The Process and Outcome from the Strategic Best Practicable Environmental Option (BPEO) Study for the Management and Disposal of Very Low Level Waste in the United Kingdom - 10228

Martin Walkingshaw[1], David Rossiter[1], Frank Taylor[1], Stephen Dooley[2], Phil Kruse[2] and Matthew Keep[2]

[1] LLW Repository Limited, LLW Repository Site, Drigg, Holmrook, Cumbria CA19 1XH

[2] Entec UK Ltd, Pacific House, Imperial Way, Reading RG2 0TD

ABSTRACT

The process to identify the strategic Best Practicable Environmental Option (BPEO) was performed to evaluate the relative merits of options for the long-term management of VLLW to be determined. The strategic options for managing VLLW waste generated from activities undertaken at nuclear licensed sites were generated, developed and explored by the options appraisal panel via a screening, weighting and scoring exercise in order to identify the preferred option(s). This paper describes the methodology, outputs and conclusions of the systematic and robust process adopted.

The assessment indicated that the reuse and recycling of appropriate wastes streams is preferential based upon the waste hierarchy. Reuse of aggregates, metals recycling, thermal treatment of combustible waste and decay storage may be appropriate for specific waste streams in specific circumstances. The disposal options all achieved broadly similar levels of performance although use of existing sites generally scored better than their corresponding new sites with the exception of the continued use of LLW repository. Disposal of VLLW at the LLW repository was considered the least preferable option.

The uncertainties identified include the accuracy of the inventory, expected market appetite for developing new facilities and uncertainties relating to achieving compliance requirements. Furthermore, location specific factors could affect the relative performance of the options.

INTRODUCTION AND BACKGROUND

Since its commissioning in 1959 the vast majority of low level waste (LLW) from the United Kingdom's nuclear programme has been disposed of to the Low Level Waste Repository (LLWR) in the north-west of England. The Nuclear Decommissioning Authority (NDA) has led a concerted programme of decommissioning leading ultimately to the final site clearance and delicensing of its sites by 2150. During this programme, substantial volumes of LLW will be generated; current estimates are in the region of 3 million m^3. The current vault at LLWR is nearly full. Development of the facility to extend the vaulted capacity at LLWR is currently underway. Notwithstanding this, the total estimated capacity of LLWR, following all of the planned developments, is in the order of 700,000 m^3; a considerable shortfall in the required capacity for disposal of LLW. In the spring of 2007 a review of UK Government policy was published encouraging a more flexible approach which included the opportunity to dispose of LLW to appropriately engineered and authorised landfill sites. The policy also defined the category of High Volume Very Low Level Waste (HV VLLW) from nuclear sites which represents approximately 60% of the volume of LLW expected during decommissioning. This waste is now referred to as High Volume Very Low Level Waste (HV VLLW) and has the following definition:

"Radioactive waste with maximum concentrations of four megabecquerels per tonne (MBq/te) of total activity which can be disposed of to specified landfill sites. For waste containing hydrogen-3 (tritium), the concentration limit for tritium is 40 MBq/te. Controls on disposal of this material, after removal from the premises where the wastes arose, will be necessary in a manner specified by the environmental regulators."

The change in Government policy also created a number of further opportunities and challenges associated with the management of LLW which include:

- A change in definition which no longer makes reference to disposal (although the limits are essentially the same);
- A definition for high volume low activity waste which essentially permits disposal to specified landfills;
- A requirement to produce plans for LLW management and to undertake open and transparent consultation;

- A requirement to apply the waste hierarchy and to minimise waste arisings and disposals;
- A requirement to consider all practicable management options;
- A requirement to develop solutions early (although not necessarily for early implementation);
- Consideration of the proximity principle in waste management solutions; and
- To restrict imports and exports of LLW except in cases where re-use or treatment to support implementation of options is required.

The Low Level Waste Repository (LLWR) is the UK's national LLW disposal facility and receives LLW from nuclear sites and other premises across the country. Current waste projections indicated that the decommissioning process will generate large quantities of VLLW that will significantly exceed the disposal capacity of LLWR. The future management and disposal of HV VLLW is therefore a key concern for the Government, funding bodies and waste generators.

LLW Disposal Routes

The LLWR Ltd is planning to introduce a new range of complementary services which will augment its current service offering of disposal to the LLWR vaults. These new services will support the emerging National LLW Strategy that aims to provide alternatives to the disposal of LLW to engineered disposal facilities such as that provided by LLWR at its site near Drigg. The three segregated services being considered by LLWR Ltd are:

- Metallic Waste Treatment;
- Combustible Waste Treatment; and
- VLLW Waste Disposal.

Strategic BPEOs have been already been undertaken for the first two elements listed above. This report summarises the findings of the National Strategic BPEO on VLLW.

DEFINITION OF PURPOSE OF THE STUDY AND APPROACH APPLIED

Purpose of the Study

A clear statement of objectives of the study is essential to the success of the BPEO approach and is critical to securing support from stakeholders. The following primary and secondary objectives were agreed by the panel:

- Primary objective - to identify the high-level preferred option for the management and disposal of VLLW in support of the development and implementation of the National Low-Level Waste Strategy.
- Secondary objective - to inform the short-term management action of VLLW at LLWR, near Drigg.

Outline of Study Methodology

The figure below (Figure 1) summarises the key features of the methodology applied throughout the study. Members of the Options Appraisal Panel were fully engaged throughout the process and were instrumental in identifying options, determining the parameters used for options appraisal, appraising options and developing conclusions.

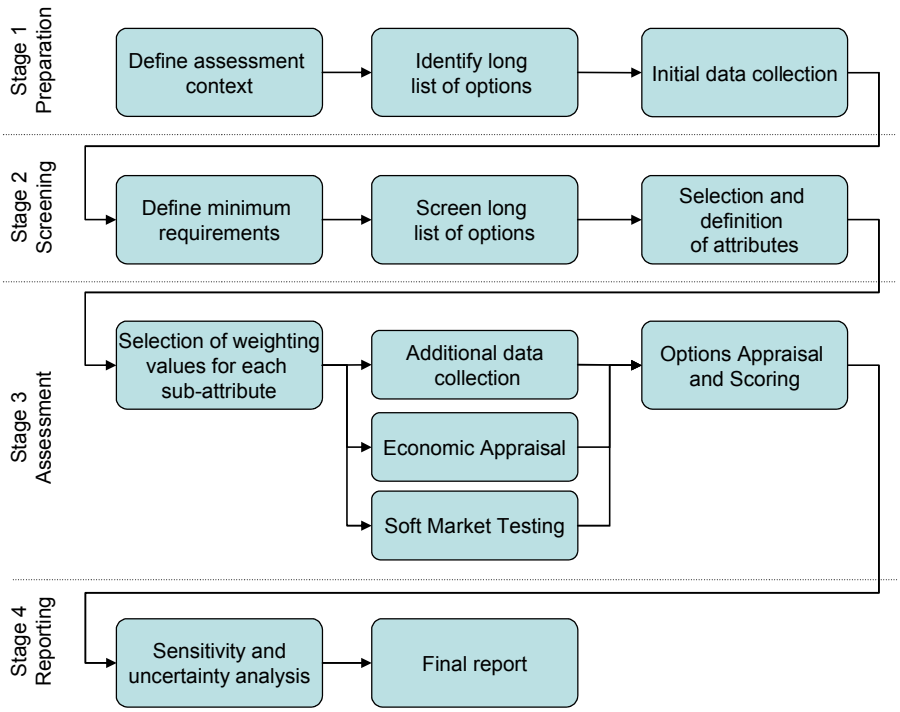

Figure 1 Outline of Key Stages within the Methodology

Identification of Options
As broad a list of possible options that were potentially capable of addressing the defined objectives of the study was required to be generated by the panel. Imaginative and innovative thinking was encouraged to ensure that the list of options was not unreasonably restricted and that additional options were generated as part of workshop.

One of the assumptions made within the study was that the VLLW was already in existence and therefore the option of avoidance (and to a large extent minimisation) was not a practicable option in this context.

Where disposal is unavoidable and necessary, three core considerations summarised as where, when and how were used to help visualise the range of the potential options available. Importantly, the study tried to maintain the process at a strategic level and therefore didn't consider specific techniques which were considered to be tactical implementation of a determined strategy.

Summary of Definitions
In keeping with the three core considerations, the following definitions were used in describing the short-listed options:

Facility Type (When)

- Existing - a facility that is physically in existence (or is currently under construction) even if it has not yet obtained all of the regulatory consents necessary to permit full operations; and
- New - a facility that is yet to be built (implying a potential option that may be available in the future).
- Method of Disposal (How)

- Co-disposal facility- the disposal of radioactive Very Low Level Waste (VLLW) alongside other commercial and municipal waste or separately located within a specific section of the facility (such as a VLLW cell); and
- Dedicated facility - the disposal of VLLW either entirely on its own or alongside other radioactive Low Level Waste (LLW).
- Basis of Facility Location (Where)
- On site/ adjacent – a facility within the boundary of a nuclear licensed site generating the waste (or contiguous to the site boundary), effectively negating the need for any off-site transport. It was acknowledged that there are some differences between on-site and adjacent from a regulatory standpoint;
- Local - a facility that accepts waste from a single site probably within the same or neighbouring planning authority;
- Regional - a facility that accepts waste from more than one nuclear licensed site regardless of where it is located;
- National - a facility that accepts a significant proportion of the national inventory and is available to any site; and
- International – a facility located outside of the UK where the radioactivity would remain outside of the UK.

Options Generated

The Panel was invited to generate as broad a list of possible options potentially capable of addressing the defined objectives of the study. Imaginative and innovative thinking was encouraged to ensure that the list of options was not unreasonably restricted and that additional options to those proposed in the briefing pack were generated as part of workshop. A final list of options was agreed by the Panel for screening.

Minimum Requirements and Screening

A screening process was undertaken to allow the development of a short-list of viable options that would be the subject of more detailed assessment. A list of minimum requirements that an option must be capable of achieving was developed by the Panel. Any option that failed to meet any of the minimum requirements was screened out. The result of this process was a list of 'viable' options that were subjected to further, detailed assessment.
The following minimum requirements (MR) were agreed by the Panel:

- MR1 - Does it / could it exist?
- MR2 - Does it comply with legislation and regulation?
- MR3 - Does it comply with Government policy?
- MR4 - Is it available at a strategic level?

Panel members appraised each of the options against the minimum requirements. Application of the minimum requirements within the first workshop produced a shortlist of options to be investigated further. Table I presents the shortlist of options with the abbreviated codes that were developed to assist the detailed multi-attribute appraisal.

Table I. Shortlist of Viable Options

No.	Option Description	Abbreviation
1	Waste Hierarchy	
1.a.	Reuse of soil and rubble	RA
1.b.	Treatment of VLLW metals to allow recycling	RM
1.c.	Thermal treatment of VLLW combustible waste (with the secondary waste subsequently disposed to an appropriately regulated facility)	TT
2	Decay storage of VLLW to exempt of to specific criteria for disposal	DS
3	Existing co-disposal local facility	
4	Existing co-disposal regional facility	
5	Existing dedicated national facility	
6	New co-disposal on-site /adjacent facility	

7	New co-disposal local facility	
8	New co-disposal regional facility	
9	New dedicated onsite /adjacent facility	NDO
10	New dedicated local facility	NDL
11	New dedicated regional facility	NDR
12	New national facility (accepting either dedicated or co-disposal)	NN

Note: Thermal treatment (TT) was included and screened within the second workshop and was classified as option 1.c.

Definition and Scoring of Attributes

Following the discussions held during the workshops, a series of key attributes for application during the scoring assessment were developed. The Panel held the opinion that site specific details would not allow a strategic view to be taken and that they were deemed to be outside the scope of the study. The attributes identified correspond to the range of factors that are deemed relevant to the identification of a preferred option(s). Where practicable, attributes were independent of each other to avoid double counting.

The attributes chosen adhered to the following criteria:

- Provide a true measure of performance by reflecting all relevant environmental and practicability criteria used in the decision process;
- Where possible, are quantifiable;
- As far as possible, are independent of one another; and
- Reflect considerations at similar levels of detail.

A preference was expressed by Panel members for options to be scored against calibrated scales rather than to be ranked. The calibrated scoring scheme was subsequently discussed, amended where necessary and agreed by the Panel. The calibration scales attempt to consider sub-attributes at a similar level of detail, although it is recognised that the strategic nature of the assessment means that, for some aspects, only generic data can be considered.

Determination of Weightings

For this study a simple weighting system was adopted that weights the scores of each sub-attribute based on an assessment of how influential it is in differentiating between the options. The weighting defined how large the relative spread and importance between the "Best" and "Worst" option was. Importantly, it did not address the significance of the sub-attribute within the scoring (which was assessed by sensitivity analysis). The weightings were one of three values:

- 1 – of low influence with little or no differentiation;
- 3 – of medium influence and/or a moderate level of differentiation between options; and
- 5 - of significant influence and/or providing a good level of differentiation between options.

Overall scoring of the options comprises the sum of the products of the sub-attribute calibrated scores and the weighting score. Weightings were developed by the Panel which was split into the following three groups comprising the LLWR team, Waste consignors (from Nuclear Licensed Sites) and Other (comprising regulators, the NDA and NuLeAF).

Scoring of the Options and Attributes/ Sub-attributes Selected

An output of the Screening Meeting was a list of assessment criteria against which each viable option was assessed. Following the collection of data and agreement of the weighting to be used in the assessment, Entec held an internal scoring workshop to consider all of the evidence assembled. The workshop included authors and peer reviewers to consider the performance of the options against the calibrated scales of the sub-attributes. These scores were then written up and presented to the Panel inviting discussion in the final workshop. The sub-attributes were discussed in order of weighting to ensure sufficient time was afforded to the most important options. Modifications to the original scoring were recorded along with the rationale for the changes. Where consensus could not be achieved the differences in score were recorded and their impacts considered within the sensitivity analysis.

RESULTS AND IDENTIFICATION OF BEST PRACTICABLE ENVIRONMENTAL OPTION (BPEO)

These discussions have been generated to reflect the outcome of the scoring exercise undertaken by Entec and the discussions held by the workshop participants within the final workshop.

General

The management and disposal options progressed to the detailed assessment stage represent the strategic waste management choices available for VLLW. It was the view of the Panel that options presented in this study will be the subject of further assessment and due process at each of the nuclear sites and that the tactics required to deliver the strategy can be tailored to consider and address some of the more site specific issues in more detail. Such tactics should be consistent with the framework provided by this strategic BPEO study and any significant deviation would require robust justification. Panel members recognised within the workshop that a subsequent assessment process will be necessary to ensure that the impacts on the population and the environment from the implementation of the strategy are minimised so far as is reasonably practicable. It was stated by the Panel that the use and reference of this strategic BPEO study should, where appropriate, be cascaded downwards into site policy at each nuclear licensed site.

Results of Scoring Exercise

A systematic and transparent assessment of waste management techniques for the management of VLLW has concluded that there are a number of options that perform consistently well against a range of considerations and influences. The Panel felt that it was not possible for the study to identify a single 'best' option due to variations in the characteristics of the VLLW inventory and other factors, including site specific issues.

Examination of the unweighted scores shows that the options that have the highest relative scores are options consistent with the waste hierarchy i.e. reuse of soil and rubble (RA), recycling metals (RM) and thermal treatment (TT). It is noted that throughout the BPEO study, the scored options (unweighted and weighted) demonstrate congruence with good waste management practice and ultimately the study should contribute to enhanced levels of environmental protection. The lowest scoring option involved continued disposal of VLLW to the LLW repository located near Drigg (Existing Dedicated National – EDN) with new co-disposal local and regional facilities (NCL and NCR) and new dedicated local and national (NDL and NN) also scoring poorly.

The majority of options, all but 5, score within 10% of the highest scoring option with the lowest scoring option (EDN) scoring within 17% of the maximum unweighted score.

Weighted results, using the mean or majority valued weights, are presented in Table II and Figure 2. The options performance is also relatively close with half of the options scoring within 10% of the best performing options (RA and RM). However, the poorest performing option (EDN) now scores only 75% of the highest performing options (RA and RM).

Table II. Weighted Results from Scoring Exercise

Sub-attribute	Mean/majority weighting values	Reuse of soil and rubble (RA)	Recycling metals (RM)	Thermal treatment (TT)	Decay storage (DS)	Existing co-disposal local (ECL)	Existing co-disposal regional (ECR)	Existing dedicated national (EDN)	New co-disposal on-site (NCO)	New co-disposal local (NCL)	New co-disposal regional (NCR)	New dedicated onsite /adjacent (NDO)	New dedicated local facility (NDL)	New dedicated regional (NDR)	New national facility (NN)
1.1 Compliance Risk	**3**	6	12	12	12	12	12	15	9	9	9	9	9	9	9
1.2 Market Appetite	**3**	3	15	15	15	15	15	15	6	9	9	9	9	9	9
2.1a Public protection (op phase)	**5**	25	25	25	25	25	15	25	25	25	15	25	25	25	25
2.1b Public protection (p-c phase)	**5**	25	25	25	15	25	25	25	25	25	25	25	25	25	25
2.2 Societal Risk	**3**	9	9	9	9	3	9	12	9	3	9	9	6	12	12
2.3 Worker protection	**3**	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3.1 Water quality	**1**	3	5	5	5	3	3	3	3	3	3	3	3	3	3
3.2 Air quality	**1**	5	3	3	5	3	3	5	3	3	3	5	5	5	5
3.3 Land quality	**3**	3	15	15	15	9	9	9	9	9	9	9	9	9	9
3.4 Waste Hierarchy	**5**	20	15	10	10	5	5	5	5	5	5	5	5	5	5
3.5 Transport	**3**	6	9	12	9	9	6	9	12	6	6	12	3	3	6
3.6 Energy Balance	**3**	15	9	15	9	9	9	3	3	3	3	3	3	3	3
3.7 Resource use	**3**	15	9	9	3	9	9	3	3	3	3	3	3	3	3
3.8 Nuisance	**3**	9	9	9	9	9	9	15	9	9	9	9	9	9	9
4.1 Capacity	**5**	20	20	10	20	15	15	5	20	20	20	20	20	20	20
4.2 Flexibility	**3**	3	3	3	9	9	9	3	9	9	15	9	9	15	15
4.3 Volume reduction	**5**	20	10	5	25	25	25	0	25	25	25	25	25	25	25
5.1 Impact on other sectors	**3**	9	9	6	12	12	12	6	12	12	12	9	9	9	6
5.2 Local/Regional Economic effects	**3**	12	12	9	9	9	9	9	9	9	9	12	12	12	12
5.3 Effect on value of property	**1**	3	1	1	3	3	3	3	2	2	2	2	2	2	2
6.1 Scope for social effects	**1**	3	3	3	3	4	4	3	4	4	4	3	4	4	5
6.2 Proximity principle	**5**	15	15	15	25	20	10	10	25	20	10	25	20	10	5
6.3 Social burden	**3**	15	15	15	12	9	9	9	6	6	6	6	6	6	6
7.1 Capital and operational Costs	**3**	15	12	12	9	15	15	3	12	15	15	12	9	12	3
7.2 Operational Costs	**5**	15	20	20	15	15	15	15	20	20	20	15	15	15	5
7.3 Balance of residual risks	**3**	25	25	25	5	15	15	15	15	15	15	15	15	15	15
Mean / Majority Weighted Totals		**302**	**308**	**291**	**291**	**290**	**273**	**228**	**283**	**272**	**264**	**282**	**263**	**268**	**245**

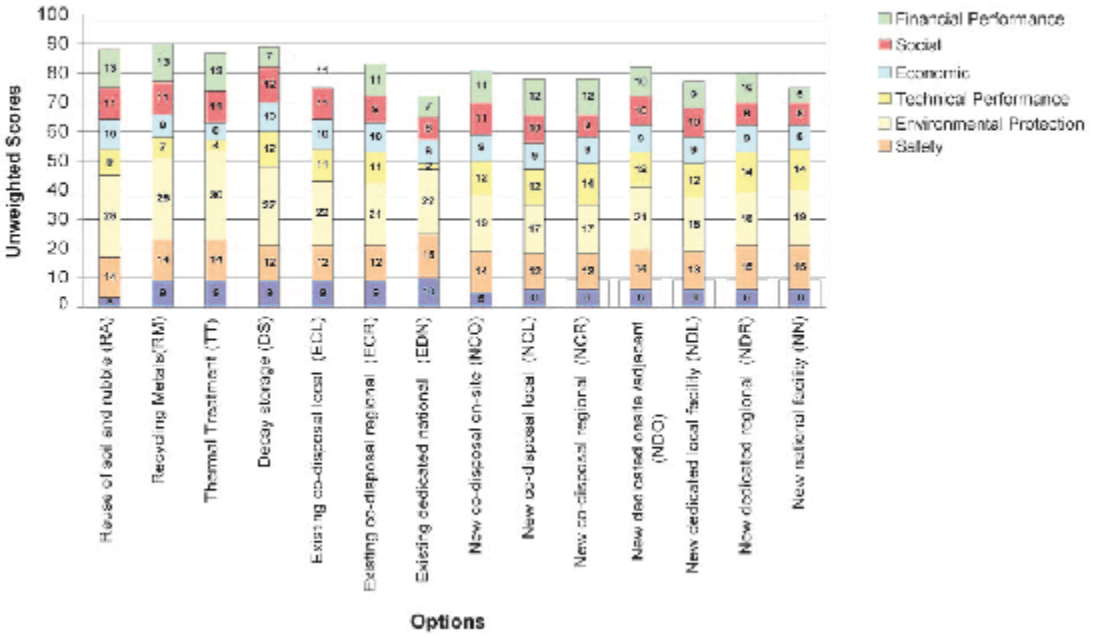

Figure 2. Chart of Weighted Scores

When the mean / majority weighting factors are applied to the scores, the differences between the options are amplified with respect to the magnitude of the weighting. The preferred options from this exercise are generally still representative of the choices that correspond to the waste hierarchy with the reuse of soil and rubble (RA), recycling metals (RM) and thermal treatment (TT) still scoring highly. The disposal options that score highest are identified as an existing co-disposal local facility (ECL), new co-disposal onsite/adjacent (NCO) and new dedicated onsite/adjacent (NDO). The remaining disposal options score at least 10% lower than the best performing option, although all disposal options except the national facilities scores are within 10% of the best disposal option, therefore options do not exhibit enough difference within the weighted scoring to recommend any of these options above another and their implementation will depend upon site specific and local factors.

The options for which the weighted scores were low in comparison to the other options again included the existing dedicated national (EDN) and the new co-disposal local and regional facilities (NCL and NCR) options. The new co-disposal options would appear to be more sensitive to location than the dedicated facility options. There is little differentiation between local, regional and national facilities at this strategic level. There is also no clear distinction between new co-disposal facilities and new dedicated facilities. With the exception of the existing national facility, existing facilities tend to score slightly better than their new counterparts although this situation is dependent upon the local, site specific factors and could change.

These results are generally consistent with the UK Strategy for the Management of Solid LLW SEA that identified the challenge posed by the diminishing capacity at the LLWR and proposed a strategy to ensure availability of management and disposal routes for Low Level Waste (LLW) and Very Low Level Waste (VLLW) by addressing three key themes:

- Application of the waste management hierarchy to extend the life of the LLWR and ensure waste is managed in a risk based, fit for purpose manner;
- Make best use of existing assets (optimise the use of the LLWR); and
- Open and exploit new fit for purpose waste routes (disposal to authorised landfill).

The results within this study recognise that waste producers should ensure better application of the waste hierarchy and optimise the use of the various options that are now available for the disposal of their VLLW waste. Fit for purpose solutions are required for certain waste streams (such as aggregates, metals and combustible wastes) and the calibrated scoring corresponds to the proportion of each stream within the current inventory volumes and composition (i.e. aggregates > metals > combustibles).
The secondary objective of the study is to inform the short-term management action of VLLW at LLWR. The results of the appraisal support the approach proposed by LLWR Ltd which is to provide a range of services that will allow alternatives to disposal in the LLWR vaults and suggest that the use of existing, conventional co-disposal landfills presents potential benefits to the management of VLLW in the short-term. This is further reinforced by the fact that development of a new co-disposal onsite/adjacent (NCO) facility or a new dedicated onsite/adjacent (NDO) facility would be difficult to achieve within the short timescales indicated by LLWR Ltd.

Environmental Assessment
The aim of the Best Practicable Environmental Option concept is to identify, via the structured appraisal process, a preferred option(s) that puts the enhancement and protection of the environment at the forefront of the assessment. Consideration of the performance of options against environmental attributes generally reflects the results observed for the unweighted and weighted scores. Those options promoting the higher levels of the waste hierarchy options (RA, RM, TT and, to a lesser extent, DS) scored well with existing facility options and new dedicated facility options representing the higher scoring disposal options. The existing dedicated national facility scores highly within this attribute section which is to be expected as a high level of engineering is present and the overall increased transport and nuisance impacts are likely to be low because in relation to the present situation. The scoring for the environmental attribute is generally consistent with the overall scores result of the BPEO study and suggests that the environmental factors are appropriately considered.

Uncertainties and Assumptions
The assessment of the options for the management and disposal of HV VLLW inevitably involves the use of assumptions and the identification of risks and uncertainties. A number of uncertainties were identified by the Panel during the review of information related to the sub-attributes. A register was maintained that included commentary on the uncertainties. A series of assumptions was developed by the Panel to address these uncertainties during the consideration and assessment of options. The main uncertainties and assumptions that the Panel considered could impact the scoring are provided below.

VLLW Inventory
Whilst the use of landfill disposal for VLLW (and other LLW) is not expected to significantly affect the remaining UK landfill capacity, the estimated inventory of VLLW totalling approximately 1.8 million m^3 arising over a period of approximately 120 years has some omissions that could represent significant VLLW volumes. Omissions include:

- All VLLW arisings from British Energy and Magnox sites;
- Contaminated land from Sellafield; and
- Undisclosed contaminated land from other sites.

The current available data, noting the omissions above, was assumed to be reasonably accurate and used as the basis for this study. The predicted annual average arising of VLLW is currently in the order of 18,000 m^3. This compares with the total remaining landfill capacity in England and Wales, as of 2006, of 694 million m^3. Total arisings of VLLW therefore represent less than one percent of this total capacity. It is likely, that even if the inventory was to rise by an order of magnitude, the impact would be low and manageable. The study is therefore not considered to be sensitivity to capacity. However, this does not consider the potential large fluctuations in arisings that are dependent on the timings of large decommissioning or remediation projects.
An increase in VLLW volumes may impact on transport and any associated nuisance from transport whether generic or site specific. Transport and local safety impacts are distinguishing factors in choices between waste management options and the transport of radioactive materials is an issue of stakeholder concern. Therefore, as with conventional waste management the principle of proximity between the location of waste arising and the location of treatment and disposal facilities is a key consideration. However, if the actual effects of VLLW transport are found to increase to such an extent that this is an issue, then there is potential for it to become a strong differentiator between options.

Market Appetite

Consultation with waste management operators highlighted that they considered engagement with the public would be critical to the success of accepting VLLW into a landfill and that this engagement would need to be supported by the environment agencies. This would allow unbiased and independent messages to be communicated to the public. The public perception of VLLW will however be affected by the local and national press who can influence public opinion as demonstrated in the case of alternate weekly collections for domestic refuse. The most contentious issue associated with the acceptance of VLLW at landfill sites is expected to be the public's perception of the process and risks involved. Such issues can be addressed through proactive consultation and campaigns to educate and raise the awareness of the issues associated with the management and disposal of VLLW. For the purposes of the study, informed by the soft market testing, it is assumed that market appetite will remain at current levels for the development of VLLW services.

There is currently a desire within the market to accept VLLW into existing sites within England and Wales. There are sites that already accept VLLW and waste management operators consider that VLLW represents a new source of high value revenue in a declining market. The reaction of the public could have an impact on the appetite for some operators to accept VLLW because it may affect their brand name and reputation or it could influence decisions for and on behalf of the local community that are made by regional and local government. Many of the waste management operators who are keen to exploit this opportunity are currently developing their approach to stakeholder engagement and public relations. Market appetite also has a key interaction with 'Compliance Uncertainty' with respect to post-closure liability.

There is some uncertainty related to the reuse of aggregate option in that there is already a market for the reuse of aggregates established in the UK. However, there are some challenges faced with establishing a VLLW feed into this market. It also has to be considered that aggregates from non-nuclear sources are still in some cases disposed to landfill and evidence from suppliers suggests that the reuse of aggregate market is a highly localised one. For the purposes of the study we have assumed that there is a market for the reuse of VLLW soil and rubble. There is also a link to the uncertainties regarding compliance that could affect market appetite and these links are explored in the next section. It is considered that the lack of a market could significantly endanger the viability of the RA option although there may be an opportunity to stimulate and incentivise the market to manage the risks and uncertainties.

Site Specific Factors

Water quality, air quality, land quality and nuisance are sub-attributes that are difficult to assess on a national, generic basis as many of the risks and uncertainties associated with the options are dependent on factors prevailing at each specific site and the precise location and nature of sensitive receptors. The assessment in this study is based on the relative performance of the options against these sub-attributes in the absence of site specific information. Two further observations are made:

The study identified that some of the options have the potential to affect air quality (e.g. incineration) and that changes in air quality may also occur during construction and operation of many of the disposal facilities due to the generation of dust. However the study notes that these impacts can be temporary and can be mitigated locally;

On the whole, the viable options appraised within the study are not expected to exhibit an effect on the land or groundwater quality but, as is the case with land quality, any disposal facility will need to demonstrate that it is compliant with the relevant regulatory risk targets prior to authorisation. On this basis, significant impacts are not expected to arise from the implementation of these options to manage VLLW.

Some of the proposed options considered have the potential to increase nuisance factors, especially during the construction of new waste management facilities or expansion of existing facilities. However, any effects will be dependent on whether it is an existing option (where the impact may not been felt to any great extent) or where such a facility is located (in terms of the sensitivity of the local community and proximity to the waste generator) and at what scale it is implemented. It was assumed that the scale of the facility increases in proportion to the number of waste generators served by the facility.

Waste planning bodies and authorities are responsible for reviewing their Regional Spatial Strategies and preparing Local Development Frameworks for waste. They also have a role as consultees to the environmental regulators during the determination of environmental applications. They are likely to be influential in the implementation of some of the BPEO options. Based on the results of the scoring, this uncertainty is of immediate relevance to RSA93 authorisation applications from existing co-disposal facility operators who currently wish to take radioactive waste from local nuclear licensed sites. It is assumed that an agreement can be reached between the regulators and the waste management operators on the relevant RSA93 conditions in the authorisation.

In the case of all the water quality, air quality, land quality and nuisance sub-attributes, future assessments of specific developments (where appropriate) will be required to identify, characterise and consider the significance of

any such effects and any project level mitigation that may be necessary. It should be noted that there is not always a difference (in scoring) between the location of options, therefore site specific factors could affect their relative performance. The options have been scored on their performance to each sub-attribute assuming that each option is consistent and compliant with the regulatory requirements and that appropriately designed and constructed facility in an appropriate location (including consideration of relevant socio-economic and environmental factors) would not have permission unreasonably withheld assuming it was consistent with the relevant local and regional plans.

Compliance with Current and Future Regulations

One source of compliance uncertainty could be addressed in the near term and resolved during (or following) the determination of a number of applications for RSA93 authorisation applications that are being undertaken by the environmental agencies. Until the first applications are assessed it is difficult to predict the reaction of waste management organisations. An indication of the extent of limitations and conditions that may be applied within the authorisation, how challenging they will be to comply with and the degree to which these conditions and limits extend to the wider, non-radiological determinands will be obtained. Similarly, the timescales and conditions attached to the post-closure institutional management of the facility and the future requirements for surrendering their RSA93 authorisation may also be presented. This will further reduce the uncertainties and allow a more assured judgement of the necessary financial provisions required to cover this liability. The study was scored on the basis that approval would not be unreasonably withheld and, importantly, that any conditions and limitations proposed would be acceptable by the waste management organisation. The impact of onerous conditions being applied could result in the reduced appetite in the market (on commercial grounds) although the consultation process and engagement between the waste management organisations and regulators could mitigate this impact.

The review of Exemption Orders and Schedule 1 RSA93 could result in activity limits being applied on a radionuclide-specific basis. The potential impacts could include changes in waste volumes (which impact the VLLW inventory) but could also beneficially increase the potential opportunities for reuse, recycling and disposal of some wastes. This uncertainty is likely to be adequately addressed by the individual site BPEO studies and, with respect to the sensitivity of the result to change, is expected to be robust. It was assumed for the purposes of scoring that whilst some waste streams (most likely those comprising a single radionuclide) could be affected by the changes, the overall volume of VLLW generated would not be affected by changes in exemption levels enough to significantly change the conclusions of this study. It was also considered that there would be sufficient capacity to deal with any fluctuations in VLLW arisings.

The uncertainty around the NII's position regarding the licensing of dedicated disposal facilities has only recently been clarified. It is now believed that their position will not adversely affect the potential of new dedicated facilities to be built, with only sites storing bulk quantities of VLLW requiring a site licence.

An overall planning risk associated with the extent of planning requirements would have to be addressed in order to secure permission when pursuing the different options has been identified. In theory this might range from there being no requirement to apply for planning permission to needing a full planning permission and EIA. The potential costs and time needed for preparation of a planning application, publicity and consultation and negotiation with the planning authority and statutory consultees may be significant and render some of the options either uneconomical to pursue or result in the refusal of the relevant approvals. The previous assumptions regarding planning permission were applied.

The reuse of aggregates (RA) option requires further consideration to assess the uncertainties around the granting of an RSA93 authorisation to allow what would, from a regulatory perspective under RSA93, technically be a disposal. As the majority of the VLLW inventory is composed of soils and concrete, the study could be sensitive to this uncertainty. It was assumed that this option would be available to all sites and although it is not well developed as an option, it has been performed for at least a couple of sites in Scotland. The impact is potentially large given the significant proportion of the inventory covered by this option. In addition, if obtaining the necessary approvals is problematic or difficult this could acts a disincentive to others looking to pursue this option. It is noted that the LLW Management plan includes actions to develop this route.

Sensitivity Analysis

Three areas of variation and uncertainty were considered in the sensitivity analysis, these were:

- Weighting sensitivity;
- Scoring sensitivity; and
- Response to key uncertainties.

The first two factors looked to establish the robustness of the assessment using the method previously defined to the subjectivities associated with the scoring and weighting process. The third area of analysis explores the implications

of the key uncertainties identified by the Panel in the assessment and aims to establish qualitatively their potential impacts.
It was considered that the approach adopted with respect to the weighting, scoring and response to key uncertainties was robust with the final results showing little sensitivity to the variation in weightings applied. The narrow range of scores, even with weighting factors applied, show that the key uncertainties could affect what would be considered to be the preferred option in a specific situation.

SENSITIVITY TO UNCERTAINTY

Inventory and Capacity

The study assumed that the VLLW waste is a relatively homogenous waste stream. It is recognised that not all of the options are open to the entire inventory. However, it is assumed that any of the options is available to the appropriate waste stream i.e. conditions for acceptance at specific facilities would not, in themselves, limit the options available. There remains considerable uncertainty over the VLLW inventory, data used in the assessment was based on the most recent submissions to LLWR (generally from in 2008). A number of organisations are yet to declare their anticipated VLLW arisings and there are some known gaps in the existing data. It was assumed that the proportion of VLLW calculated from those sites that had declared separate VLLW arisings was consistent with those sites that had not. Improved characterisation and segregation is likely to influence the VLLW inventory, both in terms of waste previously considered LLW being included in VLLW and VLLW being reclassified as exempt. Whilst the recategorisation of waste to exempt levels, either due to improved characterisation and segregation or to changes in policy, may open up more options for management it must be acknowledged that if the waste is disposed of then it still impacts the total available capacity in the UK. The LLW management plan includes work packages to investigate improved characterisation and segregation. This improved assessment of VLLW arisings will help clarify the VLLW inventory, especially for some specific waste streams.
It is qualitatively considered that due to the early stage of deliberation for many of the options, the capacity identified for existing landfill sites, the timescales over which VLLW will be generated and the reliance on some new facilities being built (be it at a onsite, local, regional or national level) that the assessment is particularly robust when considering changes in the VLLW inventory. The information gathered as part of the soft market testing supports the view that, at a high level, capacity is unlikely to be a concern and that there is enough time for considered options to be implemented in order to address volume changes.

Market Appetite

The market response to VLLW is a dynamic and evolving situation. The evaluation undertaken is considered to be reasonably accurate but it is recognised that any number of events could quickly and dramatically change the overall response of the market. The soft market testing identified a number of organisations investing in the options for VLLW management. Regulatory, political, social and economic factors could influence any organisation's progress. The evaluation of uncertainty with respect to market appetite is problematical. During the course of the assessment we have taken results from the soft market testing (completed as part of the same project) as the basis for our scoring and assumed these conditions prevail. As previously indicated, changes in policy or experience of some operators trying to develop the service could influence others in the market and their response. If there is a wholesale withdrawal of interest in the market, this could lead to the earlier development of a new national facility. However, given the number of parties expressing interest in VLLW management, it is considered to be relatively unlikely for all parties to withdraw. Due to the wide variety of possible outcomes it is not possible to evaluate the consequences of the impacts with any certainty.
Existing co-disposal sites seeking permission to accept VLLW and new facilities at a local or regional level are considered to be most exposed to this uncertainty, although each option could be affected differently and depending on the specific circumstances the scoring could be affected in either a positive or negative manner.
The market appetite for the reuse of aggregates has been qualitatively assigned a low score based on the perceived poor market appetite. Should this position change e.g. due to monetary or other incentivisation, then the market appetite could increase markedly.

Compliance Risk and Uncertainty

The impact of the exemption order review is hard to predict and could affect specific waste streams characterised by specific radionuclides. Whilst this could affect the volumes of waste produced it is unlikely to have much of an impact on the implementation of the disposal options. The waste hierarchy options (reuse, recycling, thermal treatment and decay storage) could potentially be more affected by volume changes and any knock on impact on

conditions for acceptance. A reduction in volumes available might mean that it is harder to demonstrate the economic case for investment in some new facilities.
Risks associated with planning approval could potentially impact both new facilities and existing facilities and where changes are required. As these are dependent on a number of local, site-specific factors it is not possible to evaluate their influence as any site specific issues could result in the impacts (and the scoring of these impacts) increasing or decreasing accordingly.
The reuse of aggregate option has been identified to be potentially at risk due to the challenges faced in obtaining authorisation for disposal of VLLW aggregate, especially in areas outside a licensed site. Whilst these should be resolvable until they have been successfully negotiated there remains considerable uncertainty associated with this option. This is recognised and reflected in the LLW management plan developed by NDA and LLWR. If the issues associated with the reuse of aggregate are resolved then the scoring for this option would increase dramatically as the sub-attribute is highly weighted. A situation leading to the exclusion of this option could potentially have a significant affect on the management of VLLW at a national and site level given the high volume of material that falls into this classification.

Site Specific Factors
The impact of site specific factors has not been assessed; the number of factors and the potential permutations make it impossible to come up with any meaningful analysis of site factors at a national level. Notwithstanding this, the evaluation of local factors at a site level is crucial to determine the preferred option(s). The close scoring of the options shows that these local factors would need to be carefully considered. The robustness of a site assessment would be heavily influenced by the quality of the arguments presented for site specific factors.

4.4.4 Sensitivity Analysis Conclusions
The assessment of weighting sensitivity indicates a robust outcome of the assessment with little impact on the relative performance of the options regardless of the method used and with the overall results being consistent with the individual group weighting values.
The assessment of scoring sensitivity further reinforces the robustness of the assessment's outcome with the waste hierarchy options consistently performing well through the different scenarios. Equally, the poorest performing options also score consistently low. There is some variation in ranking in the moderate performing options and this includes some of the disposal options at an onsite, local or regional level.
The assessment of key uncertainties has highlighted that a number of options and sub-attributes could be affected as more information becomes available as positions evolve. Site specific factors have the potential to significantly affect the relative performance of the different options at a local level and therefore need to be carefully considered in any site assessment. The assessment is considered relatively robust to changes in inventory and issues surrounding future capacity of options due to the timescales involved. As time progresses uncertainties associated with market appetite and compliance risk and uncertainty are likely to be resolved; however, the resolution of these factors could affect the scores for individual options either positively or negatively.

CONCLUSIONS
There is little difference between the options in both the unweighted and weighted scoring totals and although it has been possible to identify an option with the highest overall score, it is the recommendation of the Panel within this study that a range of preferred options are pursued.
This study has identified a number of key themes and observations:
- The application of the waste hierarchy to VLLW is supported and reinforced through this study;
- Whilst the performance of the disposal options are broadly comparable;
  - Options that represent existing co-disposal facilities generally scored well together with the new disposal facilities located onsite or adjacent to nuclear licensed sites;
  - On-site disposal scored better than other new disposal facility options;
  - There is little differentiation between new local, regional and national facilities; and
  - Use of LLW Repository at Drigg scores consistently low.
- Depending on the waste stream, site specific issues and the acceptance criteria of any of the options, VLLW may require disposal via an option that does not score highly in this assessment, this may still be consistent with the BPEO where specific arguments and justifications can be made;
- The key uncertainties identified are: inventory; market appetite; compliance and site specific factors. These uncertainties affect a number of sub-attributes including: transport, capacity, compliance risk and uncertainty and market appetite;

• The group of environmental attributes is the single most important group of attributes in terms of weighting scores, accounting for nearly a third of the total points available;
• The key sub-attributes identified in this assessment through a combination of weighting and spread of results are:
- Waste hierarchy;
- Capacity;
- Preservation of LLWR capacity (Volume Reduction);
- Operational cost; and
- Proximity principle.

• The least important sub-attributes (in terms of either low weighting or poor spread) are:
- Public and worker protection;
- Water and air quality;
- Scope for social effects; and
- Economic group of attributes.

The definition of least important sub-attributes in terms of either low weighting or poor spread does not mean that the sub-attributes are not important in their own right. The observation highlights that those sub-attributes do not significantly differentiate between the options.
The results advocate that a scaled response to the management of VLLW is appropriate. Through addressing some of the uncertainties identified and consideration of waste stream characteristics and site specific factors, a hierarchy of options is available to manage VLLW.
The uncertainty surrounding the reuse of aggregates (RA) option is important as the majority of the VLLW inventory is composed of soils and concrete meaning that the outcome of the study could be more sensitive to this uncertainty than any other. It is recommended that serious consideration is given to exploring the level of feasibility of this option together with the stringency of any constraints that affect its implementation.
The assessment of VLLW management options at a national strategic level has indicated that the reuse and recycling of appropriate wastes streams is preferential. Thermal treatment of combustible waste and decay storage may be appropriate for specific waste streams and provide the best solution for those types of waste although they may not be appropriate for a significant proportion of the stated VLLW inventory. It is important to reflect that decay storage may help address the radiological issues of a particular waste stream. In some instances it could open up alternative management routes and could lead to disposal via an alternative route. Therefore, any site or waste stream studies for decay storage must consider the ultimate end point when determining the BPEO at a local level.
The disposal options all achieved, in the main, broadly similar levels of performance although use of existing co-disposal facilities and new disposal facilities located onsite or adjacent to nuclear licensed sites generally scored better than for the other new disposal facilities. There was little differentiation in the location of new sites between local, regional and national facilities although it is important to note that the NDA SEA5 noted that the location of nuclear facilities has been determined by their suitability for nuclear operations rather than as waste disposal sites. It is therefore not necessarily the case that existing nuclear sites are suited to radioactive waste disposal, although they may be suited to other waste management facilities. Notwithstanding this, continued use of LLWR, near Drigg, for the disposal of VLLW is considered the least preferable option.
Importantly, each of the options identified would have some acceptance criteria or conditions for acceptance to facilitate their management. This may result in some waste streams having limited options available to them. As a result, this could lead to disposal in a lower scoring option although (for that particular waste stream) it could still be demonstrated as the BPEO. For example, this assessment does not preclude that there may still be some very specific VLLW waste streams where the BPEO could be disposal at LLWR near Drigg.
A number of uncertainties have been clearly identified in the assessment including inventory, market appetite and compliance uncertainties. Many of these uncertainties have complex inter-relationships. Furthermore, location specific factors, such as the presence and nature of sensitive receptors can affect the relative performance of the options. Therefore, it is strongly recommended that individual sites should carefully review the findings presented in this assessment and reflect on the application of these conclusions to their specific situation.
The conclusions of this study are considered to be consistent with the national LLW strategy and the supporting SEA. It is a recommendation of the Panel that this strategic BPEO study should, where appropriate, be cascaded downwards into site policy at each nuclear licensed site. This report reflects the position at the time of writing. It is acknowledged that VLLW management is in a dynamic state and that changes (for example through the publication

of regulatory position statements or external events in the market) could affect the performance of some of the options.

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FURTHER READING
The full report that presents in detail the approach and outcome can be found by following the links below:

http://www.llwrsite.com/UserFiles/File/customer-docs/StrategicBPEO/StrategicBPEO-VeryLowLevelWaste-Volume1-August2009.pdf

http://www.llwrsite.com/UserFiles/File/customer-docs/StrategicBPEO/StrategicBPEO-VeryLowLevelWaste-Volume2-August2009.pdf