conservation concern [6].

Once the subsea structures and associated debris have been removed, it is likely that the seabed sediment would fully recover from any small and localised disturbance within months though areas of larger disturbance will take longer to recover, possibly years, and that there would be no lasting negative legacy impact at any location.

10.4.3 Energy and Emissions

DNV GL estimated that the removal of the seabed infrastructure will use approximately 32,600 GJ of energy and result in the emission of approximately 2,300 tonnes of CO_2 (Table 35).

Table 35 Total Energy Use and Emissions of Programme of Work to Remove all Subsea Structures.

Operations	Energy (GJ)	Emissions to Atmosphere (tonnes)		
		CO_2	NO_X	SO_2
Direct				
Marine operations	28,233	2,082	43	35
Onshore dismantling	213	16	0	0
Onshore transport	151	11	0	0
Sum	*28,597*	*2,109*	*44*	*35*
Recycling				
Material recycling	4,044	183	1	2
Materials not recycled	0	0	0	0
Total	32,641	2,292	45	37

10.5 Mitigation Measures for Subsea Structures Programme of Work

- The campaign to remove the four subsea structures will be conducted under all necessary permits.
- Appropriate Notices to Mariners will be issued to alert other users of the sea to proposed offshore operations.
- Explosives will not be used to remove the structures.
- After the structures and any associated mattresses and grout bags have been removed an over-trawling survey or an alternative seabed verification method, as determined by OPRED, will be conducted to ensure that the area is free of debris. This may be conducted as part of the wider seabed verification survey that will be conducted after the decommissioning of the Brent installations, pipelines and the removal of debris.
- On completion of offshore operations other users of the sea will be advised of the changed status or condition of the pipelines on which these structures were located.
- Onshore, the retrieved substructures, mattresses and grout bags will be treated, recycled or disposed of through suitably-licensed onshore sites, taking care to identify any hazardous materials that may be present.
- There are no historic drill cuttings piles associated with or in the immediate vicinity of the four sub-sea structures to be removed.

10.6 Questions on the Proposed Programme of Work Raised by Stakeholders during Public Consultation

No questions on the decommissioning of the Brent Field seabed infrastructure were raised by statutory consultees or the public during the period of Public Consultation.

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11 DECOMMISSIONING THE BRENT FIELD DEBRIS

11.1 Introduction

On completion of all the approved offshore decommissioning operations we will locate and remove all visible items of oil and gas debris along a 100 m wide corridor centred on each pipeline and at the former locations of the subsea structures. If we know of any exceptional or large Brent-related items in the Field at greater distances from the facilities we will remove these as well.

Over the many years of production in the Brent Field, various items of oil and gas debris have accumulated on the seabed; the amount of debris varies across the Brent installations. Debris surveys conducted over the years have shown that the debris items include individual scaffolding poles as well as larger items that have most likely been lost over the side during bad weather or other unplanned events. Under the BEIS requirements, this debris must be cleared.

Where the drill cuttings piles remain undisturbed oil and gas debris and some sections of pipelines, may be wholly or partially buried by the drill cuttings. Any visible sections of this debris or pipelines partially embedded in the drill cuttings will be severed as close to the drill cuttings as possible without causing disturbance to the drill cuttings and recovered. Wholly buried debris items will be left in situ. If any of these items of debris or lengths of pipeline are uncovered during necessary disturbance of the drill cuttings piles, for example to complete other project scopes of work, these items will also be recovered. In the future, if any of this debris or pipeline sections become uncovered due to the degradation or movement of the drill cuttings, we will consult with BEIS to discuss and agree the most appropriate course of action.

11.2 Description of Debris Items and Material Inventory

We conducted dedicated seabed debris surveys in 2006 and 2011 and cell-top debris surveys in 2005, 2007 and 2011, and the findings of these surveys are summarised in the Pipelines TD [5] and the *Brent Field Drill Cuttings Decommissioning Technical Document* [28].

The 2006 seabed survey comprised side scan sonar sweeps, which revealed numerous objects along parts of the pipeline corridors. In 2011 an ROV video survey provided detailed information on the debris along one of the in-field pipeline corridors. The identified debris ranged from small, relatively light individual items such as scaffolding poles and anchor chains, to large heavy items such as an anchor block. The vast majority of this material is steel scaffolding poles; a very large quantity of scaffolding has been used in the 40 year history of the Field during platform upgrades, inspections and routine maintenance operations.

Table 36 Seabed Debris Identified in the Brent Bravo and Delta 500 m Safety Zones.

Debris Description	Bravo 500 m Safety Zone (1, 2)		Delta 500 m Safety Zone (1, 2)	
	Number of Items	Weight (Tonnes)	Number of Items	Weight (Tonnes)
Anchor block[3]	1	200	-	-
Anchor chain	4	69.4	0	24.1
Oil drum	1		0	
Metalwork	94		102	
Wire (not anchor cable)	115		48	
Debris	357		244	
Pipeline crossing	1		0	
Other	6		0	
Scaffolding	846	67.2	576	52.7

Notes: 1. The quantities indicated refer to individual locations identified within the survey area; each location may contain numerous individual items of debris.
2. In addition to debris items, 83 boulders and 362 boulders were identified in the Bravo and Delta 500 m safety zones respectively.
3. The anchor block for Brent Bravo lies just outside the 500 m safety zone; however, as an identifiable piece of oil and gas related equipment used during the production of hydrocarbons from the Brent Field, we must remove this item.

11.3 Programme of Work for the Removal of Debris

At the end of pipeline and subsea structure decommissioning operations, we will locate and remove all visible items of oil and gas debris within a 100 m wide corridor centred on each pipeline and at the former locations of the four subsea structures. We anticipate that the majority of these items will be historical items of debris already surveyed and mapped, but we will also remove any items of debris that have accidentally arisen as a result of the permitted decommissioning operations. As part of the debris programme, we will remove the drill guide base at the Brent 7 site (Figure 11) which is the only subsea structure remaining at the site of this former well.

All operations to remove debris will be performed from vessels. It is most likely that all the vessel-based operations to remove debris will be conducted in one or more 'campaigns' when the work for all Brent platforms (separate DP approval) and pipelines has been completed.

Debris items will probably be removed using a combination of ROVs, baskets and vessel cranes, and the programme may extend over more than one season (Section 14). All the recovered debris will be returned to shore for recycling or disposal as appropriate.

11.4 Environmental Impacts of Debris Clearance

11.4.1 Stakeholder Environmental Concerns

For the proposed programme of work for the removal of debris, the specific environmental concerns or issues raised by our stakeholders were:

- Accidental loss of debris items to sea during their recovery.
- Disturbance of drill cuttings piles.
- Disturbance to the benthos.

11.4.2 Potentially Significant Impacts in the ES

The impacts of the programme to remove debris are included and discussed in Section 10.4 describing the impacts of the removal of the four sub-sea structures. The potential impacts of the programme to remove debris are associated with (i) the disturbance of the natural seabed and the local turbidity caused by resuspended material and, (ii) the possible disturbance of historic drill cuttings piles.

Debris will be removed by ROV in one or more 'campaigns' each lasting several weeks. Some natural sediment and some OBM cuttings may be disturbed as visible items are extracted, but no excavation of natural sediment or drill cuttings will take place. Any impacts on the benthos or water column will thus be very small, of very limited extent and duration, and fully reversible. The ES found that the most significant negative impact from these activities, collectively, was disturbance to the seabed and benthos which was rated 'small-moderate negative'. There were no positive impacts.

Retrieved material will be recycled in established licenced sites. There will be no negative effects from these onshore operations.

If the majority of identified debris items are removed and recycled (most of the debris is metallic) there will be no negative legacy impacts offshore or onshore.

Some items of debris might remain completely buried in undisturbed drill cuttings piles. These will very gradually corrode or degrade, and will not be likely to cause any impacts to the benthic or pelagic ecosystems. In the future, if any of this debris becomes uncovered due to the degradation or movement of the drill cuttings, we will consult with BEIS to discuss and agree the most appropriate course of action.

11.4.3 Energy and Emissions

DNV GL estimate that the programmes of work to remove debris and then complete the seabed sweep would use approximately 215,000 GJ of energy and produce approximately 16,000 tonnes of CO_2 (Table 37).

Table 37 Total Energy Use and Emissions from Programme of Work to Remove Subsea Debris.

Operations	Energy (GJ)	Emissions to Atmosphere (tonnes)		
		CO_2	NO_X	SO_2
Direct				
Marine operations	209,764	15,472	321	263
Onshore dismantling	258	19	0	0
Onshore transport	199	15	0	0
Sum	*210,221*	*15,506*	*322*	*263*
Recycling				
Material recycling	4,893	221	1	2
Total	215,114	15,727	323	265

11.5 Mitigation Measures for Programme of Work to Remove Subsea Debris

- The campaign(s) to remove and dispose of offshore debris will be conducted under all necessary permits.
- Impacts to the marine environment will be minimised by not disturbing drill cuttings piles; we will not attempt to retrieve items of debris that are largely or wholly buried in drill cuttings piles.
- We do not intend to use underwater explosives.
- When the campaign(s) have been completed, an seabed verification survey will be conducted to ensure that the area is free of debris and that no items that might pose a snagging risk to fishermen are present in the 500 m safety zones or along the 100 m wide pipeline corridors.
- Materials will be treated, recycled or disposed of through suitably-licensed onshore sites.

11.6 Questions on the Proposed Programme of Work Raised by Stakeholders during Public Consultation

No questions on the decommissioning of seabed debris were raised by the statutory consultees or the public during the period of Public Consultation.

12 CUMULATIVE ENVIRONMENTAL IMPACTS

12.1 Introduction

This section presents an assessment of the potential cumulative environmental impacts of the proposed programme of work to decommission the Brent Field pipelines, subsea structures and debris, using the assessments and results from the Brent Field Decommissioning ES [6].

It is noted that in the period 2020 to 2024, when various campaigns for the decommissioning of the Brent pipelines, subsea structures and debris are planned to take place, other facilities in the Brent Field will also be being decommissioned. A detailed review of the potential cumulative effects of all the programmes of work on the Brent Field is presented in the Brent Field DP.

12.2 Method for Assessing Cumulative Impacts

For each of the receptor categories identified in the ES, DNV GL examined the combined impacts of the proposed programmes of work for the pipelines, subsea structures and debris. The results were displayed in a series of diagrams showing the relative severity of the impacts from each of the proposed options.

With respect to potential cumulative impacts to local communities onshore, DNV GL assessed the most likely sources of impact at the onshore dismantling facility would arise from noise, dust and odour. These would be small, localised, amenable to management and fully reversible, and DNV GL determined that individually they would not to be significant.

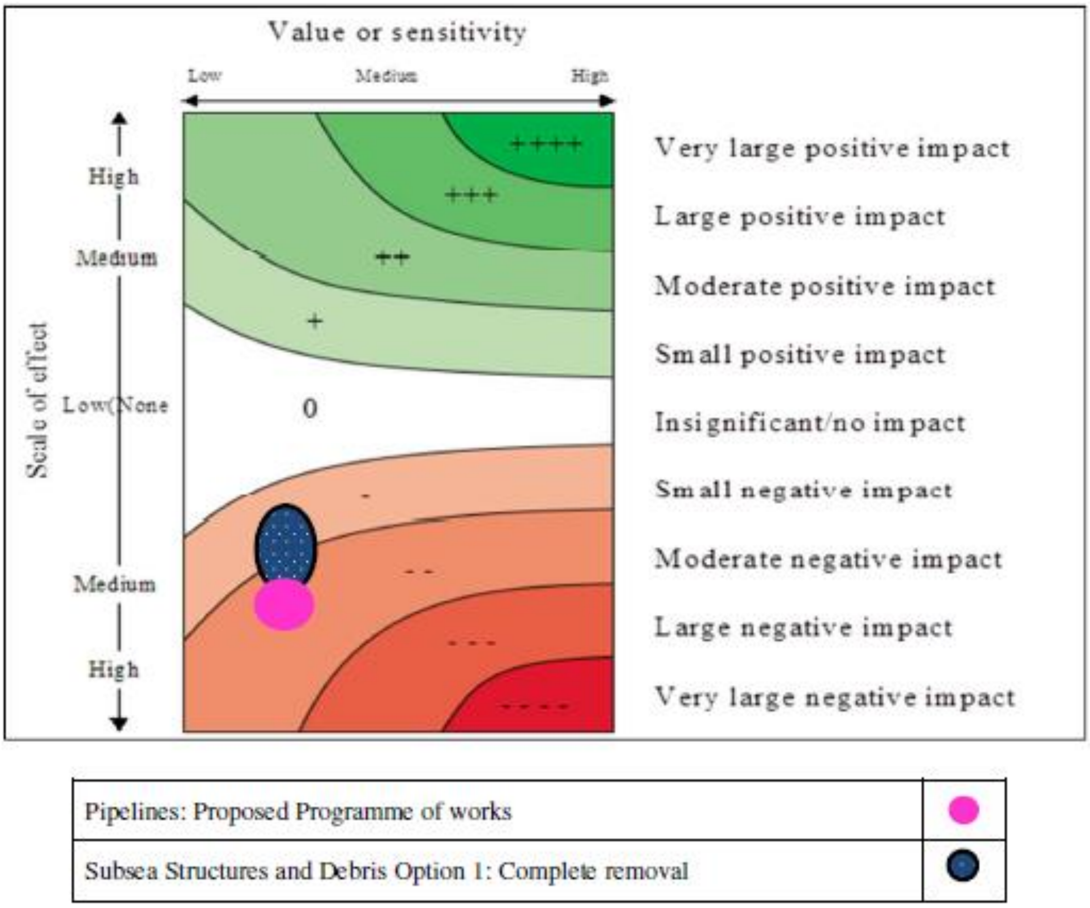
DNV GL found that for the programmes of work for the pipelines, subsea structures and debris, the categories that would be most negatively affected were “marine” and “legacy”. Figure 20 and Figure 21, respectively, show DNV GL’s assessment of the combined impacts to these two receptors from the programmes for pipelines, subsea structures and debris. The main cumulative impacts are discussed below.

It is noted that all of the potential legacy impacts are likely to occur long after all the decommissioning operations have ceased and there is no possibility that these two sources of impact would overlap.

12.3 Cumulative Effects in the “Marine” Category from Operations

Figure 20 shows DNV GL’s assessment of the cumulative impacts in the “marine” category. The decommissioning programmes of work giving rise to the most significant potential impacts were the pipelines which was assessed as ‘moderate negative’, and the subsea structures and debris (including the debris sweep), which was assessed as ‘small-moderate negative’.

Figure 20 Combined impacts in "marine" category from proposed option for each Brent facility.



12.3.1 Physical Disturbance to the Seabed from Operations

Impacts would arise from (i) the cutting and removal of subsea structures, (ii) removal of debris, and (iii) different types of operations on pipelines including cut and lift, trenching and rock-dumping. These would disturb natural sediment and some amounts of historic drill cuttings which would then drift and settle on the adjacent seabed. This might affect individual benthic organisms and populations of benthic invertebrates within <1 km of the disturbed site but recovery would begin as soon as seabed sediments and/or cuttings had settled. Apart from rock-dumping on PL001/N0501, each impact is judged by DNV GL to be "small-moderate" and localised and reversible. Some work on pipelines may affect areas previously affected by the resettlement of drill cuttings displaced to permit cell access for the removal of attic oil and interphase material, but these two operations will be separated in time. Some work on individual pipelines that were close together might affect the same area on more than one occasion, but such areas are likely to be very small in relation to the area of benthos in the Field. Rock-dumping on the long export line PL001/N0501 may affect other areas impacted by other lines close to Brent Charlie, but since the export line runs away and out of the Field, work on more distant sections of this line will not be likely to affect areas of benthos close to the Brent platforms. On the basis of the DNV GL impact assessment, we believe it is unlikely that the physical effects of operations in the Brent Field would add to any physical effects from the decommissioning of adjacent platforms and pipelines, even if these were to occur at the same time, because the nearest third-party platform is 9.6 km away from any Brent platform.

12.3.2 Effects of Underwater Noise on Marine Mammals

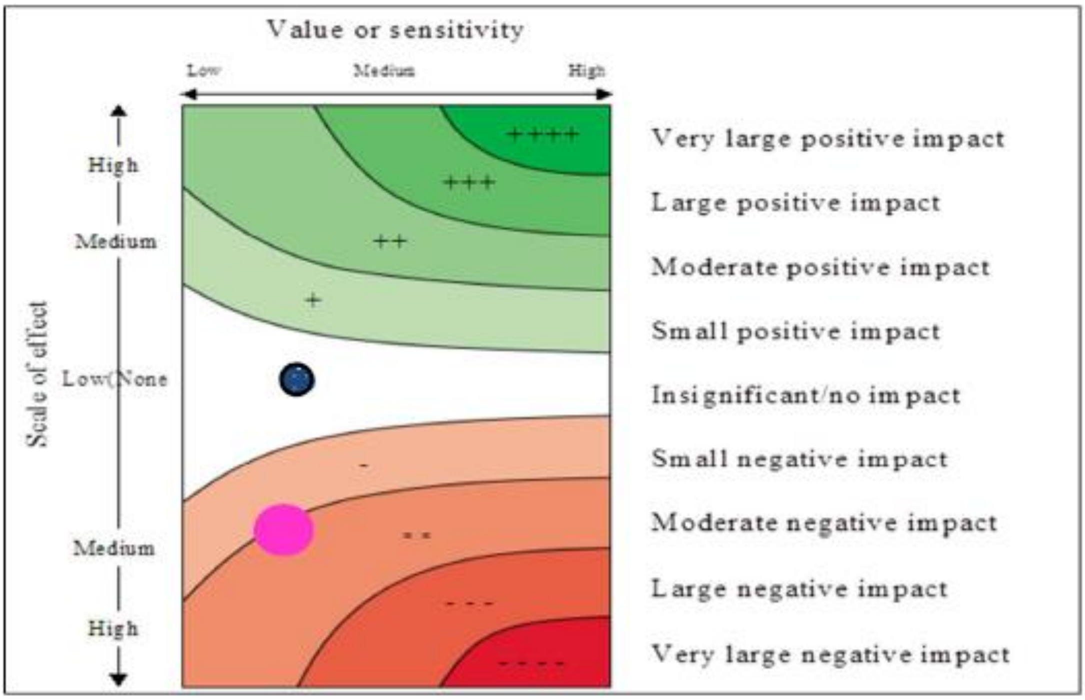
The separate noise report by DNV GL shows that some combinations of vessels may produce noise of frequencies and levels that can be detected by marine mammals. If marine mammals are close to such sources they may experience a temporary threshold shift (TTS) in hearing ability. DNV GL noted that the numbers of marine mammals that might be so exposed is likely to be very small, and that the impacts are reversible. Operations on the pipelines are likely to be conducted by a single vessel during a campaign lasting one or more seasons and so there is little likelihood of cumulative impacts from this source. A different vessel may be used to decommission the subsea structures which may add another noise source, but it is unlikely that the noise from such simultaneous operations would overlap. We do not believe it likely that underwater noise from operations in the Brent Field would add to underwater noise impacts from the decommissioning of adjacent platforms and pipelines, even if these were to occur at the same time, because the effects would not be likely to extend more than 1 km at most from the Brent facilities and the nearest third-party facility is 9.6 km away from any Brent platform.

There is not likely to be any additive or synergistic effect from the combined effects of underwater noise and seabed disturbance because these impacts affect separate aspects of the environment (marine mammals and the benthos respectively).

12.4 Cumulative Effects in the "Legacy" Category

Figure 21 shows DNV GL's assessment of the cumulative impacts in the "legacy" category, including the long-term presence of the remaining pipelines.

Figure 21 Combined impacts in "legacy" category from proposed option for each Brent facility



Pipelines: Proposed Programme of works	(pink dot)
Subsea Structures and Debris Option 1: Complete removal	(dark blue dot)

The main legacy impact from decommissioning the pipelines is associated with the permanent change in seabed habitat that would be caused by the placement of approximately 147,000 tonnes of rock dump at various locations along the export pipeline PL001/N0501. This would change the local seabed from muddy sands to rock, and thus affect the variety and numbers of epifaunal and infaunal animals present.

The area so affected would, however, be relatively small. We estimate that perhaps approximately 9 km of this line will require rock-dump because it will not be possible to trench some sections of line to the required depth of 0.6 m TOP. If the rock-dump is approximately 10 m wide over the pipeline, it would cover an area of approximately 0.09km^2.

No legacy impacts would arise from the decommissioning of the subsea structures as they are to be removed; any changes to the seabed would be limited to the un-burying and removal operations and would be expected to be short in nature. No permanent change to the seabed is expected to occur.

Items of debris that remain buried in drill cuttings would eventually degrade in situ affecting only small areas of seabed and would not be expected to have a significant individual or cumulative effect on the marine environment.

12.5 Cumulative Energy Use and Emissions

We estimate that in combined proposed decommissioning programmes of work for the pipelines, subsea structures and debris would result in the direct use of approximately 301,000 GJ of energy and the emission of approximately 22,400 tonnes of CO_2, that is, without taking into account any use of energy or emissions of CO_2 that would be associated with the new manufacture theoretically required to replace otherwise recyclable material that was left at sea or not recycled. Table 38 presents a summary of these usages and emissions.

Energy usage and gaseous emissions would occur over a period 2020 to 2024 (see Section 14) and probably fluctuate during each year, particularly in response to seasonal changes in activity offshore. The overall annual average level of gaseous emissions of approximately 4,500 tonnes CO_2 is equivalent to approximately 1% of the annual emissions of running the whole Brent Field when it was operational (396,000 tonnes in 2011), and it is very small in comparison to the total emissions from the UKCS in 2011 (14.2 million tonnes CO_2).

Table 38 Estimated Direct Use of Energy and Emission of CO_2 from the Proposed Programmmes of Work.

Source or Activity	Energy Use (GJ)	Emissions (Te CO_2)
Removing the four subsea structures	28,597	2,109
Decommissioning the pipeline system	62,016	4,761
Removing the subsea debris	210,221	15,506
Total for whole proposed programmes of work	300,834	22,376

12.6 Conclusion on Cumulative Impacts

Hydrocarbons from different sources in the Brent Field may be released into the marine environment at the same time. In the water column, because of the effects of dispersion and degradation, these inputs are very unlikely to increase the severity or extent of the short-lived and localised impacts on pelagic organisms.

In the benthos, although the concentrations of hydrocarbons in seabed sediments may increase for a time, the area impacted is not likely to be significantly greater than that already impacted by the historic discharge of drill cuttings.

None of the potential impacts from Brent offshore operations or legacy will act cumulatively with any existing or future known operations or legacy at fixed installations belonging to others.

13 FINAL CONDITION OF THE OFFSHORE ENVIRONMENT

13.1 Summary of Final Condition

As described in the preceding sections, at the end of the activities included in this DP, our sub-contractors will complete as-left surveys to confirm that all items associated with the thirty Brent Field pipelines, four subsea structures and the visible items of debris have been removed or decommissioned, as described here.

The four subsea structures and recovered debris will have been returned to shore. Assuming the pipeline recommendations are adopted 12 of the 30 Brent lines would be removed. The final disposition of the pipelines materials would be as shown in Table 39, and the final layout of the pipelines in the Field would be as show in Figure 22. Many of the Brent pipelines would be trenched, preventing them from interfering with other users of the sea and opening the relative areas to fishing activity. The layout of the pipelines which would remain on the seabed surface are shown in Figure 23.

Table 39 Final Disposition of Main Materials in the Brent Pipeline System.

Material	Material Weight (tonnes)	Material Removed to Shore (tonnes)	Material Left in Field (tonnes)
Steel	25,129	1,125	24,004
Concrete (excluding mattresses)	21,896	542	21,353
Concrete mattresses	1,762	1,085	677
Protective coatings and plastics	1,513	165	1,348
Total	50,300	2,917	47,382

13.2 Seabed Verification

After decommissioning the pipelines and umbilicals, removing the seabed structures, and removing all visible items of debris, the areas around each site and along each line will be surveyed to verify that they are free of obstructions to bottom-towed fishing gear. The nature of this survey will be determined by OPRED and may consist of non-contact methods (e.g. side scan survey) or an over-trawl of the area. Assuming an over - trawl survey, an area of about 25 km^2 (about 0.8% of ICES rectangle 51F1) would be swept. Like trawling, this activity will physically disturb the upper 5-10 cm of the seabed, re-suspending natural sediment into the water column which will then resettle. Care will be taken to ensure that the visible drill cuttings piles at the five Brent sites are not disturbed by the debris sweep.

Figure 22 Final Status of Pipelines in the Brent Field.

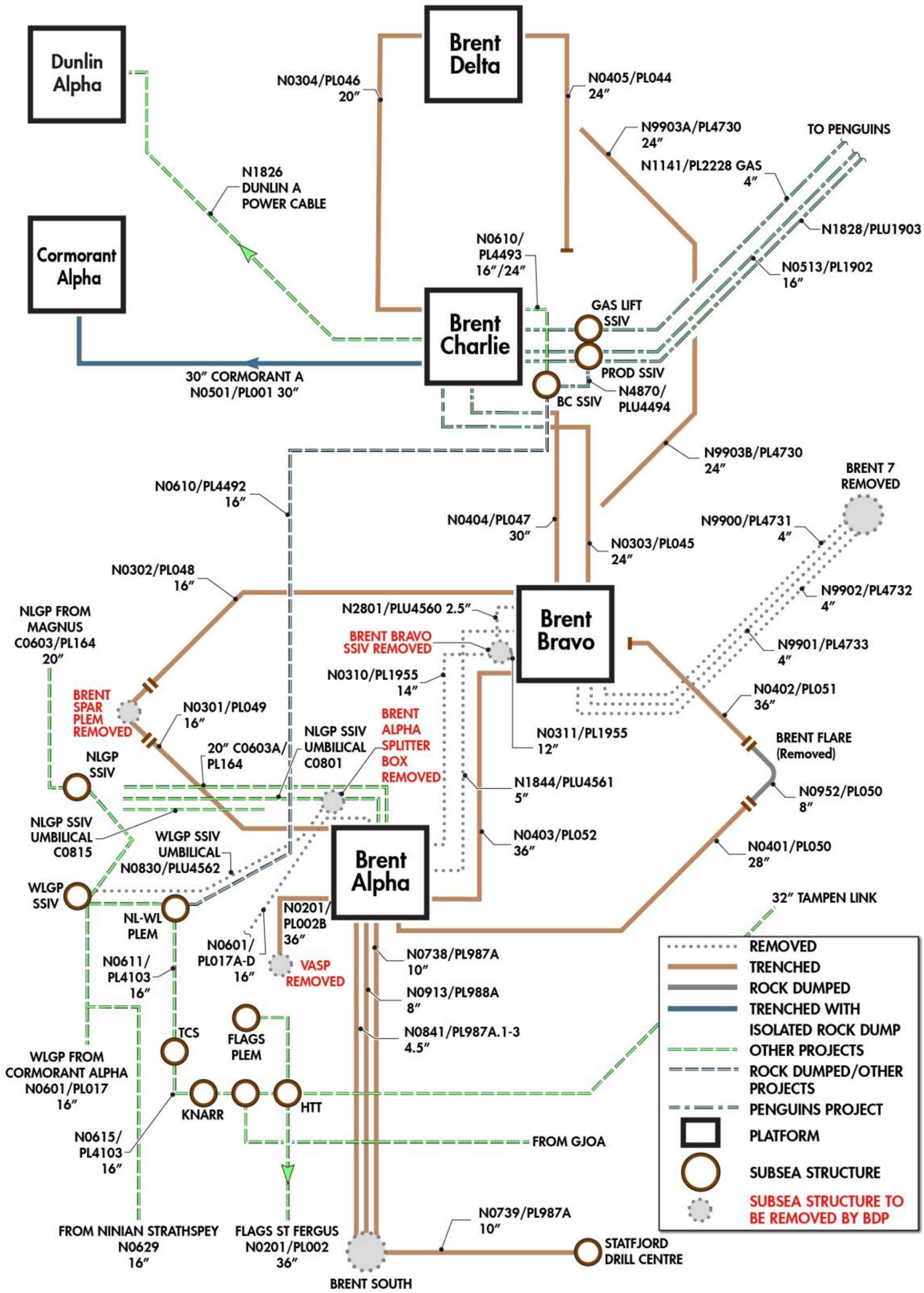
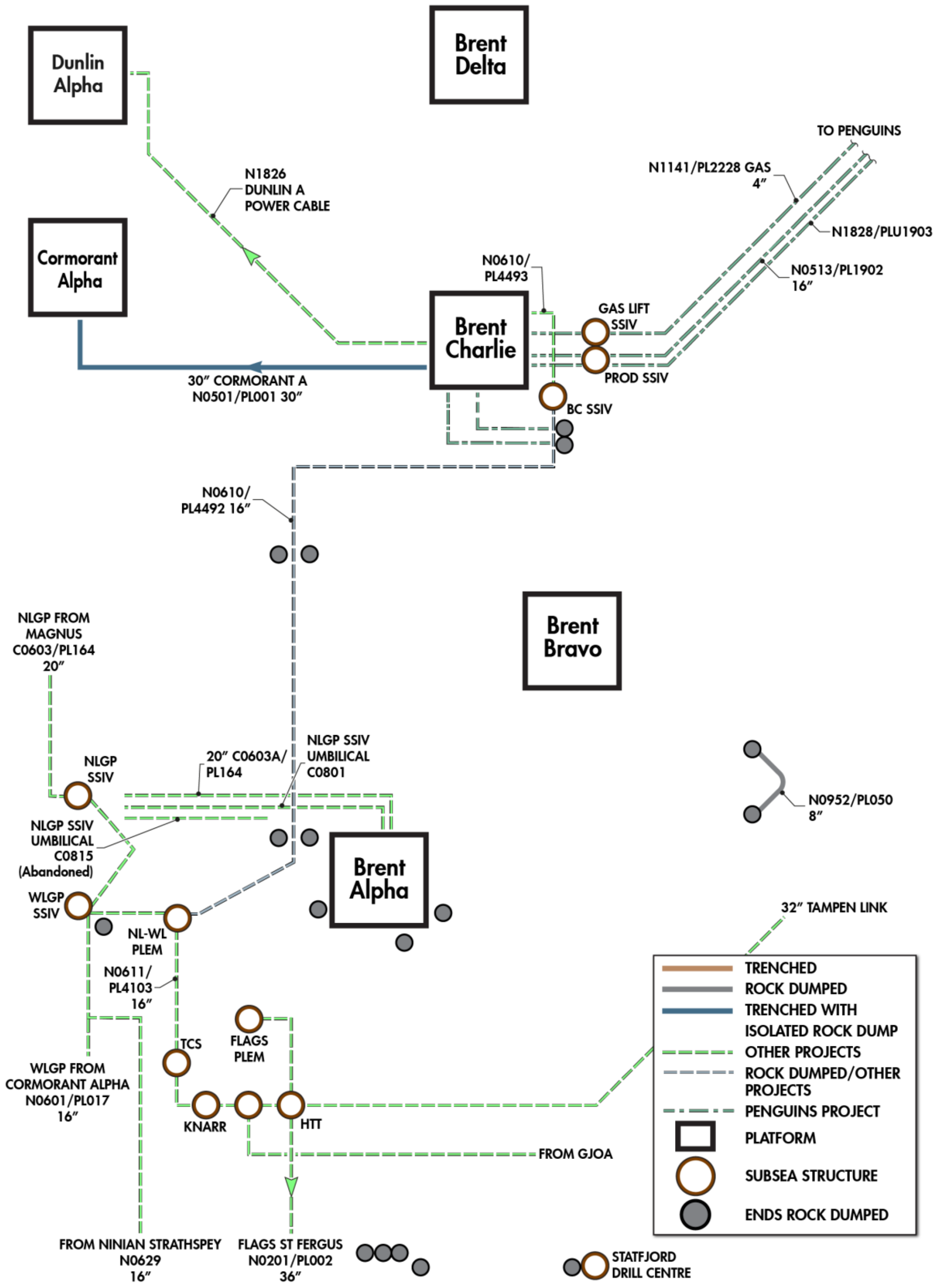


Figure 23 Final Status of Pipelines on the Seabed Surface in the Brent Field.



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14 SCHEDULE

14.1 Introduction

Planning for the Brent Decommissioning Project began in 2006, the lengthy programme to plug and abandon the wells started in 2008, and preparatory work offshore on topsides modules and systems began in 2009. All this work was and is being done under all necessary permits and licences to prepare for decommissioning, and can be carried out in advance of the submission and approval of the Decommissioning Programmes. None of the preparatory work would or will foreclose or eliminate any feasible option for the decommissioning of the facilities.

14.2 Proposed Programmes of Work

Figure 24 outlines the main phases of work in the decommissioning programmes and their approximate duration. It is planned that the offshore programme of work to decommissioning the pipelines, and to remove subsea structures and debris, will be carried out over the period 2020 to 2024.

The exact timing and durations of activities will depend on many factors including the contractors selected, the equipment, vessels or procedures they propose to use, and the possibility of devising 'campaigns' to complete common or repeated operations in the most cost-effective way. We will continue to review and learn from our ongoing activities. We will subsequently discuss and agree with BEIS any changes to the proposed methods of execution outlined in this DP.

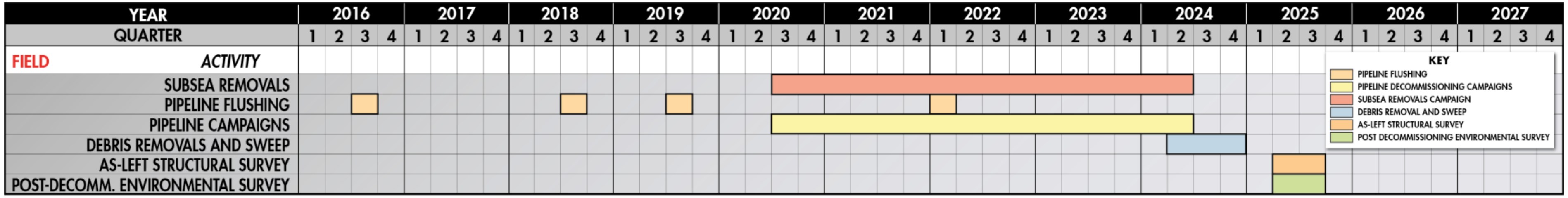
There are no licence conditions or environmental sensitivities (Section 3 and Section 12) that might influence the time of year when certain activities should be undertaken. We plan to complete all the offshore operations and submit verification and close-out reports (Section 13) by 2026.

14.3 Industrial Implications

We have striven to identify safe, efficient and cost-effective methods and procedures for decommissioning the different types of structures and facilities in the Brent Field. Many contractors and consultancies have contributed to the numerous studies and assessments that have been prepared since 2006 to inform our plans and support our decision-making processes.

During the 'Concept Select' phase of our work, leading international contractors and engineering companies prepared FEED studies describing how different technologies and programmes of work might be used to decommission the Brent structures and pipelines.

Figure 24 Indicative Timing and Duration of the Proposed Brent Field Pipelines Decommissioning Programmes of Work.



15 PROJECT MANAGEMENT AND VERIFICATION

15.1 Strategy

The strategy for this project is to maximise the use of our in-house resources and existing contracts for the preparatory work, and to award lump sum contracts to pre-qualified prime contractors for the main decommissioning activities such as the decommissioning of the Brent pipelines, subsea structure and debris.

15.2 Project Management

The project will be managed in accordance with applicable regulatory requirements and to Shell's Global Project Management standards. The project will be led by a Shell Project Director with sub-project managers, project engineers and support functions including, but not limited, to Health, Safety and Environment, Quality, and Project Services. The project will be divided into a series of sub-projects and tendered to the open market as appropriate. Synergies will be sought with other Shell project activities (and in principle other decommissioning activities) where they make economic and business sense.

The approved DP will be subject to strict change management, with any significant change to scope being agreed with BEIS prior to implementation.

15.3 Preparatory Work

We will work closely with our contracting partners to prepare the topsides and other facilities for decommissioning. This work will include pipeline flushing, isolation and making safe for handover to decommissioning contractors.

15.4 Notifying Other Users of the Sea

At least 6 weeks before any vessel-based offshore decommissioning work begins we will notify the UK Hydrographic Office so that appropriate Notices to Mariners can be distributed. At the same time an advisory notice about the planned programme of work will be placed on the Sea Fish Industry Authority's Kingfisher Bulletin.

15.5 Verification

At significant milestones in the planning and execution of the project, work will be subject to internal peer reviews by Shell and by Esso. Major technical decisions will also be subject to approval from Shell's internal 'technical authorities'.

15.6 Reporting Progress

We will report progress to BEIS throughout the offshore and onshore programmes of work. Given the multi-faceted and prolonged nature of the Brent Field decommissioning programmes, the frequency and content of these reports may vary (see Section 15.8) but this will be discussed and agreed with BEIS.

15.7 Duty of Care for Waste Materials

In planning and managing the responsible disposal of our materials we will follow the 'waste hierarchy', which states that re-use is preferred to recycling, and recycling is preferred to disposal to landfill. In order of decreasing preference, the hierarchy of how material from the Brent Field will be disposed of is therefore as follows:

- Refurbishment for re-use as a unit
- Removal of equipment for re-use
- Segregation of pipes for re-use (recovered end sections)
- Segregation of steelwork and other materials for re-use
- Segregation of materials for recycling
- Segregation of materials (including hazardous materials) for disposal

Table 40 presents a summary of how the main waste streams will be dealt with. All hazardous materials will be appropriately handled and disposed of in accordance with the relevant legislation.

Once on the quayside, any components with marine fouling will be cleaned and the organic fouling material disposed of to landfill.

Where it is deemed practical, the concrete coating on all the recovered sections of pipeline will be removed and collected for use as hardcore, leaving the steel pipes in a condition suitable for recycling.

Other materials will be collected by type and stored in separate areas for shipment to smelters or other recycling facilities.

Materials not suitable for any of the above treatments (including hazardous materials such as LSA-contaminated materials, and heavy metals) will be collected and then removed for disposal in landfill and/or other approved disposal facilities. All wastes will be dealt with in accordance with the appropriate legislation, including if applicable, the Transfrontier Shipment of Waste Regulations.

The project has set a target to recycle and re-use at least 97% by weight of the equipment and materials retrieved. We will comply with our legal duties with respect to the management, treatment and disposal of all waste equipment and materials retrieved during the decommissioning programmes.

Table 40 Summary of Methods for Managing Waste Streams.

Waste Stream	Removal and Disposal Method
Steel	Steel will be removed by dismantling or by hot (oxy-propane flame) or cold (hydraulic shears) cutting. Material will be stored, if necessary, at suitably-approved sites before onward transportation. Scrap metals will be transported by road, rail or sea to suitably-licensed facilities for processing.
Hydrocarbons	Any petroleum hydrocarbons discovered within the pipework, equipment, vessels or tanks will be drained into suitable receptacles and sent to a licensed facility for recycling or disposal.
NORM/LSA Scale	During the dismantling operations, radiation monitoring will be undertaken on any structure that is known or suspected to contain naturally-occurring radioactive materials (NORM). If monitoring reveals the presence of LSA scale a detailed method statement for the removal of the component or pipe will be prepared. This may involve encapsulating any open ends, pending disposal or further processing. All NORM will be handled, stored and treated in accordance with RSA 1993.
Other hazardous wastes	All such wastes will be disposed of under appropriate permit(s).

15.8 Close-out Report

The proposed programmes of work to decommission the Brent Field facilities are complex and will take about nine or ten years to complete (Figure 24). We envisage that we will issue several interim Close-Out Reports during this time. These interim reports will be updated when their respective onshore dismantling and waste management programmes have been completed.

When all the pipeline, subsea structures and debris decommissioning work has been completed we will submit a final Pipelines DP close-out report that will comply with BEIS's requirements. We envisage that this would be a single report covering all the pipelines, subsea structures and debris, and would only be produced when:

- All the offshore decommissioning and remediation work on pipelines, subsea structures and debris is finished
- All the retrieved material has been returned to shore and disposed of
- The debris sweeps have been performed and signed-off
- The 'as-left' structural surveys of any remaining pipelines have been completed

It is likely that this Pipelines DP Close-Out report would be available approximately 4 months after completion of the offshore and onshore work.

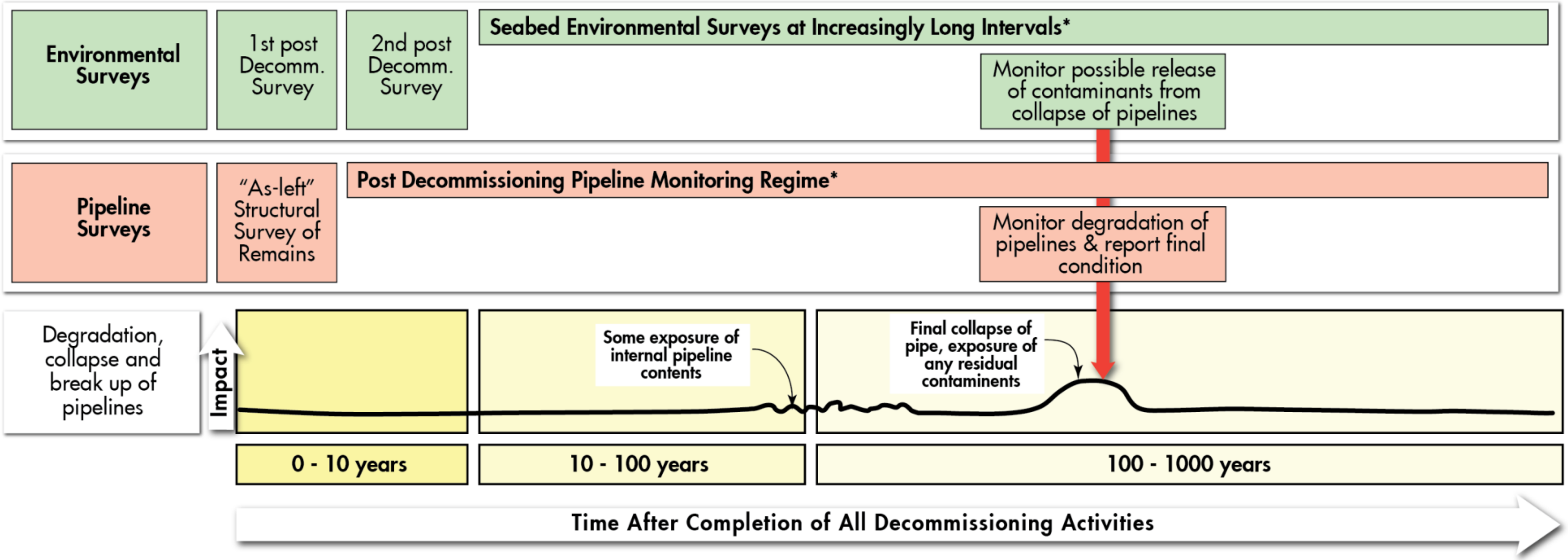
15.9 Management of Residual Liability

In accordance with the Petroleum Act 1998 (as amended) 0, the responsibility for the subsequent management of on-going residual liabilities including managing and reporting the results of the agreed post-decommissioning monitoring (described in Section 16), evaluation and any remedial programme, will remain with the owners. The owners will also be the contact point for any third-party claims arising from damage caused by any remaining infrastructure or materials left in place under the approved Brent Field Pipelines Decommissioning Programme. All the pipelines which are proposed to be left in place remain the property and responsibility of the owners, even if they were to exit the UKCS.

15.10Costs

An estimate of the overall cost of the combined proposed programmes of work has been provided separately to BEIS and OGA.

Figure 25 Relative Timescale of Impacts from Pipeline Decommissioning and Some of the Long-term Consequences of Leaving Material on the Seabed.



* To be discussed and agreed BEIS.

16 PRE- AND POST-DECOMMISSIONING MONITORING

16.1 Introduction

If the proposed Decommissioning Programmes are approved, it is possible that there will be short-term and long-term effects in the environment of the Brent Field. The offshore decommissioning operations themselves may cause generally localised and short-term effects for various environmental receptors which would disappear in time after the activities stop. The resultant end-points of those operations (i.e. the state and condition of any items left in the sea) may cause delayed, intermittent or chronic impacts in the future.

Our proposed monitoring programmes have therefore been designed to monitor two types of event (i) environmental effects and, (ii) the physical degradation and collapse of remains. Figure 25 presents a visualistion of the possible timing and sequence of the events or operations and the associated targeted surveys that might be performed around these times to monitor the disturbance or release of contaminants. This shows that after the local disturbance that may be caused by decommissioning activities over the next 5-10 years there are not likely to be any potential impacts to monitor for perhaps 100-200 years.

16.2 Pre-decommissioning Environmental Surveys

We completed a pre-decommissioning baseline environmental survey in 2007 to provide essential information for the EIA and our CAs, and repeated this survey in 2015. Together, these surveys provide a detailed assessment of the status of the seabed around each site before offshore operations begin. They add to our time-series of data showing how the character of the benthic community and the concentrations of oil and other contaminants in the seabed immediately adjacent to historic cuttings piles have changed over time, especially since the discharge of oil-based drill cuttings ceased.

16.3 Post-decommissioning Environmental Surveys

A post-decommissioning environmental survey will be conducted when offshore work has been completed for the whole Brent Field (including the pipelines and subsea structures), debris removed and the debris sweep successfully carried out. The survey will re-visit all the stations sampled in the two pre-decommissioning baseline surveys, to obtain a directly comparable set of data which would allow us to determine with a high degree of certainty if the offshore operations have had any impacts on the local environment.

16.4 Future Environmental Monitoring

At a later date, we propose to carry out a second post-decommissioning environmental survey which would be likely to revisit all the previous sampling stations. This would be the fourth in a time series of comprehensive and comparable surveys and should provide a good assessment of the extent of any perturbation caused by the offshore operations, and more data on the general character and state of the seabed in the Field. The scope and timing of this second post-decommissioning environmental survey will be discussed and agreed with BEIS.

If the post-decommissioning surveys show that there have been impacts from our operations, we will continue the environmental surveys at agreed intervals until such time as there is a clear trend showing that recovery is taking place and will occur within a reasonable time-scale.

Thereafter, we will discuss the need for further environmental surveys with BEIS. As Figure 25 shows, once the seabed has recovered from any operational impacts it is for many years unlikely to experience any further perturbation, either from residual contaminants in remains or from the physical presence of degraded remains. Future environmental surveys therefore have to be targeted to anticipated events or milestones in the slow degradation of remains when there will be a heightened risk that some residual contaminants might be exposed to the sea or escape into it. Developments in both monitoring procedures and analytical methods will be considered in the planning of future programmes.

16.5 Monitoring Degradation and Collapse of Remains

We will be responsible for all the materials which are permitted to remain in the field on completion of the Decommissioning Programmes. Once we have performed the proposed detailed 'as-left' structural surveys after completion of the proposed Decommissioning Programmes, it is unlikely that any noticeable degradation would occur for 20-50 years. Our programme of post-decommissioning structural monitoring therefore needs to be targeted and 'risk-based' since routine annual surveys will be very wasteful.

The post-decommissioning as-left structural survey will provide detailed information on any sections of pipeline that may be left in the Field. Informed by this survey, we will enter into discussions with BEIS to plan and agree the content and frequency of a risk-based long-term structural monitoring programme.

17 SUPPORTING MATERIAL

[1] The Petroleum Act, 1998.

[2] OSPAR, 1998. Decision 98/3 on the Disposal of Disused Offshore Installations. Ministerial meeting of the OSPAR commission – SINTRA: 22 – 23 July 1998.

[3] BEIS, 2018. Guidance Notes: -Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998. Department of Business, Energy and Industrial Strategy, November 2018.

[4] Shell, 2017. Brent Field Decommissioning Programme, BDE-F-GEN-AA-5880-00015.

[5] Shell, 2019. Brent Field Pipelines Decommissioning Technical Document, BDE-F-PIP-BA- 5801-00001.

[6] DNV GL, 2017. Brent Field Decommissioning Environmental Statement, published by Det Norske Veritas, BDE-F-GEN-HE-0702-00006.

[7] Shell, 2017. Brent Field Decommissioning Comparative Assessment Procedure, BDE-F-GEN-QA-6003-00007.

[8] Anatec Limited, 2011. Assessment of the safety risk to fishermen from derogated footings of the Brent Alpha steel jacket, BDE-A-JKT-HX-0709-00003.

[9] Anatec Limited, 2017. Assessment of Safety Risk to mariners from Derogated GBSs in the Brent Field, BDE-F-GBS-HX-0709-00003.

[10] Anatec Limited, 2014. Assessment of safety risk to fishermen from decommissioned pipelines in the Brent Field, BDE-F-PIP-HX-0709-00002.

[11] MacKay Consultants, 2014. Brent Decommissioning: Assessment of socio-economic effects on commercial fisheries, BDE-F-GEN-HE-0702-00003.

[12] MacKay Consultants, 2014. Brent Decommissioning: Likely economic and employment impacts, BDE-F-GEN-AA-6844-00001.

[13] Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) (Amendment) Regulations 2007.

[14] Fugro EMU, 2017. Brent Alpha Pre-Decommissioning Environmental Survey Data Report, BDE-A-GEN-HX-7880-00001

[15] Fugro EMU, 2017. Brent Bravo Pre-Decommissioning Environmental Survey Data Report, BDE-B-GEN-HX-7180-00002.

[16] Fugro EMU, 2017. Brent Charlie Pre-Decommissioning Environmental Survey Data Report, BDE-C-GEN-HX-7180-00002.

[17] Fugro EMU, 2017. Brent Delta Pre-Decommissioning Environmental Survey Data Report, BDE-D-GEN-HX-7180-00002.

[18] Fugro EMU, 2017. Brent South Pre-Decommissioning Environmental Survey Data Report, BDE-F-GEN-HX-7180-00005.

[19] Fugro EMU, 2017. Brent C to Cormorant A (N0501) Pipeline Route Habitat Assessment Survey, BDE-F-SUB-HX-0780-00001.

[20] Fugro EMU, 2017. Brent Field Temporal Report Block 211/29, BDE-F-GEN-HX-7180-00006.

[21] European Commission, 2001. European Commission (EC) Guidance in EIA Scoping, June 2001.

[22] European Commission Guidance Checklist of Criteria for Evaluating the Significance of Environmental Effects, presented in EC 2001, above.

[23] DNV, 2011. Environmental Scoping Report for the Brent Field EIA. BDE-F-GEN-HE-0702-00004.

[24] Institute of Petroleum (IoP), 2000. Guidelines for the calculation of estimates of energy use and gaseous emissions in the removal and disposal of offshore structures. ISBN 0 85293 255 3.

[25] Shell, 2017. Brent Decommissioning Stakeholder Engagement Report, BDE-F-GEN-HX-5480-00001.

[26] Oil & Gas UK, 2013. Environment Report 2013. ISBN 1 903 004 16 0, 30pp.

[27] DECC, 2008. Climate Change Act, 2008, Chapter 27.

[28] Shell, 2017. Brent Field Drill Cuttings Decommissioning Technical Document, BDE-F-SUB-BA-5801-00001.

18 ACRONYMS AND GLOSSARY

ABS	Acrylonitrile Butadiene Styrene
Ac	Actinium
Al	Aluminium
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
AOR	Attic Oil Recovery (project)
APE	Alkylphenolpolyethoxlyate: a group of chemicals of possible concern as endocrine disruptors
Attic oil	Crude oil that is physically or hydro-dynamically trapped just below the GBS cell dome.
AWJ	Abrasive Water Jet
BAT	Best Available Technique
BBY	Brent Bypass Project
BDP	Brent Decommissioning Project
BEIS	Department for Business, Energy and Industrial Strategy
BEP	Best Environmental Practice
billion	One thousand million (10^9)
Bq	Becquerel, the SI unit measuring the activity of a quantity of radioactive material
CA	Comparative Assessment
Caisson	The term used to describe the lower part of the GBS, containing the storage cells.
CCS	Carbon Capture and Storage
Cell sediment	Fine particles of sand from the reservoir fluids that have settled to the bottom of the cells
CFC	Chlorofluorocarbon
CNR	Canadian Natural Resources
CO_2	Carbon Dioxide
Conductor	A large diameter pipe that links the well bore hole to the topsides
CoP	Cessation of Production
DE	Doris Engineering
DECC	Department of Energy and Climate Change
DNV GL	Det Norske Veritas-Germanischer Lloyd
DP	Decommissioning Programme
Drill cuttings	The fragments of rock generated during the process of drilling a well
DSV	Diving Support Vessel
DTOO	Dr techn. Olav Olsen
DWC	Diamond Wire Cutting
DyP	Dynamic Positioning
EA	Environment Agency
EIA	Environmental Impact Assessment
E&P	Exploration and Production
EPDM	Ethylene propylene diene monomer (a type of rubber)
ES	Environmental Statement
ESHIA	Environmental, Social and Health Impact Assessment
FAR	Fatal Accident Rate
FEED	Front End Engineering and Development
FFDP	Final Field Development Plan
FFPV	Flexible FallPipe Vessel
FishSAFE	An electronic means of alerting vessels to the proximity of a structure in the sea. FishSAFE is a commercial fishing industry driven safety program. (www.fishsafe.eu)
FLAGS	Far North Liquids and Associated Gas System
FLTC	Fisheries Offshore Oil and Gas Industry Legacy Trust Fund Limited
GBS	Gravity Base Structure
GEP	(Charlie) Gas Export Project
GJ	Gigajoule (10^9 joules)
GPB	Pounds Sterling (UK)
Grout	A general term for usually light, pumpable cement that can be introduced into pipes or complex and/or confined spaces.
GRP	Glass-reinforced plastic
HAZID	Hazard Identification
HC	Hydrocarbon

HLV	Heavy Lift Vessel
HSE	Health and Safety Executive
H_2S	Hydrogen Sulphide
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organisation
IoP	Institute of Petroleum
IPR	Interim Pipeline Regime
IRG	Independent Review Group
JNCC	Joint Nature Conservation Committee
kg	kilogramme
km	kilometre
KP	Kilometre Point
LAT	Lowest Astronomical Tide
LSA	Low Specific Activity (scale)
LTFD	Long Term Field Development
LTOBM	Low Toxicity Oil-based Mud
LWIV	Light Well Intervention Vessel
m	metre
$msec^{-1}$	metres per second
MAH	Major Accident Hazards
MBES	Multi-Beam Echo Sounder
MBq	Megabecquerel, 1 million becquerels
MCDA	Multi-Criteria Decision Analysis
MCZ	Marine Conservation Zone
mg	milligramme (1,000 of a gramme)
MOD	Ministry of Defence
MSV	Multi Support Vessel
NGO	Non-Governmental Organisation
NLGP	Northern Leg Gas Pipeline
Nm	Nautical mile
NNR	National Nature Reserve
NORM	Naturally-Occurring Radioactive Material
NOx	Nitrous Oxides
NPF	Norske Petroleumsforening
OBM	Oil-based Mud
OCNS	Offshore Chemicals Notification Scheme
OGA	Oil and Gas Authority
OGUK	Oil and Gas UK Limited
OIW	Oil in Water
OPEP	Oil Pollution Emergency Plan
OPF	Organic Phase Fluid
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSDR	Offshore Safety Directive Regulator
OSPAR	Oslo Paris Commission
OSRL	Oil Spill Response Limited
P&A	Plug and Abandon
Pb	Lead
PCB	Polychlorinated Biphenyls
PEC	Predicted Environmental Concentration
Piles	Hollow steel tubes that fix a steel jacket to the seabed. The piles are inserted through pile guides and bonded to the guides by grout
PLEM	Pipeline End Manifold
PLL	Potential Loss of Life. A comparative measure of the safety risk of an option or programme of work
PNEC	Predicted No-Effects Concentration
POBM	Pseudo Oil-based Mud
PON	Petroleum Operations Notice
PPE	Personal Protection Equipment
ppm	parts per million
PTFE	Polytretrafluoroethylene
PVC	Polyvinylchloride
PWA	Pipeline Works Authorisation
QRA	Quantitative Risk Assessment
Ra	Radium
RCR	Risk Characterisation Ratio
Riser	A steel tube that links a pipeline on the seabed to the topside. They are fixed to the outside of steel jackets but may run inside the legs of GBSs
ROV	Remotely Operated Vehicle
ROVSV	ROV Support Vessel

RSA	Radioactive Substances Act
R4C	Resources for Change
SAC	Special Area of Conservation
SCE	Safety Critical Elements
SEPA	Scottish Environment Protection Agency
SFF	Scottish Fishermen's Federation
SLV	Single Lift Vessel
SOPEP	Shipboard Oil Pollution Emergency Plan
SOx	Sulphur Oxides
SPA	Special Protection Area
SSCV	Semi-Submersible Crane Vessel
SSIV	Subsea Isolation Valve
TBT	Tri-Butyl Tin
TD	Technical Document
te	metric tonne (1,000 kg)
TEC	The Environment Council
TF	Technical Feasibility
THC	Total Hydrocarbon Concentration
TOP	Top of Pipe
TPF	Technical Project Failure
trillion	one million million (10^{12})
TTS	Temporary Threshold Shift
UKCS	United Kingdom Continental Shelf
UKOOA	United Kingdom Offshore Operators Association
VASP	Valve Assembly Spool-Piece
WBM	Water-based Mud
WGS84	World Geodetic System 1984
WLGP	Western Leg Gas Pipeline
WONS	Well Offshore Notification Scheme
Zn	Zinc

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ANNEX 1 COMPARATIVE ASSESSMENTS FOR PL4493/N0610 AND PLU4494/N4870

A1.1 Description of PL4493/N0610

PL4493/N0610 is a new section of pipeline laid as part of the Brent Charlie GEP; it connects the new GEP SSIV to Brent Charlie via the riser formerly numbered as part of PL044/N0405. The pipeline from the GEP SSIV is 16 inch diameter and it ties in to the 24 inch riser via a spool-piece. The subsea section of the pipeline is approximately 117 m long and comprises a series of rigid spool-pieces. The pipeline is protected by 36 concrete mattresses, with a further four mattresses wet-stored in two locations; one mattress is close to this pipeline and the Brent Charlie platform, and three others are located to the east of the main GEP export pipeline PL4492/N0610. The pipeline is supported by grout bags at the spool goose necks and under any free spans; grout bags were also used to fill any gaps between the mattresses.

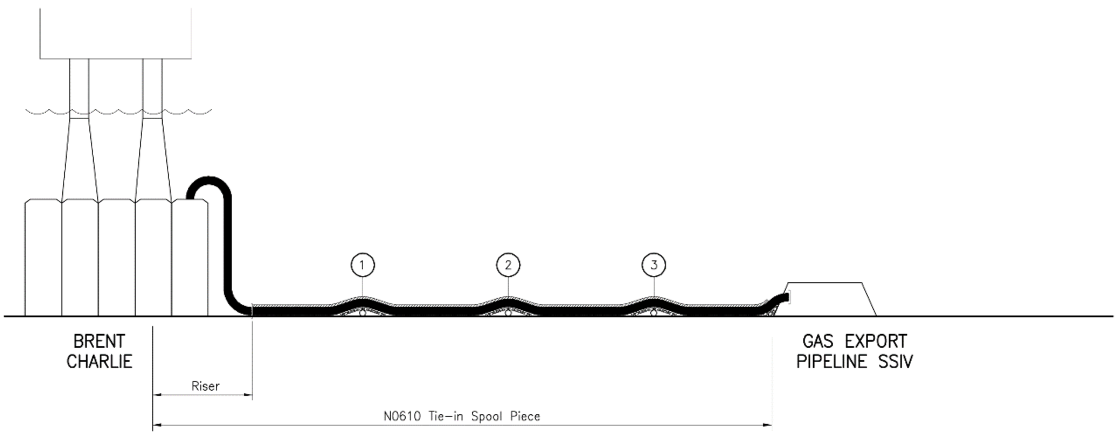
PL4493/N0610 crosses three Penguin lines near the Brent Charlie platform: the Penguin Control SSIV umbilical PLU1903/N1845, the Penguin 14 inch flexible riser section of PL1902/N0513, and the Penguin 4 inch flexible pipeline PL2228/N1141.

PL4493/N0610 Schematic.

N0610 (PL 4493) 16" Tie-in Spool Piece – BRENT CHARLIE – Gas Export Pipeline SSIV

SERVICE: GAS EXPORT

PIPELINE DATA:	Dimensions		Material	Length	Coating
	406.4 x 20.6 W/T		DNV L450 PDFU	117m	To specification LCDP-SP-CP-003
Crossings:	No.	Line	Function/Service		
	1	N1141	4" Gas		
	2	N0513	16" Oil		
	3	N1845	Umbilical		



A1.1.1 Overview

Diameter	Length	Service	Location	Type	Status
16 inch/ 24 inch	0.117 km	Gas export	BC to GEP Export SSIV	Rigid	Exposed on seabed with mattress protection along its length and grout bags for support

A1.1.2 Recommended Option

The recommended option for this pipeline is complete removal by cut and lift.

PL4493/N0610 is surface laid and protected with mattresses along its length. Due to the diameter and rigid construction of the pipeline, reverse-reeling is not technically feasible as the line is too short. However, because it is constructed of several connected spool-pieces, it can be recovered by reverse installation once the mattresses and grout bags have been recovered. As a very recently installed pipeline, there should be no issues with the integrity of either the mattresses covering the line or the subsea pipeline itself that would prevent full removal.

Cut and lift recovery is an industry-standard operation and is technically feasible using existing ROVSVs and DSVs. If for any reason the integrity of the mattresses or spool-pieces are in question, the pipeline could be removed using a basket or skid.

Operations to remove the pipeline would not be expected to pose significant or unacceptable risk to offshore or onshore project personnel; the pipeline can be cut into sections using specialist ROV units, which would reduce the need to use divers, and the amount of material that would be processed onshore is not significant. Further, the onshore processing work would be carried out at a suitably licensed and controlled disposal site. For both onshore and offshore personnel any risks could be mitigated to ALARP levels using standard risk control methods already used widely across the industry. As the pipeline would be completely removed from the seabed, there would be no long-term safety risk to fishermen. This preferred end-point could be achieved without increased risk to project personnel.

The environmental impact of removing this short length of pipeline and associated mattresses is not expected to be significant; there would be minimal disturbance to the upper layers of the seabed during the cutting and lifting operations, from which the marine fauna and flora would be expected to recover rapidly and completely. Due to the short length of the pipeline, the offshore operations would be of short duration, limiting the gaseous emissions, and because all the material would be returned to shore, recycling of the material would be maximised, limiting the requirement for new manufacture. The estimated cost of removing the pipeline is acceptable, and removal would negate the need for future monitoring.

The only other option for this pipeline is to leave the pipeline in situ or to undertake burial or rock-dumping work along the pipeline length. This option was not included in the decision tree as it was not considered to be in line with the BEIS Guidance Notes. However, even if this were a feasible option, the possible trenching of the pipeline would be technically challenging due to its very short length and its proximity to both the Brent Charlie platform and the GEP Export SSIV – at least some of the spool-pieces would have to be recovered by cut and lift to provide access in a very congested area of the seabed. Rock-dumping of the line would be achievable and would contain the pipeline as it degrades, but this would disturb an area of currently stable seabed as well as introducing more material to the seabed and, given the proximity to other infrastructure, may not be possible.

A1.2 Description of PLU4494/N4870

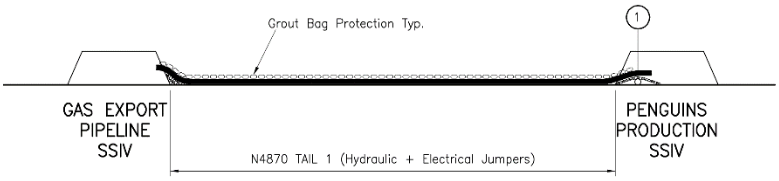
PLU4492/N4870 was installed as part of the Brent Charlie GEP and connects the GEP SSIV to the Penguins Production SSIV). The umbilical is 1 inch in diameter and approximately 60 m long. The routing of the jumpers was in two tails, comprising hydraulic and electrical jumpers from GEP SSIV to Penguins Production SSIV, and an electrical jumper from Penguins Production SSIV to Penguins Gas Lift SSIV. The umbilical was laid on the seabed and grout bags were added to protect it. Where the umbilical connects to the Penguin Production SSIV, it crosses over the mattresses protecting the Penguin Control SSIV umbilical PLU1903/N1845.

PLU4494/N4870 Schematic.

N4870 (PLU 4494) Umbilical Jumpers
GEP SSIV – Penguins Production SSIV

Pipeline Data:	Jumper	Outside Diameter	Length	Construction	Cores
	Tail 1 Hydraulic	1"	60m	Unarmoured hydraulic hose	1 x $\frac{1}{2}$" I.D.
	Tail 1 Electrical	1"	60m	Unarmoured electrical cable	2 x $1.5mm^2$

Crossings:	No.	Line	Function/Service
	1	N1845	Umbilical



A1.2.1 Overview

Diameter	Length	Service	Location	Type	Status
1 inch	0.1 km	Control umbilical	Brent Charlie 500 m zone	Flexible	Exposed on the seabed with grout bag protection

A1.2.2 Recommended Option

The recommended option for this umbilical is complete removal by reverse-reeling.

PLU4494/N4870 lies on the seabed under grout bag protection. Once the grout bags have been recovered, this small diameter, flexible line can be recovered. As a very recently installed umbilical there should be no issues with the integrity of either the grout bags covering the umbilical or the umbilical itself that would prevent full removal.

Reverse-reeling is an industry-standard operation and the safety risk to offshore personnel can be mitigated to ALARP levels using standard risk control measures and to onshore personnel by using approved procedures at a suitably licensed disposal site and specialist processing facility. The seabed would be left clear and there would be no remaining obstruction to other users of the sea.

The removal of the grout bags and the reverse-reeling of this umbilical would cause minimal disturbance to the seabed and the demersal communities in the area. The offshore operations to remove this umbilical are expected to be of short duration and so gaseous emissions would be minimal and the cost reasonable.
In addition, it is likely that the recycling of the majority of the umbilical would use less energy than the new manufacture of the same mass of material.