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ISM

SUBMARINE DISMANTLING PROJECT

COEIA MCDA Data Report

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Amendment History

Issue	Date	Details of Amendment	DCCF
V0.1	19 April 11	Draft issued to MCDA workshop invitees for review prior to workshop and comment	000
V1.0	12-May-11	Amended in line with received comments. Version 1.0 issued to MCDA workshop invitees for review and comment prior to the scoring workshop. Significant changes or additional text (since Issue 0.1) shown in red.	
V2.0	22-June-11	Updated after May 2011 MCDA Scoring Workshop to be consistent with the workshop assumptions. The transportation data in Section 4.3 and Annex C3 was simplified and duplicate text in Annex C was removed. Assumptions were added. Data provided at (and subsequent to) the Scoring Workshop is labelled accordingly and highlighted in grey boxes.	

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Glossary of Terms

Abbreviation	Meaning
AGLV	Area of Great Landscape Value
ALARP	As Low as Reasonably Practicable
AONB	Area of Outstanding Natural Beauty
AP	Assessment Phase
AQMA	Air Quality Management Area
BAT	Best Available Technology
BC	Business Case
BGS	British Geological Survey
BM	Babcock Marine (now Babcock International Group?)
BPM	Best Practical Means (Note that in England and Wales, the use of BPM terminology has been discontinued and replaced with the use of BAT (see definition above). BPM terminology is still used in Scotland and in Northern Ireland.)
CFA	Conditions for Acceptance
CoA	Concept of Analysis
COEIA	Combined Operational Effectiveness and Investment Appraisal
CONOP	Concept of Operation
CoRWM	Committee on Radioactive Waste Management
DDLP	De-fuel, De-equip and Lay-Up Preparation
DE&S	Defence Equipment and Support
DfT	Department for Transport
DLOD	Defence Lines of Devopment
DSM	Director Submarines
DNSR	Defence Nuclear Safety Regulator
DRDL	Devonport Royal Dockyard Limited
DTI	Department of Trade and Industry
EA	Environment Agency
FOC	Full Operating Capability
GDF	Geological Disposal Facility
H&S	Health and Safety
Ha	Hectare
HGV	Heavy Goods Vehicle
HMNB	Her Majesty's Naval Base

Abbreviation	Meaning
HPA	Health Protection Agency
IA	Investment Appraisal
IAB	Investment Approvals Board
IAEA	International Atomic Energy Agency
ID	Identification
ILW	Intermediate Level Waste
IOC	Initial Operating Capability
IPT	Integrated Project Team
ISMs	In Service Submarines
ISOLUS	Interim Storage of Laid up Submarines
LLW	Low Level Waste
LLWR	Low Level Waste Repository
LUSMs	Laid up Submarines
MCDA	Multi-Criteria Decision Analysis
MCP	Maritime Change Programme
MG	Main Gate
MGBC	Main Gate Business Case
MOD	Ministry of Defence
MoE	Measure of Effectiveness
MRWS	Managing Radioactive Waste Safely
MUFC	Maritime Underwater Future Capability
NDA	Nuclear Decommissioning Authority
OCF	Other Contributory Factors
OE	Operational Effectiveness
PCBs	Polychlorinated Biphenyls
PM_{10}	Particulate Matter of 10 microns in diameter or smaller
PST	Primary Shield Tank
PW	Packaged Waste
PWR	Pressurised Water Reactor
RAMSAR	Wetlands of International Importance under the RAMSAR convention
RC	Reactor Compartment
RPV	Reactor Pressure Vessel
RWMD	Radioactive Waste Management Directorate
S&MO	Salvage and Marine Operations
SAC	Special Area of Conservation
SADP	Survey and Docking Period

Abbreviation	Meaning
SDP	Submarine Dismantling Project
SEA	Strategic Environmental Assessment
SPA	Special Protected Area
SQEP	Suitably Qualified and Experienced
SSSI	Site of Special Scientific Interest
SUDs	Sustainable Urban Drainage Systems
Sv	Sievert
UFF	Used Fuel Flask
UKCP09	UK Climate Projections 2009
URD	User Requirement Document
VLLW	Very Low Level Waste
WAGR	Windscale Advanced Gas Cooled Reactor
WLC	Whole Life Cost

Note: Additional data which was provided at the May 2011 MCDA Scoring Workshop is labelled accordingly and highlighted within grey boxes.

Executive Summary

The SDP is charged with selecting and subsequently implementing an optimal solution for dismantling of decommissioned nuclear submarines and management of the waste arisings.

The overall decision making process has three assessment streams, namely the Investment Appraisal (IA), Operational Effectiveness (OE) and Other Contributory Factors (OCF).

This document contains supporting data to inform those involved in the OE assessment process, which will be conducted using Multi-Criteria Decision Analysis (MCDA) techniques.

The purpose of the data report is to provide workshop participants with sufficient information to understand the nature of the criteria under consideration; to provide them with a summary of the relevant technical information and data available to support the scoring of options against each of the criterion, and to provide details of the source and audit trail of the technical information provided. Workshop participants will also apply their own expertise, relevant to the criterion in view, to wherever a judgemental assessment is required and this will be recorded in the notes of the workshops.

Section 1 of this report provides background material, describes the process and summarises the purpose and structure of this report. This is supported by Annex A.

Section 2 provides an overview of the options, including the assumptions, the technical approaches to initial dismantling, and the potential sites which could be used for initial dismantling and/or storage of Reactor Compartments (RCs), Reactor Pressure Vessels (RPVs) and/or packaged waste. This is supported by Annex B.

The options are summarised below together with location-specific variants, where the initial dismantling will be carried out. Thus a “D” indicates that the submarine will be dismantled at Devonport (i.e. Devonport Dockyard/HMNB Devonport), an “R” at Rosyth (Rosyth Dockyard) and a “B” at both dockyards (i.e. Devonport Dockyard/HMNB Devonport and Rosyth Dockyard). It is emphasised that subsequent operations like interim storage and size reduction may not be performed at either Devonport Dockyard/HMNB Devonport or Rosyth Dockyard.

Note that all of the options (apart from the Do Minimum option) are assumed to have the same end point, which is disposal of ILW to the proposed Geological Disposal Facility (GDF).

Option 0: Do Minimum.

Option 1: RC separation with interim storage at the point of waste generation:

Variant 1D: Devonport Dockyard/HMNB Devonport. Variant 1R: Rosyth Dockyard. Variant 1B: Devonport Dockyard/HMNB Devonport & Rosyth Dockyard.

Option 2: RPV removal with interim storage at the point of waste generation:

Variant 2D: Devonport Dockyard/HMNB Devonport. Variant 2R: Rosyth Dockyard. Variant 2B: Devonport Dockyard/HMNB Devonport & Rosyth Dockyard.

Option 3: RPV removal with interim storage at a remote commercial site:

Variant 3D: Devonport Dockyard/HMNB Devonport. Variant 3R: Rosyth Dockyard. Variant 3B: Devonport Dockyard/HMNB Devonport & Rosyth Dockyard.

Option 4: RPV removal with interim storage at a remote MOD site:

Variant 4D: Devonport Dockyard/HMNB Devonport. Variant 4R: Rosyth Dockyard. Variant 4B: Devonport Dockyard/HMNB Devonport & Rosyth Dockyard.

Option 5: RPV removal and size reduction to fully packaged waste with interim storage at the point of waste generation:

Variant 5D: Devonport Dockyard/HMNB Devonport. Variant 5R: Rosyth Dockyard. Variant 5B: Devonport Dockyard/HMNB Devonport & Rosyth Dockyard.

Option 6: RPV removal and size reduction to fully packaged waste with interim storage at a remote commercial site:

Variant 6D: Devonport Dockyard/HMNB Devonport. Variant 6R: Rosyth Dockyard. Variant 6B: Devonport Dockyard/HMNB Devonport & Rosyth Dockyard.

Option 7: RPV removal and size reduction to fully packaged waste with interim storage at a remote MOD site:

Variant 7D: Devonport Dockyard/HMNB Devonport. Variant 7R: Rosyth Dockyard. Variant 7B: Devonport Dockyard/HMNB Devonport & Rosyth Dockyard.

Option 8: RPV removal and size reduction to fully packaged waste with interim storage at an approved NDA site.

Variant 8D: Devonport Dockyard/HMNB Devonport. Variant 8R: Rosyth Dockyard. Variant 8B: Devonport Dockyard/HMNB Devonport & Rosyth Dockyard.

Section 3 explains the process used to derive the criteria and groups them into 4 categories: Reduction in impact to Government and MOD (POL), Reduction of Impact to Operations (OP), Health and Safety (H&S) and Reduction of Environmental Impact (ENV).

Section 4 discusses each criterion in turn and provides an explanation of the meaning of the criterion, its scope and relevant data (where available) to assist in the consideration of the criterion. References to the sources of the data are provided. Each criterion is further discussed and includes a list of suggested topics for further consideration. Section 4 is supported by Annex C which contains additional supporting information for some of the criteria.

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1. Introduction

1.1. Background

1.1.1. The overall requirement for the Submarine Dismantling Project is "*To dismantle, cost effectively, 27 de-fuelled nuclear submarines by 2050, without exceeding the submarine storage capacity, in a safe, secure, and sustainable manner which upholds MOD's reputation as a responsible nuclear operator; stores Intermediate Level Waste (ILW) until a national disposal route is available; disposes of all other radioactive, hazardous and non-hazardous waste in accordance with legislation and minimises impact upon military capability*" [1.1].

1.1.2. The project scope includes past and current classes of nuclear submarines, 27 in all, 17 of which are already out of service and safely stored afloat at Rosyth Dockyard or at Devonport. Whilst the approved project scope does not include disposal of Astute class or Successor submarines, the project is required to retain the flexibility to become "future submarine capable", namely that the dismantling facilities will, wherever possible, be sized and flexible enough to be considered as an option for dismantling of future classes of submarines.

1.1.3. The project includes the interim storage on land of the resultant long lived ILW until at least 2040, pending the availability of the proposed national Geological Disposal Facility (GDF). For planning purposes long lived ILW storage is assumed for up to 100 years in line with CoRWM recommendations [1.2].

1.2. Option Selection Process

1.2.1. The SDP project is charged with selecting and subsequently implementing the optimal solution for meeting the requirements of the project. The overall decision making process is outlined in the Concept of Analysis (CoA) document [1.3].

1.2.2. The analysis has 3 assessment streams:

- *Investment Appraisal (IA)* - the Whole Life Cost (WLC) of each option.
- *Operational Effectiveness (OE)* - how well each option will be meet the objectives of the SDP.
- *Other Contributory Factors (OCF)* - non-measurable factors with a significant bearing on SDP, such as public perception.

1.2.3. In general, where factors can be considered in financial terms they are included within the IA. Where they cannot be considered in financial terms, but can be considered 'measurable' they are considered within the OE. If they cannot be considered in financial terms and are considered "non-measureable" but important to the SDP, they are considered within the OCF. Examples of OCF include perceived risk, public confidence and socio-economic impact. The inter-relationships between these three assessment streams are discussed further within Annex A.

1.2.4. This data report is produced in support of the OE assessment process, which is being undertaken using the Multi-Criteria Decision Analysis (MCDA) technique. Options, decision criteria and supporting data are laid out in Sections 2, 3 and 4 respectively of this document.

1.2.5. The intention is to implement the MCDA process through three two-day workshops:-

- A criteria workshop.
- A weighting workshop.
- A scoring workshop.

1.2.6. The purpose of the criteria workshop is, firstly, to discuss and agree the criteria set; some additions or changes to the criteria could be made at this stage if required. Secondly, the criteria workshop will develop and agree scoring systems for all of the criteria.

1.2.7. The purpose of the weighting workshop is to discuss and agree the weights to be allocated to the criteria within the MCDA model. The weights represent how important each issue is in the decision making process.

1.2.8. The purpose of the scoring workshop is to score each of the integrated options against all of the identified criteria, using the scoring scales developed during the criteria workshop.

1.3. Purpose of Data Report

1.3.1. This data report has been compiled with the following aims:

- To provide workshop participants with sufficient information to understand the nature and scope of the criteria under consideration.
- To provide workshop participants with a summary of the relevant technical information and data available to support the scoring of options against each of the criteria.
- To provide details of the source and audit trail of the technical information provided.

1.3.2. The intention is to issue a draft version of the data report subsequent to the criteria workshop and the final version prior to the scoring workshop. The data report is kept under strict configuration control with any amendments or additions being recorded in the document history. Any amendments made subsequent to the scoring workshop will be clearly annotated and the sensitivity of the workshop outcomes will be re-assessed accordingly.

1.4. Structure of Data Report

1.4.1. Section 2 of the data report summarises the options under consideration and Section 3 outlines the decision criteria which will be used.

1.4.2. Each criterion is discussed in turn, in Section 4, taking account of the following:

- *Meaning and Scope* -- description of what the criterion means and what is covered with in its scope.

- *Data* -- A summary of the technical data and information available from previous and current studies which will assist in the consideration of the criterion. Where applicable, the summary provided in the main body of the data report will be supported by further technical data provided in Annex C.
- *Discussion* -- A discussion of the data for the sole purpose of setting a framework for informed discussion at the workshops. Suggested topics for further discussion at the workshop are included.
- *References* -- List of references from which the data and information were obtained.

2. Options

2.1. Overview

2.1.1. The integrated options are comprised from combinations of the following [2.1]:

- Technical Approaches: Comparison of alternative technical approaches to the initial dismantling of submarines.
- Initial Dismantling Site(s): Comparison of different sites for initial radiological dismantling.
- Generic ILW Storage Site(s) / Solution: Comparison of generic categories of sites to store the Intermediate Level Waste (ILW) arising from initial dismantling.

2.1.2. Each of these areas is discussed in more detail below.

2.1.3. It should be noted that consideration of the integrated options will also include:

- Re-use, recycling or disposal of non-radioactive components.
- Transport of submarines and their waste.
- The commercial approach underpinning delivery of SDP.

2.1.4. However, the comparison of options will focus on the differences between the options, rather than factors which may be common across options.

2.2. Technical Approaches to Initial Dismantling

2.2.1. Three technical options for dismantling were previously defined and assessed during the MOD Preferred Option Study (MPOS) [2.2, 2.3]. These are:

- Reactor Compartment (RC) Separation (previously known as "cut-out").
- Reactor Pressure Vessel (RPV) Removal (previously known as RPV storage).
- RPV Removal and Size Reduction (previously known as "cut-up"). The MPOS identified this as preferred approach, but this factor should not be taken into account during these MCDA workshops.

2.2.2. The options are outlined below, with further descriptions contained within Annex B.

2.2.3. **Reactor Compartment Separation**: This option involves cutting out the entire reactor compartment (RC), which effectively means taking a "slice" from the centre section of the submarine, making it safe and placing it in storage until the proposed national GDF becomes available. The RC would serve as the interim storage and transport container. When the proposed GDF is able to accept the submarine dismantling waste, the RC will be dismantled and all waste which has been classified as long lived ILW will be packaged into containers suitable for disposal in the proposed GDF and the containers will then be transported for final disposal. Processing, packaging and disposal of Low Level Waste (LLW) at the national Low Level Waste Repository (LLWR) will also take place at this time. The storage of intact RCs is the approach taken by USA, Russia and France. This option is summarised in Figure 2.2.1.

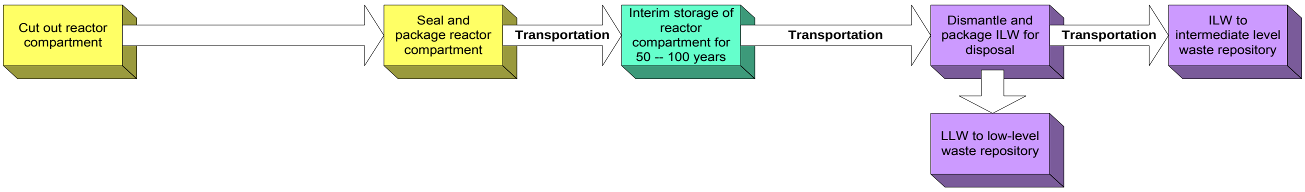

Figure 2.2.1 – MPOS Option 1: Reactor Compartment Separation

2.2.4. **Reactor Pressure Vessel Removal:** The RPV will be removed and separated from the RC within the submarine.

Further data provided at the Scoring Workshop:

At this stage it is not yet clear how the RPV can be detached from the Primary Shield Tank (PST).

2.2.5. The RPV head can be replaced with a lighter blanking plate before the RPV is removed from the RC (this is a standard dockyard operation during a refuelling period) resulting in significant size and weight reduction. The RPV head will then be disposed of as LLW. The RPV will be made safe and sealed/covered to provide a contained environment. The RPV will be stored at the Interim Storage Facility within some form of shielded containment, which may be the overpack/container designed for transportation. The stored RPVs must comply with a number of requirements, including the Ionising Radiation Regulations 1999 (IRRs) [2.4].

2.2.6. Once the proposed GDF becomes available, the RPV will be transferred from the interim store to the Size Reduction Facility, using heavy lifting equipment to transfer it, as it is assumed that size reduction will be undertaken at the interim storage site. The stored RPV will be size reduced and the ILW generated will be suitably packaged and conditioned for transfer for final disposal. The LLW generated will be characterised and where applicable, transferred to a suitable waste processing facility for size reduction/recycling and the residual LLW consigned to the LLWR for disposal. This option is summarised in Figure 2.2.2.

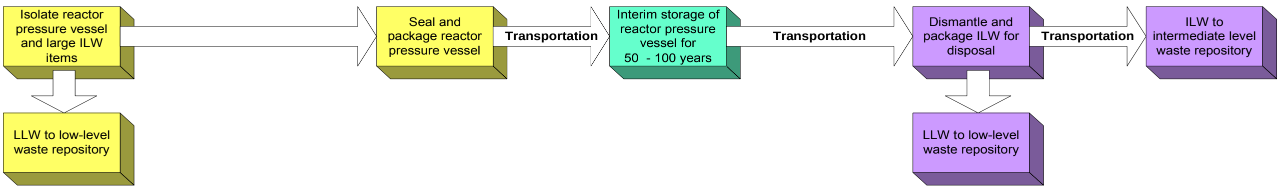

Figure 2.2.2 – MPOS Option 2: Reactor Pressure Vessel Removal

2.2.7. **Reactor Pressure Vessel Removal and Size Reduction to Fully Packaged Waste:** This option involves removal and early size reduction of the RPV and packaging of the intermediate and low level wastes, prior to interim storage. The ILW would be suitably packaged, conditioned into compliant containers and stored on land before eventually being sent for disposal. By this time, short lived ILW is expected to have substantially decayed to LLW; as a result, this would be sent to the LLWR. Long-lived ILW would be sent to the proposed GDF. These disposals would probably take place some time after 2040. This option is summarised in Figure 2.2.3.

2.2.8. This option is very similar to the RPV option discussed above, in that the RPV has to be removed from the RC. The essential difference is that for the packaged waste option, the RPV is immediately dismantled, with the ILW being packaged into GDF-compliant disposal containers 'up front' for interim storage. site, By contrast, the RPV option would see this final size reduction taking place after interim storage.

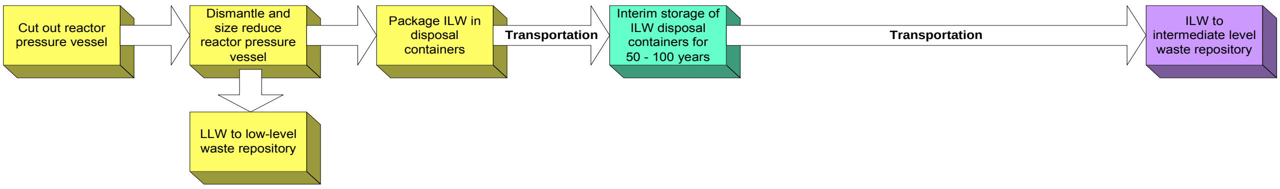

Figure 2.2.3: MPOS Option 3: Reactor Pressure Vessel Removal and Size Reduction

2.3. Potential Sites for Dismantling

2.3.1. Potential initial dismantling sites were considered during a site evaluation study [2.5] during which potential dismantling sites were screened against a pre-defined set of threshold criteria. This resulted in two 'existing' nuclear sites being considered potentially suitable for dismantling:

- Devonport Dockyard (commercial site owned by Babcock Marine)/HMNB Devonport (the adjacent MOD site).
- Rosyth Dockyard (commercial site owned by Babcock Marine).
- Or, a combination of Devonport Dockyard/HMNB Devonport and Rosyth Dockyard.

2.4. Dual Site Option

2.4.1. The dual site option utilises both of the identified sites for submarine dismantling. This provides benefits of a faster draw down on the stock of laid-up submarines, and of earlier reduction of nuclear overheads. It is anticipated that duplication of the required dismantling and packaging facilities at Rosyth Dockyard and Devonport Dockyard/HMNB Devonport will be very expensive. The following technical process provides an initial baseline, which assumes one Size Reduction and Packaging Facility only for the packaged waste option.

2.4.2. <u>Site 1 (Dismantling followed by RPV removal and transfer of RPV to another site):</u>

1. Dock submarine from stock already laid-up at this site;
2. Remove RPV.
3. Remove remaining radioactive materials and sentence the waste using existing waste disposal/recycling routes;

4. Break up the remaining hull and contents (on or off site);
5. Repeat for all of the submarines on Site 1; and
6. Prepare RPVs for transport off-site, and transfer to Size Reduction and Packaging Facility at Site 2.

2.4.3. Site 2 (Dismantling followed by RPV removal, RPV size reduction and packaging):

2.4.4. Steps 1 to 4 above would be undertaken for submarines currently stored at Site 2 or delivered there in the future at the end of their operational life. In addition the following steps will be undertaken both for RPVs produced at Site 2 and also for those transferred from Site 1:

- Receive RPV and transfer to Size Reduction Facility;
- Size reduce RPV and segregate into ILW/LLW;
- Send LLW for recycling/disposal; and
- Transfer ILW to Interim Store.

2.4.5. The definition of the dual site dismantling option makes no assumption at this stage about which of the two sites will host the Size Reduction Facility.

2.5. Potential Sites for ILW Storage

2.5.1. Potential storage sites were considered during the site evaluation study [2.5], which concluded that, on operational grounds, existing Licensed or Authorised sites were preferable. Within this type of site, four categories of site were considered potentially suitable for ILW storage:

2.5.2. **Storage at point of generation** – This would mean either Rosyth Dockyard or Devonport Dockyard and in the case of Devonport would also include potential for storage at the adjacent MOD site (HMNB Devonport). For the purposes of this document, the Devonport options are identified as Devonport Dockyard/HMNB Devonport. For the dual site dismantling option, storage at the point of generation would mean packaged waste being stored at the site used for size reduction of the RPV.

2.5.3. **Storage at remote commercial site -** A remote commercial site would be any site meeting the site screening criteria but not owned or managed by the MOD, located away from the dismantling location [2.5]. This category would include both Rosyth Dockyard and Devonport Dockyard/HMNB Devonport, where dismantling occurs at the other location.

2.5.4. **Storage at remote MOD site -** A remote MOD site would be any site meeting the site screening criteria but not owned or managed by the MOD and located away from the dismantling location. This category could also include, for example, the coastal location HMNB (Clyde) Coulport and the inland location AWE Aldermaston. This category could also include HMNB Devonport, except for options involving dismantling at Devonport Dockyard/HMNB Devonport, in which case this would count as point of generation storage.

2.5.5. **Storage at NDA site -** It may be possible for MOD waste to be stored at an NDA site, if this was provided for within a developing waste consolidation strategy and proven to be best value for money. At this stage it is not possible to define the potential NDA locations further, and therefore both coastal and non-coastal sites could be assumed. All NDA sites will have transportation links sufficient for the import of fully packaged waste, although not necessarily for RCs or RPVs.

2.6. Do Nothing and Do Minimum Options

2.6.1. **Do Nothing:** This option is a continuation of afloat storage of redundant submarines. Afloat storage capacity will run out from around 2020 with no berths available to accommodate submarines coming out of service after that date. Because this option does not comply with Government and MOD policy, and represents increasing cost and risk, it has been de-selected with the agreement of D Scrutiny.

Do Minimum: The 'Do Minimum' option is a MoD requirement and is interpreted as doing the least amount of work that has to be done to comply with external requirements. Hence it cannot not have the same end-point as the other options. The 'Do Minimum' option provides a benchmark against which to assess new investment. It provides an essential comparator against which the value for money of other options can be measured. This option is also a continuation of afloat storage of redundant submarines but identifies and implements the lowest incremental activities that can meet all mandatory requirements i.e. to continue with the existing maintenance programme, health physics surveillance and to provide additional afloat storage capacity. The prospect of identifying suitable additional afloat storage capacity is considered unlikely and the indefinite afloat storage of redundant submarines is untenable. This option is subject to the same argument as the Do Nothing option. However, this option will serve as a baseline comparator for COEIA purposes. Note that since the Do Minimum option does not have the same end point as the technical options described above, it does not progress to removal of plant or size reduction and packaging of radioactive waste.

2.7. Summary of Potential Integrated Options

2.7.1. The siting and technical options described above were combined to give complete integrated options, with any non-feasible combinations removed. This resulted in 8 option groupings being put forward, each with variants for dismantling sites.

2.7.2. Thus variants designated by a "D" (e.g. Variant 2D) indicate that the submarine will be dismantled at Devonport, variants designated by an "R" (e.g. Variant 2R) indicate that the submarine will be dismantled out at Rosyth Dockyard and variants designated by a "B" (e.g. Variant 2B) indicates that the submarine will be dismantled at both Devonport Dockyard/HMNB Devonport and Rosyth Dockyard. Depending on which option is chosen, subsequent operations like interim storage and size reduction may not be performed at either Devonport or Rosyth.

2.7.3. It is re-emphasised that all the options provide cradle to grave solutions with the exception of Option 0, Do Minimum, which only provides a continued storage solution and is presented as a baseline comparator.

2.7.4. <u>Option 0: Do Minimum</u>

2.7.5. <u>Option 1: RC separation with storage at the point of waste generation:</u>

Variant 1D[1]: RCs separated at Devonport Dockyard/HMNB Devonport

Variant 1R: RCs separated at Rosyth Dockyard

Variant 1B: RCs separated at Devonport Dockyard/HMNB Devonport & Rosyth Dockyard

2.7.6. Option 2: RPV removal with storage at the point of waste generation:

Variant 2D: RPVs removed at Devonport Dockyard/HMNB Devonport

Variant 2R: RPVs removed at Rosyth Dockyard

Variant 2B: RPVs removed at Devonport Dockyard/HMNB Devonport & Rosyth Dockyard

2.7.7. Option 3: RPV removal with storage at a remote commercial site:

Variant 3D: RPVs removed at Devonport Dockyard/HMNB Devonport

Variant 3R: RPVs removed at Rosyth Dockyard

Variant 3B: RPVs removed at Devonport Dockyard/HMNB Devonport & Rosyth Dockyard

2.7.8. Option 4: RPV removal with storage at a remote MOD site:

Variant 4D: RPVs removed at Devonport Dockyard/HMNB Devonport

Variant 4R: RPVs removed at Rosyth Dockyard

Variant 4B: RPVs removed at Devonport Dockyard/HMNB Devonport & Rosyth Dockyard

2.7.9. Option 5: RPV removal and size reduction to fully packaged ILW, with interim storage at the point of waste generation:

Variant 5D: ILW packaged at Devonport

Variant 5R: ILW packaged at Rosyth Dockyard

Variant 5B: ILW packaged at Devonport Dockyard/HMNB Devonport or Rosyth Dockyard

2.7.10. Option 6: RPV removal and size reduction to fully packaged ILW, with interim storage at a remote commercial site:

Variant 6D: ILW packaged at Devonport

Variant 6R: ILW packaged at Rosyth Dockyard

Variant 6B: ILW packaged at Devonport Dockyard/HMNB Devonport or Rosyth Dockyard

2.7.11. Option 7: RPV removal and size reduction to fully packaged ILW, with interim storage at a remote MOD site:

Variant 7D: ILW packaged at Devonport

Variant 7R: ILW packaged at Rosyth Dockyard

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[1] D stands for Devonport; R for Rosyth; B for Both (sites)

Variant 7B: ILW packaged at Devonport Dockyard/HMNB Devonport or Rosyth Dockyard

2.7.12. Option 8: RPV removal and size reduction to fully packaged ILW, with interim storage at an approved NDA site:

Variant 8D: ILW packaged at Devonport

Variant 8R: ILW packaged at Rosyth Dockyard

Variant 8B: ILW packaged at Devonport Dockyard/HMNB Devonport or Rosyth Dockyard

2.8. Assumptions

Further data provided from discussions at the Scoring Workshop:

The table below lists the assumptions used during the MCDA workshops.

Column A shows the MDAL serial number.

Column B groups the assumptions according to their appropriate “Defence Lines of Development” (DLOD) categories (e.g. concept & doctrine, infrastructure, logistics).

Column C contains the data / assumptions.

Column D provides context to the data / assumptions.

It is emphasised that these assumptions relate to the definition of options for the purposes of the options analysis. They are not project assumptions and do not relate to the feasibility of the various options.

Table 2.8.1: MCDA Assumptions

A	B	C	D
MDAL Serial #	**DLOD**	**Data / Assumption**	**Context**
15.21	Concepts & Doctrine	The Reactor Compartment (RC) and Reactor Pressure Vessel (RPV) are classed as radioactive waste.	When the RC and RPV are 'cut-out' of a submarine they are classed as radioactive waste.
12.05	Concepts & Doctrine	It is assumed that intact submarines can be safely wet towed. Although transportation of the separated RC’s fore and aft sections may require the use of a barge or heavy lift ship, it is assumed that this will not require additional (capital) dredging to be undertaken.	Transport of submarines by barge and heavy lift ship methods might require capital dredging to be undertaken (particularly at Devonport, which has restricted depth within the breakwater), but towing and load / unload

A	B	C	D
MDAL Serial #	**DLOD**	**Data / Assumption**	**Context**
			arrangements would enable this to be avoided. Such dredging would be associated with significant environmental impacts and would require licensing. The Environmental syndicate within the MCDA scoring workshops assumed that no dredging was required.
7.24	Infrastructure	There will only be one Size Reduction Facility.	Two facilities would be very expensive.
7.25	Infrastructure	For options requiring MOD bespoke new build storage facilities, there will only be one Interim Storage Facility.	New-build of two storage facilities (one on each dismantling site) would be very expensive. This does not apply to NDA options where stores will exist or be built for other wastes and multiple storage facilities might be used for SDP waste depending on arisings and lifetime plans.
20.03	Infrastructure	For purposes of options analysis, it is assumed that the size reduction facility for RC and RPV storage options will be on the same site as the interim store.	Thus for RPVs and RCs, this was a working assumption made only for the purposes of the MCDA workshops. Further transportation of RCs and RPVs to a separate size reduction facility would need to be subjected to a Value for Money (VFM) assessment based on the factors and context prevailing at that point in the future.
20.06	Infrastructure	For purposes of options analysis, if size reduction takes place immediately after initial dismantling, the initial dismantling facility and the size reduction facility will be on the same	Applicable for single site dismantling.

A	B	C	D
MDAL Serial #	DLOD	Data / Assumption	Context
		site.	
20.01	Infrastructure	For purposes of options analysis, RC storage would not require housing in a shielded warehouse as the RC is sufficient shielding.	This reflects the best available knowledge from Nuclear experts and is the current model of storage undertaken at the French ports in Cherbourg. Assumption agreed with BM & Nuvia
7.26	Infrastructure	The size reduction facilities and the waste handling facilities require a combined footprint of 5,000m².	It was recognised that the store footprints added significantly to a number of discussions, which highlighted the lack of comparative data for other facilities. The assumption was made that size reduction and waste handling facilities would in total require 5,000m². This was the figure stated within the MCDA workshops of Spring 2011 but will be further refined as concept designs develop.
20.02	Logistics	For purposes of options analysis, The cost and complexity of loading, unloading and transport of RCs to a remote storage location would render RC storage uneconomic (relative to other integrated options). Therefore, the COEIA has only considered, as a bounding case, the integrated option of RC storage at the point of generation. The only exception is the dual dismantling site, RC storage integrated option which (for cost reasons) is configured with only one RC store at one of the initial dismantling sites – therefore transportation of RCs between initial dismantling sites would be required.	The integrated option set only includes point-of-generation storage for RCs due to their bulk and the unavailability of suitable coastal sites and the cost and complexity of inter-site transportation.
16.07	Logistics	RPV transport is feasible, most likely as an IP2 container, by road or sea.	The nature of the transport package for

A	B	C	D
MDAL Serial #	**DLOD**	**Data / Assumption**	**Context**
		Rail transport of PWR1 may be feasible, dependant on overall dimensions of the transport package.	movement within a site was discussed at the MCDA Scoring Workshop. It was not considered to be a significant issue for the scoring process.
20.07	Logistics	For purposes of options analysis, it was agreed in the syndicates that movements in either direction between Scotland and England would be acceptable.	Assumption will be taken forward at OGD / Ministerial level as OCF.
20.09	Logistics	For the purposes of options analysis, it was assumed that for single site dismantling at Devonport, the submarines will only be transferred from Rosyth to Devonport when the dismantling facility is ready to receive them.	Assumption is valid for single site dismantling at Devonport. It is considered that there is insufficient storage space at Devonport for the Rosyth boats. If the assumption changes it is an opportunity with attached operational risk.
20.04	Logistics	For purposes of options analysis and consultation on RPV separation, dual site dismantling options with storage at point of generation, it is assumed that storage and size reduction would occur at only one of the initial dismantling sites. Hence RPV transport between the initial dismantling sites would be required and this could be in either direction, either seven (to be moved south) or twenty (to be moved north).	
20.05	Logistics	For purposes of options analysis and consultation on the packaged waste, dual dismantling site option, it is assumed that size reduction could occur at either initial dismantling site, hence RPV transport could take place in either direction, either seven submarines (to be moved south) or twenty submarines (to be moved north).	Dual site option.

2.9. Technical Description of Potential Options

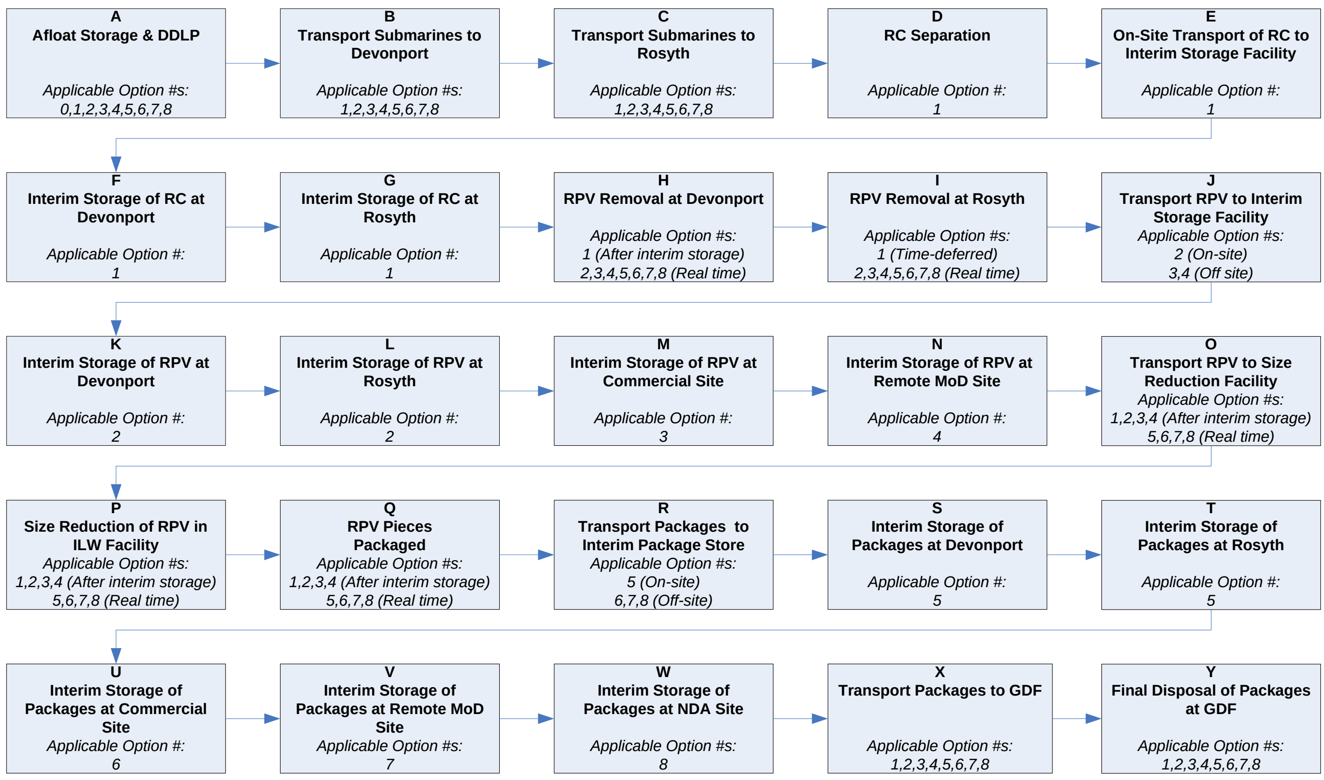
2.9.1. Figure 2.9.1 below itemises the key steps/activities involved for each of the options described above. Each box contains a description of an activity, together with a list of relevant option numbers. For example, Box A indicates that afloat storage and DDLP is applicable to Options 0 to 8.

2.9.2. Table 2.9.1 contains a brief description of each option. For example, Row A in Table 2.9.1 describes the work carried out under Box A, including where the submarines are located (i.e. Devonport Dockyard/HMNB Devonport or Rosyth Dockyard) and other relevant information.

2.9.3. To identify which steps are involved for any particular option (e.g. Option 1), look for a "1" at the bottom of each box in Figure 2.9.1. This sequence of boxes with a "1" at the bottom represents the key steps for this option.

2.9.4. Annex B provides more detailed technical descriptions for each of the main options.

2.9.5. Figure 2.9.1: Key Steps for Initial Dismantling and Waste Management



2.9.6. Descriptive text for each of the boxes contained in the above figure is shown in the table below.

2.9.7. Table 2.9.1: Description of Key Steps contained in Figure 2.9.1.

#	Description
A	Afloat storage and De-equip, De-fuel and Lay-Up Preparation (DDLP) is the start point for all submarines and common to all options. The submarines are stored afloat at Devonport Dockyard/HMNB Devonport and Rosyth Dockyard. Note that all future submarine de-fuelling will take place at Devonport.
B	Devonport Dockyard/HMNB Devonport is one of the options for the siting of a dismantling site. If this location is chosen as the dismantling site, all of the submarines will be located at Devonport. It is also possible that submarine dismantling will be undertaken at both Devonport and Rosyth Dockyards simultaneously (dual site dismantling).
C	Rosyth is one of the options for the siting of a dismantling site. If this location is chosen as the dismantling site, all of the submarines will be located at Rosyth Dockyard. It is also possible that submarine dismantling will be undertaken at both Rosyth Dockyard and Devonport Dockyard/HMNB Devonport simultaneously (dual site dismantling).
D	The RC will be separated from the submarine.
E	The separated RC will be moved to an interim storage location on the initial dismantling site.
E	**Further data provided at the Scoring Workshop:** Note that for the single site variants, this will be an on-site transport and that no off-site transportation will be required. If there only one size reduction facility, the RCs produced from dual site dismantling will need to be transported to this facility. (See Assumption 20.02)
F	If the RC is separated at Devonport, interim storage of the RC will occur on the Devonport site.
F	**Further data provided at the Scoring Workshop:** If RCs are separated at both Devonport and Rosyth under dual site dismantling, interim storage of RCs could occur on both sites. If there only one size reduction facility and this is at Devonport, the RCs will be transported to Devonport and stored there.
G	If the RC is separated at Rosyth, interim storage of the RC will occur on the Rosyth site.

#	Description
G	**Further data provided at the Scoring Workshop:** If RCs are separated at both Devonport and Rosyth under dual site dismantling, interim storage of RCs will occur on both sites. If there only one size reduction facility and this is at Rosyth, the RCs will be transported to Rosyth and stored there.
H	After a period of interim storage at Devonport, lasting at least several decades, the RPV will be removed from the separated RC (Option 1). Initial dismantling at Devonport. Removal of RPVs from the submarine.
I	After a period of interim storage at Rosyth, lasting at least several decades, the RPV will be removed from the RC. Initial dismantling at Rosyth. Removal of RPVs from the submarine.
J	RPVs will transported to the Interim Storage Facility. Note that some options (2, 3 and 4) involve interim storage prior to size reduction and this step is applicable to these options. Other options (5, 6, 7 and 8) involve interim storage after size reduction and this step is not applicable to these options.
K	Interim storage of RPVs at Devonport.
L	Interim storage of RPVs at Rosyth.
M	Interim storage of RPVs on a remote commercial site.
N	Interim storage of the RPV on a remote MOD site.
O	Transport of RPVs to the Size Reduction Facility. This step is applicable to Options 2, 3 and 4 which involve interim storage prior to size reduction. This step is also applicable to Options 5, 6, 7 and 8 which involve interim storage after size reduction.
P	Size reduction of RPVs.
Q	Production of packaged waste.
R	Transport of packaged waste to an interim store.

#	Description
S	Interim storage of packaged waste at Devonport.
T	Interim storage of packaged waste at Rosyth.
U	Interim storage of packaged waste at a commercial site.
V	Interim storage of packaged waste at a remote MOD site.
W	Interim storage of packaged waste at an NDA site.
X	Transportation of packaged waste to the proposed Geological Disposal Facility (GDF).
Y	Final disposal of the packaged waste at the proposed GDF.

3. Introduction to the MCDA Criteria

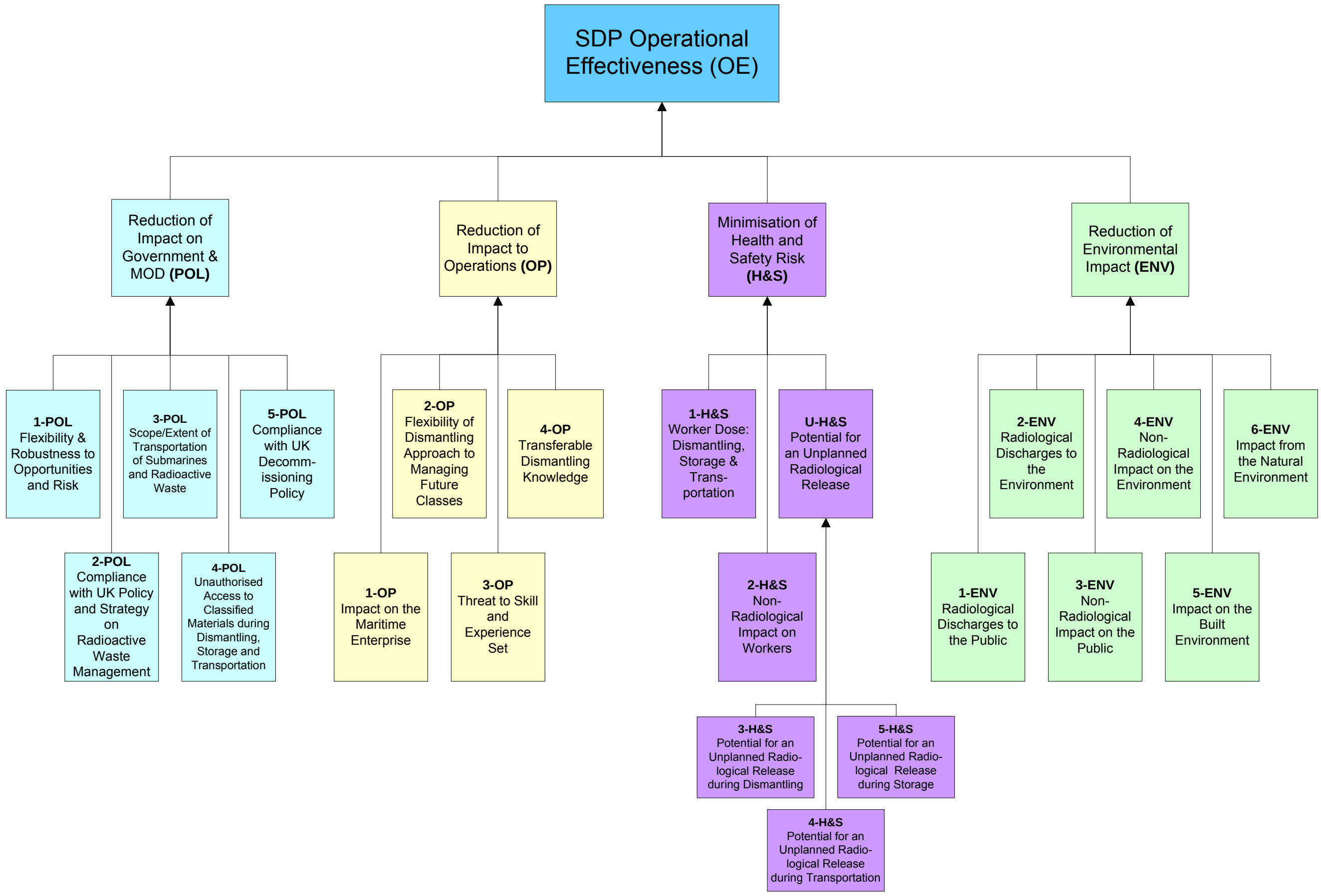
3.1.1. MCDA criteria were developed as set out in the CoA by consideration of:

- Benefits and disbenefits for Operational Effectiveness of the SDP;
- Assessment of the URD (to ensure all relevant requirements are considered); and
- Assessment of previous studies (including the SEA Scoping Report, MPOS technical options study and site evaluation study).

3.1.2. An initial criteria set was proposed and refined through a series of workshops. Consideration was also given to the definition of the threshold value (minimum requirement) and objective value (ideal performance) for each MCDA criterion [3.1]. This will be explored further at the criteria workshop.

3.1.3. The criteria presented within this data report are summarised in Figure 3.1 and Table 3.1 below.

3.1.4. Figure 3.1: MCDA Criteria



3.1.5. Table 3.1: MCDA Criteria

Criterion Number	Criterion Title	Category
1- POL	Flexibility and Robustness to Opportunities and Risk	Reduction in Impact to Government and MOD (POL)
2- POL	Compliance with UK Policy and Strategy on Radioactive Waste Management	
3- POL	Scope/Extent of Transportation of Submarines and Radioactive Waste	
4- POL	Unauthorised Access to Classified Materials during Dismantling, Storage and Transportation.	
5- POL	Compliance with UK Decommissioning Policy	
1-OP	Impact on the Maritime Enterprise	Reduction of impact to Operations (OP)
2-OP	Flexibility of Dismantling Approach to Managing Future Classes	
3-OP	Threat to Skill and Experience Set	
4-OP	Transferable Dismantling Knowledge	
5-OP	Impact on Wider MOD Operations	
	Consensus of the Workshops: Agreement was reached that 5-OP should not be considered as a separate criterion. 5- OP was therefore combined with 1-OP and all of the impacts were considered together under 1-OP.	
1-H&S	Worker Dose: Dismantling, Storage and Transportation	Minimisation of Health and Safety Risk (H&S)
2-H&S	Non-Radiological Impact on Workers	
	Potential for an Unplanned Radiological Release during Dismantling, Transportation and Storage	
3-H&S	Potential for an Unplanned Radiological Release during Dismantling	

Criterion Number	Criterion Title	Category
4-H&S	Potential for an Unplanned Radiological Release during Transportation	
5-H&S	Potential for an Unplanned Radiological Release during Storage	
1-ENV	Radiological Discharges to the Public	Reduction of Environmental Impact (ENV)
2-ENV	Radiological Discharges to the Environment	
3-ENV	Non-Radiological Impact on the Public	
4-ENV	Non-radiological Impact on the Environment	
5-ENV	Impact on the Built Environment	
6-ENV	Impact from the Natural Environment	

4. Data and Information

4.0. Introduction

4.0.1. The following sections discuss each of the decision criteria in turn. An explanation is provided of the meaning and scope of each criterion. This is followed by a presentation of available data (with references) relevant to the criterion and a discussion on relevant issues. Each discussion ends with suggestions for further discussion at the workshops. It is emphasised that the purpose of this section is to promote and assist discussion at the workshops, not to stifle creative thinking or to channel the discussion down any one pathway.

4.1. 1-POL: Flexibility and Robustness to Opportunities and Risk

4.1.1. This criterion addresses the flexibility and robustness of the options to take advantage of future opportunities and also to risk.

4.1.2. Dealing with the opportunities, the options should ideally have the ability to take advantage of situations which may develop in the future (i.e. short and long term over the next 50 or so years). The available data consists mainly of those opportunities which are currently contained within the SDP opportunities register. It is recognised that there may be additional opportunities which have still to be identified but by definition, these are not available to this data report. The project has a formal process for tracking and managing opportunities should any additional opportunities be identified during the workshop discussions.

4.1.3. Dealing with risk, the options should ideally be robust and flexible to accommodate the realisation of the mitigated risks identified in the current SDP risk register and also to those risks which may be identified in the future. The project has a formal process for tracking and managing risks should any new risks be identified during the workshop discussions.

4.1.4. **Data: Opportunities**

4.1.5. The opportunities register [4.1.1] identifies 6 potential opportunities relevant to the dismantling programme. Five of these are discussed below. The sixth opportunity which deals with buffer storage (ID: OP 58845) is currently under review.

4.1.6. **Opportunity 1: Optimisation of the SADP/DDLP/SDP joined up process (ID: OP39282).**

4.1.7. This opportunity addresses work to be carried out prior to the start of the dismantling process. This would involve early works to prepare the submarine for dismantling (e.g. decontamination of contaminated items to reduce their waste categories, stripping out and disposal of components, recycling materials).

4.1.8. This opportunity is understood to be relevant to all of the options. This opportunity will effectively time out for all of the options if the dismantling process is started without taking advantage of the opportunity to carry out the early preparation works.

4.1.9. **Opportunity 2: UK Adoption of IAEA Waste Categorisation (ID: OP41337)**

4.1.10. This opportunity addresses re-categorisation of waste to potentially allow an RC or an RPV to be disposed of to an LLWR surface disposal facility. The opportunity for re-categorisation of SDP ILW to facilitate its early disposal at LLWR is predicated partly on the argument that long lived isotopes such as Cs-137 (30 year half life) are present in the UK civil nuclear industry waste but not in SDP waste. This may allow the waste to be re-classified as Category A waste under the IAEA waste classification system [4.1.2] and disposed of to a LLW repository. The benefits would include a reduction in costs if this opportunity was realised, since it would not be necessary to construct and operate a Size Reduction Facility or an interim store. However, fairly substantial legislative, policy strategic and other changes would need to be made to realise this opportunity. This opportunity was evaluated in [4.1.3] and it was concluded that this is a low probability opportunity which could take at least a decade to come to fruition and may never be realisable. The policy lead for waste categorisation is DECC and it is likely that any change in policy would be driven by the needs of the civil nuclear industry which produces the vast majority of ILW.

4.1.11. This opportunity is not relevant to the Do Minimum option, since it does not have a disposal end-point. The opportunity is relevant to the RC separation option and the RPV removal options. The benefits arising from this opportunity would be substantially reduced if the ILW strategy was to produce packaged waste. It is still possible to re-categorise packaged waste following a period of interim storage and consign it to the LLWR, however, the costs associated with packaging and interim storage of waste would already have been committed.

4.1.12. **Opportunity 3: Shielded Mini Stores (ID: OP47437)**

4.1.13. This opportunity addresses use of shielded mini stores as a substitute for a single shielded store. It may be possible to package long lived and short lived ILW into a self shielded IP-2 box (e.g. the NDA 2m or 4m box or the so called Yellow Box). Alternatively, it may be possible to put localised shielding round a Type B package containing either long lived or short lived ILW. Both of these approaches would negate the need for a fully shielded interim store for long lived and short lived ILW. A cost benefit analysis would be required.

4.1.14. A fully shielded interim store may not be required for storage of RCs or RPVs, since a considerable amount of self shielding is already available within these structures. RCs and RPV may also have additional shielding for transportation purposes. This opportunity applies only to the packaged waste options. This opportunity would effectively time-out if the RC separation or the RPV removal option was adopted.

4.1.15. **Opportunity 4: Whole RPV Disposal (ID: OP58833)**

4.1.16. This opportunity addresses disposal of a whole RPV in the proposed GDF. A change/re-interpretation of the proposed GDF waste acceptance criteria could allow a whole RPV to be disposed of, without the need for size reduction prior to conditioning and packaging inside a disposal box. The major benefits would include the cost savings, reduced timescales and simplification of the SDP programme by not having to construct and operate a size reduction, packaging and conditioning facility.

4.1.17. This opportunity is relevant to both the RC and RPV options but not to the packaged waste options. This opportunity would effectively time-out if the ILW strategy was to produce packaged waste.

4.1.18. **Opportunity 5: Multi-stream Dismantling (ID: OP59748)**

4.1.19. An accelerated dismantling programme involving multi-stream dismantling would reduce the number of vessels requiring funded interim storage. This may reduce pressure on available berths as vessels continue to come out of service. Efficiency benefits may be realised by having SQEP personnel available to work on a number of vessels at any one time. Further work is required to determine the feasibility of this opportunity, to dismantle faster than the assumed one submarine per year. The optimum rate of dismantling would need to be determined through the Investment Appraisal process to take account of the discounted cash flows involved. This opportunity is understood to be relevant to all of the options.

4.1.20. **Data: Risk**

4.1.21. The text below provides an overview of the risk management process and the types of risks identified within the SDP. Some additional information is provided in Annex C (Section C1).

4.1.22. There are over 70 risks identified in the SDP risk register. The risks relate to the all phases of the project.

4.1.23. A structured process has been developed within SDP that allows individual risk events and overall project risk to be understood and managed proactively, optimising project success by minimising threats and maximising opportunities.

4.1.24. The risk management process starts with identification of an uncertain event or set of circumstances that, should it occur will have an effect on one or more of the project's objectives. The Risk Owner and Risk Manager carry out a quantitative assessment in terms of probability of occurrence and likely impact pre and post mitigation. The parameters: cost, time and performance are judged against a defined scoring scheme. Risk planning is conducted to consider the appropriate action required to manage the risk. Actions to prevent or reduce the probability and/or impact of the risk are identified and carried out.

4.1.25. Figure 4.1.1 below shows the SDP Risk Exposure Graph for the financial year 2010/11. The bars in the graph show the total level of risk exposure against the key milestones in the project schedule in Quarter 4. The lines in the graph compare the level of risk exposure for each previous quarter.

4.1.26. The green bubbles in the figure show some key de-risking activities that have contributed to the reduction of risk against each milestone and the red bubbles show the high level areas where risk remains against each milestone.

4.1.27. Figure 4.1.1: SDP Risk Exposure Graph

4.1.28. **Discussion**

4.1.29. Note that the opportunity element of this criterion could be in conflict with the IAEA waste management principle of intergenerational equity [4.1.4] which promotes the concept of dealing with issues in real time and not leaving them to future generations. However, government guidelines recognise that it may be appropriate to delay particular operations to benefit from new or developing technologies or from further development of existing best practice, or to take advantage of radioactive decay.

4.1.30. The fact that the risk register is a living document and that all of the risks are being managed in a professional manner suggests a degree of robustness to risk. However, this is not easy to quantify.

4.1.31. Discussion is required on a number of issues, including:

- Are any of the current opportunities contained in the opportunities register considered important enough to influence the strategic direction of the SDP?
- Are there any new (as yet undefined) opportunities which should be considered?
- Are there any risks contained in the risk register considered important enough to influence the strategic direction of the SDP?
- Are there any new (as yet undefined) risks which should be considered?
- Where does SDP stand in relation to the potential conflict between early and deferred initial dismantling?
- Does this criterion discriminate between the options?

4.2. 2-POL: Compliance with UK Policy and Strategy on Radioactive Waste Management

4.2.1. This criterion addresses the ability of the options to comply with UK policy and strategy on radioactive waste management. It includes management of LLW and ILW arising from submarine dismantling. Note that de-fuelled submarines do not contain high level waste (HLW), which is therefore not addressed here. Relevant data are presented below, and supplemented by information contained in Annex C (Section C2).

4.2.2. Data: LLW

4.2.3. LLW in the UK is described in the LLWR waste acceptance criteria [4.2.1]. It is radioactive waste which has activities greater than those of Very Low Level Waste (VLLW) and with an alpha activity of less than 4 GBq per tonne and a beta/gamma activity of less than12 GBq per tonne. VLLW is defined in [4.2.2] as radioactive waste which can be safely disposed of to an unspecified destination with municipal, commercial or industrial waste (hence the term “dustbin” disposal), each 0.1 m^3 of waste containing less than 400 kilobecquerels (kBq) of total activity or single items containing less than 40 kBq of total activity. Activity limits are also specified for waste containing Carbon-14 and/or Tritium.

4.2.4. There are two principal types of LLW produced by the SDP and both are described below with reference to their identification numbers in the national radioactive waste inventory [4.2.3].

4.2.5. Waste stream 7G102 (the national UK inventory number) consists mainly of neutron activated metals inside the RPV. It is short lived solid ILW that contains Co-60 which will decay to LLW levels within a period of about 30 years. It will not contain significant quantities of Ni-63 or other long lived isotopes. It will not be possible to recycle this type of waste. The waste will be disposed of at the LLWR.

4.2.6. Waste Stream 7G103 consists mainly of contaminated metals and other materials. It is solid LLW which can be consigned to the LLWR for disposal immediately, i.e. as soon as it is generated. It consists primarily of contaminated metals, but may also include secondary wastes such as overshoes, protective clothing and other items.

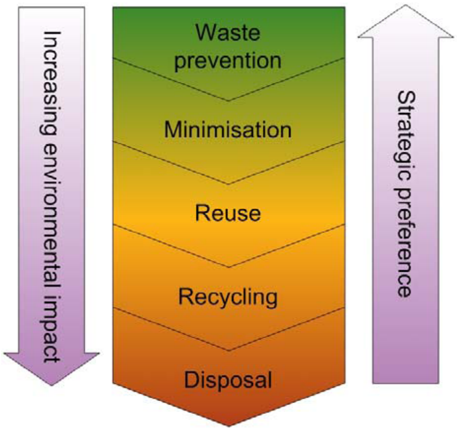
4.2.7. Annex C (Section 2) provides estimates of the amount of LLW which will be produced during dismantling, together with the amount which will be recycled and the amount which will be disposed of. It is cautioned that these are indicative quantities which are currently being updated to reflect recent waste characterisation modelling studies [4.2.4].

4.2.8. The *Policy for the Long Term Management of Solid Low Level Radioactive Waste Management in the United Kingdom* [4.2.2] provides a statement of Government Policy on the long term management of the UK's solid LLW. This policy statement covers all aspects of the generation, management and regulation of solid LLW. Note that MOD waste management policy is consistent with UK policy.

4.2.9. The *UK Strategy for the Management of Solid Low Level Radioactive Waste from the Nuclear Industry* [4.2.5] is developed from UK policy. The aim is to provide a high level framework within which LLW management decisions can be taken flexibly to ensure safe, environmentally acceptable and cost-effective management solutions that reflect the nature of the LLW concerned.

4.2.10. The UK strategy is to ensure that LLW waste arisings and the requirements for its disposal are minimised. The underlying objective is to keep the LLW disposal site in Cumbria open for as long as possible. LLW managers should plan their waste management activities in accordance with waste management hierarchy principles [4.2.5] presented below.

4.2.11. Figure 2.1: The Waste Hierarchy



4.2.12. **Prevention:** Waste prevention is the highest level of the waste hierarchy and potentially yields the greatest financial and environmental benefits compared to the other elements of the hierarchy.

4.2.13. **Minimisation:** Minimisation of the amount of waste to be managed as LLW can include:

- Separation of mixed wastes.
- Reduction in activity levels through decontamination.
- Characterisation of waste to allow appropriate sentencing. Note that at present, the UK Government is not considering any change in approach to the classification of LLW.
- Sorting and segregation into material types (e.g. metals or high volume VLLW); segregation at source where possible.
- Decontamination of facilities and materials prior to decommissioning has significant potential to minimise amount of LLW.
- Decay storage of waste to exempt or levels suitable for alternative management options may have benefits but there are significant challenges that need to be overcome, including rigorous characterisation before and after storage, regulatory requirements etc. Decay storage is particularly useful for wastes containing short lived radionuclides.
- The effective use of exemption orders requires quality assured waste characterisation to ensure wastes are properly sentenced. The strategy aims to make maximum use of exemption orders.

4.2.14. **Re-use:** Re-using materials and equipment (e.g. after decontamination) defers waste production and extends the life of resources.

4.2.15. **Recycling: –** The strategy recognises metal treatment and recycling as the main recycling technologies.

4.2.16. **Disposal:** The aim of the strategy is to ensure continued capability and capacity for LLW management. Where waste does require disposal it should be achieved in the most optimised way to minimise the impact of the disposal activities.

4.2.17. It is believed that there are no significant differences between LLW policy and strategy in England and Scotland, which would affect the SDP programme. It is worth noting that all non Dounreay LLW produced in Scotland is disposed of at the LLWR currently located in Cumbria. It is also understood that there are no VLLW disposal sites in Scotland.

4.2.18. **Data: ILW**

4.2.19. ILW in the UK is radioactive waste which has activities greater than those of LLW, i.e. has an alpha activity of greater than 4 GBq per tonne and/or a beta/gamma activity of greater than12 GBq per tonne.

4.2.20. Waste stream 7G104 [4.2.2] is long lived ILW which will remain so for the duration of the interim storage period and beyond. It consists predominantly of neutron activated metals. None of this waste stream can be recycled.

4.2.21. An interim storage period will allow for a significant decay of the Cobalt-60 activity in waste stream 7G104 (mainly activated metals), but not of the longer lived isotopes such as Nickel-63. Therefore, the interim storage period will not result in any reduction of the amount of ILW in the waste. The quantity of ILW produced will depend to some extent on the efficacy of the segregation techniques used during size reduction.

4.2.22. Annex C provides estimates of the amount of ILW which will be produced during dismantling. Note that none of this waste will be recycled. It is cautioned that these are indicative quantities which are currently being updated to reflect recent waste characterisation modelling studies [4.2.4].

4.2.23. UK ILW policy and strategy are not as well developed as the UK LLW policy and strategy. There are currently no disposal facilities in the UK for ILW and none will be available until at least 2040.

4.2.24. The three main recommendations of the 2006 report by the Committee on Radioactive Waste Management (CoRWM) [1.2] are listed below.

- Geological disposal is currently the best form of long term management for the UK's higher activity radioactive waste.
- There should be a commitment to the safe and secure interim storage of the waste during the period it will take to plan and construct the geological disposal facility.
- The UK should look to develop partnership arrangements, linked to appropriate involvement and benefit packages, with local authorities/communities as a means of securing facility siting.

4.2.25. Issues relevant to this criterion, taken from the 2004 UK Government statement on the decommissioning of nuclear facilities [4.2.6] are listed below.

4.2.26. The Government recognises that decommissioning operations may involve two or more separate stages spanning a number of decades. It may also be appropriate to delay particular operations to benefit from new or developing technologies or from further development of existing best practice, or to take advantage of radioactive decay.

4.2.27. The strategy should take into account all relevant factors…including minimising waste generation and providing for effective and safe management of wastes.

4.2.28. Strategies should harness the benefits of radioactive decay and should maximise the amount of materials suitable for re-use of recycling.

4.2.29. Through best practical means (BPM) strategies, the volume of radioactive waste created should be minimised, particularly the volume of ILW.

4.2.30. **Discussion**

4.2.31. All of the SDP options need to satisfy the waste management hierarchy. The current hierarchy has LLW at its head, but it is logical to assume that it should also include ILW. The main issues are listed below.

- Avoiding any unnecessary creation of wastes.
- Reducing waste arisings to a minimum by appropriate design and operation of the waste management processes and equipment.
- Making effective use of techniques such as waste characterisation, sorting and segregation, volume reduction and decontamination.
- Minimising the quantity of LLW for disposal by recycling.
- Minimising the quantity of ILW by decay storage (if applicable).

4.2.32. **Creation of Wastes:** None of the options will involve the unnecessarily creation of wastes. It will be necessary to create wastes when the submarines are dismantled.

4.2.33. **Waste Minimisation by appropriate design and operation:** This will be addressed during the design and operations phase of the SDP.

4.2.34. **Minimisation of quantities of ILW and LLW:** Waste stream 7G102 (mainly activated metals) contains short lived ILW which will decay to LLW to be disposed of at the LLWR. Minimisation of the quantities of short lived ILW will therefore result in production of more LLW. Minimisation of the quantities of ILW is consistent with the ILW management strategy. If only limited segregation of activated LLW (Waste Stream 7G102) is carried out for the packaged waste option, this option might result in production of less LLW (but more ILW for disposal), when compared to the other options. On the other hand, if more effort is put into segregation of ILW from LLW there is likely to be significant “consequential additional” LLW waste produced (e.g. more cutting discs, loose trash, used personal protective equipment and others) in comparison with limited or no segregation.

4.2.35. **Characterisation:** The same waste characterisation data will be used for all of the options.

4.2.36. **Waste volumes:** The volumes of waste streams 7G102 and 7G104 will impact on the footprint of the interim decay store and will therefore have an impact on cost. This will be addressed within the Investment Appraisal.

4.2.37. **Recycling:** Waste stream 7G103 (mainly contaminated metals) will be recycled (where applicable) to produce a lower category waste and residual LLW for disposal at LLWR.

4.2.38. **Decay:** Both the RC separation and the RPV removal options make provision for the in-situ decay of short lived ILW. The reduction in the Co-60 content will result in reduced external dose rates and will allow the eventual dismantling process to be performed with less shielding requirements. The packaged waste options involve real time size reduction under high dose rate conditions, hence the need for heavily shielded facilities (i.e. hot cells).

4.2.39. Discussion is required on a number of issues, including:

- Will the different options produce different quantities of ILW or LLW? If so, what is the significance of this?
- Are any of the options in conflict with national LLW and ILW management policy and strategy?
- Does this criterion discriminate between the options?

4.3. 3-POL: Scope/Extent of Transportation of Submarines and Radioactive Waste

4.3.1. This criterion addresses the scope/extent of transportation of submarines and radioactive waste. The scope of the transportations includes whole submarines, submarine components and/or radioactive wastes, which may need to be transported by rail, road and/or sea between the sites used for dismantling, interim storage and disposal.

4.3.2. Data

4.3.3. Annex C derives the numbers of the transportations described above. For the purposes of the options analysis, the following assumptions were made:

- There will only be one Interim Storage Site (MDAL Assumption 7.25).
- There will only be one Size Reduction Facility (MDAL Assumption 7.24).
- For Option 1, the Interim Storage Facility and the Size Reduction Facility will all be on the same site (MDAL Assumption 20.03).
- For Options 2, 3 and 4, the Interim Storage Facility and the Size Reduction Facility will be on the same site (MDAL Assumption 20.03).
  - The above leads to the conclusion that if both facilities are located on the same site for Option 2B, (dual site RPV removal) only one Interim Storage Facility can be deployed. This is a consequence of having only one Size Reduction Facility, which means that interim storage and size reduction cannot both be carried out at each of the two sites. For the purposes of the options, analysis, RPVs from one site will need to be transported to an interim store on the other site.

- For Options 5 to 8, the Initial Dismantling Facility and the Size Reduction Facility will be on the same site (MDAL Assumption 20.06).

4.3.4. It is emphasised that the above assumptions relate to the definition of options for the purposes of the options analysis. They are not project assumptions and do not relate to the feasibility of the options.

4.3.5. The Annex C results are summarised in the table below. The data is taken from the Annex C tables referred to in the first row of Table C3.5.1.

4.3.6. **Table 3.5.1: Summary of Submarine, RPV and Packaged Waste Transportations**

Ref.	**Table C3.1**	**Table C3.2**	**Table C3.3**	**Table C3.4**	**Table C3.5**	**Table C3.6**	**Table C3.7**	**Totals**
Options	**Sub-marines**	**RPVs**	**RPVs**	**Packaged Waste**	**RPVs**	**Packaged Waste**	**Packaged Waste**	
#0	**0**	0	0	0	0	0	0	0
#1D	**7**	0	0	162	0	0	0	169
#1R	**20**	0	0	162	0	0	0	182
#1B	**0**	0	0	162	0	0	0	162
#2D	**7**	0	0	162	0	0	0	169
#2R	**20**	0	0	162	0	0	0	182
#2B	**0**	7 or 20	0	162	0	0	0	169/182
#3D	**7**	27	0	162	0	0	0	196
#3R	**20**	27	0	162	0	0	0	209
#3B	**0**	27	0	162	0	0	0	189
#4D	**7**	27	0	162	0	0	0	196
#4R	**20**	27	0	162	0	0	0	209
#4B	**0**	27	0	162	0	0	0	189
#5D	**7**	0	0	0	0	0	162	169
#5R	**20**	0	0	0	0	0	162	182
#5B	**0**	0	0	0	0	0	162	162
#6D	**7**	0	0	0	0	162	162	331
#6R	**20**	0	0	0	0	162	162	344
#6B	**0**	0	0	0	0	162	162	324
#7D	**7**	0	0	0	0	162	162	331
#7R	**20**	0	0	0	0	162	162	344
#7B	**0**	0	0	0	0	162	162	324
#8D	**7**	0	0	0	0	162	162	331
#8R	**20**	0	0	0	0	162	162	344
#8B	**0**	0	0	0	0	162	162	324

4.3.7. Discussion

4.3.8. The “Totals” column on the far right of Table 3.5.1 indicates the required number of transportations. The trend is that the number of transports increases down the column. Thus the number of transports increases from zero (Option 0: Do Minimum) through to 344 (Option 8, RPV removal and size reduction). The reasons for this are discussed below.

4.3.9. Option 0 (Do Minimum): requires the least number of transportations, because of its very limited scope compared to the other options.

4.3.10. Option 1(RC separation with storage at point of waste generation) requires the second least number of transportations (i.e. between 162 and 182 transportations depending on the location of the initial dismantling site in relation to the interim RC storage site.

4.3.11. Option 2 (RPV removal with storage at point of waste generation) requires a similar number of transportations to Option 1 as both Options consist of 27 possible transports (either 27 RC’s for Option 1 or 27 RPV’s for Option 2) from the initial dismantling site to the interim storage site. Option 2 requires between 169 and 189 transportations.

4.3.12. Options 3 and 4 (RPV removal with storage at remote commercial site or remote MOD site) require more transportations than Options 1 & 2 as they relate to the additional transportation of 27 RPV’s from the initial dismantling site to a location off-site for interim storage. Options 3 and 4 require between 189 and 209 transportations.

4.3.13. Options 5, 6, 7 and 8 comprise early dismantling with storage as packaged waste at point of generation, at remote commercial site, at remote MOD site or at an NDA site. These require the highest number of transportations, because of the additional transports associated with transporting the packaged waste from the initial dismantling site to the interim storage site and subsequently to the proposed GDF. Options 5, 6, 7 & 8 require between 169 and 344 transportations.

4.3.14. It is important to note that the total number of transportations associated with each option could have significant impact on the total number of miles travelled per option when the locations of the initial dismantling site(s), Interim Storage Facility, Size Reduction Facility and proposed GDF are determined.

4.3.15. It might be argued that RPVs and packaged waste are at their most vulnerable during transportation. However, this is partly dispelled by a 2009 report [4.4.3] on transportation accidents and incidents. This report (together with the references in the report) contain descriptions of the number of accidents and incidents involving shipments of radioactive materials over the period 1958 to 2009. Many of these involve small packages containing radioisotopes, which are not relevant to the SDP. During 2009, 32 accidents and incidents occurred, 8 of which involved irradiated nuclear fuel flasks. None of these 32 reported events resulted in any significant radiation doses to workers or members of the public.

4.3.16. Discussion is required on a number of issues, including:

- Is the total number of transportations sufficient to differentiate between options or should they be broken down into the various categories (i.e. submarines, RPVs, packaged waste).

- If the totals in each category are considered relevant should these be weighted for scoring purposes? If so, what should the weighting be?

- Does this criterion discriminate in a meaningful way between the options?

Further data provided at the Scoring Workshop:

The Scoring Workshop participants were critical of the data presented above because it was incomplete, erroneous in parts and did not accord with some of the MCDA assumptions.

There was also considerable discussion on the scoring system to be used for this transportation criterion. The first scoring system proposed using the data in Table 3.5.1 (above) which is a summary of all of the transports (i.e. for submarines, RPVs and packaged waste) for each of the options. A graphical scoring system was proposed, whereby zero transports were considered good and merited the highest score of 9. However, there was fundamental disagreement on what the lowest score should be and what it should represent. Some workshop participants argued that the sum total of all of the transports was not a meaningful criterion since submarines, RPVs and packaged waste were all different entities.

It was eventually agreed that a more meaningful scoring system would be to utilise the number of inter-site transport campaigns, rather than the number of entities transported. For example, some options involved the transportation of submarines to a dismantling site and the eventual transport of packaged waste to the GDF, i.e. a total of 2 campaigns. Other options involved one additional transport, e.g. moving packaged waste to an off-site location for interim storage prior to transportation to the GDF.

A new data set was agreed and this was presented at the workshop and used as the basis for scoring. This data set is presented in Annex C.3, Table C3.9 and summarised below.

Annex C.3 contains a listing of the numbers of different categories of transportations for each of the options. The results are summarised below.

- Option 0 (Do Minimum) does not involve any transportations.

- All of the Devonport “D” and Rosyth ”R” options involve 2 categories of transportations, i.e. submarines to the dismantling site and packaged waste to the GDF.

- The Dual Site “B” options involve 2 categories of transportations, i.e. RCs or RPVs to the dismantling site and packaged waste to the GDF.

- The remote site interim storage options involve 3 categories of transportations, i.e. submarines or RPVs to the dismantling site, RPVs or packaged waste to the remote interim storage site and packaged waste to the GDF.

4.4. 4-POL: Unauthorised Access to Classified Materials during Dismantling, Storage and Transportation.

4.4.1. This criterion addresses the security of RCs, RPVs and packaged waste produced during the process of dismantling a submarine and during subsequent storage and transportation operations.

4.4.2. The criterion addresses issues relating to access by unauthorised persons to classified materials (e.g. submarine plant) and classified documentation (e.g. reports) which could lead to unauthorised disclosure of sensitive information.

4.4.3. The US-UK Mutual Defence Agreement (MDA) was signed by the respective governments in 1958. The MDA allows for an exchange of information on nuclear technology between the UK and US governments. Inadvertent disclosure would be prejudicial to the UK's international relations.

4.4.4. A classification system is in place to prevent unauthorised disclosure of the designs, technologies and materials addressed in the MDA [4.4.1]. The system is also intended to prevent the unauthorised disclosure of information related to trends in naval reactor design, which could be of value to others.

4.4.5. The system classifies submarine components and relevant information and this informs the level of security protection required. The higher the classification, the higher the level of security required.

4.4.6. Data

4.4.7. Security plans for submarine dismantling and waste transportation are not yet available.

4.4.8. An outline security plan for an interim MOD ILW store is contained in [4.4.2]. The main points are summarised below.

4.4.9. The study [4.4.2] assumes that a storage facility for ILW packages could be located on a number of MOD sites or on an external site. Security is regarded as a key consideration for any store siting option. In accordance with MOD's procedures, the contents of the store will be given a security classification commensurate with the contents of the waste packages.

4.4.10. The study addresses the security of an NDA approved $3m^3$ box inside the ILW store. It assumes that the ILW will be packaged into $3m^3$ boxes which will then be grouted until full. The lid will be welded in place forming a homogeneous sealed container. It may be that the nature of this package could allow a lower classification to be applied. Because the contents will not have been completely shaped destroyed, it is unlikely that the security classification of the box will reduce with time.

4.4.11. The contents of the box may be able to be viewed by suitable radiography equipment. However, attempting to interrogate such packages by X-rays and attempting to extract the material from these boxes may not disclose sufficient data to justify a high classification.

4.4.12. None of the boxes will contain Special Nuclear Material. The boxes will contain irradiated material and the gamma emissions from the Co-60 will emit radiation which will decrease with time. This radiation will result in dose rates external to the package which will decrease with distance and the amount of shielding between the box and the point of measurement.

4.4.13. The store may not necessarily be sited inside a secure MOD perimeter fence.

4.4.14. To maintain its original classification status, the ILW needs to be made secure from damage due to deliberate physical attack, theft or other authorised removal of contents. The ILW also need to be made secure from theft or acquisition of classified information on the box and from unauthorised access to the ILW and the radiological threat to personnel that this could present. Threats from fire, seismic event, flood or aircraft impact are recognised through risk management but are not included in this study.

4.4.15. The study identifies and discusses measures which could be included in a security strategy.

4.4.16. Discussion

4.4.17. The scope of this criterion includes the work carried out during the survey and docking period (SADP), the de-equip, de-fuel and lay up preparations (DDLP), separation and size reduction of RCs, removal and size reduction of RPVs, packaging of waste and subsequent storage and transportation and disposal operations. These are discussed below.

4.4.18. The SADP and DDLP pre-dismantling activities, together with the separation of an RC and/or the removal of an RPV from a submarine will continue to be conducted under secure MOD supervision on a Nuclear Licensed site with a high level of security. There will be differences associated with the timing of these operations. For example, removal of an RPV could be performed either immediately or after prolonged storage of an RC.

4.4.19. If the size reduction and waste packaging facility is also located on a Nuclear Licensed site under MOD supervision, a similarly high level of security would be enforced.

4.4.20. In the event of dual site dismantling, it is assumed that there will be equivalent security at both sites.

4.4.21. Shape destruction of classified materials prior to storage is desirable. The sooner this happens, the less the vulnerability of these materials to unauthorised persons.

4.4.22. The RC separation and storage option allows many of the internal submarine shapes to remain intact for prolonged periods, therefore this could be considered the most vulnerable option.

4.4.23. The RPV removal and storage options allow less of the internal shapes to remain intact for long periods, hence it may be possible to discern some information from them. This could be regarded as a less vulnerable option compared to the RC.

4.4.24. The RPV size reduction and storage options allow the waste to be immobilised and packaged, (but not completely shape destroyed) sooner than for the RC separation and RPV removal options. On this basis, the packaged waste options could be regarded as less vulnerable than RPV removal and storage options.

4.4.25. No matter which option is chosen, systems and procedures will be put in place to protect classified materials from unauthorised exposure. Recycling the LLW, possibly by smelting to produce metal ingots is currently being considered. It will be ensured that classified LLW components are either shape destroyed and/or mixed with LLW from other submarines to minimise the vulnerability of these materials to unauthorised persons.

4.4.26. Security procedures will be put in place for the control of classified materials for all of the options and the costs of these will this be addressed within the Investment Appraisal.

4.4.27. It might be argued that the submarine components listed above are at their most vulnerable during transportation. However, this is partly dispelled by a 2009 report [4.4.3] on transportation accidents and incidents, reported under Criterion 1-POL. Risks will be partially mitigated during transportation by deployment of appropriate control measures such as MOD escorts.

4.4.28. As stated previously, there is considerable experience of transportation of packaged waste by road and rail in the UK and worldwide. For example, loads containing radioactive fuel are transported by sea from the UK on behalf of the civil nuclear industry. Russia continues to transport submarines and submarine RCs by sea.

4.4.29. It is assumed that the transportation security plan will include police/military escorts during transport and other measures to protect the submarine components.

4.4.30. The transport data contained in Criterion 3-OP may be relevant to this discussion.

4.4.31. Discussion is required on a number of issues, including:

- Assuming that security plans are put in place for each option, will there be any differences between the options?
- Does this criterion discriminate between the options?

4.5. 5-POL: Compliance with UK Decommissioning Policy

4.5.1. This criterion addresses the ease of compliance of the various options with UK decommissioning policy.

4.5.2. Data

4.5.3. The document titled "*Ministry of Defence Policy for Decommissioning and the Disposal of Radioactive Waste and Residual Nuclear Material arising from the Nuclear Programme*" [4.5.1] states that MOD is committed to act in accordance with Government Policy on Nuclear Material including that on decommissioning, management of LLW, and management of higher activity wastes, all of which are addressed in [4.5.2 to 4.5.4].

4.5.4. MOD is currently preparing a strategy document to provide guidelines on the forward approach.

4.5.5. The principal MOD requirements [4.5.1] are summarised below.

1. Produce and maintain a decommissioning and disposal strategy for the MOD's nuclear programme.
2. Ensure through the use of best practicable means (BPM) that due consideration is given to avoiding or minimising the generation of radioactive waste and residual nuclear material at every stage of any activity involving radioactive materials.
3. Ensure through BPM that risks and doses to people now and in the future are kept as low as reasonably practicable.
4. Ensure through BPM that harm to the environment, now and in the future is minimised as far as is practicable.
5. Ensure, from conceptual stage, that for all activities involving radioactive materials, the method of eventual disposal has been considered and resources identified for all waste that is held or will be generated in the future.
6. Conform, where reasonably practicable, to the Environment Agency's Radioactive Substances Regulation and Environmental Principles, follow the Environment Agency risk screening and appraisal methodologies and the Health and Safety Executive requirements on the treatment and interim storage of radioactive waste.

4.5.6. MOD policy for the decommissioning of nuclear facilities is consistent with UK decommissioning policy and is therefore not discussed further.

4.5.7. The two main sources of UK decommissioning policy are the 1995 Command 2919 paper [4.5.2] and the 2004 amendment to Command 2919 [4.5.3]. Issues relevant to the SDP, taken from these sources, are discussed below. Additional information is provided in Annex C (Section C5). Decommissioning of a nuclear building/facility in the UK context is interpreted within the context of the SDP as the dismantling of a nuclear submarine.

4.5.8. Command 2919 describes a 3 stage decommissioning strategy, which consists of de-fuelling immediately after reactor shutdown, dismantling buildings external to the reactor shield 5 to 10 years later and demolishing the reactor after 100 years after shutdown.

4.5.9. Command 2919 also describes a variation on the 3 stage strategy, namely a safestore strategy, whereby active buildings are put under care and maintenance for about 30 years after shutdown. Arguments in favour of this variation are that it allows more time for radioactive decay and for further advances in technology and that it can be more cost effective. Arguments against are that late decommissioning leaves the physical decommissioning work to future generations; could lead to leakage of radioactivity; and sacrifices the opportunity of using the knowledge and experience of those who have worked on particular sites in the decommissioning process. Command 2919 concluded that in general the process of decommissioning nuclear plants should be undertaken as soon as reasonably practicable to do so, taking account of relevant factors. A decommissioning strategy needs to be drawn up by the operators and the timetable justified. Demonstration of the adequacy of the financial provision to implement the strategy needs to be provided.

4.5.10. It is interesting that Command 2919 mentions the MOD submarine dismantling project, stating that "MOD has based its long-term plans for the disposal of radioactive waste arising from the reactor compartments on the availability of the Nirex repository in about 2010".

4.5.11. According to the 2004 amendment to Command 2919 [4.5.3], the following needs to be considered.

- Decommissioning operations should be carried out as soon as reasonably practicable. The Government recognises that decommissioning operations may involve two or more separate stages spanning a number of decades. It may also be appropriate to delay particular operations to benefit from new or developing technologies or from further development of existing best practice, or to take advantage of radioactive decay.

- The strategy should take into account all relevant factors, assessing and presenting them in a transparent way underpinned by objective information and arguments. These include minimising waste generation and providing for effective and safe management of wastes.

- Decommissioning strategies need to take into account relevant developments in UK radioactive waste management policy.

- The Government considers that decommissioning strategies should seek to avoid the creation of radioactive wastes in forms which may foreclose options for safe and effective long term waste management.

- Strategies should harness the benefits of radioactive decay and should maximise the amount of materials suitable for re-use of recycling.

- Through best practical means (BPM) strategies, the volume of radioactive waste created should be minimised, particularly the volume of ILW.

- Decommissioning wastes should be packaged in a way that does not preclude disposal options.

- Operators may wish to bring forward operations to utilise existing skills or knowledge.

4.5.12. **Discussion**

4.5.13. All of the SDP options will need to comply with all relevant UK policy and strategy issues and guidelines relevant to the decommissioning of nuclear submarines. The MOD policy documentation referenced above highlights MOD's commitment to complying with all applicable policy, strategy and guidelines relevant to the decommissioning of nuclear submarines.

4.5.14. The Do Minimum option does not comply with the UK policy stated above, that decommissioning and disposal operations should be carried out as soon as is reasonably practicable.

4.5.15. Discussion is required on a number of issues, including:

- Are any of the options in conflict with the national decommissioning policy and strategy?
- How well do the different options balance the various policy considerations and policy objectives?
- Does this criterion discriminate between the options?

4.6. 1-OP: Impact on the Maritime Enterprise

4.6.1. This criterion addresses the impact of the SDP options on the whole of the MODs Maritime Enterprise.

4.6.2. The SDP could have both physical and non physical impacts on the maritime enterprise. Physical impacts include competition for facilities and space between SDP and other maritime enterprises. One example is the siting of an interim store.

4.6.3. Examples of non physical impacts include de-risking the business cases for future submarine classes (which must demonstrate sustainability), the coherence of options with strategic initiatives and change programmes (such as the Maritime Change Programme (MCP) and the Maritime Underwater Future Capability (MUFC)) and current and future Naval Base and Dockyard operations. Also of relevance are those commercial frameworks that are in place or being developed and which will have interdependency and compatibility issues with SDP. These include the Submarine Enterprise Performance Programme (SEPP), the Sale of Dockyards Agreement for Devonport and Rosyth Dockyards and the Terms of Business Agreements (TOBAs).

4.6.4. Subject-Matter experts (SMEs) will set the scene and lead the dialogue, by provision and discussion of the following:

- Overview of berthing capacity issues for LUSMs and future classes of submarines.
- Explanation of the details of Successor, MCP, MUFC and any other relevant maritime programmes and commercial frameworks.
- Explanation of the relevance to the SDP of the issues identified above.
- Identification of the positive and negative impacts of the SDP options on the above issues.
- Identification of any options which are inconsistent with any of the maritime programmes.
- Discussion on whether this is a discriminating criterion.

4.6.5. **Data**

4.6.6. It was suggested at the March 2011 MCDA Criteria Workshop that since siting of interim store is an issue relevant to this criterion, data on the footprint of the waste store could be a useful input to this discussion. The information contained in [4.6.1 to 4.6.2] is summarised in Annex C (Section C6) and provides information on the footprints of the various types of stores. These are discussed below.

4.6.7. The store will contain either RCs, RPVs or packaged waste. If the latter, the store will contain waste streams 7G104 (neutron activated long lived ILW) and 7G102 (neutron activated short lived ILW which becomes LLW after a period of at least 30 or so years). Waste stream 7G102 will be disposed of at the LLWR and waste stream 7G104 at the proposed GDF.

4.6.8. The evolution of the store is still at an early stage and only very limited site specific details are available. The calculated footprints for the various stores are shown in Annex C.

4.6.9. The MDAL assumption is that the storage areas shown below are required:

- Reactor Compartment: 11,600 m^2.
- Reactor Pressure Vessel: 801 m^2.
- Packaged Waste: 1005 m^2.

4.6.10. It is fairly intuitive, that storage of an RC will require the highest surface area of the three options, since a large section of the submarine is involved for this option. It is not so intuitive that packaged waste will require more storage space than RPVs.

4.6.11. The assumed stacking height for an RPV is 4 metres. The 1.2 high metre NDA boxes are stacked 3 high, resulting in an overall height of 3.6 metres. Therefore the stacking heights for both options are similar.

4.6.12. The six packaged waste boxes will be stacked in two columns. The area required for one column is 2.8 m^2 and for two columns is 5.6 m^2. This compares with 3.6 m^2 for an RPV. The different surface area requirements is why packaged waste will require more storage space than RPVs. This difference is a reflection of the different packing fractions for the two options. Initial dismantling, size reducing and packaging produces a waste volume which is greater than the original volume of the RPV.

4.6.13. There is no previous experience of storing submarine RCs or RPVs in the UK but there is considerable experience (within the civil nuclear programme) of storing packaged waste.

4.6.14. There is international experience in the US, Russia and France of storing submarine RCs.

4.6.15. Discussion

4.6.16. An RC interim store requires the largest footprint of the three options. There is no previous UK experience but there is international experience of storing RCs.

4.6.17. An RPV interim store requires the least storage space. There is no UK or international experience of storing submarine RPVs.

4.6.18. A packaged waste interim store requires ca. 25% more storage space than the RPV store. There is considerable UK and international experience of storage of packaged ILW.

4.6.19. Other issues of relevance under this criterion include not exceeding berth capacity for LUSMs, and possibly the requirement for extended berthing capacity to cope with the larger Vanguard class submarines.

4.6.20. The successful implementation, to time and cost of a programme to dismantle legacy submarines and manage the waste arisings in line with national strategy and with minimum impact on the environment should improve the overall sustainability of the submarine enterprise and de-risk the business cases for Successor and MUFC in terms of sustainability and disposal costs.

4.6.21. Discussion is required on a number of issues, including:

- Are the SDP and the Maritime Programme consistent with each other?
- What is the impact of the SDP options on available berthing space.
- How will a successful SDP improve the sustainability of the submarine enterprise and de-risk the business cases for Successor and MUFC?
- How relevant is the storage surface area to the three main options?
- Does this criterion discriminate between the options?

4.7. 2-OP: Flexibility of Dismantling Approach to Managing Future Classes

4.7.1. This criterion addresses the degree to which the future classes of submarine (e.g. Astute and SSBN (F)) may be accommodated within the dismantling process. While the current approvals do not include disposal of Astute class or Successor submarines, the project is required to retain the flexibility to become "future submarine capable", namely that the dismantling facilities will be sized and flexible enough to accommodate future classes of submarines.

4.7.2. The criterion addresses the flexibility of the dismantling approach to managing future classes of submarines. SDP includes PWR 1 and PWR 2 reactors in its programme. The issue is whether the dismantling strategy chosen for decommissioning of PWR 1 and PWR 2 reactors is applicable to the reactors of future submarines.

4.7.3. Subject-Matter experts will set the scene and lead the dialogue, by provision and discussion of the following:

- Explanation of the details of future classes of submarines.
- Information to allow discussion of the impact of an RC/RPV with different dimensions/activities on SDP processes such as dismantling, storage and transportation.

- Identification of any options which cannot be used for the dismantling of future classes of submarines.

- Discussion on whether this is a discriminating option.

4.7.4. Data

4.7.5. No data is provided for this criterion, which will be considered on the basis of SME judgement.

4.7.6. **Discussion**

4.7.7. The scope of the SDP encompasses 27 submarines. The specific attributes relevant to this discussion could include RPV mass, volume, construction materials, neutron flux, extent of neutron activation, concentrations and distribution of key radionuclides (e.g. Co-60, Ni-59, Ni-63) and others.

4.7.8. If the specific attributes of future reactors are not as onerous (e.g. substantially decreased radiation doses, smaller dimensions etc.), or are comparable with those of PRW 1 and/or PWR 2 reactors, this could generate a high degree of confidence that a similar dismantling strategy for future submarines could be deployed.

4.7.9. It is speculated that future classes of submarine are likely to become easier to dismantle. For example, records for new submarines should be better than those for legacy submarines and future designs should take account of the whole lifecycle of the submarine, including dismantling.

4.7.10. It may be that when Successor comes out of service, the existing size reduction and packaging facility will be past its useful life and a new facility will be required.

4.7.11. It is noted that newer reactors are being designed to go through life without refuelling. It is not clear what the significance of this is to this criterion.

4.7.12. Some options (e.g. RPV removal, size reduction and storage as packaged waste) will commit the SDP to design decisions (e.g. on the Size Reduction Facility) potentially before the design details of Successor or MUFC are known. Timing and sequencing may well be key differentiators between options.

4.7.13. This criterion may behave similarly to flexibility towards opportunities as discussed under Criterion 1-POL.

4.7.14. Discussion is required on a number of issues, including:

- How do the existing classes of submarine compare to future classes.

- What are the principal differences?

- What (if any) is the significance of newer reactors being designed to operate through life without refuelling.

- How flexible are the various options to the dismantling of future classes of submarines?

- Does this criterion discriminate between the options?

4.8. 3-OP: Threat to Skill and Experience Set

4.8.1. This criterion addresses the issue that first hand knowledge of the design, maintenance and operation of nuclear submarines will be lost over time to the dockyards. Simultaneously, the dismantling programme may put pressure on potentially scarce specialist skills.

4.8.2. **Data**

4.8.3. It was suggested during the 2011 MCDA criterion workshop that for discussion purposes approximately 100 specialist nuclear posts would be required for the full dismantling of a submarine. This includes the removal of plant, through to the operation of the Size Reduction and Packaging Facility and preparation for off-site transport of waste.

4.8.4. **Discussion**

4.8.5. This criterion assesses the likely availability of the required skills at the time that the dismantling activities will be undertaken. In general, the longer dismantling activities are delayed, the greater the risk that knowledge of existing processes and the industrial skill set will be lost.

4.8.6. For example, RC separation and storage has been implemented in the USA, France and Russia. Therefore, skills exist in other countries for the preparation of RCs for storage. Although there is no direct experience of RC separation and storage in the UK, there is a considerable body of knowledge at the proposed dismantling sites. This includes personnel who maintain and operate submarines (and in particular the specific submarines addressed in the SDP scope of work). This experience will be invaluable in the preparation of the RCs for interim storage. If RC dismantling is delayed by a number of years, this current operator knowledge and experience of the construct of nuclear submarines and their reactor systems may be lost. In the event of deferred dismantling, it will therefore be essential to maintain detailed records of each individual submarine, since suitably qualified and experienced personnel skilled in the maintenance of submarines would no longer be available.

4.8.7. Significant use of the existing skill set would be made during the removal of the RPVs, and preparation for interim storage. This skill set could be lost if RPV removal is delayed by a number of years. However, because there is no existing experience of size reduction of RPVs within the submarine community, delays to the size reduction programme would not have an impact on the required skill set.

4.8.8. There are some activities, (e.g. waste characterisation and design of decommissioning and dismantling processes) where specialised local knowledge and experience would be very useful. However, waste characterisation skills may well be available from the civil nuclear industry and the impact of delayed dismantling will probably be minimal. The impact of delayed dismantling on the skill set required to design the submarine decommissioning process will probably depend on specific technical issues and more data will be required to fully understand this impact.

4.8.9. Early dismantling and storage as packaged waste takes advantage of the existing knowledge and experience of SQEP. Early dismantling would allow the knowledge base of operational staff (e.g. on the status and operational history of all submarines) to be meaningfully utilised.

4.8.10. It should be recognised that experience may exist elsewhere within the nuclear industry which could be readily transferred to the submarine reactors. This viewpoint was expressed during the original ISOLUS options study [4.8.1], in which it was stated that delaying the final dismantling work would make it possible to take advantage of future skills and expertise advances developed elsewhere within the nuclear industry, including internationally, in the intervening period.

4.8.11. Discussion is required on a number of issues, including:

- Will there be a significant threat to the skill and experience set if a time-deferred option was chosen?
- Will each of the proposed dismantling sites be able to acquire sufficient SQEP to adequately perform submarine dismantling?
- Does this criterion discriminate between the options?

4.9. 4-OP:Transferable Dismantling Knowledge

4.9.1. This criterion covers the beneficial exchange of knowledge within MOD and within the UK nuclear enterprise.

4.9.2. The criterion also addresses the beneficial exchange of knowledge to overseas organisations responsible for submarine dismantling.

4.9.3. **Data**

4.9.4. No data is considered necessary for discussion of this criterion.

4.9.5. **Discussion**

4.9.6. Although there is considerable experience in other countries of RC separation and less so of RPV removal, no other countries are currently implementing a packaged waste option which involves size reduction of an RPV.

4.9.7. The main issue is whether it would be beneficial to the MOD submarine and maritime enterprise and to the UK nuclear community to share the knowledge acquired by MOD and it subcontractors through its submarine dismantling activities.

4.9.8. A secondary issue is whether this would also present an opportunity for the UK to exchange this information with selected allied countries. If so, the basis of this information exchange would need to be agreed between the various countries.

4.9.9. Discussion is required on a number of issues, including:

- What is the potential benefit to the MOD's maritime and nuclear enterprises of sharing knowledge acquired during the dismantling of submarines?

- What is the potential benefit to other UK organisations (public and private) of sharing knowledge acquired during the dismantling of submarines?
- What is the potential for mutual benefit for information exchange with overseas organisations responsible for submarine dismantling?
- Does this criterion discriminate between the options?

4.10. 5-OP: Impact on Wider MOD Operations

Conclusion of the Workshops:

Agreement was reached that 5-OP should not be considered as a separate criterion. 5- OP was therefore combined with 1-OP and all of the impacts were considered together under 1-OP.

4.10.1. This criterion addresses the impact of the SDP options on Royal Navy Fleet time operational commitments and any other wider operational commitments not addressed under Criterion 1-OP. It also addresses any impact upon the UK's wider operational commitments not addressed under Criterion OP-1.

4.10.2. Subject-Matter experts will set the scene and lead the dialogue, by provision and discussion of the following:

- Information to allow discussion on whether any of the options have a positive or negative impact on wider MOD operational commitments.
- Discussion on whether this is a discriminating option.

4.10.3. **Data**

4.10.4. No data is provided for this criterion.

4.10.5. **Discussion**

4.10.6. The first part of this criterion addresses the possibility of impacts of SDP options (for both dismantling and storage activities) on Royal Navy Fleet time operational commitments and any other wider operational commitments not addressed under Criterion 1-OP.

4.10.7. For towing a submarine or component of a submarine, it is assumed that a military escort would be required. The number of submarine movements could vary depending on whether one or two sites are selected for dismantling. One school of thought is that providing a military escort in line with the transportation security plan is not considered to be a problem and that this would not interfere with the wider operational commitments of MOD. There may be other perspectives.

4.10.8. Other issues of relevance under this criterion might include operational impacts on non-maritime, MOD owned nuclear licensed sites (i.e. sites not part of the Naval Bases) if they were selected for storage of ILW.

4.10.9. The second part of this criterion addresses any impact upon the UK's wider military capability not addressed under Criterion OP-1. There is no data available to suggest that such wider impacts exist but SMEs will be invited to discuss this further.

4.10.10. Discussion is required on a number of issues, including:

- What will the likely impact be of the proposed submarine dismantling activities, (including deplanting a submarine, radioactive waste storage, transportation and other operations) on RN Fleet time operational commitments and on the UK's wider military capability?
- Does this criterion contain any significant issues that are not addressed under Criterion 1-OP?
- Does this criterion discriminate between the options?

4.11. 1-H&S: Worker Dose – Dismantling, Storage and Transportation

4.11.1. This criterion addresses the radiation doses to workers during the SDP dismantling activities, including storage and transportation.

4.11.2. Under Treasury guidelines and in line with NDA practice, this criterion will be assessed as part of the Investment appraisal and not as part of the Operational Effectiveness of options. However, it is proposed to consider it within the MCDA process in order to benefit from SME discussion and gain appreciation of the issues and uncertainties involved.

4.11.3. **Data**

4.11.4. **Dismantling**

4.11.5. Workers could be exposed to ionising radiation during any of the SDP operations including RC separation, RPV removal, transportation, size reduction, storage and disposal.

4.11.6. External exposure comes mainly from the gamma rays emitted by Co-60 which has a half life of 5.23 years. Over a period of 10 half lives, the dose rates will reduce by a factor of ca. 1000. Radiation doses should therefore decrease with time.

4.11.7. A dose assessment was produced by Babcock Marine [4.11.1] with the objective of generating a "best estimated value" of collective dose associated with each of the main submarine dismantling options. A short synopsis of the results is provided below.

Note in support of further data provided at the Scoring Workshop:

Best Estimate Values

The NII Technical Assessment Guide (TAG) [Radiological Analysis – Normal Operation: T/AST/043 Issue 1 10/06/2009] provides advice to those responsible for assessing radiation dose to workers. Section 4.9 states that:

"*The dose to each of the operators will normally be determined from the predicted dose rates where the operators are likely to be positioned for the tasks and the expected periods of time likely to be spent doing the tasks….Assessors should ensure that all significant tasks have been included and that the estimates of the dose rates, exposure times and radiation attenuation are sufficiently conservative. For the purposes of ALARP considerations, the dose estimates should be based on* <u>best estimate values</u> *for these parameters*".

No definition of best estimate value is provided in this document.

An "estimate" is defined in [http://www.stats.gla.ac.uk/steps/glossary] as an indication of the value of an unknown quantity based on observed data and "to estimate" is defined in [http://www.yourdictionary.com/estimate] as to calculate approximately. "Best estimate" is variously defined as a realistic or actual estimate.

The above definitions can be combined and applied to provide the following meaning:

- A best estimate of worker dose is one which is based on real data relating to dose and exposure time for activities similar to those which would be encountered during submarine dismantling.

This is precisely the process used by Babcock Marine in their estimates of normal worker collective dose. The data used was based directly on the actual collective doses accrued during refitting of operational submarines.

4.11.8. The assessment was based on the [redacted] submarine, one of the highest dose submarines. The assessment was "best estimate" rather than "worst case", in line with NII guidance. This process therefore produced a "best estimate" of collective dose from a "worst case" submarine. The estimate was extended to cover the range of doses within the PWR 1 fleet of 23 submarines and provide a cumulative collective dose for each of the main options. The results are shown in Table 11.1 below. Note that no dose data is available for PWR 2 reactors.

4.11.9. Table 11.1: Collective Dose Summary for the Principal Dismantling Options.

Options	Description	[redacted] Best Estimate of the Collective Dose (man mSv)	PWR 1 Fleet: Best Estimate of the Cumulative Collective Dose (man mSv)
1	RC separation, interim storage and delayed RPV removal	9	201
2, 3, 4	RPV removal, interim storage and delayed RPV size reduction	47	523
5, 6, 7, 8	RPV removal, size reduction and interim storage	50	589

4.11.10. The dose assessment is based on submarine refitting experience, with particular attention paid to removing components from the RC (specifically the steam generators, the MCP, pressurisers and associated pipework) prior to removal of the RPV. This is recognised as the most dose intensive activity.

4.11.11. Very little dose would be associated with subsequent operations, like for example RPV size reduction and packaging, since these would be carried out using hot cells. Hence, according to [4.11.1], the radiation doses associated with Options 2, 3 and 4 (RPV removal, interim storage and delayed RPV size reduction) and 5. 6. 7 and 8 (RPV removal, size reduction and interim storage) are broadly similar. Option 1 (RC separation, interim storage and delayed RPV removal) would have the lowest radiation dose since removal of components from the RC would be deferred to a later date.

4.11.12. **Storage**

4.11.13. Workers could be exposed to ionising radiation when the submarine is being stored afloat (e.g. during maintenance operations) and during interim storage of RCs, RPVs and packaged waste.

4.11.14. Although the Do Minimum option would involve afloat storage for longer periods than the other options, this will probably have no or very little impact on worker radiation doses compared to other options which include deferred dismantling.

4.11.15. The Babcock Marine report [4.11.1] made the assumption that the maintenance and inspection of the RPV or packaged ILW during the interim storage period was not considered to contribute significantly to the ca. 1 man mSv per annum collective dose described above. This is a reasonable assumption, since waste packages need to be made passively safe prior to storage and the need for maintenance and inspection will therefore be minimised.

4.11.16. **Transportation**

4.11.17. Workers could be exposed to ionising radiation during the transportation of a submarine, RC, RPV or packaged waste.

4.11.18. The Babcock Marine report included preparation for transport in the calculation of the doses accrued from the dismantling operations, therefore this issue is not addressed further in this data report. Doses accrued during transportation were not addressed, because they were judged to be very low.

4.11.19. The dose rates from waste packages are strictly regulated by the UK Transport Regulations [4.11.2]. For all transport packages, NDA has stipulated [4.11.3] that under the conditions of non-exclusive use, the dose rate at 1 metre from the surface shall not exceed 0.1 mSv/h and the dose rate from the external surface shall not exceed 2 mSv/h. The upper limits for the dose rate from transport packages are those defined for exclusive use and these are discussed below.

4.11.20. If the size reduced waste is packaged into a $3m^3$ box waste package, it will be transported through the public domain within a reusable shielded transport container (e.g. SWTC-285) and this is designated as a Type B transport package. Calculations using the MicroShield software package [4.11.4] indicated that dose rates both at the surface of a $3m^3$ box waste package and at a distance of 1 metre from such a package would be below the relevant transport limits.

4.11.21. If an RPV is transported as a Type B package, it will be transported through the public domain within a shielded transport container, still to be defined. The same dose limits discussed above apply.

4.11.22. If the waste package or RPV is transported as an IP-2 package, there is an additional requirement that the dose rate at a distance of three metres from the unshielded surface of the grouted wasteform should not exceed 10 mSv per hour. The additional shielding afforded by the annulus between the waste and the package and by the package construction and shielding material cannot be taken into account in meeting this requirement. The radiation level at the outer edges of a vehicle carrying an IP-2 package must not exceed 2 mSv/h.

4.11.23. Exclusive use is defined by the IAEA Transport Regulations [4.11.5, 4.11.6] as "*the sole use, by a single consignor, of a conveyance or large freight container, in respect of which all initial, intermediate and final loading and unloading is carried out in accordance with the consignor or consignee*". If all of these conditions cannot be met, transport is deemed to take place under non-exclusive use.

4.11.24. The ultimate upper limits for the dose rate from transport packages are those defined for exclusive use and these are shown below.

- The dose rate at 2 metres from the surface of a transport package shall not exceed 0.1 mSv/h.

- The dose rate on its external surface shall not exceed 10 mSv/h.

4.11.25. RWMD states that waste packages resulting in transport packages with higher radiation levels may be permitted but this would be dependent on the approval certificate for the transport container, the operational procedures applied during transport and the operational safety case for a GDF.

4.11.26. A specimen calculation is shown below based on the requirement, that under the conditions of non-exclusive use, the dose rate at 1 metre from the surface of an RPV or a waste package will not exceed 0.1 mSv/h.

4.11.27. For example, if a transport operator spent 0.5 hour per journey, for 10 journeys, at a distance of 1 metre from a waste package which was emitting radiation measured at 0.1 mSv/hour at a distance of 1 metre, he/she would accrue a maximum dose of 0.5 mSv. At 10 such journeys per year, the maximum dose would be 0.5 mSv per annum. The collective dose rate for 2 such operators would therefore be 1 man mSv per annum. Assuming that the residence times, the number of journeys and the package dose would be less than the stated values, the collective dose rates will be less than 1 man mSv per annum.

4.11.28. It is concluded that the average collective worker dose associated with transportation could be <1 man mSv per annum.

4.11.29. **Discussion**

4.11.30. The discussion below is based around the values shown in Table 11.1 above.

4.11.31. All operations will be subject to ALARP assessments which will ensure that doses are As Low As Reasonably Practicable. As shown above, the doses will vary between options, but they will all be ALARP. Note that a considerable amount of resources and expenditure will be directed at maintaining low operator doses during operation of the Size Reduction and Packaging Facility. Any additional resources (and expenditure) should be directed at further reducing the (already low) dose rates associated with removal of high dose primary circuit items. These issues will be addressed further in the Investment Appraisal.

4.11.32. It is assumed for the purposes of this discussion, that an SDP dismantling work force consists of 50 personnel (e.g. mechanical fitters, electrical fitters, welders, health physics, cleaners, laggers and others) who could be exposed to radiation. If, for example, the total collective dose during SDP activities was 50 man mSv, this would mean that on average, each individual could have been exposed to a radiation dose of 1 mSv. Based on the dismantling of one submarine per year, this equates to 1 mSv per annum. It is anticipated that the actual doses will be reduced as experience of the dismantling process increases, therefore the average individual dose associated with dismantling (including storage and transport) will probably be <1 mSv per annum.

4.11.33. To provide some perspective to the dose values discussed above, it should be noted that the annual dose for the average person within the UK from background radiation is 2.7 mSv and the annual individual worker dose legal limit is 20 mSv per annum. Moreover, the doses estimated above for dismantling are less than 1% of the through-life collective dose for a Trafalgar Class submarine.

4.11.34. Discussion is required on a number of issues, including:

- Appreciation of the variations in collective and cumulative collective doses for each option.
- Appreciation that all of the estimated SDP doses for each option are relatively low.
- The application of ALARP throughout the whole dismantling process.
- Does this criterion discriminate between the options?

4.12. 2-H&S: Non Radiological Impact on Workers

4.12.1. This criterion considers the non radiological hazards and impact on the workforce of SDP activities.

4.12.2. **Data**

4.12.3. There are numerous hazards associated with ship breaking and some of these are summarised below. Annex C (Section C12) contains a check list of hazards which could be relevant to the SDP.

4.12.4. Data:

4.12.5. **Hazard Groups**

4.12.6. **Access:** Working at height, slips, trips and falls, confined spaces, work on or near water.

4.12.7. **Fire:** Combustible, ignition and oxygen sources.

4.12.8. **Hazardous Substances:** Health hazards associated with using and the creation of toxic/harmful substances, asbestos.

4.12.9. **Machinery:** Mechanical and non mechanical e.g. moving parts of machinery, heat, dust, noise.

4.12.10. **Musculo-Skeletal Hazards**: Manual handling, Upper limb disorders.

4.12.11. **Physical Energy**: Noise, vibration, temperature extremes, pressure/vacuum.

4.12.12. **Psycho-Social:** Stress, work patterns, lone working.

4.12.13. **Work Equipment**: General, electrical.

4.12.14. **Workplace**: Thermal comfort, lighting, space.

4.12.15. **Workplace Transport**: Moving vehicles.

4.12.16. Conventional safety is covered under the Health and Safety at Work etc. Act 1974 [4.12.1] and there is a large amount of supporting legislation which apply to more specific hazards including (but not limited to):

- Control of Asbestos.
- Confined Spaces.
- Work at Height.
- Electricity at Work.
- Fire.
- Hazardous Substances.
- Lifting Operations.
- Machinery.
- Manual handling.
- Noise.
- Vibration.
- Work Equipment.

4.12.17. The companies or organisations responsible for any such project are instructed to:

- Comply, as a minimum, with all applicable health and safety legislation and regulations at all places of work.
- Comply with all other requirements by regulatory bodies or clients.
- Provide safe conditions and practices of work.
- Clearly define the responsibilities and duties of all employees involved with the project.
- Consult with employees in the development of arrangements for safety, and work with them to achieve their implementation.
- Provide employees, contractors and visitors with suitable and adequate information, instruction and training to safeguard their health and safety.
- Select contractors who have effective safety management systems for work at the Company's or its clients' premises.
- Co-operate with and support clients and landlords in developing safe working practices.
- Design plant, equipment and facilities that are safe to construct, operate, maintain, and, dismantle and demolish.

4.12.18. **Discussion**

4.12.19. Accidents can happen on any industrial plant or site. Generally, the more complex and bigger the plant or project and the more the plant is used, the higher the unmitigated risk of accidents.

4.12.20. Dismantling sites will require a robust safety culture and all work must be monitored and reviewed by safety professionals. Risk assessment and hazard identification will be required from the initial desk study phase through to the completion of physical work. For example pre-identification of hazardous substances (see [4.12.2] such as asbestos will mitigate risks to the workforce.

4.12.21. Discussion is required on a number of issues, including:

- Is this criterion adequately defined and does it address all of the relevant issues?
- Does this criterion discriminate between the options?

4.13. 3, 4 and 5-H&S:Potential for an Unplanned Radiological Release during Dismantling, Transportation and Storage

4.13.1. This criterion considers in a qualitative manner, the risk of an unplanned radiological release during the SDP dismantling operations, including transportation and storage of radioactive waste. Note that all of the submarines will be de-fuelled before dismantling.

4.13.2. It is intended to score these risks as three separate criteria, however, for the purposes of this document, all three are addressed together.

> **Note relevant to the Scoring Workshop**
>
> Criteria 3-H&S, 4-H&S and 5-H&S were scored separately at the Scoring Workshop.

4.13.3. **Data**

4.13.4. For the purposes of this discussion, radiological release includes external exposure from radiation release as well as internal exposure from contamination release.

4.13.5. An unplanned radiation release could arise from inadvertent exposure to the gamma rays emitted by Co-60. This isotope is the most predominant gamma emitter inside a submarine. Co-60 has a half life of 5.23 years. Over a period of 10 half lives, the dose rates will reduce by a factor of ca. 1000. Radiation doses should therefore decrease with time.

4.13.6. An unplanned release of contamination could arise for example, because of penetration of a closed circuit/system, releasing airborne contamination into the atmosphere. If ingested or inhaled, the contamination would expose the workers to an internal radiation dose.

4.13.7. An unplanned radiological release is interpreted in this report as a maximum *credible* unplanned release, rather than a maximum *possible* unplanned release. This can be derived from a facility safety assessment, but such an assessment could only occur after strategic decisions have been taken and the project proceeds into more detailed design work leading to planning and regulatory assessments. At this stage, it is only possible to apply SME judgement and to consider the examples provided below which are based on experience within the civil nuclear industry.

4.13.8. Discussion

4.13.9. **3-H&S: Dismantling**

4.13.10. During operations to separate the RC, two cuts will be made down the submarine, bringing with it a risk of unplanned radiation and contamination release. The RC is essentially self shielding apart from on the underside, where radiation shine could occur. The RC will be decay stored for long periods, therefore the risks associated with its eventual deplanting and subsequent waste management are considered low.

4.13.11. The RPV removal and interim storage options will probably carry more risk (than the RC separation option) of inadvertent radiological exposure. Examples where workers may inadvertently be exposed to external radiation include prolonged exposure during stripping out of the primary circuit and proximity to the RPV during removal. There is also a risk of an unplanned release of contamination when breaking connections between sections of pipework.

4.13.12. The RPV removal and size reduction options may carry most risk of an unplanned radiological exposure during the size reduction and packaging process. Examples include the potential for radiation and contamination leakage from manipulators, failure of a hot cell window during size reduction operations and exposure during man-entry to a hot cell for maintenance or other purposes.

4.13.13. It is stressed that the above risks are speculative and that their probabilities and impacts will be minimised though good practice.

4.13.14. 4-H&S: Transportation

4.13.15. Transport packages for all options will be required to satisfy the extant Transport Regulations [4.11.2]. Approvals for transportation will only be given once the regulator is satisfied that the possibility of incidents and accidents has been minimised and that the radiological content of a package can be effectively contained if an incident/accident were to occur.

4.13.16. The packaged waste option will probably carry minimal risk of an unplanned radiological release during transportation. It uses an approved storage container which must comply with the transport regulations, including those which limit the contents and the external dose rates. Therefore the probability of an unplanned radiological release during transportation will be very small.

4.13.17. Provided the passive safety and regulatory requirements for transportation of RCs and RPVs have been met, these should also carry minimal risk during transportations.

4.13.18. In the report on transportation accidents and incidents [4.3.5], it was stated that up to half a million packages containing radioactive materials are transported to, from and within the UK every year, by rail, road, sea and air. It is recognised that many of these involved small packages which are not relevant to the SDP. During 2009, 32 accidents and incidents occurred. None of these 32 reported events resulted in any significant external or internal radiation doses to workers or members of the public.

4.13.19. **5-H&S:Storage**

4.13.20. During the storage period, the potential for an unplanned radiological release is linked to the passive safety of each of the packages. A passively safe wasteform is one in which the waste is chemically and physically stable, and is stored in a manner that minimises the need for safety mechanisms, maintenance, monitoring and human intervention, and that facilitates retrieval for final disposal.

4.13.21. Issues relating to passive safety will include the integrity of the storage container under normal storage conditions taking account of existing and future contents, the latter resulting from degradation of the existing contents during interim storage. CRUD and free liquids will need to be removed. The packages must be periodically inspected during storage.

4.13.22. Storage of packaged waste will probably carry minimal risk of an unplanned radiological exposure. This option uses an approved storage container which has been specifically designed for long-term interim storage and final disposal. Therefore, it has been designed to retain structural integrity and the possibility of inadvertent radiological exposure during the storage period will be very small.

4.13.23. Provided the passive safety requirements for RCs and RPVs have been met, these options should also carry minimal risk, albeit at a risk level slightly higher than that for packaged waste. It is noted that making RCs passively safe could be challenging.

4.13.24. **Discussion**

4.13.25. Discussion is required on a number of issues, including:

- Does deferring initial dismantling operations decrease or increase the risk of an unplanned radiation release?
- Does this criterion discriminate between the options?

4.14. 1-ENV: Radiological Discharges to the Public

4.14.1. This criterion considers the impact of both planned and unplanned liquid and gaseous radiological discharges on members of the public. This includes consideration of the existing sources of emissions, the nature of the likely releases and the characteristics of the potentially affected communities (which will include demographic profile of sensitive groups, such as children and pregnant women) through exposure to releases.

4.14.2. An unplanned radiological discharge is interpreted in this report as a maximum *credible* unplanned release, rather than a maximum *possible* unplanned release, as defined in 3, 4, 5-H&S above. At this stage, it is only possible to apply SME judgement and to consider the examples provided below which are based on experience within the civil nuclear industry.

4.14.3. Data

4.14.4. Whilst the nature of radiological releases is determined by the technical nature of the dismantling and storage processes, the impact on the public is determined by where these activities take place. Data is provided below on the two known initial dismantling sites at Devonport and Rosyth. The possible location of interim ILW storage is not known beyond those sites, hence no further site-specific information is presented.

4.14.5. Devonport

4.14.6. Plymouth's resident population of 256,700 is 49.2% male and 50.8% female. 53,000 are under 18 and 38,474 people are over 65 years old. The average life expectancy in Plymouth is slightly below the UK average but going up overall; however, some more deprived areas have lower than average values [4.14.1]

4.14.7. A 2006 NHS study [4.14.2] reported that Plymouth has higher cancer rates than the national average; however no geographic association was detected between cancer rates and distance to the Tamar Estuary, and no excess of cancers known to be radiation-sensitive was found. The excess of cancers was however statistically linked to socio-economic deprivation, and in particular smoking.

4.14.8. Devonport is a radon-affected area due to the prevalence of igneous bedrock underlying west Devon and Cornwall. 5 to 10% of dwellings in the Devonport area have been assessed as having radon levels above the accepted Action Level of 200 Becquerels per m^3 of air [4.14.3].

4.14.9. Existing licensed activities at Devonport Dockyard Ltd. include permitted releases to air, sewer and the Hamoaze estuary. The radionuclides include Cobalt-60, Carbon-14 and Tritium, as well as nuclides of lower radiological significance.

4.14.10. **Table 14.1: Annual Discharge Limits from Devonport Royal Dockyard**

Radionuclide/ Group	**Annual Limit to Air**	**Annual Limit to the Hamoaze**	**Annual Limit to Sewer**
Tritium	4 GBq	700 GBq	2 GBq
Carbon-14	43 GBq	1.7 GBq	-
Argon-41	15 GBq	-	-
Cobalt-60	-	0.8 GBq	0.35 GBq
Other (including C-14)	-	-	0.65 GBq
Beta/ gamma activity associated with particulates	0.3 MBq	-	-

4.14.11. In 2009, the dose to the 'critical group' (i.e. those people with the highest feasible exposure) as a result of DRDL's discharges was calculated to be 2.7 μSv (0.0027 mSv) per year. This is less than 0.3% of the statutory limit of 1 mSv per year [4.14.4] and is considered to be of low radiological significance. The UK average annual dose from all sources is about 2.7 mSv per year, whilst average annual doses from radon alone in Cornwall have been estimated at 6 mSv [4.14.5]

4.14.12. Data: Rosyth

4.14.13. Fife's resident population of 363,500 is 48.3% male and 51.7% female. The trend in Fife is of gradually improving health. Between 1995 and 2004, death rates from cancer, coronary heart disease, strokes and respiratory disease all fell significantly; West Fife now has male life expectancy significantly better than the Scotland average, whilst for females the rates are around average [4.14.1] Fife is not a radon-affected area, with less than 1% of dwellings above the Action Level.

4.14.14. The incidence of cancers around Rosyth is not significantly elevated. The incidence of childhood leukaemia and non-Hodgkin lymphoma is close to that expected (ratio = 1.03) but does appear to decrease with distance from the Naval Base. This is being investigated further [4.14.6].

4.14.15. Existing licensed activities at Rosyth Dockyard include permitted releases to air, sewer and the Forth Estuary. They include Cobalt-60, Carbon-14 and Tritium, as well as nuclides of lower radiological significance. The regulatory limit for Rosyth is 1.0 mSv per year.

4.14.16. **Table X: Annual Discharge Limits from Rosyth Royal Dockyard**

Radionuclide/ Group	Annual Limit to Air	Annual Liquid Limit
Tritium	0.2 GBq	3 GBq
Carbon-14	0.5 GBq	
Cobalt-60		0.3 GBq
Other (including C-14)	-	0.3 GBq
Mixed Beta emitters	10 KBq	-

4.14.17. In 2009, gaseous discharges from Rosyth were below the limit of detection, and gamma dose rates could not be distinguished from background. Tritium and Cobalt-60 discharges to the Firth of Forth continue to decline and are well below authorised limits. In 2009, doses to those in the immediate vicinity of Rosyth were assessed to be less than 0.005 mSv (<0.5% of the dose limit of 1 mSv) [4.14.7].

4.14.18. Data on the level of routine radioactive discharge has been taken from the proposal for dismantling HMS Renown [4.14.8]. Discharges to air will primarily consist of airborne particulate (mainly Co-60) and beta emitting radionuclides including Carbon-14. Depending on the option, this could be generated during size reduction operations. Liquid discharges could be generated from water-jet cutting, decontamination of removed components and reactor pressure vessel draining.

4.14.19. Discussion

4.14.20. All of the three main options (RC separation; RPV removal and interim storage; and RPV removal, early dismantling and interim storage of packaged waste) involve common life cycle activities, the principal difference between the options being when particular activities are undertaken. Consequently, the issues associated with each stage of the life cycle apply across all of the technical options. There will be minor differences depending on the exact techniques employed.

4.14.21. **Scheduled Operations:** As a result of radioactive decay, delaying any activity that involves work with radioactive material will result in a reduction of the total activity that could potentially be discharged to the environment during dismantling and storage operations. Immediate dismantling of the RPV into packaged waste could result in greater mitigated discharge to the environment (and hence to the public) than deferred dismantling.

4.14.22. It must be borne in mind, however, that a statutory environmental permit will be required to undertake submarine dismantling, irrespective of the selected option. Permitting will make it necessary to demonstrate that any discharges to the environment are minimised, and are within defined limits. It will also be necessary to demonstrate that any waste generating processes, waste treatment and disposal options are consistent with the principles of BAT (Best Available Techniques) and that adequate research and development has been carried out in support of the choices made.

4.14.23. **Unplanned Releases:** An unplanned radiation release could arise from an incident involving the gamma radiation emitted by Co-60, or the beta radiation emitted by other long and short-lived isotopes.

4.14.24. The risk of a credible unplanned release of radioactivity into the environment will intuitively increase in proportion to the extent of RPV dismantling, although it decreases with time. Hence, the risks associated with an unplanned event are ordered in the same way as for factors 3, 4 and 5-H&S, although they would be expected to be significantly smaller than they could be for workers.

4.14.25. At this stage, it is only possible to apply Subject-Matter Expert (SME) judgement and to consider the examples provided, based on experience within the civil nuclear industry. It is assumed that the radiological dose to the public will continue to be below statutory limits, and that the risk of accidental discharge is very low. This will be clarified by the SMEs at the workshop. It is recognised that this low level of risk may not be the public’s perception. In this respect, anxiety relating to operational activity and in particular the radioactive waste element of site’s operation may have a negative effect on the wellbeing of some within the local population.

4.15. 2-ENV: Radiological Discharges to the Environment

4.15.1. This criterion considers the impact of planned and unplanned liquid and gaseous radiological discharges on the environment. This will include consideration of the existing sources of emissions, the nature of the likely releases and the characteristics of the receiving environment. This criterion covers a range of possible environmental impacts including any aspects associated with biodiversity and nature conservation, soil and geology, air and water. By its very nature, this criterion is very similar to 1-ENV, since dose to the public will be via the wider environment, through air, water, soil and food.

4.15.2. **Data: Devonport**

4.15.3. Data on routine radioactive discharges has been taken from a number of references, as described in 1-ENV above.

4.15.4. Gaseous discharges primarily consist of airborne particulates - mainly the beta emitters Tritium, Argon-41 and Carbon-14. These could be generated during size reduction operations. Liquid discharges could be generated from water-jet cutting, the decontamination of removed components and reactor pressure vessel draining. This may include Co-60 and long-lived isotopes.

4.15.5. Plymouth has nine Sites of Special Scientific Interest. Devonport is immediately adjacent to the Plymouth Sound and Estuaries Special Area of Conservation (EU designation under the Habitats Directive), and within 5km of the Tamar Estuaries Complex Special Protection Area (EU designation under the Wild Birds Directive).

4.15.6. Existing licensed activities at Devonport Dockyard are as described in Table 14.1 for ENV-1. They include permitted releases to air, sewer and the Hamoaze estuary. They include Cobalt-60, Carbon-14 and Tritium, and other radionuclides.

4.15.7. In 2007, nuclide concentrations were below the limit of detection in the majority of marine samples, such that the dockyard's contribution to the natural background radiation dose was indistinguishable [4.14.4]. The radionuclides discharged into Plymouth Sound continue to be of low radiological significance [4.14.7]

4.15.8. **Data: Rosyth**

4.15.9. Fife's coastland and wetlands are important sites for migrating wildfowl and breeding seabird populations. Fife has 48 SSSIs, two SACs, two SPAs, one Ramsar site (designated at International level for internationally-important wetlands); seven local nature reserves and one regional park.

4.15.10. Licensed activities at Rosyth Dockyard include permitted releases to air, sewer and the Forth Estuary. They include Cobalt-60, Carbon-14 and Tritium and other radionuclides. The regulatory limit for Rosyth is 0.5 mSv per year.

4.15.11. In 2009, gaseous discharges from Rosyth were below the limit of detection. Tritium discharges to the Firth of Forth remained steady, whilst those for Cobalt 60 continue to decline. Both are well below authorised limits [4.14.7].

4.15.12. Data on routine radioactive discharges has been taken from the proposal for dismantling HMS Renown [4.14.8]. Gaseous discharges will primarily consist of airborne particulate (mainly Co-60), Carbon-14 and other beta emitting radionuclides. This could be generated during size reduction operations. Liquid discharges will be generated from water-jet cutting, the decontamination of removed components and reactor pressure vessel draining.

4.15.13. **Discussion**

4.15.14. All of the three main options (RC separation; RPV removal and interim storage; and RPV removal, early dismantling with storage as packaged waste) involve common life cycle activities, the principal difference between the options being when particular activities are undertaken.

4.15.15. **Scheduled Operations:** As a result of radioactive decay, delaying any activity that involves work with radioactive material will result in a reduction of the total activity that could potentially be discharged to the environment during normal operations. Immediate dismantling of the RPV into packaged waste could therefore result in greater mitigated discharge to the environment than deferred dismantling.

4.15.16. However, an Environmental Permit issued by the Environment Agency (and equivalent consent in Scotland) will be required to undertake submarine dismantling irrespective of the selected option. It will be necessary to demonstrate that any discharges to the environment are both minimised, and within the limits defined in the site permit. It will also be necessary to demonstrate that any waste generating processes, waste treatment and disposal options are consistent with the principles of BAT (Best Available Techniques) and that adequate research and development has been carried out in support of the choices made.

4.15.17. **Unplanned Releases:** An unplanned radiation release could arise from the gamma radiation emitted by Co-60, or the beta radiation emitted by other long and short-lived isotopes.

4.15.18. The risk of a credible unplanned release of radioactivity into the environment will intuitively increase in proportion to the extent of RPV dismantling, although it decreases with time. Hence, the risks associated with an unplanned event are ordered in the same way as for factors 3, 4 and 5-H&S, although they would be expected to be significantly smaller than they could be for workers. At this stage, it is only possible to apply SME judgement and to consider the examples provided based on experience within the civil nuclear industry. It is assumed that the radiological dose to the environment will continue to be below statutory limits, and the risk of accidental discharge is very low. This will be clarified by the SMEs at the workshop.

4.16. 3-ENV: Non-Radiological Impact on the Public

4.16.1. This criterion considers the non-radiological impact on the public of SDP activities. These activities include discharges of non radiological solids, liquids and gases into the environment, the creation of hazardous wastes, the safety risks associated with transportation of heavy, bulky items, and issues which could cause a statutory or non-statutory nuisance to the local communities, such as noise, vibration, dust and light pollution.

4.16.2. **Data**

4.16.3. The construction of the dismantling and storage facilities will require a range of materials to be transported onto the site (included aggregates, concrete, steel, timber and metals). The likely amounts of these materials that will be required cannot be ascertained at this early stage.

4.16.4. Dismantling of the submarines will generate a variety of potentially hazardous waste streams (e.g. mineral oils, hydraulic fluids, refrigerant gasses, asbestos and PCBs) as well as substantial quantities of material that will require processing, transportation and recycling.

4.16.5. Further data will be presented at the workshop.

4.16.6. **Discussion**

4.16.7. For all the options, the level of potential impact will be dependent on the site selected for dismantling and for storage and in particular, the proximity of proposed activities to sensitive receptors.

4.16.8. There is potential for construction, dismantling and interim storage activities to impact on the local environment (e.g. dust generation from earthworks, demolition, construction, and exhaust emissions from vehicles and plant) which could be a cause of local nuisance and disturbance.

4.16.9. Whilst all three technical options would ultimately lead to the production of packaged waste, the phasing of the construction of some site components could differ across the technical options. Construction disturbance could be greatest for the RC storage option if a large new-build facility of ca. 11,600 m^2 is required. Conversely, the specialist equipment for the packaged waste option may also require development of a new and bespoke facility. Both RC separation and RPV removal will require two phases of development, which may keep levels of noise and vibration low, but create two separate incidences of disturbance.

4.16.10. Operational activities may result in increased noise and vibration which could have a negative effect on the health and well-being of the local community. Causes of noise and vibration may include the use of cutting equipment and HGV movements required to transport materials, equipment and waste to/from the site.

4.16.11. The Devonport and Rosyth dockyards are located approximately 385 miles and 175 miles respectively by road and rail from the LLWR in Cumbria. Following interim storage and taking into account distance only, there is a greater potential for transport of LLW from Devonport to have a greater noise and vibration impact associated with the transport of waste.

4.17. 4-ENV: Non-Radiological Impact on the Environment

4.17.1. This criterion covers a range of possible environmental impacts including any aspects associated with air, soil and geology, water and biodiversity and nature conservation. The data presented below for Devonport and Rosyth are taken from the SEA Scoping Report [4.14.1]. The assessment will draw on the provisional outputs from a number of the environmental topics assessed in the SEA. These provisional SEA outputs will be used to complete a ‘pre MCDA’ assessment of options to feed into the assessment against this criterion and which will be presented at the workshop. Sequentially, the effects on environmental media/pathways (air, soil and water) will be considered before assessing the implications for the receptors (biodiversity and habitats).

4.17.2. **Data: Devonport**

4.17.3. Air quality in Plymouth is generally good, with the key pollutants being Nitrogen Dioxide (NO_2) and fine particulates (PM_{10}.) In 2009, annual average nitrogen dioxide (NO_2) levels in Plymouth were between 32 and 42.7 µg m^{-3} against a statutory target of 40µg m^{-3}. There are three Air Quality Management Areas (AQMAs) in Plymouth: 2 for NO_2; 1 for PM_{10}.

4.17.4. Plymouth has four geological SSSIs and a large number of unlicensed, historic waste disposal sites containing a variety of wastes, many of which were closed prior to 1974.

4.17.5. Inland water quality is generally good; 65% are in good biological condition and 100% are in good chemical condition. Plymouth Sound and Estuaries SAC and the Tamar Estuaries Complex SPA are protected water features. The water in Plymouth Sound has good ecological quality, but poor chemical quality.

4.17.6. Plymouth has nine SSSIs, one SAC and one SPA (the Tamar Estuaries Complex, which is predominantly in favourable condition). Current threats to the designated features of SACs and SPAs are mainly from increased coastal development, dredging and increased marine activity. Plymouth has six designated Local Nature Reserves, mostly situated on the eastern side of the city.

4.17.7. **Data: Rosyth**

4.17.8. Air quality in Fife is generally good. There are no AQMA's covering Rosyth dockyard or its vicinity.

4.17.9. Fife (including Clackmannanshire) has 24 geological SSSIs and 7,000 potentially contaminated sites, mainly as a result of the area's industrial heritage.

4.17.10. In Fife, water quality is relatively good. In 2007, 80% of bathing waters in Fife met quality standards. In 2006, 20% of rivers were rated as having excellent water quality; 42% were rated as good; 26% were rated fair; and 12% were rated as poor. River basin management plans are reducing agricultural and point source pollution.

4.17.11. Fife's coastland and wetlands are important sites for migrating wildfowl and breeding seabird populations. Fife has 48 SSSIs, two SACs, two SPAs, one Ramsar site, seven local nature reserves and one regional park. The environmental problems and threats affecting biodiversity in Fife include habitat fragmentation from development; invasive species; climate change impacts; agricultural practices; and land and freshwater pollution (including nutrient enrichment). Fife's wetlands, in particular, appear to be declining due to changes in habitat distribution and land use.

4.17.12. **Discussion**

4.17.13. **Air**

4.17.14. Construction, dismantling and interim storage activities could impact local air quality if unmanaged. However, the greatest potential impact is anticipated to be associated with transport of materials and waste to/from site.

4.17.15. Local air quality impacts associated with construction activities could be greatest for the RC separation option if a new build facility is required. Storage at the point of generation would minimise air pollution by minimising transport distance.

4.17.16. **Soils and Geology**

4.17.17. Construction could impact on soil quality and increase contamination risks for existing pollutants.

4.17.18. By contract, redevelopment or new build is likely to require any existing contamination in the soil to be remediated as a requirement of the EIA.

4.17.19. **Water**

4.17.20. Construction, dismantling and interim storage activities may increase demand for water resources, affect the amount of wastewater and surface run-off produced and affect water quality. Water impacts associated with the RC option have the potential to be greater due to the size of the footprint of the facility, which in turn has the greatest potential to affect existing surface run off rates. The actual effects will depend on existing conditions and the extent to which Sustainable Urban Drainage Systems (SUDs) are used.

4.17.21. Any impacts on water quality and the distribution of marine sediments at Devonport from SDP activities could impact on the adjacent Plymouth Sound SAC. It is noted that the SAC is particularly sensitive to oil pollution.

4.17.22. Assuming that limited modifications would need to be made to the existing docking facilities and no additional channel works or dredging is required, no significant adverse impacts on the distribution of marine sediments is anticipated. However, there could be the potential for effects if activities result in a significant impact on water quality, which in turn could alter the marine ecosystem (i.e. a breakdown in saltmarsh habitat).

4.17.23. The interim storage of ILW is unlikely to have any adverse impacts on water, as the ILW would be effectively contained within a secure sealed environment and any run-off would be contained and treated to statutory quality parameters prior to discharge.

4.17.24. **Biodiversity and Nature Conservation**

4.17.25. The Devonport and Rosyth dockyards are well-established dockyards, comprising buildings, dockyard infrastructure and hard-standing. SDP activities at Devonport or Rosyth are therefore unlikely to result in any direct loss of protected or notable habitats or species.

4.17.26. There is a greater potential for SDP activities at Devonport dockyard to impact on designated nature conservation sites, protected species and the structure and function of ecosystems due to the close proximity of the Plymouth Sound SAC and Tamar Estuaries Complex SPA and Ramsar site adjacent to the dockyard. The sensitivity of the marine habitats of the Plymouth Sound SAC would need to be determined by undertaking a Habitats Regulations Assessment.

4.17.27. There is also the potential for SDP activities at the Rosyth dockyard to impact on designated nature conservation sites and protected species, given the proximity of the Firth of Forth SPA and Ramsar site.

4.17.28. The bigger the storage footprint, the more potential there is for an impact on biodiversity. The footprint of RC storage is estimated in Annex C (Section C6) at 11,600m^2; the Packaged Waste option at 1,005m^2 and the RPV option 801m^2.

4.17.29. The choice of technical option would alter the timing of SDP activities and therefore when effects may be felt. In particular, RC storage may necessitate dredging to move RCs and/or the fore and aft sections of the submarines.

4.17.30. The interim storage of ILW is unlikely to have any adverse impacts on biodiversity, as the ILW would be effectively contained within a secure sealed environment.

4.18. 5-ENV: Impact on the Built Environment

4.18.1. This criterion considers the effects of any new facility on the built environment. This includes of cultural heritage, land use, landscape and townscape and the potential opportunities for sustainable design and construction.

4.18.2. Cultural heritage, including architectural and archaeological heritage, within this context is defined as below-ground and upstanding evidence of past human activity and encompasses artefacts, buried and underwater archaeological sites, earthworks, buildings, battlefields, historic gardens, historic landscapes, wrecks, hedgerows and ancient woodland.

4.18.3. Landscape in this context is defined by The European Landscape Convention as '*an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors*'. This definition is stated as covering natural, rural and urbanareas and . the urban-rural fringe, including land, inland water and marine areas. Visual effects are those effects that influence how people see a landscape or townscape, such as the erection of a building.

4.18.4. The data presented below for Devonport and Rosyth are taken from the SEA Scoping Report [4.14.1]. The assessment of this criterion will draw on the provisional outputs from three environmental topics assessed in the SEA (cultural heritage, land use and materials and landscape and townscape). These provisional SEA outputs will be used to complete a 'pre MCDA' assessment of options to feed into the assessment against this criterion and will be presented at the workshop.

4.18.5. **Data: Devonport**

4.18.6. Plymouth has 37 Scheduled Ancient Monuments, 750 listed buildings and 14 conservation areas. Many of Plymouth's most important buildings are associated with the Dockyard; there are 85 listed buildings within Devonport Naval Base (embracing all MOD and Babcock landholdings) which is over 11% of the total number of listed buildings within Plymouth. Three of these are at risk. English Heritage considers that Devonport as a whole has major significance as one of the most important historic dockyards in Europe.

4.18.7. Plymouth's diverse landscape includes historic waterfronts and dockyards; parkland, hilltop planting, steep wooded slopes, ridges and valleys. There are two Areas of Outstanding natural Beauty (AONBs) in Plymouth. Dartmoor National Park is situated to the north-east of the city.

4.18.8. **Data: Rosyth**

4.18.9. Fife has 260 Scheduled Ancient Monuments 4,910 listed buildings and 48 Conservation Areas. There 2 listed buildings in Rosyth Dockyard, both of which are in the nuclear licensed site.

4.18.10. Fife is composed of mainly open countryside, and includes six Areas of Great Landscape Value (AGLV) (covering 70,640 ha). Fife's wetlands appear to be progressively reducing, and there is a general trend of increasing development pressure on landscapes in the area.

4.18.11. **Discussion: Devonport**

4.18.12. Devonport dockyard has a rich and significant built heritage. The potential adverse effects from the SDP could include direct loss, vibration effects on the structural stability of buildings, and dust deposition on structures. There is however, potential for the project to return those buildings identified 'at risk' to viable use.

4.18.13. Since RC storage requires a large storage facility, the potential for for SDP activities to impact on cultural heritage and landscapes is significant., The RPV removal option would require the least space (801m^2), as only the RPV would remain, and the packaged waste option would require 1,005m^2. Since these facilities are far smaller, the risk of significant effect is greatly reduced. More details are provided in Annex C (Section 6).

4.18.14. There is potential for development at Devonport to impact on the landscape character of the Tamar Valley AONB, 1km to the west of the site. SDP activities could also impact on the setting and character of the Devonport Conservation Area and Devonport Registered Park and Garden immediately south, or Stonehouse Peninsula Conservation Area adjacent to the Devonport Conservation Area.

4.18.15. **Discussion: Rosyth**

4.18.16. The potential for effects on the built environment also occurs at Rosyth; however, as there are only 2 listed buildings, the significance of these is likely to be less.

4.18.17. There is potential for development within the Rosyth dockyard to impact on the landscape character of the Area of Great Landscape Value (AGLV) to the north-west. SDP activities could also impact on the setting and character of listed buildings, Conservation Areas and Rosyth Castle scheduled monument in the wider surrounding area.

4.19. 6-ENV: Impact from the Natural Environment

4.19.1. This criterion covers the vulnerability of the options to flood risk, coastal change (including sea level rise) increased storm frequency and intensity, increases in temperatures and changes in rainfall patterns caused by climate change. It also includes seismic vulnerability.

4.19.2. **Data: Devonport**

4.19.3. The UK's Climate Projections (UKCP09) [4.19.1] show that the country as a whole is likely to experience hotter drier summers, warmer wetter winters and rising sea levels, particularly in the South East of England. This is likely to have a significant effect on a range of environmental conditions, including the water environment. This may impact on submarine dismantling and storage operations.

4.19.4. Key findings for UKCP 09 South West England, 2080s Medium Emissions scenario are shown below:

- Increasing winter mean temperature of 1.6 - 4.3ºC (average 2.8ºC).
- Increasing summer mean temperature of 2.1 - 6.4ºC (average 3.9ºC).
- Increasing mean winter rainfall of 6 - 54% (average 23%).
- Decreasing summer rainfall of 6 - 49% (average 23%).

4.19.5. The relevant UKCP09 central estimate for the 2080s for the Medium Emission scenario sea level change is for a mean sea level rise of 36.3 cm compared to 1990 levels.

4.19.6. There is a recorded history of flooding within the Tamar catchment, especially where river flooding coincides with Spring tides. In Plymouth, the main sources of flooding are direct (tide/waves) and indirect (caused by the tide submerging drainage outlets). A significant amount of flooding in Plymouth is caused by ineffective drainage and insufficient sewer capacity.

4.19.7. A small stretch of North Yard (comprising the Western Promontory fronting the estuary), and land to the east of the Basin fronting the Estuary lie within the 1 in 75 yr (0.3% annual probability) flood envelope; these areas of the dockyard therefore are at high risk of flooding.

4.19.8. Devonport is not in an area of the UK where seismic activity is high. The associated hazard from seismic activity is considered low by the British Geological Survey.

4.19.9. **Data: Rosyth**

4.19.10. Rosyth lies within the 1 in 200 year (0.5% annual probability) flood envelope and is therefore at medium to high risk of coastal flooding.

4.19.11. Key findings for Scotland East, 2080s medium emissions scenario are shown below:

- Increasing winter temperature of 1 - 3.7ºC (average 2.2ºC).
- Increasing summer mean temperature of 1.8 - 5.7ºC (average 3.5ºC).
- Increasing winter rainfall of 1 - 25% (average 12%).
- Decreasing summer rainfall of 0 - 33% (average 17%).

4.19.12. The relevant UKCP09 central estimate for the 2080s for the Medium Emission scenario sea level change is for a mean sea level rise of 24.4 cm compared to 1990 levels.

4.19.13. Rosyth is not in an area of the UK where seismic activity is high; indeed earthquakes are almost completely absent from eastern Scotland. The associated hazard from seismic activity is considered low by the BGS.

4.19.14. **Discussion**

4.19.15. Both Devonport and Rosyth are vulnerable to coastal inundation or sea level rise related to climate change or extreme weather conditions.

Clarification provided at the Scoring Workshop:

Isostatic rebound following the last ice age means that Rosyth is actually rising (slower sea level rise) and Devonport is sinking (more rapid sea level rise).

4.19.16. The potential for new infrastructure dismantling to increase flood risk as a result of surface water run-off is not expected to be significant, as both sites are already largely developed, and sustainable drainage systems would have to be incorporated where necessary.

4.19.17. Assuming that limited modifications would need to be made to the existing docking facilities and no channel works or dredging is required to accommodate the SDP activities at Devonport and Rosyth, no significant adverse impacts on coastal processes and/or erosion rates is anticipated.

4.19.18. Both sites are at risk (in planning terms) from the proximity of UK, European and International designations and the protected species that they contain. Any development that might adversely affect the integrity of European sites is subject to Habitats Regulations Assessment – this is likely for both sites, although the likelihood of detailed assessments being required is slightly higher at Devonport, given that the dockyard itself fronts the EU-protected area.

5. References

#	Title	Originator	Reference / Version	Date	Classification
1.1	SDP User Requirement Document		DISM/SDP/420 /1679/Issue 4.0	February 2011	Restricted Commercial
1.2	Managing our Radioactive Waste Safely – CoRWM's Recommendations to Government.		CoRWM Doc 700	July 2006	None
1.3	SDP Concept of Analysis		DISM/SDP/420 /3220/3279, Issue 1.1	March 2011	Restricted Commercial
2.1	SDP Integrated Options		Issue 1.0	February 2011	Protect Policy
2.2	SDP Technical Options Analysis Paper		Issue 2.1	September 2010	Restricted Commercial (+ Another version marked "Protect – Policy)
2.3	MPOS Study Data Report		89330/PDT/TA F6/006 Issue B	July 2010	
2.4	Ionising Radiations Regulations (IRRs)		IRRs	1999	Unclassified
2.5	SDP Site Criteria and Screening Paper		Issue 2.0	18th March 2011	Protect Policy
3.1	Discussion of MCDA Criteria – Threshold and Objective values			28th March 2011	
4.1.1	SDP Opportunities Register			March 2011	Restricted
4.1.2	Classification of Radioactive Waste		IAEA Safety Series 111-G-1.1	1994	Unclassified
4.1.3	Review of the ILW Re-Categorisation Opportunity-		89330/PDT/TA F17/R001/Att3 Issue 1.0	May 2011	
4.1.4	The Principles of Radioactive Waste Management		IAEA Safety Series 111-F	1995	None
4.2.1	Conditions for acceptance (CFA) by LLW Repository Limited of Low Level Waste for Disposal at the Low Level Waste Repository		CFA Issue 02/08	2008	None

#	Title	Originator	Reference / Version	Date	Classification
4.2.2	The Policy for the Long Term Management of Solid Low Level Radioactive Waste Management in the United Kingdom		None	26 March 2007	None
4.2.3	The 2010 UK Radioactive Waste Inventory		URN 10D/985 NDA/ST/STY (11)0004	February 2011	None
4.2.4	Babcock Marine Report on the Rolls Royce Waste Characterisation work.			2011	
4.2.5	UK Strategy for the Management of Solid Low Level Radioactive Waste from the Nuclear Industry. UK Nuclear Industry LLW Strategy Consultation Document		None	2009 and 2010	None
4.2.6	ILW Government Statement on Decommissioning 2004			2004	
4.3.1	Transport Options for Decommissioned Submarines		S&MO/252/17	March 2009	Restricted
4.3.2	RPV Transport		2011/0330 Issue 0.0 (Draft)	30 March 2011	Restricted
4.3.3	Options for transportation of decommissioned submarine reactors.			March 2004	Company Confidential
4.3.4	Reactor Pressure Vessel Transport and Disposal Technical Feasibility.		000019419	June 2010	Restricted
4.3.5	Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Material in the UK - 2009 Review		HPA-CRCE-003.	July 2010.	None
4.4.1	Classification Guide for British Naval Nuclear Propulsion Plant			2001	
4.4.2	Outline Security Plan for Storage of Packaged Waste			2011	

#	Title	Originator	Reference / Version	Date	Classification
4.5.1	Ministry of Defence Policy for Decommissioning and the Disposal of Radioactive Waste and Residual Nuclear Material arising from the Nuclear Programme		Issue 5	09 Oct 2007	None
4.5.2	Review of Radioactive Waste Management Policy Final Conclusions" (Cm-2919)			July 1995.	None
4.5.3	The Decommissioning of the UK Nuclear Industry's Facilities – Amendment to Command 2919, DTI Paper			September 2004	None
4.5.4	Response to the Report and Recommendations from the Committee on Radioactive Waste Management (CoRWM)			2006 and 2010	None
4.6.1	SDP: ILW Store Functional Specification. Basis for ILW Storage Facility Area Assumption – Reactor Compartments		Version 1.0	2011	Protect - Management
4.6.2	SDP: ILW Store Functional Specification. Basis for ILW Storage Facility Area Assumption – Reactor Pressure Vessel			2011	Protect - Management
4.6.3	SDP: ILW Store Functional Specification. Basis for ILW Storage Facility Area Assumption – Packaged Waste			2011	Protect - Management
4.8.1	ISOLUS Technical Options Analysis Paper		Version 2.1	September 2010	Protect -Policy
4.11.1	Submarine Disposal Options- Normal Dose Assessment Calculations		000015104Sub marine Disposal / TAF 005	2010	Restricted
4.11.2	Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations		Ref. No. SI 2009 No. 1348.	2009	None

#	Title	Originator	Reference / Version	Date	Classification
4.11.3	NDA Guidance Documentation on Packaged Waste				None
4.11.4	Packaged Waste Container Selection Phases 1, 2 and 3 Combined Reports		Issue 1.0	December 2010	Protect - Policy
4.11.5	Regulations for the Safe Transport of Radioactive Material. IAEA Safety Standards. Safety Requirements		No. TS-R-1	2009	None
4.11.6	Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material. IAEA Safety Standards.		Safety Guide No. TS-G-1.1 (Rev 1)	2008	None
4.12.1	Health & Safety at Work etc. Act			1974	None
4.12.2	HMS Conqueror Green Passport			March 2010	Protect - Commercial
4.14.1	Submarine Dismantling Project - Strategic Environmental Assessment: Final Scoping Report, March 2011, Defence Equipment and Support.			March 2011	
4.14.2	Cancer Incidence in Plymouth (Follow-up Report)			2009	
4.14.3	Indicative Atlas of Radon in England and Wales.			2008	
4.14.4	Environmental Monitoring for Radioactivity around Devonport Royal Dockyard – Annual Report.			2007	
4.14.5	Ionising Radiation Exposure of the UK population		2005 Review	2005	None

#	Title	Originator	Reference / Version	Date	Classification
4.14.6	COMARE Tenth Report (2005). The incidence of cancer around nuclear installations in Great Britain.		Tenth Report	2005	Unclassified
4.14.7	Radioactivity in Food and the Environment – 15th Report.		15th Report	2010	None
4.14.8	HMS Renown Dismantling Proposal			2004 (TBC)	
4.19.1	DEFRA, UK Climate Projections 09, http://ukcp09.defra.gov.uk/content/view/20/6			2009	Unclassified
A.1.1	SDP Benefits Report		Issue 0.1	February 2011	
C2.1	Estimates of Weights, Volumes and Average Activity of Radioactive Waste Arising from Decommissioned nuclear Submarines		SM552 Paper 122/1887/3559	01 May 1998	Restricted

Annex A: Other Assessment Streams and their relationship to the OE

A.1 Analysis Strategy

A.1.1 The Concept of Analysis (CoA) establishes the approach which will be used to analyse the different options for SDP, comprising three assessment streams:

- Analysis of **Operational Effectiveness** (OE), which is 'how well' each option will meet the objectives of SDP.
- **Investment Appraisal** (IA), which provides the Whole Life Cost (WLC) of each option.
- Consideration of **Other Contributory Factors** (OCF), which comprises non-measurable factors with a significant bearing on SDP, such as public perception.

A.1.2 This data report is concerned with the analysis of OE, but it is also necessary to understand what it does not assess and which will instead be handled by the IA and OCF. This must begin with the way in which the OE was developed, based on benefits mapping.

A.2 Benefits Mapping

A1.1 A.2.1 A workshop of 2 November captured a wide range of SDP benefits and disbenefits. Subsequent analysis generated a hierarchical map of benefits and disbenefits, with the second level of benefits delivered by SDP being characterised as:

- Public confidence.
- Socio-economic impact.
- Reduction of impact on operations.
- Reduction in impact on Government and MOD.
- Reduction of environmental and safety impact.

A.3.1 The benefits and disbenefits have been mapped fully to the User Requirements Document (URD) and are described in detail in the SDP Benefits Report [A1.1].

A.3 Analysis Approach

A.3.1 The benefits map has been divided into a series of 'zones' to describe how the method by which each option will be assessed to deliver benefits.

A.3.2 Benefits and disbenefits relating to public confidence or indirect socio-economic impact (which are not included in the WLC model underpinning the IA) will be considered as OCF, as they are not readily measurable.

A.3.3 Benefits and disbenefits with direct economic impact will be considered in the IA; all the others could in *principle* be treated in the OE. However, in terms of differentiating between options, it is sometimes more appropriate to use WLC alone to differentiate between the impact on benefits and disbenefits. For example, the benefit *operations conducted safely* assumes that each option will deliver the same standard of regulatory safety, giving the same level of OE performance, but the cost will vary between them.

A.3.4 As a consequence of this process, some aspects of SDP may at first sight seem to be 'missing' from the OE. This reflects the fact that they are either considered as OCF, or as part of the IA. Two principles were used throughout the development of the OE:

- Care was taken to ensure that criteria selected do not overlap with the IA. For example, one potential criterion could be technical risk. However, the financial implications of the risks will be covered within the IA, with technical challenge translated into wider financial uncertainty bounds. The criterion would only be relevant if it also had other implications, which should really be based on what those implications are e.g. worker safety, or accident potential rather than left in general "risk" terms. Risk and/or time delays have been characterised in financial terms within the IA *unless* data does not exist or it is not feasible to model them within the WLC.

- Where possible, the criteria have been adopted which reflected the "end state" rather than the process. For example, ease of characterisation is a factor that will assist in the overall management of the submarines and resultant waste but is not an end in itself, therefore it does not need to be considered as an MCDA criterion. The difficulty of getting the required level of characterisation would be judged on cost (including cost risk) and other specific implications such as safety.

A.3.5 The following benefits and disbenefits are being considered as OCF:

- <u>Public confidence</u>, including impact on cultural heritage, public understanding, visible demonstration of commitment to dismantling, naval heritage, perceived radiation dose, perceived dismantling risk, promotion of intergenerational equity and becoming a nuclear dump.

- <u>Socio-economic impact</u>, including:

    - Improved relationships between MOD, site and local community.

    - Socio-economic impact on community, including improved fit with local vision for the area, positive socio-economic impact, negative socio-economic impact and increased direct employment.

    - Certain aspects of economic impact on the MOD, including sharing of MOD infrastructure, contract savings, workstream to balance dockyard activities and potential sale of land and assets.

A.3.6 The following benefits and disbenefits are being considered solely through the IA:

- <u>Socio-economic impact</u>, including:

- Certain aspects of economic impact on the MOD, including economic benefits removal LUSM's, economic benefit up front investment, cost of dismantling, cost of land storage and value of recycling material.

- Reduction in impact to Government & MOD, including:

    - Removal of non-hazardous waste liability, including removal and disposal.
    - Removal of hazardous waste liability, including removal and disposal.
    - Removal of LLW/VLLW, including removal and disposal.
    - Waste in form for proposed GDF, including package suitable for GDF.

- Reduction of impact to operations, including:

    - Prevention of impact when capacity full, including not exceeding berthing capacity and submarines dismantled straight after DDLP.

- Reduction of environmental & safety impact, including:

    - Operations conducted safely.

Annex B: Detailed Technical Description of the Options

B.1 Technical Description of Options

B1.1 Technical descriptions of the options are provided below with reference to the box diagram in Section 2, Figure 2.7.1.

B1.2 For all options the submarine will be transported, if required, from the afloat storage location (Box A) by sea to the dockyard selected for initial dismantling (Boxes B or C). There are three possible means of transporting the submarine by sea to the dismantling dockyard, which are discussed in more detail in [4.3.1].

- Towing the submarine directly to the dockyard.
- Floating the submarine onto a heavy lift vessel. (This has been a proven method of transport of fuelled submarines in Russia and regularly for transportation of oil rigs.)
- A combination option which involves using a heavy lift ship but removing the submarine a distance from the dock and towing in. (This is a useful option where the depth of water in the dock at the dismantling site is not sufficiently deep to allow the heavy lift ship to berth successfully if this is the chosen method of transport.)

B1.3 The submarine will be transferred to a submarine dismantling area from the sea either by the use of a dry-dock, ship-lift, floating dock or slipway, all of which are routine processes in common use on ship building and refitting.

B1.4 For all options the radioactive and non-radioactive systems must be drained prior to cut-out. For the RC option, pipework and cables protruding through the RC bulk heads must be isolated and sealed individually and contaminated systems outside of the RC will be wholly removed by cutting and sealing operations within containment tents. For all options, all radioactive material removed from the submarine will be transferred to a waste disposal facility. All removed items will be monitored, characterised and transferred to a suitable waste processing facility for disposal. Some of this work may be carried out utilising existing facilities.

B1.5 For all three main options, either new or upgraded facilities will also be required, these will consist of a LLW processing area with individual bays suitable for radiological work. The processing of LLW is a routine operation utilising simple sorting and cutting techniques with all equipment necessary for this work readily available. Wherever possible the LLW will be transported to waste treatment facilities to be processed using techniques such as shot blasting and smelting to enable recycling of materials. The remaining LLW will be packaged to conform to the Low Level Waste Repository (LLWR) requirements and a robust waste characterisation and monitoring regime will be required to ensure compliance with all LLWR radioactive limits.

B1.6 An ILW processing area will also be required, also with individual bays, suitable for remote and shielded radiological work. ILW processing will require some specialist operations (e.g. size reduction by wire cutting) which are well understood and practised in the civil nuclear industry. Mechanical handling of larger pieces of ILW may require specialist equipment which is readily available. The ILW component of the RPV will be removed, size reduced and placed in standard $3m^3$ boxes and sent for interim storage pending consignment to the proposed GDF. A suitable container is required for all ILW box on-site movements and a shielded overpack is required for the $3m^3$ ILW box transports to the proposed GDF. Transport of the shielded overpack containing 3m^3 ILW boxes will be via a specialist haulage contractor or by rail depending on the locations of the dismantling facility and the proposed GDF.

B1.7 **RC Separation and Interim Storage (Option 1)**

B1.8 Prior to separation of the RC, a simple non-seismic cradle will be fabricated and welded to the underside of the RC to provide support during separation from the hull, transportation and storage. The construction of the cradle will be based on established technology with no special requirements.

B1.9 A clear path for the hull cuts will be made by the removal of pipes, plant and equipment from the inside of the compartments adjacent to the RC and the removal of the tiles on the outside of the hull. Two cuts through the submarine hull, on either side of the RC, will be made using existing cutting techniques, including hot and cold cutting e.g. oxy/acetylene and diamond wire cutting. This latter method was used effectively in the dissection of the sunken Russian submarine, the Kursk. The two hull sections on either side of the RC will be pulled away from the RC section (Box D) using existing ship building and refitting methodologies. Metal plates will be welded onto the ends of the separated fore and aft hull sections and of the RC to seal them. The two separated hull sections will be transported to a conventional dismantling site using a heavy lift submersible ship/barge. It is unlikely that the two separated hull sections will be rejoined.

B1.10 The separated RC must be transported to the interim storage location (Box E). Because Options 1D and 1R stipulate that interim storage will be at the initial dismantling site, only on on-site transportation will be necessary. However, if there is to be only one size reduction facility, transportation to another site will be necessary for the dual site option (Option 1B). The paragraph below addresses the transportation of an RC.

Further data provided at the Scoring Workshop:

Version 1.0 of this report stated that transportation was not relevant to Option 2, but was included to allow appreciation of the transportation of an RC. However, if, for this option, the interim storage facility and the size reduction facility are to be on the same site and there is to be only one size reduction site, the dual site variant will require an RC to be transported from one of the dismantling sites to the size reduction site.

B1.11 The weight of the RC is expected to be up to 1000 tonnes therfore transportation by road would only be possible over very short distances, possibly on specially constructed or reinforced roads. Transportation over greater distances would be by sea with the RC and its associated support structure being transferred onto a transport ship or barge using existing heavy lifting equipment, such as strand jacks. There may be significant technical challenges in ensuring the RC can be transported safely and in finding a suitable port where facilities can be constructed or modified to unload it. No additional shielding is anticipated for transportation or storage, because the RC would serve as the interim storage container. This needs to be formally justified.

B1.12 At the interim storage site heavy lifting/moving equipment will be required to transfer the RC and support structure from the ship/barge the short distance from the sea receipt to the Interim Storage Facility. The Interim Storage Facility may only need to be a simple weatherproof building as the RC provides all the necessary radiation shielding and containment. However, the lack of seawater which provides additional shielding around the bottom of the hull may result in higher radiation levels under the RC and access to this area may need to be controlled, similar to that associated with dry docking. The interim store should include a water run-off catchment facility to enable monitoring for contamination resulting from a loss of containment. The facility must be secure and allow the regular inspection and monitoring of the RCs to confirm integrity of hull.

B1.13 The RCs will be stored at the Interim Storage Facility (Boxes F and/or G) until the proposed GDF is available to receive the waste. It is expected that the proposed GDF will be operational around 2040 and will accept the submarine dismantling waste possibly tens of years after this date. An RC dismantling facility will require a construction consisting of a simple steel framed structure with a large open area suitable for radiological work and built-in mechanical handling. The RC must be transferred from the interim store to the dismantling facility, the working assumption being that the facility will be at the same location as the interim store. The operations involve well understood remote handling, cutting, containment and lifting techniques and will entirely de-plant the RC. Removal of the Reactor Pressure Vessel (RPV) (Boxes H and I) involves a heavy lift which is consistent with existing capabilities. The operation will be performed by skilled nuclear workers with the worker dose being strictly controlled throughout the procedure. When the proposed GDF is able to receive the submarine dismantling ILW, the RPV will transported to the Size Reduction Facility (Box O), size reduced (Box P) and the ILW packaged (Box Q), in accordance with the following section, prior to transfer to (Box X) and disposal (Box Y) at the proposed GDF.

B1.14 **RPV Removal and Interim Storage (Options 2, 3 and 4)**

B1.15 These options require removal of the RPV from the RC and interim storage of the RPV. At a later stage, the RPV will be size reduced and the ILW will be packaged for disposal into the proposed GDF. This section of the report describes the removal of the RPV (common to both options) and then the specific requirements for RPV storage and storage of packaged ILW.

B1.16 Prior to removal of the RPV (Boxes H and I), a simple non-seismic cradle must be fabricated that the RPV can be lifted onto to provide support during future transportation and storage. The construction of the cradle will be based on established technology with no special requirements e.g. seismic. Environmental containment will be provided for the primary reactor systems and RPV removal work by constructing a temporary structure that includes a high efficiency, filtered extract ventilation system around the relevant part of the submarine hull. The containment structure would also allow equipment to be removed from the RC.

B1.17 All systems and equipments will be cut, sealed and removed from the RC, the connections to the RPV being sealed individually. All items removed from within the RC, will be monitored, characterised and transferred to a suitable waste processing facility for disposal.

B1.18 As the RPV head is expected to be activated LLW, significant size and weight reduction of the RPV may be achieved by removal of the head before the RPV is removed from the RC (this is a standard dockyard operation during a refuelling period). This has benefits in handling the RPV and in reducing the amount of material held with the RPV in an ILW store. The RPV can be sealed/covered to provide a contained environment. The advantage with separating these portions of the RPV is that the ILW component is reduced enabling the larger volume of LLW to be disposed of earlier. It is important to ensure the LLW portion of the RPV is adequately characterised through sampling and analysis with particular attention being paid to the concentrations of Tritium and Carbon-14. In calculating storage volumes, it has been assumed that this approach is feasible. If the RPV removal option is preferred this approach will need to be investigated further to confirm its viability.

B1.19 Access through the submarine hull must be made to enable the removal of the RPV. A hole will be cut into the submarine hull either on top or on the side of the RC (depending on the preferred method of removal) using existing ship building/refitting cutting techniques. If the access hole is made through the top of the RC then the RPV will be removed from the submarine using heavy lifting craneage which is routinely used in ship building dockyards. The RPV, which weighs around 50 tonnes (without head), will be craned onto the purpose built cradle. If the access hole is made through the side of the RC then the RPV will be removed from the submarine using jack lifting equipment which is also routinely used in ship building dockyards to slide the RPV out of the RC. The RPV will be transferred onto the purpose built cradle using heavy lifting equipment. Further removal of irradiated structure may be required and metal plates will be welded over all holes cut in the submarine hull to re-establish the submarine watertight integrity using existing ship building and refitting methodologies. The remaining non-radioactive submarine hull will be dismantled using conventional techniques used to dismantle marine vessels to enable the recycling of materials wherever possible after transfer to a suitable shipyard as necessary.

B1.20 If the RPV and its associated Primary Shield Tank (PST) have not yet been detached from each other, they will be transported to a facility where the RPV will be separated from its PST. The RPV will be transportation in due course to the Size Reduction Facility (Box O).

Further data provided at the Scoring Workshop:

The Primary Shield Tank should ideally be separated from the Reactor Pressure Vessel prior to removal of the RPV from the submarine. If this is technically challenging, there may be a need to transport the PST to a facility where the two entities can be separated from each other.

B1.21 For the RPV removal and interim storage options, the RPV will require transportation to the interim store (Box J) therefore suitable containment for the transportation process and subsequent storage must be established. The containment/transport and storage package should as a minimum provide contamination control as the RPV could still contain some residual sludge or crud which could be released during transportation. The contact dose rate on the RPV must conform to Road Transport Regulations therefore it is possible that the container may require additional shielding to reduce the radiation dose rate to acceptable levels. The RPV will be transferred into the container and onto a suitable transportation vehicle using heavy lifting equipment. Transportation of an irradiated RPV has not been undertaken in the UK to date. The size reduction of a submarine RPV has not been undertaken in the UK to date, although it has been undertaken for land-based reactors.

B1.22 Interim storage of the RPV will take place at a chosen location (Boxes K, L, M, N) until the proposed GDF is able to accept the submarine dismantling ILW, at which point the RPV will transported to the Size Reduction Facility (Box O), size reduced (Box P) and packaged (Box Q) accordingly. It will then be transported (Box X) and disposed of at the proposed GDF (Box Y).

B1.23 **RPV Removal, Size Reduction and Interim Storage as Packaged Waste (Options 5, 6, 7 and 8)**

B1.24 These option requires removal and size reduction of the RPV followed by packaging of ILW. The ILW packages would then be put into interim store prior to disposal in the proposed GDF.

B1.25 After removal of the RPV from the submarine (Boxes H and I), the RPV will transported (Box O) to a facility to be size reduced (Box P) and packaged (Box Q) using well understood remote handling, cutting, containment and lifting techniques. The various operations will be performed by skilled nuclear workers with the worker dose being strictly controlled throughout the procedure.

B1.26 The packaged ILW will be transported (Box R) to an Interim Storage Facility (Boxes S, T, U, V, W) until the proposed GDF is able to accept the submarine dismantling ILW.

B1.27 The packaged ILW will be transported to the proposed GDF (Box X) for final disposal (Box Y).

B1.28 Discussion

B1.29 All options will involve different methodologies and possibly different technologies, depending on the specifics of the option. Although similar size reduction processes will ultimately be required of all of the options, these will be undertaken at different timescales, which may influence the methodologies and technologies selected. It is possible that after a period of interim storage, the activity may have decayed to a level where a higher degree of manual handling is possible, simplifying the dismantling process.

B1.30 There is experience within the UK nuclear industry in the use of 3 m³ boxes for the storage of ILW waste, including the construction of interim stores. A shielded overpack is not currently available but work is ongoing within SDP to develop this.

B1.31 Waste Characterisation

B1.32 A technical challenge which will be faced by all of the options to some degree is that of waste characterisation, which will be required principally for off-site transportation, storage and disposal of wastes. Inadequate or inaccurate characterisation could lead to difficulties in obtaining statutory approvals for transport and storage and could lead to increased disposal costs.

B1.33 Characterisation will involve non-intrusive measurements (e.g. gamma spectroscopy) and intrusive sampling coupled with product analysis. A "fingerprint" of radionuclides will be established with reference to a measurable entity, probably the Cobalt-60 gamma dose rates. Measurement of these dose rates may then allow calculation of the radionuclide inventory of the waste.

B1.34 Waste characterisation is one of the most difficult tasks, and is often overlooked. Some major UK nuclear industry projects have failed in the past because inadequate attention has been paid to this requirement.

Annex C: Supplementary Information

C.1 Criterion 1-POL: Flexibility and Robustness to Opportunities and Risk

C.1.1 The text below provides additional information on the SDP risk management process, with reference to the Assessment and Demonstration phases.

C.1.2 The Assessment phase covers all of the preliminary work required to allow the Demonstration phase to proceed. This phase includes option selection, public consultation, planning applications, site selection and other work required before demonstrating the applicability of the industrial process to submarine dismantling. A successful outcome would allow the project to proceed to the Demonstration phase.

C.1.3 The Demonstration phase will involve the dismantling of one or more submarines to demonstrate process feasibility and applicability. The initial works will include obtaining the necessary planning permissions and approvals etc., to proceed. Depending on which option is chosen this could include approvals for the construction and operation of facilities to size reduce, package, store and transport ILW. A successful outcome would allow the project to proceed to the manufacturing phase and if this was successful, the industrial process and lessons learned would then be applied to the dismantling of the remaining submarines.

C.2 Criterion 2-POL: Compliance with UK Policy and Strategy on Radioactive Waste Management

C.2.1 The considerations below are taken from the following reference: [redacted]

LLW Assumption

Past public consultation data was –

Total tonnes of ILW/LLW [redacted]

Assumed ILW [redacted]

Assumed LLW [redacted]

MDAL ILW Assumption is now [redacted]

Therefore LLW should be [redacted]

Further considerations –

Activated LLW from the RPV is therefore [redacted]

to

[redacted]

Contaminated LLW external to the RPV (tonnes) (See [C.2.1]) = [redacted]

It is assumed that 95% of this will be decontaminated and recycled, leaving [redacted] tonnes of LLW for disposal.

Total LLW (tonnes) for disposal is therefore [redacted]

C.2.2 LLW and ILW Policy and Strategy

C.2.3 Policy

C.2.4 The *Policy for the Long Term Management of Solid Low Level Radioactive Waste Management in the United Kingdom* [4.2.2] provides a statement for Government Policy on the long term management of the UK's solid LLW which was developed following public consultation. The policy amends or replaces relevant parts of the Review of Radioactive Waste Policy: Final Conclusions (Cm-2919) White Paper published in July 1995 [4.5.2].

C.2.5 This policy statement covers all aspects of the generation, management and regulation of solid LLW. Management of the UK's higher activity radioactive waste has been considered by CoRWM who presented their recommendations to Government on 31 July 2006 [4.5.4].

C.2.6 Due to the large range of LLW type's, government policy does not aim to be prescriptive but to provide a high level framework within which individual LLW management decisions can be taken flexibly to ensure safe, environmentally acceptable and cost-effective management solutions that appropriately reflect the nature of the LLW concerned.

C.2.7 The policy statement differentiates between the definitions for VLLW (low volumes and bulk disposals) and the need for controls on the total volumes of VLLW in the high volume category being deposited at any one particular landfill site.

C.2.8 Nuclear industry radioactive waste management is regulated by a number of bodies:

- Health and Safety executive – regulates on-site arisings and storage of waste from H&S perspective
- Environment Agency – regulates disposal and transfer of solid waste as well as liquid and gaseous discharges
- Dept for Transport
- Office for Civil Nuclear Security

C.2.9 LLW Management Plans for the management of all radioactive waste, including LLW, must be developed by waste managers. All nuclear licensed sites should have a plan for the management of LLW holdings and predicted future arisings that is part of a wider integrated waste management strategy. Strategic Environmental Assessments (SEA) will be required by European Directive 2001/42/EC for certain plans and programmes and an environmental impact assessment may be required for projects under Directive 85/337/EC.

C.2.10 LLW management plans must take into account all current and anticipated future arisings of LLW and their radiological and non-radiological properties. Plans must be developed with regulatory and stakeholder involvement and take into account best practice. Generally, plans should be developed and agreed with regulatory bodies in advance of the production of new LLW.

C.2.11 To ensure waste arisings of LLW and the requirements for its disposal are minimised, LLW managers should plan their waste in accordance with Waste Management Hierarchy Principles:

- Not creating waste where practicable.
- Reduce waste arisings (both by activity and mass) to minimum through appropriate design and operations of the process and equipment, making effective use of techniques such as waste characterisation, sorting and segregation, volume reduction and decontamination.
- Otherwise minimise LLW through decay storage, re-use and/or recycling and incineration.
- Disposal (may, for some waste forms, include incineration).

C.2.12 The objective for LLW management plans should be to deal with potential arisings at the highest practicable level of this hierarchy. Some LLW has hazardous or toxic properties which must be taken into account in its disposal and incineration may be considered as a treatment or disposal option for some combustible LLW.

C.2.13 Strategy

C.2.14 The *UK Strategy for the Management of Solid Low Level Radioactive Waste from the Nuclear Industry* [4.2.5] is developed from UK policy. The aim is to provide a high level framework within which LLW management decisions can be taken flexibly to ensure safe, environmentally acceptable and cost-effective management solutions that reflect the nature of the LLW concerned. To deliver this aim, three strategic themes have been developed:

- The waste hierarchy
- The best use of existing LLW management assets
- The need for new fit for purpose waste management routes

C.2.15 The strategy is to apply the waste hierarchy more effectively to the management of LLW. Where the preference for higher levels of the waste hierarchy cannot be met and disposal is necessary, it must be optimised to minimise the overall impact of LLW management on people and the environment. Figure C2.1 below provides an overview of the strategy:

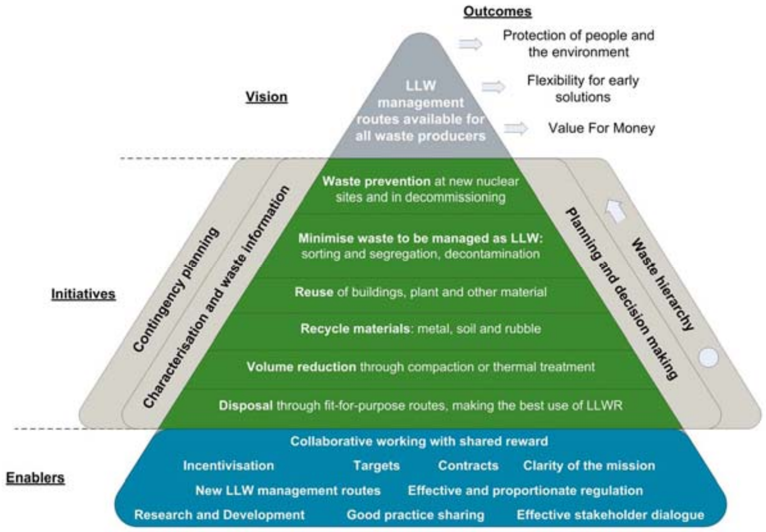


Figure C2.1: UK Nuclear Industry LLW Strategy in Summary

C.2.16 The **Proximity Principle** is an important consideration for the management of waste and suggests that waste planning should "*enable waste to be disposed of in one of the nearest installations*". The UK LLW policy recognises that transport is a very sensitive issue for communities affected by LLW management.

C.2.17 **Managing our Radioactive Waste Safely – CoRWM Recommendations to Government**

C.2.18 In September 2001, UK Government and devolved administrations instigated the first stage of its Managing Radioactive Waste Safely programme (MRWS). The second stage began in July 2002 when Government published its response to the 2001 consultation, followed in 2003 by the appointment of the independent Committee on Radioactive Waste Management (CoRWM). Government commissioned CoRWM to oversee a review of options for the long term management of the UK's higher activity radioactive waste and to recommend the option, or combination of options, that could provide a long term solution, providing protection for people and the environment. Their objective was to provide recommendations which inspired public confidence and were practicable in securing the long term safety of those wastes. CoRWM began its work in November 2003 and delivered its recommendations in its report to Government in July 2006 [4.5.4].

C.2.19 In summary, the three main elements of CoRWM's recommendations, following extensive engagement with stakeholders, members of the public and technical experts, are that:

- Geological disposal is currently the best form of long term management for the UK's higher activity radioactive waste;
- There should be a commitment to the safe and secure interim storage of the waste during the period it will take to plan and construct the geological disposal facility; and

- The UK should look to develop partnership arrangements, linked to appropriate involvement and benefit packages, with local authorities/communities as a means of securing facility siting.

> **Note added subsequent to the MCDA Workshops:**
>
> Version 1.0, Annex C2 contained information (e.g. the waste hierarchy) which was duplicated in the text of this document. The duplicate text has been removed from Annex C2.

C.3 Criterion 3-POL: Scope/Extent of Transportation of Submarines and Radioactive Waste

C.3.1 The information provided below was produced for this annex by personnel from Babcock Marine and Nuvia Ltd.

C.3.2 This criterion addresses the scope/extent of transportation of whole submarines and radioactive waste.

C.3.3 The data presented below makes the assumption that whole submarines, submarine components and/or radioactive wastes may need to be transported by rail, road and/or sea between the sites used for dismantling, interim storage and disposal.

C.3.4 Data – Background Information

C.3.5 Whole Submarine Transportation

C.3.6 A whole submarine could be transported by sea from its berthing site to a deplanting / dismantling site.

C.3.7 This criterion addresses the scope/extent of transportation of whole submarines and radioactive waste.

C.3.8 Salvage and Marine Operations IPT (S&MO IPT) were tasked by DISM SUSM to produce a top level options paper reviewing the methodologies available to support the potential movement of submarines around the UK. Their report concluded that the two principal methods would be heavy lift vessel and wet towing, but that additional work is required to produce an optimised transportation methodology [4.3.1].

C.3.9 Russia has experience of transporting (fuelled) nuclear submarines by heavy lift vessel. The first such transportation took place in 2005, with UK (S&MO IPT) as the technical lead. None of the SDP transportation will involve fuelled submarines.

C.3.10 No submarine transportations will be required for the Do Minimum option.

C.3.11 RC Transportation

C.3.12 As the options are currently defined, the only RC option is for storage at the point of generation, therefore the only transportation required will be the on-site transfer of the RC to its store.

C.3.13 The USA, Russia and France all have experience of transportation of nuclear submarine RCs.

C.3.14 RPV Transportation

C.3.15 Under a dual site dismantling regime, RPVs could be transported from the dismantling site by sea to the size reduction and packaging site. Some off-site road transport may be required, but it is not yet clear if off-site rail transport will be required. Some on-site road transport will also be required.

C.3.16 RPVs could be transported by road from the dismantling site to the interim storage site and from there to a size reduction and packaging site or directly to the proposed GDF for disposal. The packaged waste could be transported to the proposed GDF or the LLWR by road or rail.

C.3.17 The feasibility of transportation of RPVs is currently being addressed by Nuvia Ltd. and a draft report [4.3.2] is available. This report acknowledges that since no new information has come forward since the 2004 BNFL report [4.3.3] and the 2010 Babcock Marine report [4.3.4], the conclusions of these reports remain valid.

C.3.18 The two main transportation package types are Type B and IP-2. The dose rate requirements for IP-2 packages are more onerous than those for the Type B packages but the testing requirements for IP-2 are less onerous. Modelling studies indicate that an RPV could be IP-2 compliant after a 10 year decay period, but actual measurements of RPV dose rate profiles are not yet available to confirm this.

C.3.19 [4.3.2] indicates that transportation of RPV packages is physically feasible as demonstrated by similar successful operations in the UK (WAGR heat exchangers), Germany (RPV from the Rheinsberg PWR WWER-70 reactor) and the US (RPVs from the La Crosse Boiling Water reactor, the Connecticut Yankee reactor, the Yankee Rowe reactor, and the Shippingport reactor). These involved loads which were longer and heavier than a submarine RPV and utilised road, rail and sea (barge) transportation for distances which ranged from several miles (UK) to 1100 miles (US). In some cases steel overpacks were used and the RPV was grouted inside the overpack.

C.3.20 The UK Used Fuel Flask (UFF) is a Type B flask (Design number GB/3337A/B(M)F), about 4 metre high, 2.4 metres diameter and weighs 74 tonnes, dimensions which are not too dissimilar to those of an RPV. [4.3.2] suggests that the UFF may be useful analogue to the transportation of an RPV, recognising that the potential radiological hazard of an RPV is far lower than that of used fuel.

C.3.21 Packaged Waste Transportation

C.3.22 Packaged waste could be transported from the waste packaging plant to the Interim Storage Facility by road or rail and eventually from there to the proposed GDF (long lived ILW) or LLWR (short lived ILW which decays to LLW) by road or rail.

C.3.23 There is previous experience of transportation of packaged waste by road and rail in the UK and worldwide. UK policy until recently has been to store ILW at the point of origin, but this is believed to be changing into centralised ILW storage. Hence in the past, there has been no incentive to develop overpacks for transportation of packages within the UK. Some designs of overpacks are available from RWMD but they still need to be manufactured and tested. Hence MOD may need to manufacture and test an overpack for transportation of the $3m^3$ boxes. Although this is relatively unknown territory for MOD, RWMD has the necessary SQEP resources to make this a low risk activity from both technical and regulatory perspectives.

C.3.24 The numbers of packaged waste transportations required for the dual site, Devonport and Rosyth options are discussed below.

C.3.25 Submarine Hull Transportation

C.3.26 Once the ILW and LLW components and other materials have been removed, the submarine hull will be made safe and then transported by sea from the cut-out or dismantling site to the ship-recycling yard. If the RC has been separated then transportation may be more difficult as the unit will no longer be intact.

C.3.27 On the assumption that a submarine hull will be transported by single transfer to the ship-recycling yard, 27 such transports will be required. This will be common to all of the options.

C.3.28 **Discussion**

C.3.29 Approvals for inter-site transportation of NDA ILW boxes (e.g. $3m^3$ boxes) should be relatively straightforward, since such transportations are part of the UK strategy for the management of civilian nuclear industry waste.

C.3.30 Inter-site transportation of large items like RCs or RPVs are less common in the UK but approvals may also prove to be straightforward.

C.3.31 The data presented below makes the assumption that whole submarines, submarine components and/or radioactive wastes may need to be transported by rail, road and/or sea between the sites used for dismantling, interim storage and disposal.

C.3.32 Data – Breakdown of Transportations

C.3.33 Whole Submarine Transportation to Initial Dismantling Facility

C.3.34 A whole submarine may be transported by sea from its berth to an initial dismantling site.

C.3.35 For the purposes of this document, the assumptions are made that only one submarine would be transported at any one time and that for the dual site option, submarines would not be moved between sites for the purpose of establishing balanced workloads at both sites.

C.3.36 The MDAL states that the scope of the SDP relates to the dismantling of 27 submarines. 9 LUSMs are currently located at Devonport Dockyard, 7 at Rosyth Dockyard and 11 submarines are still in-service. The in-service submarines would need to be defuelled at Devonport. If the intention is to dismantle submarines at Rosyth Dockyard, these in-service submarines would need to be transported to Rosyth after defuelling. If the intention is to dismantle submarines at Devonport Dockyard, no additional transportation of in-service submarines would be required.

C.3.37 The table below shows the number of submarines which would be transported from their berthing sites to the initial dismantling site. Note that no submarine transportations will be required for the Do Minimum option (Option 0).

C.3.38 Table C3.1: Number of Submarine Transportations from Berthing Site to Initial Dismantling Site

From: Berthing Site	**Devonport**	**Rosyth**	**Likely Transports**
To: Initial Dismantling Site	**Rosyth**	**Devonport**	
#0	N/A	N/A	0
#1D	0	**7**	7
#1R	**20**	0	20
#1B	0	0	0
#2D	0	**7**	7
#2R	**20**	0	20
#2B	0	0	0
#3D	0	7	7
#3R	**20**	0	20
#3B	0	0	0
#4D	0	**7**	7
#4R	**20**	0	20
#4B	0	0	0
#5D	0	**7**	7
#5R	**20**	0	20
#5B	0	0	0
#6D	0	**7**	7
#6R	**20**	0	20
#6B	0	0	0
#7D	0	**7**	7
#7R	**20**	0	20
#7B	0	0	0
#8D	0	**7**	7
#8R	**20**	0	20
#8B	0	0	0

C.3.39 In summary:

- Locating all of the submarines to Devonport would require the transportation of 7 LUSMs from Rosyth, i.e. a total of 7 transportations.
- Locating all of the submarines to Rosyth would require the transportation of 9 LUSMs from Devonport and the 11 in-service submarines (after defuelling) from Devonport, i.e. 9 + 11 = 20 transportations.

- Locating submarines at both sites (the dual site options) would involve 0 transportations if the 9 Devonport LUSMS and the 11 in-service submarines are dismantled at Devonport Dockyard and the 7 Rosyth LUSMs are dismantled at Rosyth Dockyard.

- Thus initial dismantling at both sites (the dual site option) requires less submarine transportations (0) than the other two options. Initial dismantling at Devonport Dockyard/HMNB Devonport requires less submarine transportations (7) than the Rosyth Dockyard option (20).

C.3.40 Option 0 (Do Minimum)

C.3.41 Under Option 0 (Do Minimum), submarines remain at their berthing sites, therefore no transportations are required.

C.3.42 Option 1: (RC Separation with Storage at Point of Generation)

C.3.43 This section discusses the transportations required for Option 1, which involves the removal of the RC, interim storage, removal of the decay-stored RPV, followed by size reduction and disposal.

C.3.44 Although options exist that would involve the transportation of RCs to an Interim Storage Facility, only the most economic RC option is included in this assessment (as a bounding case for all RC options) and this option is for storage at the point of generation. This does not require any off site transportations. However, if there is to be only one Size Reduction Facility, the RCs will need to be transported to this site.

C.3.45 A summary is provided below of the transportations required for Option 1.

- Transporting an RC from the initial dismantling site to an Interim Storage Facility on the same site does not require any off-site transportations.

- Transporting an RPV from the Interim Storage Facility to a Size Reduction Facility requires 0 RPV transportations if both facilities are on the same site. Up to 27 RPV transportations are required if they are on different sites.

- Transporting packaged waste from the Size Reduction Facility to the proposed GDF involves 162 transportations.

C.3.46 More details on Option 1 are provided in the tables below.

C.3.47 Options 2, 3 and 4 (RPV Removal with Storage at Various Locations)

C.3.48 This section discusses the transportations required for Options 2, 3 and 4, which involve the removal of the RPV, interim storage followed by size reduction and disposal.

C.3.49 RPV Transportation from Initial Dismantling Site to the Interim Storage Facility

C.3.50 Under the RPV removal options (Options 2, 3 and 4), RPVs will be removed from the submarine at the initial dismantling site and transported by rail, road or sea to an

Interim Storage Facility for decay storage.

C.3.51 The RPVs will be removed at either Devonport Dockyard, HMNB Devonport or Rosyth Dockyard. Interim storage facilities could be located at the point of generation (i.e. at Devonport or Rosyth) (Option 2), a remote commercial site (Option 3) or a remote MOD site (Option 4).

C.3.52 Option 2D: If initial dismantling is carried out at Devonport Dockyard/HMNB Devonport and the RPV Interim Storage Facility is sited at Devonport Dockyard/HMNB Devonport, no RPV transportations will be required. **Number of Transports = 0**.

C.3.53 Option 2R: If initial dismantling is carried out at Rosyth Dockyard and the RPV Interim Storage Facility is sited at Rosyth Dockyard, no RPV transportations will be required. **Number of Transports = 0**.

C.3.54 Option 2B: If initial dismantling is carried out at both Devonport and Rosyth Dockyards and RPV Interim Storage Facilities are provided at both sites, no RPV transportations will be required. However, because there will only be one Size Reduction Facility, the RPVs need to be transported (20 from Devonport or 7 from Rosyth) to this facility. **Number of Transports = 20 or 7**.

C.3.55 Option 3D: If initial dismantling is carried out at Devonport Dockyard/HMNB Devonport and RPV Interim Storage Facilities are on a remote commercial site, 27 RPV transportations will be required. **Number of Transports = 27**.

C.3.56 Option 3R: If initial dismantling is carried out at Rosyth Dockyard and RPV Interim Storage Facilities are on a remote commercial site, 27 RPV transportations will be required. **Number of Transports = 27**.

C.3.57 Option 3B: If initial dismantling is carried out at both Devonport and Rosyth Dockyards and RPV Interim Storage Facilities are on a remote commercial site, 27 RPV transportations will be required. **Number of Transports = 27**.

C.3.58 Option 4D: If initial dismantling is carried out at Devonport Dockyard/HMNB Devonport and RPV Interim Storage Facilities are on a remote MOD site, 27 RPV transportations will be required. **Number of Transports = 27**.

C.3.59 Option 4R: If initial dismantling is carried out at Rosyth Dockyard and RPV Interim Storage Facilities are on a remote MOD site, 27 RPV transportations will be required. **Number of Transports = 27**.

C.3.60 Option 4B: If initial dismantling is carried out at both Devonport Dockyard/HMNB Devonport and Rosyth Dockyard and RPV Interim Storage Facilities are on a remote MOD site, 27 RPV transportations will be required. **Number of Transports = 27**.

C.3.61 The numbers of required transportations are described in the table below. Transportations highlighted in bold are considered to be the most likely transportation option.

C.3.62 **Table C3.2: Number of RPV Transportations from Initial Dismantling Site to the Interim Storage Facility**

From: Initial Dismantling Site	**Devon-port**	**Devon-port**	**Devon-port**	**Devon-port**	**Rosyth**	**Rosyth**	**Rosyth**	**Rosyth**	**Likely Trans-ports**
To: Interim Storage Facility	**Devon-port**	**Rosyth**	**Commer -cial Site**	**MOD Site**	**Rosyth**	**Devon-port**	**Remote Commer -cial Site**	**Remote MOD Site**	
#0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
#1D	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#1R	N/A	N/A	N/A	N/A	**0**	N/A	N/A	N/A	N/A
#1B	**0**	N/A	N/A	20	**0**	N/A	N/A	N/A	N/A
#2D	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
#2R	N/A	N/A	N/A	N/A	**0**	0	N/A	N/A	0
#2B	0	**20**	N/A	N/A	0	**7**	N/A	N/A	20 or 7
#3D	N/A	N/A	**27**	N/A	N/A	N/A	N/A	N/A	27
#3R	N/A	N/A	N/A	N/A	N/A	N/A	**27**	N/A	27
#3B	N/A	N/A	**20**	N/A	N/A	N/A	**7**	N/A	27
#4D	N/A	N/A	N/A	**27**	N/A	N/A	N/A	N/A	27
#4R	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**27**	27
#4B	N/A	N/A	N/A	**20**	N/A	N/A	N/A	**7**	27
#5D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#5R	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#5B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#6D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#6R	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#6B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#7D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#7R	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#7B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#8D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#8R	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
#8B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

C.3.63 A summary of the number of transportations of RPVs from the Initial Dismantling site to the Interim Storage Facility for Options 2, 3 and 4 is provided below.

- Options 2D and 2R do not require any RPV transportations.
- Option 2B requires either 20 or 7 RPV transportations.
- Options 3D, 3R and 3B require 27 RPV transportations.
- Options 4D, 4R and 4B require 27 RPV transportations.

C.3.64 **RPV Transportation from Interim Storage Facility to Size Reduction and Packaging Facility**

C.3.65 Under the RPV removal options (Options 2, 3 and 4), decay-stored RPVs will be transported from the Interim Storage Facility to a Size Reduction and Packaging Facility where the RPV would be cut up and packaged as waste.

C.3.66 Provision will be made for only one Size Reduction and Packaging Facility. This could be located at Devonport Dockyard/HMNB Devonport, Rosyth Dockyard, or at a remote commercial, MOD or NDA site. Note that no decision has yet been made on the location of the Size Reduction and Packaging Facility.

C.3.67 Option 2D: Assume that one RPV interim store is used and this is located at Devonport Dockyard/HMNB Devonport. If the Size Reduction and Packaging Facility is also located at Devonport Dockyard/HMNB Devonport, no off-site transportations of RPVs will be required. **Number of Transports = 0.**

C.3.68 Option 2R: Assume that only one RPV interim stores is used and this is located at Rosyth Dockyard. If the Size Reduction and Packaging Facility is also located at Rosyth Dockyard, no off-site transportations of RPVs will be required. **Number of Transports = 0.**

C.3.69 Option 2B: the RPV interim store must be located on the same site as the Size Reduction Facility of which there will only be. Therefore no off-site transportation of RPVs will be required. **Number of Transports = 0.**

C.3.70 Options 3D, 3R and 3B: Assume that there is only one RPV interim store and this is located on a remote commercial site. If the Size Reduction and Packaging Facility is also located on the same remote commercial site, no off-site transportation of RPVs will be required. **Number of Transports = 0.**

C.3.71 Options 4D, 4R and 4B: Assume that there is only one RPV interim store and this is located on a remote MOD site. If the Size Reduction and Packaging Facility is also located on the same remote MOD site, no off-site transportation of RPVs will be required. **Number of Transports = 0.**

C.3.72 Table C3.3: Number of RPV Transportations from Interim Storage Facility to Size Reduction and Packaging Facility

From: Interim Storage Facility	**Devon-port**	**Rosyth**	**Remote Commercial Site**	**Remote MOD Site**	**Likely Transports**
To: Size Reduction Facility	**Devon-port**	**Rosyth**	**Remote Commercial Site**	**Remote MOD Site**	
#0	N/A	N/A	N/A	N/A	0
#1D	**0**	N/A	N/A	N/A	0
#1R	N/A	**0**	N/A	N/A	0
#1B	0	0	N/A	N/A	0
#2D	**0**	N/A	N/A	N/A	0
#2R	N/A	**0**	N/A	N/A	0

From: Interim Storage Facility	**Devon-port**	**Rosyth**	**Remote Commercial Site**	**Remote MOD Site**	**Likely Transports**
To: Size Reduction Facility	**Devon-port**	**Rosyth**	**Remote Commercial Site**	**Remote MOD Site**	
#2B	0	0	N/A	N/A	0
#3D	N/A	N/A	**0**	N/A	0
#3R	N/A	N/A	**0**	N/A	0
#3B	N/A	N/A	**0**	N/A	0
#4D	N/A	N/A	N/A	**0**	0
#4R	N/A	N/A	N/A	**0**	0
#4B	N/A	N/A	N/A	**0**	0
#5D	N/A	N/A	N/A	N/A	0
#5R	N/A	N/A	N/A	N/A	0
#5B	N/A	N/A	N/A	N/A	0
#6D	N/A	N/A	N/A	N/A	0
#6R	N/A	N/A	N/A	N/A	0
#6B	N/A	N/A	N/A	N/A	0
#7D	N/A	N/A	N/A	N/A	0
#7R	N/A	N/A	N/A	N/A	0
#7B	N/A	N/A	N/A	N/A	0
#8D	N/A	N/A	N/A	N/A	0
#8R	N/A	N/A	N/A	N/A	0
#8B	N/A	N/A	N/A	N/A	0

C.3.73 A summary of the number of likely transportations of decay-stored RPVs to the Size Reduction Facility is provided below.

- Options 2D and 2R will require 0 transportations of decay-stored RPVs due to the location of the interim store on the same site as the Size Reduction Facility.
- Option 2B will require 0 transportations as the RPV interim store must be located on the same site as the Size Reduction Facility, of which there will only be one. Therefore dual site interim storage together with their associated Size Reduction Facilities is not possible, if there is only to be one Size Reduction Facility.
- Options 3D, 3R, 3B, 4D, 4R and 4B will require 0 transportations of decay-stored RPVs to the Size Reduction Facility.

C.3.74 **Packaged Waste Transportation from Size Reduction Facility to proposed GDF**

C.3.75 Under the RPV removal options (Options 2, 3 and 4), packaged waste will be transported by road or rail from the Size Reduction and Packaging Facility to the proposed GDF for final disposal.

C.3.76 It is assumed there will be approximately six $3m^3$ boxes of packaged waste per submarine, and 27 submarines in total equating to 162 packages. The number of $3m^3$ boxes generated per submarine may vary from six once the implications of recent Babcock Marine/Rolls Royce waste characterisation work [Ref. 4.2.4] are understood.

C.3.77 It is assumed that each package will require independent transportation from the Size Reduction Facility to the proposed GDF. **Number of Transports = 162.**

C.3.78 Table C3.4: Packaged Waste Transportation from Size Reduction Facility to Proposed GDF

From: Size Reduction Facility	Devonport	Rosyth	Sites other than Devonport or Rosyth	Likely Transports
To: GDF	**GDF**	**GDF**	**GDF**	**GDF**
#0	N/A	N/A	N/A	0
#1D	**162**	N/A	162	162
#1R	N/A	**162**	162	162
#1B	0 or **162**	0 or **162**	162	162
#2D	**162**	N/A	162	162
#2R	N/A	162	162	162
#2B	0 or **162**	0 or **162**	162	162
#3D	162	N/A	**162**	162
#3R	N/A	162	**162**	162
#3B	0 or 162	0 or 162	**162**	162
#4D	162	N/A	**162**	162
#4R	0	162	**162**	162
#4B	162	162	**162**	162
#5D	N/A	N/A	N/A	0
#5R	N/A	N/A	N/A	0
#5B	N/A	N/A	N/A	0
#6D	N/A	N/A	N/A	0
#6R	N/A	N/A	N/A	0
#6B	N/A	N/A	N/A	0
#7D	N/A	N/A	N/A	0
#7R	N/A	N/A	N/A	0
#7B	N/A	N/A	N/A	0
#8D	N/A	N/A	N/A	0
#8R	N/A	N/A	N/A	0
#8B	N/A	N/A	N/A	0

C.3.79 In summary:

- Options 2D, 2R, 2B, 3D, 3R, 3B, 4D, 4R and 4B each require162 transportations to move packaged waste from the Size Reduction Facility to the proposed GDF.

C.3.80 Options 5, 6, 7 and 8 (RPV Removal, Size Reduction with Storage of Packaged

Waste at Various Locations)

C.3.81 This section discusses the transportations required for Options 5, 6, 7 and 8, which involve the removal of the RPV, size reduction, followed by interim storage and disposal.

C.3.82 **RPV Transportations from Initial Dismantling Facility to Size Reduction Facility**

C.3.83 It is assumed that where possible, the initial dismantling and size reduction facilities will be on the same site.

C.3.84 It is re-iterated that there will only be one Size Reduction Facility and that its location has still to be determined.

C.3.85 **Table C3.5: RPV Transportations from Initial Dismantling Site to Size Reduction Facility**

From: Initial Dismantling Site	**Devon-port**	**Rosyth**	**Remote Commercial, Site**	**Remote, MOD Site**	**Remote, NDA Site**	**Likely Trans-ports**
To: Size Reduction Facility	**Devon-port**	**Rosyth**	**Remote Commercial, Site**	**Remote, MOD Site**	**Remote, NDA Site**	
#0	N/A	N/A	N/A		N/A	N/A
#1D	N/A	N/A	N/A		N/A	N/A
#1R	N/A	N/A	N/A		N/A	N/A
#1B	N/A	N/A	N/A		N/A	N/A
#2D	N/A	N/A	N/A		N/A	N/A
#2R	N/A	N/A	N/A		N/A	N/A
#2B	N/A	N/A	N/A		N/A	N/A
#3D	N/A	N/A	N/A		N/A	N/A
#3R	N/A	N/A	N/A		N/A	N/A
#3B	N/A	N/A	N/A		N/A	N/A
#4D	N/A	N/A	N/A		N/A	N/A
#4R	N/A	N/A	N/A		N/A	N/A
#4B	N/A	N/A	N/A		N/A	N/A
#5D	**0**	N/A	0		N/A	0
#5R	N/A	**0**	N/A		0	0
#5B	**0**	**0**	0		0	0
#6D	**0**	N/A	0		N/A	0
#6R	N/A	**0**	N/A		0	0
#6B	**0**	**0**	0		0	0
#7D	**0**	N/A	0		N/A	0
#7R	N/A	**0**	N/A		0	0
#7B	**0**	**0**	0		0	0
#8D	**0**	N/A	0		N/A	0
#8R	N/A	**0**	N/A		0	0
#8B	**0**	**0**	0		0	0

C.3.86 In summary:

C.3.87 Based on assumption that the Size Reduction Facility will be on the same site as the Initial Dismantling Facility, no transportations are required.

C.3.88 Packaged Waste Transportations from Size Reduction Facility to Interim Storage Facility

C.3.89 Table C3.6: Packaged Waste Transportations from Size Reduction Facility to Interim Storage Facility

From: Size Reduction Facility	**Devon-port**	**Devon-port**	**Devon-port**	**Rosyth**	**Rosyth**	**Rosyth**	**Likely Trans-ports**
To: Interim Store	**Devon-port**	**Rosyth**	**Remote Commercial, MOD or NDA Site**	**Rosyth**	**Devon-port**	**Remote Commercial, MOD or NDA Site**	
#0	N/A	N/A	N/A	N/A	N/A	N/A	0
#1D	N/A	N/A	N/A	N/A	N/A	N/A	0
#1R	N/A	N/A	N/A	N/A	N/A	N/A	0
#1B	N/A	N/A	N/A	N/A	N/A	N/A	0
#2D	N/A	N/A	N/A	N/A	N/A	N/A	0
#2R	N/A	N/A	N/A	N/A	N/A	N/A	0
#2B	N/A	N/A	N/A	N/A	N/A	N/A	0
#3D	N/A	N/A	N/A	N/A	N/A	N/A	0
#3R	N/A	N/A	N/A	N/A	N/A	N/A	0
#3B	N/A	N/A	N/A	N/A	N/A	N/A	0
#4D	N/A	N/A	N/A	N/A	N/A	N/A	0
#4R	N/A	N/A	N/A	N/A	N/A	N/A	0
#4B	N/A	N/A	N/A	N/A	N/A	N/A	0
#5D	0	162	**162**	N/A	N/A	N/A	0
#5R	N/A	N/A	N/A	0	162	**162**	0
#5B	0	162	**162**	0	162	**162**	0
#6D	0	162	162	N/A	N/A	**162**	162
#6R	N/A	162	162	0	162	**162**	162
#6B	0	162	162	0	162	**162**	162
#7D	0	162	162	N/A	N/A	**162**	162
#7R	N/A	N/A	162	0	162	**162**	162
#7B	0	162	162	0	162	**162**	162
#8D	0	162	162	N/A	162	**162**	162
#8R	N/A	N/A	N/A	0	162	**162**	162
#8B	0	162	162	0	162	**162**	162

C.3.90 In summary:

- Options 5D, 5R, 5B will not require any off-site transportations of packaged waste if the Interim Dismantling Facility, Size Reduction Facility and the interim store are located on the same site. 162 transportations will be required if the interim store is located on a different site.

- Options 5D, 5R, 5B through to 8D, 8R and 8B will require 162 transportations of packaged waste, based on the different locations of the Size Reduction Facility and the Interim Storage Facility.

C.3.91 **Packaged Waste Transportations from the Interim Storage Facility to the Proposed GDF**

C.3.92 For the Devonport and Rosyth options, the interim store will be at Devonport or Rosyth.

C.3.93 Table C3.7: Packaged Waste Transportations from Interim Storage Facility to the Proposed GDF

From: Interim Storage Facility	Devonport	Rosyth	Remote Commercial Site	Remote MOD Site	NDA Site	Likely Trans-ports
To: GDF	**GDF**	**GDF**	**GDF**	**GDF**	**GDF**	
#0	N/A	N/A	N/A	N/A	N/A	0
#1D	N/A	N/A	N/A	N/A	N/A	0
#1R	N/A	N/A	N/A	N/A	N/A	0
#1B	N/A	N/A	N/A	N/A	N/A	0
#2D	N/A	N/A	N/A	N/A	N/A	0
#2R	N/A	N/A	N/A	N/A	N/A	0
#2B	N/A	N/A	N/A	N/A	N/A	0
#3D	N/A	N/A	N/A	N/A	N/A	0
#3R	N/A	N/A	N/A	N/A	N/A	0
#3B	N/A	N/A	N/A	N/A	N/A	0
#4D	N/A	N/A	N/A	N/A	N/A	0
#4R	N/A	N/A	N/A	N/A	N/A	0
#4B	N/A	N/A	N/A	N/A	N/A	0
#5D	**162**	**0 or 162**	N/A	N/A	N/A	162
#5R	**0 or 162**	**162**	N/A	N/A	N/A	162
#5B	**162**	**162**	N/A	N/A	N/A	162
#6D	N/A	N/A	**162**	N/A	N/A	162
#6R	N/A	N/A	**162**	N/A	N/A	162
#6B	N/A	N/A	**162**	N/A	N/A	162
#7D	N/A	N/A	N/A	**162**	N/A	162
#7R	N/A	N/A	N/A	**162**	N/A	162
#7B	N/A	N/A	N/A	**162**	N/A	162
#8D	N/A	N/A	N/A	N/A	**162**	162
#8R	N/A	N/A	N/A	N/A	**162**	162
#8B	N/A	N/A	N/A	N/A	**162**	162

C.3.94 Transportation Summary

C.3.95 The various transportations are summarised in the table below. The data is taken from the tables referred to in the first row of Table C3.8.

C.3.96 **Table C3.8: Summary of Submarine, RPV and Packaged Waste Transportations**

Ref.	Table C3.1	Table C3.2	Table C3.3	Table C3.4	Table C3.5	Table C3.6	Table C3.7	Totals
Options	**Sub-marines**	**RPVs**	**RPVs**	**Packaged Waste**	**RPVs**	**Packaged Waste**	**Packaged Waste**	
#0	0	0	0	0	0	0	0	0
#1D	7	0	0	162	0	0	0	169
#1R	20	0	0	162	0	0	0	182
#1B	0	0	0	162	0	0	0	162
#2D	7	0	0	162	0	0	0	169
#2R	20	0	0	162	0	0	0	182
#2B	0	7/20	0	162	0	0	0	169/182
#3D	7	27	0	162	0	0	0	196
#3R	20	27	0	162	0	0	0	209
#3B	0	27	0	162	0	0	0	189
#4D	7	27	0	162	0	0	0	196
#4R	20	27	0	162	0	0	0	209
#4B	0	27	0	162	0	0	0	189
#5D	7	0	0	0	0	0	162	169
#5R	20	0	0	0	0	0	162	182
#5B	0	0	0	0	0	0	162	162
#6D	7	0	0	0	0	162	162	331
#6R	20	0	0	0	0	162	162	344
#6B	0	0	0	0	0	162	162	324
#7D	7	0	0	0	0	162	162	331
#7R	20	0	0	0	0	162	162	344
#7B	0	0	0	0	0	162	162	324
#8D	7	0	0	0	0	162	162	331
#8R	20	0	0	0	0	162	162	344
#8B	0	0	0	0	0	162	162	324

Further data provided at the Scoring Workshop:

The numbers of different categories of transportations for each of the options are provided in Table C3.9 below.

C.3.97 **Table C.3.9: Summary of Numbers of Inter-Site Transport Campaigns involving Submarines, RCs, RPVs and Packaged Waste**

Option #	Transport Subs to Dismantling Site	Transport RCs, RPVs to Interim Storage Site	Transport Packaged Waste to Interim Storage Site	Transports to the GDF	Numbers of Inter-Site Transport Campaigns

Option #	Transport Subs to Dismantling Site	Transport RCs, RPVs to Interim Storage Site	Transport Packaged Waste to Interim Storage Site	Transports to the GDF	Numbers of Inter-Site Transport Campaigns
0	0	0	0	0	**0**
#1D	Transport 7 subs from Rosyth to Devonport	0	0	Transport 162 waste packages from Devonport to the GDF	**2**
#1R	Transport 20 (9 + 11) subs from Devonport to Rosyth	0	0	Transport 162 waste packages from Rosyth to the GDF	**2**
#1B (One Size Reduction Facility)		Transport 7 RCs from Rosyth to Devonport **or** Transport 20 RCs from Devonport to Rosyth	0	Transport 162 waste packages from Devonport or Rosyth to the GDF	**2**
#2D	Transport 7 subs from Rosyth to Devonport	0	0	Transport 162 waste packages from Devonport to the GDF	**2**
#2R	Transport 20 subs from Devonport to Rosyth	0	0	Transport 162 waste packages from Rosyth to the GDF	**2**
#2B (One Size Reduction Facility)	0	Transport 7 RPVs from Rosyth to Devonport **or** Transport 20 RPVs from Devonport to Rosyth	0	Transport 162 waste packages from Devonport to the GDF **or** Transport 162 waste packages from Rosyth to the GDF	**2**
#3D	Transport 7 subs from	Transport 27 RPVs	0	162 waste packages	**3**

Option #	Transport Subs to Dismantling Site	Transport RCs, RPVs to Interim Storage Site	Transport Packaged Waste to Interim Storage Site	Transports to the GDF	Numbers of Inter-Site Transport Campaigns
	Rosyth to Devonport	from Devonport to the commercial site		from the commercial site to the GDF	
#3R	Transport 20 subs from Devonport to Rosyth	Transport 27 RPVs from Rosyth to the commercial site	0	Transport 162 waste packages from the commercial site to the GDF	**3**
#3B	0	Transport 20 RPVs from Devonport to commercial site **and** Transport 7 RPVs from Rosyth to commercial site	0	Transport 162 waste packages from the commercial site to the GDF	**2 or 3** 2 if the transports to the commercial site are not counted separately 3 if the transports to the commercial site are counted separately
#4D	Transport 7 subs from Rosyth to Devonport	Transport 27 RPVs from Devonport to the remote MOD site	0	Transport 162 waste packages from the MOD site to the GDF	**3**
#4R	Transport 20 subs from Devonport to Rosyth	Transport 27 RPVs from Rosyth to the remote MOD site	0	Transport 162 waste packages from the MOD site to the GDF	**3**
#4B	0	Transport 20 RPVs from Devonport to remote MOD site	0	Transport 162 waste packages from the remote MOD site to the	**2 or 3** (See 3B above)

Option #	Transport Subs to Dismantling Site	Transport RCs, RPVs to Interim Storage Site	Transport Packaged Waste to Interim Storage Site	Transports to the GDF	Numbers of Inter-Site Transport Campaigns
		and Transport 7 RPVs from Rosyth to remote MOD site		GDF	
#5D	Transport 7 subs from Rosyth to Devonport	0	0	Transport 162 waste packages from Devonport to the GDF	**2**
#5R	Transport 20 subs from Devonport to Rosyth	0	0	Transport 162 waste packages from Rosyth to the GDF	**2**
#5B (One Size Reduction Facility)	0	Transport 7 RPVs from Rosyth to Devonport **or** Transport 20 RPVs from Devonport to Rosyth	0	Transport 162 waste packages from Devonport to the GDF **or** Transport 162 waste packages from Rosyth to the GDF	**2**
#6D	Transport 7 subs from Rosyth to Devonport	0	Transport 162 waste packages from Devonport to the remote commercial site	Transport 162 waste packages from the remote commercial site to the GDF	**3**
#6R	Transport 20 subs from Devonport to Rosyth	0	Transport 162 waste packages from Rosyth to the remote commercial	Transport 162 waste packages from the remote commercial	**3**

Option #	Transport Subs to Dismantling Site	Transport RCs, RPVs to Interim Storage Site	Transport Packaged Waste to Interim Storage Site	Transports to the GDF	Numbers of Inter-Site Transport Campaigns
			site	site to the GDF	
#6B	0	Transport 7 RPVs from Rosyth to Devonport **or** Transport 20 RPVs from Devonport to Rosyth	Transport 162 waste packages from Devonport to the remote commercial site **or** Transport 162 waste packages from Rosyth to the remote commercial site	Transport 162 waste packages from the remote commercial site to the GDF	**3**
#7D	Transport 7 subs from Rosyth to Devonport	0	Transport 162 waste packages from Devonport to the remote MOD site	Transport 162 waste packages from the remote MOD site to the GDF	**3**
#7R	Transport 20 subs from Devonport to Rosyth	0	Transport 162 waste packages from Rosyth to the remote MOD site	Transport 162 waste packages from the remote MOD site to the GDF	**3**
#7B	0	Transport 7 RPVs from Rosyth to Devonport **or** Transport 20 RPVs from Devonport to Rosyth	Transport 162 waste packages from Devonport to the remote MOD site **or** Transport 162 waste packages	Transport 162 waste packages from the remote MOD site to the GDF	**3**

Option #	Transport Subs to Dismantling Site	Transport RCs, RPVs to Interim Storage Site	Transport Packaged Waste to Interim Storage Site	Transports to the GDF	Numbers of Inter-Site Transport Campaigns
			from Rosyth to the remote MOD site		
#8D	Transport 7 subs from Rosyth to Devonport	0	Transport 162 waste packages from Devonport to the NDA site	Transport 162 waste packages from the NDA site to the GDF	**3**
#8R	Transport 20 subs from Devonport to Rosyth	0	Transport 162 waste packages from Rosyth to the NDA site	Transport 162 waste packages from the NDA site to the GDF	**3**
#8B	0	Transport 7 RPVs from Rosyth to Devonport **or** Transport 20 RPVs from Devonport to Rosyth	Transport 162 waste packages from Devonport to the NDA site **or** Transport 162 waste packages from Rosyth to the NDA site	Transport 162 waste packages from the NDA site to the GDF	**3**

C.4 Criterion 4-POL: Unauthorised Access to Classified Materials during Dismantling, Storage and Transportation

C.4.1 No additional data.

C.5 Criterion 5-POL: Compliance with UK Decommissioning Policy

C.5.1 Decommissioning

Text discussed at the Scoring Workshop:

(Text on decommissioning extracted from previous version of Section C.2).

C.5.2 The Decommissioning of the UK Nuclear Industry’s Facilities, Amendment to Command 2919, was published by DTI during September 2004 [4.5.3]. The Decommissioning of the UK Nuclear Industry’s Facilities, Amendment to Command 2919, was published by DTI during September 2004 [4.5.3].

C.5.3 This statement of the UK Government and devolved administrations policy on the decommissioning of nuclear facilities updates and replaces the previous statement contained in the “Review of Radioactive Waste Management Policy Final Conclusions” (Cm-2919) published in July 1995 [4.5.2].

C.5.4 Decommissioning operations should be carried out as soon as reasonably practicable. The Government recognises that decommissioning operations may, however, involve two or more separate stages spanning a number of decades. It may also be appropriate to delay particular operations to benefit from new or developing technologies or from further development of existing best practice, or to take advantage of radioactive decay.

C.5.5 Each operator is expected to produce and maintain a decommissioning strategy and plan for its site, which the Government expects will take into account stakeholder views. Strategies should include a comprehensive site decommissioning plan for safely carrying out the decommissioning process with due regard to security and protection of the environment.

C.5.6 The strategy should take into account all relevant factors, assessing and presenting them in a transparent way underpinned by objective information and arguments. These include:

- Ensuring worker and public safety
- Maintaining site security
- Minimising waste generation and providing for effective and safe management of wastes
- Minimising environmental impacts including reusing or recycling materials if possible
- Maintaining adequate site stewardship
- Using resources effectively, efficiently and economically
- Providing adequate funding
- Maintaining access to an adequate and relevant skills and knowledge base
- Using existing best practice wherever possible
- Conducting research and development to develop necessary skills or best practice
- Consulting appropriate public and stakeholder groups on the options considered and the contents of the strategy.

C.5.7 These factors should be applied throughout each decommissioning programme. Operators decommissioning strategies need to take into account relevant developments in UK radioactive waste management policy. The Government considers that decommissioning strategies should seek to avoid the creation of radioactive wastes in forms which may foreclose options for safe and effective long term waste management. Strategies should harness the benefits of radioactive decay and should maximise the amount of materials suitable for re-use of recycling. Through BPM strategies the volume of radioactive waste created should be minimised, particularly the volume of ILW. Decommissioning wastes should be packaged in a way that does not preclude disposal options. Operators may wish to bring forward operations to utilise existing skills or knowledge.

C.5.8 The UK strategy for Radioactive Discharges 2001-2020 requires progressive and substantial reductions in radioactive discharges to the marine environment.

C.6 Criterion 1-OP: Impact on the Maritime Enterprise

C.6.1 **Table C6.1: Interim Storage Surface Area Requirements**

Interim Storage Option	**Surface Area Required**	**Comments**
Reactor Compartment	11,600 m^2	Area required for storage of intact Reactor Compartments based on 27 submarines each producing one RC. The storage facility includes the RC package vault, receipt, dispatch, inspection and maintenance facilities and office/admin areas. See [4.6.1].
Reactor Pressure Vessel	801 m^2	Area required for defeulled RPV based on 27 submarines each producing one RPV. The storage facility includes the RPV package vault, receipt, dispatch, inspection and maintenance facilities and office/admin areas. See [4.6.2].
Packaged Waste	1005 m^2	Area required for a storage facility for ILW in 3m^3 NDA boxes based on 27 submarines each requiring six boxes (162 in total). See [4.6.3].

C.7 Criterion 2-OP: Flexibility of the Dismantling Approach to managing future Classes

C.7.1 No additional data.

C.8 Criterion 3-OP: Threat to Skill and Experience Set

C.8.1 No additional data.

C.9 Criterion 4-OP: Transferable Dismantling Knowledge

C.9.1 No additional data.

C.10 Criterion 5-OP: Impact on Wider MOD Operations

C.10.1 No additional data.

C.11 Criterion 1-H&S: Worker Dose: Dismantling, Storage and Transportation

C.11.1 No additional data.

C.12 Criterion 2-H&S: Non Radiological Impact on Workers

C.12.1 Biological Hazards

- Hot water systems (Legionella). (Change rooms, drinking water supplies)

C.12.2 Chemical Hazards

- Creation of flammable atmospheres. (Use of gases, fuels. Dust generation)
- Exposure to hazardous substances, (COSHH). (Solvents, fuels, oils, etc.)
- Work with Asbestos. (Asbestos lagging, mineral fibres)
- Work with Lead.
- Work with Beryllium.
- Inhalation of vapours, gases, particles. (From numerous decommissioning tasks: cutting etc.)

C.12.3 Electric Hazards

- Damage to/from electrical equipment. (High/Low Voltage, On board electrical circuits, portable electrical equipment)
- Work with exposed live conductors. (Submarine electrical systems)
- Maintenance of electrical equipment. (Tools and equipment associated with decommissioning)
- Use of 240V not 110V on construction/decommissioning site work (Possible occurrence)

C.12.4 Environmental Hazards

- Working in confined spaces. (Areas of submarine)

- Hot/Cold working environment >55°C <5°C. (Inside and outside of submarine)
- Working in adverse weather conditions. (Dismantling locations in Scotland or Southern England)
- Poor lighting. (Within vessel and on dockside)
- Working in high noise levels. (Cutting, burning operations)
- Poor ventilation (dusts and fumes). (Resulting from cutting etc.)
- Inadequate floor coverings (slips trips falls). (Especially during breaking of vessel and on the dockside)
- Poor Access/Egress. (Routes in and out of the vessel)
- Escape routes. (Escape routes from potential confined spaces)
- Wastes build up and segregation of waste (fire risks/leaching).(During all phases of the dismantling process)
- Working near, above or on water. (Work undertaken at dockyard)

C.12.5 Ergonomics

- Poor design of working environment/equipment. (Equipment use leading to hand arm problems vibration etc.)
- Work with visual display units. (Desk based tasks during dismantling)
- Manual handling, white finger, Repetitive Strain Injury issues. (Use of tools during dismantling: burning, cutting)

C.12.6 Fire Explosion Hazards

- Spraying of flammable liquids/vapours. (Degreasing activities etc.)
- Fire potential of combustibles/ waste accumulation. (Flammable wastes accumulated during the dismantling process)
- Fire explosion of flammable liquids/dusts and gases. (Fuel/oil storage tanks on or off vessel)
- Poor storage of chemicals (i.e. oxidising with Inflammable). (Chemicals: cleaning materials, lubricants, fuels etc.)

C.12.7 Mechanical Hazards

- Incorrect installation of equipment. (Equipment used during the dismantling process)
- Access to dangerous machinery (poor/no guarding). (Hand tools: grinders, cutters etc.)
- Entanglement in rotating machinery. (Hand tools)
- Traps/Nips from moving parts of equipment. (Hand tools mechanical and electrically driven)
- Abrasive wheels.(Cutters, grinders)

C.12.8 Physical Hazards

- Failure of pressurised systems. (Hydraulics, compressed air supplies)
- Storage and stacking of goods. (Stacking of waste/recyclable materials)
- Compressed air/pressure systems or stored energy (including pressure water jetting). (On-board compressed air systems, pressure water jetting equipment)

- Use of sharp equipment/hand tools. (Hand tools)
- Use of compressed gas cylinders. (Gas cutting equipment)
- Incorrect use of hand/power tools (cutting/grinding/drilling). (Insufficient training on equipment)
- Working at heights/scaffolds/ ladders. (Dismantling operations on the vessel)
- Overhead obstructions. (Overhead obstructions within the vessel)
- Falling Objects to (head/feet). (Items generated by dismantling operations)
- Slips/trips/falls (same level and at height). (Work undertaken on board vessel and sites adjacent to the vessel)
- Contact with hot/cold objects/liquids. (Items generated from hot works)
- Hazards leading to eye injuries. (Cutting, grinding, pressure jet washing)
- Equipment causing vibration white finger. (Hand operated power tools)
- Hoists, slings, lifting equipment, cranes. (From lifting operations associated with dismantling)
- Safe place of work and access/egress. (Work areas associated with dismantling)
- Soldering/welding/brazing/cutting. (Dismantling operations: cutting)
- Repetitive work. (Cutting etc.)
- Workplace to hot/cold. (Cutting operations within vessel)
- Work in Confined Spaces.(Operations within the vessel)
- Hot Work. (Hot Works: cutting etc.)

C.12.9 Psychosocial Hazards

- Sources of stress. (Demands on time)
- Poor shift patterns, excessive working hours. (Long shifts, insufficient breaks)
- Improper, inadequate information/instruction/ training supervision or selection.
- Dismantling operations: supervision, use of SQEP.

C.12.10 Transport Hazards

- Loading/unloading of vehicles. (Waste/recyclable material loading. Delivery of equipment)
- Dangers from reversing/manoeuvring of vehicles/overhead crane movements. (Site movement, traffic)
- Operation of forklift trucks/ other workplace transport equipment. (Vehicular movements at the dockside)
- Travel/Transport issues to and from sites/Air/Sea/Road.
- Submarine transport.
- Worker commuting etc.
- Poor/No segregation of pedestrian and traffic movements. (Traffic planning on or adjacent to the vessel)

C.12.11 Human Factors

- Trained personnel. (SQEP employees, supervisors, managers)
- Physical capability. (SQEP personnel)
- Mental capacity. (SQEP personnel)
- Young Person. (Use of young persons during dismantling operations)

- Ergonomics. (Manual handling, repetitive operations)

C.13 Criterion 3-H&S: Potential for an Unplanned Radiological Release during Dismantling, Storage and Transportation

C.13.1 No additional data.

C.14 Criterion 1-ENV: Radiological Discharges to the Public

C.14.1 No additional data.

C.15 Criterion 2-ENV: Radiological Discharges to the Environment

C.15.1 No additional data.

C.16 Criterion 3-ENV: Non-radiological Impact on the Public

C.16.1 No additional data.

C.16.2 See store footprint data in Annex C Section C6.

C.17 Criterion 4-ENV: Non radiological Impact on the Environment

C.17.1 No additional data.

C.17.2 See store footprint data in Annex C Section C6.

C.18 Criterion 5-ENV: Impact on the Built Environment

C.19 Criterion 6-ENV: Impact from the Natural Environment

C.19.1 No additional data