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Dunlin Alpha Decommissioning Comparative Assessment Report

Fairfield Betula Limited

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CONTENTS

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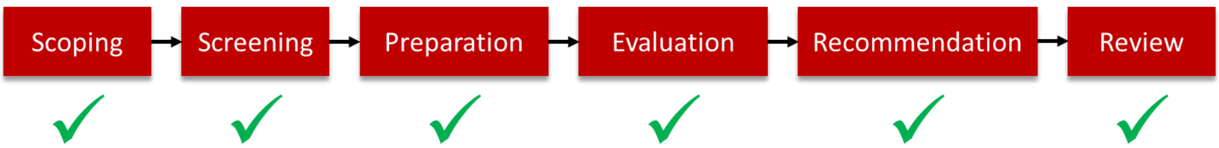
EXECUTIVE SUMMARY

As part of the wider Dunlin Alpha Decommissioning (DAD) Project, Fairfield Betula Limited (FBL) have conducted a Comparative Assessment (CA) of the potential decommissioning options for the Dunlin Alpha Concrete Gravity Base Substructure (CGBS) and associated cell contents. The CA was conducted to assess all feasible options across multiple criteria following a robust, industry proven process to enable an informed decision to be made which was supported by scientific evidence and underpinned by stakeholder participation. The CA report forms a record of the process and collective decision for the fate of the CGBS and its associated component parts. The CA has been conducted in two parts to cover both the substructure and the residual contents of the storage cells of the CGBS. The cell contents assessment is effectively a nested evaluation of the CGBS leave *in situ* options. The Dunlin Alpha Topsides will be fully removed to shore for reuse, recycling or disposal.

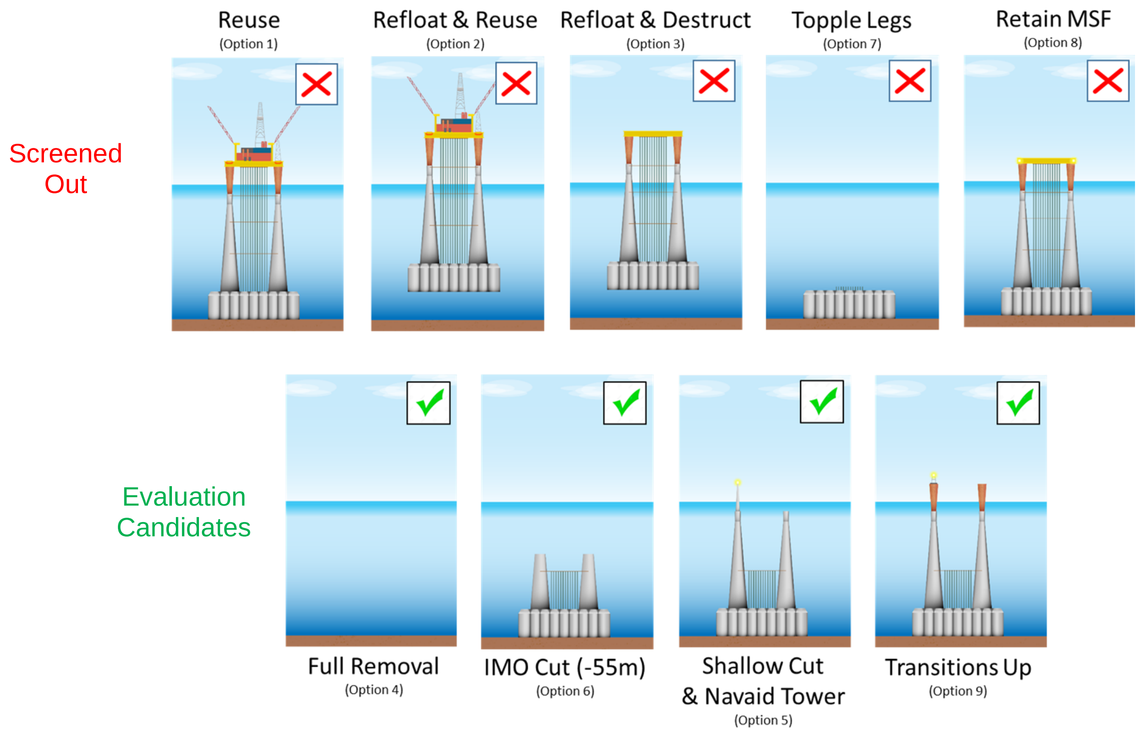
This document details the CA process and methodology adopted, the preparation works carried out, the evaluations conducted and the outcomes (emerging recommendations) from the internal and external stakeholder workshops.

The CA process adopted is based on the requirements of OSPAR Decision 98/3 ref. [1] and the Oil & Gas UK CA Guidelines ref. [2]. In summary, the following steps from the Guidelines have been completed:



Dunlin Alpha CGBS

There were a total of nine potential decommissioning options for the CGBS considered during the screening phase of the CA. These were screened down to four feasible options for the evaluation phase as follows:



It should be noted that re-float of the CGBS was not considered feasible. This was on the grounds that the required strength and integrity to perform the re-float would not be present within the CGBS as it was not designed to be removed. As such, the only remaining full removal option is deconstruction *in situ* and recovery to shore i.e. Option 4.

A comprehensive body of supporting technical and environmental studies and analyses were conducted to provide detailed, scientific and quantitative data in support of the evaluation of these remaining options.

The evaluation phase was conducted with a variety of stakeholders, with the outcome from the evaluation phase indicating Option 9 – Transitions Up to be the most preferred decommissioning option, when considered against the selected criteria and sub-criteria. Transitions Up was assessed as most preferred against four of the five primary criteria, i.e. Safety, Environment, Technical and Economic, with Safety and Technical considerations being the most significant differentiators.

Transitions Up was not the most preferred option against the final criterion, Societal. This was Option 6 – IMO Compliant Cut. The evaluation phase also revealed that preference for Option 9 was not sensitive to Economic considerations.

CGBS Emerging Recommendation
Option 9 – Transitions Up is the recommended decommissioning option for the Dunlin Alpha CGBS emerging from this Comparative Assessment.

Cell Contents

There were more than 70 options[1] considered for the decommissioning of the residual contents of the CGBS storage cells. These included partial recovery, bioremediation and capping. It should be noted that there were no credible options that could achieve full removal of the cell contents, other than full removal of the CGBS whereby full removal of the cell contents would be part of that process, although is likely to result in some loss of contents to the surrounding environment during the substructure removal.

These 70-plus options were screened down to the following four options:

- Option 1 – High case oil & sediment removal – where all cells are accessed via direct and indirect means, via 31 penetrations in the top of the cell base. Both mobile oil (74 cells) and sediment (8 cells) are recovered and returned to shore. All cell top drill cuttings are also recovered under this option;
- Option 2 – Mid case oil & sediment removal – where the cells are accessed via direct and indirect means via 18 cell penetrations in the top of the cell base. Both mobile oil (41 cells) and sediment (4 cells) are recovered and returned to shore. Minimal cell top drill cuttings disturbance and removal;
- Option 3 – Mid case oil removal – 14 cell penetrations in the top of the cell base. Mobile oil (36 cells) recovered and returned to shore. No sediment recovery. No large access holes required. Minimal cell top drill cuttings disturbance and removal;
- Option 4 – Leave *in situ* – no activities to recover or treat the cell contents are performed.

The screening process and options selected for the evaluation phase considered a number of factors, focussing on the inventory, distribution of the contents and efficiency of recovery.

A suite of supporting technical and environmental studies and analyses were conducted to provide detailed, scientific and quantitative data in support of the evaluation of these remaining options.

The evaluation phase was conducted with a variety of stakeholders, with the outcome from the evaluation phase indicating Option 4 – Leave *in situ* to be the most preferred decommissioning option, when considered against the selected criteria and sub-criteria. Leave *in situ* was assessed as most preferred against four of the five primary criteria, i.e. Safety, Environment, Technical and Economic, with Safety, Environmental and Technical considerations being the most significant differentiators.

[1] 'Footnote ref: These are listed and discussed in the Cell Contents Technical Report - Chapter 4: FBL-DUN-DUNA-FAC-24-RPT-00001'

Leave *in situ* was not the most preferred option against the Societal criterion. Option 2 and 3 were equally preferred from a societal perspective. The evaluation phase also revealed that preference for Leave *in situ* was found to be not sensitive to Economic considerations.

Cell Contents Emerging Recommendation
Option 4 – Leave *in situ* is the recommended decommissioning option for the Dunlin Alpha Cell Contents emerging from this Comparative Assessment.

1 INTRODUCTION

1.1 Purpose

The purpose of this document is to present the Comparative Assessment (CA) conducted by Fairfield Betula Limited (herein referred to as Fairfield) for the Dunlin Alpha Decommissioning (DAD) Project in support of the decommissioning programme. It is produced in satisfaction of the requirement to perform a CA into any potential derogation application against the regulatory framework detailed in OSPAR Decision 98/3 ref. [1] and as detailed in the DECC Guidance Notes for Decommissioning ref. [3] and the Oil & Gas UK CA Guidelines ref. [2].

It describes the infrastructure addressed, the decommissioning options considered, the CA methodology used and the emerging recommendations from the CA process, including evaluation.

1.2 Background

The Greater Dunlin Area consists of the Dunlin, Dunlin South West, Osprey and Merlin Fields.

The Dunlin Alpha platform is a fixed installation located in the Dunlin Field, which lies within the East Shetland Basin of the Northern North Sea, originally serving as a manned production facility for the Dunlin, Dunlin South West, Osprey and Merlin fields. The installation stands in 151 metres of water, 506 km north-north-east of Aberdeen in block 211/23a of the UK sector of the continental shelf.

The Dunlin Alpha installation is a four-leg platform, constructed on a Concrete Gravity Base Substructure (CGBS), with a steel box girder based topsides supporting two levels of modules. There is a drill cuttings pile located on the south east of the CGBS substructure which covers an area of the cell roof and spreads onto the seabed.

A schematic of the Dunlin Alpha Installation is shown in Figure 1.1.

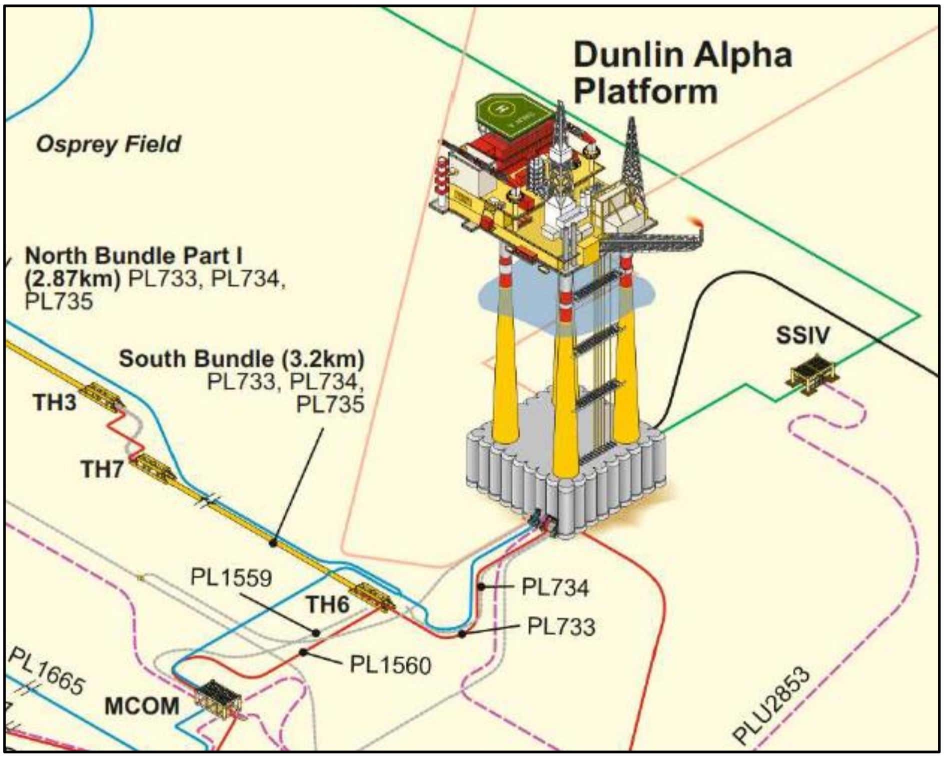


Figure 1.1: Dunlin Alpha Installation

Termination of Production from the Greater Dunlin Area was announced in June 2015, following achievement of Maximum Economic Recovery (MER) from these oilfields. Cessation of Production (COP) was agreed with the Oil and Gas Authority (OGA) on 9th July 2015, with COP confirmed to have occurred on the 15th June 2015.

1.3 Report Structure

This CA Report contains the following:

- Section 1 An introduction to the document and project, including acronyms and references
- Section 2 An overview of the regulatory framework by which this CA is governed
- Section 3 An overview of the CA process and methodology adopted
- Section 4 An overview of the potential decommissioning options considered for the CGBS and cell contents
- Section 5 An overview of the CGBS CA conducted
- Section 6 An overview of the cell contents CA conducted
- Section 7 A detailed discussion of the evaluations conducted against the CGBS and cell contents and the emerging recommendations obtained
- Appendix A An explanation of the evaluation methodology adopted
- Appendix B CA Evaluation Workshop Minutes
- Appendix C Detailed Evaluation Results
- Appendix D Dunlin Alpha CGBS – Fast Facts
- Appendix E Cell Contents – Fast Facts

1.4 Terms

Operations / Operational	In the context of this CA Report and the Dunlin Alpha Decommissioning project, the term operations and operational relates to the execution of the decommissioning option being discussed.
Potential for Loss of Life (PLL)	The primary parameter used to compare the personnel risk profile of the options against each other. It provides a cumulative measure of the risk directly related to the numbers of personnel exposed and the duration of that exposure. This is a simple, linear metric that can be used to compare the relative safety risk across the options being compared. It is calculated by Fatal Accident Rate (FAR) x Hours of Exposure for each of the worker groups provided from the summary report of the Joint Industry Project investigating the Risk Analysis into Decommissioning Activities issued by Safetec [27]. Note: this PLL represents the cumulative risk exposure for different worker groups and activities associated with an option and should not be confused with other, absolute risk exposure metrics used for assessing tolerability criteria as dictated by authorities such as the Health and Safety Executive (HSE). These PLLs tend to be very small numbers (much less than 1) and are quoted in scientific notation where 0.1 or 1/10th is written as $1x10^{-1}$, 0.01 or 1/100th is written as $1x10^{-2}$, 0.001 or 1/1000th is written as $1x10^{-3}$ and so on.

1.5 Abbreviations and Acronyms

AACE	American Association of Cost Engineers
AHP	Analytical Hierarchy Process
AORP	Attic Oil Recovery Project
AtoN	Aids to Navigation
BEIS	Department for Business, Energy and Industrial Strategy
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CA	Comparative Assessment
CGBS	Concrete Gravity Base Substructure
CGF	Conductor Guide Frame
COP	Cessation of Production
DAD	Dunlin Alpha Decommissioning
DECC	Department for Energy and Climate Change (now BEIS)
DP	Decommissioning Programme
DSV	Diving Support Vessel
EMT	Environmental Management Team
FAR	Fatal Accident Rate
FBL	Fairfield Betula Limited
FEL	Fairfield Energy Limited
HLV	Heavy Lift Vessel
HSE	Health and Safety Executive
IMO	International Maritime Organisation
IoP	Institute of Petroleum (now The Energy Institute)
IRG	Independent Review Group
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
MCDA	Multi-Criteria Decision Analysis
MEI	Major Environmental Incident
MER	Maximum Economic Recovery
MS	Much Stronger
MSF	Module Support Frame
MW	Much Weaker
N	Neutral
Navaid	Navigational Aid (sometimes referred as Aid to Navigation (AtoN))”
NLB	Northern Lighthouse Board
NNS	Northern North Sea

ODU	Offshore Decommissioning Unit
OGA	Oil & Gas Authority
OGUK	Oil & Gas UK
OPRED	Offshore-Petroleum-Regulator-for-Environment-and-Decommissioning
OSPAR	Oslo/Paris Convention (for the Protection of the Marine Environment of the North-East Atlantic)
P&A	Plug and Abandon
PAH	Polycyclic Aromatic Hydrocarbon
PLL	Potential for Loss of Life
ROV	Remotely Operated Vehicle
S	Stronger
SID	Subsea Infrastructure Decommissioning
SFF	Scottish Fishermen's Federation
TPa^2s	Tera-pascal Squared Second (Total Noise Emission metric)
UKCS	United Kingdom Continental Shelf
UKOOA	United Kingdom Offshore Operators Association (now OGUK)
VMS	Very Much Stronger
VMW	Very Much Weaker
W	Weaker
WoW	Waiting on Weather

1.6 References

1. OSPAR Decision 98/3	OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations
2. CA Guidelines	OGUK – Guidelines for Comparative Assessment in Decommissioning Programmes, Dated: October 2015, ISBN: 1 903 004 55 1, Issue: 1
3. Decommissioning Guidelines	Guidance Notes for the Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998, Version 6, Dated: March 2011, Issued by: Department of Energy & Climate Change.
4. Screening Report	Fairfield – Dunlin Alpha Decommissioning Option Screening for Comparative Assessment, Doc. No.: FBL-DUN-DUNA-HSE-01-PLN-00003, Rev.: A1, Dated: 20/10/16
5. Cell Contents Technical Report	Fairfield – Dunlin Alpha CGBS Cell Contents Technical Report, Doc. No.: FBL-DUN-DUNA-FAC-24-RPT-00001, Rev.: A2, Dated: 05/02/18
6. Environmental Appraisal	Fairfield – Dunlin Alpha Decommissioning Environmental Appraisal, Doc. No.: XOD-DUN-HSE-RPT-00005
7. Dunlin Alpha Decommissioning Programme	Fairfield – Dunlin Alpha Draft Decommissioning Programme 3), Doc. No.: FBL-DUN-DUNA-HSE-01-PLN-00001
8. Safety Summary	Xodus – CGBS Safety Summary, Doc. No.: A-301649-S06-REPT-002, Rev.: A01, Dated: 12/01/18
9. Energy & Emissions Assessment	Xodus – Energy & Emissions Assessment (Study 28), Doc. No.: A-301649-S07-REPT-004, Rev.: A05, Dated: 31/01/18
10. OSPAR Recommendation 2006/5	OSPAR Recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles
11. Leg Internals Study	Fairfield – CGBS Studies – Study 1 – Leg Internals Study, Doc. No.: FBL-DUN-DUNA-MSH-01-TCN-00008, Rev.: A6, Dated: 10/01/18
12. Transition Piece Study	Atkins – CGBS Studies for Comparative Assessment – Study 4 – Transition Piece, Doc. No.: 5153952-REP-ST-004-001, Rev.: A5, Dated: 03/11/17
13. Navaid Study	Atkins – CGBS Studies for Comparative Assessment – Study 5 – Aids for Navigation, Doc. No.: 5153952-REP-ST-005-001, Rev.: A5, Dated: 20/12/17
14. Concrete Cutting and Removal Study	Atkins – CGBS Studies for Comparative Assessment – Study 6 – Concrete Cutting and Removal, Doc. No.: 5153952-REP-ST-006-001, Rev.: A6, Dated: 20/12/17
15. Leg Failure Study	Atkins – CGBS Studies for Comparative Assessment – Study 8 – Leg Failure, Doc. No.: 5153952-REP-ST-008-001, Rev.: A5, Dated: 04/04/18
16. Cell-top Debris Study	Xodus – Cell-top Debris Study, Doc. No.: A-301649-S12-REPT-001, Rev.: A03, Dated: 26/10/17
17. Corrosion Protection	Frazer-Nash – Dunlin Alpha Transition Piece Corrosion Protection Options Study, Doc. No.: FNC 55192/45978R, Rev.: A01, Dated: 26/10/17

18. Drill Cuttings Study	Xodus – Drill Cuttings Technical Report, Doc. No.: A-301524-S09-TECH-002, Rev.: A05, Dated: 02/02/18
19. Transition Piece Longevity Study	Atkins – CGBS Studies for Comparative Assessment – Study 4a – Transition Piece Longevity, Doc. No.: 5153952-REP-ST-005-001, Rev.: A5, Dated: 20/12/17
20. Technical Risk Assessment	Atkins – CGBS Studies for Comparative Assessment – Technical Risk Assessment, Doc. No.: 5153952-REP-ST-300, Rev.: A4
21. Legacy Collision Risk Assessment	Anatec – Shipping and Fishing Decommissioning Risk Assessment, Dunlin Alpha (Block 211/23), Doc. No.: A4045-FE-CR-1, Rev.: 02
22. Operational Collision Risk Assessment	Anatec – Dunlin Alpha Decommissioning: Option 4 – Full Removal Vessel Collision Risk Assessment, Doc. No.: A4045-FE-CRA-1, Rev.: 02
23. Seabird Colonisation Study	Xodus – Seabird Colonisation, Doc. No.: A-301649-S08-REPT-001, Rev.: A02, Dated: 13/10/17
24. Marine Growth Study	Xodus – Marine Growth Assessment, Doc. No.: A-301649-S09-REPT-001, Rev.: A01, Dated: 21/06/17
25. Marine Impacts – CGBS Full Removal	Xodus – Marine Impacts Associated with Decommissioning of the Dunlin Alpha CGBS, Doc. No.: A-301649-S10-REPT-002, Rev.: A02, Dated: 01/02/18
26. Commercial Fisheries Baseline Study	Xodus – Commercial Fisheries Baseline Study, Doc. No.: A-301524-S00-REPT-003, Rev.: A01, Dated: 01/09/16
27. Decommissioning Risk (Safetec)	Safetec – Risk Analysis of Decommissioning Activities, Doc. No.: ST-20447-RA-1, Rev.: 03, Dated: 3 March 2005
28. Stakeholder Engagement Report	Fairfield – Dunlin Alpha Stakeholder Engagement Report, Doc. No.: TBA, Rev.: TBA, Dated: TBA
29. Option 9 Datasheet 1	Atkins – Datasheet 1 for Option 9, Issued by: Atkins, Doc. No.: 5153592-EXL-ST-009-001, Rev.: A5, Dated: 30/11/17
30. Option 9 Datasheet 2	Atkins – Datasheet 2 for Option 9, Issued by: Atkins, Doc. No.: 5153592-EXL-ST-009-002, Rev.: A4, Dated: 21/09/17
31. Option 9 Datasheet 3	Atkins – Datasheet 3 for Option 9, Issued by: Atkins, Doc. No.: 5153592-EXL-ST-009-003, Rev.: A3, Dated: 21/09/17
32. Shipping and Fishing Risk Assessment	Anatec – Shipping and Fishing Decommissioning Risk Assessment, Dunlin Alpha (Block 211/23) Safety Zone Sensitivity Analysis, Doc. No.: A4045-FE-CR-1-ADD-A, Rev.: 00
33. Analytical Hierarchy Process	The Analytical Hierarchy Process by T.L. Saaty, McGraw Hill, 1980.

2 REGULATORY FRAMEWORK

The decommissioning of offshore oil and gas installations and pipelines on the UKCS is controlled through the Petroleum Act 1998. Part IV of the 1998 Act provides a framework for the orderly decommissioning of disused offshore installations and offshore pipelines on the UKCS. It has been amended a number of times since coming into force, most notably by the Energy Act 2008 and the Energy Act 2016.

The Energy Act 2008 ("the 2008 Act") amended Part IV of the Petroleum Act 1998 strengthening the powers of the Secretary of State in relation to financial assurances.

The Energy Act 2016 established the Oil & Gas Authority (OGA) as an independent Government Company and Regulator tasked with Maximising Economic Recovery of offshore UK petroleum. The 2016 Act inserted into the 1998 Act new powers for, and obligations on, the OGA and others in terms of consulting the OGA, regarding decommissioning.

Decommissioning is also regulated under the Marine and Coastal Access Act 2009 and Marine (Scotland) Act 2010 (the Marine Acts). The UK's international obligations on decommissioning are primarily governed by the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (the OSPAR Convention). The responsibility for ensuring compliance with the Petroleum Act 1998 rests with the Department for Business, Energy and Industrial Strategy (BEIS - formerly DECC). BEIS is also the Competent Authority on decommissioning in the UK for OSPAR purposes and under the Marine Acts.

Agreement on the process to be applied to the decommissioning of offshore oil and gas installations within the Convention area, and hence within the UKCS, was reached at the OSPAR Commission meeting held in July 1998. That agreement was reflected in OSPAR Decision 98/3, which entered into force on 9 February 1999 and which brought a prohibition on the dumping and leaving wholly or partly in place of offshore oil and gas installations.

Derogation from OSPAR Decision 98/3 may be considered where the installation falls into one of the categories stated in Annex 1. These include the category of "gravity based concrete installations" and Dunlin Alpha Substructure is therefore a candidate for derogation.

Where a case for derogation is made, it must be supported by Comparative Assessment conducted in accordance with criteria set out in Annex 2 of OSPAR Decision 98/3. This assessment is conducted to satisfy the requirement for "significant reasons why an alternative disposal is preferable…to reuse or recycling or final disposal on land" in paragraph 3 of the Decision. This document details that assessment.

2.1 OSPAR 98/3 Annex 2 Requirements

Where an application may be made for derogation from OSPAR Decision 98/3 ref. [1], the process to be used to assess the relative merits of derogation proposals is specified in the 12 paragraphs listed in Annex 2 of the Decision. Those 12 paragraphs and a commentary on how the assessment conducted by Fairfield satisfies them, the status and / or the location of any evidence in satisfaction of the paragraphs are detailed in Table 2.1.

Description (OSPAR)	Commentary (Fairfield)
General provisions	
1. This framework shall apply to the assessment by the competent authority of the relevant Contracting Party of proposals for the issue of a permit under paragraph 3 of this Decision.	For information.
2. The assessment shall consider the potential impacts of the proposed disposal of the installation on the environment and on other legitimate uses of the sea. The assessment shall also consider the practical availability of reuse, recycling and disposal options for the decommissioning of the installation.	The potential impacts of the proposed options are addressed by the various studies developed throughout the CA process (see Section 3.3). Reuse, recycling and disposal options are addressed during the Scoping and Screening phases of the CA. These are detailed in: > Screening Report ref. [4] for the CGBS; and > Cell Contents Technical Report ref. [5] for the storage cell contents.
Information required	
3. The assessment of a proposal for disposal at sea of a disused offshore installation shall be based on descriptions of:	For information.
a. the characteristics of the installation, including the substances contained within it; if the proposed disposal method includes the removal of hazardous substances from the installation, the removal process to be employed, and the results to be achieved, should also be described; the description should indicate the form in which the substances will be present and the extent to which they may escape from the installation during, or after, the disposal;	Addressed in the definition of the CGBS options (Section 4.1) and in the various studies developed throughout the CA process (see Section 3.3). Also addressed in the definition of the Cell Contents options (Section 4.2). The cell contents are described in detail within the Cell Contents Technical Report ref. [5]). Additionally, information is detailed in the Environmental Appraisal ref. [6] submitted as part of the overall Decommissioning Programme submission.
b. the proposed disposal site: for example, the physical and chemical nature of the sea bed and water column and the biological composition of their associated ecosystems; this information should be included even if the proposal is to leave the installation wholly or partly in place;	Baseline environmental information relevant to this project is included in the environmentally focussed studies developed throughout the CA process (see Section 3.3). Additionally, this information is detailed fully in the Environmental Appraisal ref. [6] submitted as part of the overall Decommissioning Programme submission.

Description (OSPAR)	Commentary (Fairfield)
c. the proposed method and timing of the disposal.	Disposal methods and durations are detailed in the various studies developed throughout the CA process (see Section 3.3). Overall programme schedule is defined in the draft Dunlin Alpha Decommissioning Programme ref. [7].
4. The descriptions of the installation, the proposed disposal site and the proposed disposal method should be sufficient to assess the impacts of the proposed disposal, and how they would compare to the impacts of other options.	The proposed disposal site is described in the environmentally focussed studies developed throughout the CA process (see Section 3.3). Additionally, this information is detailed fully in the Environmental Appraisal ref. [6]. Disposal methods and durations are detailed in the various studies developed throughout the CA process (see Section 3.3).
Assessment of disposal	
5. The assessment of the proposal for disposal at sea of a disused offshore installation shall follow the broad approach set out below.	For information.
6. The assessment shall cover not only the proposed disposal, but also the practical availability and potential impacts of other options. The options to be considered shall include:	For information.
a. re-use of all or part of the installation; b. recycling of all or part of the installation; c. final disposal on land of all or part of the installation; d. other options for disposal at sea.	Reuse, recycling and disposal options are addressed during the Scoping and Screening phases of the CA. These are detailed in: > Screening Report ref. [4] for the CGBS; and > Cell Contents Technical Report ref. [5] for the cell contents. The proposed disposal of all or part of the installation on land is described in the studies developed throughout the CA process (see Section 3.3).
Matters to be taken into account in assessing disposal options	
7. The information collated in the assessment shall be sufficiently comprehensive to enable a reasoned judgement on the practicability of each of the disposal options, and to allow for an authoritative comparative evaluation. In particular, the assessment shall demonstrate how the requirements of paragraph 3 of this Decision are met.	The various studies developed throughout the CA process (see Section 3.3) provide the detailed, evidence based data for the assessments. This data is provided, in summary form, in the attributes tables used during the evaluation workshops allowing an authoritative Comparative Assessment to be conducted. This is detailed throughout this document and specifically in: > Section 3.3 for the preparatory studies; > Section 7 for the recommendations and conclusions where the requirements of paragraph 3 of the decision are met; and > Appendix B for the attributes tables.

Description (OSPAR)	Commentary (Fairfield)
8. The assessment of the disposal options shall take into account, but need not be restricted to:	For information.
a. technical and engineering aspects of the option, including re-use and recycling and the impacts associated with cleaning, or removing chemicals from, the installation while it is offshore;	Addressed by the various studies developed throughout the CA process (see Section 3.3).
b. the timing of the decommissioning;	Disposal methods and durations are detailed in the various studies developed throughout the CA process (see Section 3.3). Overall programme schedule is defined in the draft Dunlin Alpha Decommissioning Programme ref. [7].
c. safety considerations associated with the removal and disposal, taking into account methods for assessing health and safety at work;	Addressed by the various studies developed throughout the CA process (see Section 3.3). Specifically, the Safety Summary ref. [8].
d. impacts on the marine environment, including exposure of biota to contaminants associated with the installation, other biological impacts arising from physical effects, conflicts with the conservation of species, with the protection of their habitats, or with mariculture, and interference with other legitimate uses of the sea;	Baseline environmental information relevant to this project is included in the environmentally focussed studies developed throughout the CA process (see Section 3.3). Also discussed specifically in the Cell Contents Technical Report ref. [5]. Additionally, this information is detailed fully in the Environmental Appraisal ref. [6] submitted as part of the overall draft Decommissioning Programme submission.
e. impacts on other environmental compartments, including emissions to the atmosphere, leaching to groundwater, discharges to surface fresh water and effects on the soil;	Addressed by the environmentally focussed studies developed throughout the CA process (see Section 3.3). Specifically, the Energy & Emissions Assessment ref. [9] and the Cell Contents Technical Report ref. [5].
f. consumption of natural resources and energy associated with re-use or recycling;	Addressed by the environmentally focussed studies developed throughout the CA process (see Section 3.3). Specifically, the Energy & Emissions Assessment ref. [9] and the Cell Contents Technical Report ref. [5].
g. other consequences to the physical environment which may be expected to result from the options;	Addressed by the environmentally focussed studies developed throughout the CA process (see Section 3.3). Specifically, the Energy & Emissions Assessment ref. [9] and the Cell Contents Technical Report ref. [5].
h. impacts on amenities, the activities of communities and on future uses of the environment;	Addressed by the various studies developed throughout the CA process (see Section 3.3) and by assessment against the Societal sub-criteria of Fishing Industry and Other Groups detailed in Table 3.3 and Table 3.4. Additionally, this information is detailed fully in the Environmental Appraisal ref. [6] submitted as part of the overall draft Decommissioning Programme submission.

Description (OSPAR)	Commentary (Fairfield)
i. economic aspects.	Addressed by the cost estimates constructed from the various studies developed throughout the CA process (see Section 3.3).
9. In assessing the energy and raw material consumption, as well as any discharges or emissions to the environmental compartments (air, land or water), from the decommissioning process through to the re-use, recycling or final disposal of the installation, the techniques developed for environmental life cycle assessment may be useful and, if so, should be applied. In doing so, internationally agreed principles for environmental life cycle assessments should be followed.	Addressed by the environmentally focussed studies developed throughout the CA process (see Section 3.3). Specifically, the Energy & Emissions Assessment ref. [9] and the Cell Contents Technical Report ref. [5].
10. The assessment shall take into account the inherent uncertainties associated with each option, and shall be based upon conservative assumptions about potential impacts. Cumulative effects from the disposal of installations in the maritime area and existing stresses on the marine environment arising from other human activities shall also be taken into account.	Addressed by the various studies developed throughout the CA process (see Section 3.3). Specifically, the Energy & Emissions Assessment ref. [9] and the Cell Contents Technical Report ref. [5]. Regular dialogue with BEIS and OGA and limitations of supply chain ensure cumulative effects in any one period are capped.
11. The assessment shall also consider what management measures might be required to prevent or mitigate adverse consequences of the disposal at sea, and shall indicate the scope and scale of any monitoring that would be required after the disposal at sea.	Addressed by the various studies developed throughout the CA process (see Section 3.3). Additionally, this information is detailed in the Environmental Appraisal ref. [6] submitted as part of the overall draft Decommissioning Programme submission.
Overall assessment	
12. The assessment shall be sufficient to enable the competent authority of the relevant Contracting Party to draw reasoned conclusions on whether or not to issue a permit under paragraph 3 of this Decision and, if such a permit is thought justified, on what conditions to attach to it. These conclusions shall be recorded in a summary of the assessment which shall also contain a concise summary of the facts which underpin the conclusions, including a description of any significant expected or potential impacts from the disposal at sea of the installation on the marine environment or its uses. The conclusions shall be based on scientific principles and the summary shall enable the conclusions to be linked back to the supporting evidence and arguments. Documentation shall identify the origins of the data used, together with any relevant information on the quality assurance of that data.	This CA Report is provided in satisfaction of the requirement and documents the process followed in performing the Comparative Assessment of the Dunlin Alpha CGBS and Cell Contents. This is detailed throughout this document and specifically in: > Section 3.3 for the preparatory studies; > Section 7 for the recommendations and conclusions where the requirements of paragraph 3 of the decision are met; and > Appendix B for the attributes tables. Summary impact on the marine environment from the disposal at sea of the installation is addressed in the Environmental Appraisal ref. [6] submitted as part of the overall draft Decommissioning Programme submission.

Table 2.1: OSPAR 98/3 Assessment Requirements

2.2 OGUK Guidelines

In addition to the requirements detailed in Section 2.1, guidelines for CA ref. [2] were prepared in 2015 by Oil and Gas UK where seven steps to the CA process were recommended. Table 2.2 provides commentary on each of these steps to demonstrate the Fairfield position at the time of issue of this CA Report. The scoping, screening, preparation and evaluation phases are discussed further in Section 3.

	Description	Status	Commentary
Scoping	Decide on appropriate CA method, confirm criteria, identify boundaries of CA (physical and phase), and identify and map stakeholders	✓	**CGBS** Scoping completed for the CGBS in advance of screening. Broader range of stakeholders engaged to update on and explore activity since 2010-2012. CA methodology and sub-criteria established during 2017. **Cell Contents** Scoping completed during Q3 2017 in preparation for Screening. Stakeholder engagement carried out as part of the overall CGBS activities. CA methodology as per CGBS, sub-criteria adjusted as appropriate during Q4 2017.
Screening	Consider alternative uses and deselect unfeasible options.	✓	**CGBS** Screening Report ref. [4] detailing screening activity and screening methodology available on request. Specific studies identified to inform evaluation of options. **Cell Contents** Cell Contents Technical Report ref. [5] containing full details of the screening activity performed and the screening methodology adopted has been offered to all stakeholders and has been provided on request.
Preparation	Undertake technical, safety, environmental studies plus stakeholder engagement	✓	**CGBS** CGBS specific studies (see Section 3.3) undertaken alongside continued stakeholder engagement. Stakeholder Workshop conducted on November 8th 2017 where a wide cross-section of stakeholders attended to gain an understanding of the challenges associated with decommissioning the CGBS and the work being done to define and manage those challenges. Stakeholders were provided with the opportunity to make comment and raise queries. Comprehensive report circulated to all stakeholders for comment post-workshop and made available on website; all comments received subsequently answered. **Cell Contents** Cell contents specific study work (see Section 3.3) undertaken alongside continued stakeholder engagement. The screening and study work, along with the challenges associated with removal of the cell contents were also communicated to a wide cross-section of stakeholders during the Stakeholder Workshop held on November 8th 2017. Stakeholder comments followed up with all stakeholders, as per CGBS, including relevant documentation made available.

	Description	Status	Commentary
Evaluation	Evaluate the options using the chosen CA methodology	✓	**CGBS** Internal evaluation workshops conducted during 2017 as part of the evaluation phase. These sessions helped identify areas where additional information or definition was required to allow the options to be comparatively assessed in a robust manner. CA Evaluation Workshop conducted on March 9th, 2018, with key stakeholders where the options for evaluation were reviewed and assessed. **Cell Contents** Internal evaluation workshops conducted during Q4 2017 as part of the evaluation phase. Similarly, these sessions helped identify areas where additional information or definition was required to allow the options to be comparatively assessed in a robust manner. CA Evaluation Workshop conducted on March 9th, 2018, with key stakeholders where the options for evaluation were reviewed and assessed.
Recommendation	Create recommendation in the form of narrative supported by charts explaining key trade-offs.	✓	**CGBS & Cell Contents** Emerging recommendations as to the 'most preferred' decommissioning solution for the both the CGBS and the Cell Contents are provided for consideration in the CA Report (this document).
Review	Review the recommendation with internal and/or external stakeholders	✓	**CGBS & Cell Contents** An opportunity for the stakeholders engaged in the CA Evaluation Workshop and the wider stakeholder community to review and comment on the emerging recommendations contained within the CA Report was provided during April and May 2018. In addition, a Stakeholder Workshop to facilitate discussion of the emerging recommendations was held May 3rd 2018, with the workshop report provided for comment in June 2018.
Submit	Submit to BEIS as part of/alongside Decommissioning Programme	Q3 2018	**CGBS & Cell Contents** Formal submission of the revised CA Report containing reviewed and updated emerging recommendations shall be provided to BEIS as part of the supporting documentation for the Draft Decommissioning Programme, currently anticipated in Q3 2018.

Table 2.2: CA Process Overview and Status

3 COMPARATIVE ASSESSMENT METHODOLOGY

Each of the steps of the CA process are described in the following sub-sections.

3.1 Scoping

The scoping phase of the CA process requires the following elements to be addressed:

- Physical boundaries for CA;
- Phase boundaries for the CA; and
- Potential decommissioning options.

These are addressed in the following sub-sections:

3.1.1 Physical CA Boundaries

This Comparative Assessment is conducted against the Dunlin Alpha Concrete Gravity Base Substructure (CGBS) including its contents. A high-level summary of the scope and boundaries of the Dunlin Alpha CGBS is provided below:

- The steel transitions at the top of the concrete legs;
- The concrete legs and their internal components;
- The matrix of storage cells and the cell contents; and
- The steel skirt penetrating the seabed.

It should be noted that the following are specifically excluded from the scope of this CA:

- The conductors and conductor guide frames (CGFs)[2];
- The topsides including the Module Support Frame (MSF) – being fully removed and addressed elsewhere in the Dunlin Alpha decommissioning programme;
- Subsea infrastructure – addressed under the Subsea Infrastructure Decommissioning (SID) CA;
- Cell-top debris – whilst the removal of cell-top debris has been studied, it is not a differentiator in selecting the most preferred decommissioning option; and
- Drill cuttings – drill cuttings location, composition, residual quantities and recovery methods have been studied with a summary provided in Chapter 2 of the Environmental Appraisal ref. [6]. The studies have shown that the drill cuttings may remain *in situ* as per assessment under OSPAR Recommendation on drill cuttings ref. [10]. As such, drill cuttings will be treated in conjunction with the outcomes from the CGBS and cell contents CAs.

3.1.2 Phase CA Boundaries

The CA addresses operations from, but not including, the removal of the Module Support Frame (MSF) as part of the topside decommissioning, to the completion of the decommissioning programme.

In addition, where there are on-going monitoring requirements for any leave *in situ* options, impacts (i.e. cost, environment, safety[3], etc.) have been identified and calculated for a period of 50 years from the end of the decommissioning programme and are included in the CA.

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[2] all leave *in situ* options include removing the upper two conductor guide frames and the conductors to the level of the third CGF (76m below LAT).

[3] The Anatec data for legacy safety impact was calculated more than 1000 years into the future.

3.1.3 Decommissioning Options

All potential decommissioning options for the scope of the CA are defined. The base case decommissioning option is full removal as per the OSPAR Decision 98/3 ref. [1] and the regulatory Guidance Notes ref. [3]. As well as full removal options, the following scenarios must be considered:

- Re-use *in situ*;
- Relocation and re-use; and
- Partial removal to land.

The potential CGBS decommissioning options identified are:

- 1 – Re-use;
- 2 – Re-float & re-use in alternative location;
- 3 – Re-float & deconstruct inshore;
- 4 – Full removal (deconstruct *in situ*);
- 5 – Partial removal – shallow cut of legs with concrete monotower and navaid;
- 6 – Partial removal – IMO Compliant cut;
- 7 – Partial removal – toppling of legs;
- 8 – Leave *in situ* – including MSF; and
- 9 – Leave *in situ* – no MSF with navaid fitted.

The above options are described in more detail in the Screening Report ref. [4] and summarised in Section 4.1 and 5.1.

There were more than 70 cell contents decommissioning options identified which are listed in the Cell Contents Technical Report ref. [5]. In summary, they are the various permutations of options that address the following considerations:

- Removal of water / mobile oil / floor sediment / waxy wall deposits;
- Cell access via existing pipework or new penetrations;
- Disturbance of drill cuttings;
- *In situ* management (i.e. bioremediation or capping) / full removal;
- Waste processing *in situ* / return to shore; and
- Management of contents from all cells / targeted cells.

All above options are described in the Cell Contents Technical Report ref. [5] and summarised in Section 4.2 and 6.1.

A summary of the chemical composition of the cell contents is provided in Chapter 2 of the Environmental Appraisal ref. [6].

3.2 Screening Phase

The screening phase of the CA process is conducted in order to screen out unfeasible decommissioning options. The CA Guidelines ref. [2] recommend the use of a coarse, qualitative assessment methodology for the screening phase. The screening conducted for the Dunlin Alpha Decommissioning project is described in the following sub-sections.

3.2.1 CGBS

The screening phase for the CGBS was conducted initially in 2012 and then updated in 2016. During that time, additional potential decommissioning options were defined and added.

The methodology adopted, screening workshop attendance and outcomes obtained are detailed fully in Screening Report ref. [4]. The methodology is briefly summarised below:

- Review proposed decommissioning options for each remaining group;
- Assess decommissioning options and record assessment; and
- Compile Screening Report.

The decommissioning options were assessed against the five key criteria (shown in bold) required by OSPAR Decision 98/3 and expanded with sub-criteria in the Oil and Gas UK CA Guidelines ref. [2]. These were:

- **Safety**
  - Offshore Personnel
  - Other users of the sea (fishing & shipping)
  - Onshore personnel
- **Environmental**
  - Marine impacts
  - CO_2 emissions
  - Energy / Resource consumption
  - Other consequences (legacy)
- **Technical**
  - Risk of project failure
- **Societal**
  - Commercial fishing
  - Amenities
  - Communities
  - Compliance
- **Economic**
  - Cost estimate

The assessment was performed using a coarse, Red / Amber / Green method, as recommended in the CA Guidelines ref. [2]. The definition of these categories varies depends on the applicable criterion, however they are summarised Table 3.1.

Category	Description
Most Preferred	Attractive or highly acceptable.
Medium Preference	Neither particularly attractive nor unattractive.
Least Preferred	Unacceptable or highly undesirable.

Table 3.1: Screening Assessment Categories

Once assessed, a narrative was recorded against each of the potential decommissioning options to describe the assessment against each of the criteria. In some cases, the option was screened out due to the assessment being unfeasible in one particular area, for example, the integrity of the substructure being assessed as insufficient to perform options where re-float is required. Other options were screened out on the basis that they were assessed as highly undesirable against multiple criteria.

The screening process and outcomes obtained are detailed fully in the Screening Report ref. [4] and are summarised in Section 5.1.

3.2.2 Cell Contents

The scoping phase for the cell contents identified more than 70 potential recovery or management options. As such, a different approach to screening was adopted for the cell contents. This approach is detailed in full in the Cell Contents Technical Report ref. [5].

In defining this high number of options, consideration was given to the following:

- Potential access methods i.e. existing pipework / new penetrations;
- Contents management options i.e. removal / *in situ* treatment;
- Disturbance of drill cuttings i.e. full removal, substantial through to minimal disturbance;
- Contents phase to be addressed i.e. oil / sediment / wax;
- Volume of waste created and how this would be managed; and
- Duration of the activities.

Potential options were screened out on the basis of the relative environmental benefits and technical feasibility associated with the option. A list of questions was prepared, with the answers to those questions (fully justified in the Cell Contents Technical Report ref. [5]) used to eliminate potential cell contents decommissioning options. These questions and outcomes were as follows:

- How will the cell contents be accessed?
  - Existing pipework | New penetration in cell top | New penetration in cell side wall
- How will the cell contents be managed?
  - Removal | Bioremediation | Capping | Leave *in situ*
- Which phases of material will be targeted?
  - Mobile oil | Sediment | Wall residue | Water phase
- How will any waste created / recovered be managed?
  - Ship to Shore | Inject to Well | Onsite Treatment
- Which cells should be targeted?
  - All of the cells | Selected cells

This screening methodology enabled the high number of potential options to be screened down to a credible and manageable number for the evaluation phase. The options taken forward were deemed to have the highest efficiency in terms of the balance between effort versus achieved cleanliness and were selected to examine two key trade-offs:

- Targeting all the cells and disturbance of the drill cuttings pile; and
- Targeting mobile oil and sediment or just the residual mobile oil.

The screening process and outcomes obtained are detailed fully in the Cell Contents Technical Report ref. [5] and summarised in Section 6.1.

3.3 Preparation Phase

During the preparation phase, detailed studies and analyses have been conducted, mainly by independent industry consultants, to provide information to support the evaluation phase of the CA. Those which were required were identified early in the CA process, but supplemented where needed during the screening phase of the CA. These provided a scientific and engineering evidence base to support the evaluation of the four feasible decommissioning options taken forward following screening.

3.3.1 CGBS

In order to provide the required level of evidence-based information to allow the remaining decommissioning options for the CGBS, a wide-array of studies were conducted across four main areas:

- Technical;
- Safety;
- Environmental; and
- Societal.

The findings of these studies and analyses were gathered in preparation for the evaluation phase of the CA. Data from the studies were used to build up the associated cost estimates and key information obtained from these studies / analyses, including societal considerations were used during the evaluation phase and are provided in the attributes tables included in Appendix C.

3.3.1.1 Technical Studies

Engineering studies[4] conducted covered:

> Study 1 – Leg Internals Study ref. [11]	Provides the inventory of the equipment contained within the CGBS legs. Provides methods for the removal of the equipment, the quantities of removed materials and the estimates of durations and cost associated with the leg internals works. Also used in deriving the risk exposure from leg internals work scopes. Also used in assessing the overall costs associated with each option.
> Study 4 – Transition Piece Study ref. [12]	Addresses the condition and longevity assessment of the steel transitions. Used to inform the options where steel transitions may be retained.
> Study 5 – Aids for Navigation ref. [13]	Provides technical detail of the activities required to install and maintain the aids to navigation. Used in deriving the operational and legacy risk exposure associated with applicable options. Also used in deriving the energy and emissions assessments of the applicable options.
> Study 6 – Concrete Cutting & Removal Study ref. [14]	Provides technical detail of activities required to perform cutting of the concrete CGBS legs. Covers cutting operations at the shallow cut depth, the IMO compliant cut depth and at the top of the cell base. Also addresses the cutting operations for the deconstruction of the cell base. Used in deriving the operational and legacy risk exposure associated with applicable options. Also used in deriving the energy and emissions assessments of the applicable options.
> Study 8 – Leg Failure Study ref. [15]	Provides detailed technical assessment of the failure mechanics, likelihood and impacts associated with failure of the concrete CGBS legs. Used in assessing the impact of leg failure associated with the applicable decommissioning options.

[4] Not all consecutive numbers were used.

> Study 12 – Cell Top Debris Study ref. [16]	Conducted to define the type and quantity of debris on the top of the cell base. Incorporates previous survey data and provides estimates of activities and durations associated with the removal options. Used to inform the impact from cell top debris removal associated with the applicable decommissioning options.
> Study 16 – Transition Corrosion Protection Study ref. [17]	Provides activities required and estimated durations for the steel transition cathodic protection system. This system is installed to mitigate the external corrosion of the steel transitions in the splash zone in order for their longevity to match that of the concrete CGBS legs. Used in assessing the durations and risk exposure of the applicable decommissioning options.
> Study 19 – Drill Cuttings Study ref. [18]	Conducted to quantify the volume and composition of the drill cuttings and the potential decommissioning options for the drill cuttings. Provides activities and durations associated with drill cuttings removal. Used to inform the impact from drill cuttings disturbance / removal associated with the applicable decommissioning options.
> Study 23 – Transition Internal Coating Study ref. [19]	Provides activities required and estimated durations and resources for the internal coating of the steel transitions. This internal coating is performed to mitigate the corrosion of the steel transitions in order for their longevity to match that of the concrete CGBS legs. Used in assessing the durations and risk exposure of the applicable decommissioning options
> Study 27 – Technical Risk Assessment ref. [20]	Provides a detailed and documented technical risk assessment of the remaining decommissioning options for the evaluation phase. This technical risk assessment is conducted on the basis of those risks that would constitute a technical project failure i.e. those that would result in a requirement to resubmit the approved decommissioning programme. Used in describing and quantifying the attributes of each of the remaining CGBS decommissioning options and performing the assessment against the Technical Risk criterion.

3.3.1.2 *Safety Studies*

Safety studies conducted covered:

> Study 14 - Safety Summary ref. [8]	Provides a single location for all safety metrics derived within the various studies listed. Collates vessel durations and personnel man-hours exposures, covering both offshore and onshore. Also addresses both operational safety impacts and legacy safety impacts. Provides a detailed description of the suitability of the key safety comparison metric, Potential for Loss of Life (PLL), for CA purposes. Provides a detailed description of how the PLLs are calculated. Used in assessing all options against all safety sub-criteria.
> Study 21 – Shipping & Fishing Study ref. [21]	Provides a detailed assessment of the impact of the remaining decommissioning options from an, other users of the sea perspective. Focussed on legacy impacts. Used in assessing all options against the Legacy Risk criterion.
> Study 29 – Collision Risk ref. [22]	Provides a detailed assessment of the collision risk during the operational phase of the remaining decommissioning options. Considers all users of the sea.

3.3.1.3 Environmental Studies

> Study 3 – Seabird Colonisation Study ref. [23]	Provides an assessment of the impact of the decommissioning options in terms of seabird colonisation and migration routes.
> Study 9 – Marine Growth Study ref. [24]	Provides an assessment of the impact of the decommissioning options in terms of marine growth. Considerations include volumes of material, compositions / species and the potential processing routes.
> Study 10 - Marine Impact Full Removal ref. [25]	A detailed assessment of the marine impacts associated with the full removal option. This study was conducted to ensure that the impacts associated with the full removal of the CGBS were fully considered. Used in assessing the full removal option against the environmental criteria.
> Study 12 – Cell Top Debris Study ref. [16]	Conducted to define the type and quantity of debris on the top of the cell base. Incorporates previous survey data and provides estimates of activities and durations associated with the potential cell top debris decommissioning options. Provides assessment of the operational and legacy environmental impacts of the cell top debris removal options
> Study 19 – Drill Cuttings Study ref. [18]	Conducted to quantify the volume and composition of the drill cuttings and the potential decommissioning options for the drill cuttings. Provides assessment of the operational and legacy environmental impacts of the drill cuttings removal options.
> Study 28 – Energy & Emissions Assessment ref. [9]	Provides a single location for all environmental metrics derived within the various studies listed. Collates marine noise impacts, atmospheric emissions calculations, fuel use calculations and life-cycle environmental impacts. Addresses both operational and legacy impacts. Provides a detailed description of the methods employed in calculating atmospheric emissions, fuel use and marine noise impacts. Used in assessing all options against all environmental sub-criteria.
> Cell Contents Technical Report ref. [5]	Provides details of the modelling conducted and the outcomes obtained under various cell contents release scenarios. Used during the assessment of the legacy marine impact associated with the leave *in situ* options.

3.3.1.4 Societal Studies

> Commercial Fisheries Baseline Study ref. [26]	Provides an assessment of the impact of the decommissioning options in terms of commercial fishing operations. Used in assessing all options against the Societal – Fishing Industry criterion.

3.3.2 Cell Contents

The studies / analyses conducted during the preparation phase of the CA process for the cell contents option evaluation were as follows:

> Attic Oil Recovery Project (AORP)	Modelling and validation of the AORP execution in 2007 has been conducted to increase the confidence in the residual mobile oil volume. This was used to feed into the cell contents inventory modelling and validation.
> Cell Contents Inventory	Detailed calculations have been conducted to understand the residual contents and the confidence level of the estimates. These calculations and validation covers all the phases of the cell contents, the composition of those phases and the quantities associated with each phase. It also addresses the distribution of the phases across the 75 oil storage cell compartments. This inventory estimate basis was used to inform the environmental impacts from the recovered / residual material. It was also used to inform the activities and durations when developing the method statements.
> Cell Access	Access to cells for both retrieving additional data through survey/sample and delivery of the long-term management solution for the contents (i.e. recovery / treatment). This informed the method statements and Economic criterion.
> Drill Cuttings Assessment	Conducted to quantify the area and volume of the drill cuttings and the potential options to allow cell access. Used to inform the impact from drill cuttings disturbance / removal associated with the cell contents decommissioning options.
> Method Statements	Detailed method statements were developed for the screened-in decommissioning options to ascertain and detail the activities and resources required to deliver the option. Used as the basis for various other studies and assessments and used throughout the assessment of the remaining decommissioning options. Method statements included developing cost estimates for the decommissioning options which were used to inform the Economics criterion.
> Emissions Assessment	Fuel and energy consumption and atmospheric emissions assessment performed for the screened-in decommissioning options based upon activities and resources identified in method statements. Used during the assessment of the options against the Environment – Atmospheric Emissions and Consumptions criterion.
> Safety Assessment	Potential for Loss of Life (PLL) metrics derived for the remaining decommissioning options based upon activities and resources identified in method statements.
> Release Modelling	Release modelling conducted against a variety of release scenarios, including understanding release initiators and resulting volume of release. Used during the assessment of the options against the Environment – Operational Marine Impacts and the Environment – Legacy Marine Impacts criteria.

The findings of these studies and analyses are contained within the Cell Contents Technical Report ref. [5] and are gathered in preparation for the evaluation phase of the CA. The key information obtained from these studies / analyses, used during the evaluation phase is provided in attributes tables included in Appendix C.

3.4 Evaluation Phase

The evaluation phase of the CA is where the feasible decommissioning options identified through screening are evaluated against each other. This evaluation process is conducted according to the CA Guidelines ref. [2] and employs the data obtained during the preparation phase as summarised in the attributes tables included in Appendix C.

The evaluation phase was performed during a number of preparatory evaluation workshops where the decommissioning project team, comprising both Fairfield personnel and independent consultants, were represented. This enabled the supporting information for the CGBS and Cell Contents evaluations and associated decommissioning options to be interrogated and increased in maturity and definition.

Once the preparatory evaluation of the remaining decommissioning options was sufficiently mature, a CA Evaluation Workshop was convened with external participants on March 9th 2018. During this session the CA process to date was described and the evaluation of the options was reviewed. This CA Stakeholder Workshop (see CA Evaluation Workshop Minutes in Appendix B) enabled the attending external participants to refresh and / or gain familiarity with the evaluation methodology and information which the supporting studies and analyses had generated both through advance copies of documentation and through a presentation at the start of the workshop. It also allowed the evaluation to be challenged in key areas and, at the culmination of the workshop, outcomes for each of the decommissioning groups were presented.

3.4.1 CA Evaluation Workshop

The CA Evaluation Workshop was attended by representatives acting in the capacity of either decision-making participants, or observers. The attendees and their roles were as detailed in Table 3.2.

Name	Organisation	Role
Participants		
Philip Walker	Atkins	Structural Consultant (CGBS)
Peter Lee	Fairfield	Regulatory & Stakeholder Manager
Jeff Burns		Environmental Advisor
Gary Owen		Study Lead Engineer
Harry Yorston		Performance Delivery Facilitator
Louise Pell-Walpole	Joint Nature Conservation Committee (JNCC)	Stakeholder Representative
Dr Peter Hayes	Marine Scotland	
Peter Douglas	Northern Lighthouse Board (NLB)	
Raymond Hall	Scottish Fishermen's Federation (SFF)	
Peter West		
Caroline Laurenson	Xodus Group Limited	Technical Consultant (cell contents)
John Foreman		CA Facilitator
Kenneth Couston		Environmental Consultant
Rebecca Allan		Senior Engineer (cell contents)
Tony Millais		Environmental Consultant

<table>
<tr><th>Name</th><th>Organisation</th><th>Role</th></tr>
<tr><th colspan="3">Observers</th></tr>
<tr><td>Carol Barbone</td><td>Fairfield</td><td>Stakeholder Relations</td></tr>
<tr><td>June Calder</td><td>Health and Safety Executive (HSE)</td><td>Regulator Representative</td></tr>
<tr><td>Graham McNeillie</td><td rowspan="4">Independent Review Group (IRG)</td><td rowspan="4">Independent Review</td></tr>
<tr><td>George Fleming</td></tr>
<tr><td>Martin Muncer</td></tr>
<tr><td>Ruby Lowe</td></tr>
<tr><td>Alan Ransom</td><td rowspan="2">Oil & Gas Authority (OGA)</td><td rowspan="5">Regulator Representative</td></tr>
<tr><td>Ian Fozdar</td></tr>
<tr><td>Ben Bryant</td><td>Offshore Petroleum Regulator for Environment and Decommissioning – Environmental Management Team (OPRED EMT)</td></tr>
<tr><td>Debbie Taylor</td><td rowspan="2">Offshore Petroleum Regulator for Environment and Decommissioning – Offshore Decommissioning Unit (OPRED ODU)</td></tr>
<tr><td>Lisa Yates</td></tr>
</table>

Table 3.2: CA Evaluation Workshop Attendees

3.4.2 Evaluation Methodology

The CA Guidelines ref. [2] outline three possible methods for evaluation, these are:

- Evaluation Method A: Narrative / Red-Amber-Green (RAG);
- Evaluation Method B: Narrative + Scoring; and
- Evaluation Method C: Narrative + Scoring + Weighting.

Of the three potential evaluation methods it was decided to use Evaluation Method C which is the most fully featured method. The evaluation was undertaken and recorded utilising Xodus bespoke software based upon a Multi-Criteria Decision Analysis (MCDA) methodology. This method was selected due to the complex nature of the CGBS and cell contents decisions and the desire to provide a robust, transparent and auditable decision making process.

The MCDA method ensures that the input data is largely quantified with scientific based evidence which provides the most robust audit trail to assess the optimum emerging recommendation going forward. It allows the stakeholders to assess the relative advantages and disadvantages of each option against each of the other options and to rank these accordingly.

It should be noted that MCDA requires weighting of the assessment criteria. Fairfield decided to equally weight the five key criteria at 20% each in order not to single out any criterion as more important as any other.

Specific detail of the evaluation methodology adopted for the evaluation phase of the Dunlin Alpha Decommissioning project is provided in Appendix A.

3.4.3 Evaluation Criteria

The criteria selected for use during the evaluation phase of the CA uses the five primary criteria as detailed in the CA Guidelines ref. [2] i.e. safety, environment, technical, societal and economic. Each of these criteria are further sub divided and described by a set of sub-criteria. The sub-criteria were selected based on the suggested sub-criteria “Matters to be considered” from the guidelines and the learnings from the use of the sub-criteria during the screening phase. The sub-criteria used are slightly different for the CGBS and the Cell Contents assessments due to the nature of the options being assessed, and are defined in the following sub-sections.

3.4.3.1 CGBS Evaluation Criteria

The criteria used when performing the evaluation of the remaining CGBS decommissioning options were:

- Safety
  - Operations Personnel
  - Other Users
  - Legacy Risk
- Environmental
  - Operational Marine Impacts
  - Atmospheric Emissions / Consumptions
  - Legacy Marine Impacts
- Technical
  - Project Technical Risk
- Societal
  - Fishing Industry
  - Other Groups
- Economic
  - Operational & Legacy Costs

The description, approach to assessment, sources of information and units used in the assessment are described fully in Table 3.3.

Criteria	Sub-Criteria	Description	Approach to Assessment	Units
1. Safety (20%)	1.1 Operations Personnel (6.66%)	This sub-criterion considers elements that impact risk to offshore personnel and includes, project team, project vessel crew, diving teams, supply boat crew, and survey vessel crew. It should be noted that crew changes are performed via port calls. This sub-criterion also considers elements that impact risk to onshore personnel. Factors such as any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel. **Not considered:-** - Rest (off-shift) risk exposure for all worker groups - Helicopter travel for topside scopes / worker groups	Quantitative data is used to compare the options against this criterion. Potential for Loss of Life (PLL) metrics are calculated based on the Fatal Accident Rate (FAR) x Hours of Exposure for each of the worker groups and is considered a suitable metric for Comparative Assessment purposes. The FAR is taken from the summary report of the Joint Industry Project investigating the Risk Analysis into Decommissioning Activities issued by Safetec [27]. The Hours of Exposure is taken from the various studies / method statements developed to define the options.	PLL
	1.2 Other Users (6.66%)	This sub-criterion covers the impact associated with the risk to other users. Considers elements such as collision impact whilst performing activities. Users such as fishing vessels and commercial transport vessel are considered. **Not considered:-** - 3rd party interactions / collisions and military vessels Note: The vast majority of vessel operations will be conducted within a 500 m safety zone around the facility and thus will limit the safety impact on other users to those from transits along set corridors.	A quantitative assessment is made based on the number of vessel days associated with each of the decommissioning options. This is considered acceptable as the safety impact on other users is a function of the operational vessel numbers / durations / movements. It should be noted that the vast majority of vessel operations will be conducted within a 500 m safety zone around the facility and thus will limit the safety impact on other users.	Days
	1.3 Legacy Risk (6.66%)	This sub-criterion addresses the legacy risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, associated with the decommissioning option being assessed. Issues such as snag risk for fishing operation, collision risk for all users is considered. Any personnel risk exposure associated with long-term monitoring is also encompassed by this criterion. **Not considered:-** - Operational phase risk	A qualitative assessment of the legacy risk to other users, informed by the PLL metrics from the Anatec Fishing Risk Study. The legacy risk associated with any required monitoring is calculated in a similar manner to 1.1 above.	PLL

Criteria	Sub-Criteria	Description	Approach to Assessment	Units
2. Environmental (20%)	2.1 Operational Marine Impacts (6.66%)	Encompasses any marine environmental impacts from the operational phase of the decommissioning option being assessed. Should address both planned impacts (inherent to the option being assessed) and potential unplanned impacts (accidental releases, both large and small in scale and encompassing Major Environmental Incidents (MEIs)). Also encompasses marine noise generated by vessels, cutting operations, explosives where used, etc.	Planned and unplanned marine impacts are narrative judgements informed by estimates of volumes (m^3) / composition of any releases. Marine noise is calculated based on the vessel durations, subsea cutting operations and is a quantitative measure of cumulative sound energy level in TPa^2S.	m^3 TPa^2s.
	2.2 Atmospheric Emissions / Consumptions (6.66%)	Encompasses environmental impact of atmospheric emissions from both the operational phase and any associated legacy phase of the decommissioning option being assessed. It also encompasses the resource consumption (such as Fuel / Energy Use) associated with the decommissioning option being assessed. This includes the environmental impact of processing any returned materials, production of any replacement materials (for those left *in situ*) and any quarried rock or other new material required. This is in keeping with the principle of 'full life-cycle assessment'. **Not considered:-** NOx and SOx due to their minimal impact in an offshore environment and their proportionality to the CO_2 impact.	Emissions are quantified by CO_2 in metric tonnes. Fuel consumption is quantified in metric tonnes. Other consumptions such as steel / other fabrications are also quoted in metric tonnes. Impact of recycling / processing returned material and replacing leave *in situ* material is quoted in CO_2 in metric tonnes.	GJ (Energy) Tonnes (CO_2)
	2.3 Legacy Marine Impacts (6.66%)	Encompasses any marine environmental impacts associated with the legacy phase of the decommissioning option being assessed. Should address both planned impacts (inherent to the option being assessed) and potential unplanned impacts (accidental releases, both large and small in scale and encompassing Major Environmental Incidents (MEIs)). Specific elements such as impacts from drill cuttings and cell contents are addressed.	Planned and unplanned marine impacts are narrative judgement informed by estimates of volumes (m^3) / composition of any releases. Expected duration of releases is also provided.	m^3.

Criteria	Sub-Criteria	Description	Approach to Assessment	Units
3. Technical (20%)	3.1 Project Technical Risk (20%)	This sub-criterion relates to the various technical risks that could result in a major project failure (those that may require a DP re-submission). Concepts such as: Technical Novelty and Potential for Showstoppers can be captured along with impact on the schedule due to overruns from technical issues such as operations being interrupted by the weather. Technical Feasibility and Technical Maturity is also considered.	Supported by narrative discussion of technical risk but informed by the quantified Technical Risk Score from Atkins Technical Risk Assessment of all options.	N/A
4. Societal (20%)	4.1 Fishing Industry (10%)	This sub-criterion addresses the impact of the option on commercial fishing operations. It includes consideration of impacts from both the decommissioning activities and any residual impacts post decommissioning such as reinstatement of access to area. **Not considered:-** Safety impacts - addressed in 1.3 above.	Assessed using narrative of the impact of the decommissioning option on fishing operations. Supported by quantification of the area (km^2) of potential impact.	N/A
	4.2 Other Groups (10%)	This sub-criterion addresses any socio-economic impacts on other users both offshore and onshore where the impact may be from dismantling, transporting, treating, recycling and land filling activities relating to the option. Issues such as impact on the health, well-being, standard of living, structure or coherence of communities or amenities are considered here e.g. business or jobs creation, increase in noise, dust or odour pollution during the process which has a negative impact on communities, increased traffic disruption due to extra-large transport loads, etc. Includes the Fairfield Guiding Principle of 'Minimal business interruption to others'.	Assessed using narrative of the positive and negative impact of the decommissioning option on all groups of society (excluding fishing industry). Supported by quantification of the quantities of material being transported (metric tonnes) and amount of job creation (man-hours).	N/A
5. Economic (20%)	5.1 Operational & Legacy Costs (20%)	This sub-criterion addresses the cost of delivering the option as described. Cost certainty (a function of activity maturity) is also recorded. Also covers any long-term cost element (such as monitoring) associated with the decommissioning option, stated explicitly rather than included in overall figure.	Both operational and legacy costs are quantified in GBP. Cost certainty is generally in line with a class 4 estimate as defined by American Association of Cost Engineers (AACE) and thus covers an estimated range of -15% to +50% however a narrative around cost estimate associated with each option is provided.	£

Table 3.3: CGBS Evaluation Criteria and Sub-Criteria

3.4.3.2 Cell Contents Evaluation Criteria

The criteria used for the evaluation of the remaining cell contents decommissioning options are:

- Safety
  - Operations Personnel
  - Legacy Risk
- Environmental
  - Operational Marine Impacts
  - Atmospheric Emissions / Consumptions
  - Legacy Marine Impacts
- Technical
  - Project Technical Risk
- Societal
  - All Groups
- Economic
  - Operational & Legacy Costs

The description, approach to assessment, sources of information and units used in the assessment are described fully in Table 3.4.

Criteria	Sub-Criteria	Description	Approach to Assessment	Supporting Study Output	Units
1. Safety (20%)	1.1 Operations Personnel (10%)	This sub-criterion considers elements that impact risk to offshore personnel and includes, project team and crew from vessels supporting the project such as waste transport and supply boat crews. **Not considered:-** Due to the boundaries of the assessment onshore personnel impacts are not considered, this is a reasonable basis as the materials being brought onshore are small and do not require significant handling compared to the offshore operations. There is no inherent potential for high consequence events i.e. major accident hazard, major environmental hazard type events.	Assessment to be made based on activity durations and narrative around other factors such as legacy impact where there is a differentiator. Definition of activity types and durations allows safety metrics to be calculated to give a quantitative comparison between options.	Quantitative data is used to compare the options against this criterion. Potential for Loss of Life (PLL) metrics are calculated based on the Fatal Accident Rate (FAR) x Hours of Exposure for each of the worker groups and is considered a suitable metric for Comparative Assessment purposes. The FAR is taken from the summary report of the Joint Industry Project investigating the Risk Analysis into Decommissioning Activities issued by Safetec ref. [27]. The Hours of Exposure is taken from the various studies, datasheets and method statements developed to define the options.	PLL
	1.2 Legacy Risk (10%)	This sub-criterion addresses any residual risk from personnel risk exposure associated with long-term monitoring. **Not considered:-** Note that the residual risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, due to the presence of the facilities post decommissioning is covered in the Comparative Assessment for the CGBS.		Qualitative narrative assessment.	N/A

Criteria	Sub-Criteria	Description	Approach to Assessment	Supporting Study Output	Units
2. Environmental (20%)	2.1 Operational Marine Impacts (6.66%)	This sub-criterion encompasses any marine environmental impacts from the operations. It addresses both planned impacts (inherent to the option being assessed) and potential unplanned impacts (accidental releases, both large and small in scale including any that may be classed as Major Environmental Incidents (MEIs)). It also covers any marine noise generated during the operations by vessels, cutting operations, explosives where used, etc. The impact of both direct and indirect drill cuttings disturbance shall also be considered.	Assessment to be based on assessing noise generated by decommissioning activities. Potential discharges to sea will be quantified in terms of release size and environmental impact. Assessment to be based on quantifying the area and volume of drill cuttings disturbance along with the cause of the disturbance.	Combined Qualitative and Quantitative narrative assessment. Expected that noise is not a significant differentiator but will be incorporated on an order of magnitude qualitative basis. Qualitative narrative assessment for planned and unplanned releases, supported by quantification of release type/size (including rate and duration) and environmental impact assessment. Quantitative assessment of area/volume of drill cuttings disturbance.	m^2 / m^3
	2.2 Energy & Emissions (6.66%)	This sub-criterion relates to the amount of fuel consumed to provide energy for the vessel operations and the amount of damaging atmospheric emissions associated with the operations. **Not considered:-** Note that no other resource use energy or emissions impacts have been assessed, for example manufacturing of valves and equipment to access the cells. Creation of waste materials and processing / disposal is not addressed.	Assessment to be based on quantifying the volume of fuel used and a life-cycle emissions assessment. The output energy and CO_2 figures allow a direct, quantitative comparison between options.	Quantitative Energy and Emissions Assessment based on activities and durations for each option as defined in the method statements.	GJ (Energy) Tonnes (CO_2)
	2.3 Legacy Impacts (6.66%)	This sub-criterion relates to the marine environment impacts which could arise as a result of long-term legacy effects. Addresses releases, both large and small in scale and encompassing Major Environmental Incidents (MEIs). A further differentiator in terms of legacy relates to the presence of drill cuttings reducing the likelihood of a cell breach upon impact from a dropped object, i.e. the drill cuttings coverage provides a beneficial effect dampening the impact energy.	Assessment to be based on residual inventory upon completion of the management option. Potential discharges to sea will be quantified in terms of release size and environmental impact.	Qualitative narrative assessment for legacy impacts, supported by quantification of release type / size (including rate and duration) and environmental impact assessment.	m^3

Criteria	Sub-Criteria	Description	Approach to Assessment	Supporting Study Output	Units
3. Technical (20%)	3.1 Project Technical Risk (20%)	This sub-criterion relates to the various technical risks that could result in a major project failure. Concepts such as: Technical Novelty and Potential for Showstoppers can be captured along with impact on the schedule due to overruns from technical issues such as operations being interrupted by the weather. Technical Feasibility and Technical Maturity is also considered.	The following will be considered: Feasibility; Concept Maturity; Availability of Technology; Track Record; Risk of Failure; and Consequence of Failure.	Qualitative narrative assessment.	N/A
4. Societal (20%)	4.1 All groups (20%)	This sub-criterion addresses the positive and negative impact of the option on societal factors. It includes consideration of residual impacts post decommissioning such as temporary impact to fishing activities should there be future degradation of the substructure and release of the contents. **Not considered:-** Note that the issue of access in general to the area for fishing due to the presence of the facilities post decommissioning is covered in the Comparative Assessment for the CGBS. Onshore socio-economic impacts are not addressed due to the boundaries that have been drawn for this assessment, this is a reasonable basis as the materials being brought onshore are small and do not require significant handling compared to the offshore operations.	The following will be considered: Positive and negative impacts on fishing activities. Potential employment benefits. Industry capability development with respect to technology development and proof of concept during execution of the option.	Qualitative narrative assessment.	N/A

Criteria	Sub-Criteria	Description	Approach to Assessment	Supporting Study Output	Units
5. Economic (20%)	5.1 Operational & Legacy Costs (20%)	This sub-criterion addresses the cost of delivering the option as described. Cost certainty (a function of activity maturity) is also recorded. Also covers any long-term cost element (such as monitoring) associated with the decommissioning option, stated explicitly rather than included in overall figure.	Cost estimate for the management options under consideration. Cost estimate for the legacy management strategy under consideration (this is likely to be the same for all options and will be combined with the legacy management requirements for the CGBS itself, therefore may not be a differentiator).	Quantitative cost estimate based on activities and durations for each option as defined in the method statements. The short term operational costs and long-term legacy costs will be displayed as separate figures.	£

Table 3.4: Cell Contents Evaluation Criteria and Sub-Criteria

3.4.4 Derogation Options versus Full Removal

Early in the evaluation phase of the CA process, the attributes associated with the CGBS Option 4 – Full Removal, such as operational durations, volume of returned material, atmospheric emissions and fuel consumption, were shown to be significantly higher than the other remaining decommissioning options where it was proposed that some or all of the substructure would remain *in situ* as a derogation case.

During that early phase, the evaluation workshops showed that MCDA, which is designed to inform difficult decisions where the differences between options are small, was being dominated by the full removal option and the differences between the other remaining options were being diluted, making it difficult to identify the key differentiators.

In order to address this whilst accommodating a full removal option, as required by OSPAR 98/3, a tiered evaluation methodology was adopted where the derogation options selected via a screening process and evaluated without prejudice against each other in the first pass. The most preferred derogation option from this process was then compared, using the same methodology, against Option 4 – Full Removal.

This approach ensured that full consideration was given to the full removal option and directly compared to the assessed best derogation case on the day. It is illustrated diagrammatically in Figure 3.1.

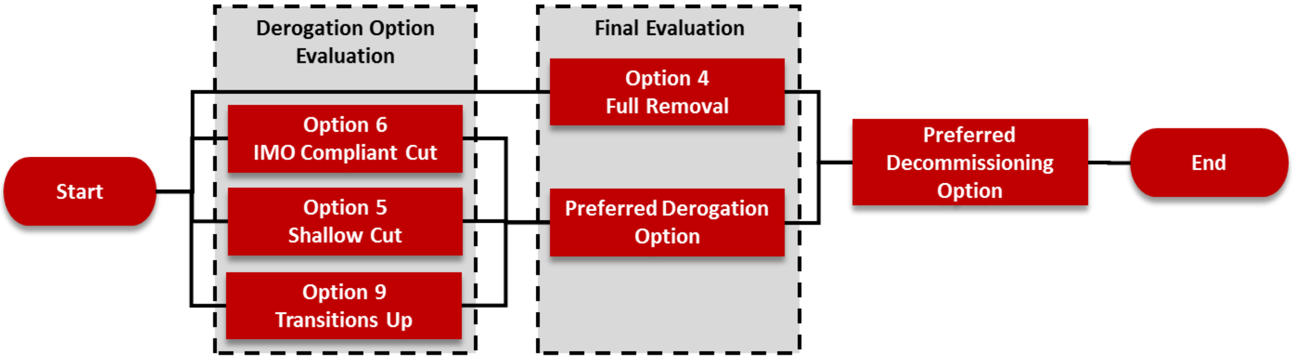


Figure 3.1: Derogation versus Full Removal Option Evaluation Methodology for the CGBS

3.5 Stakeholder Engagement

Stakeholder engagement to help inform the broader development of the options for decommissioning of the Dunlin Alpha CGBS through technical studies and reports, the subsequent refinement of options and the eventual Comparative Assessment (including evaluation) has been concentrated in two main time periods.

The first phase of engagement activity took place between 2010 and 2012 and involved a series of stakeholder workshops, the initiation and sharing of technical studies, the formation of a Cell Contents Expert Discussion Group, consultation with five OSPAR Contracting Parties, and a series of one-to-one meetings with stakeholders.

Since 2017, engagement has focused on the consideration of the four screened options for the CGBS decommissioning, together with the options for decommissioning the cell contents housed within the base of the substructure. For this, a refresh of the original list of stakeholders was undertaken and its scope broadened in order to ensure current relevance and accuracy.

The key features of the recent engagement have included consultation on the scope of proposals for environmental impact assessment to inform further studies, and bilateral and multilateral meetings with stakeholders to better understand their interests and potential concerns. A major workshop[5] to update the broader range of stakeholders and to better understand their views was also held (November 2017) as a

[5] See workshop report at http://www.fairfield-energy.com/assets/documents/Dunlin-Alpha-Stakeholder-Workshop-Report-8Nov2017-REPORT-ON-PROCEEDINGS.pdf

means of gathering insights ahead of the CA evaluation itself, and to ensure that the range of studies undertaken properly addressed all relevant points.

External stakeholders (notably regulators and regulatory advisors, and those representing other users of the sea) were also invited to take part in the final Comparative Assessment evaluation of options (March 2018), described earlier. The report was circulated to all stakeholders as a pre-read for the stakeholder workshop (held on May 3rd, 2018) and for those unable to attend. Comments and questions received were addressed during the workshop and detailed in the workshop report.

A separate report on stakeholder engagement ref. [28] will be published and issued for review during the public and statutory consultation scheduled for later this year. This will detail how stakeholder issues have been addressed within the Draft Decommissioning Programme and the Comparative Assessment and Environmental Appraisal reports which accompany it. It will also incorporate information from the original report on stakeholder activity during the period 2010-2012[6].

[6] See http://www.fairfield-energy.com/assets/documents/Stakeholder-Engagement-Summary-Report-16-January-2012.pdf

4 DECOMMISSIONING OPTIONS

4.1 CGBS

In 2016, as part of the overall CA process for decommissioning Dunlin Alpha, a coarse option screening exercise was performed against the CGBS decommissioning options. In line with the requirements of OSPAR Decision 98/3 the initial nine potential options were screened; four feasible options (illustrated in Figure 4.1) were then carried forward to the evaluation phase of the CA. The screening performed is detailed fully in the Dunlin Alpha Screening Report ref. [4].

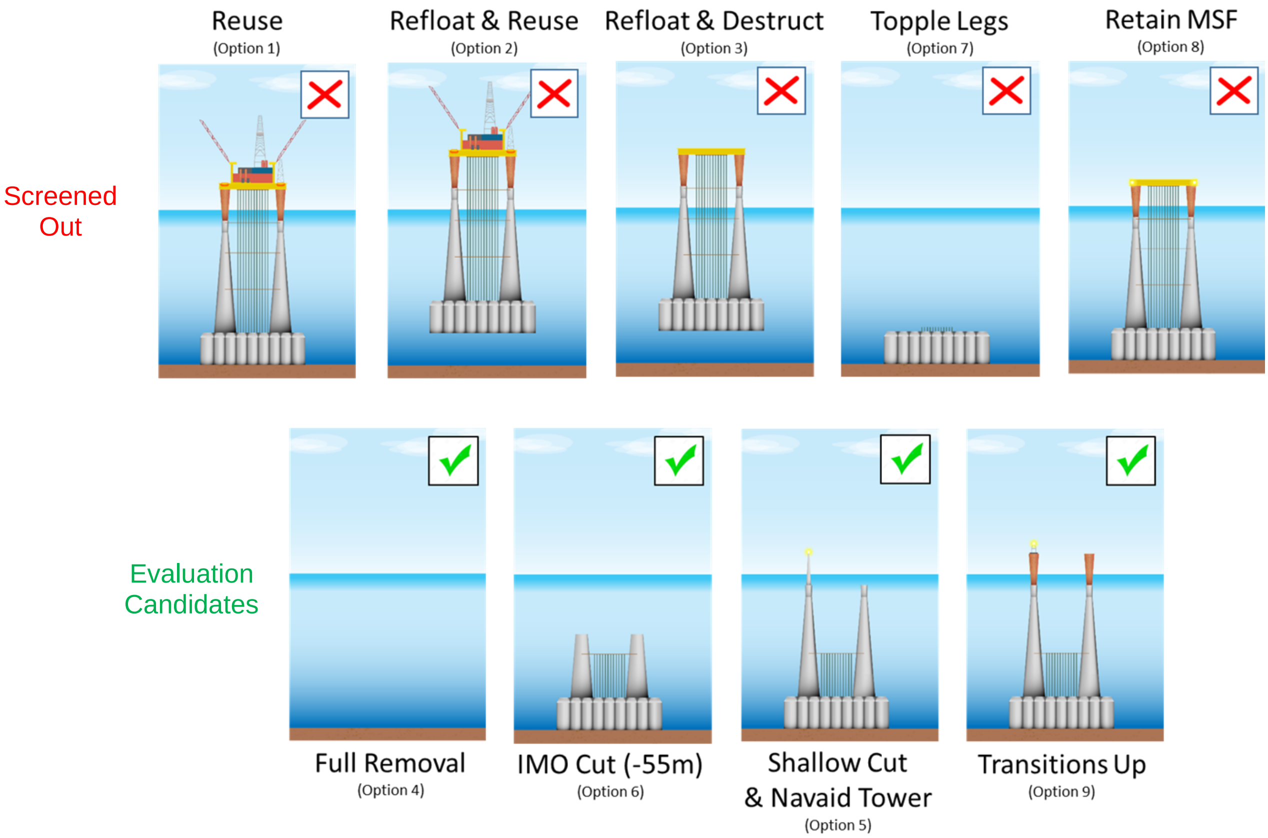
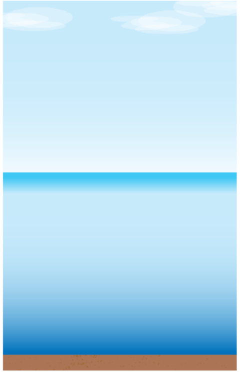


Figure 4.1: CGBS Options and Screening Summary

The four options are summarised as follows:



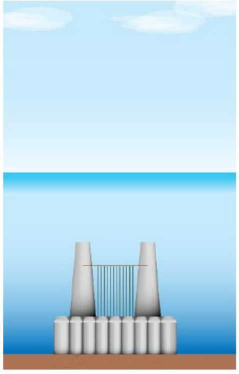
Option 4 – Full Removal

This is the OSPAR compliant full removal option. This option involves deconstructing the CGBS *in situ* using a single Heavy Lift Vessel (HLV) and a Dive Support Vessel (DSV) / barge for cut, lift, transport and recycle/disposal.

Navaid not required as the concrete would be fully removed.

The drill cuttings, cell contents, conductors down to 3 m below seabed and Conductor Guide Frames (CGFs) would be removed.

Estimated to take up to 43 years to complete.



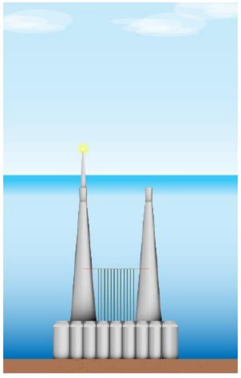
Option 6 – IMO Compliant Cut

This option involves removing the steel transitions. Shallow and IMO compliant cut zones and above will be cleared and removed.

Shallow zone cutting performed using full diameter diamond wire underwater push or pull cut using a single HLV and a DSV / barge for cut, lift, transport and recycle / disposal.

IMO compliant cutting performed by orbital cut around the perimeter of the leg, completed by a single HLV and a DSV / barge for cut, lift, transport and recycle / disposal.

Navaid not required. Estimated to take up to 5 years to complete.



Option 5 – Shallow Cut

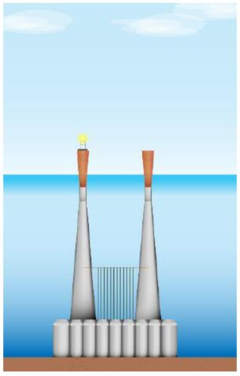
This option involves removing the steel transitions. Shallow cut zone and above will be cleared and removed.

Shallow zone cutting performed using full diameter diamond wire underwater push or pull cut using a single HLV and a DSV / barge for cut, lift, transport and recycle / disposal.

Navaid with prefabricated concrete support tower would be installed on one of remaining concrete legs (leg C or D).

Navaid annual monitoring and maintenance included for 50 years post-decommissioning for cost estimating purposes.

Estimated to take up to 5 years to complete.



Option 9 – Transitions Up

This option involves topside removal only leaving the four steel transitions in place.

The steel transitions will have their internal walls painted and a cathodic protection system installed externally in order to reduce the corrosion rate.

The transitions will be sealed with a heavily galvanised steel roof to prevent water ingress and to enable the Navaid and support frames installation on top of one of the transitions.

Navaid annual monitoring and maintenance included for 50 years post-decommissioning for cost estimating purposes.

Estimated to take up to 5 years to complete.

4.1.1 Options, Steps and Studies

The studies conducted during the preparation phase of the CA apply to one or more of the execution steps associated with the CGBS decommissioning options. Table 4.1 details the steps, the associated source studies and the applicable decommissioning option.

Step	Description	Source	Applicable Option			
			Option 4	Option 6	Option 5	Option 9
1.1	Leg internal clearance and cutting preparation	Leg Internals Study ref. [11]	✓	✓	✓	-
1.2	Leg internal coating - steel transitions	Option 9 Datasheet 1 ref. [29]	-	-	-	✓
1.3	Cathodic protection for steel transitions	Option 9 Datasheet 2 ref. [30]	-	-	-	✓
3.1	Shallow leg cut and removal including steel transitions (cut at approx. 12 m below LAT)	Navaid Study ref. [13] and Energy & Emissions Assessment ref. [9]	✓	✓	✓	-
3.2	IMO compliant leg cut and removal (cut at 55 m below LAT)	Concrete Cutting and Removal Study ref. [14] and Energy & Emissions Assessment ref. [9]	✓	✓	-	-
3.3	Leg cut above cell-top (cut at approximately 119 m below LAT)		✓	-	-	-
4.0	Caps in steel transitions	Option 9 Datasheet 3 ref. [31]	-	-	-	✓
5.0	Installation of lighthouse and navaid	Navaid Study ref. [13]	-	-	✓	-
6.0	Removal of drill cuttings	Drill Cuttings Study ref. [18] and Energy & Emissions Assessment ref. [9]	✓	-	-	-
7.0	Removal of cell-top debris	Cell-top Debris Study ref. [16]	**Note 1**	**Note 1**	**Note 1**	**Note 1**
8.0	Removal of cells, base and cell contents	Concrete Cutting and Removal Study ref. [14], Energy & Emissions Assessment ref. [9] and Marine Impacts – CGBS Full Removal ref. [25]	✓	-	-	-
9.0	Monitoring of navaid and maintenance of backup unit	Navaid Study ref. [13]	-	-	✓	✓

Table 4.1: Steps and Sources

Note: Step 2.0 intentionally unused.

Note 1: Step 7.0, Debris Removal is required for all options and is not a differentiator.

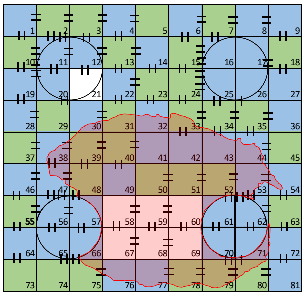
4.2 Cell Contents

During Q3 2017 screening was conducted against the potential decommissioning options for the cell contents. These decommissioning options addressed the following main categories:

- Removal of water / mobile oil / floor sediment / waxy wall deposits;
- Cell access via existing pipework or new penetrations;
- Disturbance of drill cuttings;
- *In situ* management (i.e. bioremediation or capping) / full removal;
- Waste processing *in situ* / return to shore; and
- Management of contents from all cells / targeted cells.

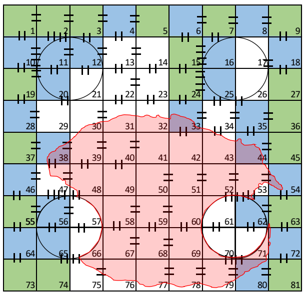
This resulted in a large number of potential permutations (more than 70) which were screened down to four options for evaluation. The screening performed is detailed fully in the Cell Contents Technical Report ref. [5].

The four most feasible options are summarised as follows:



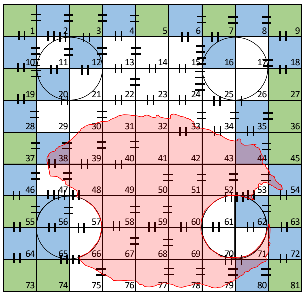
Option 1 – High Case – Oil and Sediment Removal

Requires 31 cell penetrations (23 small; 8 big).
Mobile oil recovered from 74 cells.
31 cells accessed directly (green cells on diagram).
43 cells accessed indirectly (via a directly accessed cell) (blue cells on diagram).
Sediment recovered from 8 cells.
Requires removal of all cell top drill cuttings (represented by pink 'cloud' on diagram).
Mobile oil recovery = 599 m^3 / Sediment recovery = 270 m^3.



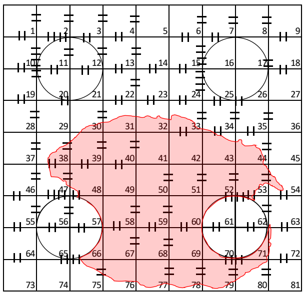
Option 2 – Mid-case – Oil and Sediment Removal

Requires 18 cell penetrations (14 small; 4 big).
Mobile oil recovered from 41 cells.
18 cells accessed directly (green cells on diagram).
23 cells accessed indirectly (via a directly accessed cell) (blue cells on diagram).
Sediment recovered from 4 cells.
Requires minimal cell top drill cuttings removal.
Mobile oil recovery = 299 m^3 / Sediment recovery = 147 m^3.



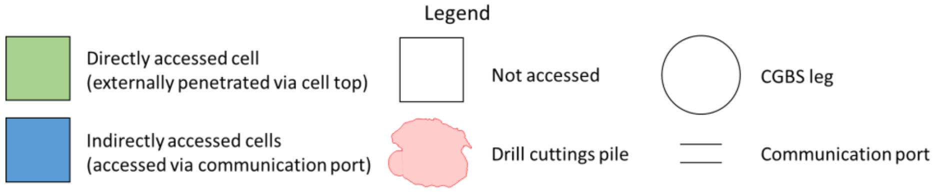
Option 3 – Mid-case – Oil Removal

Requires 15 cell penetrations (15 small; 0 big)
Mobile oil recovered 36 cells.
15 cells accessed directly (green cells on diagram).
21 cells accessed indirectly (via a directly accessed cell) (blue cells on diagram).
No sediment recovery.
Requires minimal cell top drill cuttings removal.
Mobile oil recovery = 274 m^3.



Option 4 – Leave *in situ*

All cell contents left *in situ* with no removal or remediation.



5 CGBS COMPARATIVE ASSESSMENT

5.1 CGBS Decommissioning Options & Screening Outcome

The decommissioning options identified for the Dunlin Alpha CGBS are detailed in Table 5.1. A brief description of the option, as defined at the time of the screening phase of the CA process, is provided. The colour coding (for details see Section 3.2.1) indicates the outcome obtained (red = screened out, green = screened in) with a summary of the outcome provided for convenience. Full details of the options considered, the assessment methodology adopted and the outcomes obtained appear in the Screening Report ref. [4].

Option	Description	Outcome
1 – *In situ* Re-use	- Drill cuttings left *in situ*. - Re-use would be non-oil & gas due to Dunlin Alpha having reached end of economic life. - Potential re-use options considered included CO_2 storage, hub for wind / wave power generation, scientific research centres, etc. - Would require current topsides to be replaced.	- No credible re-use options identified. - Potential re-use options assessed as not technically or economically viable. - Option is a deferral of decommissioning of installation. - Option screened out on the basis of no viable re-use options.
2 – Re-float & re-use	- Recover drill cuttings accumulations & return to shore for processing. - Re-float installation. - Tow installation to new location for re-use. - Potential re-use options as per Option 1 but including oil & gas applications.	- Re-float of installation not technically feasible due to integrity issues, high suction forces imposed by the seabed and immature technology. - Option screened out on that basis.
3 – Re-float & deconstruct	- Remove topsides & return to shore. - Recover drill cuttings accumulations & return to shore for processing. - Recover cell contents & return to shore for processing. - Re-float installation. - Tow installation to inshore location. - Partial deconstruction performed inshore. - Move partially deconstructed CGBS to dry dock. - Complete deconstruction and disposal onshore.	- Re-float of installation not technically feasible due to integrity issues, high suction forces imposed by the seabed and immature technology. - Plus would involve re-floating via a potentially sensitive coastal area. - Option screened out on that basis.
4 – *In situ* full removal	- Remove topsides & return to shore. - Recover drill cuttings accumulations & return to shore for processing. - Recover cell contents & return to shore for processing. - Recover conductors and Conductor Guide Frames (CGFs) & return to shore for recycling. - Cut CGBS legs (*in situ*), recover & return to shore for recycling / processing. - Deconstruct cell base (*in situ*), recover & return to shore for processing. - Deconstruct cell base skirt (*in situ*), recover & return to shore for recycling. - Clear seabed of all debris.	- OSPAR compliant as full removal option. - Screened in accordingly.
5 – Partial removal – shallow cut	- Remove topsides & return to shore. - Remove steel transitions by cutting CGBS legs (*in situ*) at shallow cut depth (between 8 m and 20 m below LAT), recover & return to shore for recycling / processing. - Install monotower with navaid to single leg.	- Low safety impact. - Low operational environmental impact. - Technically feasible but not proven. - Not OSPAR or IMO compliant. - Low economics. - Screened in accordingly.

Option	Description	Outcome
6 – Partial removal – IMO Compliant cut	- Remove topsides & return to shore. - Cut CGBS legs (*in situ*) at IMO compliant depth (55 m below LAT), recover & return to shore for recycling / disposal. - Maintain 500 m safety zone. (note: subsequent study work defined the basis for safety zones as not being required for structures below sea level).	- Balanced safety impact between operational and legacy elements. - Balanced environmental impact. - Technically feasible but not proven. - IMO compliant. - Balanced economics. - Screened in accordingly.
7 – Partial removal – toppling of legs	- Remove topsides & return to shore. - Recover conductors and Conductor Guide Frames (CGFs) & return to shore for recycling. - Use explosives to collapse CGBS legs (*in situ*) above top of cell base. Alternatively, cut and topple CGBS legs (*in situ*) above top of cell base. - Remove snag hazards from toppled legs.	- High safety impact due to extensive use of divers to remove snag hazards from toppled legs. - Balanced environmental impact. - Technically highly uncertain due to potential use of explosives. - Not OSPAR compliant. IMO compliant. Would be classed as 'dumping at sea' and thus not allowable. - Balanced economics.
8 – Leave *in situ* – including MSF	- Remove topsides & return to shore. - Retain MSF for additional structural support to concrete legs (note subsequent study work has shown that retention of the MSF does not provide additional strengthening or longevity to the substructure). - Install navaid on MSF. - Maintain 500 m safety zone.	- Low safety impact. - Balanced environmental impact. - Technically highly deliverable. - Not OSPAR nor IMO compliant. - Low economics. - Screened out not compliant with OSPAR or IMO.
9 – Leave *in situ* – no MSF	- Remove topsides & return to shore. - Integrity works to improve longevity of the steel transitions. - Install navaid on one leg. - Maintain 500 m safety zone.	- Low safety impact. - Low environmental impact. - Technically highly deliverable. - Not IMO compliant. - Low economics. - Screened in as option as suggested by SFF.

Table 5.1: Dunlin Alpha CGBS Decommissioning Options

In summary, the CGBS decommissioning options that remained after screening and which were taken forward to the evaluation phase of the CA process were:

> Option 4 – Full removal;

> Option 6 – Partial removal – IMO Compliant cut;

> Option 5 – Partial removal – Shallow cut; and

> Option 9 – Leave *in situ* – Transitions up.

A summary of the evaluation performed against the remaining CGBS decommissioning options is provided in Section 5.2 for the evaluation of the derogation options against each other and Section 5.3 for the preferred derogation option versus Option 4 – Full Removal. This tiered approach, as described in Section 3.4.4, was considered appropriate by both the project team and external consultants and is in satisfaction of the OSPAR 98/3 requirement to maintain a full removal option throughout the evaluation phase.

More detail of the evaluation conducted can be found in Appendix C.1 and Appendix C.4. A detailed discussion of the relative merits of the each of the options and the outcomes obtained can be found in Section 7.

5.2 Evaluation Summary – CGBS Derogation Options

<table>
<tr><th colspan="5">CGBS Derogation Options</th></tr>
<tr><td rowspan="3">Screening</td><td colspan="2">1 – Re-use</td><td>2 – Re-float & Re-use</td><td>3 – Re-float & deconstruct</td></tr>
<tr><td colspan="2">4 – Full removal</td><td>5 – Partial removal – shallow cut</td><td>6 – Partial removal – IMO compliant cut</td></tr>
<tr><td colspan="2">7 – Partial removal – toppling of legs</td><td>8 – Leave in situ – including MSF</td><td>9 – Leave in situ – no MSF</td></tr>
<tr><td colspan="5">Note: for full attributes tables and assessment see Appendix C.1</td></tr>
<tr><td rowspan="6">Evaluation</td><td colspan="2">6 – Partial removal – IMO Compliant cut</td><td>5 – Partial removal – shallow cut</td><td>9 – Leave in situ – no MSF</td></tr>
<tr><td>Safety</td><td colspan="3">Option 9 is assessed as the most preferred against the Operations Personnel criterion. This assessment is due to the risk exposure being much lower. The assessment against the Other Users criterion is similar.
The differences between the options against the Legacy Risk criterion were smaller and this was reflected in the assessment. Both Option 5 and Option 9 were considered equally preferred as they carry lower legacy risk than Option 6.
Option 9 is assessed as the most preferred option against the Safety criterion.</td></tr>
<tr><td>Environment</td><td colspan="3">Option 9 is assessed as the most preferred option against the Operational Marine Impact criterion. Option 9 was considered stronger than Option 5 and Option 6 due to the significantly reduced potential for a dropped object (resulting from cutting and lifting operations) to redistribute drill cuttings and/or puncture the cells. Option 9 also has limited noise disturbance due to the lack of cutting operations.
Option 9 is also assessed as the most preferred option against the Atmospheric Emissions & Consumptions criterion. Option 6 and Option 5 were considered similar; however, Option 9 has sufficiently lower emissions and fuel consumption to make it preferred.
All options are assessed as equally preferred against the Legacy Marine Impacts criterion as all options have the same residual inventory.
Option 9 is assessed as the most preferred option against the Environment criterion.</td></tr>
<tr><td>Technical</td><td colspan="3">Option 6 has the significant technical challenges associated with performing large scale, unproven subsea concrete cutting operations. Option 5 has similar but smaller technical challenges for the subsea concrete cutting (although still unproven). It does have the added challenge of developing and installing a concrete structure to place the required navaid at the appropriate height above LAT. This structure must withstand the environmental forces experienced in the splash zone and must have a similar longevity to the concrete leg upon which it is being installed. This is exacerbated by the potential for loss of leg strength associated with potentially performing the cut at 20 m below LAT and the loss of the ring beam in the cut leg.
There are limited technical challenges associated with Option 9 as the leg preparation works (internal coating and installation of a cathodic protection system) are considered largely routine activities, thus making this option preferred.
Option 9 is assessed as the most preferred option against the Technical criterion.
Note: The Technical Risk Assessment ref. [20] was updated after the CA Evaluation Workshop. Whilst the level of technical risk associated with the derogation options changed, these changes were insufficient to adjust the assessment of the options against the Technical criterion conducted during the workshop.</td></tr>
<tr><td>Societal</td><td colspan="3">Option 6 is assessed as the most preferred against the Fishing Industry criterion. This is due to the removal of the safety zone around the facility with Option 6 and thus the full area is returned to the industry for fishing. Under both Option 5 and Option 9, due to the leg(s) breaking the surface of the water, the safety zone would be retained, precluding the return of the area to the industry for fishing. There are submerged potential snagging hazards associated with Option 5 making this marginally less preferred than Option 9.
All options are assessed as being similar against the Societal – Other Groups criterion. This is due to the benefits of job creation / retention associated with the options that require longer durations and higher operational hours being offset by the negative aspects relating to the processing of returned concrete. The returned concrete is challenging to re-use and is likely to end up in landfill currently and that disposal route is likely to be less permissible in the future.
Option 6 is assessed as the most preferred option against the Societal criterion.</td></tr>
<tr><td>Economic</td><td colspan="3">Option 9 is assessed as being the most preferred option as it has the lowest estimated costs of the options. Option 5 is next with the cost being around 2.5 times higher. Option 6 is the least preferred with the costs being around 5 times higher than Option 9. It is noted that both Option 5 and Option 9 have a legacy cost associated with the maintenance of the navaids whereas Option 6 does not.
Option 9 is assessed as the most preferred option against the Economic criterion.</td></tr>
</table>

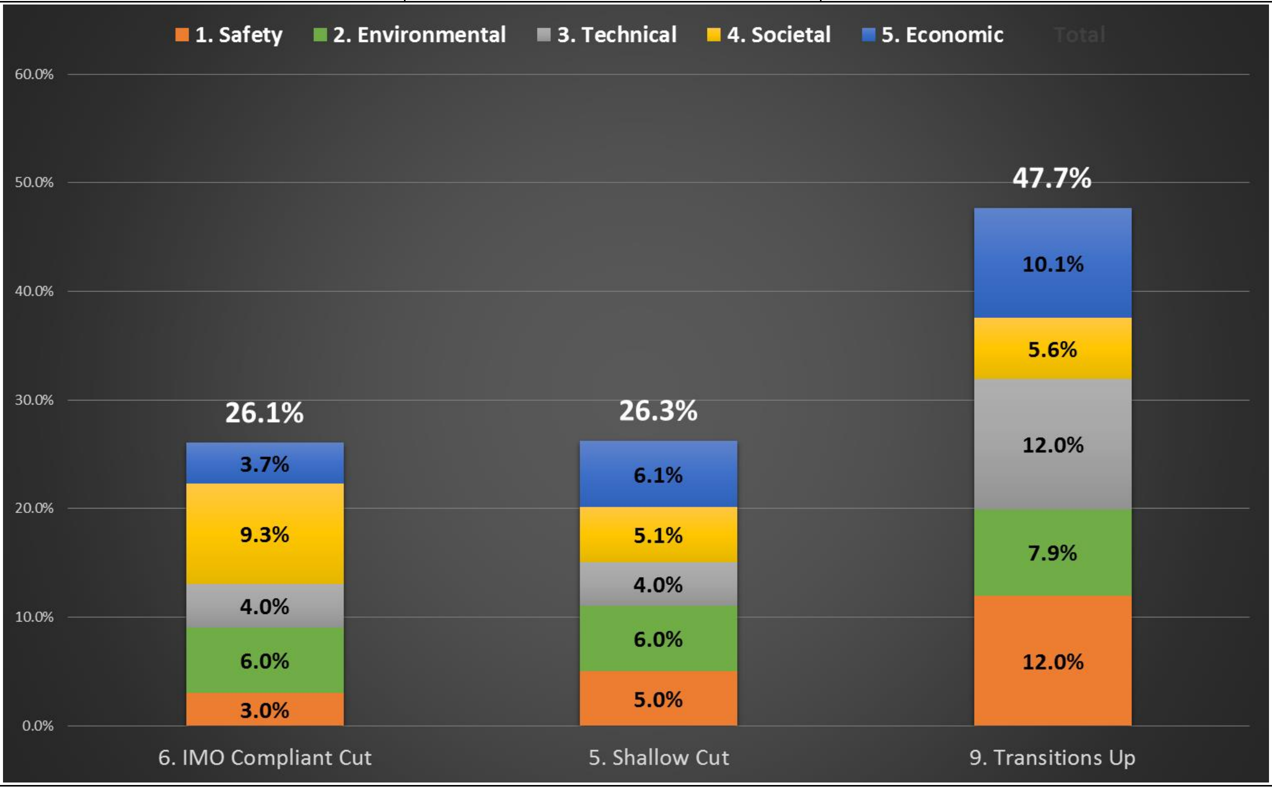
<table>
<tr><th colspan="4">CGBS Derogation Options</th></tr>
<tr><td>Summary</td><td colspan="3">Overall, Option 9 is assessed as the most preferred of the derogation options.
The assessment showed that Option 9 is the clear preferred option against the Safety, Technical and Economic criteria. It is also the preferred option against the Environmental criterion, although the preference was less pronounced. Option 9 is not the preferred option against the Societal criterion (this was Option 6) however, this is not enough to offset the preferences against all other criteria.
Option 9 is selected as the most preferred of the potential derogation options and was carried forward to evaluation against Option 4 – Full Removal.</td></tr>
<tr><td rowspan="2">Summary</td><td>6 – Partial removal – IMO Compliant cut</td><td>5 – Partial removal – shallow cut</td><td>9 – Leave in situ – no MSF</td></tr>
<tr><td colspan="3">
</td></tr>
</table>

Table 5.2: CGBS Derogation Options Evaluation Summary

5.3 Evaluation Summary – CGBS Full Removal versus Preferred Derogation Option

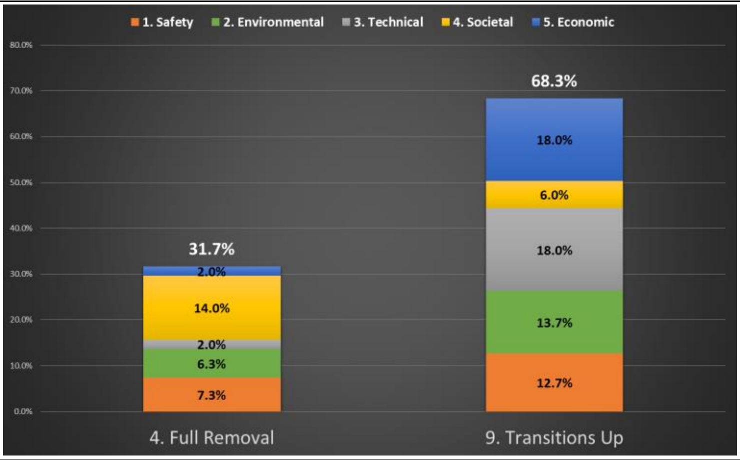
<table>
<tr><th colspan="4">CGBS Full Removal Versus Selected Derogation Option
Note: for full attributes tables and assessment see Appendix C.4</th></tr>
<tr><td rowspan="6">Evaluation</td><td></td><td>4 – Full Removal</td><td>9 – Leave in situ – no MSF</td></tr>
<tr><td>Safety</td><td colspan="2">Option 9 is assessed as the most preferred against the Operations Personnel criterion. This assessment is due to the risk exposure being around 300 times lower. Option 9 is also the most preferred against the Other Users criterion as the duration of operations is around 800 times lower.
Option 4 is the most preferred against the Legacy Risk criterion as there is no legacy risk associated with the full removal option.
Option 9 is assessed as the most preferred option against the Safety criterion.</td></tr>
<tr><td>Environment</td><td colspan="2">Option 9 is assessed as the most preferred option against the Operational Marine Impacts criterion. This is due to the potential for marine impacts from the in situ deconstruction of the cell base, the removal of the contaminated drill cuttings and the impact in the benthic environment from performing Option 4 over many years (decades).
Option 9 is also assessed as the most preferred option against the Atmospheric Emissions & Consumptions criterion as the emissions are around 700 times lower.
Option 4 is assessed as the most preferred option against the Legacy Marine Impacts criterion. This is due to the full removal option eliminating the majority of legacy impacts. It was noted that there is a legacy impact to the benthic environment from performing Option 4 over many years (decades) and there is minor benefit from the ‘artificial reef’ principle associated with Option 9.
Option 9 is assessed as the most preferred option against the Environment criterion.</td></tr>
<tr><td>Technical</td><td colspan="2">Option 4 has significant technical challenges associated with performing large scale, unproven subsea concrete cutting operations. Further challenges include the in situ deconstruction of the cell base, and limiting releases of cell contents to the environment. There are limited technical challenges associated with Option 9 as the leg preparation works (internal coating and installation of a cathodic protection system) are considered largely routine activities.
Option 9 is assessed as the most preferred option against the Technical criterion.</td></tr>
<tr><td>Societal</td><td colspan="2">Option 4 is assessed as the most preferred against the Fishing Industry criterion. This is due to it being the full removal case and thus returns the location to an ‘as-found’ condition.
Option 4 and Option 9 are assessed as being similar against the Societal – Other Groups criterion. This is due to the benefits of significant job creation / retention associated with Option 4 being offset by the negative aspects relating to the processing of hundreds of thousands of tonnes of returned concrete. The returned concrete is challenging to re-use and is likely to end up in landfill currently and that disposal route is likely to be less permissible in the future.
Option 4 is assessed as the most preferred option against the Societal criterion.</td></tr>
<tr><td>Economic</td><td colspan="2">The estimated costs of Option 9 are around 200 times lower than Option 4. It is noted that Option 9 has a legacy cost associated with the maintenance of the navaids whereas Option 4 does not.
Option 9 is assessed as the most preferred option against the Economic criterion.</td></tr>
<tr><td>Summary</td><td colspan="2">Overall, Option 9 is assessed as the most preferred option.
The assessment showed that Option 9 is the clear preferred option against the Safety, Technical, Environmental and Economic criteria. Whilst Option 4 is the clear preferred option against the Societal criterion, this is not enough to offset the preferences against all other criteria.
Option 9 is selected as the most preferred of the Dunlin Alpha CGBS decommissioning options and is the Emerging Recommendation from this Comparative Assessment.</td><td>
</td></tr>
</table>

Table 5.3: CGBS Full Removal Versus Selected Derogation Option Evaluation Summary

5.4 Evaluation Sensitivities

Sensitivity analysis has been conducted on the outcome obtained during the evaluation phase of the CA (as detailed in Section 5.2). This analysis was conducted based on challenges made during the evaluation workshop.

Four sensitivities have been investigated, these are:

1. CGBS Leg Collapse Scenario
2. Safety zones for all derogation options
3. No safety zones for all derogation options
4. Removal of the economic criterion.

The rationale behind performing the sensitivities and findings obtained are described in the following sections.

5.4.1 CGBS Leg Collapse

The basis of the assessment conducted during the evaluation workshop against the derogation options was that the primary failure mode of the concrete CGBS legs that remain *in situ* was spalling. Spalling is where the legs slowly degrade and 'crumble' over time rather than suffer catastrophic leg collapse and subsequent impact and penetration of the cell base, considered extremely unlikely as described in Leg Failure Study ref. [15].

There was a challenge to this during the evaluation workshop on the basis that were the legs to collapse and penetrate the cell base, the legacy marine impact would be higher than had been considered. As such, a sensitivity has been conducted where the impact of a leg collapse and penetration of the cell base was considered. The assessment was informed by modelling of the release scenario, resulting in 'low' environmental impact as detailed in the Cell Contents Technical Report ref. [5]. A discussion of the impact of this sensitivity is provided in Table 5.4.

	Sub-criteria	Sensitivity Impact Discussion
Safety	1.1 Operations Personnel Safety	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Safety	1.2 Other Users	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Safety	1.2 Legacy Risk	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Environment	2.1 Operational Marine Impact	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Environment	2.2 Atmospheric Emissions and Consumption	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Environment	2.3 Legacy Marine Impact	The derogation options were originally assessed as being Neutral to each other against this criterion. This sensitivity has resulted in Option 6 being assessed as Stronger than Option 5 and Stronger than Option 9. This is due to the likelihood of a leg collapse and cell penetration being lower under Option 6 as the legs are cut to the IMO compliant depth of 55 m below LAT. The thickness of the legs is greater and the forces the legs are subjected to are lower. Option 5 is assessed as Neutral to Option 9 as whilst the steel transitions are removed for Option 5, the weakest point (and thus the most likely failure point) is where the legs transition from cylindrical to conical cross-section which is consistent across both options. The forces experienced by the legs are also likely to be similar due to both options having portions of the legs extending through the splash zone.

	Sub-criteria	Sensitivity Impact Discussion
Technical	3.1 Project Technical Risk	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Societal	4.1 Fishing Industry	**This sensitivity has no impact on the original evaluation performed against this criterion.**
	4.2 Other Groups	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Economic	5.1 Operational & Legacy Costs	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Summary	Performing the sensitivity where the collapse failure mode of the CGBS concrete legs is considered against the legacy marine impact criterion has a small impact on the original assessment. Option 6 is now considered marginally preferred to Option 5 (this is the reverse of how the options compared originally). Option 9 is still clearly the most preferred of the potential derogation options. **This sensitivity has adjusted the assessment but these adjustments are insufficient to alter the outcome of the original evaluation i.e. Option 9 being the most preferred of the CGBS derogation options.**	

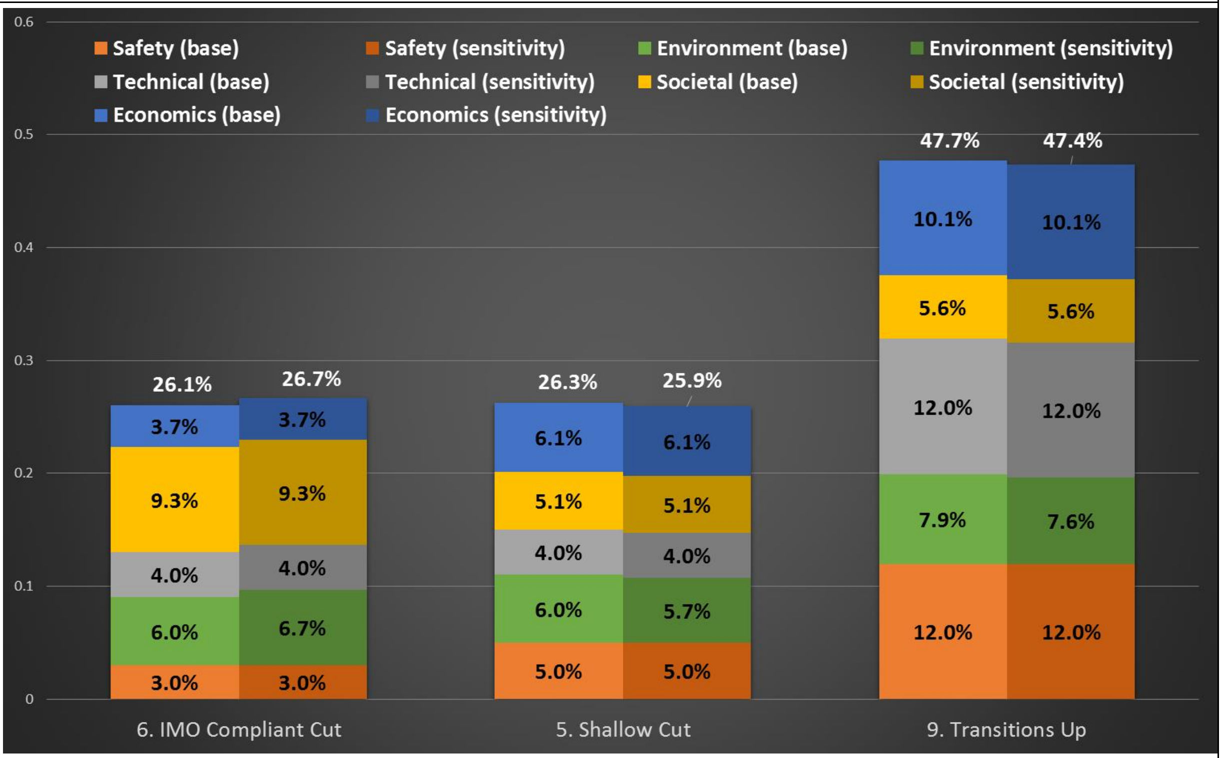


Table 5.4: Sensitivity – CGBS – Leg Collapse

5.4.2 Safety zones for all derogation options

The assessment conducted during the CA Evaluation Workshop against the derogation options had the assumption that the existing safety zone around the facility would be removed under Option 6 – IMO Compliant Cut and would remain for Option 5 – Shallow Cut and Option 9 – Transitions Up. This was challenged during the workshop as, whilst this situation is currently the case, there are discussions between regulatory bodies, stakeholders and operators to potentially introduce an alternative regime for leave *in situ* options.

A sensitivity has been conducted where all derogation options are assessed with the safety zone maintained. The sensitivity has been conducted with input from the revised Shipping and Fishing Risk Assessment ref. [32]. A discussion of the impact of this sensitivity is provided in Table 5.5.

	Sub-criteria	Sensitivity Impact Discussion
Safety	1.1 Operations Personnel Safety	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Safety	1.2 Other Users	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Safety	1.3 Legacy Risk	Option 6 was originally assessed as Weaker than both Option 5 and Option 9 against this criterion. This was due to the PLL associated with Option 6 being around double that of Option 5 and Option 9. Option 5 was originally assessed as Neutral to Option 9 as the PLL was similar. Running this sensitivity resulted in a reduced PLL for Option 6 due to the reduction in potential for snag and collision hazards where a safety zone is maintained for Option 6. The PLLs for Option 5 and Option 9 are unchanged. This reduced PLL for Option 6 brought the PLLs for all derogation options sufficiently close together for them to be assessed as Neutral to each other against this criterion.
Environment	2.1 Operational Marine Impact	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Environment	2.2 Atmospheric Emissions and Consumption	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Environment	2.3 Legacy Marine Impact	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Technical	3.1 Project Technical Risk	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Societal	4.1 Fishing Industry	Option 6 was originally assessed as Much Stronger than both Option 5 and Option 9 as the area of the current safety zone would be returned to the fishing industry for transit and fishing operations. Option 5 was originally assessed as Weaker than Option 9 as, whilst both these options have a safety zone maintained, there is a shallow snag hazard associated with Option 5 that is not present with Option 9. Running this sensitivity resulted in the area currently lost to fishing operations being maintained for all options. Option 5 is still considered the least attractive due to the shallow snag hazard. Option 6 is now assessed as Stronger than Option 5 as, whilst all options have a safety zone and thus the area is lost to fishing operations and therefore not a differentiator, there is no shallow snag hazard associated with Option 6, which is present with Option 5. Option 6 is now assessed as Neutral to Option 9 as neither option has a shallow snag hazard. Option 5 is now assessed as Weaker than Option 5, again on the basis of the shallow snag hazard.
Societal	4.2 Other Groups	**This sensitivity has no impact on the original evaluation performed against this criterion.**

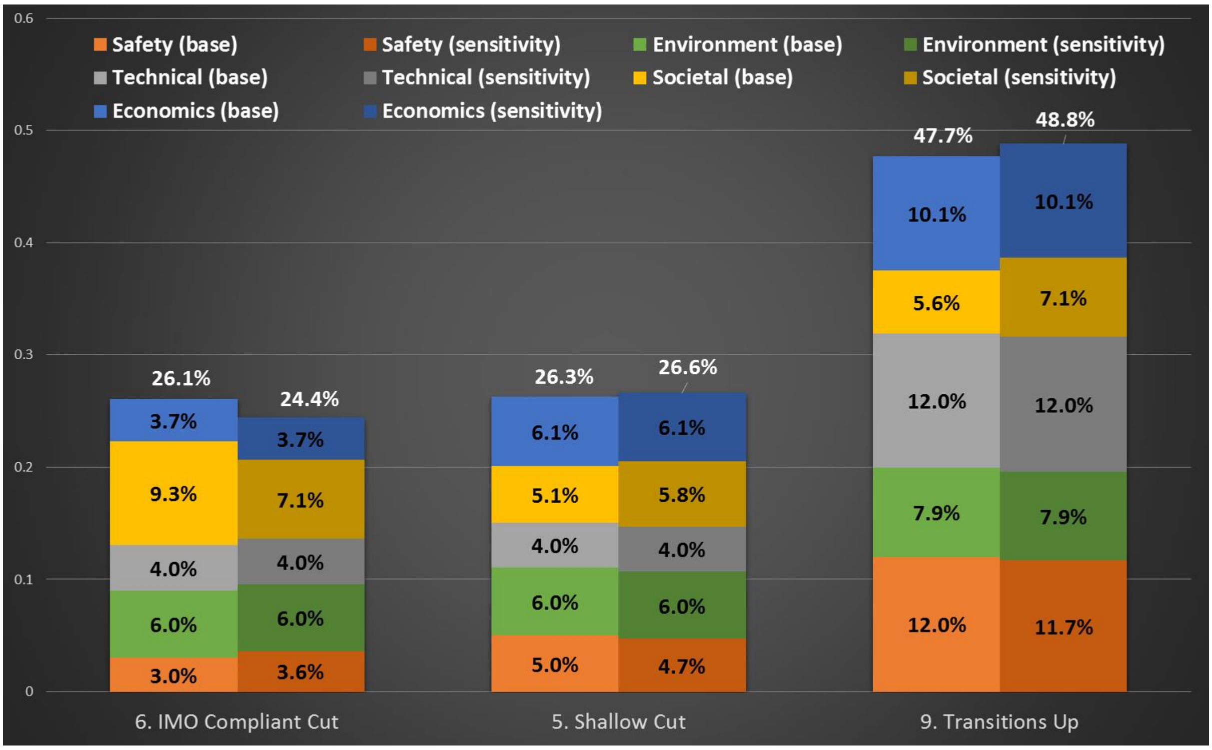
	Sub-criteria	Sensitivity Impact Discussion
Economic	5.1 Operational & Legacy Costs	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Summary	Performing the sensitivity where the safety zone is maintained for all derogation options has a small impact on the original assessment. Option 6 is now marginally less attractive than originally assessed as whilst the potential snag hazard is reduced with a maintained safety zone, this is offset by the loss of the area for fishing operations, which attracted a strong positive assessment originally. Option 5 and Option 9 are both marginally more attractive than originally assesed for similar reasons. Option 9 is still clearly the most preferred of the potential derogation options. **This sensitivity has adjusted the assessment but these adjustments are insufficient to alter the outcome of the original evaluation i.e. Option 9 being the most preferred of the CGBS derogation options.** 	

Table 5.5: Sensitivity – Safety Zone – All Derogation Options

5.4.3 No safety zones for all derogation options

An additional sensitivity has been conducted, for similar reasons as those described in Section 5.4.2, where all derogation options are assessed with the safety zone removed. Again, this sensitivity has been conducted with input from the revised Shipping and Fishing Risk Assessment ref. [32]. A discussion of the impact of this sensitivity is provided in Table 5.6.

	Sub-criteria	Sensitivity Impact Discussion
Safety	1.1 Operations Personnel Safety	**This sensitivity has no impact on the original evaluation performed against this criterion.**
	1.2 Other Users	**This sensitivity has no impact on the original evaluation performed against this criterion.**
	1.3 Legacy Risk	Option 6 was originally assessed as Weaker than both Option 5 and Option 9 against this criterion. This was due to the PLL associated with Option 6 being around double that of Option 5 and Option 9. Option 5 was originally assessed as Neutral to Option 9 as the PLL was similar. Running this sensitivity resulted in increased PLLs for both Option 5 and Option 9 due to the increase in potential for snag and collision hazards where the safety zone is removed for these options. The PLL for Option 6 is unchanged. This increased PLL for Option 5 and Option 9 brought the PLLs for all derogation options sufficiently close together for them to be assessed as Neutral to each other against this criterion.
Environment	2.1 Operational Marine Impact	**This sensitivity has no impact on the original evaluation performed against this criterion.**
	2.2 Atmospheric Emissions and Consumption	**This sensitivity has no impact on the original evaluation performed against this criterion.**
	2.3 Legacy Marine Impact	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Technical	3.1 Project Technical Risk	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Societal	4.1 Fishing Industry	Option 6 was originally assessed as Much Stronger than both Option 5 and Option 9 as the area of the current safety zone would be returned to the fishing industry for transit and fishing operations. Option 5 was originally assessed as Weaker than Option 9 as, whilst both these options have a safety zone maintained, there is a shallow snag hazard associated with Option 5 that is not present with Option 9. Running this sensitivity resulted in the area currently lost to fishing operations being returned for all options. Option 5 is still considered the least attractive due to the shallow snag hazard. Option 6 is now assessed as Stronger than Option 5 as there is no shallow snag hazard associated with Option 6. Option 6 is now assessed as Neutral to Option 9 as neither option has a shallow snag hazard. Option 5 is now assessed as Weaker than Option 5, again on the basis of the shallow snag hazard.
	4.2 Other Groups	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Economic	5.1 Operational & Legacy Costs	**This sensitivity has no impact on the original evaluation performed against this criterion.**

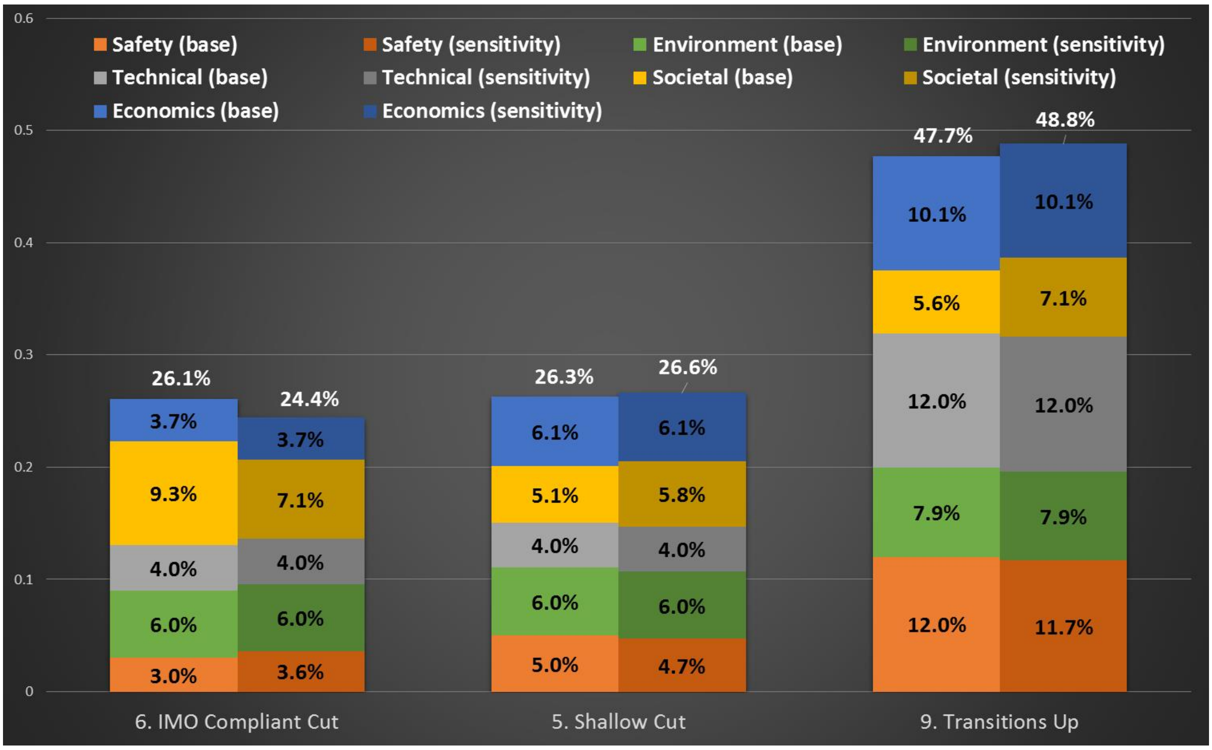
	Sub-criteria	Sensitivity Impact Discussion
Summary	Performing the sensitivity where the safety zone is removed for all derogation options has a small impact on the original assessment. Option 6 is now marginally less attractive than originally assessed as whilst the potential snag hazard is increased for Option 5 and Option 9 by the removal of the safety zone, this is offset as Option 6 is no longer more attractive than Option 5 and Option 9 as the area is returned for fishing operations with all derogation options. **This sensitivity has adjusted the assessment but these adjustments are insufficient to alter the outcome of the original evaluation i.e. Option 9 being the most preferred of the CGBS derogation options.**	
		

Table 5.6: Sensitivity – No Safety Zone – All Derogation Options

5.4.4 Removal of Economic Criterion – Derogation Options

A sensitivity analysis has been conducted on the evaluation of the potential derogation options by removing the economic criterion. This is performed in order to ensure economics are not the driver behind the outcome obtained as per OSPAR Decision 98/3 ref. [1]. The outcome from this sensitivity is shown in Figure 5.1.

By removing the economic criterion, the revised results chart for the overall outcome did not change, i.e. Option 9 – Transitions Up, was still assessed as the most preferred of the potential derogation options. The magnitude of the preference over the other options is largely similar. One key change is that with the economic criterion removed, Option 6 – IMO Compliant Cut and Option 5 – Shallow Cut have moved from being assessed as being almost identical (albeit with Option 5 marginally higher scoring) to there being a clear preference for Option 6 over Option 5.

In summary, removing the economic criterion from the evaluation had no impact on the most preferred option.

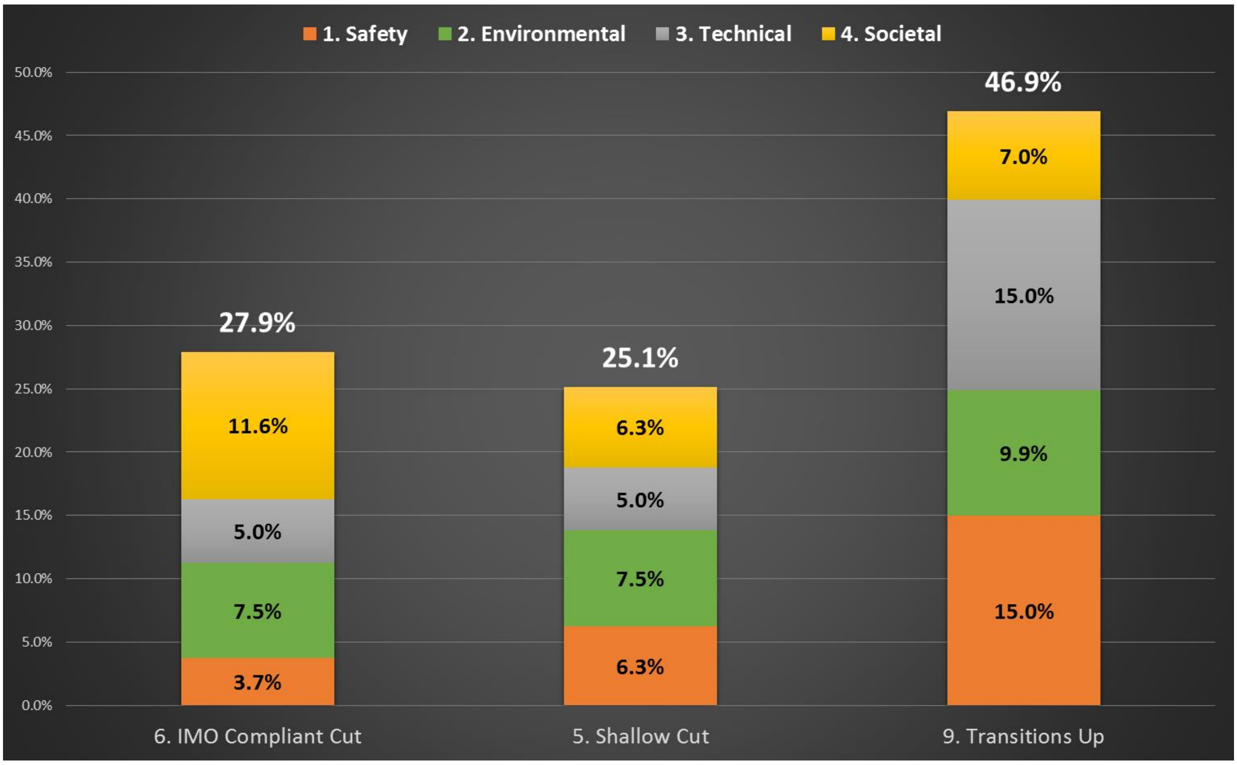


Figure 5.1: Sensitivity – CGBS Derogation Options – Removal of Economics

5.4.5 Removal of Economic Criterion – Full Removal v Preferred Derogation Option

A sensitivity analysis has also been conducted on the evaluation of the full removal option versus the selected potential derogation option by removing the economic criterion. The outcome from this sensitivity is shown in Figure 5.2.

By removing the economic criterion, the revised results chart for the overall outcome did not change, i.e. Option 9 – Transitions Up, was still assessed as the most preferred option with the magnitude of the differential reducing slightly as would be expected.

In summary, removing the economics from the evaluation had no impact on the most preferred option.

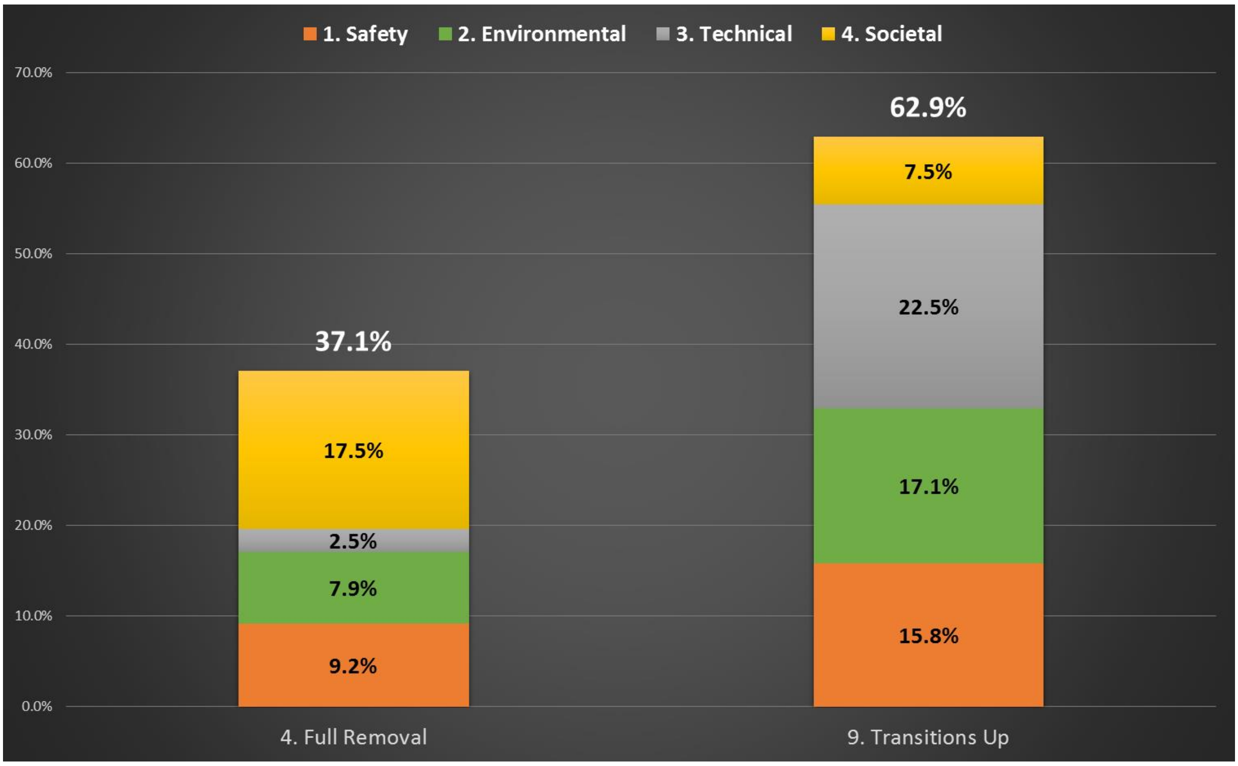


Figure 5.2: Sensitivity – CGBS Full Removal v Preferred Derogation Option – Removal of Economics

6 CELL CONTENTS COMPARATIVE ASSESSMENT

6.1 Decommissioning Options & Screening Outcome

The key considerations and parameters considered when identifying the potential decommissioning options for the cell contents are detailed in Table 6.1. Assessment of these parameters resulted in more than 70 discrete options.

The screening eliminated options on environmental, technical feasibility and operational duration grounds. This had the effect of removing a high number of the potential options, leaving the options with the highest efficiency and feasibility remaining for more detailed evaluation. Table 6.1 provides a brief justification for the elimination of the other options. The colour indicates the outcome obtained (red = screened out, green = screened in) with a summary of the outcome provided for convenience. Full details of the options considered, the assessment methodology adopted and the outcomes obtained can be found in the Cell Contents Technical Report ref. [5].

Parameter	Options	Outcome
Cell Access	Existing pipework (i.e. vent lines, rundown lines, water ballast, etc.)	- Access via vent system is not feasible as the existing vent lines were found to be cut and removed or grouted. - Access via risers and j-tubes, may be feasible for survey but not contents management. - Access via the rundown lines, currently being investigated for survey/sampling however it is felt that recovery of the cell CGBS inventory via this pipework system is not achievable due to integrity and safety concerns. Also limited to Cell Groups A, C & D as the B line is permanently isolated by a mechanical plug for integrity reasons.
	New penetration in cell top (requires cell top clearance)	- Assessment assumes use of existing Enpro technology - Proven for 2 7/8" diameter access hole - Larger penetration would require further engineering development and testing
	New penetration in cell side wall	- Potentially attractive as limits drill cuttings disturbance. - Unproven method / technology - Only accesses perimeter cells
Drill Cuttings Disturbance	Full removal	- A review of the options for drill cuttings pile management has shown that the preferred option is to leave them undisturbed, however there is significant drill cuttings accumulation over the cell tops that would require to be removed to create new access points into the cells. During screening the implications of disturbance to the drill cuttings was not well understood, nor the viewpoints of stakeholders on whether disturbance to enable cell contents management would be acceptable, therefore the interaction with the drill cuttings was retained within the cell contents management options taken into the evaluation phase.
	Substantial removal	
	Minimal removal	
Contents Management	Removal	- Removal of contents can be physically monitored and status of residual contents verified during operations - Recovers hydrocarbon - Recovers sediments (including heavy metals)

Parameter	Options	Outcome
	Bioremediation	- Uncertain capabilities in this area (slow reaction time due to cell conditions and cold temperatures) - Difficult to predict the effectiveness of this option over time - Requires cell access to implement, therefore it would logical to use this access point to recover contents as far as possible instead - Requires replenishment and resources such as nutrients and oxygen to be effective - Is not effective for heavy metals - Would require ongoing monitoring to assess effectiveness
	Capping	- Highly challenging to implement - Sediment is unevenly distributed (8 cells will be worst affected with up to 1 m of deposits), with only a thin layer present in the majority of the cells, this makes capping of all the cells a less efficient option and may require delivery of more capping material than the original inventory - Requires cell access to implement, therefore it would logical to use this access point to recover contents as far as possible instead - Provides an additional barrier, however existing CGBS is already an excellent primary barrier - Capping would prevent accumulation of mobile oil in the cell tops due to the diffusion of hydrocarbons from the sediment over time, however hydrocarbon content of the sediment is low across the majority of the cells due the uneven distribution of the sediment
	Leave *in situ*	- Initial investigations showed that it is not technically feasible to remove all cell contents without removing the CGBS - The majority of the mobile hydrocarbons have already been recovered by a gas displacement technique undertaken in 2007 - Modelling has shown that the residual contaminant inventory of the cells is relatively small compared to the bulk water phase volume - Contaminants are distributed across 75 cells, with the oil further compartmentalised due to a lattice formwork arrangement in the cell tops
Material Phase Targeted	Mobile oil	- Recovery could be achieved in an acceptable time frame i.e. days to months - Some uncertainty as to the efficiency of recovery due to the difficulty accessing all the compartments, including formwork and triangle cells located at the corners of the cells directly underneath the legs.
	Sediment	- Recovery could be achieved in an acceptable time frame i.e. days to months - Some uncertainty as to the efficiency of recovery due to fluidisation of the materials
	Wall residue	- Recovery would take months / years - Uncertain / unproven methods - Uncertain outcomes

Parameter	Options	Outcome
	Water phase	- Recovery would take years - As water is replaced as it is removed the effect would at best only dilute the water within the cells - Large volumes / slow extraction rate - Processing of waste on site would most likely look to treat to a suitable quality (<30 mg/l) before discharging overboard. This would in fact accelerate the rate at which the water phase from the cells is released into the environment, compared to the leave *in situ* scenario that would be a more gradual release and interchange with the water column.
Waste Management	Ship to Shore	- Most attractive waste management option - Capability for oil & water processing readily available - Transportation of waste to shore routine operations - There can be a higher cost for onshore treatment depending on the volume and nature of the waste material
	Inject to Well	- Existing (topsides) waste disposal well limits waste injection rates - Scheduling of well plug & abandonment programme not aligned with injection of waste to existing wells - Use of other wells in area would require vessel transportation - New disposal wells costly - Unlikely to be more attractive than ship to shore option
	Onsite Treatment	- There are two sub options, either using the existing facilities to process waste or to bring in temporary modular equipment - Existing facilities not capable of processing expected types of waste - Facilities have not been operational since 2015 and would be challenging and expensive to re-commission - Modular temporary systems can be tailored to the feed materials, experience of this is growing in the industry for oily water processing - Evidence that onsite processing of storage tank solids has proven challenging – failure would mean transporting material to shore anyway - Onsite treatment can be very effective for reducing the volume of waste transported to shore for further processing
Cell Targeted	All cells	- Consideration should be given to feasibility of accessing all 75 cells either directly or indirectly through a neighbouring cell
	Selected cells	- Given that each cell requires the same level of effort in terms of physically accessing the cell by creating the new cell top penetration it could be more effective for the project to focus on the cells with the highest inventory and therefore the highest recovery potential versus effort.

Table 6.1: Cell Contents Decommissioning Options

6.2 Decommissioning Options for Evaluation

The decommissioning options for the cell contents that remained after screening and which were taken forward to the evaluation phase of the CA process are:

- Option 1 – High Oil & Sediment Removal
- Option 2 – Mid Oil & Sediment Removal
- Option 3 – Mid Oil Removal
- Option 4 – Leave *in situ*

The options taken forward were deemed to have the highest efficiency in terms of the balance between effort versus achieved cleanliness and were selected to examine two key trade-offs:

- Targeting all the cells and disturbance of the drill cuttings pile; and
- Targeting mobile oil and sediment or just the residual mobile oil.

A summary of the evaluation performed against the remaining decommissioning options is provided in Section 6.3 and in more detail in Appendix C.7. A detailed discussion of the relative merits of the each of the options and the outcomes obtained can be found in Section 7.

6.3 Evaluation Summary – Cell Contents

<table>
<tr><th colspan="6">Cell Contents</th></tr>
<tr><td>Screening</td><td colspan="5">Note: Screening reduced 74 options down to the four remaining here. See Section 6.1 for more details.</td></tr>
<tr><td colspan="6">Note: for full attributes tables and assessment see Appendix C.7</td></tr>
<tr><td rowspan="6">Evaluation</td><td></td><td>1 – High Oil & Sediment Removal</td><td>2 – Mid Oil & Sediment Removal</td><td>3 – Mid Oil Removal</td><td>4 – Leave in situ</td></tr>
<tr><td>Safety</td><td colspan="4">Option 4 is assessed as the most preferred against the Operations Personnel criterion. This assessment is due to the risk exposure of this leave in situ option being zero versus all the other options having various degrees of risk exposure associated with performing the option.
All options are assessed as equal against the Legacy Risk criterion due to there being no impact from any of the options in terms of legacy risk specifically from the cell contents.
Option 4 is assessed as the most preferred option against the Safety criterion.</td></tr>
<tr><td>Environment</td><td colspan="4">Option 4 is assessed as the most preferred option against the Operational Marine Impacts criterion. This assessment is dominated by the potential for marine impacts from the removal and recovery of the drill cuttings from the top of the cell base, an inherent part of all cell contents removal options. Other impacts considered are marine noise, potential loss during execution of the cell contents removal operations and impacts from vessels performing the options. In each case, these impacts are similar across the three removal options and lower for Option 4.
Option 4 is also assessed as the most preferred option against the Atmospheric Emissions & Consumptions criterion as there is no vessel activity and fuel use to result in atmospheric emissions. The three removal options are assessed as largely similar.
Option 1 is assessed as the most preferred option against the Legacy Marine Impacts criterion. This is due to all of the cell top drill cuttings having been removed and there being smaller residual quantities of oil and sediment in the cells.
Option 4 is assessed as the most preferred option against the Environment criterion.</td></tr>
<tr><td>Technical</td><td colspan="4">There are technical challenges associated with the three removal options. The ability to upscale the existing cell penetration technology, whilst not considered unfeasible, it is currently unproven. Cell penetration technology has been proven at a 2 7/8” hole size and would need to be increased to approximately a 6” hole size to allow the sediment recovery under Option 1 and Option 2. The ability to perform the sediment removal is also uncertain, as is the ability to perform the cell contents recovery from the indirectly accessed cells. Clearly, there are no technical challenges associated with the leave in situ option, hence the reason Option 4 is assessed as most preferred.
Option 4 is assessed as the most preferred option against the Technical criterion.</td></tr>
<tr><td>Societal</td><td colspan="4">In general, the societal benefits associated with the options are minimal. Whilst there is a small benefit associated with job creation / retention from the removal options, these are offset by the negative aspects relating to the processing of contaminated drill cuttings. There are also minor benefits associated with the continued development and proof of cell access methods and cell oil and sediment recovery. Option 2 and Option 3 are assessed as preferred due to the benefits of job creation / retention and advancement of cell contents removal and recovery being greater than the negative impact of processing a small volume of containated drill cuttings. Option 1 is less attractive as this option requires full removal of the drill cuttings pile which would result in a large volume of waste being created for management onshore.
Option 2 and 3 are assessed as the equal most preferred options against the Societal criterion.</td></tr>
<tr><td>Economic</td><td colspan="4">Option 4 is assessed as being the most preferred option as there are no planned activities to implement this option and therefore has zero cost associated with it. The three removal options have associated costs and thus are less preferred. Of the removal options, Option 3 has the lowest cost., Option 2 was next with the cost being around 30% higher and finally, Option 1 was the least preferred with the costs being around double Option 3.
Option 4 is assessed as the most preferred option against the Economic criterion.</td></tr>
</table>

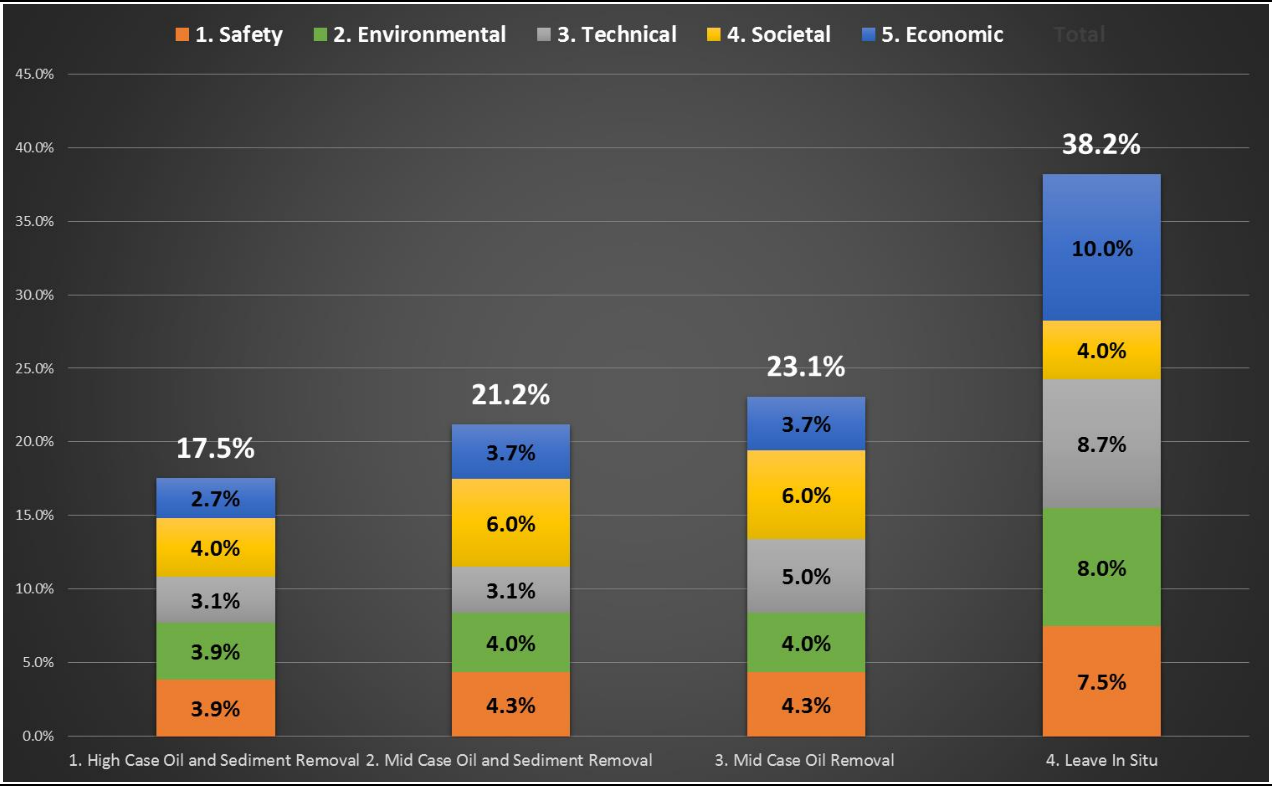
<table>
<tr><th colspan="5">Cell Contents</th></tr>
<tr><td>Summary</td><td colspan="4">Overall, Option 4 is assessed as the most preferred option
The assessment showed that Option 4 is the clear preferred option against the Safety, Environment, Technical and Economic criteria. Whilst Option 2 and Option 3 are the equally preferred option against the Societal criterion, this is not enough to offset the preferences against all other criteria.
Option 4 is selected as the most preferred of the Cell Contents decommissioning options and is the Emerging Recommendation from this Comparative Assessment.</td></tr>
<tr><td rowspan="2">Summary</td><td>1 – High Oil & Sediment Removal</td><td>2 – Mid Oil & Sediment Removal</td><td>3 – Mid Oil Removal</td><td>4 – Leave in situ</td></tr>
<tr><td colspan="4">
</td></tr>
</table>

Table 6.2: Cell Contents Evaluation Summary

6.4 Evaluation Sensitivities

Sensitivities have been conducted on the outcome of the evaluation of the cell contents (as detailed in Section 6.2), based on challenges made during the evaluation workshop.

Four sensitivities have been investigated, these are:

1. Increased cell contents recovery threshold
2. No presence of drill cuttings to manage to allow cell access
3. Combined case of increased cell contents recovery threshold and no presence of drill cuttings to manage to allow cell access
4. Removal of the economic criterion.

The rationale behind performing the sensitivities and findings obtained are described in the following sections.

6.4.1 Increased Cell Contents Recovery Threshold

One of the assumptions used to define the cell contents recovery options was that recovery of 50% of the residual inventory would be considered 'project success'. This 50% recovery threshold was selected to ensure that the project was not unfairly burdened by an unrealistic recovery threshold, especially given the inventory recovery activities previously performed having already recovered the vast majority of the mobile oil within the cells.

This assumption was challenged during the CA evaluation workshop as being too pessimistic. As such, a sensitivity has been conducted where the recovery threshold has been increased to 90%. In recovering a higher proportion of the cell contents this reduces the residual inventory that could be released to the environment due to future degradation of the substructure by a factor of 10. The environmental impact of the leave *in situ* option has already been assessed as low and therefore this has resulted in no discernible change to the CA evaluation for the legacy impact.

By increasing the recovery threshold to 90%, the durations of the activities associated with the recovery options have increased. A discussion of the impact of this sensitivity is provided in Table 6.3.

	Sub-criteria	Impact Discussion
Safety	1.1 Operations Personnel Safety	Durations of activities for the recovery options are increased under this sensitivity. As such, the risk exposure for the three recovery options is greater. These increases are largely proportional across the three recovery options and, as such, the original assessment remains valid. The increases versus Option 4 – Leave *in situ* were not assessed as significant enough to alter the original assessment. **This sensitivity has no impact on the original evaluation performed against this criterion.**
Safety	1.2 Legacy Impact	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Environment	2.1 Operational Marine Impact	Durations of activities for the recovery options are increased under this sensitivity. As such, the potential operational marine impacts are marginally higher for the three recovery options as there are more vessel days required. These increases are largely proportional across the recovery options and, as such, the original assessment remains valid. The increases versus Option 4 – Leave *in situ* were not assessed as significant enough to alter the original assessment. **This sensitivity has no impact on the original evaluation performed against this criterion.**

	Sub-criteria	Impact Discussion
Environment	2.2 Atmospheric Emissions and Consumption	The longer durations also result in higher atmospheric emissions and consumption. Again, these increases are largely proportional across the three recovery options and, as such, the original assessment remains valid. The increases versus Option 4 – Leave *in situ* were not assessed as significant enough to alter the original assessment. **This sensitivity has no impact on the original evaluation performed against this criterion.**
	2.3 Legacy Marine Impact	Increasing the recovery threshold has the effect of reducing the residual cell inventory post decommissioning. This applies to the three recovery options and again, the improvement is proportional across the three recovery options. These improvements versus Option 4 – Leave *in situ* were not assessed as sufficient to alter the original assessment. **This sensitivity has no impact on the original evaluation performed against this criterion.**
Technical	3.1 Project Technical Risk	The increased recovery threshold will make the three recovery options more challenging to successfully deliver. This increased challenge is consistent across the three recovery options and insufficient to alter the original assessment versus Option 4 – Leave *in situ*. **This sensitivity has no impact on the original evaluation performed against this criterion.**
Societal	4.1 All Groups	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Economic	5.1 Operational & Legacy Costs	The longer durations also result in higher operational costs to execute the option. Again, these increases are largely proportional across the three recovery options and, as such, the original assessment remains valid. The increases versus Option 4 – Leave *in situ* were not assessed as significant enough to alter the original assessment. **This sensitivity has no impact on the original evaluation performed against this criterion.**
Summary	Performing the sensitivity where the cell contents recovery is increased from 50% to 90% has no impact on the evaluation originally performed. The increased durations associated with this higher recovery threshold are largely proportional across the recovery options. They are assessed as insufficient when comparing the recovery options against Option 4 – Leave *in situ*. The reduction in residual cell contents post-decommissioning was also assessed as insufficient to alter the orignal assessment. **This sensitivity has no impact on the original evaluation performed or on Option 4 being the most preferred cell contents decommissioning option.**	

Table 6.3: Sensitivity – Cell Contents – Increased Recovery Threshold

6.4.2 No Drill Cuttings Recovery

Another challenge received during the CA evaluation workshop relates to the impact from disturbing and recovering drill cuttings as part of the cell contents recovery options. It was suggested that the impact of disturbing and recovering the drill cuttings to allow access to the cells tops was pessimistic. While it is difficult to quantify the impact of disturbing or removing the drill cuttings it is accepted that this is not a desirable activity to undertake, with the preference being to leave any drill cuttings undisturbed. This is reflected in the original evaluation against the Operational Marine Impact criterion. However, it could be perceived that including the interaction with the drill cuttings masks the assessment of the cell contents, therefore the cell contents removal options were redefined hypothetically assuming no presence of drill cuttings.

This sensitivity eliminating drill cuttings from the evaluation is described in Table 6.4.

	Sub-criteria	Impact Discussion
Safety	1.1 Operations Personnel Safety	Durations of activities for the three recovery options are reduced if there are no drill cuttings to disturb under this sensitivity. The risk exposure for the three recovery options for the cell contents is therefore reduced. These reductions are largely proportional across the recovery options and, as such, the original assessment remains valid. The reductions versus Option 4 – Leave *in situ* were not assessed as significant enough to alter the original assessment. **This sensitivity has no impact on the original evaluation performed against this criterion.**
Safety	1.2 Legacy Impact	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Environment	2.1 Operational Marine Impact[7]	Whilst durations are reduced for the recovery options under this sensitivity, the key adjustment is the elimination of the marine impacts associated with the drill cuttings disturbance and removal. The original assessment was dominated by the impact from removing the drill cuttings. As such, the comparisons have been reduced as follows: Option 1 is assessed as being Weaker to Option 2 and Option 3 (was Much Weaker) and Much Weaker than Option 4 (was Very Much Weaker). The remaining assessments are still valid as the negative impact from recovering drill cuttings were less significant for Options 2 and 3 (these options do not involve disturbance of the main cuttings pile). **This sensitivity has altered the original evaluation performed against this criterion.**
Environment	2.2 Atmospheric Emissions and Consumption	The shorter durations result in lower atmospheric emissions and consumption which are largely proportional across the recovery options and, as such, the original assessment remains valid. The reductions versus Option 4 – Leave *in situ* were not assessed as significant enough to alter the original assessment. **This sensitivity has no impact on the original evaluation performed against this criterion.**
Environment	2.3 Legacy Marine Impact	Leaving the drill cuttings *in situ* alters the assessment against the legacy marine impact criterion. The original assessment was influenced by the benefit in terms of legacy marine impacts from removing the drill cuttings. The assessment is adjusted as follows: Option 1 is assessed as being Neutral to Option 2 and Option 3 (was Stronger) and remains Much Stronger than Option 4. The remaining assessments are still valid as the positive impacts from recovering drill cuttings were less significant for Options 2 and 3. **This sensitivity has altered the original evaluation performed against this criterion.**
Technical	3.1 Project Technical Risk	If there are no drill cuttings to remove this makes the cell contents recovery options marginally less challenging to deliver. This reduced challenge is consistent across all recovery options and is insufficient to alter the original assessment versus Option 4 – Leave *in situ*. **This sensitivity has no impact on the original evaluation performed against this criterion.**

[7] Post Review Note: Directionally, under the Operational Marine Impact sub-criterion, option 1 becomes more attractive in comparison to the other options when disturbance of cuttings is ignored. This is partially offset, however, by option 1 having less merit when considering the Legacy Marine Impacts sub-criterion. This offset explains why there is a slight, rather than significant, increase (3.9% to 4.3%) in the overall environmental score for option 1 under this sensitivity. An additional benefit to option 1 under this sensitivity is the improved societal assessment – resulting from no longer carrying the burden of bringing large volumes of drill cuttings ashore for processing.

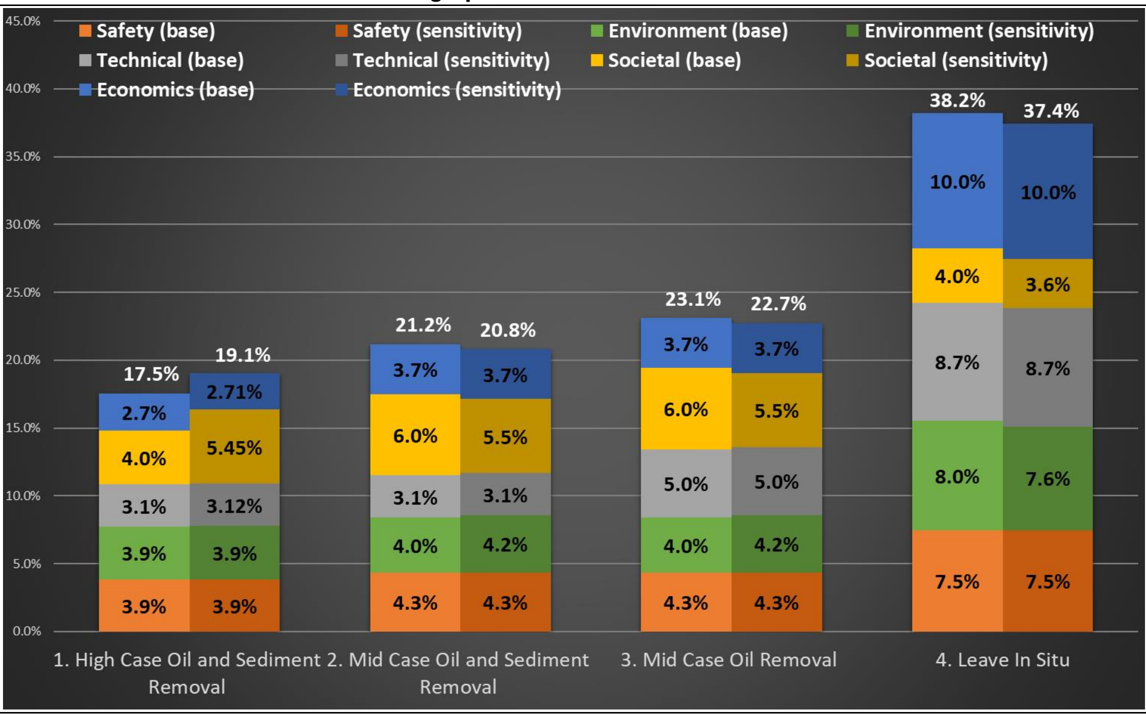
<table>
<tr><th></th><th>Sub-criteria</th><th>Impact Discussion</th></tr>
<tr><td>Societal</td><td>4.1 All Groups</td><td>A key parameter considered during the original assessment against the Societal – All Groups criterion was the negative impact of returning contaminated drill cuttings to shore for processing. This was especially significant when comparing Option 1 to the other options due to the large volumes associated with Option 1. This sensitivity removes that negative impact and, as such, the revised assessment is as follows: Option 1 is assessed as being Neutral to Option 2 and Option 3 (was Weaker). Option 1 is assessed as being Stronger than Option 4 (was Neutral).
The remaining assessments are still valid as the negative impact from the smaller volumes of contaminated drill cuttings was not considered to have as significant an impact in the original assessment.
This sensitivity has altered the original evaluation performed against this criterion.</td></tr>
<tr><td>Economic</td><td>5.1 Operational & Legacy Costs</td><td>The reduced durations also result in lower operational costs to execute the option. Again, these reductions are largely proportional across the three recovery options and, as such, the original assessment remains valid. The reductions versus Option 4 – Leave in situ were not assessed as significant enough to alter the original assessment.
This sensitivity has no impact on the original evaluation performed against this criterion.</td></tr>
<tr><td rowspan="2">Summary</td><td colspan="2">Performing the sensitivity where there are no drill cuttings to be disturbed or recovered has an impact on the assessment against the environmental and societal criteria. It has the effect of making Option 1 more attractive from an operational marine impact and societal – all groups perspective when compared to Option 4 – Leave in situ. The reduced durations from removing the requirement to recover the drill cuttings are largely proportional across the recovery options. They are assessed as insufficient when comparing the recovery options against Option 4 – Leave in situ.
This sensitivity has adjusted the assessment against the environment and societal criteria, however, the adjustments are insufficient to alter the outcome of the original evaluation i.e. Option 4 being the most preferred cell contents decommissioning option.</td></tr>
<tr><td colspan="2">
</td></tr>
</table>

Table 6.4: Sensitivity – Cell Contents – No Drill Cuttings Recovery

6.4.3 Increased Cell Contents Recovery Threshold & No Drill Cuttings Recovery

As a further investigation, a scenario where the increase in cell contents recovery threshold from 50% to 90% and removing the impact of drill cuttings disturbance and removal was considered. This scenario was considered as it defines the best possible outcome in terms of cell contents recovery efficiency, whilst not burdening the options with the impacts associated with drill cuttings removal. This scenario is a combination of the preceding sensitivities and the impact and outcome is described in Table 6.5.

	Sub-criteria	Impact Discussion
Safety	1.1 Operations Personnel Safety	In this combined scenario, the durations of the activities are similar to the original assessment. As such, the original assessment remains valid. **This sensitivity has no impact on the original evaluation performed against this criterion.**
Safety	1.2 Legacy Impact	**This sensitivity has no impact on the original evaluation performed against this criterion.**
Environment	2.1 Operational Marine Impact	Again, under this combined scenario, the operational durations and thus vessel days are largely similar to the original assessment. The main change is the reduced impact from drill cuttings recovery. This has adjusted the original assessment as follows: Option 1 is assessed as being Weaker to Option 2 and Option 3 (was Much Weaker) and Much Weaker than Option 4 (was Very Much Weaker). The remaining assessments are still valid as the negative impact from recovering drill cuttings were less significant for Options 2 and 3. **This sensitivity has altered the original evaluation performed against this criterion.**
Environment	2.2 Atmospheric Emissions and Consumption	Again, the operational durations are similar to the original assessment under this combined scenario. As such, the original assessment remains valid. **This sensitivity has no impact on the original evaluation performed against this criterion.**
Environment	2.3 Legacy Marine Impact	There are two impacts with this combined scenario. These are, reduction in the residual cell contents and the additional drill cuttings left post decommissioning. The dominant factor is removing the benefit in terms of legacy marine impacts from removing the drill cuttings. The revised assessment is as follows: Option 1 is assessed as being Neutral to Option 2 and Option 3 (was Stronger) and remains Much Stronger than Option 4. The remaining assessments are still valid as the positive impacts from recovering drill cuttings were less significant for Options 2 and 3. **This sensitivity has altered the original evaluation performed against this criterion.**
Technical	3.1 Project Technical Risk	If there are no drill cuttings to remove this makes the cell contents recovery options marginally less challenging to deliver. Increasing the recovery threshold makes the recovery options more challenging. These adjustments cancel each other out. As such, the original assessment remains valid. **This sensitivity has no impact on the original evaluation performed against this criterion.**
Societal	4.1 All Groups	Increasing the recovery threshold was assessed as having no impact against this criterion. As such, the adjustment under this combined scenario is due to the elimination of the requirement to return contaminated drill cuttings. The revised assessment is as follows: Option 1 is assessed as being Neutral to Option 2 and Option 3 (was Weaker). Option 1 is assessed as being Stronger than Option 4 (was Neutral). The remaining assessments are still valid as the negative impact from the smaller volumes of contaminated drill cuttings was not considered to have as significant an impact in the original assessment. **This sensitivity has altered the original evaluation performed against this criterion.**

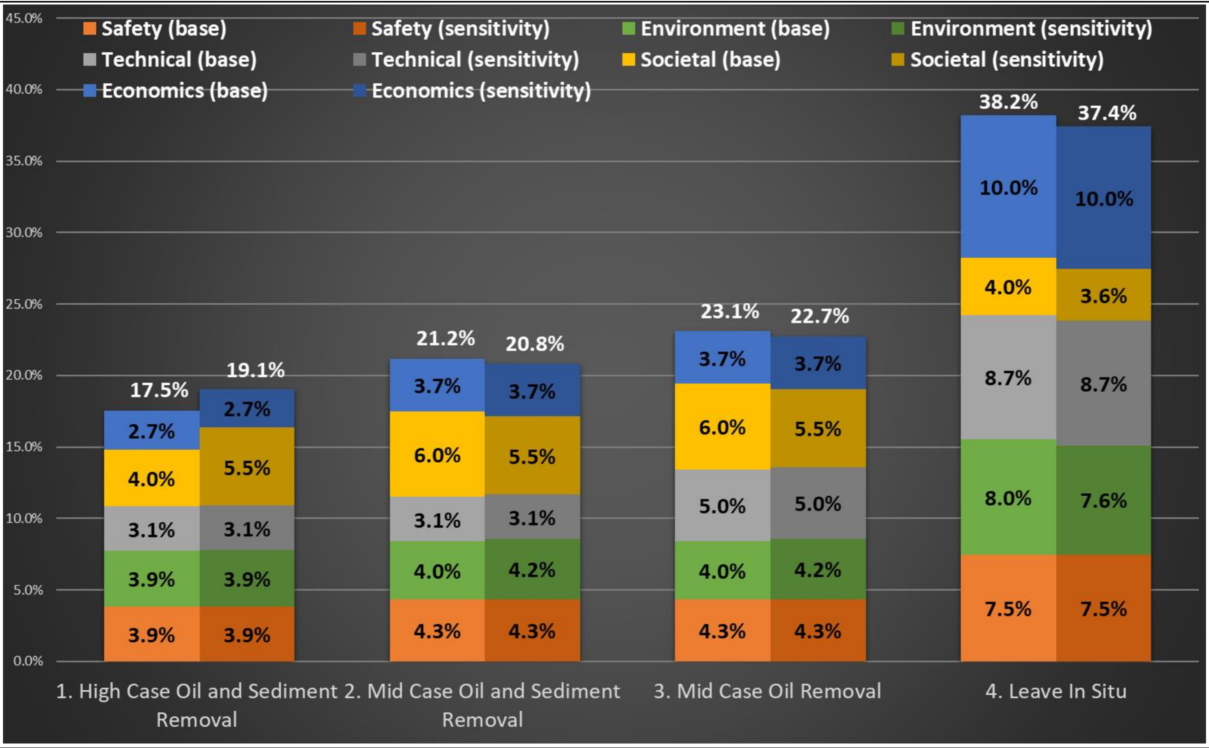
<table>
<tr><th></th><th>Sub-criteria</th><th>Impact Discussion</th></tr>
<tr><td>Economic</td><td>5.1 Operational & Legacy Costs</td><td>In this combined scenario, there are changes to the operational costs to execute the option, however these changes are not assessed as significant enough to alter the original assessment.
This sensitivity has no impact on the original evaluation performed against this criterion.</td></tr>
<tr><td rowspan="2">Summary</td><td colspan="2">Combining the increased cell contents recovery and removing the requirement for drill cuttings recovery has altered the original assessment performed. This altered assessment is dominated by the impact from removing the requirement for drill cuttings recovery. This has the effect of making Option 1 more attractive from an operational marine impact and societal – all groups perspective at the expense of Option 4 – Leave in situ.
The operational durations under this combined scenario are largely similar to those from the original assessment as the increased cell contents recovery increases durations, whilst removing the requirement to recover the drill cuttings reduces the durations.
This sensitivity has adjusted the assessment against the environment and societal criteria, however, the adjustments are insufficient to alter the outcome of the original evaluation i.e. Option 4 being the most preferred cell contents decommissioning option.</td></tr>
<tr><td colspan="2">
</td></tr>
</table>

Table 6.5: Sensitivity – Cell Contents – Increased Recovery Threshold & No Drill Cuttings Recovery

6.4.4 Removal of Economic Criterion

In a similar manner to the CGBS, a sensitivity analysis has been conducted on the evaluation of the cell contents decommissioning options by removing the economic criterion. The outcome from this sensitivity is shown in Figure 6.1.

By removing the economic criterion, the revised results chart for the overall outcome did not change, i.e. Option 4 – Leave *in situ*, was still assessed as the most preferred option. The differential between Option 4 – Leave *in situ* and the recovery options did reduce as would be expected, but not sufficiently to affect the evaluation.

In summary, removing the economic criterion from the evaluation has no impact on the most preferred option.

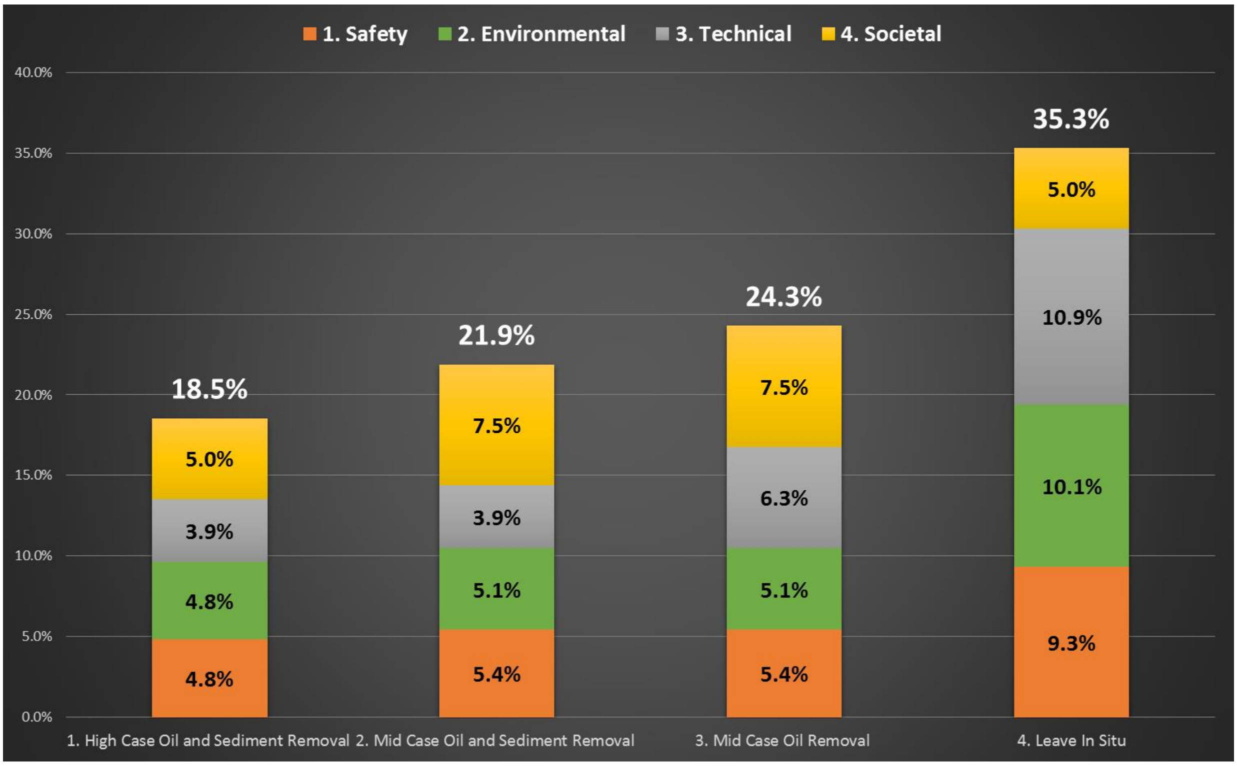


Figure 6.1: Sensitivity – Cell Contents – Removal of Economics Criterion

7 DISCUSSION

In order to give a balanced view of the potential decommissioning options for the Dunlin Alpha CGBS and the associated residual contents of the storage cells, Fairfield have conducted, via external consultancies, an extensive programme of scientific studies and analysis over more than eight years, undertaken with increasing degrees of detail and refinement as the Dunlin Alpha Decommissioning project has matured. Above all, the goal has been to develop the fullest possible understanding of the potential implications of different options and to quantify these to enable a robust process of Comparative Assessment and evaluation.

Full removal of the Dunlin Alpha CGBS has been the starting point for the work undertaken. This is in compliance with the requirements of OSPAR Decision 98/3. Partial removal options were explored given Dunlin Alpha's candidacy for derogation as a CGBS should full removal not be possible.

This section provides discussion in support of the evaluation conducted and the summary outcomes already illustrated in Section 5 and 6.

7.1 CGBS Evaluation

Option 4 – Full Removal was the starting point for decommissioning pre-planning, in spite of the major technical challenges associated with the removal of a 342,000 tonne concrete and steel substructure and lack of precedent for such a task. The main benefits of the full removal option are:

- Clear seabed;
- Removal of legacy safety risk; and
- Removal of legacy environmental risk.

These are important benefits which have been given due consideration during this CA. However, when trying to arrive at a balanced view of the most preferred decommissioning outcome, these benefits must be weighed against the impacts associated with delivering the option such as:

- Significant operational environmental impact (hundreds of thousands of tonnes of CO_2);
- Impact on benthic environment of long-term (40+ years) subsea deconstruction activities;
- Operational (safety) risk exposure (40+ years of challenging deconstruction activities);
- Technical feasibility (likelihood of delivering a successful subsea deconstruction activity on this scale);
- Societal impact of returning and processing steel-reinforced concrete (hundreds of thousands of tonnes, unlikely to have re-use potential); and
- High economic cost (more than £2 billion).

Despite this contrast between perceived benefits and potential impacts, Option 4 was fully evaluated before being compared with the preferred option from the three partial removal options. These three derogation options are listed here in decreasing order of resources required to help inform the discussion in the subsections which follow:

- Option 6 – IMO Compliant Cut - where all four concrete CGBS legs would be cut and removed at an IMO compliant depth of 55 m below LAT.;
- Option 5 – Shallow Cut – where all four concrete CGBS legs would be cut and removed at a shallow cut depth (to be decided during detailed design) ranging somewhere between approximately 8 m below LAT (i.e. at the concrete to steel transition interface) and approximately 20 m below LAT (selected as operational window for subsea cutting operations likely to be much greater as outside the 'splash zone'. Once the legs were cut and removed, a navaid would be installed, at the original deck height (23 m above LAT) on a concrete monotower, fixed to one of the cut legs; and

- Option 9 – Transitions Up – where there is no cutting of the CGBS legs. The steel transitions would be coated internally and a cathodic protection system installed to mitigate against corrosion in order to align the longevity of the steel transitions with the tops of the concrete CGBS legs, i.e. c250 years. A navaid would be installed, at the original deck height (23 m above LAT), on one of the steel transitions.

The evaluation of the derogation options was conducted using the methodology introduced in Section 3.4 and detailed more fully in Appendix A with the detailed results described in Appendix C. Option 9 was identified by the evaluation as the 'most preferred' of the potential derogation options. The contributing factors to this outcome are discussed below.

7.1.1 Safety Criterion

The attributes used to perform the assessment against the Safety criterion and associated sub-criteria were derived from the various studies and analyses developed during the preparation phase of the CA and Dunlin Alpha Decommissioning project as summarised in the Safety Summary ref. [8].

Option 9 was assessed as the most preferred of the derogation options against the Safety - Operations Personnel sub-criterion. This sub-criterion considered all personnel included during the operational phase of the decommissioning option including offshore and onshore worker groups. Given that option 9 had by far the lowest number of operational hours and Potential for Loss of Life (PLL), it carried the lowest risk exposure of all the options.

Option 9 was also assessed as the most preferred option against the Safety – Other Users sub-criterion. This sub-criterion took into account the number of vessel days required to deliver the various options. Option 9 had far fewer vessel days and thus far fewer transits than any of the other options. As such, the potential safety impact on other users of the sea was assessed as being the lowest for Option 9.

Option 5 and Option 9 were assessed as equally preferred against the Safety – Legacy Risk sub-criterion. This assessment was conducted based on the quantification of the snagging and collision risk posed to merchant vessels and fishing vessels from the decommissioning option once the decommissioning operations were complete. This information was provided in the Legacy Collision Risk Assessment ref. [21]. The snagging risk dominated this assessment and was calculated as being much higher for Option 6 than for Options 5 and 9. It should be noted that the legacy collision and snagging risks were calculated based upon the existing 500 m safety zone being removed under Option 6 (as the legs no longer break the surface of the water) but being retained for Options 5 and 9 (as legs break the surface of the water). Clearly, this credible scenario, which is as per current legislation, has a material impact on the assessment conducted against this sub-criterion.

A sensitivity was conducted where the impact of maintaining the safety zone for all derogation options in terms of Safety – Legacy Risk was assessed. The details of this sensitivity are included in Section 5.4.2. Running this sensitivity had no impact on the overall outcome of the evaluation.

A further sensitivity was conducted where the impact of removing the safety zone for all derogation options in terms of Safety – Legacy Risk was assessed. The details of this sensitivity are included in Section 5.4.3. Running this sensitivity had no impact on the outcome of the evaluation.

7.1.2 Environment Criterion

The attributes used to perform the assessment against the Environment criterion and associated sub-criteria were also derived from various studies and analyses developed during the preparation phase of the CA and Dunlin Alpha Decommissioning project. These attributes are summarised in the Energy & Emissions Assessment ref. [9].

It was noted during the assessment that the location of Dunlin Alpha was not a designated marine protected area or in close proximity to any, nor had the characterisation in the habitats survey revealed the presence of any Annex I species or habitats. It was also noted that, given the assumption that no explosives would be used for any of the proposed options, decommissioning activity would pose, at worst, a short-term nuisance to marine mammals from a noise perspective, caused by vessels and the relatively short-duration subsea diamond wire cutting operations associated with some of the decommissioning options. The background to these assumptions are fully documented in the Energy & Emissions Assessment ref. [9].

Option 9 was assessed as the most preferred of the derogation options against the Environment – Operational Marine Impact sub-criterion. This sub-criterion considered all marine impacts during the operational phase of the decommissioning option. Attributes were provided from the Energy & Emissions Assessment ref. [9] with most operational environmental impacts being assessed as relatively insignificant, such as impacts from vessels, and marine noise being below the damage threshold. The main differentiator was the potential for a large dropped object occurring during the decommissioning phase that could either penetrate the cell base or cause significant disturbance of the contaminated drill cuttings on and around the CGBS. The likelihood of this, whilst small, is present under Options 5 and 6 due to the large scale leg cutting and removal operations and absent from Option 9. Option 9 would also have the least noise disturbance due to the lack of cutting operations.

Option 9 was also assessed as the most preferred of the derogation options against the Environment – Atmospheric Emissions and Consumption sub-criterion. Whilst none of the derogation options could be considered to have a particularly high contribution to atmospheric emissions on a global scale or in terms of climate change, there were differences between the options. These differences were largely proportional to the vessel days associated with the option. The emissions and consumptions data was provided from the Energy & Emissions Assessment ref. [9] and was much lower for Option 9 than any of the other options.
The derogation options were originally assessed as having no differentiation when considering the Environment – Legacy Marine Impact sub-criterion. The assessment that all options were equal was based on all derogation options leaving identical quantities of material in the cell base and thus legacy impacts were consistent for all options.

A sensitivity was performed to evaluate the potential for increased legacy marine impacts resulting from a leg collapse if left *in situ* (as per Options 5 and 9). Modelling of the release scenario has predicted "low" environmental impact. Nevertheless, as Option 6 precludes this release scenario completely, Option 6 is considered to be the most preferred option against the Environment – Legacy Impact sub-criterion.

7.1.3 Technical Criterion

The technical criterion covers elements such as the availability of technology, track record and likelihood for project failure. It is informed by the Technical Risk Assessment ref. [20] where an assessment of the potential for project failure was conducted against each of the options. A project failure was defined as an event that occurs that would lead to a requirement to re-submit the decommissioning programme for approval by the relevant regulatory body. A good example of this would be an inability to successfully perform the cutting of one of the concrete legs. The technical risk assessment provides the key risks for each option and a score, both of which are used as attributes when assessing the options against this criterion.

Option 9 was assessed as the most preferred of the derogation options against the Project Technical Risk criterion as the activities are considered largely routine. There are significant technical challenges associated with the other derogation options, such as subsea concrete leg cutting at a scale that has never been performed before which would need to be applied to Options 5 and 6, including the challenge of installing a concrete monotower which would be at least 30 m, onto a submerged concrete leg with uncertain residual strength and thus longevity.

7.1.4 Societal Criterion

Option 6 was assessed as the most preferred of the derogation options against the Societal – Fishing Industry sub-criterion. The assessment was performed based on the definition of the options, background information from the Commercial Fisheries Baseline Study ref. [26], and with the input of the attendees during the CA evaluation workshop who included the Scottish Fishermen's Federation (SFF), with whom earlier engagement had also been held. There was a strong preference from the SFF for the area currently covered by the 500 m safety zone to be opened up to the fishing community, which would result from the adoption of the deep cut associated with Option 6, in spite of the potential for submerged snag hazards.

All options were assessed as equally preferred against the Societal – Other Groups sub-criterion. Attributes used in conducting this assessment were provided from various technical studies and analyses and included the hours associated with delivering each option and the volumes and types of materials returned to shore for processing. The evaluation considered the societal benefit of job creation and / or retention of the longer duration options to be offset by the larger quantities of concrete returned for processing with those options.

The returned concrete was considered a negative societally due to significant concerns with potential contamination resulting in it being unlikely to be re-used and thus destined for landfill.

A sensitivity was conducted where the impact of maintaining the safety zone for all derogation options in terms of commercial fishing operations was assessed. The details of this sensitivity are included in Section 5.4.2. Running this sensitivity had no impact on the overall outcome of the evaluation.

A further sensitivity was conducted where the impact of removing the safety zone for all derogation options in terms of commercial fishing operations was assessed. The details of this sensitivity are included in Section 5.4.3. Running this sensitivity had no impact on the outcome of the evaluation.

7.1.5 Economic Criterion

Option 9 was assessed as the most preferred of the derogation options against the Economic – Operational & Legacy Costs sub-criterion. The assessment was performed based on the cost estimates developed alongside the various technical studies conducted during the preparation phase of the CA. These estimates are in line with a class 4 estimate (based on the American Association of Cost Engineers (AACE) scale) and cover an approximate range of -15% to +50% as appropriate for CA purposes.

Both Option 5 and 9 have a legacy component to their cost estimates for performing maintenance and monitoring of the navaid associated with these options. It should be noted that for the purposes of the CA this legacy cost basis is calculated for 50 years.

A sensitivity was conducted to test the assessment outcome with the Economics criterion removed. The details of this sensitivity are included in Section 5.4.4. Running this sensitivity had no impact on the overall outcome of the evaluation.

7.1.6 Summary

Option 9 was assessed as the most preferred derogation option against the following sub-criteria (primary criteria are shown in brackets):

- 1.1 Operational Personnel (Safety);
- 1.2 Other Users (Safety);
- 2.1 Operational Marine Impacts (Environment);
- 2.2 Atmospheric Emissions & Consumption (Environment);
- 3.1 Project Technical Risk (Technical); and
- 5.1 Operational & Legacy Costs (Economic).

Option 9 was also assessed as the equal most preferred option against the following sub-criteria:

- 1.3 Legacy Risk (Safety) (equal with Option 5);
- 2.3 Legacy Marine impacts (Environment) (equal with Options 5 and 6); and
- 4.2 Other Groups (Societal) (equal with Options 5 and 6).

Given that Option 9 is the equal or most preferred derogation option against nine of the ten sub-criteria it is the clear most preferred of the derogation options.

7.2 Full Removal Option v Selected Derogation Option

Option 4 – Full Removal was then evaluated against the selected derogation option, Option 9 – Transitions Up. The evaluation was conducted using the same methodology as before, with the detailed results described in Appendix C and the contributing factors discussed below.

7.2.1 Safety Criterion

Option 9 was assessed as the most preferred option against the Safety - Operations Personnel and Safety – Other Users sub-criteria. The assessment was again informed by the various studies and analyses developed during the preparation phase of the CA and Dunlin Alpha Decommissioning project as summarised in the Safety Summary ref. [8]. The differences were stark because Option 4 operations last more than 40 years with more than 8 million man hours versus Option 9 operations taking just a few months.

Option 4 was assessed as the most preferred option against the Safety – Legacy Risk sub-criterion. The assessment was once again conducted based on the quantification of the snagging and collision risk posed to merchant vessels and fishing vessels from the decommissioning option once the decommissioning operations were complete. Clearly, Option 4 – Full Removal has no legacy risk associated with it hence its most preferred assessment.

7.2.2 Environment Criterion

Option 9 was assessed as the most preferred option against the Environment – Operational Marine Impact and Environment – Atmospheric Emissions and Consumption sub-criteria. Attributes were provided from the Energy & Emissions Assessment ref. [9] with Option 4 having significant impacts from a marine noise perspective due to the long durations (40+ years) of subsea concrete cutting operations and the associated potential impacts from releases that may occur from the cell base whilst deconstructing it. An additional parameter introduced during the workshop was the impact to the benthic environment of 40+ years of subsea deconstruction activities. As these activities are consecutive, the ability of the benthic environment to recover would be compromised. The emissions and consumptions for Option 4 are also very large in scale, albeit spread over 40+ years. Note: even if parallel works were undertaken to halve the duration of decommissioning operations, the recovery would still be impaired.’

Option 4 was assessed as the most preferred option against the Environment – Legacy Marine Impacts sub-criterion. Whilst there is no legacy marine impact from cell contents under the full removal option, there is likely to be a legacy impact to the benthic environment from the long durations of the subsea deconstruction activities. There is a clear legacy impact from leaving the cell base *in situ* under Option 9 as it is accepted that, eventually, the residual cell contents will be released into the marine environment. This is expected to happen very gradually over many decades and is expected to be hundreds, if not thousands of years after the decommissioning activities are complete. It should be noted that this release scenario was assessed as having a 'low to very low' environmental impact i.e. no response required and has concluded that it would not result in significant adverse environmental impact (see Cell Contents Technical Report ref. [5]).

7.2.3 Technical Criterion

Option 9 was assessed as the most preferred option against the Project Technical Risk criterion. The challenges associated with the deconstruction of the CGBS *in situ* are many and varied and are detailed in the Technical Risk Assessment ref. [20]. It was clear that the technical risks associated with Option 4 are much greater than those for Option 9.

7.2.4 Societal Criterion

Option 4 was assessed as the most preferred option against the Societal – Fishing Industry sub-criterion. Clearly, removing the CGBS and returning the area currently covered by the safety zone to the fishing industry is the most preferred outcome.

Both Options 4 and 9 were equally preferred against the Societal – Other Groups sub-criterion. This is again due to balancing the societal benefits of years of job creation / retention with the negative societal contribution of returning hundreds of thousands of tonnes of concrete for processing and, most likely, landfill.

7.2.5 Economic Criterion

Option 9 was assessed as the most preferred option against the Economic – Operational & Legacy Costs sub-criterion. The assessment was again performed based on the cost estimates developed alongside the various technical studies conducted during the preparation phase of the CA. This was a clear preference given that the costs associated with Option 9 were around £12 million, whereas the cost of Option 4 was more than £2 billion. Costs of all options are listed in Appendix C.4.

A sensitivity was conducted to test the assessment outcome with the Economics criterion removed. The details of this sensitivity are included in Section 5.4.5. Running this sensitivity had no impact on the overall outcome of the evaluation.

7.2.6 Summary

Option 9 was assessed as the most preferred decommissioning option against the following sub-criteria (primary criteria in brackets):

- 1.1 Operational Personnel (Safety);
- 1.2 Other Users (Safety);
- 2.1 Operational Marine Impacts (Environment);
- 2.2 Atmospheric Emissions & Consumption (Environment);
- 3.1 Project Technical Risk (Technical); and
- 5.1 Operational & Legacy Costs (Economic).

Option 9 was also assessed as equally preferable to Option 4 against the following sub-criteria:

- 4.2 Other Groups (Societal) (equal with Option 4).

Option 4 was assessed as the most preferred decommissioning option against the following sub-criteria:

- 1.3 Legacy Risk (Safety);
- 2.3 Legacy Marine impacts (Environment); and
- 4.1 Fishing Industry (Societal).

Given that Option 9 is equal or most preferred decommissioning option against seven of the ten sub-criteria it is the clear most preferred of the decommissioning options.

7.3 Cell Contents Evaluation

The cell contents evaluation is intrinsically linked to the CGBS itself as the only credible way in which all cell contents can be removed is by removing the CGBS in its entirety. Given that there is no credible option for full cell contents removal in a derogation case, the remaining cell contents decommissioning options, post the screening phase of the CA, have been evaluated in the same way as the CGBS. The only difference is that the sub-criteria have been tailored for the cell contents evaluation. Detailed results appear in Appendix C.

As a reminder, four options for decommissioning cell contents were taken forward from the screening stage.

- Option 1 – High case oil & sediment removal – where all cells are accessed via direct and indirect means, via 31 penetrations in the top of the cell base. Both mobile oil (74 cells) and sediment (8 cells) are recovered and returned to shore. All cell top drill cuttings are recovered;
- Option 2 – Mid case oil & sediment removal – where the cells are accessed via direct and indirect means via 18 cell penetrations in the top of the cell base. Both mobile oil (41 cells) and sediment (4 cells) are recovered and returned to shore. Minimal cell top drill cuttings disturbance and removal;

- Option 3 – Mid case oil removal – 15 cell penetrations in the top of the cell base. Mobile oil (36 cells) recovered and returned to shore. No sediment recovery. No large access holes required. Minimal cell top drill cuttings disturbance and removal; and
- Option 4 – Leave *in situ* – no activities to recover cell contents are performed.

7.3.1 Safety Criterion

The attributes used for performing the assessment of the cell contents decommissioning options are the same as those used for the CGBS, i.e. hours associated with the option and a calculated PLL. The attributes are taken from the detailed Cell Contents Technical Report ref. [5] where method statements were constructed and detailed for each of the options.

Option 4 was assessed as the most preferred of the options against the Safety - Operations Personnel sub-criterion. This sub-criterion considered all offshore personnel included during the operational phase of the decommissioning option. Onshore personnel were not considered, as the boundary of this assessment was drawn at the quayside. Whilst none of the operational durations for the removal options are excessively large, they are all more than 100,000 hours and, when compared to the leave *in situ* option, this is the clear preferred option.

All options were assessed as equally preferred against the Safety – Legacy Risk sub-criterion. This was due to there being no legacy safety impact from any of the cell contents decommissioning options.

7.3.2 Environment Criterion

The attributes used to perform the assessment against the Environment criterion and associated sub-criteria were derived from various studies and analyses developed during the preparation phase of the CA. These attributes are summarised in the Cell Contents Technical Report ref. [5].

Option 4 was assessed as the most preferred of the options against the Environment – Operational Marine Impact sub-criterion. This sub-criterion considered all marine impacts during the operational phase of the decommissioning option. The dominating parameter in this assessment was the impact from removing the drill cuttings and the potential for their redistribution with associated release of hydrocarbons and heavy metals. Marine noise was not considered a significant differentiator as this was assessed as being below the damage threshold for mammals.

Option 4 was also assessed as the most preferred of the options against the Environment – Atmospheric Emissions and Consumption sub-criterion. None of the options have a particularly high contribution to atmospheric emissions on a global scale or in terms of climate change. The differences were largely proportional to the vessel days associated with the option. The emissions and consumptions data was provided from the Cell Contents Technical Report ref. [5] and was zero for the leave *in situ* option, hence it being the clear most preferred option.

Option 1 was assessed as the most preferred option against the Environment – Legacy Marine Impact sub-criterion. There were two main components to this assessment, again provided by the technical studies performed during the preparation phase of the CA and detailed in the Cell Contents Technical Report ref. [5]. These components are, the residual cell contents left after the decommissioning option and the removal of drill cuttings. Option 1 was assessed as most preferred as this leaves the least residual contents in the cells. It also recovers all drill cuttings from the top of the cell base, removing any potential legacy impact.

A sensitivity was conducted to test the assessment outcome by increasing the recovery potential from 50% of the residual cell contents to 90%. The details of this sensitivity are included in Section 6.4.1. Running this sensitivity had no impact on the overall outcome of the evaluation.

A further sensitivity was conducted to test the assessment outcome by removing the requirement to disturb and recover the drill cuttings present on the top of the CGBS cell base. The details of this sensitivity are included in Section 6.4.2. Running this sensitivity had no impact on the overall outcome of the evaluation.

A final environmental sensitivity was conducted where these sensitivities were combined, i.e. increased residual cell contents recovery to 90% and no disturbance or recovery of cell top drill cuttings. The details of this sensitivity are included in Section 6.4.3. Running this sensitivity had no impact on the overall outcome of the evaluation.

7.3.3 Technical Criterion

Option 4 was assessed as the most preferred of the options against the Technical Project Failure criterion. The assessment was informed by the qualitative assessment conducted during the preparation phase of the CA, detailed in the Cell Contents Technical Report ref. [5]. Considerations included the availability of technology, track record and likelihood for project failure.

One of the key technical challenges is the requirement to scale the currently proven (Enpro) cell penetration technology. This technology has been used in similar circumstances to create penetrations of 2 7/8" diameter. For both Options 1 and 2 there is a requirement to have approximately 6" penetrations for sediment recovery. Whilst this scaling is considered feasible, it is not proven. The other consideration is the ability to recover the sediment under Options 1 and 2, where there are known industry experiences of technical failure in this area. Clearly, there are no technical challenges with the leave *in situ* option, hence it being the clear most preferred option.

Extensive investigations into the options of how to manage the residual cell contents have been undertaken. The findings were that physically enter the cells to recover the contents would be technically challenging to execute and that a guarantee that all contents had been recovered would be impossible due to the nature of the materials and the design of the substructure. The key point to note is the residual inventory is compartmentalised across the cells and also within the structure of the cell tops, this makes it both more time consuming to access for recovery and less likely to be released simultaneous due to a dropped object or degradation of the substructure.

7.3.4 Societal Criterion

Options 2 and 3 were assessed as the most preferred of the cell contents removal options against the Societal – All Groups criterion. The assessment was performed based on the definition of the options and attributes provided from various technical studies and analyses and included the hours associated with delivering the option and the volumes and types of materials returned to shore for processing. The assessment performed considered the societal benefit of job creation and / or retention of the longer duration options to be offset by the associated requirement to return and process contaminated drill cuttings, considered societally negative. There was deemed to be a small benefit in developing and proving the new technology to recover the sediment materials, associated with Options 1 and 2.

7.3.5 Economic Criterion

Option 4 was assessed as the most preferred of the derogation options against the Economic – Operational & Legacy Costs sub-criterion. The assessment was performed based on the cost estimates developed alongside the various technical studies conducted during the preparation phase of the CA. As with the CGBS, these estimates are in line with a class 4 estimate (based on the AACE scale) and cover an approximate range of -15% to +50% as appropriate for CA purposes.

None of the options for the cell contents removal has a direct legacy cost component as, whilst execution of any of the options would leave some residual contents, it was assumed that any legacy monitoring requirement would be conducted in conjunction with the CGBS. As such legacy costs were not a differentiator.

The removal options had significant operational costs, whereas the leave *in situ* option with zero cost was clearly the most preferred option.

A sensitivity was conducted to test the assessment outcome with the Economics criterion removed. The details of this sensitivity are included in Section 6.4.4. Running this sensitivity had no impact on the overall outcome of the evaluation.

7.3.6 Summary

Option 4 was assessed as the most preferred cell contents decommissioning option against the following sub-criteria (primary criteria in brackets):

- 1.1 Operational Personnel (Safety);
- 2.1 Operational Marine Impacts (Environment);
- 2.2 Atmospheric Emissions & Consumption (Environment);
- 3.1 Project Technical Risk (Technical); and
- 5.1 Operational & Legacy Costs (Economic).

Option 4 was also assessed as equally preferred to the other options against the following sub-criteria:

- 1.2 Legacy Impact (Safety) (equal with all options).

Option 1 was assessed as the most preferred option against the following sub-criteria:

- 2.3 Legacy Marine impacts (Environment);

Option 2 and 3 were assessed as the equal most preferred option against the final sub-criteria:

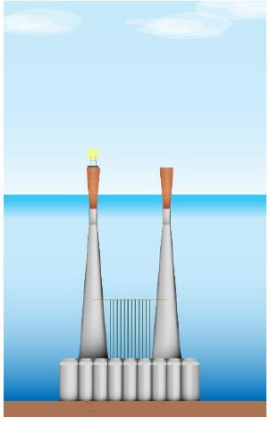
- 4.1 All Groups (Societal).

Given that Option 4 is the equal or most preferred option in six of the eight sub-criteria it is the clear most preferred of the cell contents decommissioning options.

7.4 Emerging Recommendations

Given the CA performed, the outcomes obtained from the screening phase, the extensive technical studies and analysis work conducted during the preparation phase, and the detailed, auditable and transparent evaluation methodology conducted, there are clear emerging recommendations for both the CGBS and the Cell Contents.

For the CGBS, the clear most preferred decommissioning option is:



Option 9 – Transitions Up

This option involves topside removal only leaving the four steel transitions in place.

The steel transitions will have their internal walls painted and a cathodic protection system installed externally in order to reduce the corrosion rate.

The transitions will be sealed with a heavily galvanised steel roof to prevent water ingress and to enable the Navaid and support frames installation on top of one of the transitions.

Navaid annual monitoring and maintenance included for 50 years post-decommissioning for cost estimating purposes.

For the cell contents, the clear most preferred decommissioning option is:

Option 4 – Leave *in situ*

All cell contents left *in situ* with no removal or remediation.

APPENDIX A EVALUATION METHODOLOGY

Appendix A.1 CA Evaluation Methodology

Fairfield has selected a Multi Criteria Decision Analysis (MCDA) methodology for the evaluation phase of the CA. This methodology uses a pairwise comparison system based on the methodologies of the Analytical Hierarchy Process (AHP) by T.L. Saaty, described in various publications, such as Analytical Hierarchy Process ref. [33]. This allows the relative importance of each differentiating criteria to be judged against each other in a qualitative way, supported by quantification where appropriate. The key steps for the evaluation phase of the CA are as follows:

> Define Differentiating Criteria – listed in Table 7.1;

> Define Options – completed as part of CA Screening;

> Pre-populate worksheets for internal CA workshops – based on all the studies undertaken the worksheets were pre-populated in advance of the internal CA workshops;

> Perform internal CA workshop;

> Discuss attributes of each option against each differentiating criteria – the discussion was recorded 'live' during the workshop in order that informed opinion and experience was factored into the decision-making process;

> Perform scoring (see Section Appendix A.5);

> Perform sensitivity analyses to test the decision outcomes;

> Export worksheets as a formal record of the workshop attendees' combined opinion on the current preferred options, the 'Emerging Recommendations';

> Evaluate whether the CA needs to 'recycle' to the Preparation phase to obtain any further information to help inform decision making;

> Discuss Emerging Recommendations with stakeholders (planned May 2018); and

> Recycle process as required prior to decision on the selected options which will be presented in the Decommissioning Programme and assessed in the Environmental Impact Assessment.

The sections below describe how the MCDA methodology has been applied.

Appendix A.2 Differentiating Criteria & Approach to Assessment

A key step in setting up the CA was agreeing and defining the appropriate criteria that differentiates between each of the tabled options. As a starting point, the criteria considered for this CA were taken from the DECC (now BEIS) Guidelines for Decommissioning of Offshore Oil and Gas Installations and Pipelines which are as follows (in no particular order):

> Safety

> Environmental

> Economic

> Technical

> Societal

These differentiating criteria were found to be appropriate for the decommissioning options tabled and were taken forward as the primary differentiating criteria for the CA. Additional sub-criteria and definitions were added for clarity and are shown Table 7.1 alongside the approach used for assessment under each criteria or sub-criteria.

Criteria	Sub-Criteria	Description	Approach to Assessment	Units
1. Safety (20%)	1.1 Operations Personnel (6.66%)	This sub-criterion considers elements that impact risk to offshore personnel and includes, project team, project vessel crew, diving teams, supply boat crew, and survey vessel crew. It should be noted that crew changes are performed via port calls. This sub-criterion also considers elements that impact risk to onshore personnel. Factors such as any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel. **Not considered:-** - Rest (off-shift) risk exposure for all worker groups - Helicopter travel for topside scopes / worker groups	Quantitative data is used to compare the options against this criterion. Potential for Loss of Life (PLL) metrics are calculated based on the Fatal Accident Rate (FAR) x Hours of Exposure for each of the worker groups and is considered a suitable metric for Comparative Assessment purposes. The FAR is taken from the summary report of the Joint Industry Project investigating the Risk Analysis into Decommissioning Activities issued by Safetec [27]. The Hours of Exposure is taken from the various studies / method statements developed to define the options.	PLL
	1.2 Other Users (6.66%)	This sub-criterion covers the impact associated with the risk to other users. Considers elements such as collision impact whilst performing activities. Users such as fishing vessels and commercial transport vessel are considered. **Not considered:-** - 3rd party interactions / collisions and military vessels Note: The vast majority of vessel operations will be conducted within a 500 m safety zone around the facility and thus will limit the safety impact on other users to those from transits along set corridors.	A quantitative assessment is made based on the number of vessel days associated with each of the decommissioning options. This is considered acceptable as the safety impact on other users is a function of the operational vessel numbers / durations / movements. It should be noted that the vast majority of vessel operations will be conducted within a 500 m safety zone around the facility and thus will limit the safety impact on other users.	Days
	1.3 Legacy Risk (6.66%)	This sub-criterion addresses and legacy risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, that is associated with the decommissioning option being assessed. Issues such as snag risk for fishing operation, collision risk for all users is considered. Any personnel risk exposure associated with long-term monitoring is also encompassed by this criterion. **Not considered:-** - Operational phase risk	A qualitative assessment of the legacy risk to other users, informed by the PLL metrics from the Anatec Fishing Risk Study. The legacy risk associated with any required monitoring is calculated in a similar manner to 1.1 above.	PLL

Criteria	Sub-Criteria	Description	Approach to Assessment	Units
2. Environmental (20%)	2.1 Operational Marine Impacts (6.66%)	Encompasses any marine environmental impacts from the operational phase of the decommissioning option being assessed. Should address both planned impacts (inherent to the option being assessed) and potential unplanned impacts (accidental releases, both large and small in scale and encompassing Major Environmental Incidents (MEIs)). Also encompasses marine noise generated by vessels, cutting operations, explosives where used, etc.	Planned and unplanned marine impacts are narrative judgements informed by estimates of volumes (m^3) / composition of any releases. Marine noise is calculated based on the vessel durations, subsea cutting operations and is a quantitative measure of cumulative sound energy level in TPa^2S.	m^3 TPa^2S.
	2.2 Atmospheric Emissions / Consumptions (6.66%)	Encompasses environmental impact of atmospheric emissions from both the operational phase and any associated legacy phase of the decommissioning option being assessed. It also encompasses the resource consumption (such as Fuel / Energy Use) associated with the decommissioning option being assessed. This includes the environmental impact of processing any returned materials, production of any replacement materials (for those left *in situ*) and any quarried rock or other new material required. **Not considered:-** NOx and SOx due to their minimal impact in an offshore environment and their proportionality to the CO_2 impact.	Emissions are quantified by CO_2 in metric tonnes. Fuel consumption is quantified in metric tonnes. Other consumptions such as steel / other fabrications are also quoted in metric tonnes. Impact of recycling / processing returned material and replacing leave *in situ* material is quoted in CO_2 in metric tonnes.	GJ (Energy) Tonnes (CO_2)
	2.3 Legacy Marine Impacts (6.66%)	Encompasses any marine environmental impacts associated with the legacy phase of the decommissioning option being assessed. Should address both planned impacts (inherent to the option being assessed) and potential unplanned impacts (accidental releases, both large and small in scale and encompassing Major Environmental Incidents (MEIs)). Specific elements such as impacts from drill cuttings and cell contents are addressed.	Planned and unplanned marine impacts are narrative judgement informed by estimates of volumes (m^3) / composition of any releases. Expected duration of releases is also provided.	m^3

Criteria	Sub-Criteria	Description	Approach to Assessment	Units
3. Technical (20%)	3.1 Project Technical Risk (20%)	This sub-criterion relates to the various technical risks that could result in a major project failure (those that may require a DP re-submission). Concepts such as: Technical Novelty and Potential for Showstoppers can be captured along with impact on the schedule due to overruns from technical issues such as operations being interrupted by the weather. Technical Feasibility and Technical Maturity is also considered.	Supported by narrative discussion of technical risk but informed by the quantified Technical Risk Score from Atkins Technical Risk Assessment of all options.	N/A
4. Societal (20%)	4.1 Fishing Industry (10%)	This sub-criterion addresses the impact of the option on commercial fishing operations. It includes consideration of impacts from both the decommissioning activities any residual impacts post decommissioning such as reinstatement of access to area. **Not considered:-** Safety impacts - addressed in 1.3 above.	Assessed using narrative of the impact of the decommissioning option on fishing operations. Supported by quantification of the area (km^2) of potential impact.	N/A
	4.2 Other Groups (10%)	This sub-criterion addresses any positive and negative socio-economic impacts on other users both onshore where the impact may be from dismantling, transporting, treating, recycling and land filling activities relating to the option and offshore. Issues such as impact on the health, well-being, standard of living, structure or coherence of communities or amenities are considered here e.g. business or jobs creation, increase in noise, dust or odour pollution during the process which has a negative impact on communities, increased traffic disruption due to extra-large transport loads, etc. Includes the FAIRFIELD Guiding Principle of 'Minimal business interruption to others'.	Assessed using narrative of the positive and negative impact of the decommissioning option on all groups of society (excluding fishing industry). Supported by quantification of the quantities of material being transported (metric tonnes) and amount of job creation (man-hours).	N/A
5. Economic (20%)	5.1 Operational & Legacy Costs (20%)	This sub-criterion addresses the cost of delivering the option as described. Cost certainty (a function of activity maturity) is also recorded. Also covers any long-term cost element (such as monitoring) associated with the decommissioning option, stated explicitly rather than included in overall figure.	Both operational and legacy costs are quantified in GBP. Cost certainty is generally in line with a class 4 estimate as defined by American Association of Cost Engineers (AACE) and thus covers an estimated range of -15% to +50% however a narrative around cost estimate associated with each option is provided.	£

Table 7.1: CGBS Evaluation Criteria and Sub-criteria Definition

Criteria	Sub-Criteria	Description	Approach to Assessment	Supporting Study Output	Units
1. Safety (20%)	1.1 Operations Personnel (10%)	This sub-criterion considers elements that impact risk to offshore personnel and includes, project team and crew from vessels supporting the project such as waste transport and supply boat crews. **Not considered:-** Due to the boundaries of the assessment onshore personnel impacts are not considered, this is a reasonable basis as the materials being brought onshore are small and do not require significant handling compared to the offshore operations. There is no inherent potential for high consequence events i.e. major accident hazard, major environmental hazard type events.	Assessment to be made based on activity durations and narrative around other factors such as legacy impact where there is a differentiator. Definition of activity types and durations allows safety metrics to be calculated to give a quantitative comparison between options.	Quantitative data is used to compare the options against this criterion. Potential for Loss of Life (PLL) metrics are calculated based on the Fatal Accident Rate (FAR) x Hours of Exposure for each of the worker groups and is considered a suitable metric for Comparative Assessment purposes. The FAR is taken from the summary report of the Joint Industry Project investigating the Risk Analysis into Decommissioning Activities issued by Safetec. The Hours of Exposure is taken from the various studies, datasheets and method statements developed to define the options.	PLL
	1.3 Legacy Risk (10%)	This sub-criterion addresses any residual risk from personnel risk exposure associated with long-term monitoring. **Not considered:-** Note that the residual risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, due to the presence of the facilities post decommissioning is covered in the Comparative Assessment for the CGBS.		Qualitative narrative assessment.	N/A

Criteria	Sub-Criteria	Description	Approach to Assessment	Supporting Study Output	Units
2. Environmental (20%)	2.1 Operational Marine Impacts (6.66%)	This sub-criterion encompasses any marine environmental impacts from the operations. It addresses both planned impacts (inherent to the option being assessed) and potential unplanned impacts (accidental releases, both large and small in scale including any that may be classed as Major Environmental Incidents (MEIs)). It also covers any marine noise generated during the operations by vessels, cutting operations, explosives where used, etc. The impact of both direct and indirect drill cuttings disturbance shall also be considered.	Assessment to be based on assessing noise generated by decommissioning activities. Potential discharges to sea will be quantified in terms of release size and environmental impact. Assessment to be based on quantifying the area and volume of drill cuttings disturbance along with the cause of the disturbance.	Combined Qualitative and Quantitative narrative assessment. Expected that noise is not a significant differentiator but will be incorporated on an order of magnitude qualitative basis. Qualitative narrative assessment for planned and unplanned releases, supported by quantification of release type/size (including rate and duration) and environmental impact assessment. Quantitative assessment of area/volume of drill cuttings disturbance.	m^2 / m^3
	2.2 Energy & Emissions (6.66%)	This sub-criterion relates to the amount of fuel consumed to provide energy for the vessel operations and the amount of damaging atmospheric emissions associated with the operations. **Not considered:-** Note that no other resource use energy or emissions impacts have been assessed, for example manufacturing of valves and equipment to access the cells. Creation of waste materials and processing/disposal is not addressed.	Assessment to be based on quantifying the volume of fuel used and a life-cycle emissions assessment. The output energy and CO2 figures allow a direct, quantitative comparison between options.	Quantitative Energy and Emissions Assessment based on activities and durations for each option as defined in the method statements.	GJ (Energy) Tonnes (CO_2)
	2.3 Legacy Impacts (6.66%)	This sub-criterion relates to the marine environment impacts which could arise as a result of long-term legacy effects. Addresses releases, both large and small in scale and encompassing Major Environmental Incidents (MEIs). A further differentiator in terms of legacy relates to the presence of drill cuttings reducing the likelihood of a cell breach upon impact from a dropped object, i.e. the drill cuttings coverage provides a beneficial effect dampening the impact energy.	Assessment to be based on residual inventory upon completion of the management option. Potential discharges to sea will be quantified in terms of release size and environmental impact.	Qualitative narrative assessment for legacy impacts, supported by quantification of release type/size (including rate and duration) and environmental impact assessment.	m^3

Criteria	Sub-Criteria	Description	Approach to Assessment	Supporting Study Output	Units
3. Technical (20%)	3.1 Project Technical Risk (20%)	This sub-criterion relates to the various technical risks that could result in a major project failure. Concepts such as: Technical Novelty and Potential for Showstoppers can be captured along with impact on the schedule due to overruns from technical issues such as operations being interrupted by the weather. Technical Feasibility and Technical Maturity is also considered.	The following will be considered: Feasibility; Concept Maturity; Availability of Technology; Track Record; Risk of Failure; and Consequence of Failure.	Qualitative narrative assessment.	N/A
4. Societal (20%)	4.1 All groups (20%)	This sub-criterion addresses the positive and negative impact of the option on societal factors. It includes consideration of residual impacts post decommissioning such as temporary impact to fishing activities should there be future degradation of the substructure and release of the contents. **Not considered:-** Note that the issue of access in general to the area for fishing due to the presence of the facilities post decommissioning is covered in the Comparative Assessment for the CGBS. Onshore socio-economic impacts are not addressed due to the boundaries that have been drawn for this assessment, this is a reasonable basis as the materials being brought onshore are small and do not require significant handling compared to the offshore operations.	The following will be considered: Positive and negative impacts on fishing activities. Potential employment benefits. Industry capability development with respect to technology development and proof of concept during execution of the option.	Qualitative narrative assessment.	N/A

Criteria	Sub-Criteria	Description	Approach to Assessment	Supporting Study Output	Units
5. Economic (20%)	5.1 Operational & Legacy Costs (20%)	This sub-criterion addresses the cost of delivering the option as described. Cost certainty (a function of activity maturity) is also recorded. Also covers any long-term cost element (such as monitoring) associated with the decommissioning option, stated explicitly rather than included in overall figure.	Cost estimate for the management options under consideration. Cost estimate for the legacy management strategy under consideration (this likely to be the same for all options and will be combined with the legacy management requirements for the CGBS itself, therefore may not be a differentiator).	Quantitative cost estimate based on activities and durations for each option as defined in the method statements. The short term operational costs and long-term legacy costs will be displayed as separate figures.	£

Table 7.2: Cell Contents Evaluation Criteria and Sub-criteria Definition

Appendix A.3 Differentiator Weighting

The 5 primary differentiating criteria all carry a 20% weighting. That is, all criteria are neutral to each other. Figure 7.1 shows the pairwise comparison matrix. Fairfield decided that equal weightings offer the most transparency and do not single out any criterion as more important as any other.

Criteria	1. Safety	2. Environmental	3. Technical	4. Societal	5. Economic	Weighting
1. Safety	N	N	N	N	N	20%
2. Environmental	N	N	N	N	N	20%
3. Technical	N	N	N	N	N	20%
4. Societal	N	N	N	N	N	20%
5. Economic	N	N	N	N	N	20%

Figure 7.1: Example Pairwise Comparison Matrix (N = Neutral)

Appendix A.4 Option Attributes

The next step in the CA process was to describe and discuss the attributes of each option with respect to each of the differentiating criteria. In preparation, all relevant data and information developed during the preparation phase were pre-populated into the attributes table for each option. Appendix C contains the completed Attributes Tables.

Any additional discussion around the relative merits of the options was also recorded in the attributes matrix. A summary discussion of why options are considered more or less attractive with respect to each of the differentiating criteria was also recorded.

Appendix A.5 Option Pair-Wise Comparison

Once the option attributes were compiled and discussed, a pair-wise comparison was performed for each of the differentiating criteria where the proposed options were compared against each other. The pairwise comparison adopted in this case used phrases such as stronger, much stronger, weaker, much weaker, etc. to make qualitative judgements (often based on quantitative data) of the options against each other. Adopting these phrases rather than the more common numerical 'importance scale' from the Analytical Hierarchy Process (AHP) is often more intuitive and representative of the sentiment of a workshop.

One of the challenges of applying the numerical importance scale historically, is that often when scoring a pair of options against each other as a score of 3, delegates implied the comparison was 3 times better, etc. rather than 'slightly better' as the importance scale suggests.

To manage this, the numerical principle of the AHP in the pairwise comparison matrix was replaced with a narrative or descriptive approach. This is already programmed into the AHP in the importance scale explanations (see Table 7.3). It was agreed that three positions from equal (and their reciprocals) would be sufficient for this CA. These positions were:

Title	Scope	Relative Preference Ratio
Neutral	Equal Importance, equivalent to 1 in the AHP importance scale.	50 / 50
Stronger (S) / Weaker (W)	Moderate importance of one criteria / option over the other, equivalent to 1.5 in the AHP importance scale.	60 / 40
Much Stronger (MS) / Much Weaker (MW)	Essential / strong importance of one criteria / option over the other equivalent to 5 or 6 in the AHP importance scale.	75 / 25
Very Much Stronger (VMS) / Very Much Weaker (VMW)	Extreme importance of one criteria / option over the other equivalent to 8 or 9 in the AHP importance scale.	90 / 10

Table 7.3: Explanation of Phrasing Adopted for Pairwise Comparison

Using this transposed scoring system made it simpler and, more importantly, more effective at capturing the mind-set and feeling of the attendees at the workshops. Phrases such as 'what are the relative merits of pipeline removal on a project versus rock dumping from a safety perspective? Are these Neutral to each other? Are they stronger? If so, how much stronger? If you had to prioritise one over the other, which would it be?' This promoted a collaborative dynamic in the workshop and enabled the collective mind-set of the attendees to be captured. Where there was quantitative data to provide back-up and evidence to support the collective assertions, so much the better.

A summary example of the completed pair-wise comparisons for differentiating criteria versus options are shown in Figure 7.2.

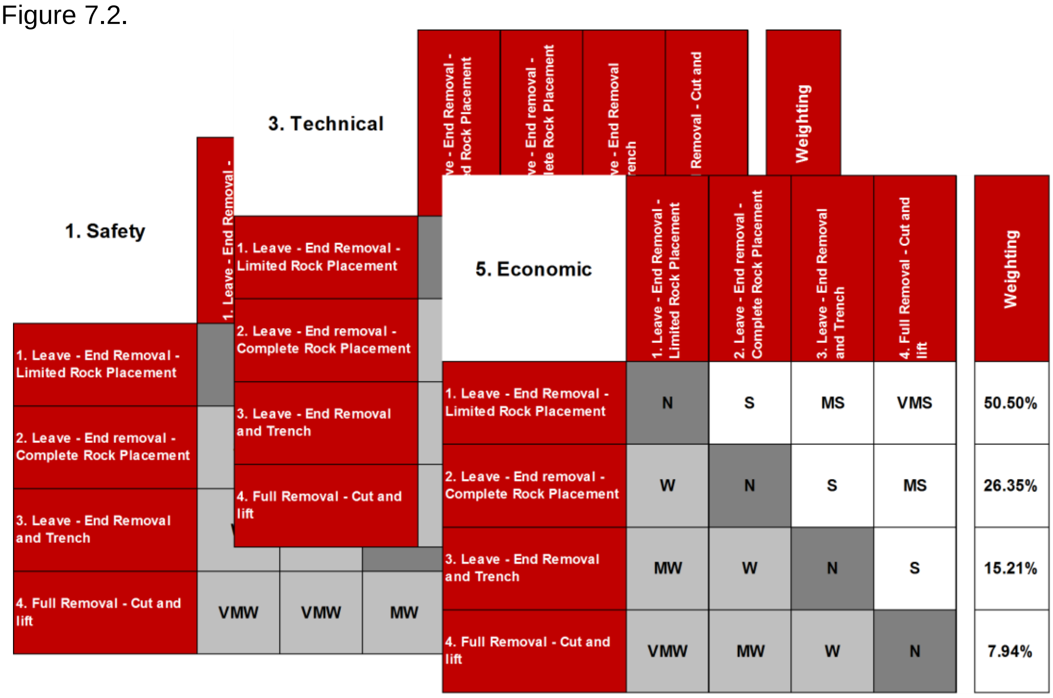


Figure 7.2: Example Option Pair-Wise Comparison

Appendix A.6 Visual Output and Sensitivities

The decision-making tool used the above pairwise comparisons to automatically generate a visual output indicating the highest scoring option i.e. the option which represents the most 'successful' solution in terms of its overall contribution to the set of differentiating criteria. At this stage, opportunity was provided to fine tune the judgements provided, to ensure that all attendees were happy to endorse the outcome. The visual outputs from each decision point are included in Appendix C. An example of the visual output obtained is shown in Figure 7.3.

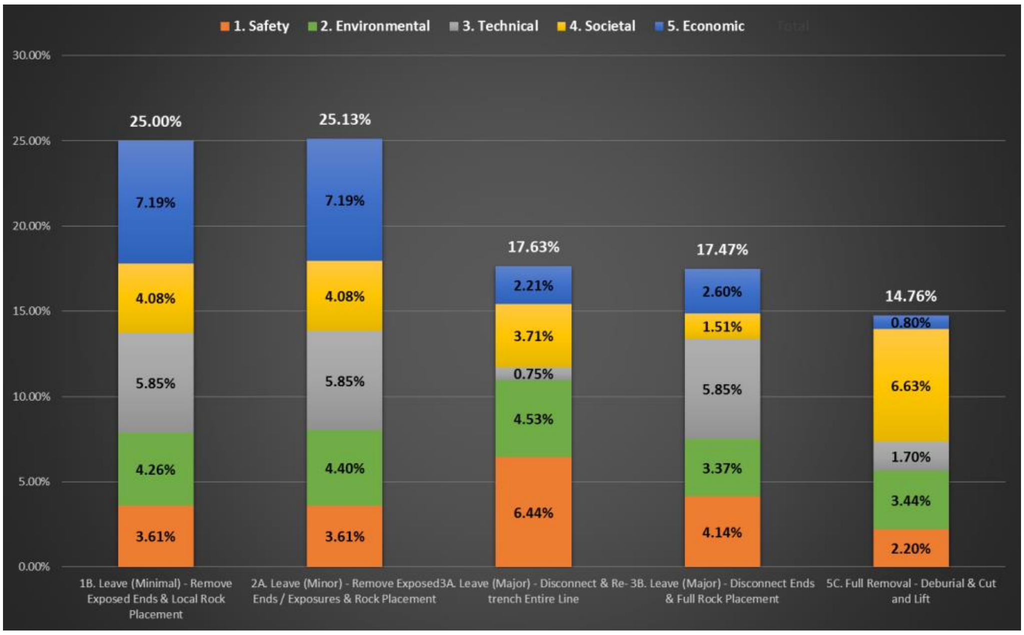


Figure 7.3: CA Visual Output Example

The CA output can then easily be stress tested by the workshop attendees by undertaking a sensitivity analysis:

- By applying a modification to the weighting of the criteria – bearing in mind that the base case for this assessment is to have all criteria equally weighted, and / or
- Modifying the pair-wise comparison of the options against each other within the criteria where appropriate.

These sensitivities will help inform workshop attendees as to whether a particular aspect is driving a preferred option, or indeed if the preferred option remains the same when the sensitivities are applied.

Appendix A.7 Ground Rules & Assumptions

A number of ground rules were adopted in performing the CA evaluation of the CGBS and the Cell Contents. These are:

- All data considered valid and shall be used. Where concerns are raised regarding the validity of the data this shall be flagged and taken offline for discussion and rectification where appropriate.
- Where there is significant difficulty in reaching a consensus, a sensitivity shall be performed against the differing positions.
- Some option attributes may be considered very similar (i.e. noise / emissions), however where a judgement can be made that justifies a departure from Neutral, this should be taken. This is a Comparison rather than an absolute score.

- In performing a comparison of the options from an economic perspective, the estimated costs shall be used.
- There are two on-going potential impacts to fishing. High impacts such as loss of vessel, loss of life, which are considered under the Safety criterion. Lower impacts such as net damage / loss, which are considered under the Societal criterion.

Appendix A.8 Key Assumptions

A number of assumptions were made in the course of performing the CA. These were:

- It is recognised that there is a responsibility for the substructure and its contents in perpetuity, however for the purposes of comparing options, on-going monitoring is calculated over a 50 year time frame for all options.
- All decommissioning activities are considered largely comparable to normal offshore and onshore construction and deconstruction activities. As such, Fatal Accident Rates (FARs) used in deriving Potential for Loss of Life (PLL) metrics are considered to include the impact of dropped objects within those operations.

Appendix A.9 CGBS Additional Assumptions

A variety of additional assumptions applicable to the CGBS scope have been made. These are shown below, along with the CGBS option number(s) that the assumption applies to.

No.	Applicable Options	Assumption
1	All	CA completed in accordance with current (2017) industry legislation and guidelines
2	All	Leg internal works completed whilst topsides is in place
3	All	All leg internal removals will be piece small removed up and out which is worst case resource usage. Lowering material into remaining leg section or removal with concrete by tying in will be optimisation options analysed during FEED
4	All	All leg internals below the final cut line will remain
5	All	Drill cuttings are below OSPAR (2006/5) threshold levels and will remain in place (unless option 4 were selected and removal is Fait Accompli)
6	All	Conductors will be removed to 74 m below LAT (unless option 4 were selected and removal will be to 3 m below seabed).
7	All	Upper two guide frames will be removed to 74 m below LAT leaving lower conductor guide frame in place (unless option 4 were selected and removal will be to 3 m below seabed).
8	All	Energy and emissions derived from vessel days, onshore transportation and onshore manufacturer/processing using Xodus environmental norms (using IoP 2000 and UKOOA 2008 guidelines) for each activity/equipment/vessel type
9	All	Option sub-activities will be assessed in isolation rather on a campaign basis (e.g. no economies of scale)
10	All	Underwater noise derived from vessel time and underwater cutting duration using Xodus environmental norms
11	All	Labour durations derived from ‘on tool’ exposure using Xodus norms
12	All	PLL’s & FAR derived from labour groups and duration / exposure levels against HSE Safetec industry norms
13	All	PLL for all leg internal work is taken from the Abseilor work group
14	All	Labour costs include Non Productive Time and Indirects

No.	Applicable Options	Assumption
15	All	Societal risks (other users of the sea) taken from Anatec reports
16	All	Costs estimated in money of the day, and as most likely known cost (i.e. no contingency added, however estimated Waiting on Weather (WOW) will be included, along with Facility Running Costs if work is extended to beyond scheduled execution durations)
17	All	Costs are Order of Magnitude for CA option selection purposes
18	All	Decommissioned materials will be transported by road from onshore decommissioning yard 150 km (round trip) to final disposal point. Lorry fuel use is based on DEFRA guidelines 2005
19	All	Drill cutting offloading at quayside would take 12 hours per trip
20	6 / 5 / 9	Require an OSPAR derogation
21	5 / 9	Navaid maintenance completed for 50 years (until ~2070)
22	5 / 9	500 m safety zone remains in place for fishing in perpetuity (option 6 would remove safety zones for non-fishing vessels)
23	6 / 5 / 9	For CA purposes no remedial works post decommissioning (~2020+) should a failure occur
24	4 / 6 / 5	HLV / Subsea work is seasonal (Option 9 can support all year round working)
25	4 / 6 / 5	No underwater explosives will be used
26	4 / 6 / 5	No leg shear restraints will be added to prevent lateral movement during/after each cut
27	4 / 6 / 5	Shallow cut is between 8 m below LAT and 20 m below LAT to improve ROV and air diver operability in tidal zone (lower is better) this affects option 5 navaid tower performance as upper ring beam will likely be removed
28	6 / 5	Underwater cutting (shallow and IMO compliant) is achievable albeit not proven (leg internals within the cut zone will be cleared)
29	5	HLV will hold the leg section whilst cut is performed (shallow cut only)
30	4 / 6	HLV will not hold the leg section whilst the IMO compliant cut is performed
31	6	Each leg would be removed in two pieces (transitions +23 m to shallow cut, and upper leg shallow cut to IMO compliant cut)
32	6 / 5	Cut legs will be left open to sea and not capped/plugged
33	5 / 9	One Navaid will be installed at minimum 14 m above LAT and of an AtoN type as buoys are not recommended by the NLB
34	9	Steel through the splash zone is acceptable
35	9	Legs will be flooded to +70 m prior to topsides removal
36	9	Legs will be sealed at +23 m to prevent water ingress (part of topside scope)
37	9	Transitions will degrade in line with the first leg concrete failure at 20 m below LAT (circa 250 yrs)
38	4	Leg removal from 55 m below LAT to 119 m below LAT (64 m) will be one piece per leg
39	4	Full removal option analysed separately and not loaded into MCDA software due to enormity of resources overshadowing the other options
40	4	Cell caisson cutting times derived from CUT estimates for leg cutting
41	4	Under cell to seabed grouting volume and status is unknown (OSPAR 98/3 does not require anything under the seabed to be removed)

Table 7.4: CGBS Additional Assumptions

Appendix A.10 Cell Contents Additional Assumptions

A variety of additional assumptions applicable to the Cell Contents scope have been made. These are shown below, along with the Cell Contents option number(s) that the assumption applies to.

No.	Applicable Options	Assumption
Mobile Hydrocarbons		
1	1 / 2 / 3 / 4	There is no emulsion present within the cells. Product in the storage cells had been settling out for over two years prior to the attic oil removal operations and there were no reports of problems with emulsion layers during the historical operations previously. In reality, there may be a minimal volume that could increase the volume of free oil within the cells.
2	1 / 2 / 3 / 4	The CO_2 utilised to displace the oil was evenly distributed across the cells and therefore residual oil is evenly distributed. This is supported by the dynamic modelling work undertaken.
3	1 / 2 / 3 / 4	Upon completion of the Attic Oil recovery Project (AORP) there would have been a residual layer of oil present between the gas and water interfaces with a depth of 10 cm across all the cells. This is in addition to the hydrodynamic oil created during flowing conditions.
4	1 / 2 / 3 / 4	The calculations assume one cell (No 16) is oil free due to the leak into Leg A reducing the oil inventory.
5	1 / 2 / 3 / 4	The diffusion rate of oil from the sediment in the bottom of the cell and the waxy wall residues will be similar to the rate of oil loss from a cuttings pile.
Sediment		
6	1 / 2 / 3 / 4	Concentrations of metals within the oil are assumed to be between that of oil sampled from Sullom Voe and the limited data available from samples of the Dunlin wells.
7	1 / 2 / 3 / 4	Available data for sand can be used to establish a value which is representative of the period of interest, accommodating changes over time for water cut and production rate.
8	1 / 2 / 3 / 4	Any solids content transported into the cells or created within the cells is not transported back out by either the water phase or the oil export systems.
9	1 / 2 / 3 / 4	No sediment accumulation is present within the Conductor Cell Group.
10	1 / 2 / 3 / 4	Scale would not have acted as a carried for wax and oil deposition in the sediment layer, as it is assumed that scale would only form below the bulk oil layer.
11	1 / 2 / 3 / 4	During production system shutdowns, the topsides vessels would periodically be entered to recover built-up solids materials. No records on these operations historically are now available, but it is assumed that the materials recovered were either treated on-site and discharged overboard or containerised and brought back to shore for disposal. No materials we disposed of within the storage cells.
12	1 / 2 / 3 / 4	Clay content is similar to the clay fractions (size <2 μm) reported for the Dunlin Alpha separators and Sullom Voe storage tank sludge deposits.
13	1 / 2 / 3 / 4	During the initial production period it is assumed that the produced water was composed of unmodified reservoir formation water, such that Barium and Strontium entered the cells at formation concentrations.
14	1 / 2 / 3 / 4	In applying an average value for the Barium and Strontium concentrations across wells, there is an implicit assumption that all wells will be producing at the average produced water flowrate. In practice, wells with highest Barium and Strontium concentration (i.e. before injection water breakthrough) will have lower produced water throughput, the effect of this assumption will be to overestimate Barium and Strontium availability in the cells.
15	1 / 2 / 3 / 4	Sulphate scale formation can only occur in the storage cells when seawater is present.
16	1 / 2 / 3 / 4	The sulphate concentration of seawater is not limiting (i.e. if any seawater is present all Barium and Strontium will be precipitated).

No.	Applicable Options	Assumption
17	1 / 2 / 3 / 4	The presence of seawater resulted in availability of sulphate. However, the water within the storage cells would have been anoxic for much of the time, and thus the sulphate would have converted to sulphide, decreasing the sulphate availability for deposition of Barium or Strontium Sulphate scale. The assumption of complete sulphate availability is therefore conservative.
18	1 / 2 / 3 / 4	Carbonate has only been precipitated as a result of pH changes during the AORP.
19	1 / 2 / 3 / 4	Sand is not a significant carrier of trace metals and acts as a diluent.
20	1 / 2 / 3 / 4	NORM is associated with scales only. From the sample results, 228 Ra activity was not reported therefore it was assumed that this isotope is in secular equilibrium with its short lived (6.13 h) daughter 228 Ac. For those samples which were below the screening limit of 3 cps, an activity of 33% of the mean of the assessed samples was assumed.
21	1 / 2 / 3 / 4	Data for metals in deep sea clays provide representative concentrations for metals in geologically derived clays.
22	1 / 2 / 3 / 4	Marine authigenic deposits (hydrothermal and ferro-manganese deposits) provide representative values for metals in scales.
Wall Residue		
23	1 / 2 / 3 / 4	For the purposes of thermal modelling to estimate the wax deposition a maximum fluid temperature of 39°C was used (which is the structural limit for fluids entering the cells).
24	1 / 2 / 3 / 4	For the purposes of thermal modelling to estimate the wax deposition a seawater temperature was taken to be 4°C (minimum annual temperature).
25	1 / 2 / 3 / 4	The internal heat transfer coefficient was assumed to be given by that for natural convection. The Best Estimate calculation assumes natural convection under laminar flow conditions. Under turbulent conditions both heat and mass transfer coefficients are higher. The higher heat transfer coefficient will tend to reduce the temperature difference between oil and wall, thereby reducing deposition, whereas the greater mass transfer coefficient will increase deposition. For the Upper Bound calculation, a turbulent convection was used under conditions which gave a higher net deposition rate. This was applied to the 'Fill' and 'Discharge' elements of a typical batch cycle for a cell group.
26	1 / 2 / 3 / 4	The calculation was carried out for a single mixture which represents the average blend of well fluids over the period the cells were in continuous use. The blend was derived from the total production from Upper and Lower parts of the reservoir and produced water.
27	1 / 2 / 3 / 4	Wax deposition is dominated by the external walls of the cells. Temperature gradient across the internal walls would be insignificant by comparison and much of the heat transfer between inner and outer cells would be by movement of fluids through the oil and water ports at top and bottom of the cells.
28	1 / 2 / 3 / 4	The wax deposited on the initial (first use) warm up of the storage cells was included in the calculation, on the external walls and on the roof of the cells.
29	1 / 2 / 3 / 4	There is no additional wax deposition as a result of the temperature gradient between the storage cell groups and the Conductor Cell Group. Similarly, the wax deposition rate is assumed to not be affected by insulating effects of the drill cuttings pile.
30	1 / 2 / 3 / 4	The wax deposits are assumed to have the same component composition as crude oil.
Water Phase		
31	1 / 2 / 3 / 4	Calculations assume that the storage cells were entirely filled with seawater following the attic oil recovery.
32	1 / 2 / 3 / 4	All sulphate, originating from seawater in the cells, has been converted to dissolved sulphide.
33	1 / 2 / 3 / 4	All Ammonium Chloride added during the AORP is present as un-ionised ammonia.

No.	Applicable Options	Assumption
34	1 / 2 / 3 / 4	Metals are present at the concentrations reported in the literature [Chemical Oceanography 2nd Edition by F. J. Millero and Marine Geochemistry by R. Chester] for dissolved metal enrichment at oxic/anoxic boundaries. Metals which are not significantly enriched above seawater concentration under these conditions are excluded.
35	1 / 2 / 3 / 4	The water phase is saturated with Benzene, Toluene, Ethylbenzene and Xylene (BTEX) components. BTEX components represent the components of the dissolved phase hydrocarbons which are both appreciably soluble and potentially toxic. It is assumed that other OSPAR-regulated components of the deposited material (e.g. PAHs) are not soluble.
36	1 / 2 / 3 / 4	The Total Hydrocarbon Content of the water phase will be variable however an average of 40 mg/l has been assumed. This is considered to be conservative as the amount of hydrocarbon contamination in the other phases is small in comparison to the volume of the water phase.
Cell Access		
37	1 / 2 / 3	Some disturbance/removal of the drill cutting on the cell tops will be required to achieve access to execute the cell management option.
38	1 / 2 / 3	Existing industry capability of drilling small hole (~2 7/8 inches) in cell tops (Enpro Technology) can be engineered to scale up a larger hole in cell tops (around 5 inches).
39	1 / 2 / 3	Creation of the new cell access point will be executed from a vessel and can be performed by ROV with no diver intervention.
40	1 / 2 / 3	Creation of the new cell access point will take 6 days for a small hole and 7 day for a larger hole (per cell).
Cell Contents Management Options Execution		
41	1 / 2 / 3	Time to recover mobile oil and water phases is based on flowrates of 3 m^3/h for a small access hole, 5 m^3/h and for a large access hole)
42	1 / 2 / 3	Time to recover sediment is based on flowrates of 5.6 m^3/h
43	1 / 2 / 3	Time to recover wall residue is based on flowrates of 0.053 m^3/h
44	1 / 2 / 3	The duration of work in any campaign to manage the cell contents is limited to maximum of 180 days.
45	1 / 2 / 3	Where cell contents management scopes are carried out over an extended period is assumed that the vessels and crew would return to the port every three weeks to replenish supplies and crew change.
46	1 / 2 / 3	Indirect cell access to neighbouring cells from an externally accessed 'hub' cell is achievable in order to recover the mobile oil.
Cell Contents Release Scenario		
47	1 / 2 / 3 / 4	Conservative worst case release is based on loss of containment from four of the cells.
48	1 / 2 / 3 / 4	Environmental modelling uses the metocean conditions which give the highest potential beaching scenario, which may not reflect actual conditions during release.

Table 7.5: Cell Contents Additional Assumptions

APPENDIX B CA EVALUATION WORKSHOP MINUTES

Fairfield Energy Limited

(Registered No. 5562373)

Minutes

Meeting Name:	Dunlin Alpha Installation Decommissioning - Comparative Assessment Workshop
Date:	9th March 2018
Venue:	Fairfield, Westhill

Participants:	Louise Pell-Walpole	Joint Nature Conservation Committee (JNCC)
	Raymond Hall	Scottish Fishermen's Federation (SFF)
	Peter West	Scottish Fishermen's Federation
	Dr Peter Hayes	Marine Scotland (MS)
	Peter Douglas	Northern Lighthouse Board (NLB)
	Peter Lee	Fairfield Energy Limited (FEL)
	Jeff Burns	Fairfield Energy Limited
	Gary Owen	Fairfield Energy Limited
	Harry Yorston	Fairfield Energy Limited
	John Foreman	Xodus
	Caroline Laurenson	Xodus
	Kenneth Couston	Xodus
	Rebecca Alan	Xodus
	Tony Millais	Xodus
	Philip Walker	Atkins
Observers:	Debbie Taylor	Offshore Petroleum Regulator for Environment and Decommissioning – Offshore Decommissioning Unit (ODU)
	Lisa Yates	
	Ben Bryant	Offshore Petroleum Regulator for Environment and Decommissioning – Environmental Management Team (EMT)
	Ian Fozdar	Oil and Gas Authority (OGA)
	Alan Ransom	Oil and Gas Authority
	June Calder	Health and Safety Executive (HSE)
	Ruby Lowe	Independent Review Group (IRG)
	Graham McNeillie	Independent Review Group
	George Fleming	Independent Review Group
	Martin Muncer	Independent Review Group
	Carol Barbone	Fairfield Energy Limited

Note: A list of the studies used as the basis of the comparative assessment evaluation is included at Appendix 1.

Actions

1. PURPOSE OF THE MEETING

The purpose of the workshop was to perform a comparative assessment (CA) evaluation of the options to decommission the Dunlin Alpha concrete gravity based structure (CGBS) and its cell contents. The objective of the meeting was to identify "preferred options" in the form of emerging recommendations. The emerging recommendations will be tested with the wider stakeholder audience at a workshop to be held on May 3rd 2018 prior to the preparation of a Draft Decommissioning Programme for statutory and public consultation.

2. INTRODUCTIONS

Peter Lee (PL) thanked the workshop attendees for taking time to contribute to the workshop, reading the studies and reports issued in advance and ongoing engagement. It was explained that in addition to active participants at today's workshop, there are observers present from the OGA, OPRED, HSE and the IRG. PL advised that there will be a further engagement workshop in May 2018 with a wider group of stakeholders at which the outcome of today's meeting would be discussed.

3. SETTING THE SCENE – CONCRETE GRAVITY BASED STRUCTURE (CGBS)

PL described the construction and dimensions of the CGBS and decommissioning options. In 2015 FEL identified nine options to decommission the CGBS. Following extensive studies, five of the nine were screened out ahead of the formal CA Evaluation Workshop as part of the ongoing CA process :

- Option 1, re-use in-situ, was screened out as there are no further hydrocarbon reserves to develop
- Option 2, re-use elsewhere, was screened out as it is not practical to re-float the CGBS due to integrity concerns
- Option 3, destruct elsewhere, was screened out as it is not practical to re-float the CGBS due to integrity concerns
- Option 7, removal of legs at cell tops, was screened out as too technically challenging and OPRED confirmed that the legs may not be toppled onto the seabed as it would be classified as dumping at sea which is not permissible given the legislation
- Option 8, leaving the CGBS in-situ including the module support frame (MSF), was screened out as leaving the MSF in place provides no material benefit when compared to removal from a leg longevity perspective and has the added burden of ongoing monitoring and maintenance

Four options were brought forward to the evaluation phase of the CA:

- Option 4, full removal, in-situ destruct
- Option 5, shallow subsea cut at between -8m and -20m below the transition pieces and installation of a concrete monotower with navaid
- Option 6, IMO compliant, shallow cut followed by a deep subsea cut at -55m
- Option 9, no subsea cut, retain transition pieces and installation of a navaid on one of the transition pieces

PL described each of the four options in detail and explained that for the purposes of the CA Evaluation Workshop Options 5, 6 and 9 will be compared against each-other and the most preferred leave in-situ derogation option compared against Option 4. PL explained that the reasoning is that Option 4 is at the extreme end of the scale of the CA evaluation process when compared against the leave in-situ derogation options due to requiring more than 40 years of seasonal Remote Operated Vehicle (ROV) work to destruct the CGBS at a rate of about 2-3 cells per year. PL stated that where relevant 50 years of future monitoring and remedial costs have been included in the economics of each option.

The degradation of the concrete legs is expected to occur some several hundred years from now. The integrity of the storage cells is assumed to last for more than a thousand years before breaking up due to spalling of the concrete.

PL further explained that it is assumed that, for all but the full removal option, the 45 well conductors will be removed down to the lower conductor guide frame (CGF) at -75m to avoid disturbing the drill cuttings pile on top of the cells. The lower CGF also provides support for the remaining conductor stubs. The Scottish Fishermen's Federation (SFF) asked if the remaining stubs of the conductors would break up over time. PL responded that this was unlikely to occur within 200 years as the lower CGF provides substantial protection to the stubs, there is much less environmental loading at -75m, corrosion levels are significantly lower at -75m and an additional anode skid (sacrificial anodes used to provide cathodic protection to structures) was installed in 2014.

MS observed that the possibility of toppling the CGBS legs had been proposed by a stakeholder at the Dunlin Alpha Decommissioning Stakeholder Workshop on November 8th 2017. PL responded that OPRED have confirmed that this option is not permissible as it constitutes dumping at sea as well as being significantly technically challenging which may lead to an uncertain outcome.

JNCC asked if undertaking Option 6 (the deep-cut) could damage the storage cells during the removal process and potentially cause environmental contamination through release of contents into the water column and onto the surrounding seabed. PL responded that the programme would be managed to minimise the risk of that outcome.

OPRED EMT asked why the proposed monotower for a navaid for Option 5 is to be made of concrete. Atkins explained that concrete is preferred for longevity.

HSE asked who will undertake the leg cutting trials in the event of Options 5 or 6 being selected. PL responded that CUT UK are recognised industry experts and will undertake the trials.

PL gave an outline of the 24 studies undertaken to inform the CA process.

MS asked if there were contingency plans for the deep-cut and total removal options should they fail. PL responded that the possibility of early failure is recognised in the technical evaluation of each option. The probability of such an outcome is low and does not drive the decision but the Operator would have to undertake remedial operations should it occur.

MS asked which of the two options with navaids would be more prone to early failure. Atkins advised that both options have technical challenges but that Option 5 has greater project technical risk than Option 9, attributed to the installation and connection of the tower to the cut leg.

SFF asked if FEL had studied leg strength in the splash-zone. PL replied that studies estimated that the legs have a life expectancy of 250 years towards the top of the legs, 1,000 years lower down the legs and up to 1,400 years at the bottom of the legs. Study 21 assesses leg life expectancy in relation to fishing impact. PL pointed out that there are uncertainties in relation to the life expectancy of the concrete legs as it is a relatively new material to be used in this way in a the marine environment and there are no precedents.

4. COMPARATIVE ASSESSMENT EVALUATION

Xodus described the CA process and confirmed that it is aligned to the Guidelines for Comparative Assessment in Decommissioning Programmes published by Oil and Gas UK. It is the same process as previously used for the Greater Dunlin Area subsea infrastructure. The primary evaluation criteria are aligned to the OPRED and OGUK Guidelines, namely Safety, Environmental, Technical, Societal and Economics. The options have been assessed against these criteria using the Xodus Evaluation Methodology based upon the principles of the Analytical Hierarchy Process and the principles of pair-wise assessment. It was explained that the CA evaluation tool had been pre-populated ahead of the meeting based on the 29 studies but that attendees were invited to challenge the scoring. PL offered to start with a blank score-sheet if the workshop participants preferred but all agreed it was better to use the pre-populated sheet providing that challenge was welcome.

SFF commented that the CA process used was more complicated than they have previously experienced with other Operators and requested careful explanation of each criterion's results.

At this stage the HSE, OPRED and OGA reiterated that they were in attendance in an observer capacity.

4.1 CONCRETE GRAVITY BASED STRUCTURE (CGBS)

4.1.1 Safety

The Safety criterion was subdivided into Operational Personnel, Other Users and Legacy Risk. Xodus explained the key safety considerations used to assess each sub-criteria and it was observed that each sub-criteria may have conflicting outcomes.

HSE commented that it was useful to see the process that had been undertaken to assess safety risk and asked if onshore risk had been included in the assessment. PL confirmed the analysis included onshore and offshore personnel and that appropriate Potential for Loss of Life (PLL) metrics have been used for each role.

HSE asked which "Other Users" were included in the analysis. PL explained that any additional vessels in the Dunlin vicinity such as fishing and merchant shipping had been included.

JNCC asked if transit time for vessels was included in the analysis. PL confirmed that it is and that vessel time is broadly split as 80% within the 500m safety and 20% in transit.

SFF asked where the data had been sourced for fishing vessel activity. PL replied that the data had been sourced from an Anatec report.

IRG and JNCC proposed that fishing vessel collision risk and snagging risk should be equally weighted within the Other Users sub-criterion as there is no risk of collision with Option 6. Xodus responded that collision risk is not significant versus snagging risk so should be less of a contributor to the overall legacy risk assessment.

SFF asked if it is assumed that the 500m safety exclusion zone will remain for any of the options considered. PL responded that Fairfield understands that the safety zone will continue for options 5 and 9 where the remaining infrastructure breaks the sea surface. OPRED and MS confirmed this conclusion.

OGA requested that FEL repeat the safety analysis assuming that there will not be a 500m safety exclusion zone in the future. **FEL**

SFF stated that the Oil and Gas industry was originally granted temporary access to the North Sea to develop hydrocarbons and that an undertaking was made to return the seabed to its original state. A permanent 500m safety exclusion zone would limit access to fishing grounds, an issue which is made worse by the cumulative impact across multiple installations. PL acknowledged this comment and replied that assessment of returning access to fishing grounds is included in the Societal criterion.

SFF further commented that Option 6 removes any potential for collision and the need for a safety exclusion zone.

In response to a question on the height of the navaid tower, Atkins confirmed that it would be sufficiently high to be seen in all weathers and wave-heights.

MS asked if ongoing maintenance is allowed for in Options 5 and 9. PL confirmed that a defined monitoring and maintenance programme for fifty years has been included in the economics, although this would not preclude intervention at any stage after that should it be required. PL also clarified to the HSE that no personnel will be required to land on the substructure for monitoring and maintenance purposes as all work will be undertaken from a helicopter.

The workshop participants agreed that, on the basis of the study data supporting the CA, Option 9 was the safest option although the SFF stated this is not their preferred option.

4.1.2 Environmental

The Environmental Criterion was subdivided into Operational Marine Impacts, Atmospheric Emissions / Consumptions and Legacy Marine Impacts. Xodus summarised the key environmental considerations.

HSE queried the number of hours assumed for leg cutting as it appeared light. PL replied that FEL are confident in the estimate of hours and explained that the hours reflected operational time only and that significant additional time will be required to set-up and dismantle the cutting equipment.

JNCC observed that the noise impact of the cutting process will be very temporary and asked if there is any chance that the cutting process might disturb the drill cuttings pile on top of the cells. PL said that would not happen.

MS asked that that the supporting analysis be updated to reflect that increasing the number of cuts and lifts increases the chance of dropped objects potentially impacting the cells. The resulting effect in terms of environmental impact due to distribution of the drill cuttings onto the neighbouring seabed should also be defined. **FEL**

IRG asked FEL to consider that the CA Report includes reference data for emitters of CO2, to put the emissions from the proposed activities into context. **FEL**

MS questioned whether the risk of large fallen objects from Options 5 and 9 should be considered in legacy impacts. PL stated that the fate of the legs would be through spalling and long term degradation rather than collapse.

IRG suggested that photographs and diagrams be added to the CA report to illustrate the spalling effect which will degrade the concrete legs over the next 250-1,000 years. **FEL**

The workshop participants agreed that, on the basis of the study data supporting the CA, Option 9 was the most environmentally considerate option.

4.1.3 Technical

Xodus summarised the key technical challenges.

SFF observed that the key technical challenge was that concrete leg cutting in a marine environment has yet to be done and there is no obvious drive from Fairfield to prove it can be done. PL responded that the basis of the options definition is that the options are deliverable. SFF further observed that the oil and gas industry overcame similar challenges to explore for and develop hydrocarbons. HSE commented that the market for subsea concrete leg cutting is not large enough to incentivise innovation. OGA commented that just because leg cutting can be done does not mean it should be done – "it is more dangerous".

MS expressed surprise that the deep cut is perceived to be less challenging than the shallow cut. Atkins explained that this was because the shallow cut option requires the connection of a monotower navaid close to the surface which is a more challenging environment to work in than at -55m.

The workshop participants agreed that on the basis of the study data supporting the CA, Option 9 carries the lowest risk of technical failure.

4.1.4 Societal

The Societal Criterion was subdivided into Fishing Industry and Other Groups. Xodus summarised the key societal considerations.

SFF stated that more clarity is required on the future of 500m safety exclusion zones for decommissioned installations. HSE explained that safety exclusion zones are the responsibility of multiple Government Departments and that the assumption must be that they will remain post-decommissioning for Options 5 and 9. SFF stated that Option 6 is their preferred option as a deep cut removes the risk of collision and the exclusion zone. If the CGBS legs remain in-situ then SFF preference is that all four legs remain above the water i.e. Option 9.

OGA and IRG expressed concerns that the onshore jobs created through Option 6 were at the expense of significant volumes of scrap steel and concrete being brought ashore and was not a benefit to society. HSE countered that is was a benefit to local communities. Jeff Burns (JB) added that the potential contamination of concrete, including salt content, meant that it was not a desirable material to be re-used for creating aggregate. HSE asked if SEPA had been consulted. JB stated that SEPA have been engaged on waste management in general and that the issue of concrete mattresses had been discussed. IRG observed that the option of landfill will disappear in line with Scottish Government policy. It was agreed that job creation or retention must be balanced against materials returned to shore that have no benefit and are destined for landfill.

The workshop participants agreed that on the basis of the study data supporting the CA, Option 6 delivered the most societal benefits dominated by the impact on the fishing industry.

4.1.5 Economics

Xodus summarised the key economic considerations.

HSE asked if for Option 9 the leg internals will be coated after decommissioning is complete. PL confirmed that leg preparations will be undertaken before the topsides are removed.

JNCC asked if the phasing of expenditures had been considered as relevant. PL responded that the cash-flows have not been discounted but if they were it would further enhance Option 9.

The workshop participants agreed that on the basis of the study data supporting the CA, Option 9 was the most economic.

4.1.6 Summary

The overall result, based on each criterion having equal weighting, was that Option 9 scored 47.7%, Option 5 scored 26.3%, and Option 6 scored 26.1%. Therefore Option 9 (no subsea cut, retain transition pieces and installation of a navaid) was the most preferred leave in situ derogation option. SFF acknowledged that the outcome was clear but stated that it is dependent on the 500m safety exclusion zone remaining in place. It was observed that Options 6 and 5 are very close and in fact the scoring shows no real differentiation between the two when all criteria are considered.

NLB asked about the life expectancy of the steel transition pieces. PL advised that they will be prepared to last for around 250 years, this is to effectively match the longevity of the upper section of the concrete legs.

4.1.7 Preferred Leave In-Situ Derogation Case versus Option 4 – Full Removal

Option 9 was compared against Option 4, Full Removal.

For safety it was calculated that the PLL of Option 4 is the equivalent of 20 years of platform operations during production.

For environmental impact, JNCC expressed concerns that Option 4 requires the drill cuttings to be disturbed and removed with an associated impact on benthos, particularly since the recovery time of the seabed is unknown. IRG expressed concerns that Option 4 moved the problem of treating and disposing of drill cuttings, including heavy metals, to an onshore environment and agreed that removal disturbance of the seabed would occur. JB confirmed that a small release of trapped hydrocarbons, around 1.5 tonnes per annum, would likely occur over time in Option 4 as each cell is removed, potentially exposing adjacent cells.

PL observed that atmospheric emissions and consumption for Option 4 is the equivalent of 10 years of platform operations during production.

Technical risk for Option 4 was agreed as very much greater than Option 9 as it will require 30-40 years of challenging subsea deconstruction activities with an ROV and recovery to shore for onward processing and disposal.

For Societal Impact JNCC asked if the safety exclusion zone would remain for the duration of the decommissioning activity and therefore limit fishing grounds during this time. PL confirmed that it would. IRG stated that there is not a UK facility capable of handling the waste generated in Option 4. The workshop participants agreed that overall Option 4 was a stronger option than Option 9 as it creates jobs for the duration of the project to remove the CGBS and upon completion the safety exclusion zone could be removed to return the area for fishing. This is offset by the requirement to process and send a large amount of concrete material to landfill and also handling and processing of contaminated drill cuttings.

For economics it was agreed that Option 4 is very much weaker than Option 9 due to the substantial cost differential.

The overall result, based on each criterion having equal weighting, was that Option 9 scored 68.3%, Option 4 scored 31.7%,

Option 9 (no subsea cut, retain transition pieces and installation of a navaid) is therefore the emerging recommendation to be included in the Decommissioning Programme for statutory and public consultation.

4.2 Cell Contents

PL explained that a CA of options for cell contents was relevant for Options 5, 6 and 9 of the CGBS CA. As Option 9 was the emerging recommendation, the workshop participants should now consider the cell contents options.

Caroline Laurenson (CL) presented a summary of the Cell Contents Technical Report and explained the construction, operational history, historic attic oil recovery project and current status. CL stated that the overall remaining volume of mobile hydrocarbons in the tops of the cells is estimated to be 1,565m^3, around 0.6% of the total cell volume with water making up the largest proportion of the internal volume of the cells at 98.6%. The contents of each of 75 cells varies depending on location and proximity to the rundown lines. MS asked if the contents data was obtained by sampling. CL replied that the data is based on studies and dynamic modelling but that there are ongoing investigations to validate the data through sampling.

CL explained that the key considerations for the Cell Contents CA options screening were the volume of drill cuttings on top of the cells, the number of penetrations required for access purposes, the volume of waste that could potentially be extracted and the duration of operations. Approximately 70 options were scoped and four emerged from the screening process:

- Option 1 – high oil and sediment recovery requiring 31 cell penetrations over three offshore activity seasons. In order to gain access to the cells the full drill cuttings pile would need to be removed.
- Option 2 – mid oil and sediment recovery requiring 18 cell penetrations over two offshore activity seasons. Cells outside of the main drill cuttings pile would be targeted to minimise disturbance and requirement to remove drill cuttings.
- Option 3 – mid oil-only recovery requiring 15 cell penetrations over two offshore activity seasons. Cells outside of the main drill cuttings pile would be targeted to minimise disturbance and requirement to remove drill cuttings.
- Option 4 – leave in-situ, with no further physical intervention.

CL summarised the extraction method to be used for each option involving diverless operations.

In response to a question regarding Brent cell contents, CL explained that due to the 2007 attic oil recovery project, Dunlin cells have significantly lower hydrocarbon content and much lower sediment due to lower sand production and reservoir conditions. PL emphasised that Dunlin cell contents must be evaluated on their own merits and not compared with other installations.

Xodus presented the pre-populated CA analysis based on the Cell Contents Technical Report. It was explained that the same process was used as the CGBS although some sub-criteria were different.

4.2.1 Safety

The workshop participants agreed that, on the basis of the study data supporting the CA, Option 4 was the safest option as no offshore activities are required.

4.2.2 Environmental

MS asked what quantity of drill cuttings would require to be removed to access the cells. CL stated that just over 10,000m^3 would be recovered for Option 1, compared with 300-400m^3 for Options 2 and 3. The drill cuttings would be recovered to shore, rather than be moved elsewhere on the seabed. It is estimated that 10% of the oil within the cuttings would decouple during the recovery process. MS stated that it is overly conservative to assume that this quantity of hydrocarbons will be lost into the water column during recovery operations. JNCC asked if the cells could be accessed without moving the drill cuttings. CL explained that was not possible due to the cuttings being too deep. IRG reiterated that there are heavy metals in the drill cuttings and the preference in industry is that they should not be disturbed.

JNCC clarified that although there are noise impacts to mammals associated with Options 1, 2 and 3, it is not significant enough to be a differentiator. JNCC added that removal of the drill cuttings will provide a legacy marine benefit.

JNCC asked if the cells are left in-situ, would an instantaneous contents release occur. PL responded that there is a low probability of a failure scenario and that any release would impact a maximum of four cells. The cells are likely to erode slowly over 100's of years though spalling. The project team have defined scenarios for the likely contents release events, some being instantaneous and others gradual due to exposure of the contents. The environmental modelling has used a conservative basis of 50-100m^3 mobile oil release as an instantaneous event. The conclusions of the environmental impact analysis work has shown that a release of this nature would not be classed as a Major Environmental Incident and would be highly unlikely to require any remedial response. It was noted that for all four options there will be a residual hydrocarbon inventory as recovery of the full inventory is unlikely to be technically feasible.

The workshop participants agreed that, on the basis of the study data supporting the CA, Option 4 was the most environmentally considerate option.

4.2.3 Technical

The workshop participants agreed that on the basis of the study data supporting the CA, Option 4 carries the lowest risk of technical failure.

4.2.4 Societal

The workshop participants agreed that on the basis of the study data supporting the CA, Options 2 and 3 deliver the most societal benefits.

4.2.5 Economics

The workshop participants agreed that on the basis of the study data supporting the CA, Option 4 was the most economic.

4.2.6 Summary

Having reviewed the options, the workshop participants agreed that Option 4 was the emerging recommendation with a CA score of 38.2%. Options 1 to 3 scored in the range 17.5% to 23.1%. It was observed by MS that Option 4 surprisingly scored highest for environmental but this was because of the negative environmental impact of disturbing the drill cuttings for other options.

Given the influence of the drill cuttings on the emerging recommendation, FEL were asked by JNCC to ensure that the evaluation shows how this has been considered and perform a sensitivity to check the CA result as if there were no interaction with the drill cuttings. **FEL**

Related to a previous action identified in the CGBS review, the environmental impact of distribution of the drill cuttings onto the neighbouring seabed should also be defined. This could happen as the structure degrades and sections of concrete become loose and fall into the drill cuttings pile. **FEL**

4.3 Economic Sensitivity

PL commented that the emerging recommendations for the CGBS and Cell Contents do not change if economic considerations are removed from the CA.

Next Steps

PL thanked the meeting attendees for their participation in the CA Evaluation Workshop and associated review of the extensive pre-read materials. Minutes of the meeting would be circulated to those present for comment.

FEL will complete the actions arising from the CA evaluation prior to issuing the CA report on 13th April for review by all stakeholders, not just those present at the current meeting. In particular FEL will assess the impact on the CA outcome of removing the 500m safety exclusion zone from Options 5 and 9 for the CGBS and similarly assess the CA outcome should the influence of the drill cuttings be removed from the option assessment for the Cell Contents.

A wider stakeholder engagement workshop will be held on 3rd May to explore the emerging recommendations. The Draft Decommissioning Programme will then be prepared and subsequently issued for public consultation during Q3 2018.

Appendix 1: Comparative Assessment Evaluation Supporting Studies

ID	Study Topic	Author, Document Number, Revision & Date
1	Leg Internals Study	Fairfield – CGBS Studies – Study 1 – Leg Internals Study, Doc. No.: FBL-DUN-DUNA-MSH-01-TCN-00008, Rev: A6, Dated: 10/01/18
3	Seabird Colonisation	Xodus - Dunlin CA Studies – Seabird Colonisation Study A-301649-S08-REPT-001, Rev: A02, Dated: 13/10/17
4	Transition Piece Study	Atkins – CGBS Studies for CA – Study 4 – Transition Piece, Doc. No.: 5153952-REP-ST-004-001, Rev: A5, Dated: 03/11/17
4a	Transition Longevity Study	Atkins – CGBS Studies for CA – Study 4a – Transition Piece Longevity, Doc. No.: 5153952-REP-ST-100, Rev: A5, Dated: 20/12/17
5	Navaid Study	Atkins – CGBS Studies for CA – Study 5 – Aids for Navigation, Doc. No.: 5153952-REP-ST-005-001, Rev: A5, Dated: 20/12/17
6	Concrete Cutting & Removal Study	Atkins – CGBS Studies for CA – Study 6 – Concrete Cutting & Removal, Doc. No: 5153952-REP-ST-006-001, Rev: A6, Dated: 20/12/17
8	Leg Failure Study	Atkins – CGBS Studies for CA – Study 8 – Leg Failure, Doc. No.: 5153952-REP-ST-008-001, Rev: A4, Dated: 06/11/17
9	Marine Growth Assessment	Xodus – Dunlin CA Studies - Marine Growth Assessment, Doc No: A-301649-S09-REPT-001, Rev: A01, Dated: 21/06/17
10	Marine Impacts – CGBS Full Removal	Xodus – Marine Impacts Associated with Decommissioning of the Dunlin Alpha CGBS, Doc. No.: A-301649-S10-REPT-002, Rev: A02, Dated: 01/02/18
12	Cell-top Debris Study	Xodus – Cell-top Debris Study, Doc. No.: A-301649-S12-REPT-001, Rev: A03, Dated: 26/10/17
14	Safety Summary	Xodus – CGBS Safety Summary, Doc. No.: A-301649-S06-REPT-002, Rev: A01, Dated: 12/01/18
16	Corrosion Protection	Frazer-Nash – Dunlin Alpha Transition Piece Corrosion Protection Options Study, Doc No: FNC 55192/45978R, Rev: 2, Dated: 31/05/17
17	Cell Contents Impact Assessment	Intertek-Metoc – Dunlin Alpha Cell Contents Impact Assessment, Doc No: P1215C-RN2478, Rev: 0, Dated: 02/06/11
18	Cell Contents Technical Report	Fairfield – Dunlin Alpha CGBS Cell Contents Technical Report, Doc. No.: FBL-DUN-DUNA-FAC-24-RPT-00001, Rev: A2, Dated: 05/02/18
19	Drill Cuttings Study	Xodus – Drill Cuttings Study, Doc. No.: A-301524-S09-TECH-002, Rev: A05, Dated: 02/02/18
20	Drill Cuttings Survey	Fugro - Dunlin Alpha Pre-Decommissioning Cuttings Assessment Survey UKCS Block 211/23, Doc No: 160120_15 Rev: 5, Dated: 24/08/17
21	Legacy Collision Risk Assessment	Anatec – Shipping and Fishing Decommissioning Risk Assessment, Dunlin Alpha (Block 211/23), Doc. No.: A4045-FE-CR-1, Rev: 02
23	Transition Coating	CAN - Methodology and Cost Estimates for Coating Application to Transition Pieces, Doc No: DA-J6B11632-S-01, Rev: 02, Dated: 24/11/17
24	Leg Cutting Study	CUT - Review of Technologies and Conceptual Methods for Cutting of Dunlin A Concrete Legs, Doc No: UK17016_FS, Rev: 00, Dated: 27/03/17
25	Transition Cutting Study	Fairfield - Methodology for Separation of Dunlin Transition Columns, Doc No: FBL-DUN-DUNA-DTR-38-RPT-00008, Rev A1, Dated 25/05/17
26	Airgap Analysis	Atkins – CGBS Studies for CA - Study 26 - Wave Radar Airgap Analysis, Doc No: 5153'952-REP-ST-026-001, Rev: A1, Dated: 20/12/17
27	Technical Risk Assessment	Atkins – CGBS Studies for CA – Technical Risk Assessment, Doc. No.: 5153952-REP-ST-300, Rev: A2
28	Energy & Emissions Assessment	Xodus – Energy & Emissions Assessment (Study 28), Doc. No.: A-301649-S07-REPT-004, Rev: A05, Dated: 31/01/18

ID	Study Topic	Author, Document Number, Revision & Date
29	Operational Collision Risk Assessment	Anatec – Dunlin Decommissioning: Full Removal Vessel Collision Risk Assessment, Doc. No.: A4045-FE-CRA-1, Rev: 02, Dated 06/12/17
n/a	CA Briefing Document	Xodus - Comparative Assessment Briefing Document, Doc No: A-301649-S07-REPT-002, Rev: A01, Dated:16/02/18

APPENDIX C DETAILED EVALUATION RESULTS

Appendix C.1 CGBS Derogation Options – Attributes Sheets

	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up
	Step 1.1: Leg Internal Scope - internal leg preparations and clearance.	**Step 1.1:** Leg Internal Scope - internal leg preparations and clearance.	**Step 1.1:** Leg Internal Scope - internal leg preparations and clearance.
	Step 1.2: Transition Piece - internal coating	**Step 1.2:** Transition Piece - internal coating	**Step 1.2:** Transition Piece - internal coating
	Step 1.3: Transition Piece - cathodic protection system	**Step 1.3:** Transition Piece - cathodic protection system	**Step 1.3:** Transition Piece - cathodic protection system
	Step 2.0: FEL Owner Costs i.e. FRC	**Step 2.0:** FEL Owner Costs i.e. FRC	**Step 2.0:** FEL Owner Costs i.e. FRC
	Step 3.1: Removal of steel transitions, cut and remove all legs at shallow cut depth.	**Step 3.1:** Removal of steel transitions, cut and remove all legs at shallow cut depth.	**Step 3.1:** Removal of steel transitions, cut and remove all legs at shallow cut depth.
	Step 3.2: Cut and remove all legs at IMO cut depth.	**Step 3.2:** Cut and remove all legs at IMO cut depth.	**Step 3.2:** Cut and remove all legs at IMO cut depth.
	Step 3.3: Cut and remove all legs at cell top.	**Step 3.3:** Cut and remove all legs at cell top.	**Step 3.3:** Cut and remove all legs at cell top.
	Step 4.0: Leg Capping / Transition piece installation.	**Step 4.0:** Leg Capping / Transition piece installation.	**Step 4.0:** Leg Capping / Transition piece installation
	Step 5.0: Install mono-tower and Navaid.	**Step 5.0:** Install mono-tower and Navaid.	**Step 5.0:** Install mono-tower and Navaid.
	Step 6.0: Removal of drill cuttings.	**Step 6.0:** Removal of drill cuttings.	**Step 6.0:** Removal of drill cuttings.
	Step 7.0: Removal of cell-top cell debris.	**Step 7.0:** Removal of cell-top cell debris.	**Step 7.0:** Removal of cell-top cell debris.
	Step 8.0: Removal of cells, base and cell contents.	**Step 8.0:** Removal of cells, base and cell contents.	**Step 8.0:** Removal of cells, base and cell contents.
	Step 9.0: Monitoring, storage and maintenance of Navaid / backup units.	**Step 9.0:** Monitoring, storage and maintenance of Navaid / backup units.	**Step 9.0:** Monitoring, storage and maintenance of Navaid / backup units.
1. Safety – 1.1 Operations Personnel	Offshore:- 233,083 hrs / 1.32E-02 PLL Onshore:- 153,429 hrs / 1.15E-02 PLL **Total option hours:- 386,512** **Total option PLL:- 2.47E-02**	Offshore:- 108,867 hrs / 6.25E-03 PLL Onshore:- 69,760 hrs / 5.66E-03 PLL **Total option hours:- 178,627** **Total option PLL:- 1.19E-02**	Offshore:- 51,664 hrs / 2.57E-03 PLL Onshore:- 10,464 hrs / 1.00E-03 PLL **Total option hours:- 62,128** **Total option PLL:- 3.57E-03**
Comparison	**W** | **VMW**	**MW**	
Summary	The summary Potential for Loss of Life (PLL) metrics for the options are 2.47E-02, 1.19E-02, 3.57E-03 respectively. The assessment of the risk exposure for the various worker groups is as follows: Option 6 is assessed as being Weaker than Option 5 as it is around double the risk exposure. Option 6 is assessed as being Very Much Weaker than Option 9 as it is around 7 times higher risk exposure. Option 5 is assessed as being Much Weaker than Option 9 as it is around 3 times higher risk exposure. Overall, Option 9 would be the preferred option from a risk to operations personnel perspective.		
1. Safety – 1.2 Other Users	HLV: 57.5 Days Tug: 39.5 Days **Total vessel days: 97 days**	HLV: 31 Days Tug: 13 Days CSV/ROV Support: 1 Day **Total vessel days: 45 days**	DSV: 10 Days CSV/ROV Support: 1 Day **Total vessel days: 11 days**
Comparison	**W** | **VMW**	**MW**	
Summary	The assessment of the impact of each of the options on Other Users is largely driven by the durations that vessels are located in the area during the decommissioning works. The assessment is as follows: Option 6 is assessed as being Weaker than Option 5 due to the significantly higher number of days of vessel operations on site. Option 6 is assessed as being Very Much Weaker than Option 9 due to the much higher number of days of vessel operations on site. Option 5 is assessed as being Much Weaker than Option 9 due to the much higher number of days of vessel operations on site. Overall Option 9 would be the preferred option from a risk to other users perspective.		

<table>
<tr><th></th><th></th><th colspan="2">6. IMO Compliant Cut</th><th>5. Shallow Cut</th><th>9. Transitions Up</th></tr>
<tr><td>1. Safety</td><td>1.3 Legacy Risk</td><td colspan="2">Monitoring: No monitoring with this option
Other users:
Fishing Vessel Snagging: 3.15E-02 PLL

Total Legacy PLL: 3.15E-02</td><td>Operations:-
Monitoring: 4,128 hrs / 6.91E-04 PLL

Other users:-
Merchant Vessel Collision: 1.95E-04 PLL
Fishing Vessel Collision: 2.23E-04 PLL
Fishing Vessel Snagging: 1.42E-02 PLL

Total Legacy PLL: 1.53E-02</td><td>Operations:-
Monitoring: 4,128 hrs / 6.91E-04 PLL

Other users:-
Merchant Vessel Collision: 2.02E-04
Fishing Vessel Collision: 3.12E-04
Fishing Vessel Snagging: 1.24E-02

Total Legacy PLL: 1.36E-02</td></tr>
<tr><td colspan="2">Comparison</td><td>W</td><td>W</td><td>N</td><td></td></tr>
<tr><td colspan="2">Summary</td><td colspan="4">The summary Potential for Loss of Life (PLL) metrics associated with the legacy risk for the options are 3.15E-02, 1.53E-02 and 1.36E-03 respectively. The assessment of the risk exposure is as follows:
Option 6 is assessed as being Weaker than Option 5 as it is around double the risk exposure despite there being no collison risk and no associated monitoring risk. Option 6 is assessed as being Weaker than Option 9 as it is also around double the risk exposure.
Option 5 is assessed as being Neutral to Option 9 as the risk exposure is similar.
Overall, Option 5 and 9 would be the equally preferred options from a legacy risk perspective.</td></tr>
<tr><td>2. Environmental</td><td>2.1 Operational Marine Impacts</td><td colspan="2">Concrete leg cutting and lifting operations required as part of this option results in potential for a dropped object leading to cell penetration / drill cuttings disturbance and the associated environmental impact.

Additional Operational Marine Impacts are limited to vessel noise and noise from cutting operations as there may be no requirement to evacuate cell contents or disturb drill cuttings under this option.

Cutting operations are estimated as 48 hrs per leg x 4 (192 hrs) for the shallow water cut and 72 hrs per leg x 4 (288 hrs) for the IMO compliant cut - 480 hrs total.

Overall Cumulative Sound Exposure:-
260 dB re 1mP / 100 TPa2s</td><td>Concrete leg cutting and lifting operations required as part of this option results in potential for a dropped object leading to cell penetration / drill cuttings disturbance and the associated environmental impact.

Additional Operational Marine Impacts are limited to vessel noise and noise from cutting operations as there may be no requirement to evacuate cell contents or disturb drill cuttings under this option.

Cutting operations are estimated as 48 hrs per leg x 4 - 192 hrs total.

Overall Cumulataive Sound Exposure:-
257 db re 1mP / 45 TPa2s</td><td>There is no requirement to evacuate cell contents or disturb drill cuttings under this option so Marine Impacts limited to those related to vessel noise and noise from cutting operations.

No subsea lifting operations.

No cutting operations are associated with this option.

Overall Sound Exposure:-
243 dB re 1mp / 2 TPa2s</td></tr>
<tr><td colspan="2">Comparison</td><td>N</td><td>W</td><td>W</td><td></td></tr>
<tr><td colspan="2">Summary</td><td colspan="4">The assessment of the impact of each of the options in terms of Operational Marine Impacts is driven by the potential for cell penetration / drill cuttings disturbance that may occur due to dropped object during operations. It was determined that the impact from the generated marine noise for each of the options was not a differentiator between the options due to the assessment that the marine noise generated does not exceed the damage threshold for marine mammals (but does exceed the 'nusiance' threshold).
The assessment is as follows:
Option 6 is assessed as being Neutral to Option 5 depsite the cumulative noise exposure being around double this is assessed as an insignificant difference. Option 6 is assessed as being Weaker than Option 9 due to the risk associated with the concrete leg cutting and lifting operations with Option 6.
Option 5 is assessed as being Weaker than Option 9 due to the risk associated with the concrete leg cutting and lifting operations with Option O5.
Overall Option 9 would be the preferred option from a Marine Impact perspective.</td></tr>
</table>

		6. IMO Compliant Cut		5. Shallow Cut	9. Transitions Up
2. Environmental	2.2 Atmospheric Emissions / Consumptions	Overall Emissions:- CO2e: 5,395 tonnes Fuel: 1,647 tonnes		Overall Emissions:- CO2e: 2,906 tonnes Fuel: 887 tonnes	Overall Emissions:- CO2e: 980 tonnes Fuel: 299 tonnes
		N	W	W	
		The assessment of the impact of each of the options in terms of Emissions and Comsumption is as follows: Option 6 is assessed as being Neutral to Option 5 as, whilst the emissions / consumption is around double, this was not considered significant enough to be a differentiator between the options. Option 6 is assessed as being Weaker than Option 9 due to the emissions / consumption is around 5 times higher. Option 5 is assessed as being Weaker than Option 9 due to the emissions / consumption being around 3 times higher. Overall Option 9 would be the preferred option from an Emissions and Consumption perspective.			
2. Environmental	2.3 Legacy Marine Impacts	Potential for legacy marine impacts from seepage of hydrocarbon from remaining in-situ drill cuttings / potential for cell contents seepage over very long durations. This is the same for all remaining options so not a differentiator. Note: There may be an environmental benefit provided by the remain in-situ options from an artificial reef perspective which would act as an offset against any full removal option. This is the same for all leave in-situ options so not a differentiator.		Potential for legacy marine impacts from seepage of hydrocarbon from remaining in-situ drill cuttings / potential for cell contents seepage over very long durations. This is the same for all remaining options so not a differentiator. Note: There may be an environmental benefit provided by the remain in-situ options from an artificial reef perspective which would act as an offset against any full removal option. This is the same for all leave in-situ options so not a differentiator.	Potential for legacy marine impacts from seepage of hydrocarbon from remaining in-situ drill cuttings / potential for cell contents seepage over very long durations. This is the same for all remaining options so not a differentiator. Note: There may be an environmental benefit provided by the remain in-situ options from an artificial reef perspective which would act as an offset against any full removal option. This is the same for all leave in-situ options so not a differentiator.
Comparison		N	N	N	
Summary		The assessment of the Legacy Marine Impact of each of the options is as follows: All options considered largely similar in terms of legacy marine impacts and are scored as Neutral to each other in all cases. All options are equally preferred.			
3. Technical	3.1 Project Technical Risk	Greatest technical risks associated with Option 6 are: • Developed cutting tool for -12m cut fails to pass scale tests. • Developed cutting tool for -55m cut fails to pass scale tests. • The technology development for the cutting tool was scored as a new technology. Cutting through concrete at this scale subsea in the North Sea environment has not been carried out before. • Collapse of shaft during the cutting phase due to adverse weather and excessive wave conditions with the shaft partially cut (beyond the point of no return) resulting in the shaft collapsing onto cells. **Overall Technical Risk Score:- 2.04**		Greatest technical risks associated with Option 5 are: • Developed cutting tool for -12m cut fails to pass scale tests. • Inability to find a solution for a Concrete Navaid Lighthouse Tower due to strength of the leg / loss of the ringbeam. • Collapse of shaft during the cutting phase due to adverse weather and excessive wave conditions with the shaft partially cut (beyond the point of no return) resulting in the shaft collapsing onto cells. • Delay during the cutting phase through winter leads to partial collapse of shaft, resulting in additional intervention work required to stabilise the cut. • Failure of the Concrete Navaid Lighthouse Tower due to poor leg capacity resulting in the tower collapsing and impacting the cells. **Overall Technical Risk Score:- 1.84**	Greatest technical risks associated with Option 9 are: • Leakage of steel pipework resulting in drawdown no longer at +70m above seabed. • Dropped object of Cathodic Protection (CP) system results in an impact to the cells causing a rupture. **Overall Technical Risk Score:- 0.37**
Comparison		N	MW	MW	
Summary		The assessment of the Technical Risk associated with each of the options is as follows: Option 6 is assessed as being Neutral to Option 5, as, whilst there is additional risk associated with the -55m leg cut (Option 6), this is offset by the risk associtaed with the challenges relating to the installation and structural integrity of the monotower (Option 5). Option 6 is assessed as being Much Weaker than Option 9 as there are no leg cutting risks with Option 9. Option 5 is assessed as being Much Weaker than Option 9 due there being no monotower challnges with Option 9. Overall Option 9 would be the preferred option from a Technical Risk perspective.			

<table>
<tr><th></th><th></th><th colspan="2">6. IMO Compliant Cut</th><th>5. Shallow Cut</th><th>9. Transitions Up</th></tr>
<tr><td>4. Societal</td><td>4.1 Fishing Industry</td><td colspan="2">For the -55m solution, a potential snag hazard remains however some fishing operations and transits will be able to continue in previously excluded area.
It is expected that submerged hazards such as this would be represented in the Fish Safe system as with other submerged hazards and on admiralty charts.</td><td>Small area remains unavailable for fishing – will be marked on chart with safety zone. Navaid in place (required by law). There will be 3 x submerged snag hazards associated with this option.</td><td>Small area remains unavailable for fishing – will be marked on chart with safety zone. Navaid in place (required by law).</td></tr>
<tr><td colspan="2">Comparison</td><td>MS</td><td>MS</td><td>W</td><td></td></tr>
<tr><td colspan="2">Summary</td><td colspan="4">The assessment of each of the options in terms of the Societal impact on the Fishing Industry is as follows:
Option 6 is assessed as being Much Stronger than Option 5 due to the area being returned to the fishing industry as safety zone will be removed. Option 6 is also assessed as being Much Stronger than Option 9 for similar reasons.
Option 5 is assessed as being Weaker than Option 9 as whilst the safety zone being retained (with the associated continued loss of this area to the fishing industry) is the same for both options, there is the submerged snag hazards associated with Option 5.
Overall Option 6 would be preferred from a Societal - Fishing Industry perspective.</td></tr>
<tr><td>4. Societal</td><td>4.2 Other Groups</td><td colspan="2">294t of scrap material (leg internals) returned to shore (recyclable).
1600t steel transitions returned to shore (recyclable).
11,300t concrete from legs (landfill).
700t of steel from concrete legs (recyclable).
386,512 hours worth of operations.</td><td>72t of scrap material (leg internals) returned to shore (recyclable).
1600t steel transitions returned to shore (recyclable).
900t concrete from legs (landfill).
Fabrication works will generate a small amount of onshore work.
178,627 hours worth of operations.</td><td>Fabrication works will generate a small amount of onshore work.

Overall - Negligible societal contribution.</td></tr>
<tr><td colspan="2">Comparison</td><td>N</td><td>N</td><td>N</td><td></td></tr>
<tr><td colspan="2">Summary</td><td colspan="4">The assessment of each of the options in terms of the Societal impact on the Other Users is as follows:
Option 6, Option 5 and Option 9 are all assessed as being Neutral to each other. The justification is that whilst there are societal benefits in terms of job creation / retention and recycling / re-use of material for Option 6, this is offset by the requirement to process and send a large amount of concrete material to landfill. This is similar for Option 5 which has smaller potential for job creation / retention but also a smaller proportion of material being returned to shore and put to landfill. Option 9 was assessed as having no material societal benefit.
Overall Option 6, Option 5 and Option 9 would be equally preferred from a Societal - Other Users perspective.</td></tr>
<tr><td>5. Economic</td><td>5.1 Operational & Legacy Costs</td><td colspan="2">Step 1.1 - Leg Internal Scope
Cost: £8.956 M

Step 2.0 - FEL Owner Costs i.e. FRC
Cost: £10.000 M

Step 3.1 - Shallow Cut
Cost: £12.843 M

Step 3.2 - IMO Cut
Cost: £30.850 M

Step 9.0 - No legacy costs associated with this option.

Total Cost: £62.648 M</td><td>Step 1.1 - Leg Internal Scope
Cost: £3.167 M

Step 2.0 - FEL Owner Costs i.e. FRC
N/A

Step 3.1 - Shallow Cut
Cost: £12.843 M

Step 5.0 - Install Monotower & Navaid
Cost: £9.040 M

Step 9.0:-
Monitoring: £102,550 per annum - £5.128 M over 50 years.

Total Operational Cost: £25.049 M
Total Legacy Cost: £5.584 M (inc. £0.456 M for Navaid Unit)
Total Cost: £30.633 M</td><td>Step 1.2 - Leg Coating
Cost: £1.950 M

Step 1.3 - Leg Cathodic Protection
Cost: £3.734 M

Step 2.0 - FEL Owner Costs i.e. FRC
N/A

Step 4.0 - Leg Capping
Cost: £1.200 M

Step 9.0:-
Monitoring: £102,550 per annum - £5.128 M over 50 years.

Total Operational Cost: £6.884 M
Total Legacy Cost: £5.584 M (inc. £0.456 M for Navaid Unit)
Total Cost: £12.467 M</td></tr>
<tr><td colspan="2">Comparison</td><td>W</td><td>MW</td><td>W</td><td></td></tr>
<tr><td colspan="2">Summary</td><td colspan="4">The assessment of each of the options in terms of the Economic impact is as follows:
Option 6 is assessed as being Weaker than Option 5 as it is estimated to cost around double. Option 6 is assessed as being Much Weaker than Option 9 as it is around 5 times more expensive.
Option 5 is assessed as being Weaker than Option 9 as it is around 2.5 times more expensive.
Overall Option 9 would be the preferred option from an Economic perspective.</td></tr>
</table>

Appendix C.2 CGBS Derogation Options – Pairwise Matrices

1.1 Operations Personnel	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up	Weighting
6. IMO Compliant Cut	N	W	VMW	10%
5. Shallow Cut	S	N	MW	19%
9. Transitions Up	VMS	MS	N	71%

1.2 Other Users	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up	Weighting
6. IMO Compliant Cut	N	W	VMW	10%
5. Shallow Cut	S	N	MW	19%
9. Transitions Up	VMS	MS	N	71%

1.3 Legacy Risk	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up	Weighting
6. IMO Compliant Cut	N	W	W	25%
5. Shallow Cut	S	N	N	38%
9. Transitions Up	S	N	N	38%

2.1 Operational Marine Impacts	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up	Weighting
6. IMO Compliant Cut	N	N	W	29%
5. Shallow Cut	N	N	W	29%
9. Transitions Up	S	S	N	43%

2.2 Atmospheric Emissions / Consumptions	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up	Weighting
6. IMO Compliant Cut	N	N	W	29%
5. Shallow Cut	N	N	W	29%
9. Transitions Up	S	S	N	43%

2.3 Legacy Marine Impacts	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up	Weighting
6. IMO Compliant Cut	N	N	N	33%
5. Shallow Cut	N	N	N	33%
9. Transitions Up	N	N	N	33%

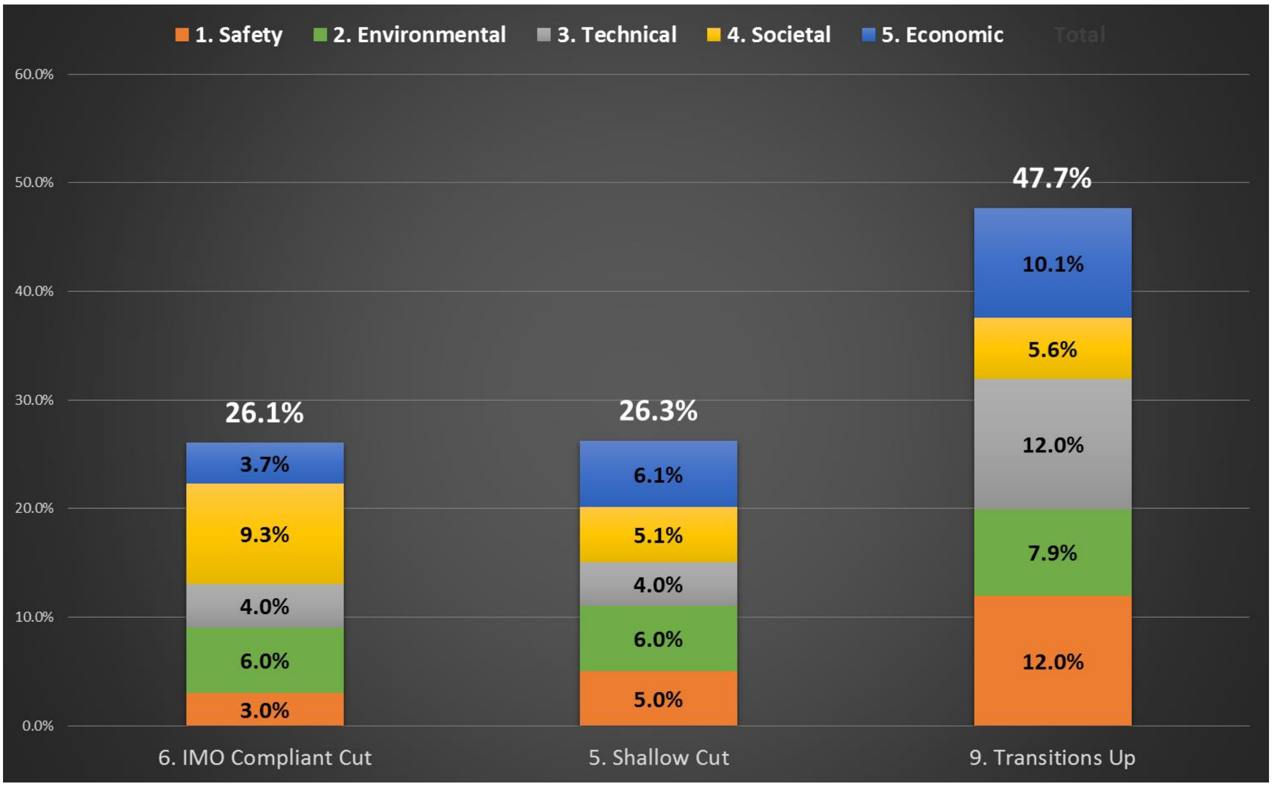
3. Technical	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up	Weighting
6. IMO Compliant Cut	N	N	MW	20%
5. Shallow Cut	N	N	MW	20%
9. Transitions Up	MS	MS	N	60%

4.1 Fishing Industry	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up	Weighting
6. IMO Compliant Cut	N	MS	MS	60%
5. Shallow Cut	MW	N	W	17%
9. Transitions Up	MW	S	N	23%

4.2 Other Groups	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up	Weighting
6. IMO Compliant Cut	N	N	N	33%
5. Shallow Cut	N	N	N	33%
9. Transitions Up	N	N	N	33%

5. Eco	6. IMO Compliant Cut	5. Shallow Cut	9. Transitions Up	Weighting
6. IMO Compliant Cut	N	W	MW	19%
5. Shallow Cut	S	N	W	31%
9. Transitions Up	MS	S	N	51%

Appendix C.3 CGBS Derogation Options – Results Chart



Appendix C.4 CGBS Full Removal v Derogation Option – Attributes Sheet

	4. Full Removal	9. Transitions Up
	Step 1.1: Leg Internal Scope - internal leg preparations and clearance.	**Step 1.1:** Leg Internal Scope - internal leg preparations and clearance.
	Step 1.2: Transition Piece - internal coating	**Step 1.2:** Transition Piece - internal coating
	Step 1.3: Transition Piece - cathodic protection system	**Step 1.3:** Transition Piece - cathodic protection system
	Step 2.0: FEL Owner Costs i.e. FRC	**Step 2.0:** FEL Owner Costs i.e. FRC
	Step 3.1: Removal of steel transitions, cut and remove all legs at shallow cut depth.	**Step 3.1:** Removal of steel transitions, cut and remove all legs at shallow cut depth.
	Step 3.2: Cut and remove all legs at IMO cut depth.	**Step 3.2:** Cut and remove all legs at IMO cut depth.
	Step 3.3: Cut and remove all legs at cell top.	**Step 3.3:** Cut and remove all legs at cell top.
	Step 4.0: Leg Capping / Transition piece installation.	**Step 4.0:** Leg Capping / Transition piece installation
	Step 5.0: Install mono-tower and Navaid.	**Step 5.0:** Install mono-tower and Navaid.
	Step 6.0: Removal of drill cuttings.	**Step 6.0:** Removal of drill cuttings.
	Step 7.0: Removal of cell-top cell debris.	**Step 7.0:** Removal of cell-top cell debris.
	Step 8.0: Removal of cells, base and cell contents.	**Step 8.0:** Removal of cells, base and cell contents.
	Step 9.0: Monitoring, storage and maintenance of Navaid / backup units.	**Step 9.0:** Monitoring, storage and maintenance of Navaid / backup units.
1. Safety – **1.1 Operations Personnel**	Offshore:- 7,707,153 hrs / 9.37E-01 PLL Onshore:- 445,413 hrs / 4.29E-02 PLL **Total option hours:- 8,152,566** **Total option PLL:- 9.79E-01**	Offshore:- 51,664 hrs / 2.57E-03 PLL Onshore:- 10,464 hrs / 1.00E-03 PLL **Total option hours:- 62,128** **Total option PLL:- 3.57E-03**
Comparison	**VMW**	
Summary	The summary Potential for Loss of Life (PLL) metrics for the options are 9.79E-01 and 3.57E-03 respectively. The assessment of the risk exposure for the various worker groups is as follows: Option 4 is assessed as being Very Much Weaker than Option 9 due to risk exposure being around 300 times higher. Overall, Option 9 would be the preferred option from a risk to operations personnel perspective.	
1. Safety – **1.2 Other Users**	HLV: 476 Days DSV: 5,999 Days Barge: 504 Days Tug: 539 Days DP Tanker: 1,485 Days Hopper: 46 Days CSV/ROV Support: 42 Days **Total vessel days: 9,091 days**	DSV: 10 Days CSV/ROV Support: 1 Day **Total vessel days: 11 days**
Comparison	**VMW**	
Summary	The assessment of the impact of each of the options on Other Users is largely driven by the durations that vessels are located in the area during the decommissioning works. The assessment is as follows: Option 4 is assessed as being Very Much Weaker than Option 9 due to the vessel days being over 800 times greater. Overall Option 9 would be the preferred option from a risk to other users perspective.	
1. Safety – **1.3 Legacy Risk**	There is no legacy risk associated with this full removal option.	Operations:- Monitoring: 4,128 hrs / 6.91E-04 PLL Other users:- Merchant Vessel Collision: 2.02E-04 Fishing Vessel Collision: 3.12E-04 Fishing Vessel Snagging: 1.24E-02 **Total Legacy PLL: 1.36E-02**
Comparison	**VMS**	
Summary	The summary Potential for Loss of Life (PLL) metrics associated with the legacy risk for the options are zero and 1.36E-02 respectively. The assessment of the risk exposure is as follows: Option 4 is assessed as being Very Much Stronger than Option 9 due to there being no legacy risk from the full removal option. Overall Option 4 would be the preferred option from a legacy risk perspective.	
2. Environmental – **2.1 Operational Marine Impacts**	There are benthic impacts associated with the full removal option which occurs over many years. This impacts the ability of the benthic environment to recover in the intervening periods between deconstruction activities. This impact is considered dominant in assessing the operational marine impact. In addition, there is marine impact associated with the requirement to disturb and remove all drill cuttings and cell contents. Potential for hydrocarbon release from cell base is estimated at 1.5 tonnes per year over 25 years as part of the deconstruction of the cell base in situ. There is also potential for loss of an estimated 10% of the contaminated drill cuttings volume (through the water column) during removal and recovery to shore. This has an associated impact from hydrocarbon loss and dispersal thus impacting a wider area. There is further marine impact from the noise generated by cutting operations and vessels. Cutting operations are estimated as 48 hrs per leg x 4 (192 hrs) for the shallow water cut, 72 hrs per leg x 4 (288 hrs) for the IMO compliant depth cut and 72 hrs per leg x 4 (288 hrs) for the deepwater cut (just above cell tops) 768 hrs total. Further cutting noise is generated during the deconstruction of the cell base, estimated as 69 days of cutting operations per year for 27 years = 1863 days or 44,712 hours. **Overall Sound Exposure:-** **278 dB re 1mP / 6,251 TPa2s**	There is no requirement to evacuate cell contents, disturb drill cuttings or perform cutting operations under this option so Marine Impacts limited to those related to vessel noise and is very low. **Overall Sound Exposure:-** **243 dB re 1mp / 2 TPa2s**
Comparison	**VMW**	
Summary	The assessment of the impact of each of the options in terms of Marine Impact is as follows: Option 4 is assessed as being Very Much Weaker than Option 9 due to the benthic impact of performing Option 4 over many years and the marine impact from drill cuttings and cell contents removal. Overall Option 9 would be the preferred option from a Marine Impact perspective.	

	4. Full Removal	9. Transitions Up
2. Environmental – 2.2 Atmospheric Emissions / Consumptions	Overall Emissions:- CO2e: 697,962 tonnes Fuel: 213,042 tonnes	Overall Emissions:- CO2e: 980 tonnes Fuel: 299 tonnes
Comparison	VMW	
Ratio	1:0.001 or 712.206:1	
Summary	The assessment of the impact of each of the options in terms of Emissions / Consumption is as follows: Option 4 is assessed as being Very Much Weaker than Option 9 due to the emissions and consumptions being around 700 times higher. Overall Option 9 would be the preferred option from an Emissions / Consumption perspective.	
2. Environmental – 2.3 Legacy Marine Impacts	This full removal option eliminates any potential for legacy marine impacts from loss of hydrocarbon from remaining in-situ drill cuttings. Recovery of seabed and habitats once decommissioning programme is complete and structure is fully removed is likely to take longer than few years due to the extended operational duration for this option. This has an associated legacy impact. Overall, the legacy marine impact is limited as all materials are removed.	Potential for legacy marine impacts from seepage of hydrocarbon from remaining in-situ drill cuttings / potential for release of cell contents but likely over very long durations. Note: There may be an environmental benefit provided by this remain in-situ option from an artificial reef perspective which would act as a minor offset against the full removal option.
Comparison	MS	
Summary	The assessment of the Legacy Marine Impact of each of the options is as follows: Option 4 is assessed as being Much Stronger than Option 9 due to largely eliminating legacy marine impact by full removal. The impact of the full removal option on the seabed / habitats and the minor benefit of the 'artificial reef' principle associated with Option 9 contributed to the assessment being Much Stronger rather than Very Much Stronger. Overall Option 4 would be the preferred option from a Legacy Marine Impact perspective.	
3. Technical – 3.1 Project Technical Risk	Greatest technical risks associated with Option 4 are: • Unable to develop coring and cutting technology for the cell roof and walls and the base slab. • Unable to develop technology for removal of base sediments. • Disturbance of base sediments / sludge leads to major visibility problems for ROV operation. • Sludge contamination on ROV & umbilical causes unacceptable hydrocarbon release to sea. • Break up of cell base grout cover leads to continual blockage of ROV suction equipment leading to an inability to clean cell floor. • Repeated failure of cell cutting through cell roof and walls. • Exposed cell floor shows that cleaning has been unsatisfactory. • Vertical cut through base slab & solid ballast not technically feasible. • Solid ballast saturated with hydrocarbon. • Excessive cutting times required to cut through solid ballast using diamond wire. • Lifting arrangement using tank buoyancy is technically inadequate. **Overall Technical Risk Score:- 64.43**	Greatest technical risks associated with Option 9 are: • Leakage of steel pipework resulting in drawdown no longer at +70m above seabed. • Dropped object of Cathodic Protection (CP) system results in an impact to the cells causing a rupture. **Overall Technical Risk Score:- 0.37**
Comparison	VMW	
Summary	The assessment of the Technical Risk associated with each of the options is as follows: Option 4 is assessed as being Very Much Weaker than Option 9 due to the significant technical challenges associated with the successful delivery of Option 4 versus the minor challenges with delivering Option 9. Overall Option 9 would be the preferred option from a Technical Risk perspective.	
4. Societal – 4.1 Fishing Industry	The full area would be returned for fishing operations under this full removal option.	Small area remains unavailable for fishing – will be marked on chart with safety zone. Navaid in place (required by law).
Comparison	VMS	
Summary	The assessment of each of the options in terms of the Societal impact on the Fishing Industry is as follows: Option 4 is assessed as being Very Much Stronger than Option 9 due to the area being fully returned to the fishing industry versus continued loss of fishing grounds as within safety zone. Overall Option 4 would be preferred from a Societal - Fishing Industry perspective.	
4. Societal – 4.2 Other Groups	708t of scrap material (leg internals) returned to shore (recyclable). 1600t steel transitions returned to shore (recyclable). 32,900t concrete from legs (landfill). 220,374t concrete from base (landfill). 15,074t steel from concrete legs, skirts and cell internals (recyclable). 19,555m^3 of drill cuttings returned to shore for processing 8,152,566 hours worth of operations.	Fabrication works will generate a small amount of onshore work. Overall - Negligible societal contribution.
Comparison	N	
Summary	The assessment of each of the options in terms of the Societal impact on the Other Users is as follows: Option 4 and Option 9 are assessed as being Neutral to each other. The justification is that whilst there are societal benefits in terms of job creation / retention and recycling / re-use of material for Option 4, this is offset by the requirement to process and send a large amount of concrete material to landfill and for handling and processing of the contaminated drill cuttings. Option 9 was assessed as having no material societal benefit. Overall Option 4 and Option 9 would be equally preferred from a Societal - Other Users perspective.	

5. Economic		4. Full Removal	9. Transitions Up
	5.1 Operational & Legacy Costs	Step 1.1 - Leg Internal Scope Cost: £14.547 M Step 2.0 - FEL Owner Costs i.e. FRC Cost: £221.200 M Step 3.1 - Shallow Cut Cost: £12.843 M Step 3.2 - IMO Cut Cost: £30.850 M Step 3.3 - Deep Cut Cost: £31.530 M Step 6.0 - Remove Drill Cuttings Cost: £5.346 M Step 8.0 - Remove cells, base and contents an perform seabed sweep Cost: £2,049.298 M Step 9.0 - No legacy costs associated with this full removal option. **Total Cost: £2,365.6 M**	Step 1.2 - Leg Coating Cost: £1.950 M Step 1.3 - Leg Cathodic Protection Cost: £3.734 M Step 2.0 - FEL Owner Costs i.e. FRC N/A Step 4.0 - Leg Capping Cost: £1.200 M Step 9.0:- Monitoring: £102,550 per annum - £5.128 M over 50 years. Total Operational Cost: £6.884 M Total Legacy Cost: £5.584 M (inc. £0.456 M for Navaid Unit) **Total Cost: £12.467 M**
Comparison		VMW	
Summary		The assessment of each of the options in terms of the Economic impact is as follows: Option 4 is assessed as being Very Much Weaker than Option 9 due the costs being almost 200 times higher. Overall Option 9 would be the preferred option from an Economic perspective.	

Appendix C.5 CGBS Full Removal v Derogation Option – Pairwise Comparisons

1.1 Operations Personnel	4. Full Removal	9. Transitions Up	Weighting
4. Full Removal	N	VMW	10%
9. Transitions Up	VMS	N	90%

1.2 Other Users	4. Full Removal	9. Transitions Up	Weighting
4. Full Removal	N	VMW	10%
9. Transitions Up	VMS	N	90%

1.3 Legacy Risk	4. Full Removal	9. Transitions Up	Weighting
4. Full Removal	N	VMS	90%
9. Transitions Up	VMW	N	10%

2.1 Operational Marine Impacts	4. Full Removal	9. Transitions Up	Weighting
4. Full Removal	N	VMW	10%
9. Transitions Up	VMS	N	90%

2.2 Atmospheric Emissions / Consumptions	4. Full Removal	9. Transitions Up	Weighting
4. Full Removal	N	VMW	10%
9. Transitions Up	VMS	N	90%

2.3 Legacy Marine Impacts	4. Full Removal	9. Transitions Up	Weighting
4. Full Removal	N	MS	75%
9. Transitions Up	MW	N	25%

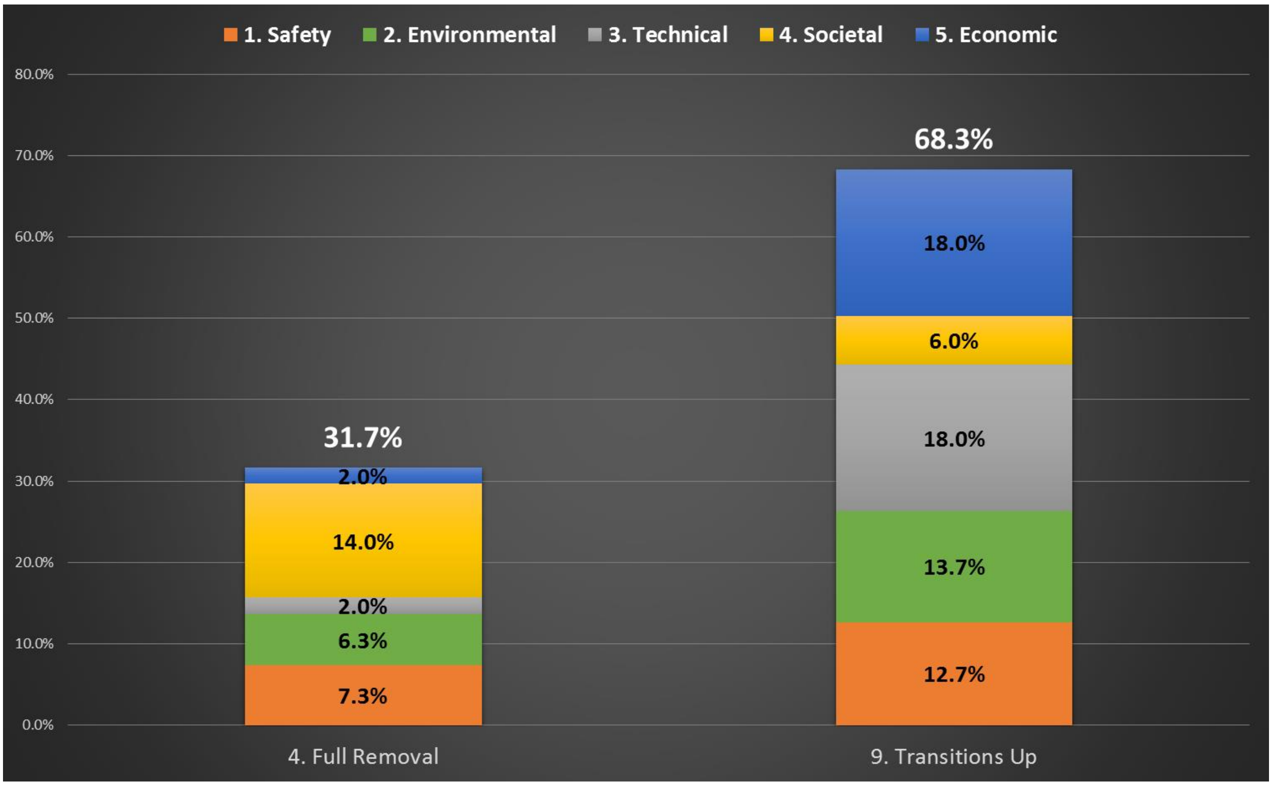
3. Technical	4. Full Removal	9. Transitions Up	Weighting
4. Full Removal	N	VMW	10%
9. Transitions Up	VMS	N	90%

4.1 Fishing Industry	4. Full Removal	9. Transitions Up	Weighting
4. Full Removal	N	VMS	90%
9. Transitions Up	VMW	N	10%

4.2 Other Groups	4. Full Removal	9. Transitions Up	Weighting
4. Full Removal	N	N	50%
9. Transitions Up	N	N	50%

5. Eco	4. Full Removal	9. Transitions Up	Weighting
4. Full Removal	N	VMW	10%
9. Transitions Up	VMS	N	90%

Appendix C.6 CGBS Full Removal v Derogation Option – Results Chart



Appendix C.7 Cell Contents – Attributes Sheet

<table>
<tr><th></th><th></th><th colspan="3">1. High Case Oil and Sediment Removal</th><th colspan="2">2. Mid Case Oil and Sediment Removal</th><th>3. Mid Case Oil Removal</th><th>4. Leave In Situ</th></tr>
<tr><td></td><td></td><td colspan="3">Involves 31 cell penetrations into all four cell groups to recover both oil and sediment.
Access to the cells will require full removal of drill cuttings.
Offshore activities are expected to last 3 seasons.</td><td colspan="2">Involves 18 cell penetrations into all four cell groups to recover both oil and sediment.
Access to the cells will require some removal of drill cuttings.
Offshore activities are expected to last 2 seasons.</td><td>Involves 15 cell penetrations into all four cell groups to recover only oil.
Access to the cells will require some removal of drill cuttings.
Offshore activities are expected to last 2 seasons.</td><td>Cell contents to be left in situ without any further management / treatment.</td></tr>
<tr><td>1. Safety</td><td>1.1 Operations Personnel</td><td colspan="3">Total option hours:- 409,488
Total option PLL:- 2.32E-02</td><td colspan="2">Total option hours:- 252,816
Total option PLL:- 1.44E-02</td><td>Total option hours:- 206,640
Total option PLL:- 1.18E-02</td><td>No offshore activities required.</td></tr>
<tr><td></td><td></td><td>W</td><td>W</td><td>MW</td><td>N</td><td>MW</td><td>MW</td><td></td></tr>
<tr><td>Summary</td><td></td><td colspan="7">The summary Potential for Loss of Life (PLL) metrics for the options are 2.32E-02, 1.44E-02, 1.18E-02 and Zero respectively. The assessment of the risk exposure for the various worker groups is as follows:
Option 1 is assessed as being Weaker than Option 2 as it is around double the risk exposure. Option 1 is assessed as being Weaker than Option 3 as it is also around double the risk exposure. Option 1 is assessed as being Much Weaker than Option 4 as there is risk exposure for Option 1 versus none for Option 4.
Option 2 is assessed as being Neutral to Option 3 as the risk exposure is largely similar. Option 2 is assessed as being Much Weaker than Option 4 as there is risk exposure for Option 2 versus none for Option 4.
Option 3 is assessed as being Much Weaker than Option 4 as there is risk exposure for Option 3 versus none for Option 4.
It should be noted that all options require similar activities just with longer or shorter durations. It should be further noted that none of the options have planned diving activities.

Overall, Option 4 would be the preferred option from a risk to operations personnel perspective.</td></tr>
<tr><td>1. Safety</td><td>1.2 Legacy Impact</td><td colspan="3">There are no safety impacts from the legacy of leaving the cell contents partially or fully in situ. The legacy safety impacts are only related to the CGBS itself and are therefore addressed during the Comparative Assessment of the CGBS.

As such, legacy safety impact is not a differentiator between the cell contents options.</td><td colspan="2">There are no safety impacts from the legacy of leaving the cell contents partially or fully in situ. The legacy safety impacts are only related to the CGBS itself and are therefore addressed during the Comparative Assessment of the CGBS.

As such, legacy safety impact is not a differentiator between the cell contents options.</td><td>There are no safety impacts from the legacy of leaving the cell contents partially or fully in situ. The legacy safety impacts are only related to the CGBS itself and are therefore addressed during the Comparative Assessment of the CGBS.

As such, legacy safety impact is not a differentiator between the cell contents options.</td><td>There are no safety impacts from the legacy of leaving the cell contents partially or fully in situ. The legacy safety impacts are only related to the CGBS itself and are therefore addressed during the Comparative Assessment of the CGBS.

As such, legacy safety impact is not a differentiator between the cell contents options.</td></tr>
<tr><td></td><td></td><td>N</td><td>N</td><td>N</td><td>N</td><td>N</td><td>N</td><td></td></tr>
<tr><td>Summary</td><td></td><td colspan="7">As it has been assessed that there are no legacy safety impacts associated with the cell contents (other than those relating to the CGBS itself which are assessed elsewhere under the CGBS CA), the legacy safety impact is not considered a differentiator between the options.

All options are therefore assessed as being Neutral to each other from a Legacy Safety Risk perspective.</td></tr>
</table>

Criterion	1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ
2. Environmental – 2.1 Operational Marine Impact	Planned Release: It is the goal of the cell contents removal activities that no material be released from the cells during the operations. There is an inherent planned release and associated potential environmental impact associated with drill cuttings removal, required as part of this option. This is quantified as approx. 10% of the total volume of 10,333 m^3 contaminated drill cuttings (from top of cells) which is lost during the recovery of drill cuttings to shore. Unplanned Release: Considers the impact associated with accidental loss of containment of cell contents whilst being recovered and vessel based incidents. The impacts are informed as follows: Mobile oil (max.) = 15 m^3, Sediment (max.) = 0.2 m^3 Vessel Activities = 4 vessels and 445 days total Marine Noise: The impact from marine noise generated from the vessels and marine cutting / coring operations is considered largely similar across the options and sufficiently low impact to be a nuisance to marine mammals rather than exceeding the damage threshold. As such, impact from marine noise is not considered a differentiator between the options.	Planned Release: It is the goal of the cell contents removal activities that no material be released from the cells during the operations. There is an inherent planned release and associated potential environmental impact associated with drill cuttings removal, required as part of this option. This is quantified as approx. 10% of the total volume of 358 m^3 contaminated drill cuttings (from top of cells) which is lost during the recovery of drill cuttings to shore. Unplanned Release: Considers the impact associated with accidental loss of containment of cell contents whilst being recovered and vessel based incidents. The impacts are informed as follows: Mobile oil (max.) = 15 m^3, Sediment (max.) = 0.2 m^3 Vessel Activities = 4 vessels and 272 days total Marine Noise: The impact from marine noise generated from the vessels and marine cutting / coring operations is considered largely similar across the options and sufficiently low impact to be a nuisance to marine mammals rather than exceeding the damage threshold. As such, impact from marine noise is not considered a differentiator between the options.	Planned Release: It is the goal of the cell contents removal activities that no material be released from the cells during the operations. There is an inherent planned release and associated potential environmental impact associated with drill cuttings removal, required as part of this option. This is quantified as approx. 10% of the total volume of 303 m^3 contaminated drill cuttings (from top of cells) which is lost during the recovery of drill cuttings to shore. Unplanned Release: Considers the impact associated with accidental loss of containment of cell contents whilst being recovered and vessel based incidents. The impacts are informed as follows: Mobile oil (max.) = 15 m^3 Vessel Activities = 4 vessels and 224 days total Marine Noise: The impact from marine noise generated from the vessels and marine cutting / coring operations is considered largely similar across the options and sufficiently low impact to be a nuisance to marine mammals rather than exceeding the damage threshold. As such, impact from marine noise is not considered a differentiator between the options.	No offshore recovery activities therefore no planned/unplanned release.
	MW | MW | VMW	N | MW	MW	
Summary	The assessment of the impact of each of the options in terms of Operational Marine Impacts is dominated by the impact from the drill cuttings removal and associated potential for hydrocarbon and heavy metals release although it is noted that the oil within the drill cuttings is low toxicity and will readily disperse/evaporate. It was determined that the impact from the generated marine noise for each of the options was not a differentiator between the options due to the assessment that the marine noise generated does not exceed the damage threshold for marine mammals (but does exceed the 'nuisance' threshold) and is largely similar for all recovery options. The impact of loss from cell penetration activities is minimal. The assessment is as follows: Option 1 is assessed as being Much Weaker than Option 2 due to the impact of the contaminants released from recovery of the contaminated drill cuttings which is a much higher volume. Option 1 is assessed as being Much Weaker than Option 3 for similar reasons. Option 1 is assessed as being Very Much Weaker than Option 4 as there is no environmental impact from Option 4. Option 2 is assessed as being Neutral to Option 3 as the operational environmental impacts are similar. Option 3 is assessed as being Much Weaker than Option 4 as there is no environmental impact from Option 4. Option 3 is assessed as being Much Weaker than Option 4 as there is no environmental impact from Option 4. Overall Option 4 would be the preferred option from a Marine Impact perspective.			
2. Environmental – 2.2 Atmospheric Emissions & Consumption	- Emissions = 34,256 Te CO_2 equiv - Energy = 449,394 GJ - Fuel use = 10,451 Te	- Emissions = 20,382 Te CO_2 equiv - Energy = 267,386 GJ - Fuel use = 6,218 Te	- Emissions = 16,848 Te CO_2 - Energy = 221,026 GJ - Fuel use = 5,140 Te	No recovery activities therefore emissions and energy consumption are zero.
	W | W | MW	N | MW	MW	
Summary	The assessment of the impact of each of the options in terms of Emissions and Consumptions is as follows: The assessments made consider the scale of the emissions and consumptions for each of the options in a wider context. Option 1 is assessed as being Weaker than Option 2 due to the emissions / consumptions being are a little under double, but of a reasonable absolute quantity which was sufficient for there to be a minor preference for the lower quantity. Option 1 is assessed as being Weaker than Option 3 for similar reasons. Option 1 was assessed as being Much Weaker than Option 4 as the emissions / consumptions associated with Option 1 are significant when compared to a zero emissions / consumptions option. Option 2 is assessed as Neutral to Option 3 as, whilst there is a differential between the emissions / consumptions, this differential is considered insignificant when placed into context. Option 2 is assessed as being Much Weaker than Option 4 as the emissions / consumptions associated with Option 2 are significant when compared to a zero emissions / consumptions option Option 3 is assessed as being Much Weaker than Option 4 for similar reasons. Overall Option 4 would be the preferred option from an Emissions and Consumptions perspective.			

	1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ
2. Environmental – **2.3 Legacy Marine Impact**	Legacy impact is linked to the quantity / type of material remaining in situ and how it may be released in the future i.e. an instantaneous release scenario due to impact on the structure or a chronic release scenario due to slow degradation of the structure. Instantaneous Release Scenario:- Release equivalent to the residual inventory of 4 cells, based on transition piece impact with cell base affecting maximum of 4 cells. No sediment release under this scenario. Mobile Oil (max.) = 31 m^3 Water Phase (max.) = 12,821 m^3 Long-term Release Scenario:- Total residual hydrocarbon (Mobile Oil & Sediment) = 1,259 m^3 Drill cuttings (from roof of cell base) are fully removed (10,333 m^3 removed) so there is a reduced legacy marine impact from drill cuttings with this option. Modelling of the Instantaneous Release Scenario on a worst-case basis shows that a release of this size has 'low to very low' environmental impact i.e. no response required. This assessment is based on the quantity of release, duration of the release and the impact being spread over a large area of shoreline and the likelihood of occurrence.	Legacy impact is linked to the quantity / type of material remaining in situ and how it may be released in the future i.e. an instantaneous release scenario due to impact on the structure or a chronic release scenario due to slow degradation of the structure. Instantaneous Release Scenario:- Release equivalent to the residual inventory of 4 cells, based on transition piece impact with cell base affecting maximum of 4 cells. No sediment release under this scenario. Mobile Oil (max.) = 31 m^3 Water Phase (max.) = 12,821 m^3 Long-term Release Scenario:- Total residual hydrocarbon (Mobile Oil & Sediment) = 1,596 m^3 Drill cuttings (from roof of cell base) are partially removed (358 m^3 removed) so there is a reduced legacy marine impact from drill cutting with this option. Modelling of the Instantaneous Release Scenario on a worst-case basis shows that a release of this size has 'low to very low' environmental impact i.e. no response required. This assessment is based on the quantity of release, duration of the release and the impact being spread over a large area of shoreline and the likelihood of occurrence.	Legacy impact is linked to the quantity / type of material remaining in situ and how it may be released in the future i.e. an instantaneous release scenario due to impact on the structure or a chronic release scenario due to slow degradation of the structure. Instantaneous Release Scenario:- Release equivalent to the residual inventory of 4 cells, based on transition piece impact with cell base affecting maximum of 4 cells. No sediment release under this scenario. Mobile Oil (max.) = 31 m^3 Water Phase (max.) = 12,821 m^3 Long-term Release Scenario:- Total residual hydrocarbon (Mobile Oil & Sediment) = 1,666 m^3 Drill cuttings (from roof of cell base) are partially removed (303 m^3 removed) so there is a reduced legacy marine impact from drill cutting with this option. Modelling of the Instantaneous Release Scenario on a worst-case basis shows that a release of this size has 'low to very low' environmental impact i.e. no response required. This assessment is based on the quantity of release, duration of the release and the impact being spread over a large area of shoreline and the likelihood of occurrence.	Legacy impact is linked to the quantity / type of material remaining in situ and how it may be released in the future i.e. an instantaneous release scenario due to impact on the structure or a chronic release scenario due to slow degradation of the structure. Instantaneous Release Scenario:- Release equivalent to the residual inventory of 4 cells, based on transition piece impact with cell base affecting maximum of 4 cells. No sediment release under this scenario. Mobile Oil (max.) = 62 m^3 Water Phase (max.) = 12,789 m^3 Long-term Release Scenario:- Total residual hydrocarbon (Mobile Oil & Sediment) = 1,939 m^3 Modelling of the Instantaneous Release Scenario on a worst-case basis shows that a release of this size has 'low to very low' environmental impact i.e. no response required. This assessment is based on the quantity of release, duration of the release and the impact being spread over a large area of shoreline and the likelihood of occurrence.
	S | S | MS	N | S	S	
Summary	The assessment of the impact of each of the options in terms of Legacy Marine Impact is as follows: Option 1 is assessed as being Stronger than Option 2 due to there being less residual sediment and all cell top contaminated drill cuttings are removed. Option 1 is assessed as being Stronger than Option 3 for similar reasons. Option 1 was assessed as being Much Stronger than Option 4 as there is less sediment, oil and drill cuttings remaining. Option 2 is assessed as Neutral to Option 3 as the residual materials are similar. Option 2 is assessed as being Stronger than Option 4 as there is less sediment, oil and drill cuttings remaining. Option 3 is assessed as being Stronger than Option 4 for similar reasons. Overall Option 1 would be the preferred option from a Legacy Marine Impact perspective.			

		1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ
3. Technical	3.1 Project Technical Risk	Concept Maturity = Further research, development and engineering would be required (for cell access and recovery of oil and sediment) Availability of Technology = Technology to allow larger access holes into the cell tops requires to be developed Track Record = Small access holes have been successful for Shell Brent Delta Risk of Failure = Recovery of sediment particularly technically challenging, high risk of failure. However due to the campaign durations there is potential that project efficiencies improve especially due to the repetitive nature of the tasks. Consequence of Failure = May require renegotiation with regulator/stakeholders on the status of the facilities. Requires full drill cuttings removal - which has its own risk of project failure profile which the project will need to consider.	Concept Maturity = Further research, development and engineering would be required (for cell access and recovery oil and sediment) Availability of Technology = Technology to allow larger access holes into the cell tops requires to be developed Track Record = Small access holes have been successful for Shell Brent Delta Risk of Failure = Recovery of sediment particularly technically challenging, high risk of failure. However due to the campaign durations there is potential that project efficiencies improve especially due to the repetitive nature of the tasks. Consequence of Failure = May require renegotiation with regulator/stakeholders on the status of the facilities. Requires partial drill cuttings removal - which has its own risk of project failure profile which the project will need to consider.	Concept Maturity = Further research, development and engineering would be required (for cell access and recovery of oil) Availability of Technology = Technology already exists to access cells Track Record = Small access holes have been successful for Shell Brent Delta Risk of Failure = Due to the campaign durations there is potential that project efficiencies improve especially due to the repetitive nature of the tasks. Consequence of Failure = May require renegotiation with regulator/stakeholders on the status of the facilities. Requires partial drill cuttings removal - which has its own risk of project failure profile which the project will need to consider.	Leave in situ requires no offshore works therefore there is no technical risk.
		N / W / MW	W / MW	W	
Summary		The assessment of the Technical Risk associated with each of the options is as follows: The main differentiator between the recovery options is the requirement for sediment recovery under Options 1 and 2 which requires larger access holes (unproven) and more difficult recovery techniques (unproven). Option 1 is assessed as being Neutral to Option 2 as the technical challenges are similar for both options. Option 1 is assessed as being Weaker than Option 3 due to there being no requirement for sediment recovery with Option 3. Option 1 is assessed as being Much Weaker than Option 4 due to there being technical challenges with Option 1 and no technical challenges with Option 4. Option 2 is assessed as being Weaker than Option 3 due to there being no requirement for sediment recovery with Option 3. Option 2 is assessed as being Much Weaker than Option 4 due to there being technical challenges with Option 2 and no technical challenges with Option 4. Option 3 is assessed as Weaker than Option 4 due to the smaller technical challenges with Option 3 and no technical challenges with Option 4. Overall Option 4 would be the preferred option from a Technical Risk perspective.			
4. Societal	4.1 All Groups	Employment benefits will be limited This option may bring a minor benefit to future similar decommissioning campaigns through: 1) enhancing the knowledge and industry experience of the external cell penetration process 2) experience in mobile oil and sediment removal from an in-situ CGBS These minor potential benefits are offset by the requirement to process 10,333 m^3 of contaminated drill cuttings.	Employment benefits will be limited. This option may bring a minor benefit to future similar decommissioning campaigns through: 1) enhancing the knowledge and industry experience of the external cell penetration process 2) experience in mobile oil and sediment removal from an in-situ CGBS These minor potential benefits are offset by the requirement to process 358 m^3 of contaminated drill cuttings.	Employment benefits will be limited. This option may bring a minor benefit to future similar decommissioning campaigns through: 1) enhancing the knowledge and industry experience of the external cell penetration process 2) experience in mobile oil recovery from an in-situ CGBS These minor potential benefits are offset by the requirement to process 303 m^3 of contaminated drill cuttings.	Leave in-situ will have no R&D benefit therefore less preferable than the recovery options. However, there is no requirement for handling and processing contaminated drill cuttings which carries a small Societal benefit.
		W / W / N	N / S	S	
Summary		The assessment of each of the options in terms of the Societal impact on the All Groups is as follows: In general the societal benefits to performing contents recovery options are minor. There may be some small benefits to industry and technology advancement which could be exported. The handling and processing of the contaminated drill cuttings is considered a negative. Option 1 is assessed as being Weaker than Option 2 due to the handling and processing of significantly more contaminated drill cuttings - other elements being balanced. Option 1 is assessed as Weaker than Option 3 for similar reasons. Option 1 is assessed as being Neutral to Option 4 as the positive (technology advancement / minimal job creation / retention) and negative (handling contaminated drill cuttings) attributes associated with these options are balanced. Option 2 is assessed as being Neutral to Option 3 as the technology and job creation / retention attributes are similar, as are the quantities of contaminated drill cuttings. Option 2 is assessed as Stronger than Option 4 due to the job creation / retention generated and the technology advancement versus no benefits on this area for Option 4. It should be noted that the relatively small quantity of contaminated drill cuttings handling was not considered enough to offset this judgement. Option 3 is assessed as Stronger than Option 4 for similar reasons. Overall Option 2 and 3 would be equally preferred from a Societal - All Groups perspective.			

		1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ
5. Economic	5.1 Operational & Legacy Costs	Operational Cost = £62.5 million	Operational Cost = £38.8 million	Operational Cost = £29.6 million	No contents recovery therefore operational cost is zero
		W | W | MW	N | MW	MW	

Summary

The assessment of each of the options in terms of the Economic impact is as follows:
All options require similar activities just with longer or shorter durations. Only the operational cost of the options are compared as, should there be any legacy costs for monitoring, these will be addressed under the CGBS assessment and would be the same across the four options.
Option 1 is assessed as being Weaker than Option 2 and as it is estimated to cost a little under double. Option 1 is assessed as being Weaker than Option 3 as it is estimated to cost a little over double. Option 1 is assessed as being Much Weaker than Option 4 due to the large differential between the costs coupled with the requirement for a significant spend versus no spend.
Option 2 is assessed as being Neutral to Option 3 as, whilst there is a differential between the costs, this differential was not deemed significant enough to depart from the neutral position. Option 2 is assessed as being Much Weaker than Option 4 due to the large differential between the costs coupled with the requirement for a significant spend versus no spend.
Option 3 is being assessed as Much Weaker than Option 4 for similar reasons.

Overall Option 4 would be the preferred option from an Economic perspective.

Appendix C.8 Cell Contents – Pairwise Comparisons

1.1 Operations Personnel	1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ	Weighting
1. High Case Oil and Sediment Removal	N	W	W	MW	14%
2. Mid Case Oil and Sediment Removal	S	N	N	MW	18%
3. Mid Case Oil Removal	S	N	N	MW	18%
4. Leave In Situ	MS	MS	MS	N	50%

1.2 Legacy Impact	1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ	Weighting
1. High Case Oil and Sediment Removal	N	N	N	N	25%
2. Mid Case Oil and Sediment Removal	N	N	N	N	25%
3. Mid Case Oil Removal	N	N	N	N	25%
4. Leave In Situ	N	N	N	N	25%

2.1 Operational Marine Impact	1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ	Weighting
1. High Case Oil and Sediment Removal	N	MW	MW	VMW	6%
2. Mid Case Oil and Sediment Removal	MS	N	N	MW	19%
3. Mid Case Oil Removal	MS	N	N	MW	19%
4. Leave In Situ	VMS	MS	MS	N	56%

2.2 Atmospheric Emissions & Consumption	1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ	Weighting
1. High Case Oil and Sediment Removal	N	W	W	MW	14%
2. Mid Case Oil and Sediment Removal	S	N	N	MW	18%
3. Mid Case Oil Removal	S	N	N	MW	18%
4. Leave In Situ	MS	MS	MS	N	50%

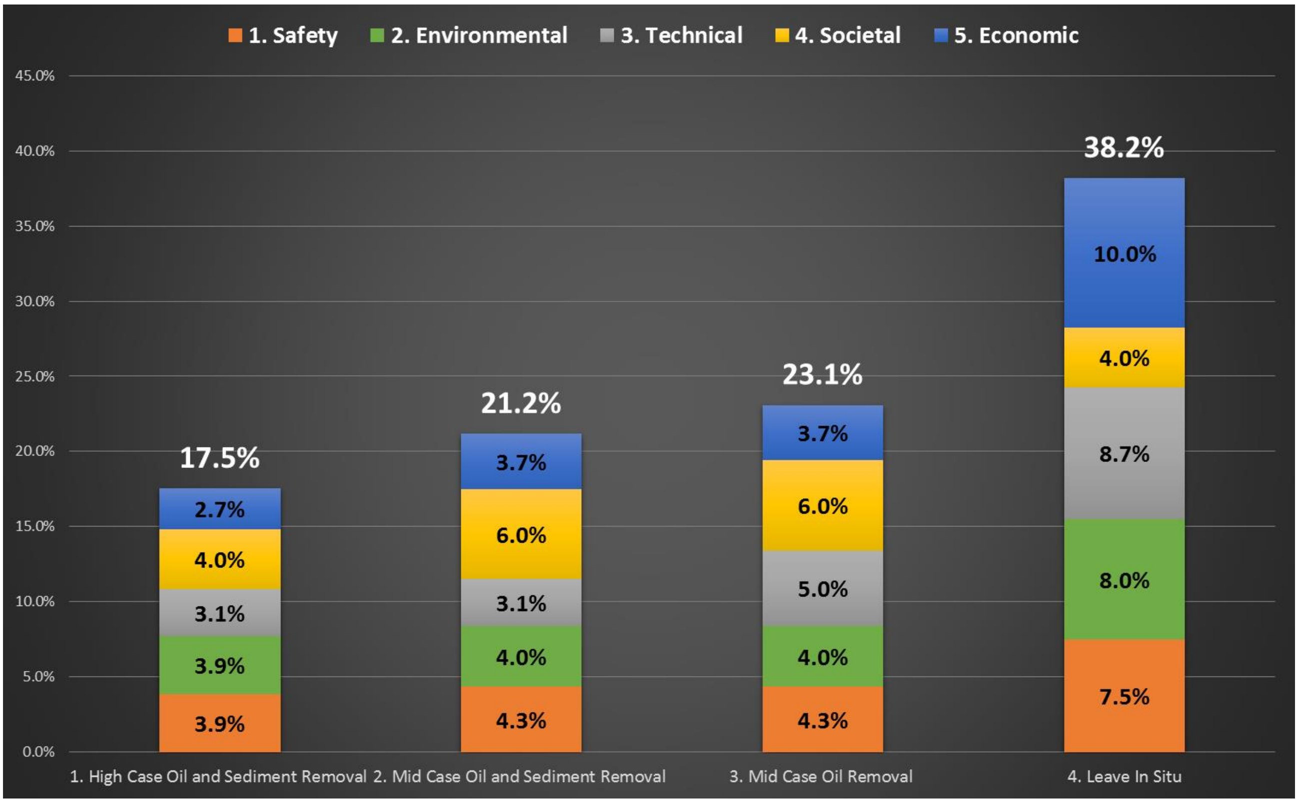
2.3 Legacy Marine Impact	1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ	Weighting
1. High Case Oil and Sediment Removal	N	S	S	MS	38%
2. Mid Case Oil and Sediment Removal	W	N	N	S	24%
3. Mid Case Oil Removal	W	N	N	S	24%
4. Leave In Situ	MW	W	W	N	15%

3. Technical	1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ	Weighting
1. High Case Oil and Sediment Removal	N	N	W	MW	16%
2. Mid Case Oil and Sediment Removal	N	N	W	MW	16%
3. Mid Case Oil Removal	S	S	N	W	25%
4. Leave In Situ	MS	MS	S	N	44%

4.1 All Groups	1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ	Weighting
1. High Case Oil and Sediment Removal	N	W	W	N	20%
2. Mid Case Oil and Sediment Removal	S	N	N	S	30%
3. Mid Case Oil Removal	S	N	N	S	30%
4. Leave In Situ	N	W	W	N	20%

5. Economic	1. High Case Oil and Sediment Removal	2. Mid Case Oil and Sediment Removal	3. Mid Case Oil Removal	4. Leave In Situ	Weighting
1. High Case Oil and Sediment Removal	N	W	W	MW	14%
2. Mid Case Oil and Sediment Removal	S	N	N	MW	18%
3. Mid Case Oil Removal	S	N	N	MW	18%
4. Leave In Situ	MS	MS	MS	N	50%

Appendix C.9 Cell Contents – Results



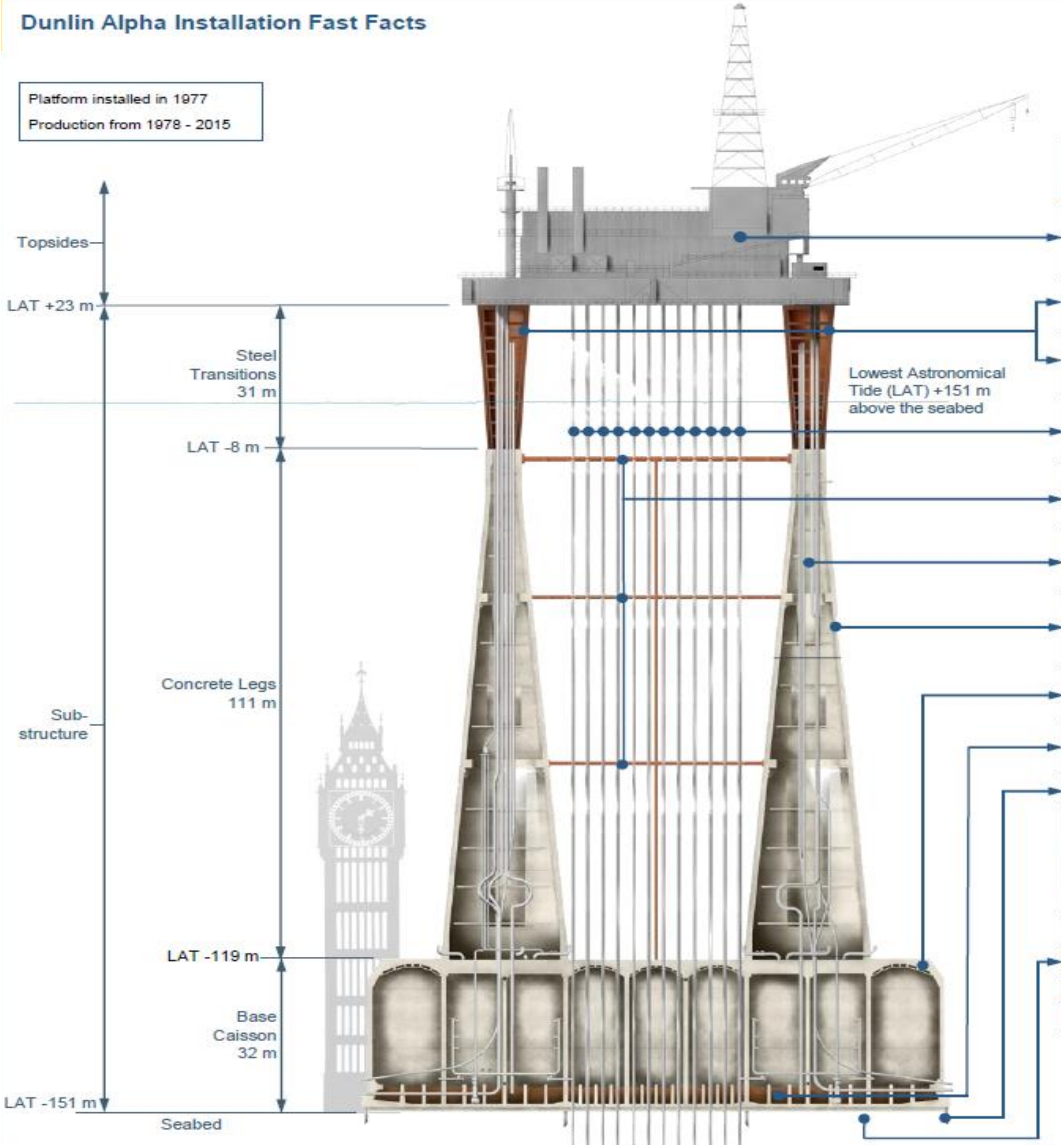
APPENDIX D DUNLIN ALPHA CGBS – FAST FACTS

Dunlin Alpha Installation Fast Facts

FEL-DUN-HSE-DAT-00003 Rev A4

FairfieldEnergy

Platform installed in 1977
Production from 1978 - 2015



Infrastructure	Dimensions	Weight (te)	Weight Excludes
Topsides (dry)	19,255 te 63.7 m x 82.3 m Incl. 30 te of NORM 355 te of hazardous materials	**≈19,640**	Operational Weights e.g. Process Fluids Laydown
Steel Transition A & B	2 x 295 te 5.4 m in diameter (cylindrical) 31 m tall	**≈590**	Leg Internals Marine Growth
Steel Transition C & D	2 x 500 te 5.4 m to 8.9 m in diameter (conical) 31 m tall	**≈1,000**	Leg Internals Marine Growth
Conductors	45 x 185 m (long) x 30" conductors from LAT+31 m to below seabed	**≈3,840**	Inner completions Marine Growth Clamps / Braces
Conductor Guide Frames and Vertical Supports	1 at LAT-10 m 1 at LAT-40 m 1 at LAT-76 m	**≈540**	Marine Growth Cathodic Protection Skid
Leg Internals (e.g. pipework, stairs)	Within 4 steel transitions and concrete legs from LAT+23 m to LAT-119 m	**≈1,250**	-
Concrete Legs (reinforced concrete)	Concrete legs: 4 x 8,625 te 22.65 m to 6.7 m in diameter (conical) 111 m tall	**≈34,500**	Leg Internals
Base Caisson	104 m x 104 m x 32 m	**≈202,000**	Base Caisson Internals Cell Contents Ballast
Iron Ore Ballast and Concrete Cover Layer	Approximately 104 m x 104 m x 3 m deep	**≈96,800**	-
Seabed Skirts	8 x 104 m x 4 m	**≈1,450**	-
Total Weight of substructure (including contingency)	-	**≈342,000**	Topsides Marine Growth Debris Drill Cuttings Cell Contents Under Caisson Grout
Marine Growth (wet)	-	**≈1,400**	-
Under Caisson Grout	-	**≈500**	-
Drill Cuttings	19,555 m³ over 9,184 m²	**≈48,888**	-

Note: Weights are as of CoP

Rev: Jun 18

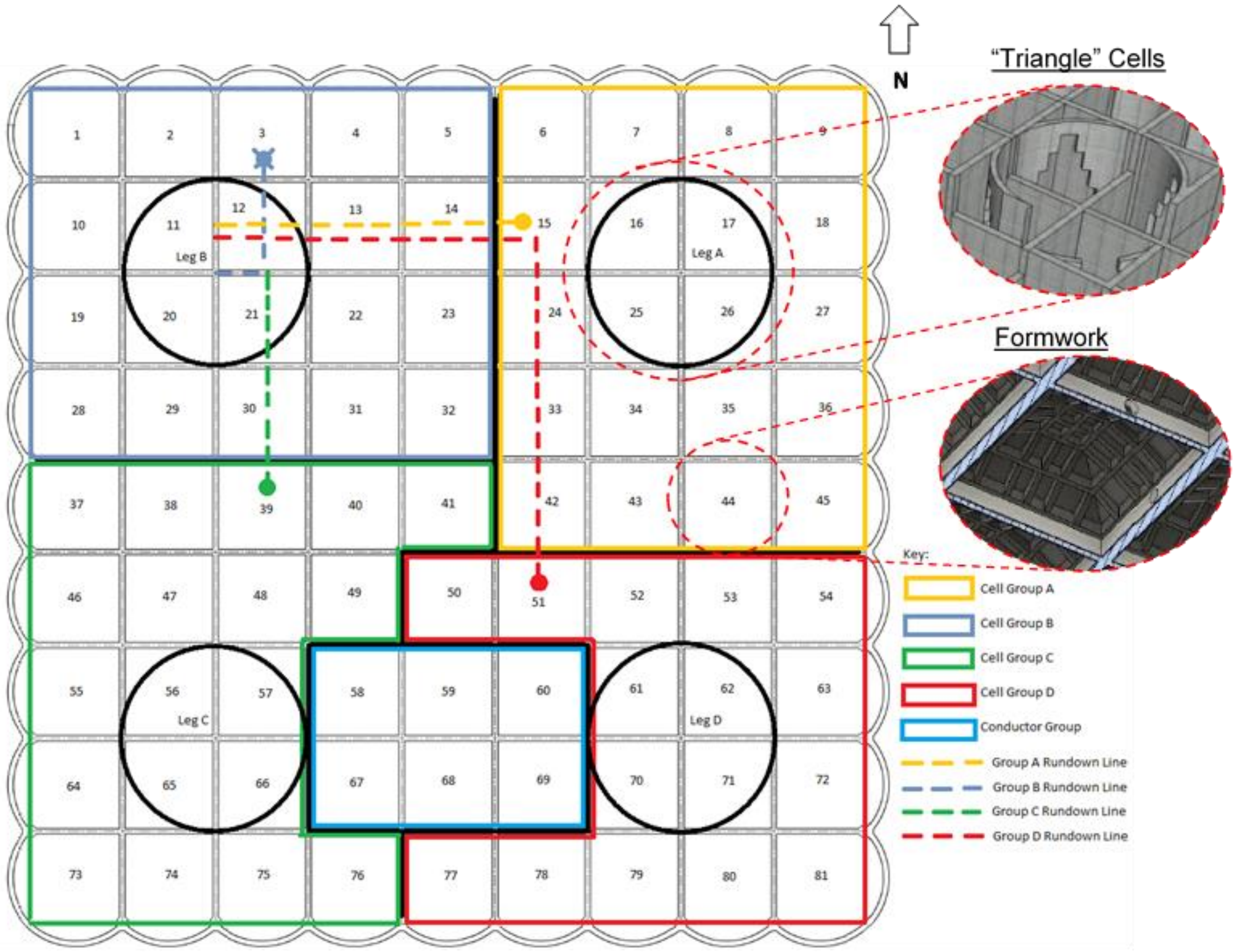
APPENDIX E CELL CONTENTS – FAST FACTS

Storage Cell Overview

This fact sheet provides an overview of the Dunlin Alpha cell contents characterisation work to define the residual inventory within the Concrete Gravity Base Structure (CGBS).

Production commenced in 1978, with the cells operating on a continual basis through until 1995, where thereafter use was limited to occasional periods mainly during start-up. In 2004 the decision was made to no longer use the storage cells and planning commenced to take them out of service permanently. Over this production history the throughput totalled nearly 139 million m^3 of oil and produced water combined.

In 2007, Shell executed a project to recover the mobile oil from within the cells using Carbon Dioxide (CO_2) gas to displace the oil.

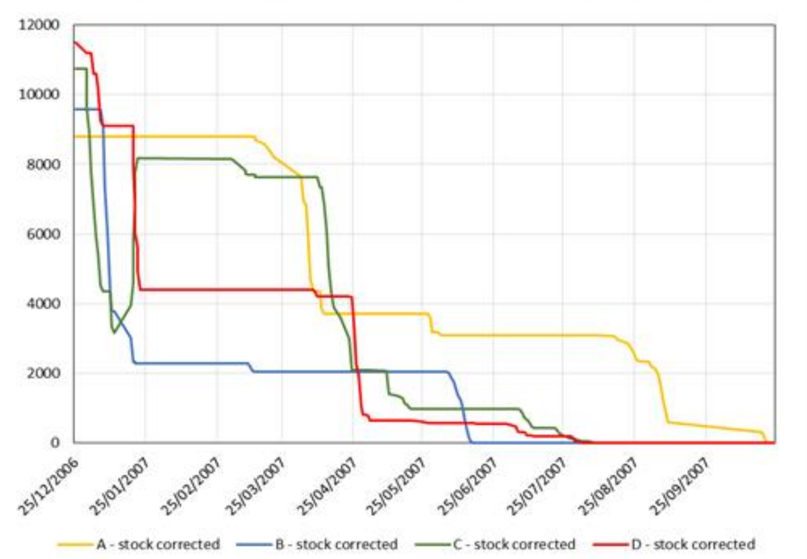


Cell Contents Inventory Summary

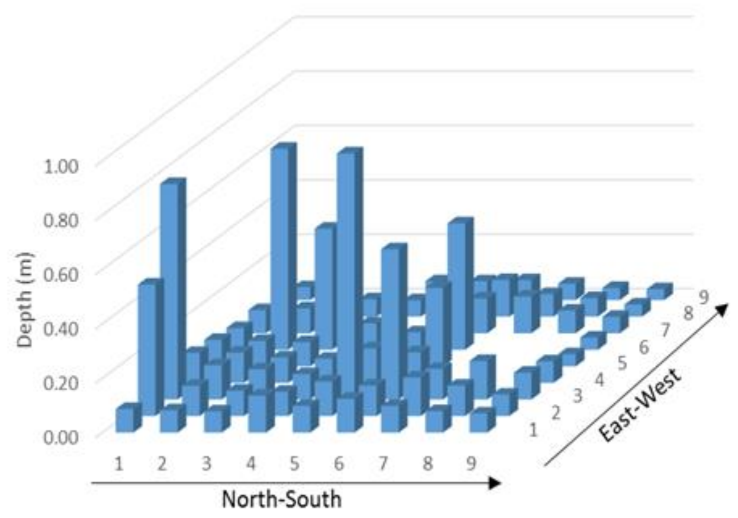
Total Inventory	Volume (m^3)	%
Residual Attic Oil	988	0.42
Trapped Oil	449	0.19
Diffused Oil	128	0.05
Total Mobile Oil	**1,565**	**0.66**
Sand / Clay	363	0.15
Scale	159	0.07
Hydrocarbon	363	0.15
Water	363	0.15
Total Sediment	**1,248**	**0.53**
Wall Residue	**462**	**0.19**
Water Phase	**233,631**	**98.62**

Variation from Individual Cell to Cell	Volume (m^3)	
	Min	Max
Mobile Oil	14.5	59.7
Sediment	5.7	101
Wall Residue	2.3	11.4
Water Phase	2627	3479

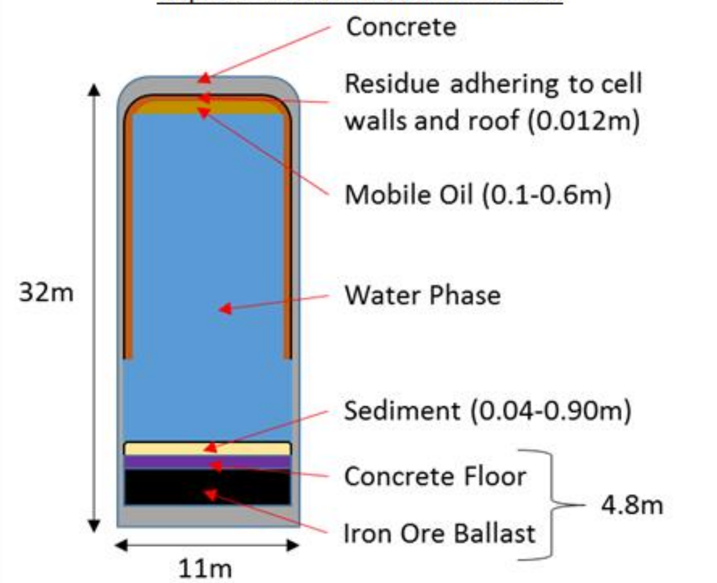
2007 Attic Oil Recovery Project (AORP) – Cell Stock Levels (m^3)



Sediment Distribution



Representation of an Individual Cell



Cell Contents Management Option	Option 1 - High Oil and Sediment Recovery (R7 Hybrid)	Option 2 - Mid Oil and Sediment Recovery (R12 Hybrid)	Option 3 - Mid Oil Recovery (R12)	Option 4 - Leave *in situ*
Number of cell penetrations and directly accessed cells (XX small + X larger = XX total)	23 small + 8 larger = 31 total	14 small + 4 larger = 18 total	15 small + 0 larger = 15 total	0 small + 0 larger =0 total
No of cells indirectly accessed	43	23	21	0
No of cells mobile oil to be recovered from	74	41	36	0
No of cells sediment to be recovered from	8	4	0	0
Total volume of materials recovered	Mobile Oil = 599 m^3, Sediment = 270 m^3	Mobile Oil = 299 m^3, Sediment = 147 m^3	Mobile Oil = 274 m^3, Sediment = 0 m^3	Mobile Oil = 0 m^3, Sediment = 0 m^3
Residual inventory	Mobile Oil = 966 m^3, Sediment = 978 m^3	Mobile Oil = 1,266 m^3, Sediment = 1,101 m^3	Mobile Oil = 1,291 m^3, Sediment = 1,248 m^3	Mobile Oil = 1,565 m^3, Sediment = 1,248 m^3
Waste generated	Mobile Oil = 599 m^3, Sediment Slurry = 2,701 m^3	Mobile Oil = 299 m^3, Sediment Slurry = 1,470 m^3	Mobile Oil = 274 m^3, Sediment Slurry = 0 m^3	Mobile Oil = 0 m^3, Sediment Slurry = 0 m^3
Loss of containment (operational)	Mobile Oil = 15 m^3, Sediment = 0.2 m^3	Mobile Oil = 15 m^3, Sediment = 0.2 m^3	Mobile Oil = 15 m^3, Sediment = 0 m^3	Mobile Oil = 0 m^3, Sediment = 0 m^3
Loss of containment (legacy)	Mobile Oil = 31 m^3, Water = 12,821 m^3	Mobile Oil = 31 m^3, Water = 12,821 m^3	Mobile Oil = 31 m^3, Water = 12,821 m^3	Mobile Oil = 62 m^3, Water = 12,789 m^3
Extent of drill cuttings disturbance	Full removal	Minimal removal	Minimal removal	No removal
Area of drill cuttings disturbed	6,431 m^3	2,057 m^3	1,815 m^3	0 m^3
Volume of drill cuttings disturbed	10,333 m^3	358 m^3	303 m^3	0 m^3
Offshore Execution Duration	445 days	272	224	0
Number of Seasons Campaign	3	2	2	0