MacCulloch Decommissioning Programme: Comparative Assessment Report for Subsea Infrastructure

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BMT UK 2 Ltd

Broadfold House

Broadfold Road

Bridge of Don, Aberdeen

UK, AB23 8EE

Tel: +44(0)1224 414200

Fax: +44(0)1224 414250

Email: aberdeen@bmtglobal.com

Website: www.bmt.org

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ABBREVIATIONS

Abbreviation	Meaning
API	American Petroleum Institute
BEIS	Department for Business, Energy and Industrial Strategy
bbl	Barrel (oilfield barrel)
BMT	British Maritime Technology
CA	Comparative Assessment
CCS	Carbon Capture and Storage
CNS	Central North Sea
CO_2	Carbon Dioxide
CoP	Cessation of Production
DECC	Department of Energy and Climate Change
Defra	Department for Food and Rural Affairs
EDC	Eastern Drill Centre
EWC	European Waste Catalogue
FPSO	Floating Production Storage and Offloading Vessel
GJ	Giga Joules
ICES	International Council for the Exploration of the Sea
IoP	Institute of Petroleum
JNCC	Joint Nature Conservation Committee
km	kilometres
Ltd	Limited
m	metres
mmbbls	One million barrels (oilfield barrels)
MOD	Ministry of Defence
ND	No Data
NSPC	North Sea Production Company
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSPAR	Oslo Paris Convention
PDi	Project Development International Limited
POB	Personnel on Board
ppm	parts per million
ROV	Remotely Operated Vehicle
RSR	Repsol Sinopec Resources
SAC	Special Area of Conservation
SCANS	Small Cetaceans in European Atlantic waters and the North Sea
SPA	Special Protection Area
STOOIP	Stock Tank Original Oil in Place
Te	Tonnes
UK	United Kingdom
UKDMAP	United Kingdom Digital Atlas
UKCS	United Kingdom Continental Shelf
WDC	Wester Drill Centre

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NON-TECHNICAL SUMMARY

In line with Department for Business, Energy and Industrial Strategy (formerly Department of Energy and Climate Change) 'Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998', ConocoPhillips (U.K.) Limited have undertaken a Comparative Assessment of the feasible decommissioning options for the infrastructure in the MacCulloch field (UKCS Block 15/24b). This Comparative Assessment comprises three groups of subsea infrastructure associated with the proposed decommissioning programme; flowlines and umbilicals; concrete mattresses and the mooring system piles.

The Comparative Assessment provided a framework for assessing proposed decommissioning options and assigning scores to five main criteria, further divided into nine sub-criteria (Table A).

Table A: Comparative Assessment criteria

Criteria	Sub Criteria
Technical Feasibility	Technical feasibility
	Risk of project failure
Safety	Risk to personnel offshore
	Risk to onshore personnel
	Risk to other users of the sea
Environmental	Environmental risk (Biodiversity)
	Energy use and CO_2 emissions
Societal	Socioeconomic risk/ impact
Economic	Project cost

Initial Screening identified all possible options and these were assessed for technical feasibility and presented in an Options Selection Report (PDi, 2015). The options deemed technically feasible were then further assessed against the remaining criteria (Table A). As part of the Comparative Assessment process, ConocoPhillips (U.K.) Limited also undertook a workshop to evaluate the environmental and societal impacts from the activities/ operations of the options taken forward.

The scores were then ranked and weighted to allow direct comparisons between the criteria for each option. This enabled a balanced and transparent comparison in order to identify a preferred option for decommissioning of the MacCulloch subsea infrastructure.

Post the CA assessment scoring ConocoPhillips subsea team has continued to work with Bibby Offshore to maximise the efficiency of the subsea removals in particular with regards to concrete mattresses. This collaboration has resulted in the recognition that full removal using a reverse installation methodology would give the greatest time and cost efficiency and reduce the environmental impact by restoring the original habitat.

This Comparative Assessment identifies **full removal**, as the recommended option for the decommissioning of the flowlines, umbilicals, concrete mattresses, and mooring chains with the buried anchor blocks left in situ.

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1.0 INTRODUCTION

This report describes the Comparative Assessment (CA) of technically feasible decommissioning options for flowlines, umbilicals and the remaining mooring system, which ConocoPhillips (U.K.) Limited (ConocoPhillips) intend to decommission as part of the MacCulloch Decommissioning Project.

This CA has been undertaken in line with Department for Business, Energy and Industrial Strategy (BEIS) (formerly the department of Energy and Climate Change (DECC)) 'Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998' (DECC, 2011), however, when writing this report new 'Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines' (BEIS, 2018) were considered.

1.1 Background

The MacCulloch field is in UK Central North Sea (CNS) Block 15/24b, in a water depth of 149 m. Developed in 1996/ 97, the field had an expected life of ten years. Production commenced via the FPSO in August 1997.

The MacCulloch field was developed using a Floating Production Storage Offloading (FPSO) vessel, the North Sea Producer. This vessel was owned by the North Sea Production Company (NSPC). MacCulloch production was via two Drill Centres, West (WDC) and East (EDC), located 1.6 km and 2.9 km to the west and south east of the vessel location, respectively. Ten gas lifted production wells produced through three flexible flowlines from WDC and one from EDC. Oil and gas were exported from the FPSO vessel to the Repsol Sinopec Resources (RSR) Operated Piper Bravo platform through the RSR owned 10" oil pipeline and 6" gas pipeline.

The MacCulloch reservoir produced light crude, 32-37^{o} API. At the point of development, recoverable reserves were estimated at 58 mmbbls. At the Cessation of Production (CoP) on 3rd May 2015 the field had produced 119 mmbbls (a 50% recovery factor) from an estimated 241 mmbbls STOOIP.

Producing around 60,000 bbl/day at its peak, production declined to around 7,200 bbl/day gross with five wells remaining online and an average water cut of ~88% prior to the MacCulloch CoP.

The NSP FPSO was disconnected from the MacCulloch infrastructure and removed from the field in 2015 following a pipeline flushing programme. In 2017, the MacCulloch Owners undertook a well intervention campaign, installing two verified well suspension barriers (bridge plugs) in each well, one deep and one shallow, to isolate the Xmas-trees from the reservoir pressure. Pressure gauges were installed in each well to allow ongoing monitoring of the well suspension barriers.

1.2 Infrastructure Within the Scope of this Comparative Assessment

The subsea infrastructure included within the MacCulloch decommissioning programme is highlighted green in Figure 1.1. The flowlines and umbilicals included within the scope of this CA are listed below in Table 1.1. There are 510 mattresses in the MacCulloch filed associated with the subsea infrastructure and these are detailed in Table 1.2. A summary of the mooring system and it's constitute parts is provided in Table 1.3. The supporting studies and reports which have been undertaken and used in the preparation of the MacCulloch Decommissioning Project are summarised in Table 1.4. Figure 1.2 provides an overview of where the exposed sections of subsea flowlines and umbilicals lie in relation to the overall field layout. The subsea well heads and associated well structures will be removed as part of the well plugging and abandonment campaign. The manifolds templates and protective frames will also be removed.

Table 1.1: Flowlines and umbilicals included in the CA scope

Pipeline/ umbilical ID	Description	Total length (km)	Date of installation	Contents during operation	Length exposed (m) [mattressed]	% Exposure [matressed] in 2014	Number of areas potentially requiring remediation*
PL1326	7.8" Production Flowline and 4.0" Jumper #1	1.6	1996	Crude Oil	16 [178]	1.05 [11.66]	5
PL1327	7.8" Production Flowline and 6.0" Jumoer #2	1.4	1996	Crude Oil	18 [131]	1.20 [8.77]	4
PL1328	7.8" Production Flowline and 4.0" Jumper #3	1.5	1996	Crude Oil	37.5 [153]	2.66 [10.69]	5
PL1329	8.9" Production Flowline	2.8	1996	Crude Oil	21 [297]	0.74 [10.45]	Substantial areas (~1 km)
PL1330	4" 3" and 2.5" Gas Lift Flowline	2.3	1996	Gas	60 [89]	3.29 [4.88]	3
PL1331	3" Gas Lift Flowline	2.8	1996	Gas	57 [76]	2.05 [2.74]	3
PL1332	8" Water Injection Flowline	2.0	1996	Water	51 [131]	2.78 [7.14]	2
PL1333	6" Water Injection Flowline	2.8	1996	Chemicals	42 [115]	1.49 [4.09]	8
PL1334	Chemical control Umbilicals (West)	2.3	1996	Chemicals	96 [160]	6.16 [10.26]	2
PL1334 JW10	Chemical Control Umbilical	0.1	-	Chemicals	-	-	-

Pipeline/ umbilical ID	Description	Total length (km)	Date of installation	Contents during operation	Length exposed (m) [mattressed]	% Exposure [matressed] in 2014	Number of areas potentially requiring remediation*
PL1335	4.3” OD Static Umbilical (East)	3.0	1996	Chemicals	53 [272]	1.85 [9.48]	3
PL1336	Oil Export	>0.1	1996	Crude Oil	-	-	-
PL1337	Gas Export	>0.1	1996	Gas	-	-	-
PL2569	Gas Lift Flowline	>0.1	n/a	Gas	-	-	-
PL2571	Gas Lift Flowline	>0.1	n/a	Gas	-	-	-

*Remediation not required as recommendation is full removal.

Table 1.2: Estimated mattress quantities in the MacCulloch field

Location	Number of concrete mattresses	References
West drill centre	356	9532-CSO-04-DR-9119-001 (Z3)
East drill centre	56	9532-CSO-04-DR-9118-001 (Z3)
Miller crossing	57	9532-CSO-04-DR-9111-001 (Z1) 9532-CSO-04-DR-9112-001 (B4)
Flowline/ umbilical cover	41	2014 Survey Footage
Total	**510**	

Table 1.3: FPSO mooring system details (nine chains and anchors in total)

Drag anchor, spiral strand wire and mooring chain No.	Heading (°)	Coordinates (m)		Chain length (m)	Exposed chain length (m)	Wire length (m)	Weight (Te)
		Northing	Easting				
1	211.95	6 466 286.5	366 261.5	425	190	650	170
2	217.00	6 466 331.8	366 183.4	425	167	650	170
3	222.05	6 466 385.7	366 111.2	425	231	650	170
4	331.95	6 468 056.9	366 316.8	425	150	650	170

Drag anchor, spiral strand wire and mooring chain No.	Heading (°)	Coordinates (m)		Chain length (m)	Exposed chain length (m)	Wire length (m)	Weight (Te)
		Northing	Easting				
5	337.00	6 468 091.9	366 400.2	425	150	650	170
6	342.05	6 468 125.3	366 483.1	425	198	650	170
7	091.95	6 467 115.0	367 827.0	425	150	650	170
8	096.99	6 467 024.8	367 821.1	425	164	650	170
9	102.05	6 466 936.8	367 798.8	425	150	650	170

Sources: Chain length, wire length and weight taken from – MacCulloch Field Inventory Report 2014-REP-101-REV C1. PDi Ltd 2014

Exposed Chain lengths taken from – Marine Growth Assessment Report, RPS 2015

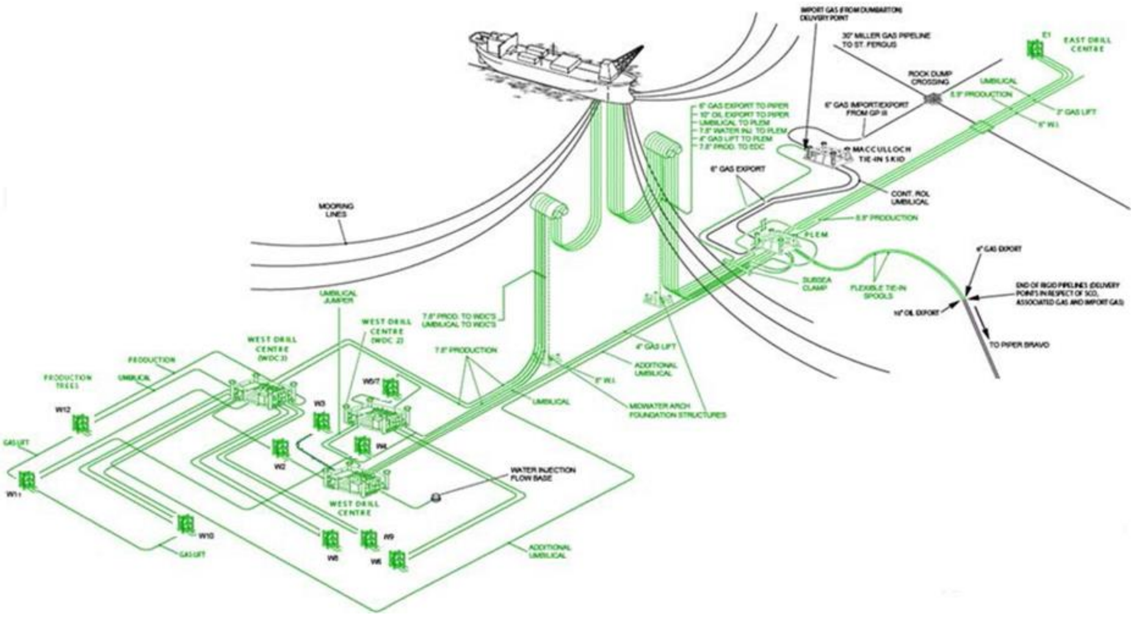


Figure 1.1: The MacCulloch infrastructure to be decommissioned

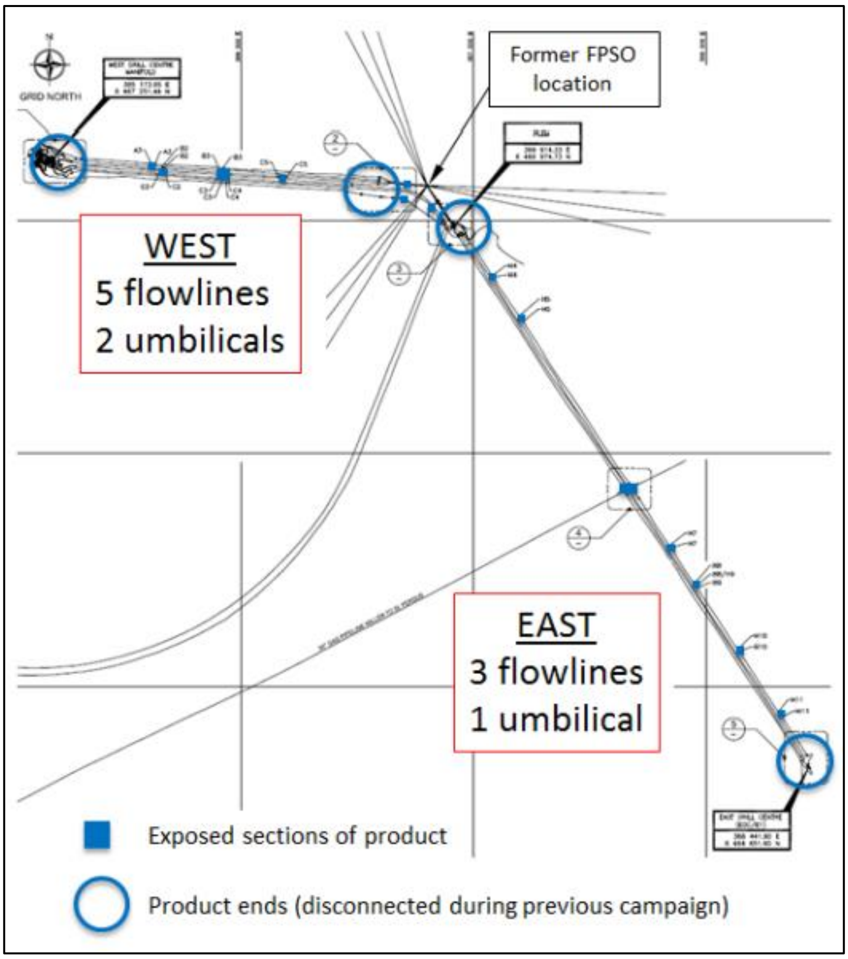


Figure 1.2: MacCulloch Field Layout showing unburied sections of flowlines and umbilicals, both EDC and WDC

Table 1.4: Studies commissioned by ConocoPhillips to support the MacCulloch Decommissioning Project

Survey Reference	Survey Title
2135-REP-003 PDI-CNS-M-MAC-X-HS-02-0001	MacCulloch Option Selection Report (PDi)
2135-REP-001 PDI-CNS-M-MAC-P-HS-02-00001	Pipeline Degradation Study (PDi)
2135-REP-002PDI-CNS-M-MAC-P-HS-02-00002	Pipeline Historical and Present Conditions (PDi)
RPS-CNS-M-MAC-X-HS-02-00001	Marine Growth (RPS)
DCL-CNS-M-MAC-S-HS-02-00001	MacCulloch Field Subsea Infrastructure. Stage 1 Materials Inventory.

2.0 ENVIRONMENTAL AND SOCIETAL SETTING

The following section provides a summary of the baseline environmental and societal setting within the vicinity of the MacCulloch field and its associated subsea infrastructure (Table 2.1 and Figure 2.1).

Table 2.1: Environmental and Societal considerations in the vicinity of the MacCulloch field

Aspect	Detail
Site overview	
The MacCulloch subsea structure to be decommissioned is located within Block 15/24b in the UK sector of the central North Sea, 250 km NE of Aberdeen in water depth of, approximately, 149 m.	
Environmental Aspects	
Conservation Interests	
Offshore and Coastal Marine Protected Areas and Annex I habitats	
Scanner Pockmark Special Area of Conservation (SAC)	Designated for submarine structures made by leaking gases (JNCC, 2018a). Located 10.5 km southeast of the MacCulloch Field.
Norwegian Boundary Sediment Plain Nature Conservation Marine Protected Area (NCMPA)	Designated due to the presence of ocean quahog (*Arctica islandica*), which is listed on an OSPAR Threatened and/ or Declining species (JNCC, 2018b). Located 52 km southeast of the MacCulloch Field.
Central Fladen NCMPA	Designated for burrowed mud (including seapens, tall seapens and burrowing megafauna) and Sub-glacial tunnel valley representative of the Fladen Deeps Key Geodiversity Area (JNCC, 2018c). Located 67 km northwest of the MacCulloch Field.
Braemar Pockmarks SAC	Designated for submarine structures made by leaking gases (JNCC, 2018d). Located 84 km northeast of the MacCulloch Field.
Offshore and Coastal Annex II species	
Harbour porpoise	• Sightings across the MacCulloch area range from low to very high throughout the year. The highest abundance of harbour porpoise in Quadrant 15 has been recorded during July (UKDMAP, 1998; Reid et al., 2003; SCANS III, 2017).
Bottlenose dolphins	• Reid et al., (2003) suggest there could be some bottlenose dolphin presence in the area, however this is not supported by UKDMAP (1998) or SCANS III (2017).
Grey seals	• Grey seal density along the decommissioning area ranges from 0 to 1 seals per 25 km^2 (Jones et al., 2015). • Haul-out and breeding sites are located on Orkney and Shetland, more than 100 km from the decommissioning area.
Harbour seals	• Harbour seal density along the decommissioning area ranges from 0 to 1 seals per 25 km^2 (Jones et al., 2015). • Haul-out and breeding sites are located on Orkney and Shetland, more than 100 km from the decommissioning area.

Aspect	Detail
Plankton	
Plankton in the area surrounding the MacCulloch subsea infrastructure is typical for this area of the North Sea. Dominant phytoplankton species are dinoflagellates of the genus Ceratium, including *C. fusus*, *C. furca* and *C. lineatum*. High numbers of the diatoms such as *Thalassiosira* spp. and *Chaetoceros* spp. are also present. The zooplankton community comprises *Calanus finmarchicus* and *C. helgolandicus* as well as *Paracalanus* spp., *Pseudocalanus* spp., *Acartia* spp., *Temora* spp. and cladocerans such as *Evadne* spp. (OESEA3, 2016).	
Benthic environment	
Seabed sediments	The seabed sediments of the MacCulloch survey area were classified as the habitat SS.SMu.OMu, offshore circalittoral mud. The species present within the grab stations were broadly similar to the biotope SS.SMu.OMu.LevHet, offshore circalittoral mud and sandy mud (Fugro EMU Ltd., 2012).
Benthic fauna	Macrofaunal analysis of the survey samples collected around the MacCulloch Floating Production and Offloading (FPSO) unit, the produced water discharge location and the east and west drill sites indicated that numbers of taxa and individuals were moderate to high across the survey area and comparable with those recorded in previous surveys in the area (Fugro Emu Ltd., 2012). Across the survey area, the macrofaunal communities comprised of species consistent with sediments of very fine and silty sands. Overall, approximately 48.8% of taxa were annelids, 25.3% arthropods, 16.7% molluscs, 3.7% echinoderms and 5.6% other phyla (e.g. nemerteans, phoronids and cnidarians) (Fugro EMU Ltd., 2012).
Socioeconomic Aspects	
Fish and shellfish – spawning and nursery areas	
Spawning areas	There are spawning areas for cod, *Nephrops* and Norway pout within ICES rectangle 45F0 and Block 15/24 (Coull et al., 1998; Ellis et al., 2010).
Nursery areas	There are potential nursery areas in the ICES rectangle for blue whiting, anglerfish, European hake, ling, Norway pout, cod, herring, mackerel, *Nephrops*, sandeel, spotted ray, spurdog and whiting within ICES rectangle 45F0 and Block 15/24. Sprat also have potential nursery areas within ICES rectangle 45F0 (Coull et al., 1998; Ellis et al., 2010). A high probability of age 0 (juveniles) anglerfish and medium probability for European hake has been reported within Block 15/24 (Aries et al., 2014).
Marine Mammals	
Cetaceans	Minke whale, common dolphin, killer whale, Risso's dolphin, white-beaked dolphin, white-sided dolphin and harbour porpoise, have been sighted in the decommissioning area (Quadrant 15 and surrounding quadrants) (UKDMAP, 1998). Reid et al., (2003) also indicate the presence of bottlenose dolphins within this Quadrant.
Seals	Grey and harbour seals can be potentially found in both blocks of interest, although in very low density (Jones et al., 2015).

Cetaceans in Quadrant 15 and surrounding quadrants

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Harbour porpoise	L*	M*		L	VH	L	H*	M*	L	L		VH
Minke whale					L	L*		L				
Common dolphin								L				
Killer whale											L*	
Risso's dolphin							L					
White-beaked dolphin		M	M		M	L	H*	L	M	L	M*	L
White-sided dolphin							VH*	L	H			

Aspect	Detail											
Key – cetaceans abundance (* observations within Quadrant 15) (UKDMAP, 1998)												
VH	Very high	**H**	High	**M**	Moderate	**L**	Low		No data			
Seabirds												
The most common species of seabird found in the MacCulloch area include: Arctic Skua, Arctic Tern, Black Guillemot, Common Gull, Cormorant, Fulmar, Gannet, Great Black-backed Gullt, Great Skua, Guillemot, Herring Gull, Kittiwake, Lesser Black-backed Gull, Little Auk, Manx Shearwater, Razorbill, Puffin, Shag, Sooty Shearwater and Storm Petrel (Stone at al., 1995).												
Seabird sensitivity	Seabird sensitivity to surface pollution has been recorded as very low to low between January and October with no data available for November and December in Block 15/24. Very high sensitivity was recorded in January and December in neighbouring Block 15/28 (Webb et al., 2016).											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Block 15/18	5	5	5	4	4	5	5	5	4	4	ND	ND
Block 15/19	5	5	5	5	5	5	5	5	5	5	ND	ND
Block 15/20	5	5	5	5	5	4	5	5	5	5	ND	ND
Block 15/23	5	5	5	4	4	5	5	5	4	4	ND	ND
Block 15/24	5	5	5	5	5	4	5	5	4	4	ND	ND
Block 15/25	5	5	5	5	5	4	5	5	5	5	ND	ND
Block 15/28	2	5	5	4	4	5	5	5	4	4	ND	2
Block 15/29	5	5	5	5	5	5	5	5	4	4	ND	ND
Block 15/30	5	5	5	5	5	5	5	5	5	5	ND	ND
Key – seabirds sensitivity (ND – no data)												
1	Extremely high	**2**	Very high	**3**	High	**4**	Medium	**5**	Low			
Socioeconomic												
Fisheries	Commercial fisheries landings were 4,155 tonnes with a value of £3,642,550 for 2016 within ICES rectangles 45F0. Demersal, pelagic and shellfish species were targeted with majority of catches attributed to pelagic species. In 2016 mainly trawls were used in terms of fishing gear. (Scottish Government, 2017)											
Shipping	Overall shipping density in the vicinity of the MacCulloch field is considered low (BEIS, 2017).											
Oil and gas industries	There are several fields within 10 km of the MacCulloch field, including Nicol (4.8 km southeast), Donan (7 km northeast) and Galley (8.6 km southwest). The closest surface is the FPSO Global Producer III, which is located 8.5 km northeast of the MacCulloch field. There are also 31 wells within Block 15/24 and 24 pipelines that intersect the block (UK Oil and Gas Data, 2018).											
Offshore renewables	There are no current or proposed windfarms located within, or in the vicinity of Block 15/24 (Crown Estate, 2017).											
Aggregate activities	There are no designated aggregate extraction areas in the vicinity of Block 15/24 (Crown Estate, 2017).											
Carbon Capture and Storage (CCS)	Goldeneye CCS agreement for lease is located 63 km southwest from the MacCulloch field (Crown Estate, 2017)											
Military activities	There is no military activity expected within 100 km of the MacCulloch field (MoD, 2017).											
Wrecks	There are no chartered wrecks within Block 15/24 (wrecksite, 2018)											
Telecommunications	There are no submarine cables which intersect, or lie close to, Block 15/24 (NMPI, 2018)											

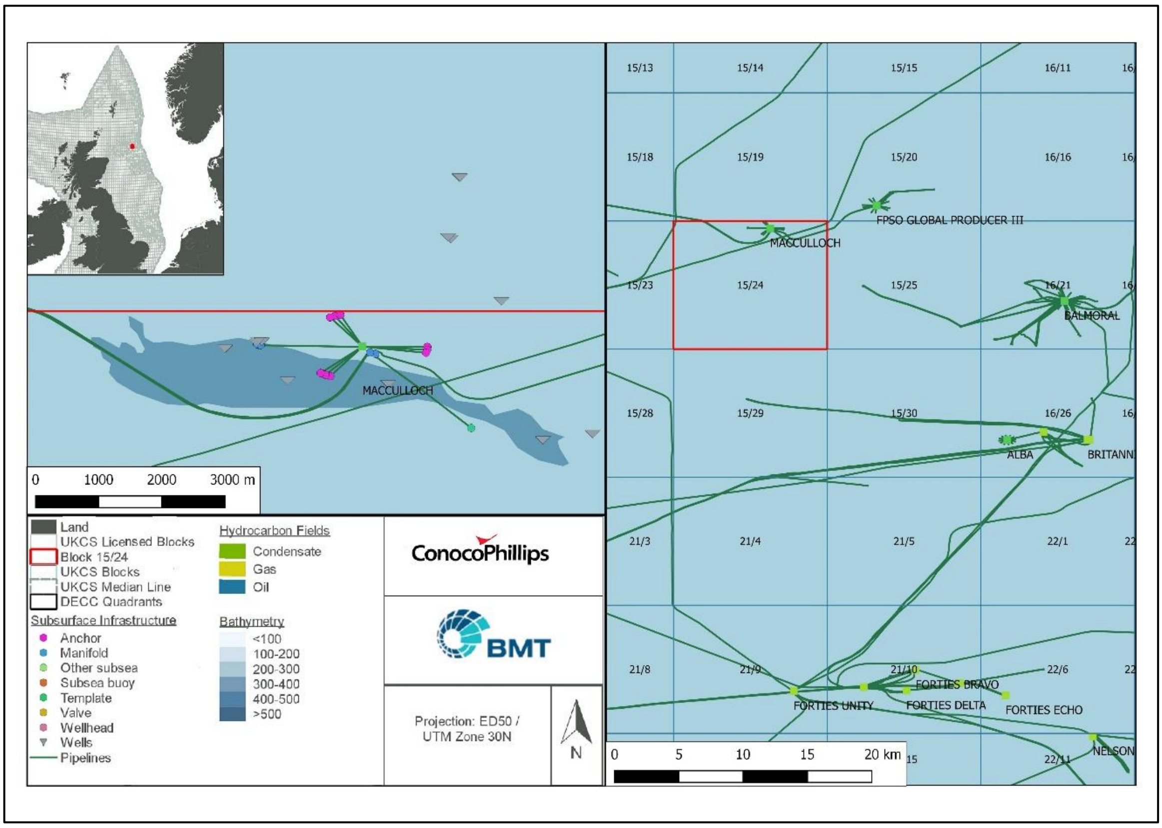


Figure 2.1: Location of MacCulloch and other assets in the vicinity of the field

3.0 HIGH-LEVEL CA OPTION SCREENING

For the purposes of the assessment, the infrastructure has been grouped into three categories; flowlines and umbilicals, concrete mattresses and the mooring system. Whilst it is assumed that all mattresses will be removed, an assessment has been carried out to allow for any eventuality where by a mattress cannot be recovered and may need to consider an alternative decommissioning method. A summary of the high-level screening of the options initially considered along with justification for the decisions made are presented in Tables 3.1 to 3.3.

Table 3.1: High-level screening of options considered for decommissioning flowlines and umbilicals

Flowlines and umbilicals							
Option	**Description**	**Technical feasibility**	**Safety**	**Environmental**	**Societal**	**Economic**	**Comments**
1	Decommission in situ – No intervention				Residual risk to commercial fishermen.	Long term monitoring, Increased cost uncertainty, as remediation may be required and extent of monitoring period uncertain.	Discarded – Residual risk and liability to other users of the sea is present due to over 1,000 m of pipeline infrastructure being exposed. This appears to be relatively stable over time but unmitigated presents a degree of risk. This option also will require a monitoring programme post decommissioning.

Flowlines and umbilicals							
Option	**Description**	**Technical feasibility**	**Safety**	**Environmental**	**Societal**	**Economic**	**Comments**
2	Decommission in situ – Burial of exposed sections				Seabed relatively stable but potential for some pipework to become exposed over time.	Long term monitoring, Increased cost uncertainty, as remediation may be required and extent of monitoring period uncertain.	Discarded – There is no technical, safety or environmental criteria to justify decommissioning in situ and leaving a legacy risk to other uses of the sea or the associated cost uncertainty of monitoring the pipeline infrastructure post decommissioning.
3	Decommission in situ – Rock placement on exposed sections			Depositing hard substrate in an otherwise soft substrate environment, the total footprint is relatively small compared to the total similar habitat available in the wider North Sea.	Seabed relatively stable but potential for some pipework to become exposed over time.	Long term monitoring, Increased cost uncertainty, as remediation may be required and extent of monitoring period uncertain.	Discarded – There is no technical, safety or environmental criteria to justify decommissioning in situ and leaving a legacy risk to other uses of the sea or the associated cost uncertainty of monitoring the pipeline infrastructure post decommissioning.

Flowlines and umbilicals							
Option	**Description**	**Technical feasibility**	**Safety**	**Environmental**	**Societal**	**Economic**	**Comments**
4	Partial removal and burial			Partial removal of the pipelines will disturb the sediment and increase sediment loading in the water column. However, this will be a short-term impact and the marine environment will recover.	Seabed relatively stable but potential for some pipework to become exposed over time.	Most costly option, long term monitoring. Increased cost uncertainty.	Taken forward for further assessment
5	Complete Removal			Removal of the pipelines will disturb the sediment and increase sediment loading in the water column. However, this will be a short-term impact and the marine environment will recover.		Moderate costs to undertake decommissioning work. No residual cost or liability.	Taken forward for further assessment

Table 3.2: High-level screening of options considered for decommissioning concrete mattresses

Concrete mattresses							
Option	**Description**	**Technical feasibility**	**Safety**	**Environmental**	**Societal**	**Economic**	**Comments**
1	Decommission in situ – No intervention			Mattresses left in situ will degrade over time and any associated plastics will potentially be released to the water column.	Exposed mattresses may pose a snagging hazard.	Long term monitoring, Increased cost uncertainty, as remediation may be required and extent of monitoring period uncertain.	Discarded – Risk and liability present due to risk of fishermen snagging on material.
2	Decommission in situ and remediate with rock if required			Addition of rock is a deviation from the natural soft seabed sediments.		High initial cost, residual monitoring, minor cost uncertainty as rock berm may deteriorate over time.	Current industry practice, from other decommissioning projects. Taken forward for further assessment.
3	Remove from pipeline and leave on seabed			Mattresses left in situ will degrade over time and any associated plastics will potentially be released to the water column.	Exposed mattresses may pose a snagging hazard.	Long term monitoring, Increased cost uncertainty, as remediation may be required and extent of monitoring period uncertain.	Discarded – Risk and liability present due to risk of fishermen snagging on material. Where mattresses are moved, ConocoPhillips intends to return these to shore for disposal.

Concrete mattresses							
Option	**Description**	**Technical feasibility**	**Safety**	**Environmental**	**Societal**	**Economic**	**Comments**
4a	Relocate mattress and cover with rock						Discarded – Did not meet the ConocoPhillips' decommissioning philosophy due to the addition of further substrate and increased environmental disturbance and impact and energy and emissions required in the operation. Where mattresses are moved, ConocoPhillips intends to return these to shore for disposal.
4b	Relocate and bury mattresses in an excavated hole	Not proven, backfilling required.			Could be perceived as marine dumping.	Residual monitoring and cost uncertainty.	Discarded - There is currently no known industry experience of performing this operation to the scale considered in MacCulloch. The challenge associated with backfilling such an excavation is significant. Where mattresses are moved, ConocoPhillips intends to return these to shore for disposal. This method also controversies London Convention which is further reason for its dismissal.
5	Reuse mattresses	No reuse site identified.		If reused on shore there is a minor risk of contamination to soils by precipitates.			Discarded – This option has been discounted on the basis that ConocoPhillips have identified no potential reuse locations at MacCulloch for concrete mattresses.

Concrete mattresses							
Option	**Description**	**Technical feasibility**	**Safety**	**Environmental**	**Societal**	**Economic**	**Comments**
6	Complete removal			Small-scale sediment disturbance and increased sediment loading of water column. Short-term impact and highly localised.		High initial cost to remove but no residual monitoring or liability.	Taken forward for further assessment.

Table 3.3: High-level screening of options considered for decommissioning the mooring system

Mooring system							
Option	**Description**	**Technical feasibility**	**Safety**	**Environmental**	**Societal**	**Economic**	**Comments**
1	Decommission in situ – No intervention				Potential snagging hazard.	Residual monitoring and cost uncertainty.	Discarded due to the residual liability risk to other users of the sea.
2	Decommission in situ – Burial of exposed sections	No known method for undertaking this effectively.			Residual snagging risk potential if mooring becomes re-exposed.	Potential cost uncertainty and monitoring required	Discarded – there is no known experience for trenching a mooring line. The alternative to use a mass flow excavator is deemed impracticable. Once the chain is cut for FPSO removal, the chain will fall to a tangled bundle on seabed owing to potential difficulty in arranging the chain into a suitable layout for trenching. There is also uncertainty over trenching equipment to be used and whether a specific weather window would be required
3	Partial removal - Cut and recover exposed mooring					High initial cost and minor cost uncertainty	Taken forward for further assessment.
4	Partial removal – Cut and recover exposed chain to anchor						On a technical basis, Option 4 was deemed to be the same operation as Option 3, with no differing factors and as such would not be considered as a stand-alone option.
5	Complete Removal						Taken forward for further assessment.

3.1 Concrete Mattresses

The location of the concrete mattresses at East and West Drill Centres are shown in Figures 3.1 and 3.2 (after Gardline, 2106). Mattresses were manufactured post 1995.

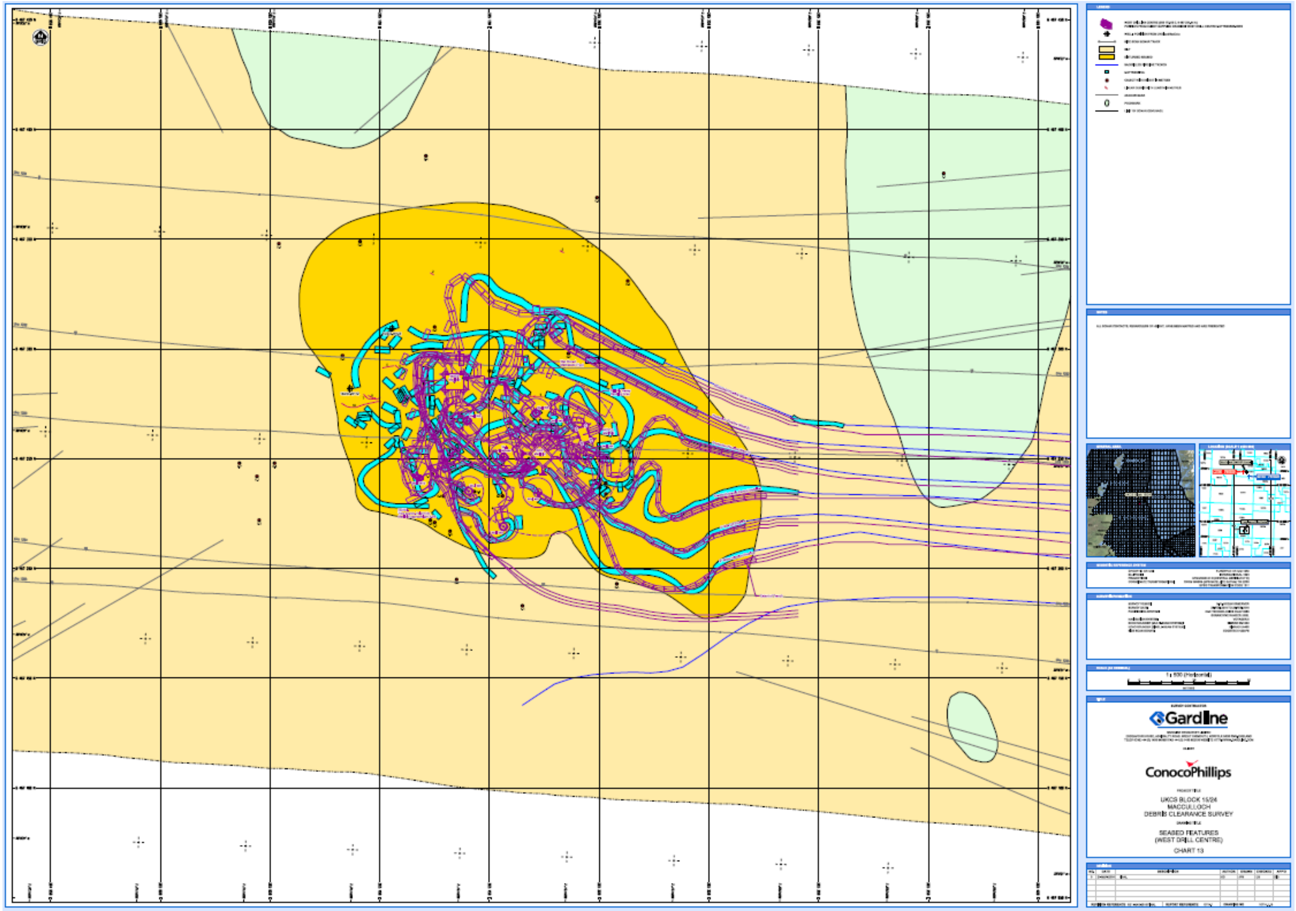


Figure 3.1: Location of the concrete mattresses (light blue) in the MacCulloch Field (West Drill Centre)

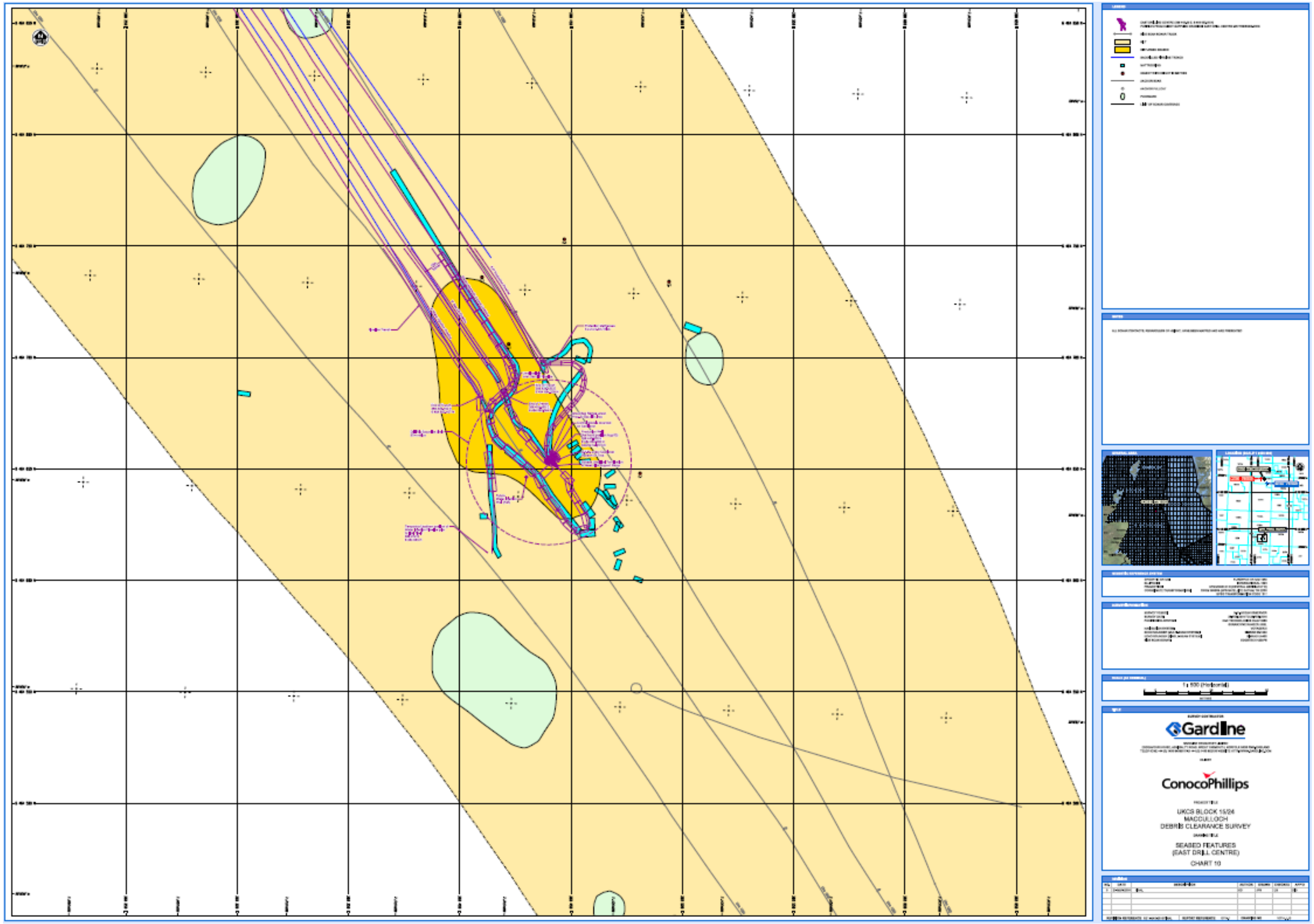


Figure 3.2: Location of the concrete mattresses (light blue) in the MacCulloch Field (East Drill Centre)

4.0 DECOMMISSIOING OPTIONS ASSESSED IN THE COMPARATIVE ASSESSMENT

Following the initial screening, Tables 4.1 to 4.3 describe the decommissioning options taken forward by ConocoPhillips for further assessement with in each infrastructure grouping.

Table 4.1: Flowlines and umbilical decommissioning options considered in CA

Decommissioning options	Method	Pipelines Considered	Description
Option 4 – Partial removal and burial	Cut and lift	All pipelines	Only exposed/ spanned sections of pipeline would be removed. Cut ends of pipelines would be covered by rock-placement. Reasonable attempts to remove all mattresses would be undertaken where safe to do so. Any remaining pipeline would be left open, ends covered with rock and flooded with seawater. Ongoing survey monitoring required post-decommissioning.
Option 5 – Full removal	Cut and lift	All pipelines	Pipelines would be exposed using jetting methods (as required) and would be removed by cutting with an underwater pipe cutter. Cut pipeline sections would then be lifted onto a vessel for transportation to shore. Reasonable attempts to remove all mattresses would be undertaken where safe to do so. No ongoing monitoring required post-decommissioning.

Table 4.2: Concrete mattress decommissioning options considered in CA

Decommissioning options	Method	Description
Option 2 – Decommission in situ (with remedial action if required)	Leave mattresses in situ	Decommission mattresses in current state. Any mattresses which require overtrawl remediation would be covered with rock. Ongoing survey monitoring would be required.
Option 6 – Full removal	Mattresses lifted and removed for onshore disposal	All mattresses will be completely removed from the seabed and returned to shore. It is assumed a speed loader will be used to recover the mattresses. No ongoing survey required post-decommissioning.

Table 4.3: Mooring system decommissioning options considered in CA

Decommissioning options	Method	Description
Option 3/4 – Partial removal	Cut and recover exposed Mooring string	Only exposed/ spanned sections of mooring system would be removed. Any remaining mooring system would be left buried. Ongoing monitoring would be required.
Option 5 – Full removal	Complete removal by cut and lift	The mooring system will be completely removed from the seabed and recovered to shore. No-ongoing monitoring required post-decommissioning.

Option Definitions

- **Decommission in situ** – leave as is in current condition and location, assume future monitoring requirements.

- **No intervention** – no remediation, removal or interference with current status.
- **Burial** – trench or further burial of infrastructure by water jetting or other burial method.
- **Exposed sections** – infrastructure above the mean seabed (including flowlines with mattress covering).
- **Rock-placement/ rock cover** – localised placement of rock material on top of exposed sections or cut pipe ends, designed with an overtrawlable profile.
- **Remove pipeline** – move from current location/ position on top of pipeline.

It should be noted that BEIS require any pipelines that are decommissioned in situ to be buried to a suitable depth, in most cases 0.6 m for the top of the pipeline to mean seabed level.

4.1 Assumptions and Considerations

To enable a clear CA to be made between the various decommissioning options, only those factors which differentiated the options and activities in relation to each other were taken into consideration.

General

- No pre-existing conditions were identified during the CA workshop
- The option selection process should have taken into consideration any conditions that would hinder the option discussed in terms of integrity.
- No integrity issues were assumed for the options taken forward to the CA workshop.
- Any option which involved decommissioning in situ had a future survey schedule of two, five, and ten years factored into the assessment with relevant impacts considered.
- Guard vessel presence beyond the decommissioning phase was not considered.

Safety

- Safety risks were discounted when assumed to have the same impact or exposure to people across the options (i.e. risk exposure during transit and mobilisation was considered non-differential across the options and across the fleet of vessel referred to).
- It shall be assumed that Personnel on Board (POB) will be equally at risk during mobilisation, transits to and from site and demobilisation regardless of vessel type.
- Aside from divers, all POB will have the same level of risk exposure when resting compared to when working on vessels.
- The duration of the activities and number of vessels involved in completing each option were reviewed to indicate potential POB safety exposure levels for comparison.

Environmental

- Energy and emissions values were calculated based on the initial materials inventory provided on the 24th March 2015 and subsequent further information provided after this date.

- All flowlines were cleaned to acceptable levels prior to the FPSO leaving the field and that any subsequent risk of subsea releases would be from the direct decommissioning operations (subsea release of hydraulic oil from ROV) or diesel inventory loss from vessel due to collision with another vessel (worst case).
- Vessel fuel consumption rates have been taken from the IoP (2000) guidelines.

Technical Feasibility

- Technical feasibility criteria and scores were taken directly from the PDi Options Selection Report, 2135-REP-003, Rev C3 Nov 2015.

Energy and Emissions

<u>Offshore vessel Assumptions</u>

- Fuel consumption rates, energy usage factors and CO_2 emissions for all vessels have been taken from the IoP (2000) and Defra (2013) guidelines and Defra (2015) greenhouse gas factors repository.
- Cutting, dredging and trenching operations are only considered as part of the overall fuel consumption for vessels.
- Rock-placement will be sourced in Norway. It has been assumed that this has been allowed for in the transit times of the rock-placement vessels.
- Ongoing monitoring surveys are expected to be undertaken at two, five and ten years post-decommissioning.
- One helicopter return flight of 426 km from Aberdeen to site has been allowed for crew change every 14 days.

<u>Materials Assumptions</u>

- All flowlines and umbilicals are 100% EWC 17 04 05 iron and steel for the purposes of recycling/ remanufacturing (D3 Consulting, 2014) and the standard steel energy conversion factors have been used.
- All mattresses are 100% EWC 17 01 01 concrete for the purposes of recycling/ remanufacturing (D3 Consulting, 2014) and the concrete energy conversion factors have been used.
- Rock-placement introduces new material into the environment,but does not require a manufacture of replacement materials calculation.

<u>Onshore Haulage Assumptions</u>

- Calculation have been made assuming that an articulated HGV with a maximum capacity of 33 tonnes and a fuel consumption of 0.038 tonnes/ 100 km (Defra, 2015) makes a round trip of 600 km from Aberdeen to the Central Belt of Scotland per full load of materials for recycling or disposal.

Economics

- Cost compared against were taken directly from the method statements for work presented in the PDi Option Selection Report 2135-REP-003, Rev C3 Nov 2015.

5.0 COMPARATIVE ASSESSMENT METHODOLOGY

The following section details the CA process by which the most appropriate options for decommissioning the subsea infrastructure were assessed.

Separate assessments and scoring have been applied to the three groupings of infrastructure. However, where options have similar impacts, activities and/ or receptors these have been assessed together to reduce the level of duplication and improve efficiency in the CA process.

In preparation for the CA assessments, ConocoPhillips identified and described the decommissioning options, decided upon the assessment criteria (and sub-criteria) to be used in the CA (Section 5.2) and established the weighting to be applied to scores for the individual assessment criteria that reflects the balance of ConocoPhillips' decision-making priorities, corporate values and stakeholder views (Section 5.3).

5.1 Comparative Assessment Workshops

As part of the CA, a workshop was undertaken to assess technical feasibility and the environmental and societal risks. These were independently facilitated and chaired by RPS. Participants at the workshop included a mix of disciplines and specialists from ConocoPhillips and RPS, including:

- ConocoPhillips (U.K.) Ltd
  - Nick Gill, Delivery Lead (MacCulloch Field Overview)
  - Rachel Myers, Environmental Scientist
  - Paul Hatton, Senior Environmental Scientist
  - Rebecca Wood, Environmental Scientist
  - Paul Howitt, Diving and ROV Coordinator
  - Jim McGarrity, Technical Safety Engineer
  - Ahmed Ali, Pipeline Engineer
  - Steven McColl, Integration and Strategy Manager, Decommissioning
  - Robert Stevenson, Decommissioning Project Integration Manager
  - Liam Williams, Pipelines Technical Authority
- RPS
  - Lucy Tait, Associate Director (Comparative Assessment Chair)
  - Charlotte Nott, Senior Consultant
  - Claire Carrigan, Consultant (Scribe)
- PDi
  - Lee Senoussi, Project Engineer (option selection, method statements)

Additional information that was pertinent to safety and cost were noted and taken forward into a workshop session on Safety and a desk-based assessment of Economic Cost.

5.2 Assessment criteria

The individual decommissioning options were assessed against the five main assessment criteria and associated sub-criteria, details of which are provided in Table 5.1. These were based on the BEIS Guidance Notes (DECC, 2011; BEIS, 2018).

Table 5.1: Assessment criteria/ sub-criteria and a brief description of method used to assess each option.

Main Criteria	Sub-criteria	Description of Assessment Methodology
Technical Feasibility	• Technical Feasibility • Recoverability from Major Project Failure	Qualitative assessment of Technical Feasibility and Recoverability from Major Project Failure. – The assessment was carried out as part of a workshop session involving participants with expert knowledge of the project and a range of relevant specialist disciplines. – Following a discussion on the decommissioning methods available and the issues associated with each option, separate scores for each option were assigned for technical feasibility and recoverability, within five feasibility/ recoverability levels defined within a scoring matrix. Scoring was based on a majority decision from the participants. – Any option that scored as a major or severe risk or being unfeasible or irrecoverable was discontinued from the process and not assessed further. Section 6.1 provides the result of the assessment.
Safety	• Risk to Workforce (onshore/ offshore) • Risk to 3rd Party's (onshore/ offshore)	Qualitative assessment of Safety, both onshore and offshore, based on risk of injury to either the Decommissioning Workforce or the 3rd Party's, such as the general public and commercial fishermen. – The assessment was carried out as part of a workshop session between BMT and ConocoPhillips Decommissioning Team. – Following a discussion on the decommissioning methods and the issues associated with the individual decommissioning activities, separate scores for each option were assigned based on a risk matrix provided by ConocoPhillips (Section 6.2). This matrix defined the likelihood of risk and the consequence of an accident on the receiving individual, each of these descriptors had five levels of likelihood/ severity. Section 6.2 provides the results of the assessment and Appendix A provides further detail from the output of the workshops.
Environmental	• Environmental Risk: ○ Onshore ○ Marine	Qualitative assessment of Environmental Risks onshore and offshore for each of the options using ConocoPhillips' risk assessment methodology and matrix (Section 6.3). The assessment was carried out in a workshop involving participants with expert knowledge of the project and a range of relevant specialist disciplines. Environmental risks and societal risks (see below) were both assessed within these two workshops. – Each option was broken down into its component activities/ operations and end-points. For each of these components, the CA workshop participants conducted an environmental risk assessment, which identified potential causes of impact to receptors, and assessed the likelihoods of occurrence, consequences and levels of risk using the risk assessment matrix. Causes,

Main Criteria	Sub-criteria	Description of Assessment Methodology
		consequences, mitigation, implications for the option and any follow-up actions relating to risks within the High and Significant categories were recorded. – For each option, the values of the scores for the different categories of risk were totalled, and the options were then ranked on the basis of these totals (lowest number = 'best' option). Appendix A provides further detail from the output of the workshops.
	• Energy Usage and CO_2 Emissions	Quantitative estimation of Energy Usage and CO_2 Emissions for each of the options (Section 6.4) using the method given in IoP (2000). – Total quantities of energy usage and CO_2 emissions for each option were calculated by estimating parameters such as fuel usage for vessels, helicopters and vehicles used in road haulage, re-manufacture of recyclable material to compensate for that decommissioned in situ, and recycling and disposal of materials returned to shore. – These quantities, fuel and materials were then multiplied by energy and emissions conversion factors detailed in Appendix E. The estimated energy and emissions were then summed to provide a total figure for each decommissioning option, and the options were then ranked on the basis of these totals (lowest number = 'best' option). Appendix B provides more detail on the methodology and results for the energy usage and emissions estimates.
Societal	• Socioeconomic Risk: ○ To other users of the sea ○ To those on land	Qualitative assessment of Societal Risks onshore and offshore using ConocoPhillips' risk assessment methodology and matrix (Section 6.5). – These assessments were made within the same workshop, using the same method, operations/ activities and end-points, as for the environmental risk assessment (except that societal criteria were used for scoring). The scores for each option were summed and the options were ranked on the basis of the total scores (lowest number = best option). Appendix A provides more detail on the outputs from the workshops.
Economic	• Comparative Cost	A quantitative estimation of Cost for each option (Section 6.6) was calculated, this included estimates for vessel usage, recycling and disposal of material, licencing fees, future monitoring, liability and seabed remediation.

5.3 Assessment Scoring

Initially, the scores from each of the assessments were expressed in their respective quantitative and qualitative units. Justification for the scores assigned during the assessments, as well as assumptions and limitations were noted and a detailed breakdown of this is provided in Sections 6.1 to 6.6, as well as in the relevant appendices. To enable a comparison to be made of the options, the results were collated and compared using a normalised/ weighted scoring system. The results of each of the five assessments were expressed in common units and ranked in order of performance from best to worst, based on the weightings assigned by ConocoPhillips (Table 5.2).

The maximum weighting was assigned to the best scoring option for each individual criterion. For example, a maximum weighted score of 30 for Safety was assigned to the best performing option.

$$Weighted\ score = \frac{best\ performing\ option\ score}{current\ option\ score} \times weighting$$

All subsequent options were assigned a normalised weighted value in proportion to the best performing option. The output was a matrix presenting normalised/ weighted values for the criteria/ sub-criteria for every option.

An overall value was established by totalling the normalised/ weighted values for the assessments and comparing the totals. ConocoPhillips used the output from the CA to select its preferred decommissioning option, with the CA report documenting the justification for their choice.

Table 5.2: Weightings of options

Criteria/ sub-criteria		Weighting (percentage)
Feasibility	Technical Feasibility	5
	Risk of Major Project Failure	5
Safety	Safety Risk (workforce and 3rd party's)	30
Environmental	Environmental Risk	15
	Energy Usage	5
	Emissions	5
Societal	Socioeconomic Risk	10
Economic	Cost	25
	Total	**100**

6.0 COMPARATIVE ASSESSMENT RESULTS

The following section presents the results of the CA of the flowlines and umbilicals, mattresses and mooring system decommissioning options. Tables 6.1 to 6.3 provide the scored results for the options (out of a maximum of 100 points). The overall scores are presented below, with the highest normalised/ weighted score representing the best option:

Flowlines and Umbilicals

- Option 4 (Partial Removal and burial – Cut and Lift): 69.28/ 100.00
- Option 5 (Full Removal – Cut and Lift): 98.33/ 100.00

Concrete Mattresses

- Option 2 (Leave in situ – with Rock Cover) 99.96/ 100.00
- Option 6 (Full Removal – Speed Loader) 85.78/ 100.00

Mooring System

- Option 3/4 (Partial Removal – Cut and Lift Exposed Mooring): 67.54/ 100.00
- Option 5 (Full Removal – Cut and Lift): 100.00/ 100.00

Sections 6.1 to 6.6 highlight why the options were considered to be strongly or weakly differentiated from each other and provides a more detailed explanation for the scores awarded to each option.

Table 6.1: Results of the Comparative Assessment of the flowlines and umbilicals decommissioning options, ranked in order of preference (highest to lowest score)

Criterion	Feasibility	Safety	Environmental Impact			Societal Impact	Economic	Normalised/ weighted total value
Assessment scope:	Feasibility of successful completion and recoverability from major project failure	Safety risk offshore & onshore	Environmental risk offshore & onshore	Energy	Emissions	Societal risk offshore & onshore	Cost	
Metric:	Qualitative comparison	Summed total of safety risks	Summed total of environmental risks	Quantity of energy used (GJ)	Quantity of and CO_2 emitted (Tonnes)	Summed total of societal risks	Estimated project cost in £ sterling	
Maximum possible normalised/ weighted value:	**10**	**30**	**15**	**5**	**5**	**10**	**25**	**100**
Option 5: Full removal								
Assessment result	6	97	37	39,276	3,276	15	7,172,656	
Normalised/weighted value	**8.33**	**30.00**	**15.00**	**5.00**	**5.00**	**10.00**	**25.00**	**98.33**
Option 4: Partial removal and burial								
Assessment result	5	146	51	78,630	5,909	23	10,751,498	
Normalised/weighted value	**10.00**	**19.93**	**10.88**	**2.50**	**2.77**	**6.52**	**16.68**	**69.28**

Table 6.2: Results of the Comparative Assessment of the concrete mattress decommissioning options, ranked in order of preference (highest to lowest score)

Criterion	Feasibility	Safety	Environmental Impact			Societal Impact	Economic	Normalised/ weighted total value
Assessment scope:	Feasibility of successful completion and recoverability from major project failure	Safety risk offshore & onshore	Environmental risk offshore & onshore	Energy	Emissions	Societal risk offshore & onshore	Cost	
Metric:	Qualitative comparison	Summed total of safety risks	Summed total of environmental risks	Quantity of energy used (GJ)	Quantity of and CO_2 emitted (Tonnes)	Summed total of societal risks	Estimated project cost in £ sterling	
Maximum possible normalised/ weighted value:	**10**	**30**	**15**	**5**	**5**	**10**	**25**	**100**
Option 2: Leave in situ with rock cover								
Assessment result	4	74	41	29,212	6,031	17	6,453,092	
Normalised/weighted value	**10.00**	**30.00**	**15.00**	**4.97**	**4.99**	**10.00**	**25.00**	**99.96**
Option 6: Full removal								
Assessment result	5	98	47	29,053	6,017	20	6,951,083	
Normalised/weighted value	**8.33**	**22.65**	**13.09**	**5.00**	**5.00**	**8.50**	**23.21**	**85.78**

* Removal of exposed mattresses only where safe to do so

Table 6.3: Results of the Comparative Assessment of the mooring system decommissioning options, ranked in order of preference (highest to lowest score)

Criterion	Feasibility	Safety	Environmental Impact			Societal Impact	Economic	Normalised/ weighted total value
Assessment scope:	Feasibility of successful completion and recoverability from major project failure	Safety risk offshore & onshore	Environmental risk offshore & onshore	Energy	Emissions	Societal risk offshore & onshore	Cost	
Metric:	Qualitative comparison	Summed total of safety risks	Summed total of environmental risks	Quantity of energy used (GJ)	Quantity of and CO_2 emitted (Tonnes)	Summed total of societal risks	Estimated project cost in £ sterling	
Maximum possible normalised/ weighted value:	**10**	**30**	**15**	**5**	**5**	**10**	**25**	**100**
Option 5: Full removal (anchors to be left in situ)								
Assessment result	5	78	31	20,664	1,969	18	2,077,494	
Normalised/weighted value	**10.00**	**30.00**	**15.00**	**5.00**	**5.00**	**10.00**	**25.00**	**100.00**
Option 3/4: Partial removal – Cut and recover exposed mooring string								
Assessment result	5	100	45	40,139	3,345	29	4,295,152	
Normalised/weighted value	**10.00**	**23.40**	**10.33**	**2.57**	**2.94**	**6.21**	**12.09**	**67.54**

6.1 Technical Feasibility Differentiation

Technical feasibility criteria and scores were taken directly from the PDi Options Selection Report 2135-REP-003. Rev C3 Nov 2015.

6.1.1 Flowlines and Umbilicals

The scores for the two options and their performance when assessed against technical feasibility and risk of operational failure are presented in Table 6.4. Both options performed similarly because they are both using a cut and lift methodology for removal, full removal methodology is reverse lay (reeling) by CSV. The main differentiator is the partial removal has higher technical challenges due to the additional uncertainty with respect to the condition of the lines which are out-with design life.

Table 6.4: Technical feasibility assessment results and normalised weightings for flowlines and umbilicals

	Technical Feasibility		Risk of Operational Failure		
Option	Risk Score	Normalised weighted score	Risk Score	Normalised weighted value	Combined Feasibility and Failure Risk Scores
4: Partial removal and burial	3	5.00	2	5.00	10.00
5: Full removal	3	5.00	3	3.33	8.33

As with the pipeline comparison, both options are very closely matched with the main differentiator being the number of mattresses requiring to be removed (Table 6.5). The mattresses are primarily of a polypropylene design, but there may be some older specification steel wire mattresses which may prove difficult to lift if the steel wires interlocking the concrete blocks have deteriorated.

Table 6.5: Technical feasibility assessment results and normalised weightings for concrete mattresses

	Technical Feasibility		Risk of Operational Failure		
Option	Risk Score	Normalised weighted score	Risk Score	Normalised weighted value	Combined Feasibility and Failure Risk Scores
2: Decommission in with rock cover	2	5.00	2	5.00	10.00
6: Full removal	2	5.00	3	3.33	8.33

6.1.2 Mooring system

The two mooring system options carried forward had no discernible technical feasibility differentiators. The method of removal is principally a cut and lift operation and therefore both are equally viable (Table 6.6).

Table 6.6: Technical feasibility assessment results and normalised weightings for mooring system

	Technical Feasibility		Risk of Operational Failure		
Option	Risk Score	Normalised weighted score	Risk Score	Normalised weighted value	Combined Feasibility and Failure Risk Scores
3/4: Partial removal	3	5.00	2	5.00	10.00
5: Full removal	3	5.00	2	5.00	10.00

6.2 Safety Differentiation

This section presents a comparison of the Safety risk scores for each of the decommissioning options. The safety risk scores were determined through a qualitative approach using a workshop session assessing likelihood of an accident and the consequence of an incident on the receiving individuals.

6.2.1 Flowlines and Umbilicals

The two options present differing risks (Table 6.7). Although the operations are similar in terms of the techniques applied, there are a number of offshore operations involved in Option 4 which present more risk to the offshore personnel.

Table 6.7: Flowlines and umbilicals safety assessment results and normalised weightings

Option	Safety risk	Normalised weighted score
5: Full removal	97	30.00
4: Partial Removal and burial	146	19.93

6.2.2 Concrete Mattresses

The decommission in situ option has a lower safety risk score than that of full removal; Table 6.8. This is directly related to the extended period of operations and the potential requirement for divers to undertake many of the operations either wholly or in conjunction with ROV operations. In addition, the full removal requires handling the mattresses out of the water column, on to a vessel deck and then on to the quay side prior to being disposed.

Table 6.8: Concrete mattress safety assessment results and normalised weightings

Option	Safety risk	Normalised weighted score
2: Decommission in situ with rock cover	74	30.00
6: Full removal	98	22.65

6.2.3 Mooring system

The main differentiators between the scores, presented in Table 6.9, relate to the potential for residual material to be left on the seabed which could become exposed over time. This could potentially cause a snagging hazard.

Table 6.9: Mooring system safety assessment results and normalised weightings

Option	Safety risk	Normalised weighted score
5: Full removal (excluding anchors)	78	30.00
3/4: Partial Removal – Cut and recover exposed mooring string	100	23.40

6.3 Environmental Impact Differentiation

The assessment enabled a distinction to be made between four categories of risk: High, Significant, Medium and Low. Differentiation between decommissioning options was based on the level of risk assessed for each receptor and the total number of potentially impacted receptors per activity/ operation or endpoint.

6.3.1 Flowlines and Umbilicals

The main environmental differentiators are associated with the additional rock-placement that is proposed with Option 4 (Table 6.10). This represents a permanent shift from the natural sediment type in the area; however, the footprint is relatively small. Full removal does pose some temporary environmental impact associated with the sediment disturbance and resuspension of sediments however, this is highly localised and will be temporary in nature. Fully removing the pipelines negates any residual contamination over time as the pipework degrades.

Table 6.10: Flowlines and umbilicals environmental assessment results and normalised weightings

Option	Environmental risk	Normalised weighted score
5: Full removal	37	15.00
4: Partial removal and burial	51	10.88

6.3.2 Concrete Mattresses

Although the scores are similar for these two options (Table 6.11), these are derived from different aspects. Option 2 introduces new hard substrate in an environment that is primarily soft seabed sediments. In addition, leaving the mattresses in the marine environment would have the potential to contribute to the marine plastic contamination. This is due to a number of the mattresses being constructed with polypropylene rope, which as it degrades, produces micro plastic particles. Option 6 would require a degree of excavation of marine sediments which are covering some of the mattresses. As a result, there would be associated seabed disturbance and sediment resuspension. Also, all mattresses removed to shore would be placed in landfill at present as no suitable onshore reuse option has been identified.

Table 6.11: Concrete mattress environmental assessment results and normalised weightings

Option	Environmental risk	Normalised weighted score
2: Decommission in situ with rock cover	41	15.00
6: Full removal	47	13.09

6.3.3 Mooring System

The primary differentiators for the scores presented in Table 6.12 are in relation to the level of seabed disturbance and additional surveying requirements for Options 3/4. This relates to overtrawlability trials which would be undertaken at the site post decommissioning and potentially throughout the residual lifetime of the material that is decommissioned in situ.

Table 6.12: Mooring system environmental assessment results and normalised weightings

Option	Environmental risk	Normalised weighted score
5: Full removal (excluding anchors)	31	15.00
3/4: Partial removal	45	10.33

6.4 Energy and Emissions Differentiation

This section presents the quantitative estimates of energy usage and subsequent emissions that provide the basis for differentiating between options. The method outlined here follows the "Guidelines for Calculation of Energy Use and Gaseous Emissions in Decommissioning" (IoP, 2000).

The method considers the fate of decommissioned material from pre-decommissioning preparation to an onshore end-point, such as recycling or disposal to landfill. The total quantities of energy usage and CO_2 emissions were calculated by:

- Estimating quantities of diesel fuel consumed by vessels involved in the work programmes offshore;
- Estimating quantities of diesel consumed during the haulage onshore of the materials to landfill, treatment or recycling facilities;
- Estimating quantities of aviation fuel used for helicopter operations;
- Estimating quantities of materials required hypothetically for the manufacture of new materials equivalent to the materials lost to society by leaving recyclable material in situ in the seabed or by disposal to landfill;
- Estimating the energy required for the recycling of pipeline materials; and

- Multiplying these quantities by energy content and emission factors (IoP, 2000) which are provided in Appendix B; Table B2.

The calculations and initial assessment were undertaken in 2015, there have been no significant changes to the proposed scope since the completion of these calculations.

A full breakdown of the contributing factors and their relating energy and emission values is presented in Appendix B; Tables B3 to B7.

6.4.1 Flowlines and Umbilicals

The differentiators between Options 4 and 5 are driven by the fact that a large portion of the energy and emissions attributed to the partial removal method has to account for the hypothetical replacement of material decommissioned in situ. This is more energy demanding and emits more emissions to the environment than recycling the steel (Table 6.13).

Table 6.13: Energy and emissions assessment results and normalised weightings for the flowlines and umbilicals

Option	Energy		Emissions		Combined normalised weighted score
	Energy usage (GJ)	Normalised weighted score	Emissions (Tonne/ CO_2)	Normalised weighted score	
5: Full removal	39,276	5.00	3,276	5.00	10.00
4: Partial removal and burial	78,630	2.50	5,910	2.77	5.27

6.4.2 Concrete Mattresses

Table 6.14 compares the two options considered for the decommissioning of the concrete mattresses. There is no significant difference between the two sets of values but they are derived from different aspects. Option 2 relates to energy and emissions associated with the hypothetical remanufacture of the material decommissioned in situ. Option 6 relates to the significant vessel activity required to undertake the removal works and the prolonged duration.

Table 6.14: Energy and emissions assessment results and normalised weightings for the concrete mattresses

Option	Energy		Emissions		Combined normalised weighted score
	Energy usage (GJ)	Normalised weighted score	Emissions (Tonne/ CO_2)	Normalised weighted score	
2: Decommission in situ with rock cover	29,053	5.00	6,017	5.00	10.00
6: Full removal	29,212	4.97	6,031	4.99	9.96

6.4.3 Mooring System

As with the energy and emissions associated with the flowlines and umbilicals, the partial removal option (Options 3/ 4) scores are heavily driven by the hypothetical remanufacture of material decommissioned in situ in combination with the removal operations and recycling of this removed material on shore (Table 6.15).

Table 6.15: Energy and emissions assessment results and normalised weightings for the mooring system

Option	Energy		Emissions		Combined normalised/ weighted score
	Energy usage (GJ)	Normalised weighted score	Emissions (Tonne/ CO_2)	Normalised weighted score	
5: Full removal	20,664	5.00	1,969	5.00	10.00
3/4: Partial removal	40,139	2.57	3,345	2.94	5.51

6.5 Societal Impact Differentiation

Societal risk assessments were undertaken concurrently with the environmental risk assessment and followed the same methodology (Section 5.0). The risk was assigned by participants at the CA workshop. This section summarises the results of the societal impact assessment, with Appendix A providing a detailed breakdown of how these results were achieved. Generally, differentiation between the groupings and options was low as the offshore area is not fished particularly heavily thus the residual risk to fishermen is perceived to be low. However, this may simply be an effect of there being a de facto closed area due to the presence of the FPSO and its mooring system. Once this is removed, the area may open up to fishing.

6.5.1 Flowlines and Umbilicals

The scores and normalised weighted values for the two options considered for the decommissioning of the flowlines and umbilicals are presented in Table 6.16. The key differentiator is that under Option 4, there is a significant length of pipeline decommissioned in situ which has the potential overtime to become exposed or degrade and present a snagging hazard over time.

Table 6.16: Societal risk assessment results and normalised weightings for flowlines and umbilicals decommissioning options

Option	Societal risk	Normalised weighted value
5: Full removal	15	10.00
4: Partial removal	23	6.52

6.5.2 Concrete Mattresses

The values presented in Table 6.17 are relatively similar for the two options considered. The differentiators are that for mattresses decommissioned in situ there is a small chance that these will degrade and present a snagging hazard and any rock berm deposited on top of the mattresses will spread and dissipate over time. In addition, there is a minor risk of the polypropylene rope degrading and releasing micro plastic particles into the marine environment. However, removing all the mattresses also poses a small societal impact, as this material will have to go to landfill. ConocoPhillips has been unable to find a viable onshore reuse for the mattresses.

Table 6.17: Societal risk assessment results and normalised weightings for concrete mattress decommissioning options

Option	Societal risk	Normalised weighted value
2: Decommission in situ with rock cover	15	10.00
6: Full removal	23	8.50

6.5.3 Mooring System

The values presented in Table 6.17 are consistent with those presented for the flowlines and umbilicals. Although the values indicate a two-fold increase in impact this is primarily an effect of only having two options to consider. Generally, due to the relatively low commercial fishing effort in the area, the residual risk of having infrastructure decommissioned in situ is minimal.

Table 6.17: Societal risk assessment results and normalised weightings for mooring system decommissioning options

Option	Societal risk	Normalised weighted value
5: Full removal	18	10.00
3/4: Partial removal	29	6.21

6.6 Economic Differentiation

This section provides cost estimates for the five decommissioning options. Vessel days and rates have been estimated based on costs provided by ConocoPhillips (as per August 2015, plus a 10% inflationary increase).

6.6.1 Flowlines and Umbilicals

The main differentiator between the options presented in Table 6.18 is attributed to the methodology in recovering the flowlines and the shorter schedule to complete the full removal option in comparison to partial removal.

Table 6.18: Cost estimates and normalised weightings for flowlines and umbilicals decommissioning options

Option	Estimated cost	Normalised weighted score
5: Full removal	£7,172,656	25.00
4: Partial removal and burial	£10,751,498	16.68

6.6.2 Concrete Mattresses

There is no discernible difference between the two options considered and presented in Table 6.18. The cost of removing the mattresses is estimated to be similar to that required to fund a monitoring and remediation programme.

Table 6.19: Cost estimates and normalised weightings for flowlines and umbilicals decommissioning options

Option	Estimated cost	Normalised weighted score
2: Decommission in situ with rock cover	£6,453,092	25.00
6: Full removal	£6,951,083	23.21

6.6.3 Mooring System

The costs presented in Table 6.20 are differentiated by the more costly underwater operations associated with the partial removal operation, monitoring and potential remediation and the extended schedule of vessel time compared to the full removal method.

Table 6.20: Cost estimates and normalised weightings for mooring system decommissioning options

Option	Estimated cost	Normalised weighted score
5: Full removal	£2,077,494	25.00
3/4: Partial removal	£4,295,152	12.09

7.0 CONCLUSIONS

The cumulative scoring of the criteria for the decommissioning options is listed below from the highest to the lowest scores. The performances of the evaluation criteria for the options are represented graphically such that the higher normalised/ weighted value the better the outcome. These have been separated into the infrastructure groupings.

7.1 Flowlines and Umbilicals

Option 5: Full removal

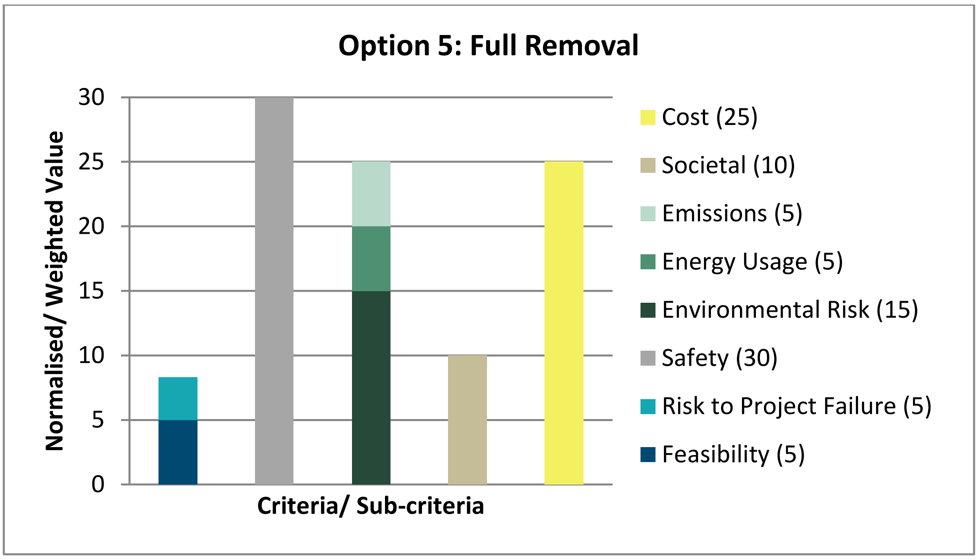
Full removal scored the highest (**98.33/ 100.00**) with technical feasibility the only criteria not scoring maximum values (Figure 7.1)

Option 4: Partial removal and burial (with rock)

Option 4 came second (**69.28/ 100.00**). Option 4 scored higher on technical feasibility, but due to pipework being decommissioned in situ, the option scored poorly on Environment, Societal, Safety and Cost due to the ongoing risk and liability to other users of the sea and addition of rock material to the marine environment. This option would require a monitoring programme with potential for remediation, adding to cost uncertainty (Figure 7.2).

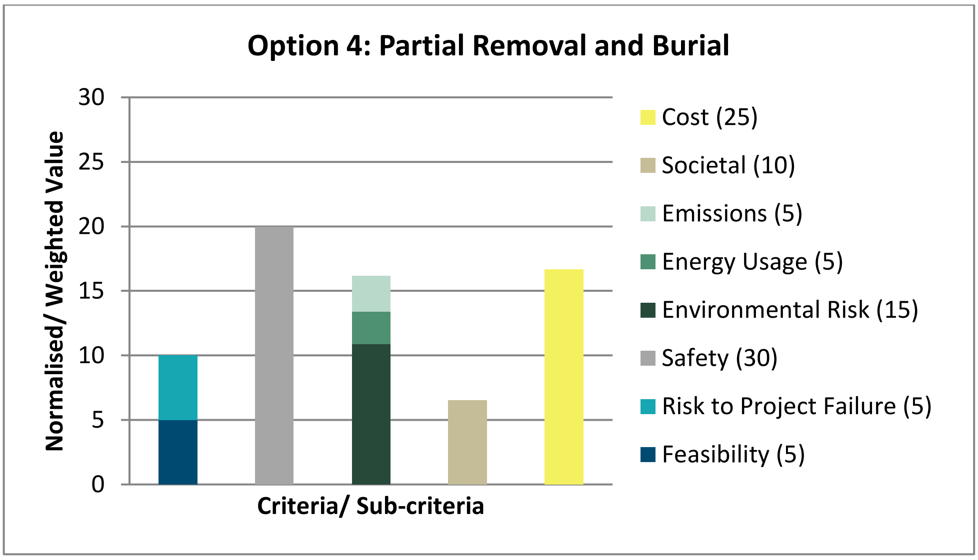
Recommendation

The CA recommends that flowlines and umbilicals are to be decommissioned via **full removal**. This removes any ongoing liability and negates any requirements to further monitor or remediate post-decommissioning with no introduction of rock material to the marine environment and only short term environmental impacts. It may be possible to consider decommissioning the flowlines and umbilicals in situ, providing they be accurately mapped, have satisfactorily passed an overtrawl assessment and a risk based monitoring programme is agreed with OPRED.



[Total scores available for each criteria given in brackets]

Figure 7.1: Weightings per criteria for Option 5



Total scores available for each criteria given in brackets]

Figure 7.2: Weightings per criteria for Option 4

7.2 Concrete Mattresses

Option 2: Decommission in situ with rock cover

Decommissioning the mattresses in situ scored the highest (**99.96/ 100.00**), however, the differentiation between this option and full removal was not significant (Figure 7.3). This option would require a monitoring programme with potential for remediation, adding some degree of cost uncertainty.

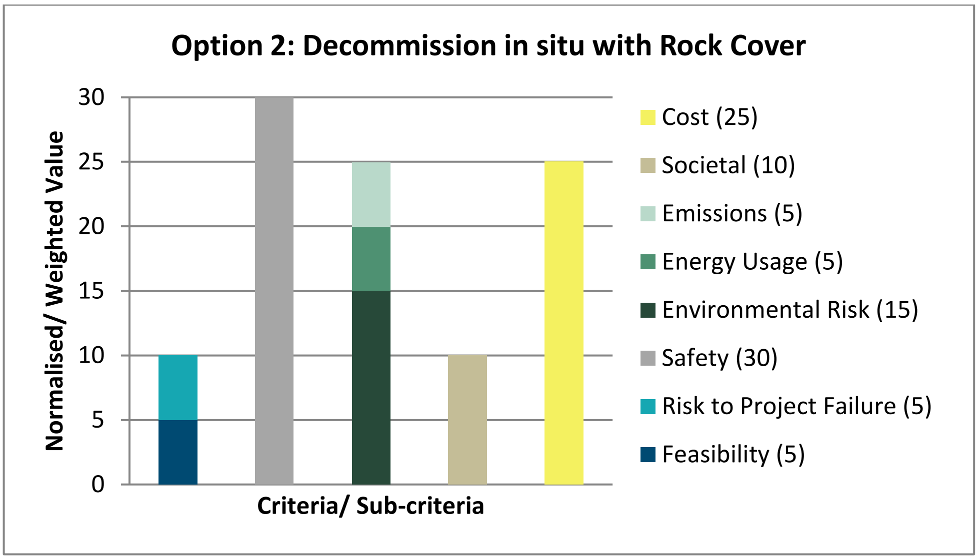
Option 6: Full removal

Option 6 came second (**85.78/ 100.00**). Option 6 scored marginally lower than Option 2 on Technical Feasibility, Safety, Environment, Societal and Economic criteria. These differences were due to issues including diver safety, use of landfill for recovered mattresses, environmental impacts derived from leaving pipework in situ and associated risks and liabilities related to other users of the sea (Figure 7.4).

Recommendation

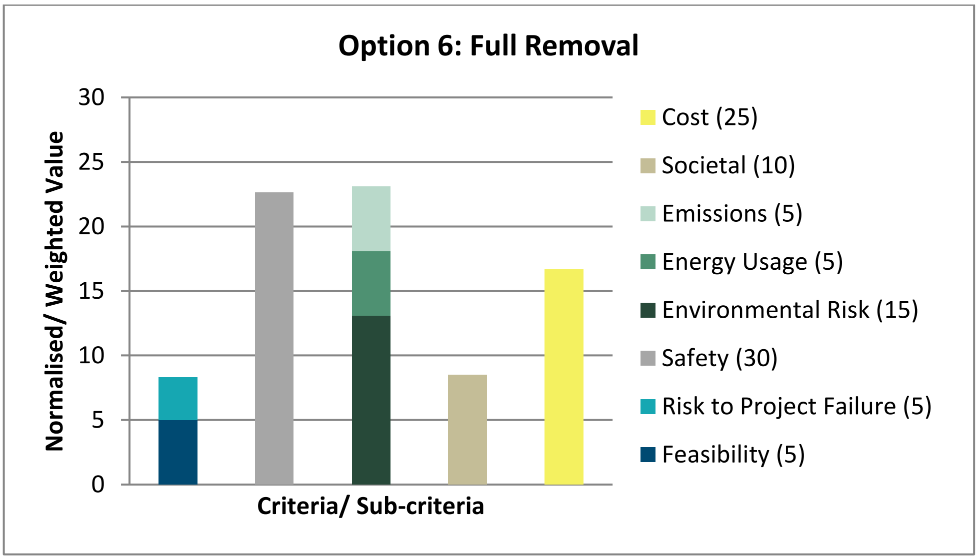
The CA recommends for concrete mattresses that these be decommissioned in situ. This option was dismissed, as it also likely to controversies the London Convention, and is not given further consideration. Given that the initial stance the OPRED expects operators to take is to target a clean seabed post-decommissioning, ConocoPhillips can find no evidence to justify decommissioning the mattresses in situ unless there is a failure during the removal of a mattress. In this case, the CA would support a decommission in situ approach and has already demonstrated that there are minimal impacts from this providing adequate mitigation is put in place. Post the CA assessment scoring ConocoPhillips subsea team has continued to work with Bibby Offshore to maximise the efficiency of the subsea removals in particular with regard to concrete mattresses. This collaboration has resulted in the recognition that full removal using a reverse installation methodology would give the greatest time and cost efficiency and reduce the environment impact by restoring the original habitat.

Therefore, ConocoPhillips has decided to **fully remove all concrete mattresses** where exposed and safe to do so. Should there be a technical issue during the removal and a mattress cannot be safely removed, the CA supports a decommission in situ approach providing adequate mitigations and monitoring are put in place.



Total scores available for each criteria given in brackets]

Figure 7.3: Weightings per criteria for Option 2



Total scores available for each criteria given in brackets]

Figure 7.4: Weightings per criteria for Option 6

7.3 Mooring System

Option 5: Full removal

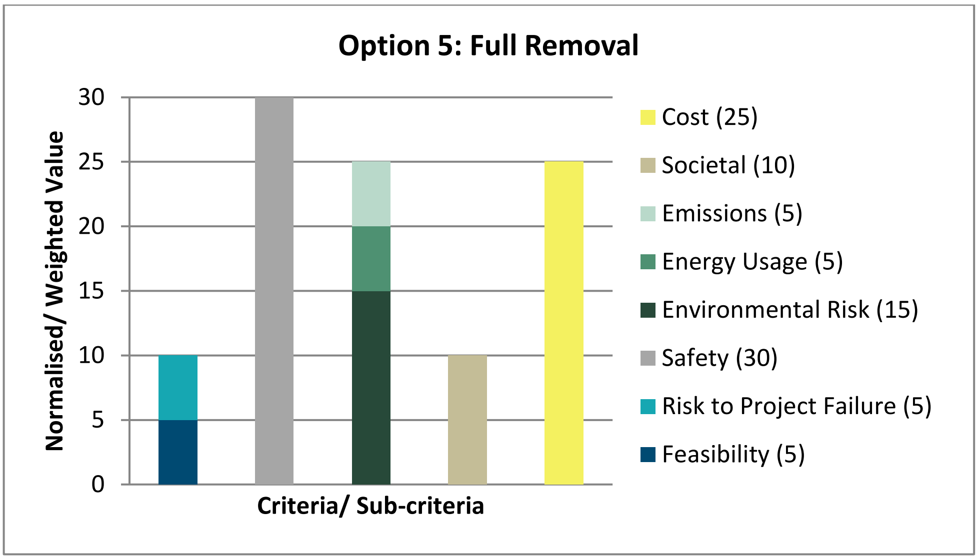
Full removal scored the highest (**100.00/ 100.00**) and aligns with the OSPAR principals of a clean seabed and full removal of installations (Figure 7.5).

Option 3/4: Partial removal – cut and recover exposed mooring string

Option 3/4 came second (**67.54/ 100.00**). Option 3/4 scored poorly on Cost, Safety, Societal and Environmental. However, it was taken forward to the CA to enable discussions should the removal of the mooring not be possible. The mooring anchors are not visible on the seabed and have remained buried since installation but would most likely pose little threat of snagging if recovery failed. Accurate recording of the mooring system would be conducted post-decommissioning with an overtrawl trial and an agreed monitoring programme with OPRED (Figure 7.6).

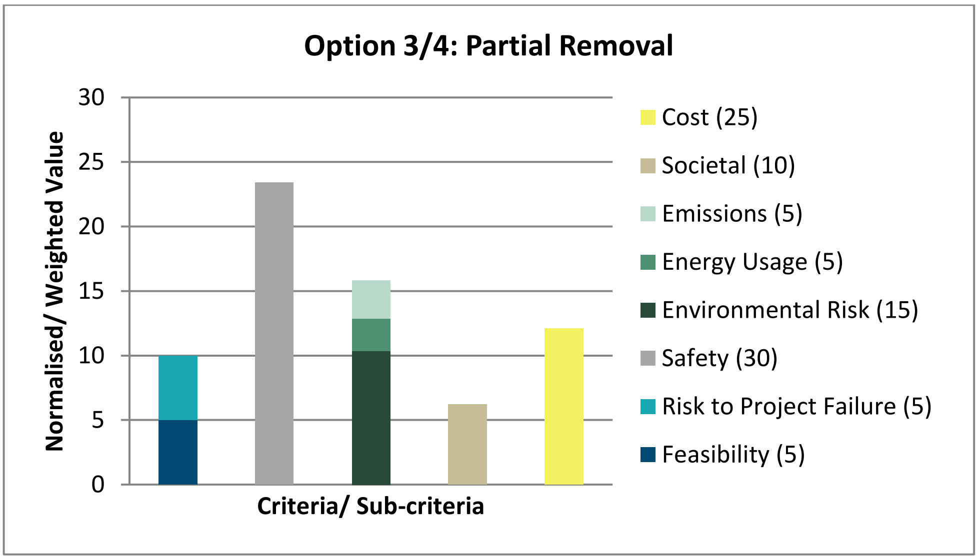
Recommendation

The CA recommends that for the FPSO mooring, these elements should be **removed** with the exception of the anchors which are left in situ due to their burial depth. If removal is attempted there will be a degree of sediment disturbance and a residual seabed depression would be left behind which would most likely require remediation.



Total scores available for each criteria given in brackets]

Figure 7.5: Weightings per criteria for Option 5



Total scores available for each criteria given in brackets]

Figure 7.6: Weightings per criteria for Option 3/4

8.0 IN SUMMARY

Based on the findings from the CA presented in this report, ConocoPhillips has concluded that the following decommissioning options are the preferred approaches for the groupings of infrastructure:

- Flowlines and Umbilicals – Full removal
- Concrete Mattresses – Full removal where safe to do so.
- Mooring System – Full removal (excluding buried anchor blocks) where feasible.

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APPENDICES

APPENDIX A
METHODOLOGIES AND RESULTS TABLES FOR CRITERION

B1 Technical Feasibility

The technical feasibility of each option was assessed using a desk-based assessment using the matrix presented in Table B1 and based on evidence presented in the supporting study conducted by PDi "MacCulloch Decommissioning Study Option Selection Report, 2135-REP-003. The report [resented a high-level sequence of operations for each option and these sequences were then scored with a focus on the following subcriteria:

- Technical challenge and use of proven technologies or equipment; and
- Risk of operations failure including weather sensitivity.

Table B2 provides a summary of the scoring results for the various options considered.

Table B1: Technical feasibility criterion descriptors

Subcriteria	Impact matrix				
	Slight	Minor	Moderate	Major	Severe
	1	2	3	4	5
Technical challenge and use of proven technology or equipment.	Standard operation. Technological feasibility of the concept is beyond doubt. Existing, proven equipment used for specific task for which it was designed.	Regular construction task using generic procedure. Technological feasibility of the concept requires minor engineering development. Existing proven equipment requiring minor modifications for specific task	Regular construction task requiring detailed procedures. Technological feasibility of the concept requires moderate engineering development. Existing proven equipment used for new application.	Non-routine task. Low level of historic experience. Technological feasibility of the concept requires major engineering development. Novel technique or equipment.	No industry experience of operations. Technology, research and development required to perform task.
Risk of operations failure including weather sensitivity.	Very low risk of operations failure. Good prospects of recovery.	Low risk of operations failure. Good prospects of recovery	Medium risk of operations failure. Moderate prospects of recovery	High risk of operations failure. Limited prospects of recovery	Very high risk of operations failure. No prospects of recovery.

Table B2: Technical feasibility scores for each grouping

Option No.	Description	Technical challenge	Risk of operational failure recovery
Flowlines and umbilicals			
1	Decommission in situ – No intervention	1	1
2	Decommission in situ – Burial of exposed sections	2	2
3	Decommission in situ – Rock placement on exposed sections	2	2
4	Partial removal and burial	3	2
5	Complete Removal	3	3
Concrete mattresses			
1	Decommission in situ – No intervention	1	1
2	Decommission in situ and cover with rock	2	2
3	Remove from pipeline and leave on seabed	2	2
4a	Relocate mattress and cover with rock	2	2
4b	Relocate and bury mattresses in an excavated hole	4	2
5	Reuse mattresses	4	3
6	Complete removal	2	3
Mooring system			
1	Decommission in situ – No intervention	1	1
2	Decommission in situ – Burial of exposed sections	5	2
3	Partial removal – Cut and recover exposed mooring	3	2
4	Partial removal – Cut and recover exposed mooring string	3	2
5	Complete Removal	3	2

B2 Environmental, Societal and Safety

The environmental, societal and safety criteria were assessed using on a qualitative assessment of risk. This is based upon the assessment matrices within ConocoPhillips' HSE Risk Assessment Standard (Issue No. 4). The assessment uses a likelihood and consequence matrix, which is presented in Tables B3 and B4, to differentiate between four categories of risk; High, Significant, Medium and Low. All scoring was assessed post-mitigation. The assessment standard provides descriptors of the management required for each category of risk and these are presented below:

- High Risk (RR IV)
    - Manage risk using additional or improved risk-reducing measures **with priority**.
    - Inform appropriate management level with risk assessment detail and obtain appropriate approvals per the business unit's requirements.
- Significant Risk (RR III)
    - Manage risk using additional or improved risk-reducing measures **with priority**.
    - Inform appropriate management level with risk management detail and obtain appropriate approvals per the business unit's requirements.
- Medium Risk (RR II)

    - No additional risk-reducing measures required where controls can be verified as functional.
    - Improvements based on lessons learned are encouraged.
- Low Risk (RR I)
    - No additional risk-reducing measures required.
    - Improvements based on lessons learned are encouraged.

The descriptors for each level of consequence are presented in Table B4.

The environmental and societal criteria considered a range of receptors and the score relating to the most severely impacted receptor was presented in Tables B5 to B6. The receptors assessed are below:

<u>Environmental receptors</u>

- Sediment structure
- Seabed Integrity/ Physical change
- Water quality
- Air quality
- Land
- Fresh-water
- Sediment biology (benthos)
- Water column (plankton)
- Finfish and shellfish
- Sea mammals
- Seabirds
- Ecosystem Integrity
- Conservation sites
- Terrestrial flora & fauna

<u>Societal receptors</u>

- Commercial fishing
- Shipping
- Government, institution users (e.g. MOD)
- Other commercial users
- Recreation and amenity users
- Onshore Communities (Resources)

The Safety receptors scores are presented as separate columns. These receptors included the following:

- Risk to personnel Offshore
- Risk to Personnel Onshore
- Risk to 3rd Party Post Operations

Table B3: Likelihood and consequence matrix

		Consequence Severity				
		Level 1	Level 2	Level 3	Level 4	Level 5
Likelihood	Frequent (5)	RR II	RR II	RR III	RR IV	RR IV
	Probable (4)	RR I	RR II	RR III	RR III	RR IV
	Rare (3)	RR I	RR II	RR II	RR III	RR III
	Remote (2)	RR I	RR I	RR II	RR II	RR II
	Improbable (1)	RR I	RR I	RR I	RR I	RR II

Low Risk – RR I	Medium Risk – RR II	Significant Risk – RRIII	High Risk – RR IV

Assessing likelihood is a subjective process. Professional judgment should be used.

Frequent (5) - Occurs multiple times per year within ConocoPhillips business unit.
Probable (4) - Occurred within the ConocoPhillips business unit or more than once per year within ConocoPhillips.
Rare (3) - Occurred within ConocoPhillips or more than once per year within the oil and gas industry.
Remote (2) - Occurred or has been heard of within the oil and gas industry.
Improbable (1) - Virtually unrealistic, never heard of in the oil and gas industry.

Table B4: Consequence descriptors

	Consequence Severity				
	Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Safety Impact	Minimal Heath effect (First aid case or less)	Minor health effects (Restricted workday case, medical treatment case)	Significant health effects (lost workday case without permanent impairment)	Major health effects (permanent impairment)	Severe health effects (fatality and / or multiple hospitalisations)
Environmental Impact	• Negligible environmental impact • Immediate or instantaneous duration, no remediation required. • Small contained release that stays on site. • No exceedance or single exceedance of a permit or regulatory limit – regulatory enforcement unlikely (all media).	• Minor environmental impact, but with impacts being readily remediated or addressed by natural attenuation process. • Onshore release impact limited to facility and adjacent surrounding area. • Minor offshore release to sea mitigated through natural attenuation. • Single or multiple exceedances of a permit or regulatory limit – regulatory enforcement likely (all media).	• Moderate environmental impact, most likely requires emergency response but not always. • Uncontained release with off-site environmental impacts realised greater than the surrounding area of the facility with observable off-site impacts to flora/fauna. • Multiple exceedances of regulatory limit during a prolonged incident or operational condition – regulatory enforcement likely (all media). • Off-site localised groundwater contamination.	• Major environmental impact, requires significant mitigation measures that address ecological systems or sensitive habitats. • Off-site impacts realised from one to several miles or more. • Release affecting public infrastructure or roads which result in public evacuation or closure of transportation routes such as roads or waterways. • Widespread surface water or groundwater contamination.	• High environmental impact very severe such as resulting from catastrophic release. • Long-term impacts to sensitive habitats and multiple ecosystems. • Impacts causing closure to drinking water supplies or fishing areas. • Significant offshore release with potential to impact shoreline.
Social Impact	• No Restriction on access and no impact on operations. • Negligible impact to/from key stakeholders. Issue resolved quickly.	• Brief restriction on access (1 day to 1 month) and minor impact to operations or planned activities. • Minor impact to/from key stakeholders. Likely addressed by	• Temporary restriction on access (1 to 3 months) and moderate impact to operations or planned activities. • Moderate impact to/from key stakeholders. Mitigation requires	• Permanent partial restriction on access 3 months to 2 years) and major impact to operations or planned activities. • Major impact to/from key stakeholders. Mitigation	• Extended permanent loss of access (greater than 2 years) and loss of operation or planned activities. • Severe impact t/from key stakeholders

	Consequence Severity				
	Level 1	Level 2	Level 3	Level 4	Level 5
		prompt mitigation by stakeholder engagement professionals. • Issue resolved in a minimum amount of time.	focused efforts with various business unit groups. • Issue resolved in a moderate amount of time.	requires senior level management involvement. • Issue will take a significant amount of time to resolve.	requiring executive level involvement. • Damage permanent.

Table B5: Environmental, societal and safety impacts in relation to decommissioning of flowlines and umbilicals

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
Partial Removal and Burial of Flowlines and Umbilicals									
1.4.01	Mobilise & demobilise vessels (DSV, CSV & trawler)	• Marine operations • Longer scheduled operations (+60 days) • 3 vessels involved • Lifting operations – external lift • Personnel onshore • POB exposure • Atmospheric emissions • Noise from engines	C	1	1		3		Change to emissions due to presence of 3 vessels. Increased exposure due to presence of 3 vessels.
			L	2	1		3		
			R	2	1		9		
1.4.02	x3 Vessel transit to and from filed and set up	• Physical presence of vessels • Marine operations • POB exposure • Atmospheric emissions • Noise from engines	C	1	1	3			Transiting emissions higher than those 'on location', although still low. Risk to personnel: 'approved passage plans' in place; risk during marine operations; high likelihood of minor injuries on boats (however, the risk minimised by procedures being in place). No anticipation of accidents occurring if procedures in place & followed.
			L	1	1	2			
			R	1	1	6			
1.4.03	DSV pre-survey of flowlines and umbilicals & CSV as lay survey	• Physical presence of vessels • Marine operations • Lifting operations (ROV) • POB exposure • Atmospheric emissions • Noise from engines • Interference with 3rd party's	C	1	1	3			Launch and recovery from boat carries risk of injury; safety barriers in place; safety measures in place and pipe tracker attached. Hydraulic systems used; Small amounts of hydraulic fluid release during operations . Physical presence - seabird disturbance. Seabird sensitivity very high in January and December. Societal - EDC and WDC have statutory exclusion zones in place therefore no reduction in access within these areas. No additional exclusions required. Guard vessel to be confirmed. Depends on timing for guard vessel cover cannot be used as a mitigation measure. Other sea users aware of obstruction through statutory exclusion zones. Risk to personnel due to launch and recovery equipment/ accident/ injury. Mitigation measures assumed to be in place as standard protocol.
			L	4	2	3			
			R	4	2	9			
1.4.04a	Diver(s) in water & preparatory clearance works subsea	• Underwater ROV/ Diving operations/ Management • Saturation diving management (WC –Divers/ POB) • Diver dredging operations • Constraint working environment • Seabed disturbance during dredging (WC- Bio) • Hydraulic release from ROV • Assumption: No residual risk from infrastructure (no pressure and clean lines)	C	1	1	5			Exposed flexible flow lines cut into sections by hydraulic shears - 8 " diameter flow lines. Assumption - divers to do preparatory work not actual cutting - divers may carry out dredging activities/ marine clearance/ water jetting. Inherent risks associated with diving. Nb. Pipeline clean and depressurised. Routine safety management of divers. Nb. This work can be completed without divers. Diver preparatory work added.
			L	5	1	3			
			R	5	1	15			

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety			Comments
						Risk to personnel Offshore	Risk to Personnel Onshore	Risk to 3rd Party Post Operations	
1.4.04b	Cut into 10 m sections (217 cuts @1.5h/ cut) mechanical shears, controlled from vessel/ no divers present	• Hydraulic release from shearing unit (WC- Bio- Benthos) • Lifting operations / overboarding • Residual risk of contaminants from pipeline • Saturation diving management • Cutting equipment (PTW) • Constrained working environment • Noise from cutting • Disturbance to marine mammals • Assumption : No residual risk from infrastructure (no pressure and clean lines)	C	1	1	3			Mechanical Shearing - actual cut should only take about 5 mins if straight forward. Full operation up to 1.5 hours. Release of contents from pipe not being considered as pipes are already open ended? Not confirmed. Assumption - lines are cleaned and depressurised but still risk of residual release of contaminants - impacting benthos. Risk to POB - lifting/ overboarding of equipment - usual precautions taken. Risk to others - during cutting no associated risk given.
			L	3	1	3			
			R	3	1	9			
1.4.05	Bundle cut sections assumed, rigging attached & located (36 bundles @ 6 bundles/ h)	• Underwater ROV/ Diving Operations • Saturation diving management • Constrained working environment • Vessel noise • Seabed disturbance, Benthos smothering (WC-Bio) • Loss of fishing gear (WC-Other Users) • Assumption: No residual risk from infrastructure (no pressure and clean lines)	C	1	1			5	Divers required for rigging. ROV required at all times for monitoring divers and operations. Seabed disturbance from cutting and relocation of pipes and bundles. Timescale for bundles being left on seabed debated. Piles can't be left longer than 5/ 6 months due to recertification of rigging gear (6 month expiration). Anticipated that as soon as DSV has finished cutting and piling the CSV can collect piles (dependant on weather/ operating conditions). DSV can be used to collect piles however there are cost implications. Vessel management/ operation sequence to be considered to maximise vessel usage. Possible that piles will be left outside the exclusion zone. Bundles left on seabed for long time will create potential for snagging. Guard vessels required.
			L	5	1			3	
			R	5	1			15	
1.4.06	Rectification / burial of product cut ends by divers/ water jetting (108 ends @ 2h/ end)	• Underwater ROV / Diving Operations (WC- POB/ Divers) • Saturation diving management • Cutting equipment (PTW) • Constrained working environment • Noise from jetting • Seabed disturbance • Smothering of benthos (WC-Bio) • Assumption: No residual risk from infrastructure (no pressure and clean lines)	C	1		5			Divers bury ends manually using water jetting. Diving - classed as routine for them - no increased risk due to duration or exposure. Smothering of benthos likely.
			L	2		3			
			R	2		15			
1.4.07	CSV recovery of cut bundle sections (36 lifts @ 3h/ lift)	• Marine Operations • ROV Operations • Hydraulic Release from ROV • Seabed disturbance (lift/ dragging / dropped objects) WC-Bio • Dropped Objects • NORM Scale / handling • Lifting operations WC-POB	C	1	1	3			ROV will cause seabed disturbance. DP class 2 vessel used so dragging /dropping unlikely. CSV - potential extension of schedule of work. Risk to POB - NORM scale testing - competent person onboard. Lifting operations. Potential for NORM scale interaction with POB.
			L	4	1	4			
			R	4	1	12			

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
		• POB exposure • Atmospheric Emissions • Noise from engine • Noise from recovery operations							
1.4.08	Perform overtrawl trials over selected areas	• Physical presence of vessel • Marine Operations • POB exposure • Atmospheric Emissions • Seabed disturbance • Noise from engine • Interference with 3rd Party's • Damage to subsea infrastructure • Snagging during trial	C	2	1	3			Environmental seabed disturbance - seabed disturbance - trawling. Well head abandonment (W12) discussed. After decommissioning - to be decided. Risk over snagging wellhead only associated with W12 well. Oil spill modelling available. Other users - Once overtrawls completed risk will be removed. Socioeconomic - positive impact. Negative impact very low.
			L	5	1	3			
			R	10*	1	9			
1.4.09	Buried infrastructure to remain (Post operations)	• 3rd party asset damage (WC-Other User) • 3rd part safety risk • 3rd party business interruption / fishing. Restricted zones in place (WC-SC) • Degradation of flow lines / release of material & contaminants, scale/ NORM (WC-Bio- benthos) • Future exposure or damage to infrastructure • Natural sediment shifting	C	1	2			2	Risk to other users - area is trenched so unlikely to cause snagging or loss of vessel. Potential for snagging if exposed due to environmental conditions and passage of time. 10% removal/ recovery.
			L	4	2			2	
			R	4	4			4	
1.4.10	Future survey regime/ commitments (x3) 2, 5, 10 years	• Physical presence of survey vessel • Disruption to 3rd Party activities • Atmospheric Emissions • General waste produced during operations	C	1	1	3			Launch and recovery from boat carries risk of injury; safety barriers in place; safety measures in place and pipe tracker attached. Hydraulic systems used; Small amounts of hydraulic fluid release during operations . Physical presence - seabird disturbance. Seabird sensitivity very high in January and December. Societal - EDC and WDC have statutory exclusion zones in place therefore no reduction in access within these areas. No additional exclusions required. Guard vessel to be confirmed. Depends on timing for guard vessel cover cannot be used as a mitigation measure. Other sea users aware of obstruction through statutory exclusion zones. Risk to personnel due to launch and recovery equipment/ accident/ injury. Mitigation measures assumed to be in place as standard protocol. Post operations risk to other users - Vessel collision risk to POB and other users. Area will still have exclusion zone until W12 P&A. There may be a guard vessel in the area with potential for collision, though unlikely due to communications and radar systems. Biodiversity - W/C loss of diesel; wellhead snag/ blow out. Moderate risk - spill modelling - does not beach.
			L	4	2	3			
			R	4	2	9			

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
1.4.11	Unplanned Events	• Vessel Collision (WC-POB) • Man Overboard • Loss of diesel inventory to sea (WC-SC) • Onboard Fire • Dropped Object to sea • Snagging w12 wellhead during trawler trials- Loss of hydrocarbons to sea (WC-Bio)	C	3	2	5		4	Well head snagging of W12 - greatest environmental consequence if occurred. Only applicable if trawling the whole site not if applied locally. Trawl plan required. No trawling anticipated around live wellhead. Biodiversity impact will depend on time of year & sea bird presence. Oil spill modelling available. No beaching highlighted. Vessel collision risk to POB and other users. Area will still have exclusion zone until W12 P&A. There may be a guard vessel in the area with potential for collision, though unlikely due to communications and radar systems. Biodiversity - W/C loss of diesel; wellhead snag/ blow out. Moderate risk - spill modelling - does not beach.
			L	2	2	2		2	
			R	6	4	10		8	
1.4.12	Onshore disposal of recovered flowlines & umbilicals (10% of total inventory volume)	• Waste handling Onshore/ Offshore • NORM Scale • Marine Growth/ Fouling/ Smell (WC-SC) • Lifting operations, vessel/ quayside (WC) • Personnel onshore • Accumulated personnel exposure doing waste handling/ transfer/ disposal (WC-PO) • Waste transportation by road • Waste disposal/ cleaning • Landfill (WC-Bio-Land)	C	1	1		3		Onshore disposal - 10% recovery. Emissions from waste disposal (recycling/ treatment etc.) captured in emissions section. Subject can be elaborated on in the ES using atmospheric emissions calculations previously prepared. Including marine growth and NORM removal. Waste transport to be covered in atmospheric emissions section. Landfill? How much is likely? This is unknown at the moment - assumption 100% recycled. Smell associated with disposal of marine growth. Risk to onshore personnel - this activity covers a large range of activities from quayside to disposal site - accumulated exposure.
			L	1	4		4		
			R	1	4		12		
Complete Removal of Flowlines and Umbilicals									
1.5.01	Mobilise & demobilise vessels (DSV, CSV, trawler)	• Marine operations • Equipment onto vessels/ increased schedule time • Lifting operations – heavy lift/ spread • Personnel onshore • POB exposure • Atmospheric Emissions • Noise from engine	C	1	1		3		Change to emissions due to presence of 3 vessels. Increased exposure due to presence of 3 vessels.
			L	2	1		3		
			R	2	1		9		
1.5.02	X3 vessels transit to and from field and set up	• Physical presence of vessel • Marine operations • POB exposure • Atmospheric emissions • Noise from engine	C	1	1	3			As option above
			L	1	1	2			
			R	1	1	6			
1.5.03	DSV pre-survey of flowlines and	• Physical presence of vessel • Marine operations	C	1	1	3			As option above

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
	umbilicals and CSV as lay survey	• POB exposure • Atmospheric emissions • Noise from engine • Interference from 3rd party's	L	4	2	3			
			R	4	2	9			
1.5.04	Divers to attach rigging to product end fittings (6.5 hrs/ product. 11 products)	• Underwater diving operations • Hydraulic release from ROV (WC-Bio) • Saturation diving management • Constrained working environment • Assumption: no residual risk from infrastructure (no pressure and clean lines)	C	1		5			Rigging/ tensioners to be installed onboard vessel – associated risks. Schedule time increased to include this. CSV used for reel. Multiple trips required – increased exposure. Fabrication onboard – associated risks.
			L	2		3			
			R	2		15			
1.5.05	Recovery of products to vessel (rate of recovery 90 m/hr). Attach crane to first end and recover product to deck (1/2 day per product). Tailing 2nd end on deck and securing to reel (1/2 day per product)	• Marine operations • Lifting/ winching/ spooling operations • Equipment/ parts under heavy load/ tension • POB exposure • Atmospheric emissions • Noise from engine/ operations • Seabed disturbance WC-Bio • Smothering of benthos • Suspended sediment in water column	C	3	1	5			Spooling required. Winches on deck. Crane operations involved. Operations likely to cause suspended sediment. Habitat change. Pipelines buried 1 m deep. Further assessment required as to how to recover – for example whether to excavate first or pull directly from seabed. Aggressive seabed disturbance using either method – assessed as such. Risk to POB – reverse reel procedure used – reeling fairly common practice – although this was debated. Tension level different to normal reeling – increased risk.
			L	4	1	3			
			R	12**	1	15			
1.5.06	Perform overtrawl trials over selected areas	• Physical presence of vessel • Marine operations • POB exposure • Atmospheric emissions • Seabed disturbance • Noise from engine • Interference with 3rd party's • Damage to subsea infrastructure • Snagging during trail	C	2	1	3			As option above.
			L	5	2	3			
			R	10	2	9			
1.5.07	Unplanned events	• Vessel collision (WC-POB) • Man overboard • Loss of diesel inventory to sea (WC-SC) • Onboard fire • Dropped objects to sea • Snagging w12 wellhead during trawler trials (WC-Other users) – Loss of hydrocarbons to sea (WC-Bio)	C	3	2	5		4	As previous operation, remaining wellheads may still result in an entanglement hazard for other users until full plug and abandonment of wells and drill centres. This risk is considered here for 3rd party's post-operation, without the presence of a guard vessel. Guard vessel itself may cause a hazard being on location by entanglements on remaining in remaining infrastructure (wellheads are considered the WC for other users).
			L	2	2	2		2	
			R	6	4	10		8	

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
1.5.08	Onshore disposal of flowlines and umbilicals (100% pf inventory)	• Waste handling • NORM • Marine growth/ fowling/ smell (WC-SC) • Lifting operations, quayside operations& cutting/ bundling • Personnel onshore • POB exposure during offloading/ cutting/ handling and transportation of waste (WC-PO) • Waste transportation by road • Waste disposal/ cleaning	C		1		4		Due to size of infrastructure – likely to be categorised as 'notifiable loads'. Disposal methods still to be confirmed. Pulled methods still to be confirmed. Pulled onshore then cut for transfer – cutting carried out by guillotine onshore. Also mentioned – cutting onboard, unsure of landing site, unknown reel lengths, unknown transport/ disposal method. Potential loads for reels and vessels given as:2 full lines per reel, 1 full line per reel. Several trips involved to remove all reels (full inventory).
			L		4		4		
			R		4		16		

* Post the CA assessment, it has been confirmed that the Well P&A will be fully completed ahead of commencing any overtrawl activity.

** Post the CA assessment scoring ConocoPhillips subsea team has continued to work with Bibby Offshore to maximise the efficiency of the subsea removals in particular with regard to concrete mattresses. This collaboration has resulted in the recognition that full removal using a reverse installation methodology would give the greatest time and cost efficiency and reduce the environment impact by restoring the original habitat. The short term impacts associated with recovery of products to a vessel are not anticipated to be significant.

Table B6: Environmental, societal and safety impacts in relation to decommissioning of concrete mattresses

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety			Comments
						Risk to personnel Offshore	Risk to Personnel Onshore	Risk to 3rd Party Post Operations	
Decommission in situ of Concrete Mattresses with Rock Cover (as required)									
2.2.01	Mobilise & Demobilise Vessels (DSV, CSV & trawler)	• Marine operations • Lifting operations – external lift • Personnel onshore • POB exposure • Atmospheric emissions • Noise from engines	C	1	1		3		Localised impact likely. Noise will be generated. Mobilisation at commercial port operations deemed as normal. Risk to personnel only during survey not much lifting involved more manual handling – low risk. Demobilisation – personnel risk minor – potential for injury or medical treatment.
			L	2	1		2		
			R	2	1		6		
2.2.02	X2 vessels transit to and from filed and setup	• Physical presence of vessels • Marine operations • POB exposure • Atmospheric emissions • Noise from engine	C	1	1	3			Transiting emissions higher than those 'on location', although still low. Risk to personnel: 'approved passage plans' in place; risk during marine operations; high likelihood of minor injuries on boats (however, the risk minimised by procedures being in place). No anticipation of accidents occurring if procedures in place & followed.
			L	1	1	2			
			R	1	1	6			
2.2.03	Pre-survey and as-left survey of mattress locations	• Physical presence of vessels • Marine operations • Lifting operations (ROV) • POB exposure • Atmospheric emissions • Noise from engines • Interference with 3rd party's	C	1	1	3			Launch and recovery from boat carries risk of injury; safety barriers in place; safety measures in place and pipe tracker attached. Hydraulic systems used; Small amounts of hydraulic fluid release during operations. Physical presence - seabird disturbance. Seabird sensitivity very high in January and December. Societal - EDC and WDC have statutory exclusion zones in place therefore no reduction in access within these areas. No additional exclusions required. Guard vessel to be confirmed. Depends on timing for guard vessel cover cannot be used as a mitigation measure. Other sea users aware of obstruction through statutory exclusion zones. Risk to personnel due to launch and recovery equipment/ accident/ injury. Mitigation measures assumed to be in place as standard protocol.
			L	4	2	3			
			R	4	2	9			
2.2.04	Rock placement over exposed areas (100Te/ hr)	• Smothering of benthos • Seabed sediment disturbance • Noise from rock-placement • Atmospheric emissions • Physical presence of vessel • Marine operations • POB exposure to noise • POB exposure to moving equipment	C	2	1	3			Only addressing operation i.e. placement of rock—loss of localised habitat quality etc. See unplanned event for post-operations impact. Other users – N/A decided to score as long term. Physical presence of rock – introducing material to seabed. Not long-term assessment line.
			L	5	1	3			
			R	10	1	9			
2.2.05	Perform overtrawl trials over selected areas	• Physical presence of vessels • Marine operations • POB exposure • Atmospheric emissions	C	2	1	3			Environmental seabed disturbance – seabed disturbance – trawling. Wellhead abandonment (W12) discussed. After decommissioning – to be decided. Risk over snagging wellhead only associated with W12 well.
			L	5	2	3			

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
		• Seabed disturbance • Noise from engine • Interference with 3rd party's • Damage to subsea infrastructure • Snagging during trail	R	10	2	9			Oil spill modelling available. Socio-cultural – positive impacts. Negative impact very low. Other users – once overtrawls completed hazard will be considered to be low risk. Potential for entanglement during overtrawl trials.
2.2.06	Mattresses remain at current location but buried	• 3rd party asset damage • 3rd party safety risk • 3rd party business interruption • Future exposure or damage to infrastructure • Future degradation of mattress materials	C	1	2			2	Protected by mattress covering, no spanning, no exposure of flowlines which are covered, no condition status confirmed on inventory below the mattress or subsequent buried/ gradually sunk.
			L	4	2			2	
			R	4	4			4	
2.2.07	Future survey regime/ commitments (x3) 2, 5, 10 years	• Physical presence of survey vessel • Disruption to 3rd party activities • Atmospheric emissions • General waste produced during operations	C	1	1	3			Future survey requirements – same as pre-survey. Presence of survey vessel during survey operations – risk to other users considered in unplanned events.
			L	4	2	3			
			R	4	2	9			
2.2.08	Unplanned events	• Vessel Collision • Man Overboard • Loss of diesel inventory to sea • Onboard Fire • Dropped Object to sea	C	3	2	5		4	Wellhead snagging of W12 greatest environmental consequence if occurred. Only applicable if trawling the whole of the site not if applied locally. Trawl plan required. No trawling anticipated around live wellhead. Biodiversity impact will depend on time of year and sea bird presence. Oil spill modelling available. No beaching highlighted. Post-operations risk to other users – vessel collision? Area will still have exclusion zone until W12 is P&A'd. There may be a guard vessel in the area with potential for collision, though unlikely due to communications and radar systems. Biodiversity – WC loss of diesel; wellhead snag/ blow-out. Moderate risk s-spill modelling – does not beach.
			L	2	2	2		2	
			R	6	4	10		8	
Complete Removal of Concrete Mattress									
2.6.01	Mobilise and Demobilise vessel (DSV and trawler)	• Marine operations • Lifting operations- external lift • Personnel onshore • POB exposure • Atmosphere emissions • Noise from engines	C	1	1		3		Localised impacts likely. Noise will be generated. Mobilisation at commercial port operations deemed as normal. Risk to personnel only during survey not much lifting involved more manual handling – low risk. Demobilisation – personnel risk minor – potential for injury or medical treatment
			L	2	1		2		
			R	2	1		6		
2.6.02	X3 vessel transit to and from field and	• Physical presence of survey vessel • Marine operations	C	1	1	3			Transiting emissions higher that those 'on location' although still low. Risk to personnel: 'approved passage plans' in place; risk during marine operations; high likelihood of minor injuries on boats (however the risk
			L	1	1	2			

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
	DP trials and setup	• POB exposure • Atmospheric emissions • Noise from engine	R	1	1	6			minimised by procedures being in place). No anticipation of accidents occurring if procedures in place and followed.
2.6.03	Perform as-found and as-lay survey of laydown areas	• Physical presence of vessel • Marine operations • Lifting operations (ROV) • POB exposure • Atmospheric emissions • Noise from engine • Interference with 3rd party's	C	1	1	3			Launch and recovery from boat carries risk of injury; safety barriers in place; safety measures in place and pipe tracker attached. Hydraulic systems used; Small amounts of hydraulic fluid release during operations. Physical presence - seabird disturbance. Seabird sensitivity very high in January and December. Societal - EDC and WDC have statutory exclusion zones in place therefore no reduction in access within these areas. No additional exclusions required. Guard vessel to be confirmed. Depends on timing for guard vessel cover cannot be used as a mitigation measure. Other sea users aware of obstruction through statutory exclusion zones. Risk to personnel due to launch and recovery equipment/ accident/ injury. Mitigation measures assumed to be in place as standard protocol.
			L	4	2	3			
			R	4	2	9			
2.6.04	Deploy speed loaders (81 at 1/hour)	• Marine operations • Lifting operations • POB exposure • Atmospheric emissions • Noise from engine • Noise from recovery operations	C	1	1	3			Lifting operations, subsea placement and disturbance, loss of loader/ dropped objects.
			L	4	2	3			
			R	4	2	9			
2.6.05	Mattress recovery operations (510 mattresses 2/ hour)	• Marine operations • Lifting operations • POB exposure • Atmospheric emissions • Noise from engine • Noise from recovery operations	C	2	1	5			Increased risk due to divers required in the water. Instability of mattresses, safe weather window. Lifting operations and underwater operations and hazards. Recovery onto vessel and handling.
			L	4	2	3			
			R	8	2	15			
2.6.06	Interim mobilisations (ops crew	• Helicopter transfers/ mobilisations/ demobilisations and landings • Back to back crew		1	1	3			Transiting emissions higher than those 'on location' although still low. Risk to personnel: 'approved passage plans' in place; risk during marine operations; high likelihood of minor injuries on boats (however the risk

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
	change assumed every 14 days). Helicopter or vessel crew change (return to shore) to be established	• Handovers • Boat transfers (back-up)		4	2	3			minimised by procedures being in place). No anticipation of accidents occurring if procedures in place and followed. Increased risk if helicopter operations are required.
				4	2	9			
2.6.07	Perform overtrawl trials over selected areas	• Physical presence of vessel • Marine operations • POB exposure • Atmospheric emissions • Seabed disturbance • Noise from engine • Interference with 3rd party's • Damage to subsea infrastructure • Snagging during trial		2	1	3			Environmental seabed disturbance – seabed disturbance – trawling. Wellhead abandonment (W12) discussed. After decommissioning – to be decided. Risk over snagging wellhead only associated with W12 well. Oil modelling available. Socio cultural – positive impact. Negative impact very low. Other users – once overtrawls completed hazard will be considered to be if low risk. Potential for entanglement during overtrawl trials through.
				5	2	3			
				10	2	9			
2.6.08	Unplanned events	• Helicopter collision (WC-POB) • Helicopter ditching • Vessel collision • Man overboard • Loss of diesel inventory to a • Onboard fire • Dropped object to sea • Loss of power control		3	2	5		4	Increased risk due to underwater operations involving divers and helicopter transfer operations
				2	2	3		2	
				6	4	15		8	
2.6.09	Onshore disposal	• Waste handling • Marine growth/ fouling/ smell • Lifting operations, quayside • Personnel onshore • POB exposure on vessel • Waste transportation by road • Waste disposal/ cleaning • Landfill (WC-Bio-Land)		2	1		3		Handling and exposure to marine growth for onshore personnel. Foul smelling impact. Reduced onshore landfill volume.
				4	4		4		
				8	4		12		

Table B7: Environmental, societal and safety impacts in relation to decommissioning of the mooring system

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
Partial Removal – Cut and Recover Exposed Mooring									
3.3.01	Mobilise & Demobilise Vessels (AHV with WROV, cutting gear and recovery rigging and trawler)	• Marine operations • Lifting operations – external lift • Personnel onshore • POB exposure • Atmospheric emissions • Noise from engines	C	1	1		3		Localised impact likely. Noise will be generated. Mobilisation at commercial port operations deemed as normal. Risk to personnel only during survey not much lifting involved more manual handling – low risk. Demobilisation – personnel risk minor – potential for injury or medical treatment.
			L	2	1		2		
			R	2	1		6		
3.3.02	X2 vessels transit to and from filed and setup	• Physical presence of vessels • Marine operations • POB exposure • Atmospheric emissions • Noise from engine	C	1	1	3			Transiting emissions higher than those 'on location', although still low. Risk to personnel: 'approved passage plans' in place; risk during marine operations; high likelihood of minor injuries on boats (however, the risk minimised by procedures being in place). No anticipation of accidents occurring if procedures in place & followed.
			L	1	1	2			
			R	1	1	6			
3.3.03	Pre-survey and as-left survey of mattress locations	• Physical presence of vessels • Marine operations • Lifting operations (ROV) • POB exposure • Atmospheric emissions • Noise from engines • Interference with 3rd party's	C	1	1	3			Launch and recovery from boat carries risk of injury; safety barriers in place; safety measures in place and pipe tracker attached. Hydraulic systems used; Small amounts of hydraulic fluid release during operations. Physical presence - seabird disturbance. Seabird sensitivity very high in January and December. Societal - EDC and WDC have statutory exclusion zones in place therefore no reduction in access within these areas. No additional exclusions required. Guard vessel to be confirmed. Depends on timing for guard vessel cover cannot be used as a mitigation measure. Other sea users aware of obstruction through statutory exclusion zones. Risk to personnel due to launch and recovery equipment/ accident/ injury. Mitigation measures assumed to be in place as standard protocol.
			L	4	2	3			
			R	4	2	9			
3.3.04	Carry out debris or obstruction clearance, as required	• Underwater ROV operation/ management • Saturation diving • Seabed disturbance during dredging (WC-Bio) • Hydraulic release from ROV • Assumption: no residual risk from infrastructure (no pressure and clean lines)	C	1	1	3			Underwater operations using ROV
			L	1	1	2			
			R	1	1	6			
3.3.05	Deploy equipment to recover the mooring strings	• ROV operations • Marine operations • Lifting/ winching operations • POB exposure to moving equipment	C	1	1	3			Underwater operations using ROV
			L	4	1	3			

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
	to storage locker onboard		R	4	1	9			
3.3.06	Deploy WROV to cut the mooring strings as close to the mud line as possible	• Marine operations • Deployment of equipment • Lifting operations • Smothering of benthos and seabed • Hydraulic release from ROV (WC-Bio) • Atmospheric emissions • Noise from operations • Sediment disturbance • Benthos disturbance • Increase in sediment suspended n water column	C	2		3			Underwater operations using ROV
			L	1		2			
			R	2		6			
3.3.07	Recover chains to vessel/ chain lockers following cut	• Marine operations • Deployment of equipment • Lifting/ winching operations • Atmospheric emissions • Noise from operations • Increase in sediment suspended n water column • Seabed disturbance/ dragging (WC-Bio) • Benthos disturbance dependant on duration in situ • Physical presence of survey vessel	C	1	1	3			Mooring chains stored on chain lockers once on board. Anchor handling deemed a normal procedure, no additional risk.
			L	4	1	3			
			R	4	1	9			
3.3.08	WROV to dredge the end of the chain/ wire below sea level	• Marine operations • ROV operations • Lifting operations • Smothering of benthos • Sediment disturbance (WC-Bio) • Benthos disturbance • Atmospheric emissions • Increased in sediment suspended in water column • Physical presence of vessels	C	2	1	3			Seabed disturbance from dredging
			L	4	4	2			
			R	8	4	6			
3.3.09	Perform overtrawls over selected area	• Physical presence • Marine operations • POB exposure • Atmospheric emissions • Seabed disturbance • Noise from engine • Interference with 3rd party's • Damage to subsea infrastructure	C	1	2				Environmental seabed disturbance – seabed disturbance – trawling. Wellhead abandonment (W12) discussed. After decommissioning – to be decided. Risk over snagging wellhead only associated with W12 well. Oil modelling available. Socio cultural – positive impact. Negative impact very low. Other users – once overtrawls completed hazard will be considered to be if low risk. Potential for entanglement during overtrawl trials through.
			L	4	2				
			R	4	4				

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety			Comments
						Risk to personnel Offshore	Risk to Personnel Onshore	Risk to 3rd Party Post Operations	
		• Snagging during trial							
3.3.10	Buried inventory remaining at site	• 3rd party asset damage • 3rd party safety risk • 3rd party business interruption • Future exposure or damage to infrastructure	C	1	2			2	Potential for future exposure of buried infrastructure
			L	4	2			2	
			R	4	4			4	
3.3.11	Future survey regime/ contaminants (x3) 2,5, 10 years	• Physical presence of survey vessel • Disruption to 3rd party activities • Atmospheric emissions • General waste produced during operations	C	1	1	3			Potential for entanglement during future survey
			L	4	2	3			
			R	4	2	9			
3.3.12	Unplanned events	• Vessel collision • Man overboard • Loss of diesel inventory to sea • Onboard fire • Dropped object to sea	C	3	2	5			Only applicable if trawling the whole site not if applied locally. Trawl plan required. No trawling anticipated around live wellhead. Biodiversity impact will depend on time of year and sea bird presence. Oil spill modelling available. No beaching highlighted. Post operations risk to other users – vessel collisions. Area will still have exclusion zone until W12 is P&Ad. There may be a guard vessel in the area with potential for collision, though unlikely due to communications and radar systems. Biodiversity – WC loss of diesel, wellhead snag/ blowout. Moderate risk – spill modelling – does not beach.
			L	2	2	2			
			R	6	4	10			
3.3.13	Onshore disposal of recovered mooring chain	• Waste handling • Marine growth/ fouling/ smell • Lifting operations, quayside • Personnel onshore • POB exposure on vessel • Waste transportation by road • Waste disposal/ cleaning/ WC-Bio-Land	C	1	1		3		Handling and exposure to marine growth for onshore personnel. Foul smelling impact. Environmental impact of future recycling/ processing and wash down of equipment.
			L	1	4		4		
			R	1	4		12		
Complete Removal of Mooring System									
3.5.01	Mobilise and Demobilise vessel (AHV with WROV, cutting gear and recovery rigging and trawler)	• Marine operations • Lifting operations- external lift • Personnel onshore • POB exposure • Atmosphere emissions • Noise from engines	C	1	1		3		Time dependant exposure Gear entanglement highlighted
			L	2	1		2		
			R	2	1		6		
3.5.02	X2 vessel transit to and from field and	• Physical presence of survey vessel • Marine operations	C	1	1	3			Transiting emissions higher that those ‘on location’ although still low. Risk to personnel: ‘approved passage plans’ in place; risk during marine operations; high likelihood of minor injuries on boats (however the risk
			L	1	1	2			

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
	DP trials and setup	• POB exposure • Atmospheric emissions • Noise from engine	R	1	1	6			minimised by procedures being in place). No anticipation of accidents occurring if procedures in place and followed.
3.5.03	Pre-survey of 9x abandoned chain ends – identity end links	• Physical presence of vessel • Marine operations • Lifting operations (ROV) • POB exposure • Atmospheric emissions • Noise from engine • Interference with 3rd party's	C	1	1	3			Launch and recovery from boat carries risk of injury; safety barriers in place; safety measures in place and pipe tracker attached. Hydraulic systems used; Small amounts of hydraulic fluid release during operations. Physical presence - seabird disturbance. Seabird sensitivity very high in January and December. Societal - EDC and WDC have statutory exclusion zones in place therefore no reduction in access within these areas. No additional exclusions required. Guard vessel to be confirmed. Depends on timing for guard vessel cover cannot be used as a mitigation measure. Other sea users aware of obstruction through statutory exclusion zones. Risk to personnel due to launch and recovery equipment/ accident/ injury. Mitigation measures assumed to be in place as standard protocol.
			L	4	2	3			
			R	4	2	9			
3.5.04	Carry out debris or obstruction clearance	• Marine operations • Deployment of equipment • Lifting operations • Smothering of benthos and seabed sediment disturbance • Benthos disturbance • Atmospheric emissions • Increase in sediment suspended in water column • Physical presence of vessels	C	1	1	3			Underwater operations using ROV
			L	1	1	2			
			R	1	1	6			
3.5.05	Deploy WROV and equipment to recover the mooring chains and anchors to vessel	• ROV operations • Marine operations • Lifting/ winch operations • POB exposure to moving equipment	C	1	1	4			Underwater operations using ROV
			L	4	1	3			
			R	4	1	12			
3.5.06	Maintain tension on winch. Not exceeding	• Marine operations • Deployment of equipment	C	2		3			Anchor depth can be up to 10 m – time dependant as to depth and location. Need to consider failure to release anchor- may need to consider to leave in situ if traditional attempts fail.

Ref.	Activities/ Operations/ Unplanned Operations	Potential impacts	Scoring Criteria	Environmental	Societal	Safety: Risk to personnel Offshore	Safety: Risk to Personnel Onshore	Safety: Risk to 3rd Party Post Operations	Comments
	mooring break load to recover wire and disengage anchor from seabed	• Lifting/ winching operations • Equipment under tension/ heavy load • POB exposure • Atmospheric emissions • Physical presence of vessel • Sediment disturbance (WC-Bio) • Benthos disturbance	L	4		3			Burial depth unknown at present. Increased risk to personnel due to potential depth of anchor- increased tension.
			R	8		9			
6.2.07	Perform overtrawl trials over selected areas	• Physical presence of vessel • Marine operations • POB exposure • Atmospheric emissions • Seabed disturbance • Noise from engine • Interference with 3rd party's • Damage to subsea infrastructure • Snagging during trial	C	1	2				Environmental seabed disturbance – seabed disturbance – trawling. Wellhead abandonment (W12) discussed. After decommissioning – to be decided. Risk over snagging wellhead only associated with W12 well. Oil modelling available. Socio cultural – positive impact. Negative impact very low. Other users – once overtrawl completed hazard will be considered to be if low risk. Potential for entanglement during overtrawl trials through.
			L	4	2				
			R	4	4				
6.2.08	Unplanned events	• Vessel collision • Man overboard • Loss of diesel inventory to a • Onboard fire • Dropped object to sea	C	3	2	5		4	Only applicable if trawling the whole site not if applied locally. Trawl plan required. No trawling anticipated around live wellhead. Biodiversity impact will depend on time of year and sea bird presence. Oil spill modelling available. No beaching highlighted. Post operations risk to other users – vessel collisions. Area will still have exclusion zone until W12 is P&Ad. There may be a guard vessel in the area with potential for collision, though unlikely due to communications and radar systems. Biodiversity – WC loss of diesel, wellhead snag/ blowout. Moderate risk – spill modelling – does not beach.
			L	2	2	2		2	
			R	6	4	10		8	
6.2.09	Onshore disposal of received mooring chains and anchors	• Waste handling • Marine growth/ fouling/ smell • Lifting operations, quayside • Personnel onshore • POB exposure on vessel • Waste transportation by road • Waste disposal/ cleaning • Landfill (WC-Bio-Land)	C	1	1		3		Potential for entire inventory to be recycled. Disposal method still to be confirmed. See examples – griffin – mares if possible (thought unlikely to be available).
			L	1	4		4		
			R	1	4		12		

APPENDIX B – ENERGY AND EMISSIONS

B1(A): Flowlines and Umbilicals – Option 4: Partial removal and burial

Tables B1.1 to B1.4 provide the results of the assessments of the vessel, material, haulage and total energy usage (GJ) and CO2 emissions calculations (tonnes of CO2) for Option 4. It is assumed that:

- Energy usage and emissions would originate principally from two sources: (1) combustion of diesel fuel by the three vessels involved in trenching and survey operations, (2) combustion of aviation fuel by the helicopter, (3) the recycling of the recovered pipeline and (4) the hypothetical manufacture of new materials to replace those lost to society because the pipelines have been left in place buried in seabed sediments.
- Total time spent mobilising, transiting, on site and demobilising by the vessels would be a maximum of 69.5 days.
- Fuel consumption rates have been taken from IoP (2000) guidelines.

Table B1.1: Energy usage and emissions for Option 4: Partial removal and burial

Activity	No.	Days	Fuel consumption		Energy usage (GJ)	CO_2 emissions (tonnes)
			Tonnes/ day	Tonnes		
DSV						
Mob/ demob	1	4.50	3	13.50	581.85	43.20
Transit to/ from site	1	1.00	22	22.00	948.20	70.40
DP trials	1	0.50	18	9.00	387.90	28.80
Perform pre-survey of products	1	2.50	18	45.00	1,939.50	144.00
Cutting	1	13.50	18	243.00	10,473.30	777.60
Bunding	1	9.00	18	162.00	6,982.20	518.40
Rectification/ Burial	1	9.00	18	162.00	6,982.20	518.40
WOW	1	3.40	10	34.00	1,465.40	108.80
Subtotal					**29,760.55**	**2,209.60**
CSV						
Mob/ demob	1	1.50	2	3.00	129.30	9.60
Transit to/ from site	1	1.00	26	26.00	1,120.60	83.20
DP trials	1	0.50	18	9.00	387.90	28.80
Recovery of cut bundle sections	1	4.50	18	81.00	3,491.10	259.20
Perform as-left survey of products	1	2.50	18	45.00	1,939.50	144.00
WOW	1	0.70	9	6.30	271.53	20.16
Subtotal					**7,339.93**	**544.96**
Trawler (overtrawl trials)						
Mob/ demob	1	1.00	0	0.20	8.62	0.64
Transit to/ from site	1	1.00	1	0.80	34.48	2.56
Perform overtrawl trials	1	1.00	1	0.70	30.17	2.24
WOW	1	1.00	1	0.07	3.02	0.22
Subtotal					**76.29**	**5.66**
Survey vessel (monitoring surveys)						
Mob/ demob	3	1.00	3	9.00	387.90	28.80
Transit to/ from site	3	2.00	22	132.00	5,689.20	422.40
Perform monitoring survey	3	2.50	18	135.00	5,818.50	432.00
WOW	3	0.25	10	7.50	323.25	24.00
Subtotal					**12,218.85**	**907.20**
Helicopter trips	**No. trips**	**Return distance (km)**	**Tonnes/ 1000 km**			
Return helicopter trips to well location	2	426.00	5	4.26	196.39	13.63
Subtotal					**196.39**	**13.63**
Total emissions from Option 4					**49,592.00**	**3,681.06**

Table B1.2: Materials energy usage and emissions for Option 4: Partial removal and burial

Replacement by new materials equivalent to:	Materials	Total weight of materials (tonnes)	Energy usage (GJ)	CO_2 emissions (tonnes)
Pipelines remaining in situ	Standard steel	1,116	27,900.00	2,108.12
Subtotal			27,900.00	2,108.12
Materials recycled	**Materials**	**Total weight of materials (tonnes)**	**Energy usage (GJ)**	**CO_2 emissions (tonnes)**
Pipelines recovered	Standard steel	122	1,098.00	117.12
Subtotal			1,098.00	117.12
Total emissions from Option 4			**28,998.00**	**2,225.24**

Table B1.3: Haulage energy usage and emissions for Option 4: Partial removal and burial

Activity	Distance (km)	Fuel consumption rate (tonnes/ 100 km)	Fuel consumed (tonnes)	Energy usage (GJ)	CO_2 emissions (tonnes)
Transport of pipelines (partial)	2,400.00	0.038	0.91	40.13	2.92

Table B1.4: Total energy usage and emissions for Option 4: Partial removal and burial

Umbilicals & flowlines – Option 4	Vessels	Materials	Haulage	Total
Energy usage (GJ)	49,592.00	28,998.00	40.13	78,630.13
CO_2 emissions (tonnes)	3,681.06	2,225.24	2.92	5,909.22

B1(B) Flowlines and umbilicals – Option 5: Complete removal

Tables B1.5 to B1.8 provide the results of the assessments of the vessel, material, haulage and total energy usage (GJ) and CO2 emissions calculations (tonnes of CO2) for Option 5. It is assumed that:

- Energy usage and emissions would originate principally from two sources: (1) combustion of diesel fuel by the three vessels involved in trenching and survey operations, (2) combustion of aviation fuel by the helicopter, (3) the recycling of the recovered pipeline and (4) the hypothetical manufacture of new materials to replace those lost to society because the pipelines have been left in place buried in seabed sediments.
- Total time spent mobilising, transiting, on site and demobilising by the vessels would be a maximum of 47 days.
- Fuel consumption rates have been taken from IoP (2000) guidelines.

Table B1.5: Energy usage and emissions for Option 5: Complete removal

Activity	No.	Days	Fuel consumption		Energy usage (GJ)	CO_2 emissions (tonnes)
			Tonnes/ day	Tonnes		
DSV						
Mob/ demob	1	1.50	3	4.50	193.95	14.40
Transit to/ from site	1	1.00	22	22.00	948.20	70.40
DP trials	1	0.50	18	9.00	387.90	28.80
Perform pre-survey of products	1	2.50	18	45.00	1,939.50	144.00
Diver ops	1	2.00	18	36.00	1,551.60	115.20
WOW	1	0.45	10	4.50	193.95	14.40
Subtotal					**5,215.10**	**387.20**
CSV						
Mob/ demob	1	8.50	2	17.00	732.70	54.40
Transit to/ from site	1	1.00	26	26.00	1,120.60	83.20
DP trials	1	0.50	18	9.00	387.90	28.80
Recovery ops	1	22.00	18	396.00	17,067.60	1,267.20
Perform as-left survey of products	1	2.50	18	45.00	1,939.50	144.00
WOW	1	2.45	9	22.05	950.36	70.56
Subtotal					**22,198.66**	**1,648.16**
Trawler (overtrawl trials)						
Mob/ demob	1	1.00	0	0.20	8.62	0.64
Transit to/ from site	1	1.00	1	0.80	34.48	2.56
Perform overtrawl trials	1	3.00	1	2.10	90.51	6.72
WOW	1	0.30	1	0.21	9.05	0.67
Subtotal					**142.66**	**10.59**
Helicopter trips	**No. trips**	**Return distance (km)**	**Tonnes/ 1000 km**			
Return helicopter trips to well location	2	426.00	5	4.26	196.39	13.63
Subtotal					**196.39**	**13.63**
Total vessel energy use and emissions from Option 5					**27,752.80**	**2,059.58**

Table B1.6: Materials energy usage and emissions for Option 5: Complete removal

Materials recycled	Materials	Total weight of materials (tonnes)	Energy usage (GJ)	CO_2 emissions (tonnes)
Pipelines recovered	Standard steel	1,238	11,142.00	1,188.48
Subtotal			11,142.00	1,188.48
Total emissions from Option 5			**11,142.00**	**1,188.48**

Table B1.7: Haulage energy usage and emissions for Option 5: Complete removal

Activity	Distance (km)	Fuel consumption rate (tonnes/ 100 km)	Fuel consumed (tonnes)	Energy usage (GJ)	CO_2 emissions (tonnes)
Transport of pipelines (complete)	22,800.00	0.038	8.66	381.22	27.72

Table B1.8: Total energy usage and emissions for Option 5: Complete removal

Umbilicals & flowlines – Option 5	Vessels	Materials	Haulage	Total
Energy usage (GJ)	27,752.80	11,142.00	381.22	39,276.02
CO_2 emissions (tonnes)	2,059.58	1,188.48	27.72	3,275.79

B2(A) Mattresses – Option 2: Decommission in situ with rock cover

Tables B2.1 to B2.3 provide the results of the assessments of the vessel, material and total energy usage (GJ) and CO2 emissions calculations (tonnes of CO2) for Option 2. It is assumed that:

- Energy usage and emissions would originate principally from three source: (1) combustion of diesel fuel by the three vessels, (2) combustion of aviation fuel by the helicopter and (3) the hypothetical manufacture of new materials to replace those lost to society because the mattresses have been left in place on the seabed.
- Total time spent mobilising, transiting, on site and demobilising by the vessels would be a maximum of 38.5 days.
- Fuel consumption rates have been taken from IoP (2000) guidelines.

Table B2.1: Vessel energy usage and emissions for Option 2: Decommission in situ with rock cover

Activity	No.	Days	Fuel consumption		Energy usage (GJ)	CO_2 emissions (tonnes)
			Tonnes/ day	Tonnes		
Rock dump/ fall pipe vessel						
Mob/ demob	1	1.50	2	3.00	129.30	9.60
Transit to/ from site	1	1.00	8	8.00	344.80	25.60
DP trials	1	0.50	8	4.00	172.40	12.80
Perform pre/ as-left survey of products	1	3.00	15	45.00	1,939.50	144.00
Rock dump mattresses	1	13.00	15	195.00	8,404.50	624.00
WOW	1	1.60	15	24.00	1,034.40	76.80
Subtotal					**12,024.90**	**892.80**
Trawler (overtrawl trials)						
Mob/ demob	1	1.00	0	0.20	8.62	0.64
Transit to/ from site	1	1.00	1	0.80	34.48	2.56
Perform overtrawl trials	1	1.00	1	0.70	30.17	2.24
WOW	1	0.10	1	0.07	3.02	0.22
Subtotal					**76.29**	**5.66**

Survey vessel (monitoring surveys)						
Mob/ demob	3	1.00	3	9.00	387.90	28.80
Transit to/ from site	3	2.00	22	132.00	5,689.20	422.40
Perform monitoring survey	3	2.50	18	135.00	5,818.50	432.00
WOW	3	0.25	10	7.50	323.25	24.00
Subtotal					**12,218.85**	**907.20**
Helicopter trips	**No. trips/ week**	**Return distance (km)**	**Tonnes/ 1000 km**			
Return helicopter trips to well location	1	426.00	5	2.13	98.19	6.82
Subtotal					**98.19**	**6.82**
Total vessel energy use and emissions from Option 2					**24,418.23**	**1,812.48**

Table B2.2: Materials energy usage and emissions for Option 2: Decommission in situ with rock cover

Replacement by new materials equivalent to:	Materials	Total weight of materials (tonnes)	Energy usage (GJ)	CO_2 emissions (tonnes)
Mattresses remaining in situ	Concrete	4,794	4,794.00	4,218.72
Subtotal			**4,794.00**	**4,218.72**
Total materials energy use and emissions from Option 2			**4,794.00**	**4,218.72**

Table B2.3: Total energy usage and emissions for Option 2: Decommission in situ with rock cover

Mattresses – Option 2	Vessels	Materials	Haulage	Total
Energy usage (GJ)	24,418.23	4,794.00	-	29,212.23
CO_2 emissions (tonnes)	1,812.48	4,218.72	-	6,031.20

B2(B) Mattresses – Option 6: Complete removal

Tables B2.4 to B2.7 provide the results of the assessments of the vessel, material, haulage and total energy usage (GJ) and CO2 emissions calculations (tonnes of CO2) for Option 6. It is assumed that:

- Energy usage and emissions would originate principally from three sources: (1) combustion of diesel fuel by the two vessels, (2) the combustion of aviation fuel by the helicopter, (3) the HGV used to transport the material to the landfill site and (4) the hypothetical manufacture of new materials to replace those lost to society if the resources are sent to landfill.
- Total time spent mobilising, transiting, on site and demobilising by the vessels would be a maximum of 38.5 days.
- Fuel consumption rates have been taken from IoP (2000) guidelines.

Table B2.4 Vessel energy usage and emissions for Option 6: Complete removal

Activity	No.	Days	Fuel consumption		Energy usage (GJ)	CO_2 emissions (tonnes)
			Tonnes/ day	Tonnes		
DSV						
Mob/ demob	1	2.50	3	7.50	323.25	24.00
Interim mobilisations	6	1.00	3	18.00	775.80	57.60
Transit to/ from site	7	1.00	22	154.00	6,637.40	492.80
DP trials	1	0.50	18	9.00	387.90	28.80
Perform pre-survey of products	1	3.00	18	54.00	2,327.40	172.80
Deploy speed loaders	1	3.50	18	63.00	2,715.30	201.60
Mattress recovery ops	1	11.00	18	198.00	8,533.80	633.60
WOW	1	1.75	10	17.50	754.25	56.00
Subtotal					**22,455.10**	**1,667.20**
Trawler (overtrawl trials)						
Mob/ demob	1	1.00	0	0.20	8.62	0.64
Transit to/ from site	1	1.00	1	0.80	34.48	2.56
Perform overtrawl trials	1	3.00	1	2.10	90.51	6.72
WOW	1	0.30	1	0.21	9.05	0.67
Subtotal					**142.66**	**10.59**
Helicopter trips	**No. trips**	**Return distance (km)**	**Tonnes/ 1000 km**			
Return helicopter trips to well location	2	426.00	5	4.26	196.39	13.63
Subtotal					**196.39**	**13.63**
Total vessel energy use and emissions from Option 6					**22,794.15**	**1,691.42**

Table B2.5 Materials energy usage and emissions for Option 6: Complete removal

Replacement by new materials equivalent to:	Materials	Total weight of materials (tonnes)	Energy usage (GJ)	CO_2 emissions (tonnes)
Mattresses remaining in situ	Concrete	4,794	4,794.00	4,218.72
Subtotal			**4,794.00**	**4,218.72**
Total materials energy use and emissions from Option 6			**4,794.00**	**4,218.72**

Table B2.6: Haulage energy usage and emissions for Option 6: Complete removal

Activity	Distance (km)	Fuel consumption rate (tonnes/ 100 km)	Fuel consumed (tonnes)	Energy usage (GJ)	CO_2 emissions (tonnes)
Transport of mattresses	87,600	0.038	33.29	1,464.67	106.52

Table B2.7: Total energy usage and emissions for Option 6: Complete removal

Mattresses – Option 6	Vessels	Materials	Haulage	Total
Energy usage (GJ)	22,794.15	4,794.00	1,464.67	29,052.82
CO_2 emissions (tonnes)	1,691.42	4,218.72	106.52	6,016.67

B3(A) Moorings – Option 3/4: Cut and recover exposed mooring string

Tables B3.1 – B3.4 provide the results of the assessments of the vessel, material, haulage and total energy usage (GJ) and CO2 emissions calculations (tonnes of CO2) for Option 3/4. It is assumed that:

- Energy usage and emissions would originate principally from three sources: (1) combustion of diesel fuel by the three vessels, (2) combustion of aviation fuel by the helicopter, (3) the recycling of the mooring chain and wire and (4) the hypothetical manufacture of new materials to replace those lost to society because the anchors will be left on the seabed.
- Total time spent mobilising, transiting, on site and demobilising by the vessels would be a maximum of 47.5 days.

Table B3.1: Vessel energy usage and emissions for Option 3/4: Cut and recover exposed mooring string

Activity	No.	Days	Fuel consumption		Energy usage (GJ)	CO_2 emissions (tonnes)
			Tonnes/ day	Tonnes		
AHV						
Mob/ demob	1	4.00	2	8.00	344.80	25.60
Transit to/ from site	1	1.00	50	50.00	2,155.00	160.00
DP trials	1	0.50	5	2.50	107.75	8.00
Perform pre/ as-left survey of products	1	3.00	5	15.00	646.50	48.00
Recovery of mooring strings (including cutting/ dredging)	1	18.00	5	90.00	3,879.00	288
WOW	1	2.10	30	63.00	2,715.30	201.60
Subtotal					**9,848.35**	**731.20**
Trawler (overtrawl trials)						
Mob/ demob	1	1.00	0	0.20	8.62	0.64
Transit to/ from site	1	1.00	1	0.80	34.48	2.56
Perform overtrawl trials	1	1.00	1	0.70	30.17	2.24
WOW	1	0.10	1	0.07	3.02	0.22
Subtotal					**76.29**	**5.66**
Survey vessel (monitoring surveys)						
Mob/ demob	3	1.50	3	13.50	581.85	43.20
Transit to/ from site	3	1.00	22	66.00	2,844.60	211.20
DP trials	3	0.50	18	27.00	1,163.70	86.40
Perform monitoring survey	3	3.00	18	162.00	6,982.20	518.40
WOW	3	0.30	10	9.00	387.90	28.80
Subtotal					**11,960.25**	**888.00**

Helicopter trips	**No. trips**	**Return distance (km)**	**Tonnes/ 1000 km**			
Return helicopter trips to well location	1	426.00	5	2.13	98.19	6.82
Subtotal					**98.19**	**6.82**
Total vessel energy use and emissions from Option 3/4					**21,983.08**	**1,631.68**

Table B3.2: Materials energy usage and emissions for Option 3/4: Cut and recover exposed mooring string

Replacement by new materials equivalent to:	**Materials**	**Total weight of materials (tonnes)**	**Energy usage (GJ)**	**CO_2 emissions (tonnes)**
Moorings remaining in situ - anchors	Standard steel	270	6,750.00	510.03
Subtotal			**6,750.00**	**510.03**
Materials recycled	**Materials**	**Total weight of materials (tonnes)**	**Energy usage (GJ)**	**CO_2 emissions (tonnes)**
Moorings – chain + wire	Standard steel	1,225	11,025.00	1,176.00
Subtotal			**11,025.00**	**1,176.00**
Total emissions from Option 3/4			**17,775.00**	**1,686.03**

Table B3.3: Haulage energy usage and emissions for Option 3/4: Cut and recover exposed mooring string

Activity	**Distance (km)**	**Fuel consumption rate (tonnes/ 100 km)**	**Fuel consumed (tonnes)**	**Energy usage (GJ)**	**CO_2 emissions (tonnes)**
Transport of moorings – chain + wire	22,800	0.038	8.66	381.22	27.72

Table B3.4: Total energy usage and emissions for Option 3/4: Cut and recover exposed mooring string

Moorings – Option 3/4	**Vessels**	**Materials**	**Haulage**	**Total**
Energy usage (GJ)	21,983.08	17,775.00	381.22	40,139.30
CO_2 emissions (tonnes)	1,631.68	1,686.03	27.72	3,345.43

B3(B) Moorings – Option 5: Complete removal

Tables B3.5 – B3.8 provide the results of the assessments of the vessel, material, haulage and total energy usage (GJ) and CO2 emissions calculations (tonnes of CO2) for Option 5. It was assumed that:

- Energy usage and emissions would originate principally from three sources: (1) combustion of diesel fuel by the two vessels, (2) the combustion of aviation fuel by the helicopter, (3) the HGV used to transport the material to the landfill site and (4) the recycling of the moorings.
- Total time spent mobilising, transiting, on site and demobilising by the vessels would be a maximum of 20 days.
- Fuel consumption rates have been taken from IoP (2000) guidelines.

Table B3.5: Vessel energy usage and emissions for Option 5: Complete removal

Activity	No.	Days	Fuel consumption		Energy usage (GJ)	CO_2 emissions (tonnes)
			Tonnes/ day	Tonnes		
AHV						
Mob/ demob	1	4.00	2	8.00	344.80	25.60
Transit to/ from site	1	1.00	50	50.00	2,155.00	160.00
DP trials	1	0.50	5	2.50	107.75	8.00
Perform pre/ as-left survey of products	1	2.50	5	12.50	538.75	40.00
Recovery of mooring strings (including cutting)	1	9.00	5	45.00	1,939.50	144.00
WOW	1	1.15	30	34.50	1,486.95	110.40
Subtotal					**6,572.75**	**488.00**
Trawler (overtrawl trials)						
Mob/ demob	1	1.00	0	0.20	8.62	0.64
Transit to/ from site	1	1.00	1	0.80	34.48	2.56
Perform overtrawl trials	1	1.00	1	0.70	30.17	2.24
WOW	1	0.10	1	0.07	3.02	0.22
Subtotal					**76.29**	**5.66**
Helicopter trips	**No. trips**	**Return distance (km)**	**Tonnes/ 1000 km**			
Return helicopter trips to well location	1	426.00	5	2.13	98.19	6.82
Subtotal					**98.19**	**6.82**
Total vessel energy use and emissions from Option 5					**6,747.23**	**500.48**

Table B3.6 Materials energy usage and emissions for Option 5: Complete removal

Replacement by new materials equivalent to:	Materials	Total weight of materials (tonnes)	Energy usage (GJ)	CO_2 emissions (tonnes)
Moorings – chain + wire + anchors	Standard steel	1,495	13,445.00	1,435.20
Subtotal			**13,455.00**	**1,435.20**
Total emissions from Option 5			**13,455.00**	**1,435.20**

Table B3.7: Haulage energy usage and emissions for Option 5: Complete removal

Activity	Distance (km)	Fuel consumption rate (tonnes/ 100 km)	Fuel consumed (tonnes)	Energy usage (GJ)	CO_2 emissions (tonnes)
Transport of moorings (including anchors)	27,600	0.038	10.49	461.47	33.56

Table B3.8: Total energy usage and emissions for Option 5: Complete removal

Moorings – Option 5	Vessels	Materials	Haulage	Total
Energy usage (GJ)	6,747.23	13,455.00	461.47	20,663.70
CO_2 emissions (tonnes)	500.48	1,435.20	33.56	1,969.24