LLW Repository Ltd

Low Level Waste Repository

LLWR Environmental Safety Case

LLWR Authorisation Schedule 9 Requirement 1 Study

NNL(09)10232 **Issue 1.1** **Date: March 09**

		Name	Signature	Date
Checked by	Environmental & Technical Manager	Simon Hunter	S E Hunter	31/3/09
Approver	ESC Programme Manager	Richard Cummings	pp S E Hunter	31/3/09

This page is left blank intentionally.

National Nuclear Laboratory

LLWR Authorisation Schedule 9, Requirement 1 Study

NNL (09) 10232
Issue 1.1

A report prepared for and on behalf of
Low Level Waste Repository

Date 31 March 2009

LLWR Authorisation Schedule 9, Requirement 1 Study

NNL (09) 10232
Issue 1.1

Helen Sparks, Joanna Cubitt, Jeremy Edwards and Andrew Nickson, March 2009

Checked by :	Neil Dickinson	[signature]	31/3/09
Approved by :	Matthew Randall	[signature]	31/3/09
Work Order No.	03663.100		

EXECUTIVE SUMMARY

This study addresses the requirements of improvement conditions set out in the RSA Authorisation and associated CEAR documents, and considers options with regard to the future operation of the LLWR site for radioactive waste disposals for gaseous, liquid and solid waste streams. One off arisings are managed on a case-by-case basis in accordance with LLWR procedures, and are not, due to their very nature, included within this study.

Schedule 9 of the Low Level Waste Repository's Radioactive Substances Act (RSA) Authorisation from the Environment Agency [2], places a number of requirements for improvement on the LLWR site. One of which, Requirement 1, is summarised below;

> *"The Operator shall provide the Agency with a full report of a comprehensive review of whether the current disposal practices for waste generated on the site continue to represent the best practicable environmental option, together with a programme for carrying out any necessary changes identified by the review"*

Additional information and detail of Requirement 1 is provided within the Compilation of Environment Agency Requirements (CEAR documents) [3] as follows:

> *"The Operator's BPEO assessment shall provide a detailed assessment of the benefits and detriments of alternative waste disposal options and shall cover liquid, gaseous and solid waste produced on the site".*

In order to fulfil this requirement, a number of 'mini' BPEO studies were undertaken, in a manner consistent with Environment Agency guidance. This report provides an auditable trail of the options, considerations and discussion of differentiators between options, and ranking and analysis of the realistic options.

The results confirm that in most cases, current practice represents the BPEO. This is concurrent with the fact that activity levels for LLWR discharges are comparatively low and have been for many years. In addition, to implement some of the high scoring options identified would incur disproportionate costs and resources for little environmental benefit. Some considerations of options for the future are constrained by the outcome of the 2011 Environmental Safety Case (ESC) and this study should be reviewed for consistency with the outcomes of the ESC when finalised. A summary of findings from the study is presented below:

Gaseous discharges from DGF- Current practice is confirmed to represent the BPEO.

Gaseous discharges from the Magazines - Acceleration of POCO of the Magazines was found to represent the BPEO. However, a strategy is in place and the plan for POCO will, over a short time period, become the current practice.

Gaseous discharges from Trenches and Vaults 8 and 9- Current practice is confirmed to represent the BPEO.

Trench Leachate and Vault 8 Runoff liquid discharges - Current practice is confirmed to represent the BPEO.

Minor Arisings of liquid discharges - *C*urrent practice for borehole water represents the BPEO. For small arisings other than borehole water, treatment on site represents the BPEO.

Solid wastes-Barrier Waste and Grout from DGF - Current practice is confirmed to be the BPEO.

Solid wastes -Operational and Decommissioning LLW from the Magazines –

Reuse of equipment represents BPEO; however, since this is only applicable to a small proportion of the waste streams, current Practice (Segregation of PCM for Storage and LLW for Disposal), represents the BPEO for items that cannot be re-used.

This study makes a number of recommendations (below), where opportunities for improvements have been identified. The recommendations are made to ensure improvements continue to be made and where best practice is currently employed, its full application is made to gain maximum possible environmental benefit.

Recommendation 1:

Low-flow sampling technique should always be considered for borehole sampling, to minimise waste arisings.

Recommendation 2:

Consider the possibility of using existing ion exchange units (currently used for PCM shower effluent), for other minor arisings.

Recommendation 3:

In line with the National Low Level Waste Strategy, full implementation of utilisation of waste routes should be developed for wastes generated by LLWR. In addition, LLWR should ensure wastes treatment routes are utilised as they become available.

Recommendation 4:

Review current practice to ensure, where possible, equipment is re-used and the NDA database of plant equipment for POCO and Decommissioning is utilised.

Recommendation 5:

Improvements are currently planned for the segregation of PCM and LLW from the Magazines POCO and decommissioning activities, by the use of an alpha bag monitor. LLWR should ensure this is implemented as soon as reasonably practicable, to ensure the most appropriate disposal route is used for these waste arisings.

VERIFICATION STATEMENT

This document has been verified and is fit for purpose. An auditable record has been made of the verification process. The scope of the verification was to confirm that: -

- The document meets the requirements as defined in the task specification/scope statement
- The constraints are valid
- The assumptions are reasonable
- The document demonstrates that the project is using the latest company approved data
- The document is internally self consistent

HISTORY SHEET

Issue Number	Date	Comments
Issue 0.1	23/03/09	Draft for comment
Issue 1	27/03/09	Issue for comment
Issue 1.1	31/03/09	Issued to customer

CONTENTS

1. Introduction

The Low Level Waste Repository (LLWR), near Drigg, is the UK's national low level waste (LLW) disposal facility and has been operational since 1959. LLWR is managed and operated on behalf of the Nuclear Decommissioning Authority (NDA) by LLWR Ltd.

The site comprises a number of trenches (1–7), where historic disposals have been made, a currently operating disposal vault (8) and a new vault (9), not yet operational. Based on currently forecasted LLW arisings, the remaining capacity of Vault 8 will be exhausted in 2009 [1]. In addition, the Environment Agency's assessment of the 2002 Environmental Safety Case (ESC) identified a number of issues regarding the viability of the site for disposal beyond Vault 8.

Schedule 9 of the Low Level Waste Repository's Radioactive Substances Act (RSA) Authorisation from the Environment Agency [2] places a number of requirements for improvement on the LLWR site. One of which, Requirement 1 is:

> *"The Operator shall provide the Agency with a full report of a comprehensive review of whether the current disposal practices for waste generated on the site continue to represent the best practicable environmental option, together with a programme for carrying out any necessary changes identified by the review"*

Additional information on Requirement 1 is provided within the Compilation of Environment Agency Requirements (CEAR document) [3] as follows:

> *"The Operator's BPEO assessment shall provide a detailed assessment of the benefits and detriments of alternative waste disposal options and shall cover liquid, gaseous and solid waste produced on the site".*

Definition of BPEO

The definition of the BPEO concept is provided in the twelfth report from the Royal Commission on Environmental Pollution (RCEP) 1988, and is as follows:

> *'The outcome of a systematic and consultative decision-making procedure, which emphasises the protection and conservation of the environment across land, air and water. The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as in the short term.'*

BPEO is applied to decisions where a strategic choice between different approaches to managing environmental impact is required. In addition, "Guidance to the Environment Agency's Assessment of Best Practicable Environmental Option Studies at Nuclear Sites" [4] should be referred to when undertaking a BPEO study.

The definition of Best Practicable Means (BPM) is as follows;

> *"Within a particular waste management option, the BPM is that level of management and engineering control that minimises, as far as practicable, the release of radioactivity into the environment whilst taking account of a wider range of factors, including cost effectiveness, technological status, operational safety, social and environmental factors"*

Therefore, within the context of BPEO, BPM is the optimisation of the chosen option, or, at plant level, the way that plant is operated to minimise its impact on the Environment. Although this report assesses all feasible best practicable environmental options for LLWR discharges, where current disposal practices at LLWR are identified as the BPEO, the identified option should be optimised to demonstrate BPM as required by the authorisation.

The National Nuclear Laboratory (NNL) has been tasked with supporting the delivery of Requirement 9, Task 1 on behalf of LLWR Ltd.

1.1. Site Process Descriptions

Drigg Grouting Facility

The Drigg Grouting Facility (DGF) produces grout for the grouting of LLW into ISO containers for disposal or storage pending final disposal. Ordinary Portland Cement (OPC) powder and Pulverised Fuel Ash (PFA) are delivered to the DGF by road tanker and transferred (air blown) into storage silos located externally, in the DGF compound. The OPC, PFA and small amounts of a superplasticiser are mixed with water to produce a grout, which is poured into the ISO containers packed with LLW in the four grouting bays. As the grout is added, voidage air is displaced, this air being extracted and passed through HEPA filtration prior to discharge.

The powder storage and transfer system consists of two separate silos connected to weigh vessels. The system is sealed to prevent powder releases and the powders are blown across to the receiving vessels by compressed air. Reverse jet filters are installed in the silos, hoppers and mixer to prevent pressurisation of the vessels.

PCM Magazines

The site houses a number of historical Plutonium Contaminated Material (PCM) storage Magazines. A programme of retrieval and repackaging of PCM has been undertaken and the bulk of PCM has now been removed and transferred to Sellafield for long-term storage. However, a number of residual operations associated with the removal of secondary PCM wastes still need to be carried out in the Magazines, before they can undergo Post Operations Clean-Out (POCO).

In order to safely retrieve the bulk PCM from the Magazines, each magazine has been fitted with a Retrieval Facility (RF). Each RF is equipped with an extract system, which filters the air via two sets of HEPA filters (in series) to remove particulates. The filtered air is then discharged to atmosphere via a stack. This ventilation and filtration system is considered to be over-engineered with respect to current levels of activity inside the Magazines. The ventilation system will be required for operations associated with POCO.

Leachate System

During the early years of disposal at the LLWR, the method of disposal was to ‘tumble tip’ the waste into clay lined trenches (1-7). This practice ceased after the construction of Vault 8 and Trenches 1-7 were covered over with an interim clay membrane and soil cap. This interim cap will ultimately be overcapped with an engineered multi-barrier final cap, consisting of layers of impermeable membranes, clay/bentonite and rock, topped with soil and grass. Vault 8 has an engineered concrete base and side walls, although since disposals are currently underway, it has no cap. The waste is grouted into isofreights which are then placed into the vault. Some oversized waste has been directly encapsulated into its walls.

The LLWR site leachate system comprises a collection system which drains leachate from each of the seven trenches via the Trench Leachate Drain and the GD4 weir, to the two Marine Holding Tanks (MHT), which have a combined capacity of 1050m^3. When effluent levels in the MHTs reach a pre-set limit, the effluent is automatically pumped to the Irish Sea. In the event of pump failure, the effluent can also be discharged via a gravity bypass. LLWR is consented to discharge a maximum of 6500 m^3 of leachate in any 24 hour period.

Vault 8 incorporates a cross-directional drainage system in its base and around its perimeter. Rainfall is collected and runs into the site leachate system, where it combines with the leachate from the trenches and is routed to the MHTs.

The leachate is sampled, and retrospectively analysed, before being discharged to sea through the marine pipeline. If rainfall is very high and the capacity in the MHTs is low, an automatic diverter will switch the flow of the Vault 8 system into the Drigg stream, upstream of where it joins the effluent from the trenches.

In addition to the leachate drainage, a surface water drainage system, consisting of a number of surface water drains and weirs, is in place to collect and direct rainwater into the Drigg stream which cuts through the site.

2. Scope of study

This study has undertaken a number of BPEO studies, which consider the following routine active arisings on site:

- Gaseous from Trenches and Vaults 8 and 9;
- Gaseous from the five Magazines and DGF;
- Trench leachate and Vaults 8 and 9 runoff;
- Minor liquid arisings;
- 'Barrier' waste and grout from DGF;
- Operational and decommissioning LLW from the Magazines;
- Any other arisings generated occasionally on site.

'One-off' arisings, such as might result from a remediation task. BPEO assessments have not been undertaken in this study. However, a description of the relevant procedures applied is detailed in section 5.3. These arisings are addressed on a case-by-case basis by separate assessment and in accordance with LLWR procedures.

2.1. Technical Process

A standard process, consistent with EA regulatory BPEO guidance [4] and LLWR procedures, has been adopted. The guidance identifies the following eight possible BPEO stages:

- Definition of purpose and scope;
- Identification of options;
- Screening;
- Selection of attributes;
- Options analysis;
- Weighting factors;
- Identification of the BPEO and
- Integration into decision making.

Site data, technical reports and procedures were utilised to prepare draft BPEO studies; further details on each of the stages undertaken is discussed below. These studies were presented, discussed, raised and agreed at a workshop, attended by LLWR technical experts, Environmental specialists and facilitators from the NNL. A standard approach has been applied across the individual BPEO studies.

2.2. Identification of Options

Following a site visit and provision of information from LLWR, NNL experts generated a number of options for each of the BPEO studies. The generation of options utilised the experience of the NNL and its experts and considered industry custom and practice. Generated options for each of the BPEO areas were recorded; at this stage, options that were unrealistic or impractical were provisionally screened out, with reason for screening out of the option recorded, forming an auditable record of the assessment. This left a number of remaining options for further consideration and assessment.

2.3. Selection of Attributes

To allow the options generated to be ranked or scored, a number of attributes against which to assess the options were identified. The attributes used in the BPEO studies are listed in Table 1. The individual attributes selected were grouped into the following five elements:

- Environment
- Safety
- Economic
- Technical
- Stakeholder acceptance

The attributes were scored on a scale ranging from Very Good to Very Poor; further details on the scoring are presented below. Table 1 also provides a description of the requirements for a score of Very Good and for a score of Very Poor, providing benchmarking and guidance for the scoring.

Table 1: LLWR Attribute and Options Scoring Table.

Attribute	Attribute description and descriptor range	
	Very Good	**Very Poor**
Environmental Issues	Reduced discharges and demonstrable compliance with the WMH e.g. free release rather than LLW. Reduced energy and resources inc. water usage	Increased discharges and/or increased secondary wastes e.g. filters – reduced demonstrable compliance with WMH requirements. Increased energy and resource inc. water usage
Regulatory Compliance	Full compliance with Authorisation and CEAR requirements with no changes required	Major variations to Authorisations and supporting justifications required to implement option
Safety Radiological Issues e.g. public/worker dose	Low dose impact – no increase over current or reduced discharge	High dose impact and significant increase over current or increased discharge
Safety (conventional)	Few conventional Safety issues- non radiological hazards and risks, to operating personnel and the local public associated with implementation and operation	Significant conventional safety issues - non radiological hazards and risks, to operating personnel and the local public associated with implementation and operation
Impact on LLWR safety case	No impact on LLWR safety case requirements	Significant impact on LLWR safety case requirements
Costs (project/lifetime)	Cost savings identified- to include consideration of operational, lifetime and resource costs	Significant additional costs identified to implement option – to include operational, lifetime and resource costs
Technical Feasibility	Few technical issues to implement option – considering availability/compatibility with existing operations/complexity and risk of failure	Significant technical issues to implement option – considering availability/compatibility with existing operations/complexity and risk of failure
Stakeholder acceptance	Improved stakeholder acceptance of LLWR operations due to option implementation	Implementation of option unlikely to gain stakeholder acceptance or reduce confidence of LLWR operations.

2.4. Options Analysis

For each BPEO study, the options were scored relative to each other against each of the attributes in turn. The following descriptors were used to assess the various options against the attributes; in order to quantify the results of the options assessment, a numerical score is assigned to each of the descriptors, as shown in brackets:

- Very Good (5)
- Good (4)
- Medium (3)
- Poor (2)
- Very Poor (1)

The options were reviewed and scored as a desktop exercise, with the background to the scoring explained. The scores were discussed, modified where required and agreed at the workshop. The workshop recorded the key benefits and disadvantages of each option and the justification for the scoring.

At the end of the scoring process, the total score for each option was summed up. The option with the highest score was identified as the lead option or possible BPEO.

Given the small scale of the waste arising, no stakeholder engagement was included in the workshop; this is in accordance with the principle that the studies should be undertaken in a manner that is proportionate to the risk.

2.5. Weighting and Sensitivity

Following the workshop, the attributes were grouped together under the five elements; environmental issues, safety, technical feasibility, cost and stakeholder acceptance. The scores for the five elements were then calculated from the sum of the constituent attributes.

In order to test the sensitivity of the leading option to the scoring process, a weighting factor of 2 was applied to each of the elements in turn. A weighting factor of 2 was chosen to demonstrate the effect of applying bias to the elements, to determine if the effect on the overall rankings. It should be noted there is an inbuilt bias towards 'Environmental', which has two attributes, and 'Safety', which has three, as opposed to the remaining elements, which have one each. The applied weighting factor is multiplied by the score for that element and the total scores calculated from the sum of the elements to produce the weighted score for each option for each of the sensitivity tests.

Sensitivity of the scoring is considered and used to help develop the lead(ing) options and underpin the discussion.

2.6. Identification of the BPEO

An optioneering study informs the operator's or the regulator's decision making; however, it is rarely the sole criterion for making the choice and very few decisions are made solely on the basis of an optioneering study [4]. The ranking of options on the basis of a scoring system is the starting point for the identification of a preferred strategy; however, the conclusion may still be that it is not the preferred option. The optioneering study informs consideration of the balance between the various factors that need to be taken into consideration and helps reveal the key issues and assumptions. The discussions of the BPEO studies presented in this report consider the leading options and provide the basis for the justification of the proposed way forward.

2.7. *Waste Management Hierarchy*

In order to demonstrate the application of BPM to the disposal of waste, the chosen waste disposal option must follow the principles of the Waste Management Hierarchy (WMH), where disposal is the final option. The WMH can be described as:

1	Prevent	Eliminate/Substitute/Design out/ Modify process
2	Reduce	Minimise usage
3	Re-use	e.g. Re-use storage container
4	Recover	Recycle/Energy Recovery/Compost
5	Treat	Physical/Thermal/Chemical/Biological e.g. Segregate, Incinerate, Decontaminate, Concentrate, Compact
6	Store	Interim
7	Dispose	Final

The Waste Management Hierarchy is intended to guide choices about waste management options. The hierarchy encourages the adoption of options for managing waste in the following order of priority:

- Waste should be prevented or reduced at source as far as possible, to secure the conservation of nature and resources
- Where waste cannot be prevented, waste materials or products should, where appropriate, be reused directly or refurbished then reused
- Waste materials should then be recycled or processed into a form that allows them to be reclaimed as a secondary raw material, where appropriate
- Where useful secondary materials cannot be reclaimed, the energy content of waste should be recovered and used as a substitute for non-renewable energy resources, where appropriate
- Only if waste cannot be prevented, reclaimed or recovered, should it be disposed of into the environment and this should only be undertaken in a controlled and authorised manner.

3. BPEO Studies for Aerial Releases

3.1. Gaseous Discharges from the Drigg Grouting Facility

The discharge of radioactive aerial effluents is authorised under the RSA authorisation [2]. The discharge of non-radioactive particulate matter to atmosphere from the DGF is regulated by Copeland Borough Council under the Pollution Prevention and Control (England and Wales) Regulations 2000. The permit to operate issued under these regulations requires that there shall be no visible emissions of particulate matter, and that filtration plant operates to an emission standard of less than 10 mg/m^3 for particulate matter. It also requires the site to carry out recorded monitoring of emissions from the DGF, including making frequent visual assessments of particulate emissions.

A number of Authorised Discharge Outlets are identified in the RSA authorisation, which includes the DGF stack. No activity limits on gaseous discharges from the individual Authorised Discharge Outlets or the LLWR site as a whole are given in the RSA authorisation. However, the LLWR is required to sample discharges from the Authorised Discharge Outlets and report the sum of the alpha- and beta-emitting radionuclides to the EA quarterly [3]. As such, the DGF stack is fitted with sampling instruments and the filter cards collected twice a week (due to the high particulate loadings) for analysis. Although the RSA does not specify discharge limits, action levels have been set for the purposes of monitoring and investigating changes in plant conditions. Discharges from the DGF stack are consistent and at low levels (less than 10^{-3}MBq alpha and beta per month); however, a more simplified method of calculating stack discharges and new action levels have recently been proposed for the site [6].

3.1.1. Identification and Consideration of Options

Option 1: Discharge to atmosphere following HEPA filtration (current practice)

The ventilation and filtration systems are already in place and operating. The activity levels discharged from this stack are low, and are masked by the extent of aerial discharges from Sellafield (activity levels for gaseous discharges from the LLWR site as a whole are low compared with Sellafield. The environmental impact of these discharges is low.

Advantages –

- Impact of current discharges low.
- Plant and equipment is already in place and operating satisfactorily.

Option 2: Additional abatement of aerial effluents prior to discharge

The activity of the aerial discharges could be reduced further by additional treatment e.g. by additional HEPA filtration or activated carbon filtration (to reduce radioactive gaseous discharges rather than gaseous radioactive particulate). This would have the effect of also reducing the non-radiological particulate emissions. However, this would require the installation of additional plant/equipment and possible increased energy usage to maintain flows.

Advantages –

- Reduced emissions to atmosphere.

Disadvantages –

- May be difficult to update and alter existing plant.
- The cost of installation may be high.
- Will generate additional secondary wastes in the form of spent HEPA filters.
- Likely to increase energy usage in order to maintain flows.
- Impact of current discharges is considered to be low, hence benefit unlikely to be proportional to cost.

Option 3: Design improved ventilation and filtration system in DGF2

A second DGF plant (DGF2) is being considered to supersede the existing plant for the support of Vault 9. A new system would aim to minimise the use of resources (e.g. energy) and the generation of secondary wastes. Unlike retrofitting an existing plant which can be costly, this will have both environmental and economic benefits. The investment will effectively be spread over the lifetime of the new plant, rather than just for the remaining operational life of DGF.

Advantages –

- Improved efficiency/operation of the ventilation and filtration system and possible reduced operating costs and discharges with respect to older plant.
- Meets regulatory expectations of new plant standards and improvement over plant which is being replaced.

Disadvantages –

- Plant optimisation should be designed to balance the benefits of reduced discharges against the production of secondary wastes and increased costs.

Option 4: Amend CFA to reduce allowed voidage in LLW containers

On the DGF plant radioactive emissions arise only from displacement of the voidage air when grouting containers. This air is extracted and passed through HEPA filtration prior to discharge. If the allowed voidage in containers is reduced, this would result in smaller volumes of displacement air being produced and hence a reduction in the amount of activity extracted into the filtration/ventilation system. This is in line with the principles of the Waste Management Hierarchy (WMH), since it is reducing the discharge at source. Since a lower volume of displacement air would require filtration, less secondary waste in the form of HEPA filters would be produced. This would also be in line with the principles of the WMH with respect to solid wastes, since decreasing voidage in containers would increase the amount of waste that can be placed in each container, thus minimising the number of containers that require disposal. It would also minimise the use of resources (grout).

It should be noted, higher packing efficiencies may have implications for long term safety.

Advantages -

- Reduced secondary LLW generated (filters).
- Lower volumes of air can be extracted whilst maintaining efficiency.
- Possible reduced activity discharged.
- More efficient use of repository.

Disadvantages -

- Technically complex and needs to be considered in context of proposed changes in management and role at LLWR.
- The current method of operation requires a certain amount of container voidage to allow the grout to fully infiltrate the container (the container must be grouted for engineering and safety reasons), so it may not be possible to reduce voidage significantly.

3.1.2. Screening of options

Options which have been not considered further are presented below, with the reasons for non-progression to the scoring and ranking exercise recorded below.

Option 3: 'Design improved ventilation and filtration system in DGF2' - This option can be screened out due to the fact that building a new DGF is now not in the current plan and has been put on hold for the time being. However, it should be noted that any future facility be built to modern standards, hence the ventilation and filtration systems could be designed to minimise the environmental impact.

Option 4: 'Amend CFA to reduce allowed voidage in LLW containers' – Significant further decreases in voidage would not be justified just to achieve reduction in emissions. This needs to be addressed as part of wider initiatives to develop LLWR's role in National LLW management.

3.1.3. Ranking of options

The options are scored against a selection of attributes as listed in the table below. Initial scores for the options reveal that Option 1 (Current Practice) is the preferred option, with Option 2 (Additional Abatement) scoring lower. The key differentiators are the additional cost of abatement and the conventional safety issues associated with construction of additional plant.

Options	1.Discharge to atmosphere after HEPA filtration (current practice)	2. Additional abatement of aerial effluents prior to discharge
Environmental Issues e.g. increased discharges, 2ry waste	5	4
Regulatory Compliance	5	5
Safety-Radiological safety issues e.g. public/worker dose	4	5
Conventional safety Issues	5	3
Impact on LLWR safety case	4	4
Costs (project/lifetime)	4	2
Technical Feasibility	5	4
Stakeholder Acceptance	3	3
Total	**35**	**30**

3.2. Gaseous discharges from the Magazines

A number of Authorised Discharge Outlets are identified in the RSA authorisation, including four stacks listed as serving the Magazines and a stack listed as serving the Transportable PCM Waste Storage Facility. The Transportable PCM Waste Storage Facility is actually a Magazine and is therefore also within the scope of this BPEO. The term 'Magazine' will be used to collectively refer to all five facilities.

No activity limits on gaseous discharges from the individual Authorised Discharge Outlets or the LLWR site as a whole are given in the RSA authorisation because they are so low. However, the LLWR are required to sample discharges from the Authorised Discharge Outlets and report the sum of the alpha- and beta-emitting radionuclides to the Environmental Agency (EA) quarterly. As such, all of the Magazine stacks are fitted with sampling instruments and the filter cards collected weekly for analysis. Although the RSA does not specify discharge limits, action levels have been set for the purposes of monitoring and investigating changes in plant conditions. Discharges from the Magazine stacks are consistent and at low levels (less than 10^{-2}MBq alpha- and beta- per stack per month). A simplified method of calculating stack discharges based on an estimated discharge rather than analysed samples, has recently been proposed to the EA for all stacks. [3]

3.2.1. Identification and consideration of Options

Option 1: Discharge to atmosphere after 2 stage HEPA filtration (current practice)

The ventilation and filtration systems are already in place and operating. The activity levels discharged and impact from these stacks are low, and are effectively masked by the aerial discharges from Sellafield (activity levels for gaseous discharges from the entire LLWR site are very low compared with Sellafield discharges).

Advantages –

- No additional cost.
- Impact of current discharges low.
- Plant and equipment is already in place.

Disadvantages –

- The ventilation and filtration system is over-engineered with respect to the levels of activity currently present.
- Generation of secondary wastes (spent HEPA filters).
- Cost of powering/maintaining plant.

Option 2: Reduce ventilation flow rate and discharge to atmosphere after HEPA filtration

The majority of the stacks operate continuously at a stack flow rate of 10 000 – 12 500 m^3/h, with the exception of the Transportable PCM Waste Storage Facility stack, which operates at a lower flow rate of approximately 3600 m^3/h. Considering that the levels of activity present in the air inside the Magazines is currently lower than during retrieval operations, the rate of extraction could be reduced but the air still filtered, thus reducing the consumption of resources (energy) and generation of secondary wastes (spent HEPA filters), without impacting on discharge levels.

Advantages –

- No physical changes required to the installation of plant/equipment.
- Potential for cost savings with respect to energy usage.
- If higher rate of extract is required again can increase stack flow back to current levels.

Disadvantages –

- Will require adjustment of fan speeds.
- May impact on stack sampling, will require the stack flow rates to be adjusted in databases used for the purposes of discharge calculations.
- Spent HEPA filters will still be generated.
- Operators are routinely entering the Magazines (which are C5 areas) to carry out maintenance and cleanup operations; the impact on the operators of any change to the ventilation system must be considered.

Option 3: Remove one set of HEPA filters

The ventilation/filtration system is over-engineered with respect to current levels of airborne activity inside the Magazines. Removal of the second set of HEPA filters is unlikely to adversely impact on current discharges but would reduce the amount of secondary waste produced. However, the filters would have to be replaced for POCO.

Advantages –

- Prevents unnecessary generation of secondary wastes (spent HEPA filters).

Disadvantages –

- Physical changes required to the installation of plant/equipment.
- Second set of HEPA filters will have to be replaced prior to POCO.
- Considering timescales, may be little benefit since HEPA filters tend to have a lifetime of about 5 years (sometimes 10) if they don't become blinded or don't require replacing more often due to activity levels.

Option 4: Turn off ventilation/filtration system but leave system in place

Since retrievals or decommissioning work is not currently being carried out in the Magazines, a forced extract system may not even be required since significant airborne contamination is not being generated. The ventilation and filtration systems form part of the RF and hence were only installed on the magazines when retrievals operations began; when the Magazines were in use as PCM stores, only passive ventilation was provided. The extract system could be turned off but left in situ, so that it can be used during POCO.

Advantages –

- No physical changes required to the installation of plant/equipment.
- Cost savings with respect to energy usage/maintenance.
- Prevents unnecessary use of resources (energy) and generation of wastes (spent HEPA filters).
- When extract is required again, can re-start the system.

Disadvantages –

- Will impact upon stack sampling.
- Plant will require inspection and potentially maintenance prior to being re-started.
- Operators are routinely entering the Magazines (which are C5 areas) to carry out maintenance and cleanup operations; as such the impact on the operators of any change to the ventilation system must be considered.
- Potential for back flow of air and hence contamination from Magazine into RF, thus contaminating the clean areas of RF leading to generation of large amounts of secondary waste and decommissioning issues.

Option 5: Remove ventilation/filtration system

If a forced extract system is not required, the option exists to remove it altogether ahead of any other decommissioning work. However, this would remove the potential for using it during POCO.

Advantages –

- Cost savings with respect to energy usage/maintenance.
- Reduced generation of secondary waste (spent HEPA filters).

Disadvantages –

- Physical changes required to the installation of plant/equipment.
- Once the ventilation/filtration system has been removed it cannot be re-used during POCO/decommissioning; new system will have to be installed resulting in unnecessary usage of resources and creation of waste (two systems will ultimately require decommissioning).
- Will impact upon stack sampling; EA will require notification of removal of stack.
- Operators are routinely entering the Magazines (which are C5 areas) to carry out maintenance and cleanup operations; the impact on the operators of any change to the ventilation system must be considered.
- Potential for back flow of air and hence contamination from Magazine into RF, thus contaminating the clean areas of RF leading to generation of large amounts of secondary waste and decommissioning issues.

Option 6: Additional treatment of aerial effluents prior to discharge

The activity of the aerial discharges could be reduced further by additional treatment of the effluents prior to discharge, e.g. by additional HEPA filtration. However, this would require the installation of additional plant/equipment.

Advantages –

- Reduction in activity of discharges.

Disadvantages –

- Physical changes required to the installation of plant/equipment.
- Additional filters may be difficult/ costly to retrofit to existing plant.
- System is already over-engineered with respect to current levels of activity inside the Magazines, hence additional filtration is of questionable benefit considering low level of discharges.

Option 7: Acceleration programme for POCO of Magazines

There is a programme in place for the POCO and decommissioning of the PCM facilities, with the completion of POCO scheduled for 2010, with decommissioning/demolition to follow. The ventilation/filtration systems will no longer be required after POCO, hence the aerial discharges will cease from these stacks and it is assumed that the Magazines and RFs will be decommissioned and demolished. If the programme for POCO/decommissioning of the magazines could be accelerated the aerial discharges will cease earlier, potentially minimising the amount of activity discharged to atmosphere.

Advantages –

- Strategy already in place for POCO/decommissioning of Magazines.
- Removes aerial discharges completely.

Disadvantages –

- Although POCO/decommissioning of Magazines will be ultimately carried out, early completion will bring costs forward.
- May not be feasible and programmed timescales are not far into the future.
- May cause short-term increase in discharges, but this will occur during decommissioning anyway.

3.2.2. Screening of Options

Options which have been not considered further are presented below, with the reasons for non-progression to the scoring and ranking exercise recorded below.

Option 2: 'Reduce ventilation flow rate and discharge to atmosphere after HEPA filtration' - This option is not possible due to the potential radiological impact on operators and has been screened out.

Option 3: 'Remove one set of HEPA filters' - Considering the second set of HEPA filters would be required for POCO, implementing this option would have little benefit in the timescales concerned (POCO is scheduled to be completed by 2010). It is anticipated that the safety case will be in place within a few weeks to allow scabbling to commence in the Magazines, hence the second set of HEPA filters will soon be required. As such, this option has been dismissed.

Option 4: 'Turn off ventilation/filtration system but leave system in place' - As for Option 3, this option is not possible due to the potential radiological impact on operators. Additionally, the risk of back flows of air and hence contamination from the Magazines into the clean areas of the RFs is not acceptable. Therefore, this option has been screened out. It is noted that this will occur in a phased manner as part of decommissioning, when activity levels in the Magazines warrant it.

Option 5: 'Remove ventilation/filtration system' - The ventilation/filtration system will be required during POCO, both for radiological safety purposes and to prevent discharges to the environment. Removing it prior to this is not prudent as it could result in a new ventilation/filtration system having to be installed for these operations, which would be costly, time consuming and wasteful. Additionally, this option has the same adverse impacts as Option 4. Therefore, this option has been dismissed. It should be noted that this will ultimately happen during decommissioning anyway, at the appropriate time.

Option 6: 'Additional treatment of aerial effluents prior to discharge' - Additional treatment of the effluents prior to discharge would require the installation of additional plant/equipment, such as additional HEPA filters, which would incur additional costs and generate additional wastes (spent HEPA filters). Given the low level of the discharges from the stacks and the fact that the system is over engineered for current operations, it is considered that the cost of adding additional filtration and the additional secondary waste that will be generated as a result would far outweigh any environmental benefits. Therefore, this option has been screened out.

3.2.3. Ranking of Options

The options are scored against a selection of attributes as listed in the table below.

Initial scores for the options reveal that Option 7 (Acceleration of POCO) is the preferred option with Option 1 (Current Operations) a very close second. It should be noted that the cost element for Option 7 was based on the fact that there would be no cost increase for acceleration. On the basis that a programme for POCO would be undertaken as soon as possible, the two options could be combined as the preferred option. This would represent BPM.

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	7. Acceleration of programme for POCO of Magazines
Environmental issues e.g. increased discharges, 2ry waste	4	5
Regulatory Compliance	5	5
Safety-Radiological safety issues e.g. public/worker dose	4	5
Conventional safety Issues	5	5
Impact on LLWR safety case	5	4
Costs (project/lifetime)	3	4
Technical Feasibility	5	4
Stakeholder Acceptance	3	5
Total	**34**	**37**

3.3. Gaseous discharges from Trenches and Vaults 8 and 9

Gaseous effluents, primarily in the form of landfill gases and radon, are produced by Trenches 1 – 7 and discharged to atmosphere via vents and fugitive means. Aerial emissions arise from the LLW disposed of in Vault 8. It should be noted that there are no activity limits on gaseous discharges given for the LLWR site in the RSA authorisation because of their low impact [2].

Surveys of gases sampled from trench probes have been carried out to quantify the landfill gases and radon being discharged from the trenches to the atmosphere. Landfill gases result from the decomposition of organic wastes, whereas the radon emitted from these trenches results from the decay of radium. Levels of landfill gases present have been found to be below those found at typical landfill sites. Radon concentrations of gases sampled from the trench probes have been found to be consistent with the radium inventory of the trenches. However, measurements taken on top of the trench cap have found radon levels typical of normal background levels, which indicate that the trench cap is acting as an effective barrier to radon migration. Additionally, radon monitoring carried out in buildings within 250m of the trenches has not found radon present at above background levels.

Radon has also recently been monitored adjacent to Vault 8. The concentration of radon was recorded as not present, with the occasional reading of 30-40 Bq/m^3 [7]. Considering that the average radon level in homes in the UK is 20 Bq/m^3 and the action level recommended by the Health Protection Agency is 200 Bq/m^3, this can be considered to be negligible.

It is known that carbon-14 is also discharged from the trenches, primarily as carbon-14 radio labelled carbon dioxide and methane. However, the amount of activity released is believed to be low, with a monitoring regime being instigated to confirm actual levels.

The potential does exist for small quantities of other radioactive substances to be discharged to air from the trenches and Vault 8. However, it should be noted that the activity of the ambient air at the site is sampled using a High Volume Air Sampler (HVAS), located near the entrance gate. The levels of activity recorded by this sampler are low. Given the low levels of aerial discharges from the LLWR as a whole, it is likely that the effect of aerial discharges from the LLWR on the ambient air quality are overwhelmed by the effect of Sellafield's discharges, which can be determined by radionuclide fingerprinting of the collected samples.

3.3.1. Identification and consideration of Options

Option 1: Discharge direct to atmosphere (current practice)

Sampling and analysis of the trench gases has shown that only low levels of gases are discharged from the trenches. It has also been shown that the levels of radon emitted from Vault 8 are negligible and activity levels for gaseous discharges from the LLWR site as a whole are low compared with Sellafield, being masked by the extent of the aerial Sellafield discharges. It is considered that the environmental impact of these discharges is low. Additionally, since there are no houses/public access in the immediate vicinity, it is unlikely that these discharges can cause harm to public. The vents currently in place in the interim trench cap provide managed and directed discharge routes to which personnel access is controlled.

Advantages –

- Does not incur extra costs.
- Environmental impact of current discharges considered to be low.
- Potential for causing harm to public is low.
- Monitoring regime is in place to monitor trench gases so any increases in discharges will be recorded and investigated.
- Engineered discharge routes in place.

Disadvantages –

- Since the trench cap afford some containment of radon, the potential exists for radon discharges from the trenches to increase if the trench cap/lining becomes cracked/damaged (clay can be prone to cracking in dry weather).

Option 2: Treatment of aerial effluents prior to discharge

Gaseous discharges from the trenches and vault 8 could be collected and treated prior to discharge to reduce the activity of the discharges. At the levels at which radon is present in the discharges, removal would be technically challenging and costly. Therefore, treatment options are limited. Radon has a relatively short half life (approximately 4 days), hence collecting the discharges and holding them in a delay tank to allow the radon to decay prior to discharge (thus reducing the activity) is a possible option. Alternatively, the engineered discharge pathways could be lengthened, resulting in delay of discharge to atmosphere, reducing the activity as the radon decays.

Advantages –

- Reduction in activity of discharges.
- Engineered discharge routes in place.

Disadvantages –

- Treatment likely to be expensive and technically challenging.
- New plant required.
- Environmental impact already low, so cost likely to be disproportionate to benefit, especially considering that the interim cap will be ultimately replaced.
- New plant will use energy, possibly water and require decommissioning.

Option 3: Early progression of programme to permanently cap Trenches

Installation of the interim trench cap and cut-off wall occurred in two phases:

- Phase 1 - in the late 1980s involved capping of trenches 1 to 6 and the installation of the cut-off wall.
- Phase 2 – in 1995 involved capping of Trench 7 and extending of the cut-off wall.

As discussed in the Trench Leachate BPEO, the Trench cap was primarily designed to reduce the production of leachate by minimising the percolation of rainwater into the trenches, whilst the cut-off wall was designed to minimise the lateral migration of potentially contaminated leachate out of the trenches and the ingress of groundwater into the trenches. However, the trench cap and cut off wall will also provide some gaseous containment.

Although it is not planned to replace the interim trench cap with the engineered multi-barrier final cap until Vault 8 is full, the earlier capping of the trench area should be considered. This would provide better containment of gases and allow improved engineered discharge systems to be fitted. This would also have advantages for reducing the amounts of trench leachate produced (see Trench Leachate BPEO).

Advantages –

- Will provide better containment of gases and engineered discharge routes.
- Does not require significantly higher use of resources (e.g. clay, water, energy) since permanent capping will ultimately be carried out anyway.

Disadvantages –

- Although permanent capping will be ultimately carried out, early capping will bring costs forward.
- May increase capping costs overall if capping is carried out in two phases.

- Some decisions are awaiting the outcome of the ESC e.g. removal of radium inventory. Capping of trenches affected by ESC outcome would have to be delayed until this is finalised.

Option 4: Early progression of capping programme to permanently cap part of Vault 8

The areas of Vault 8 that are full could be capped earlier than planned, providing better containment for gases and allowing engineered discharge systems to be fitted. It should be noted that currently levels of discharge are very low. Vault 8 is currently in use for both disposal and storage. However, once Vault 8 is full (estimated to be in 2009), this would be more of a viable option. LLWR plan to cap once ESC is demonstrated as being acceptable to the Environment Agency.

Advantages -

- Allows improved management of discharge through better containment.
- Reduces the amount of rain water run off produced by Vault 8 (reduced leachate).
- Does not require significantly higher use of resources (e.g. clay, water, energy) since permanent capping will ultimately be carried out anyway.

Disadvantages -

- Vault 8 currently in use for both disposal and storage.
- May add to overall complexity of capping task.

Option 5: Remove waste from Trenches for treatment/processing

Rather than moving to finally cap the trenches, the waste in trenches could be removed (main issue radium) and treated/processed, thus removing the source of the gaseous discharges. This concept is in line with the principles of the Waste Management Hierarchy (WMH), since it prevents the discharge occurring. It could also have long term safety and environmental benefits, since the waste could be put into a more engineered passive form for final disposal if additional treatment were not possible. The possibility of retrieving the waste from the trenches is currently being considered and will be assessed in the 2011 Environmental Safety Case (ESC).

Advantages –

- Will remove source of discharges, thus preventing the discharge from occurring.
- Waste can be treated or processed into an engineered passive form for alternative final disposal.

Disadvantages –

- Likely to be expensive and technically challenging.
- New plant and equipment required.
- Environmental impact already low, so cost likely to be disproportionate to benefit.
- May generate secondary wastes and require additional resources (energy, water, grout if waste requires grouting etc.).

Option 6: Cap existing trench vents

Capping the existing trench vents would prevent the gases discharging to atmosphere via this route, thus reducing the activity discharged. However, it will not completely stop the discharges, as there are fugitive emissions resulting from unknown discharge routes. In fact, sealing the engineered trench vents would probably increase fugitive emissions, as the gases will be forced to find alternative discharge routes, due to the build-up of gas pressure. This approach might, however, allow additional time for the radon to decay. It is noted that this option might have safety implications, since it could increase gas pressure in the trenches and allow a methane-rich atmosphere to build up, potentially leading to explosions. It should also be noted that this is not a practice commonly used in landfill sites.

Advantages –

- May reduce discharges as preferential pathway removed, allowing increased decay of radon.
- Reduction in activity possible without generation of operational secondary wastes.
- Low cost.

Disadvantages –

- Magnitude of benefit questionable, since fugitive emissions occur anyway.
- Less managed discharges as ultimately fugitive releases will increase.
- Might cause unacceptable risks to safety (risk of explosion).
- Environmental impact already low, so safety risk likely to be disproportionate to benefit.

Option 7: Add forced ventilation to current cap vents

Extraction and improved ventilation systems could be fitted to the interim cap vents to improve atmospheric dispersion. This would also emit the discharges more quickly, but would not reduce the mass of activity discharged.

Advantages –

- Will improve gas dispersion and prevent gas build-up in the trenches.

Disadvantages –

- Likely to be expensive as new equipment will be required and associated running costs.
- Environmental impact already low, so cost likely to be disproportionate to benefit, with no reduction in activity discharged.
- Extract fans will consume energy and will ultimately require decommissioning.

3.3.2. Screening of Options

Options which have been not considered further are presented below, with the reasons for non-progression to the scoring and ranking exercise recorded below.

Option 2: 'Treatment of aerial effluents prior to discharge' - Considering the low level of the discharges, this option has been dismissed as it is considered the cost will be disproportional to the environmental benefit. This option would potentially require the installation of extract fans which would use energy, hence causing an increased environmental impact in terms of resource usage. Any additional equipment would generate additional secondary waste streams and decommissioning issues.

Option 3: 'Early progression of programme to permanently cap Trenches' - At the current time, the Environment Agency (EA) will not permit the final cap to be put on the Trenches, hence this option has been screened out. The timescale for permanently capping the trenches will be considered next year, as part of the production of the ESC.

Option 4: 'Early progression of capping programme to permanently cap part of Vault 8' - As for Option 3, Option 4 has been screened out as it is not currently permitted by the EA.

Option 5: 'Remove waste from Trenches for treatment/processing' - This option has been screened out because the possibility of retrieving the waste from the trenches is currently being considered and will be assessed in the 2011 Environmental Safety Case (ESC)- hence no decision can be made prior to the ESC. Irrespective of the ESC consideration, this option will have significant cost, implications and the potential to generate secondary wastes and large use of resource. This would be disproportionate to the benefit of preventing the aerial discharges occurring as they are currently very low. It should be noted that this option is more viable if long term safety and environmental impacts are being considered rather than just low level gas discharges, and as such will be assessed in ESC.

Option 6: 'Cap existing trench vents' - It is uncertain whether this option would result in reduced discharges, since it is likely fugitive emissions would increase due to the build up of gas pressure caused by capping the vents. Considering this, and the fact that capping the vents would cause a high risk to safety, this option has been screened out.

Option 7: 'Add forced ventilation to current cap vents' - This option has been screened out because it is considered that the cost and the resource consumption required (energy to run fans, installation of new equipment) are disproportionate to any potential benefit. As this option will not reduce the activity of the aerial discharges, it is questionable if there is any real environmental benefit.

3.3.3. Ranking of Options

Following the screening of options, only one option remains, option 1, which is current practice.

Following the outcome of the 2011 ESC, options 3 and 5 may be further considered and progressed. Therefore, the conclusion of this assessment confirms current practice as the BPEO.

4. BPEO Studies for Liquid Releases

4.1. Trench Leachate and Vault 8 Runoff

The discharge of effluents generated on the LLWR site is regulated by the Water Resources Act, via a Consent [8] to discharge and under the RSA93 Authorisation [2]. Discharge of radioactive effluent under RSA 93 is directed to the Irish Sea, with no numerical limits set for these discharges under this Authorisation.

The effluent system comprises a collection system which drains leachate from each of the seven Trenches via the Trench Leachate Drain and the GD4 weir to two Marine Holding Tanks (MHT); these have a combined capacity of 1050m^3. When effluent levels in the MHTs reach a pre-set limit, the effluent is automatically pumped to the Irish Sea. The effluent can also be discharged via a gravity bypass, in the event of pump failure. LLWR is consented to discharge a maximum of 6500 cubic metres of leachate in any 24 hour period and a regulator valve is in place to restrict discharges to ~55 litres/second.

Discharges to the Drigg stream are allowed but only in the following emergency situations i.e.

Overflow at the Vault 8 outlet is permitted if:

- The liquor in the MHTs has reached a pre-determined set level and the Vault 8 overflow regulator has closed and the storage capacity within the Vault 8 drainage system upstream has been exceeded;
- Electrical power failure has occurred.

Overflow at GD4 outlet is permitted if:

- The influent rate is greater than the pumping rate to sea pipeline;
- An extended period of blockage or failure of the outfall or pipeline;
- Electrical power failure.

The activity levels associated with Vault 8 runoff are assumed to be trace active or non-active. Vault 9 runoff is purely rain water as it is currently under construction.

Recycling of the leachate at landfill sites is preferred by the Environment Agency. This may be influenced by the criteria affecting other landfill sites where there are certain advantages to be gained from using leachate to control the temperature within the landfill. However, even though these criteria do not apply to the LLWR site, LLWR have been proactive in undertaking this study by considering the possibilities for recycling leachate in accordance with the Waste Management Hierarchy and BPM.

4.1.1. Identification and consideration of Options

Option 1: Discharge to sea (current practice)

This option maintains the current LLWR position of discharging all leachate/rainfall liquor to the sea via the site leachate drainage system. An Authorisation is in place with the infrastructure to support this. Vault 8 runoff activity levels are low and provide adequate dilution for the leachate liquors passing through the MHTs. Without this dilution effect, the leachate from the trench leachate drain would become more concentrated leading to higher activity levels in the MHTs.

Activity levels for LLWR discharges are low compared with Sellafield and are masked by the extent of historic discharges from Sellafield. In addition, leachate is diluted by about 20% from other inputs by the time it is actually discharged from MHTs.

Option 2: Recycle as makeup for grout in DGF

Leachate could potentially be used as makeup with domestic water for DGF grout. It is estimated that between 18 and 24m^3 of domestic water is used daily. Concerns are that the quality of the water and flow rates (especially in a dry summer period) might be inconsistent. However, in this case, the facility for domestic water make up would still be available.

Advantages –

- Reduces the use of a natural resource and costs of providing domestic (treated) water – could be considered BAT and re-uses that which would otherwise be disposed of, which demonstrates application of WMH.
- Reduces total amount discharged to sea.

Disadvantages –

- If significant activity in leachate, DGF would become a C2 building causing operability problems.
- May interfere with grout product quality e.g. dissolved solids, pH, chlorides and possibly activity.
- Pumping of active liquors through C1 areas maybe unacceptable.

Option 3: Recycle as makeup for the grout in DGF2

A second DGF plant (DGF2) may be required to supersede the existing plant for the support of Vault 9, which is subject to planning permission for disposal. The recycling of leachate should at least be a consideration in the design specification for DGF2 which would be located near DGF.

Advantages -

- Including operability issues in the safety case and ensuring that the infrastructure needed for the changes becomes part of the plant in the early stages of design, will have environmental and economic benefits, as opposed to trying to retrofit to an existing plant.
- A new plant will also allow for longer term processing of liquors rather than just for the remaining operational life of DGF.

Disadvantages -

- The use of active or trace active liquors in the DGF processes will inevitably lead to the generation of more LLW and place increased demand on health physics requirements or if PVC entries are required, e.g. into mixer vessel, that are C1 areas in the current facility.

Option 4: Treatment of leachate prior to discharge

Treating the liquors by passing them through filters or ion exchange plants would reduce the amount of activity discharged to sea. This would require new plant at LLWR unless large volumes of liquor could be transported to Sellafield, via tanker, for treatment e.g.

in SIXEP. This would require variation to Regulatory permits and Authorisations, for both LLWR and Sellafield Ltd.

Advantages –

Reduced activity discharged to Irish Sea

Disadvantages-

- Significant amount of resource involved e.g. energy, water, concrete etc.
- Cost of building a new plant would far outweigh any environmental benefits.
- Additional secondary waste streams e.g. LLW/ILW e.g. ion exchange resins and sludges.

Option 5: Evaporation

Evaporation is a tried and tested industrial process and would involve driving off the bulk of the water from the leachate, resulting in a more concentrated liquor / slurry (LLW/ ILW) for subsequent disposal or further treatment. The off gases could be condensed and neutralised prior to discharge. AWE Aldermaston have adopted an evaporation process to reduce discharges to the River Thames.

Advantages -

- Reduced discharge volume and activity, possible immobilisation of generated concentrate or further treatment possible.
- Technology demonstrated by use at AWE.

Disadvantages -

- Requires new plant at LLWR unless the liquor could be transported via tanker to another site e.g. Sellafield which is unlikely due to the large volumes of leachate.
- Requires variations to Regulatory Permits and Authorisation for both LLWR and Sellafield Ltd.
- Significant amount of energy usage in this process.
- Capital expenditure of new plant expected to be high.

Option 6: Early progression of programme to permanently cap Trenches

Installation of the interim trench cap and cut-off wall occurred in 2 phases:

- Phase 1 - in the late 1980s involved capping of trenches 1 to 6 and the installation of the cut-off wall.
- Phase 2 – in 1995 involved capping of Trench 7 and extending of the cut-off wall.

The Trench cap was primarily designed to reduce the production of leachate by minimising the percolation of rainwater into the trenches, whilst the cut-off wall was designed to minimise the lateral migration of potentially contaminated leachate out of the trenches and the ingress of groundwater into the trenches.

The performance of the trench cap is being monitored currently, with work to improve the uncertainties in the trench water balance and cap integrity progressing. A general assumption was made that 10% permeability could occur in the 30 year design life of the cap, with current limited knowledge indicating this level could be being exceeded.

Thus with current capping potentially not have achieved the expected performance levels, early permanent capping could be considered. Early capping would have the following key advantages and disadvantages;

Advantages -

- Would improve impermeability of trench cap, reduce leachate volumes and activity discharged.
- The EA have identified early trench capping may represent BPM.
- Would reduce leachate volumes which will allow additional capacity with current system to accommodate additional volumes resulting from Vault 9.

Disadvantages -

- This cannot be done in advance of 2011 ESC, therefore the difference in early progression and planned permanent capping is no or a short length of time, therefore not advantageous.
- If it was brought forward in advance of ESC costs it may affect long term plans.
- Over capping may not provide significant benefit as other complicating factors exist e.g. Trench 4 may be affected by blockages.

Option 7: Vault 9 make-up water for concrete

A temporary concrete batching plant will be installed to produce 17,700 m^3 of concrete for the construction of Vault 9. Use of Vault runoff could be considered to provide the make up for the batching plant in a similar manner to DGF. Quality issues may arise but are not thought to be significant.

Advantages -

- Reduces the use of a natural resource and costs of providing domestic (treated) water and demonstrates application of WMH through re-use.
- Reduces total amount discharged to sea.

Disadvantages -

- Interference with an already well established design and tender process would be unhelpful to the timely completion of Vault 9, a major feature of the site business case.

Option 8: Store in Decay Tanks

In this option, the leachate is directed to and held up or stored in tanks for a period of time to allow the short lived beta activity to decay, after which the liquor is discharged to sea as routine. This would require installation of several new tanks. Large volumes of leachate are produced annually [10] (~180m^3/day), which would require several large tanks. Activity levels discharged from LLWR are a fraction of Sellafield levels which would mask LLWR discharges.

Advantages -

- Reduced activity of discharges.

Disadvantages -

- High cost and little perceived benefit as discharge activity levels are low.
- Tanks would create decommissioning issues.

Option 9: Installing an LDPE membrane

Installation of an additional temporary cap i.e. low density polyethylene semi-permanent membrane, would decrease permeability of trench cap and therefore reduce leachate volumes. This could either be placed over the whole of the Trench area or alternatively just cover parts of the current cap to target weak areas.

Advantages -

- Reduced volume of leachate generated.
- Reduced total activity of discharges.
- Could be targeted to weak areas.

Disadvantages -

- Cost.
- Final trench capping already planned.

4.1.2. Screening of Options

Options which have been not considered further are presented below, with the reasons for non-progression to the scoring and ranking exercise recorded below.

Option 3: 'Recycle as makeup for the grout in DGF2' can be screened out due to the fact that building a new DGF is now not in the current business plan and has been shelved for the time being.

Option 7: 'Vault 9 make-up water for concrete' can be screened out due to the fact that construction is already underway and major adjustments to the batching plant would be required which would cause significant delays to Vault 9 project. It is unlikely this could be justified in the site business case.

Option 8: – 'Storage in Decay Tanks' can is screened out at this stage due to:

- Beta activity levels in LLWR discharges are very low. These are likely be long-lived beta activity as short- lived beta should already have decayed by the time the waste reaches LLWR and hence, will require long storage times.
- Large volumes of leachate requiring storage leading to cost implications for new tanks.

Option 9: 'Installing an additional temporary membrane' can effectively be screened out on the basis that unnecessary additional costs would be incurred by applying this option. Detailed planning would begin in 2013 if supported by the ESC. In addition, timescales are such that, with the lead time for installation, there would be little or even no time before the permanent cap was installed.

4.1.3. Ranking of Options

The options are scored against a selection of attributes as listed in the table below.

Options	1. Current practice	2. Recycle as makeup for grout in DGF	4. Treatment of leachate prior to discharge	5.Evaporation	6. Early permanent Trench capping
Environmental Issues e.g. increased discharges, 2ry waste	4	3	3	2	4
Regulatory Compliance	5	3	3	3	5
Safety-Radiological safety issues e.g. public/worker dose	5	3	3	3	4
Conventional safety Issues	5	3	4	4	4
Impact on LLWR safety case	4	3	3	3	4
Costs (project/lifetime)	5	3	3	2	1
Technical Feasibility	5	4	4	4	4
Stakeholder Acceptance	4	4	2	2	1
Total	**37**	**26**	**25**	**23**	**27**

Initial scores for the options reveal that Option1 (current practice) is the preferred option with Option 6 (Early permanent Trench capping) following on in second place. Option 2 (Recycle as makeup for the grout in DGF) is next preferred. The worst scoring options is 'evaporation' due to the cost of new build, operating cost and perceived stakeholder acceptance issues.

4.2. Minor Arisings from site

A number of small volumes of liquid effluents are generated onsite comprising borehole and other minor arisings. These waste streams are very low in terms volumes and activity compared with other site arisings. Therefore, the cost of further treatment is likely to be disproportionate to the benefit gained. These are described below.

There are approximately 140 boreholes in and around the LLWR site which require sampling on a quarterly basis. The method currently employed for taking samples of groundwater from boreholes is predominantly the 'low flow' technique. This involves purging the stagnant water in the borehole to obtain a fresh water sample for analysis. A bladder pump is inserted into the borehole at the level of the water. A pressure is then applied to the bladder which then pushes water up the tube. When the bladder deflates, more fresh water is drawn up the tube. This is repeated until the water reaches the surface.

Purging the borehole removes approximately 1-2 litres of water before a representative sample can be taken. The laboratory requires approximately 7.5 litres for analysis after which it is returned to site for disposal. The total annual arisings for these sampling procedures amount to a maximum of 1600 litres (or approximately the volume of one and a half IBCs) of purgings, and 1500 litres of samples.

The original method of 'bailing' recommended that it was best practice to remove a minimum of three volumes of purge water i.e. approximately 60 litres in order to obtain a 'fit for purpose' sample. However, the low-flow method requires a fraction of this volume, hence, it could already be considered as BPM. The purge rate target for low flow sampling is between 0.1 and 1.0 litre per minute. A recommendation is therefore made to ensure low-flow sampling technique should always be considered for borehole sampling, to minimise waste arisings.

Under the Water Resources Act, 'Waste Disposal Site Leachate' consent [8], 'additional minor arisings' e.g. groundwater from boreholes, may be discharged to the leachate drains via GD4, after prior consent from the liquid effluent co-ordinator.

Other minor arisings from LLWR site include the following:

- Effluent from the PCM magazine showers – this passes through ion exchange units before draining into a holding tank. When the tank capacity has been reached, the liquor is drained into a mobile bowser and transferred to GD4 for discharge.
- 749 experimental tank effluent – these arisings are as a result of long term vault experiments and the volumes are small.
- Vault 9 leachate – construction effluent arisings.

The activity levels associated with these discharges is very low (e.g. most groundwater samples being below excepted package levels) and no disposal currently ever having not met the requirement for disposal at GD4.

4.2.1. Identification and consideration of Options

Option 1: Disposal via leachate line (borehole waste)

This option has been employed by contractors whereby the purge water from all sampled boreholes has been collected over the course of a year and retained in 1-2 IBCs. A sample is taken for analysis and provided these are within site acceptance limits and approval has been granted, the IBC(s) can then be discharged to the leachate drain.

Advantages –

- Minimises approvals from site discharge effluent co-ordinator (one discharge rather than numerous).

Disadvantage –

- If sample results are outside specification limits, alternative disposal route required. May be able to seek approval for total to be split into smaller volumes to provide a greater volume of dilution during discharge.
- Not all borehole sampling uses the low-flow technique.

Option 2: Transfer off site for treatment

Treating the various effluents by passing them through ion exchange plants would reduce the amount of activity discharged to sea. Volumes from minor arisings are small compared to leachate, effluent could be transported via tanker and treated at Sellafield.

Advantages -

- Activity discharged to Irish sea would be reduced.

Disadvantages -

- Transport costs and issues.
- Changes to Regulatory Authorisations for both LLWR and Sellafield.
- Agreement for SIXEP to take wastes and require inclusion in plant strategy.

Option 3: External laboratory to dispose of samples (borehole wastes)

Borehole samples are currently transferred to VT Nuclear Laboratories at Westlakes for analysis. Normal procedure is for laboratory to return the remainder of samples to LLWR for disposal. Proposal is to require laboratory to dispose of the samples directly.

Advantages –

- Reduces transport journeys and costs.
- Reduces volume of liquor for disposal at LLWR site (BPM).
- Would encourage laboratory to develop test methods requiring lower sample volumes.

Disadvantages –

- Laboratory may require amendment to consent to discharge.
- Additional costs to LLWR.

Option 4: Treatment on site (all minor arisings)

Shower effluent from the PCM magazine store is already passed through ion exchange units, which reduces activity and hence, is considered to follow BPM. This could be extended to include all minor arisings.

Advantages –

- Reduced activity for discharges.
- Plant currently available.

Disadvantages –

- Resin beds would require more frequent regeneration / would generate additional secondary wastes resin.
- Additional secondary wastes may not meet the CFA at LLWR and may need to be transferred to alternative sites.
- Uncertain timeframe availability of plant as facilities moves into POCO.
- Maybe additional engineering required.
- Current ion exchange units must be capable of taking additional effluents and type of resin compatible with the radionuclide profile.

Option 5: Solidify and Dispose of as Waste

This option discusses the potential for encapsulating the effluents in cement or specialised polymers and disposal of the solid waste at LLWR. Compared with leachate volumes produced, minor arisings would amount to considerably less e.g. 3-4 IBCs per annum.

Advantages -

- Reduction in activity and volume discharged, though volumes are small in relation to leachate.

Disadvantages -

- Would require a separate mixing facility. DGF is a non radioactive facility and effluent could potentially be low active or contain PCM.
- Not cost beneficial to build new plant due to relatively small volumes involved.
- Detriment with regard to WMH as additional amounts of waste are being generated for solid disposal rather than as effluent.

4.2.2. Screening of Options

Options which have been not considered further are presented below, with the reasons for non-progression to the scoring and ranking exercise recorded below.

Option 5: 'Solidify and Dispose of as Waste' can effectively be screened out due to the small volumes involved and the capital outlay required to gain minimum environmental benefit. Effectively this option would generate larger volumes of solid waste and use resources in the process. The waste generate would require disposal as LLW.

All remaining options have progressed to the ranking phase of the assessment.

4.2.3. Ranking of Options

The options are scored against a selection of attributes as listed in the table below.

Options	1. Disposal via Leachate line	2. Transfer off site for treatment	3. External Laboratory to dispose of samples	4. Treatment on site
Environmental Issues e.g. increased discharges, 2ry waste	4	3	3	3
Regulatory Compliance	5	3	5	5
Safety-Radiological safety issues e.g. public/worker dose	5	4	5	5
Conventional safety Issues	5	4	5	4
Impact on LLWR safety case	4	4	4	4
Costs (project/lifetime)	5	3	2	3
Technical Feasibility	5	5	5	5
Stakeholder Acceptance	4	3	3	3
Total	**37**	**29**	**32**	**32**

Initial scores for the options reveal that Option 1 (Disposal via leachate line) is shown as the preferred option. Option 2 scores consistently lower throughout the exercise. It should be noted that as different options apply to different minor arisings, a combination of options 1, 2 and 4 may represent the BPEO depending on the waste stream.

A recommendation is made to ensure the low flow sampling technique should always be considered for borehole sampling, to minimise waste arisings.

As option 3 is predominantly related to borehole arisings, it is considered the above recommendation is better placed to provide a BPM enhancement, by reducing at source, as opposed to altering the disposal route, such that no action regarding option 3 is proposed.

A recommendation is however made to consider the use of current ion exchange facilities for other minor arisings (as highlighted via option 4).

5. BPEO Study for Solid Wastes

5.1. Barrier Waste and Grout from DGF

The Drigg Grouting Facility (DGF) receives Ordinary Portland Cement (OPC) and Pulverised Fuel Ash (PFA) by road tanker, which is subsequently transferred into storage silos located within the DGF. The mixed grout is then poured into containers sitting in each of the four grouting bays within the DGF for grouting of the ISO containers. Excess grout produced is used to grout the next ISO container to be filled. Waste grout remaining in the mixing tank after completion of grouting and any spillages of grout are disposed of by transfer of the grout into a product container (half-height ISO container). Containers of waste grout are disposed of within the LLWR; approximate two to three containers of this non-compactable waste are disposed of each year (in 2008, three containers of grout were disposed of). Settled solids are consigned to a licensed tip suitable for disposal.

Barrier wastes are produced from these operations. These wastes comprise PPE and disposable items, including respirators, Windscale suits, paper suits, gloves, towels, hand wipes, etc. These wastes are dispatched to the Waste Monitoring and Compaction (WAMAC) facility at Sellafield; the compacted and containerised waste is then disposed of as LLW at the LLWR. In 2008, four ISO containers of barrier waste were disposed of in the LLWR.

5.1.1. Identification and Consideration of Options

Option 1: Dispose Non-compactable and Compactable Waste in the LLWR (Current Practice)

The quantity of non-compactable waste is small (approximately four ISO containers per annum) compared to the quantity of waste currently disposed of at the LLWR and the disposal is aligned with existing processes. Disposal of compactable barrier waste via compaction at WAMAC and subsequent disposal at the LLWR reduces the volume of waste for disposal and is consistent with similar LLW waste from Sellafield.

Advantages -

- Small volumes.
- Practice consistent with similar wastes from Sellafield.

Disadvantages -

- Disposal is the last choice when considering WMH, to be undertaken when other options are not possible.

Option 2: Waste Grout Segregation or Re-categorisation (non-compactables)

Currently, both clean and potentially contaminated waste grout is collected for disposal as non-compactable waste in the LLWR. Segregation of the clean grout from the potentially contaminated grout would allow the clean grout to be disposed of as free release, either as inert waste to conventional landfill or for use as hard core. This would reduce the quantity of waste grout disposed of as LLW in the LLWR. Alternatively, it may be possible to re-categorise the waste grout as VLLW.

This option assumes that compactable waste continues to be disposed of at the LLWR via WAMAC.

Advantages -

- Reduced disposal to LLWR.
- If waste is re-categorised may be re-used.

Disadvantages -

- Cost associated.
- Volumes of waste small.
- Disposal cost still apply to conventional landfill.

Option 3: Reuse of Waste Grout as Infill or Hardcore (non-compactables)

Crushing the waste grout could provide a material that could be used to fill voids within ISO containers, thereby reducing the total quantity of grout used and reducing the number of containers of waste grout disposed of. Similarly, crushed waste grout could be stored for use as hardcore for new facilities, reducing the quantity disposed. Both of these options are likely to require new facilities for crushing waste grout; alternatively, it may be possible to transfer the waste grout to Sellafield for crushing and use as infill in non-compactable waste containers.

This option assumes that compactable waste continues to be disposed of at the LLWR via WAMAC.

Advantages -

- Reduced disposal.
- Fully demonstrates application of WMH.
- Reduced voidage in ISO containers, less grout required.

Disadvantages -

- Small volumes.
- Additional transport and handling of material.
- Cost of new plant / cost associated with use of Sellafield crushing facilities.

Option 4: Monitoring and Segregation of Compactable Waste (compactables)

Monitoring the compactable waste at source would allow the segregation of contaminated and clean waste. The clean waste could then be disposed of to conventional landfill, minimising the amount of radioactive waste treated at WAMAC and disposed of in the LLWR. Monitoring is resource intensive and has the potential to increase operator dose, and the potential reduction in radioactive waste may be relatively minor.

This option assumes that non-compactable waste continues to be disposed of directly in the LLWR.

Advantages-

- Reduced disposal to LLWR.

Disadvantages -

- Resource intensive with associated costs.
- Small volumes.
- Potential operator dose implication.

Option 5: Incineration of Compactable Waste On-site (compactables)

Waste incineration is a potential waste volume reduction option for the compactable waste. It is anticipated that stakeholder opinion would be strongly against such a development on the LLWR site. It is likely that the resulting ash would then be disposed of at the LLWR, resulting in a significant volume decrease in the waste disposed.

Advantages -

- Facility could be used not only for LLWR compactables but waste generated on other sites, could be Nationally strategic facility and fit with National LLW strategy.
- Very large waste volume reductions.
- May recover energy from wastes.

Disadvantages -

- Cost of plant.
- Highly emotive plant, stakeholder concerns likely.

Option 6: Incineration of Compactable Waste Off-site (compactables)

As with Option 5, waste incineration potentially provides a mechanism for waste reduction of compactable wastes. Given the uncertainty associated with construction of a facility on the LLWR site, it may be feasible to transfer the waste to other incinerators accepting radioactive wastes. The resulting ash would then be returned for disposal at the LLWR, resulting in a significant volume decrease in the waste disposed. In addition, LLWR is setting up an incineration service as part of the National Strategy. LLWR will have these routes available for its own wastes.

Advantages-

- Very large volume reductions.
- May recover energy from wastes.

Disadvantages -

- Transport and incineration costs.
- Small volumes of this waste stream.
- Current incineration capacity low for some radionuclides.
- High level of stakeholder interest in incinerator sites.

Option 7: Nitric Acid Wash (compactables)

Treatment of compactable wastes by washing with nitric acid is used at other facilities to reduce the activity of waste below radioactive waste disposal levels. Washing with nitric acid creates an effluent which would then require further treatment to remove the activity. There are currently no facilities on site to carry out this operation.

Advantages -

- Reduces LLW volumes.

Disadvantages -

- Secondary wastes liquid effluent generated for which no disposal route exists
- New plant required.
- Energy usage.
- No real advantage – disposal to conventional landfill still required.

5.1.2. Combined Options

Options 2 and 3 provide alternatives to the current practice for non-compactable waste, whilst options 4, 5, 6 and 7 provide alternatives to the current practice for compactable waste. It is therefore possible that the BPEO could be a combination of the options, i.e., one option for non-compactable waste and another option for compactable waste.

5.1.3. Screening of Options

Options which have been not considered further are presented below, with the reasons for non-progression to the scoring and ranking exercise recorded below.

Option 7: 'Nitric acid wash' - can be screened out due to the fact that no suitable facilities are currently available and the process would create an effluent requiring further treatment.

5.1.4. Ranking of Options

The options are scored against a selection of attributes as listed in the table below.

Options	1. Dispose Non-compactable Waste and Compactable Waste in the LLWR	2. Waste Grout Segregation or Re-categorisation	3. Reuse of Waste Grout as Infill or Hardcore	4. Monitoring and Segregation of Compactable Waste	5. Incineration of Compactable Waste (on-site)	6. Incineration of Compactable Waste (off-site)
Environmental Issues e.g. increased discharges, 2ry waste	4	5	5	5	4	4
Regulatory Compliance	5	5	4	5	3	4
Safety-Radiological safety issues e.g. public/worker dose	4	3	5	2	3	3
Conventional safety Issues	5	3	3	3	3	3
Impact on LLWR safety case	5	4	2	4	3	3
Costs (project/lifetime)	4	4	4	3	1	1
Technical Feasibility	5	3	3	4	2	3
Stakeholder Acceptance	3	5	3	4	1	2
Total	**35**	**32**	**29**	**30**	**20**	**23**

Initial scores for the options reveal that Option1 (current practice) is the preferred option with Option 2 (Waste Grout Segregation or Re-categorisation) for non- compactables following in close second. Next preferred is Option 4 (Monitoring and segregation of compactable waste). The worst scoring option is No 5 (Incineration of Compactable Waste On-site), due to cost and stakeholder acceptance issues. As detailed earlier the BPEO could be a combination of options 1 (for all wastes), option 2 (non compactables wastes) and option 4 (compactable wastes).

Where an existing incinerator exists, cost would be lower than for on site incineration. However the scoring used has taken into account that the off site incineration route is not yet clear. Once this is finalised and LLWR utilise these routes for LLWR generated wastes, the cost scores will be enhanced relative to other options.

Stakeholder acceptance of incineration practice has historically been demonstrated as an issue with local communities. However, as incineration technology has improved and combines both heat recovery with large waste volume reductions, this technique is now more widely applied and fully demonstrates application of the WMH. It should be noted, a number of incinerators are planned for around the country for municipal waste streams.

The low score applied reflects historic stakeholders views and worst case scenarios. However, local communities are now more supportive and this may not now be an issue.

The LLWR will align with the National LLW strategy when in place and a recommendation is made to reflect this.

5.2. Operational and Decommissioning LLW from the Magazines

Historically, the Magazines were used to store Plutonium Contaminated Material (PCM). A programme of retrieval and repackaging of PCM has been undertaken and the bulk of PCM has now been removed and transferred to Sellafield for long-term storage.

Residual operations include activities to characterise, assess/evaluate, package and transport secondary PCM wastes to the storage and disposal destination, either PCM stores at Sellafield or the LLWR. Waste materials included in the residual operations which comprise bitumen waste drums, empty clean PCM waste drums, empty contaminated PCM waste drums, contaminated bricks, uranium hydride drums, heavy concrete waste box and heavy concrete waste drums.

Post Operations Clean-Out (POCO) will follow the residual operations. The scope of POCO includes Fork Lift Trucks and batteries, drum crusher, assay equipment, scissor lift, scaffold, furnace, drum stillages and drum tipping equipment. POCO will also include preliminary decontamination using scabbling techniques to remove gross levels of contamination.

Following POCO, the magazines will be demolished and the land remediated. Demolition activities will be assessed as a one-off disposal and are therefore outside the scope of this BPEO.

Barrier waste is generated at barriers at each of the Magazines. Most is compactable LLW soft waste; the BPEO review of compactable waste for the DGF is considered to be applicable for the LLW barrier waste from the Magazines. A small quantity of non-compactable waste is directly disposed within the LLWR (grouted within skips or ISO containers). Non-compactable LLW from the Magazines covers a range of items, all present in small quantities; no specific alternative options have been identified for these miscellaneous items. The application of BPM should be used to confirm that wastes are minimised and appropriate disposal routes used in each case. Small quantities of barrier waste are sentenced as PCM for long-term storage at Sellafield; operational practices are designed to minimise the quantities of PCM in accordance with BPM.

The Retrieval-modules, installed to enable the safe retrieval of PCM from the Magazines were designed in accordance with the Institute of Civil Engineers Demolition Protocols to ensure optimum material reuse, recycling and waste reduction. 2 of the 18 retrieval facilities are to be retained for future use on site, and that 16 of the 18 facilities are to be removed from site and provide the potential for re-sale, thus realising a higher asset value than the material recycling value.

5.2.1. Identification and Consideration of Options

Option 1: Segregation of PCM for Storage at Sellafield and LLW for Disposal in the LLWR (Current Practice)

Current operations and proposals for the Magazines involved the separation of LLW and PCM waste for appropriate disposal. This minimises the quantity of higher level waste and represents best practice. An LLW Bag-Monitor (Alpha) is planned for incorporation into operations at LLWR to enable the improved segregation of PCM from LLW.

Advantages-

- Current practice, with further improvements to be incorporated.
- In line with WMH requirements.

Option 2: Reuse of Equipment

A number of items of equipment identified may have potential future use at other nuclear licensed sites. This would represent good practice within the waste management hierarchy. The NDA asset transfer database provides a means for implementing this option. Disadvantages may include delays to the removal of equipment from site and potential decontamination that may be required for the equipment to be moved to the new site. As indicated above the intent is for the retrieval modules to be available for resale/reuse.

Advantages-

- Meets waste management hierarchy requirements.
- NDA database used previously but has not been applied to POCO yet.

Disadvantages -

- May generate secondary wastes.
- Handling and treatment issues associated with cleaning to free release.
- Equipment may require decontamination prior to transfer to other sites.

Option 3: Decontamination and Free Release

Many of the waste items from residual operations (and some from POCO) are metals. Where practicable, decontamination techniques may allow the metal to be free released such that the material can be recycled. Disadvantages include the requirement for careful monitoring and the secondary waste generated as a result of the decontamination technique. However, there may be opportunities to utilise decontamination facilities at other local sites. In addition, some dismantling may be required for monitoring or segregation of clean wastes.

Advantages -

- Meets waste management hierarchy requirements.

Disadvantages-

- May generate secondary wastes.
- Handling and treatment issues associated with cleaning to free release.

Option 4: Smelting

Smelting of metal wastes allows metals with minor levels of contamination to be recycled. This may be suitable for, in particular, the clean waste drums. Smelting facilities for Metals recycling (for onward transfer of wastes to smelting facilities), are available local to the LLWR site. Disadvantages are that the acceptable waste streams for the smelting facilities are limited; further investigation into the suitability of the Magazine wastes for these facilities would be required.

Advantages -

- Meets WMH requirements through reuse.
- Generates small volumes of secondary wastes and majority of metal is reused.

Disadvantages -

- Minimum volumes of same materials are required for acceptance for smelting.
- Transportation and treatment costs.
- High energy usage for smelting.
- Increased handling of contaminated materials.

5.2.2. Screening of Options

Screening of the options has determined that all the options are viable; hence, no options have been screened out.

5.2.3. Ranking of Options

The options are scored against a selection of attributes as listed in the table below.

Options	1. Segregation of PCM for Storage and LLW for Disposal (Current Practice)	2. Reuse of Equipment	3.Decontamination and Free Release	4. Smelting
Environmental Issues e.g. increased discharges, 2ry waste	4	5	3	5
Regulatory Compliance	5	5	4	3
Safety-Radiological safety issues e.g. public/worker dose	4	4	2	3
Conventional safety Issues	5	5	3	4
Impact on LLWR safety case	5	4	3	5
Costs (project/lifetime)	3	5	3	3
Technical Feasibility	5	4	2	2
Stakeholder Acceptance	3	4	3	3
Total	**34**	**36**	**23**	**28**

Initial scores for the options reveal that Option 2 (Reuse of equipment) and Option 1 (Current Practice) are the preferred options. Options 3 and 4, which both involve treatment to recycle the metallic wastes, are the worst scoring options.

Therefore a recommendation is made to ensure where possible, to reuse equipment.

An additional recommendation is made to support enhancements to current practice, through the introduction of an alpha bag monitor.

5.2.4. Combined Options

The alternative options identified are not applicable to all the individual waste types. Therefore, it is likely that the BPEO for individual waste types may differ. Where an option scores highly, this is an indication that the option should be considered for individual waste types as their disposal arises.

5.3. Other Waste Arisings Generated Occasionally on Site

This considers other waste streams arising routinely, albeit infrequently. One-off arisings, for example those which may result from a remediation task, are not considered here and will be addressed on a case-by-case basis.

A number of miscellaneous items arise during activities on site. These may include, for example, asbestos, TNT (unexploded ordnance) and trench cap vegetation such as gorse, bushes and trees. These items are managed on a case-by-case basis in accordance with LLWR procedures: RSP 2.03 (Minimising the accumulation of and disposal of radioactive waste), LLWMS QP/1 (Management and control of LLW from LLWR Site for disposal at LLWR Site) and OI 0.1.10 (Operating instruction for the disposal of non active and SLLW generated on the Drigg Site). No options have been considered and identified within this study for these miscellaneous waste streams; these are dealt with as they arise, as described above.

Included within this category are used HEPA filters, which arise from the DGF plant stack and from the Magazines. The number of filters generated on site is small due to the low levels of activity borne within aerial releases. These are disposed of as LLW compactable waste (into the LLWR via compaction at WAMAC) or stored as PCM at Sellafield. This is in accordance with standard practice for HEPA filters. Due to the small quantity of filters used at the LLWR, no alternative viable options have been identified. The current practice is therefore considered to represent the BPEO.

6. Sensitivity Analysis

Following the scoring process, the attributes have been grouped together under five Elements; Environmental; safety; technical feasibility; cost and stakeholder acceptance. A weighting factor of 2 has been applied to assess the sensitivity of the overall scores to these elements and the impact on the ranking of the options. This has been used to help underpin and develop discussion around the lead option(s) and demonstrate the effect of changing the relative importance of an element.

Tables showing the scoring for the sensitivity results for all options can be found in **Appendix 1**. A summary of weighted scores presented by weighted element, for each study, is shown in the tables below.

6.1. Aerial releases

Weighted elements summary table for 'Gaseous discharges from the Drigg Grouting Facility'

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	2. Additional abatement of aerial effluents prior to discharge
Environmental weighting	**45**	**39**
Safety weighting	**48**	**42**
Costs weighting	**39**	**32**
Technical Feasibility weighting	**40**	**34**
Stakeholder Acceptance weighting	**38**	**33**
Un-weighted scores for comparison	**35**	**30**

Weighted elements summary table for 'Gaseous discharges from the Magazines'

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	7. Acceleration programme for POCO of Magazines
Environmental weighting	43	47
Safety weighting	48	51
Costs weighting	37	41
Technical feasibility weighting	39	41
Stakeholder acceptance weighting	37	42
Un-weighted scores for comparison	34	37

6.2. Liquid Releases

Weighted elements summary table for 'Trench leachate and Vault 8 runoff'

Options	1. Current practice	2. Recycle as makeup for grout in DGF	4. Treatment of leachate prior to discharge	5. Evaporation	6. Early permanent Trench capping
Environmental weighting	46	32	31	28	36
Safety weighting	51	35	35	33	39
Costs weighting	42	29	28	25	28
Technical feasibility weighting	42	30	29	27	31
Stakeholder acceptance weighting	41	30	27	25	28
Un-weighted scores for comparison	37	26	25	23	27

Weighted elements summary table for 'Minor Arisings'

Options	1. Disposal via Leachate line	2. Transfer off site for treatment	3. External Laboratory to dispose of samples	4. Treatment on site
Environmental weighting	**46**	**35**	**40**	**40**
Safety weighting	**51**	**41**	**46**	**45**
Costs weighting	**42**	**32**	**34**	**35**
Technical Feasibility weighting	**42**	**34**	**37**	**37**
Stakeholder Acceptance weighting	**41**	**32**	**35**	**35**
Un-weighted scores for comparison	**37**	**29**	**32**	**32**

6.3. Solid waste

Weighted elements summary table for 'Barrier Waste and Grout from DGF'

Options	1. Dispose Non-compactable Waste and Compactable Waste in the LLWR	2. Waste Grout Segregation or Re-categorisation	3. Reuse of Waste Grout as Infill or Hardcore	4. Monitoring and Segregation of Compactable Waste	5. Incineration of Compactable Waste (on-site)	6. Incineration of Compactable Waste (off-site)
Environmental weighting	**44**	**42**	**38**	**40**	**27**	**31**
Safety weighting	**49**	**42**	**39**	**39**	**29**	**32**
Costs weighting	**39**	**36**	**33**	**33**	**21**	**24**
Technical feasibility weighting	**40**	**35**	**32**	**34**	**22**	**26**
Stakeholder acceptance weighting	**38**	**37**	**32**	**34**	**21**	**25**
Un-weighted scores for comparison	**35**	**32**	**29**	**30**	**20**	**23**

Weighted elements summary table for 'Operational and Decommissioning LLW from the Magazines'

Options	1. Segregation of PCM for Storage and LLW for Disposal (Current Practice).	2. Reuse of Equipment	3.Decontamination and Free Release	4. Smelting
Environmental weighting	**43**	**46**	**30**	**36**
Safety weighting	**48**	**49**	**31**	**40**
Costs weighting	**37**	**41**	**26**	**31**
Technical feasibility weighting	**39**	**40**	**25**	**30**
Stakeholder acceptance weighting	**37**	**40**	**26**	**31**
Un-weighted scores for comparison	**34**	**36**	**23**	**28**

Since the lead options have scored consistently well, sensitivity analysis has minimal effect in changing the ranking of the options.

7. Conclusions and Identification of the BPEO

This study addresses the requirements of improvement conditions set out in the RSA Authorisation and CEAR documents, and considers options with regard to the future operation of the LLWR site.

Schedule 9 of the Low Level Waste Repository's Radioactive Substances Act (RSA) Authorisation from the Environment Agency [2], places a number of requirements for improvement on the LLWR site. One of which, Requirement 1, is summarised below;

> *"The Operator shall provide the Agency with a full report of a comprehensive review of whether the current disposal practices for waste generated on the site continue to represent the best practicable environmental option, together with a programme for carrying out any necessary changes identified by the review"*

Additional information and detail of Requirement 1 is provided within the Compilation of Environment Agency Requirements (CEAR documents) [3] as follows:

> *"The Operator's BPEO assessment shall provide a detailed assessment of the benefits and detriments of alternative waste disposal options and shall cover liquid, gaseous and solid waste produced on the site".*

This study considers options for radioactive waste disposals at the LLWR site for gaseous, liquid and solid waste streams. A number of 'mini' BPEO studies were undertaken, in a manner consistent with Environment Agency guidance. This report provides an auditable trail of the options, considerations and discussion of differentiators between options, and ranking and analysis of the realistic options.

The results confirm that in most cases, current practice represents the BPEO. This is concurrent with the fact that activity levels for LLWR discharges are comparatively low and have been for many years. In addition, to implement some of the high scoring options identified would incur disproportionate costs and resources for little environmental benefit. Some considerations of options for the future are constrained by the outcome of the 2011 Environmental Safety Case and this study should be reviewed for consistency with the outcomes of the ESC when finalised.

Where reasonably possible, LLWR has sought to employ techniques which are in accordance with the Waste Management Hierarchy and the principles of BPM.

7.1. Aerial Discharges BPEO

Gaseous discharges from DGF

Current practice (Option 1) is confirmed as the BPEO. Following option selection and screening, only 2 viable options remained (current practice and installation of additional abatement). Ranking of the options and recording of the differentiators, showed confirmation of the current practice as the BPEO. This confirmation reflects the very low current discharges and that any further reduction in discharges that could be achieved by additional abatement, could not be justified on cost grounds, or on the amount of secondary waste that would be generated. Although Option 1 scored consistently throughout this process, the biggest differentiator can be seen when the when a weighting is applied to cost.

Current practice confirmed as the BPEO.

Gaseous discharges from the Magazines

The acceleration programme for POCO of Magazines (Option 7) is shown to be the leading option in this study, although Option 1 (Current Practice) also scores consistently highly overall. This is concurrent with the fact that activity levels for LLWR discharges are low and have been for many years. Following generation and screening of options, only these two options remained for assessment. Application of sensitivity analysis supports Option 7 and the main differentiators are shown as increased stakeholder acceptance and environmental improvements.

A strategy is already in place for POCO/decommissioning of the Magazines and, until that time, the ventilation/filtration system will need to continue operating in the current manner. On the basis that a programme for POCO is currently in place, Option 7 will in effect become current practice.

Acceleration of POCO of the Magazines represents the BPEO.

Gaseous discharges from Trenches and Vaults 8 and 9

Following consideration of the seven options identified, screening left only one realistic option - Option 1, (Discharge to atmosphere - current practice).

No scoring was therefore undertaken, however an auditable trail of the options is presented within section 3. It should be noted following the outcome of the 2011 ESC, the viability of Option 3 (Early progression of programme to permanently cap Trenches) and Option 5 (Remove waste from Trenches for treatment/processing) may change.

The current conclusion of this assessment confirms current practice as the BPEO.

Current practice confirmed as the BPEO.

7.2. Liquid Discharges

Trench Leachate and Vault 8 Runoff

Following assessment, the leading option is Option 1 (Discharge via the leachate line – current practice). In support of this option, when element weightings are applied, this remains the consistent leader. Option 7 (Early permanent Trench capping) is the next best scoring option, again scoring consistently with element weightings applied.

A permanent trench cap is currently in the LLWR business plans for completion when Vault 8 has reached capacity. However, LLWR have stated it is unlikely that Option 7 will be brought forward before the scheduled date of 2013 as this is constrained by the outcome of the 2011 ESC. This report has shown that the option is worth revisiting when considering the potential benefits e.g. significantly lower leachate volumes and reductions in the total activity discharged to sea. This is in accordance with BPM and WMH principles and a recommendation is made to this effect.

Current practice confirmed as the BPEO.

Minor Arisings

The leading option is Option 1 (Disposal via leachate line- current practice), which scored highly across all attributes. The next preferred option is still Option 4 (Treatment on site), which the site is already carrying out in the form of ion exchange for the PCM showers (and could be extended).

However since Options 1 and 3 relate to borehole water disposal, Option 1 can be presented for disposal of borehole water as representing the BPEO.

Options 2 and 4 relate to other small arisings, and Option 4 (treatment on site) is presented as the leading option and therefore represents the BPEO. It should be noted if application of Option 4 is not feasible, Option 1 would therefore represent the BPEO.

Current practice for borehole water represents the BPEO

Treatment on site (small arisings other than borehole water) represents the BPEO

7.3. Solid Discharges

Barrier Waste and Grout from DGF

Option 1 (Dispose Non-compactable and Compactable Waste in the LLWR **-** current practice) is the leading option. Sensitivity analysis confirms this to be the case. These waste categories comprise compactable and non-compactable streams. Option 2: Waste Grout Segregation or Re-categorisation (non-compactables) and Option 4: Monitoring and Segregation of Compactable Waste (compactables) perform well also in this assessment. This is mainly due to the benefits derived in lower waste volumes; however, the cost benefit due to the low waste volumes is difficult to justify and cost becomes a differentiator and the additional exposures involved in handling the wastes. Incineration options (Options 5 and 6) score notably poorly on stakeholder acceptance an costs.

Current practice confirmed as the BPEO.

Operational and Decommissioning LLW from the Magazines

From the four options assessed, the leading option is shown as Option 2 (Reuse of equipment), with the next very closely scoring option as Option 1 (Segregation of PCM for Storage and LLW for Disposal - Current Practice). Both these options perform well-ahead of Options 3 (Decontamination and Free Release) and Option 4 (Smelting), scoring low on several criteria, but the differentiators being technical feasibility and radiological safety. However, Option 3 may be viable for any wastes that can be demonstrated as clean without the requirement for decontamination. Clearly, the preferred option of reuse will only be applicable to a small number of waste streams.

The current practice has been demonstrated to be a robust option and will be applicable where equipment cannot be reused. Improvements are to be made to Option 1 by incorporation of the LLW Bag-monitor (Alpha) aimed at enabling the better segregation of LLW from PCM materials which require processing at Sellafield.

Reuse of equipment represents BPEO

However since this is only applicable to a small proportion of the waste streams;

Current Practice - Segregation of PCM for Storage and LLW for disposal represents the BPEO

8. Recommendations

A major milestone for the site is the 2011 ESC and it's findings. The ESC therefore constrains major decisions including timing and design of final trench capping and retrievals. This study has considered these constraints when developing, screening and ranking of options and therefore ESC findings may impact on the identification of the BPEO. With this in mind, this study may require review against the findings of the ESC.

Over the next year, following the outcome (of which optimisation is a part) and Post Closure Safety Case review, LLWR will be addressing issues including timing and design of capping and retrievals.

This study makes a number of recommendations (below), where opportunities for improvements have been identified. The recommendations are made to ensure improvements continue to be made and where best practice is currently employed, its full application is made to gain maximum possible environmental benefit.

Recommendation 1:

Low-flow sampling technique should always be considered for borehole sampling, to minimise waste arisings.

Recommendation 2:

Consider the possibility of using existing ion exchange units (currently used for PCM shower effluent), for other minor arisings.

Recommendation 3:

In line with the National Low Level Waste Strategy, full implementation of utilisation of waste routes should be developed for wastes generated by LLWR. In addition, LLWR should ensure wastes treatment routes are utilised as they become available.

Recommendation 4:

Review current practice to ensure, where possible, equipment is re-used and the NDA database of plant equipment for POCO and Decommissioning is utilised.

Recommendation 5:

Improvements are currently planned for the segregation of PCM and LLW from the Magazines POCO and decommissioning activities, by the use of an alpha bag monitor. LLWR should ensure this is implemented as soon as reasonably practicable, to ensure the most appropriate disposal route is used for these waste arisings.

9. References

1. LLWR Initial Operating Strategy. 10009/LLWR/LTP –Issue 2. S Anderson. January 2009.

2. Radioactive Substances Act 1993, Certificate of Authorisation (resulting from Transfer) and Introductory Note – Disposal of Radioactive Waste from Nuclear Site, Low-Level Waste Repository, Drigg, Cumbria, Transfer Number BZ2508/CA8485 relating to Authorisation Number BZ2508/BZ2508 as varied by Variation Notice Number BZ2508/CA8485, 29 July 2007.

3. Compilation of Environment Agency Requirements made under Authorisation BZ2508/CB8189 issued to LLW Repository Ltd.

4. Guidance for the Environment Agencies' Assessment of Best Practicable Environmental Option Studies at Nuclear Sites. Environment Agency & Scottish Environment Protection Agency. February 2004.

5. Permit No. B9 for Bulk Cement Process at LLWR, Drigg. Copeland Borough Council. 7th November 2006.

6. Calculating LLWR stack discharges from health physics monitoring results, A Ronaldson, LLWR EHS&S Department.

7. Letter from J Hornsby to J Hillary regarding Vault 8/9 Radon Monitoring, Reference P09003.090005.9061/ceb, 11/02/09.

8. Waste Disposal Site Leachate - WRA consent no. NPSWQD002191. Environment Agency.

9. Qualitative Assessment of the Performance of the Interim Cap and Cement Bentonite Cut-off wall. RP103547/4510034188/PROJ/00008/A. M. McBarron. April 2007.

10. Summary of Recent Drigg Repository Site Water Balance Calculations and Implications for Current Hydrological Monitoring. Dr E Henderson. October 2005. Nexia (05)6522.

Appendix 1

The tables below present the sensitivity weightings for each of the BPEOs. Each of the 5 elements, in turn, was given a weighting of 2 (whilst the remaining categories had a weighting of 1). The scores were summed to give a total for each option (Summary tables, Section 6).

Aerial Releases

Gaseous Discharges from the Drigg Grouting Facility - Environmental Weighting

Options	1.Discharge to atmosphere after HEPA filtration (current practice)	2. Additional abatement of aerial effluents prior to discharge	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**20**	**18**	**2**
Safety-Radiological safety issues e.g. public/worker dose	**13**	**12**	**1**
Costs (project/lifetime)	**4**	**2**	**1**
Technical Feasibility	**5**	**4**	**1**
Stakeholder Acceptance	**3**	**3**	**1**
Total	**45**	**39**	

Gaseous Discharges from the Drigg Grouting Facility – Safety Weighting

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	2. Additional abatement of aerial effluents prior to discharge	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**10**	**9**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**26**	**24**	**2**
Costs (project/lifetime)	**4**	**2**	**1**
Technical Feasibility	**5**	**4**	**1**
Stakeholder Acceptance	**3**	**3**	**1**
Total	**48**	**42**	

Gaseous Discharges from the Drigg Grouting Facility – Costs Weighting

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	2. Additional abatement of aerial effluents prior to discharge	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**10**	**9**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**13**	**12**	**1**
Costs (project/lifetime)	**8**	**4**	**2**
Technical Feasibility	**5**	**4**	**1**
Stakeholder Acceptance	**3**	**3**	**1**
Total	**39**	**32**	

Gaseous Discharges from the Drigg Grouting Facility – Technical Feasibility Weighting

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	2. Additional abatement of aerial effluents prior to discharge	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**10**	**9**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**13**	**12**	**1**
Costs (project/lifetime)	**4**	**2**	**1**
Technical Feasibility	**10**	**8**	**2**
Stakeholder Acceptance	**3**	**3**	**1**
Total	**40**	**34**	

Gaseous Discharges from the Drigg Grouting Facility –Stakeholder Acceptance Weighting

Options	Discharge to atmosphere after HEPA filtration (current practice)	Additional abatement of aerial effluents prior to discharge	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**10**	**9**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**13**	**12**	**1**
Costs (project/lifetime)	**4**	**2**	**1**
Technical Feasibility	**5**	**4**	**1**
Stakeholder Acceptance	**6**	**6**	**2**
Total	**38**	**33**	

Gaseous Discharges from the Magazines – Environmental Weighting

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	7. Acceleration programme for POCO of Magazines	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**18**	**20**	**2**
Safety-Radiological safety issues e.g. public/worker dose	**14**	**14**	**1**
Costs (project/lifetime)	**3**	**4**	**1**
Technical Feasibility	**5**	**4**	**1**
Stakeholder Acceptance	**3**	**5**	**1**
Total	**43**	**47**	

Gaseous Discharges from the Magazines - Safety Weighting

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	7. Acceleration programme for POCO of Magazines	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**10**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**28**	**28**	**2**
Costs (project/lifetime)	**3**	**4**	**1**
Technical Feasibility	**5**	**4**	**1**
Stakeholder Acceptance	**3**	**5**	**1**
Total	**48**	**51**	

Gaseous Discharges from the Magazines -Costs Weighting

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	7. Acceleration programme for POCO of Magazines	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**10**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**14**	**14**	**1**
Costs (project/lifetime)	**6**	**8**	**2**
Technical Feasibility	**5**	**4**	**1**
Stakeholder Acceptance	**3**	**5**	**1**
Total	**37**	**41**	

Gaseous Discharges from the Magazines –Technical Feasibility Weighting

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	7. Acceleration programme for POCO of Magazines	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**10**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**14**	**14**	**1**
Costs (project/lifetime)	**3**	**4**	**1**
Technical Feasibility	**10**	**8**	**2**
Stakeholder Acceptance	**3**	**5**	**1**
Total	**39**	**41**	

Gaseous Discharges from the Magazines – Stakeholder Acceptance Weighting

Options	1. Discharge to atmosphere after HEPA filtration (current practice)	7. Acceleration programme for POCO of Magazines	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**10**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**14**	**14**	**1**
Costs (project/lifetime)	**3**	**4**	**1**
Technical Feasibility	**5**	**4**	**1**
Stakeholder Acceptance	**6**	**10**	**2**
Total	**37**	**42**	

Trench Leachate and Vault 8 Runoff – Environmental Weighting

Options	1. Current practice	2. Recycle as makeup for grout in DGF	4. Treatment of leachate prior to discharge	5. Evaporation	6. Early permanent Trench capping	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**18**	**12**	**12**	**10**	**18**	**2**
Safety-Radiological Issues e.g. public/worker dose	**14**	**9**	**10**	**10**	**12**	**1**
Costs (project/lifetime)	**5**	**3**	**3**	**2**	**1**	**1**
Technical Feasibility	**5**	**4**	**4**	**4**	**4**	**1**
Stakeholder Acceptance	**4**	**4**	**2**	**2**	**1**	**1**
Total	**46**	**32**	**31**	**28**	**36**	

Trench Leachate and Vault 8 Runoff – Safety Weighting

Options	1. Current practice	2. Recycle as makeup for grout in DGF	4. Treatment of leachate prior to discharge	5. Evaporation	6. Early permanent Trench capping	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**6**	**6**	**5**	**9**	**1**
Safety-Radiological Issues e.g. public/worker dose	**28**	**18**	**20**	**20**	**24**	**2**
Costs (project/lifetime)	**5**	**3**	**3**	**2**	**1**	**1**
Technical Feasibility	**5**	**4**	**4**	**4**	**4**	**1**
Stakeholder Acceptance	**4**	**4**	**2**	**2**	**1**	**1**
Total	**51**	**35**	**35**	**33**	**39**	

Trench Leachate and Vault 8 Runoff – Costs Weighting

Options	1. Current practice	2. Recycle as makeup for grout in DGF	4. Treatment of leachate prior to discharge	5. Evaporation	6.. Early permanent Trench capping	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**6**	**6**	**5**	**9**	**1**
Safety-Radiological Issues e.g. public/worker dose	**14**	**9**	**10**	**10**	**12**	**1**
Costs (project/lifetime)	**10**	**6**	**6**	**4**	**2**	**2**
Technical Feasibility	**5**	**4**	**4**	**4**	**4**	**1**
Stakeholder Acceptance	**4**	**4**	**2**	**2**	**1**	**1**
Total	**42**	**29**	**28**	**25**	**28**	

Trench Leachate and Vault 8 Runoff – Technical Feasibility Weighting

Options	1. Current practice	2. Recycle as makeup for grout in DGF	4. Treatment of leachate prior to discharge	5. Evaporation	6.. Early permanent Trench capping	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**6**	**6**	**5**	**9**	**1**
Safety-Radiological Issues e.g. public/worker dose	**14**	**9**	**10**	**10**	**12**	**1**
Costs (project/lifetime)	**5**	**3**	**3**	**2**	**1**	**1**
Technical Feasibility	**10**	**8**	**8**	**8**	**8**	**2**
Stakeholder Acceptance	**4**	**4**	**2**	**2**	**1**	**1**
Total	**42**	**30**	**29**	**27**	**31**	

Trench Leachate and Vault 8 Runoff – Stakeholder Acceptance Weighting

Options	1. Current practice	2. Recycle as makeup for grout in DGF	4. Treatment of leachate prior to discharge	5. Evaporation	6.. Early permanent Trench capping	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**6**	**6**	**5**	**9**	**1**
Safety-Radiological Issues e.g. public/worker dose	**14**	**9**	**10**	**10**	**12**	**1**
Costs (project/lifetime)	**5**	**3**	**3**	**2**	**1**	**1**
Technical Feasibility	**5**	**4**	**4**	**4**	**4**	**1**
Stakeholder Acceptance	**8**	**8**	**4**	**4**	**2**	**2**
Total	**41**	**30**	**27**	**25**	**28**	

Minor Arisings – Environmental Weighting

Options	1. Disposal via Leachate line	2. Transfer off site for treatment	3. External Laboratory to dispose of samples	4. Treatment on site	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**18**	**12**	**16**	**16**	**2**
Safety Radiological Issues e.g. public/worker dose	**14**	**12**	**14**	**13**	**1**
Costs	**5**	**3**	**2**	**3**	**1**
Technical Feasibility	**5**	**5**	**5**	**5**	**1**
Stakeholder Acceptance	**4**	**3**	**3**	**3**	**1**
Total	**46**	**35**	**40**	**40**	

Minor Arisings – Safety Weighting

Options	1. Disposal via Leachate line	2. Transfer off site for treatment	3. External Laboratory to dispose of samples	4.Treatment on site	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**6**	**8**	**8**	**1**
Safety Radiological Issues e.g. public/worker dose	**28**	**24**	**28**	**26**	**2**
Costs	**5**	**3**	**2**	**3**	**1**
Technical Feasibility	**5**	**5**	**5**	**5**	**1**
Stakeholder Acceptance	**4**	**3**	**3**	**3**	**1**
Total	**51**	**41**	**46**	**45**	

Minor Arisings – Costs Weighting

Options	1. Disposal via Leachate line	2. Transfer off site for treatment	3. External Laboratory to dispose of samples	4.Treatment on site	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**6**	**8**	**8**	**1**
Safety Radiological Issues e.g. public/worker dose	**14**	**12**	**14**	**13**	**1**
Costs	**10**	**6**	**4**	**6**	**2**
Technical Feasibility	**5**	**5**	**5**	**5**	**1**
Stakeholder Acceptance	**4**	**3**	**3**	**3**	**1**
Total	**42**	**32**	**34**	**35**	

Minor Arisings – Technical Feasibility Weighting

Options	1. Disposal via Leachate line	2. Transfer off site for treatment	3. External Laboratory to dispose of samples	4.Treatment on site	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**6**	**8**	**8**	**1**
Safety Radiological Issues e.g. public/worker dose	**14**	**12**	**14**	**13**	**1**
Costs	**5**	**3**	**2**	**3**	**1**
Technical Feasibility	**10**	**10**	**10**	**10**	**2**
Stakeholder Acceptance	**4**	**3**	**3**	**3**	**1**
Total	**42**	**34**	**37**	**37**	

Minor Arisings – Stakeholder Acceptance Weighting

Options	1. Disposal via Leachate line	2. Transfer off site for treatment	3. External Laboratory to dispose of samples	4.Treatment on site	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**6**	**8**	**8**	**1**
Safety Radiological Issues e.g. public/worker dose	**14**	**12**	**14**	**13**	**1**
Costs	**5**	**3**	**2**	**3**	**1**
Technical Feasibility	**5**	**5**	**5**	**5**	**1**
Stakeholder Acceptance	**8**	**6**	**6**	**6**	**2**
Total	**41**	**32**	**35**	**35**	

Barrier Waste and Grout from DGF – Environmental Weighting

Options	1. Dispose Non-compactable Waste and Compactable Waste in the LLWR	2. Waste Grout Segregation or Re-categorisation	3. Reuse of Waste Grout as Infill or Hardcore	4. Monitoring and Segregation of Compactable Waste	5. Incineration of Compactable Waste (on-site)	6. Incineration of Compactable Waste (off-site)	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**18**	**20**	**18**	**20**	**14**	**16**	**2**
Safety-Radiological safety issues e.g. public/worker dose	**14**	**10**	**10**	**9**	**9**	**9**	**1**
Costs (project/lifetime)	**4**	**4**	**4**	**3**	**1**	**1**	**1**
Technical Feasibility	**5**	**3**	**3**	**4**	**2**	**3**	**1**
Stakeholder Acceptance	**3**	**5**	**3**	**4**	**1**	**2**	**1**
Total	**44**	**42**	**38**	**40**	**27**	**31**	

Barrier Waste and Grout from DGF – Safety Weighting

Options	1. Dispose Non-compactable Waste and Compactable Waste in the LLWR	2. Waste Grout Segregation or Re-categorisation	3. Reuse of Waste Grout as Infill or Hardcore	4. Monitoring and Segregation of Compactable Waste	5. Incineration of Compactable Waste (on-site)	6. Incineration of Compactable Waste (off-site)	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**10**	**9**	**10**	**7**	**8**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**28**	**20**	**20**	**18**	**18**	**18**	**2**
Costs (project/lifetime)	**4**	**4**	**4**	**3**	**1**	**1**	**1**
Technical Feasibility	**5**	**3**	**3**	**4**	**2**	**3**	**1**
Stakeholder Acceptance	**3**	**5**	**3**	**4**	**1**	**2**	**1**
Total	**49**	**42**	**39**	**39**	**29**	**32**	

Barrier Waste and Grout from DGF – Costs Weighting

Options	1. Dispose Non-compactable Waste and Compactable Waste in the LLWR	2. Waste Grout Segregation or Re-categorisation	3. Reuse of Waste Grout as Infill or Hardcore	4. Monitoring and Segregation of Compactable Waste	5. Incineration of Compactable Waste (on-site)	6. Incineration of Compactable Waste (off-site)	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**10**	**9**	**10**	**7**	**8**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**14**	**10**	**10**	**9**	**9**	**9**	**1**
Costs (project/lifetime)	**8**	**8**	**8**	**6**	**2**	**2**	**2**
Technical Feasibility	**5**	**3**	**3**	**4**	**2**	**3**	**1**
Stakeholder Acceptance	**3**	**5**	**3**	**4**	**1**	**2**	**1**
Total	**39**	**36**	**33**	**33**	**21**	**24**	

Barrier Waste and Grout from DGF – Technical Feasibility Weighting

Options	1. Dispose Non-compactable Waste and Compactable Waste in the LLWR	2. Waste Grout Segregation or Re-categorisation	3. Reuse of Waste Grout as Infill or Hardcore	4. Monitoring and Segregation of Compactable Waste	5. Incineration of Compactable Waste (on-site)	6. Incineration of Compactable Waste (off-site)	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**10**	**9**	**10**	**7**	**8**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**14**	**10**	**10**	**9**	**9**	**9**	**1**
Costs (project/lifetime)	**4**	**4**	**4**	**3**	**1**	**1**	**1**
Technical Feasibility	**10**	**6**	**6**	**8**	**4**	**6**	**2**
Stakeholder Acceptance	**3**	**5**	**3**	**4**	**1**	**2**	**1**
Total	**40**	**35**	**32**	**34**	**22**	**26**	

Barrier Waste and Grout from DGF – Stakeholder Acceptance Weighting

Options	1. Dispose Non-compactable Waste and Compactable Waste in the LLWR	2. Waste Grout Segregation or Re-categorisation	3. Reuse of Waste Grout as Infill or Hardcore	4. Monitoring and Segregation of Compactable Waste	5. Incineration of Compactable Waste (on-site)	6. Incineration of Compactable Waste (off-site)	**Weighting**
Environmental Issues e.g. increased discharges, 2ry waste	**9**	**10**	**9**	**10**	**7**	**8**	**1**
Safety-Radiological safety issues e.g. public/worker dose	**14**	**10**	**10**	**9**	**9**	**9**	**1**
Costs (project/lifetime)	**4**	**4**	**4**	**3**	**1**	**1**	**1**
Technical Feasibility	**5**	**3**	**3**	**4**	**2**	**3**	**1**
Stakeholder Acceptance	**6**	**10**	**6**	**8**	**2**	**4**	**2**
Total	**38**	**37**	**32**	**34**	**21**	**25**	

Operational and Decommissioning LLW from the Magazines – Environmental Weighting

Options	1. Segregation of PCM for Storage and LLW for Disposal (Current Practice)	2. Reuse of Equipment	3.Decontamination and Free Release	4. Smelting	**Weighting**
Environmental Issues	**18**	**20**	**14**	**16**	**2**
Safety	**14**	**13**	**8**	**12**	**1**
Costs (project/lifetime)	**3**	**5**	**3**	**3**	**1**
Technical Feasibility	**5**	**4**	**2**	**2**	**1**
Stakeholder Acceptance	**3**	**4**	**3**	**3**	**1**
Total	**43**	**46**	**30**	**36**	

Operational and Decommissioning LLW from the Magazines – Safety Weighting

Options	1. Segregation of PCM for Storage and LLW for Disposal (Current Practice)	2. Reuse of Equipment	3.Decontamination and Free Release	4. Smelting	**Weighting**
Environmental Issues	**9**	**10**	**7**	**8**	**1**
Safety	**28**	**26**	**16**	**24**	**2**
Costs (project/lifetime)	**3**	**5**	**3**	**3**	**1**
Technical Feasibility	**5**	**4**	**2**	**2**	**1**
Stakeholder Acceptance	**3**	**4**	**3**	**3**	**1**
Total	**48**	**49**	**31**	**40**	

Operational and Decommissioning LLW from the Magazines – Costs Weighting

Options	1. Segregation of PCM for Storage and LLW for Disposal (Current Practice)	2. Reuse of Equipment	3.Decontamination and Free Release	4. Smelting	**Weighting**
Environmental Issues	**9**	**10**	**7**	**8**	**1**
Safety	**14**	**13**	**8**	**12**	**1**
Costs (project/lifetime)	**6**	**10**	**6**	**6**	**2**
Technical Feasibility	**5**	**4**	**2**	**2**	**1**
Stakeholder Acceptance	**3**	**4**	**3**	**3**	**1**
Total	**37**	**41**	**26**	**31**	

Operational and Decommissioning LLW from the Magazines – Technical Feasibility Weighting

Options	1. Segregation of PCM for Storage and LLW for Disposal (Current Practice)	2. Reuse of Equipment	3.Decontamination and Free Release	4. Smelting	**Weighting**
Environmental Issues	**9**	**10**	**7**	**8**	**1**
Safety	**14**	**13**	**8**	**12**	**1**
Costs (project/lifetime)	**3**	**5**	**3**	**3**	**1**
Technical Feasibility	**10**	**8**	**4**	**4**	**2**
Stakeholder Acceptance	**3**	**4**	**3**	**3**	**1**
Total	**39**	**40**	**25**	**30**	

Operational and Decommissioning LLW from the Magazines – Stakeholder Acceptance Weighting

Options	1. Segregation of PCM for Storage and LLW for Disposal (Current Practice)	2. Reuse of Equipment	3.Decontamination and Free Release	4. Smelting	**Weighting**
Environmental Issues	**9**	**10**	**7**	**8**	**1**
Safety	**14**	**13**	**8**	**12**	**1**
Costs (project/lifetime)	**3**	**5**	**3**	**3**	**1**
Technical Feasibility	**5**	**4**	**2**	**2**	**1**
Stakeholder Acceptance	**6**	**8**	**6**	**6**	**2**
Total	**37**	**40**	**26**	**31**	

DISTRIBUTION

Name	Location
Richard Cummings	Low Level Waste Repository Drigg
Simon Hunter	Low Level Waste Repository Drigg
Stephen Miller	Low Level Waste Repository Drigg
NNL Document Control	Risley