LLW Repository Ltd

Nuclear Decommissioning Authority

LLW Repository

LLW Strategic Review

LLW Strategic Review

Issue 1

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Document History

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CONDITIONS OF PUBLICATION

This LLW Strategic Review was prepared under the auspices of the Nuclear Decommissioning Authority (NDA) by Low Level Waste Repository Ltd. (LLWR). Much of the information utilised in preparation on this report, including project and life cycle costs, waste inventory content and volumes, and site strategies from each NDA site, was based on Lifetime Plan (LTP) 2008 submissions to NDA and/or the National Inventory 2007 returns, as appropriate. In some cases, the LTP information was submitted in draft form to NDA. Each site was requested to review the baseline information for completeness, accuracy of interpretation prior to issue. Future updates of this report will utilise the latest submission of the LTP and waste inventory from each site**.**

Executive Summary

UK Nuclear Waste Management (UKNWM) Ltd. undertook a Preliminary Strategic Review as part of preparation of the Low Level Waste Repository (LLWR) tender in 2006. The review identified a number of potential opportunities to improve Low Level Waste (LLW) management across the UK. From these opportunities, a number of preliminary LLW Topical Strategies have been developed and consulted via the National LLW Strategy Group and the LLWR website during April and May 2008. The Topical Strategies set out potential high-level strategic approaches to improve the application of the waste management hierarchy, waste packaging, transportation and inventory management across the UK.

Given that the Preliminary Strategic Review was undertaken in 2006, there is a need to update this analysis based on the current situation or 'baseline' in 2008. The aims and objectives of this LLW Strategic Review are as follows:

- Establish a credible 2008 UK LLW baseline
- Use the UK LLW baseline to identify where opportunities and synergies exist for integration of waste management on a national, regional or multi-site basis
- Identify ways to help the NDA to reduce LLW costs across its sites by 10% below the baseline

This strategic analysis will inform NDA's strategic decision-making and the development of the Nuclear Industry LLW Strategy and the associated LLW Management Plan. Whilst the objective of this Strategic Review is to identify potential ways to reduce NDA's liabilities by more than 10% it is recognised that this is just one factor that needs to be considered in the context of the overall national LLW strategy. Therefore it is important to recognise impacts in other relevant areas such as the environment, safety, stakeholder acceptance and preservation of the LLWR capacity as a national resource.

The baseline has been measured at 1st April 2008 and was initially compiled by NDA and LLWR on behalf of each site from information provided in Lifetime Plan (LTP) 2008 submissions and/or the National Inventory 2007 returns, as appropriate. Each site was requested to review the baseline to check its completeness and to ensure that the information from LTPs or National Inventory submissions has been correctly interpreted. The UK LLW Baseline can be described in terms of several interrelated aspects namely:

1. Current site LLW management strategies
2. LLW Inventory
3. Costs and liabilities associated with LLW management
4. Assets and infrastructure (existing and planned) for LLW management

Site LLW strategies have been summarised for NDA sites by extracting the relevant sections for LLW from the Integrated Waste Strategies (IWS) submitted with the 2008 LTPs. All NDA sites reference application of the waste management hierarchy principles as a core part of their waste strategy. However, there appears to be significant variation in the practical application of these principles between nuclear industry sites. For the majority of sites, the current baseline disposal strategy for LLW is high-force compaction (where applicable) followed by disposal to the LLWR near Drigg in Cumbria; however, a number of sites are considering opportunities to reduce volumes in accordance with the broader options now available under the Government's Solid LLW Policy. Many sites such as Dounreay, Magnox, Springfields, Sellafield, and Harwell have been evaluating a range of alternative disposal strategies over the past few years, including the potential to dispose of some decommissioning wastes on-site.

The baseline UK LLW inventory at March 2008 has been developed into the latest version of the Waste Inventory Disposition Route Assessment Model (WIDRAM) from the 2007 UK National Inventory and the LTP08 Waste Accountancy Templates (WAT). The 2008 LLW inventory predicts raw arisings to be around 3 million m^3 over the period 2008 and 2129 (the end of LLW generation). This covers a broad spectrum of activity levels and materials including concrete, rubble, soils, plastics, ferrous and non-ferrous metals, and cellulosic materials. This does not include large volumes of potentially-contaminated land yet to be characterised. Approximately 60% of the current inventory has been declared as VLLW or mixed LLW/VLLW. However, some discrepancies have been identified with activity declarations which make it difficult to predict VLLW volume with a high degree of confidence. Analysis on the updated inventory shows around 2.4 million m^3 of LLW will potentially require management at LLWR or a new national LLW repository under the 'business-as-usual' scenario compared with remaining volumetric capacity at LLWR of around 0.7 million m^3, subject to planning and regulatory approvals. A new repository (LLWR2) could therefore be required by 2037, or possibly even earlier if waste currently destined for other facilities had to be disposed to LLWR.

The undiscounted costs in NDA's LTPs for management and disposal of solid LLW generated by operations and decommissioning of NDA's sites is currently estimated at around £9.87 billion. This includes the design, construction, operation, decommissioning of any solid LLW management facilities required in addition to the cost of treatment (characterisation, packaging, conditioning, etc), transport and waste disposal itself. In general, the management of contaminated land and groundwater remediation has not been included although the costs associated with the management and disposal of any material that is already declared as LLW are included. Approximately £2.8 billion is currently included within consignors LTPs for off-site disposal of LLW and VLLW; however, this may not necessarily represent the true lifecycle cost liability of LLWR and LLWR2 that NDA will ultimately incur. The baseline primarily focuses on identifiable solid LLW and VLLW costs residing within every NDA site's LTP08. It is possible that other LLW costs may be embedded elsewhere (e.g. in decommissioning projects) and hence are not currently included in the LLW baseline.

Developing a baseline of the current assets and infrastructure available for the management of the UK's LLW is key to understanding how waste is managed currently and identify potential improvements to optimise the system. Typically all nuclear industry sites have some small-scale sorting & size reduction processes and equipment in addition to monitoring equipment and facilities for loading and packing of Half-Height ISO-Containers (HHISOs) or other containers. Most sites also have low-force compaction (e.g. in-drum) equipment and/or access to a High Force Compaction service at Sellafield for compactable waste via the LLWR contracts. In addition to compaction, some sites employ other wet or dry decontamination equipment ranging from small-scale mobile equipment to larger industrial-scale fixed plants such as the Wheelabrators at Sellafield. A number of NDA and non-NDA sites including Dungeness, Oldbury, Wylfa, Sizewell A, Hartlepool, Heysham, and Hinkley Point B have operational incinerators, primarily for their own waste or the adjoining reactor station. A number of commercial LLW treatment facilities are currently available to waste producers both in the UK and overseas. These services use technologies such as supercompaction, incineration and metal melting. Despite the availability of techniques, facilities, and a supportive regulatory regime under the LLW Policy, there are still large volumes of potentially treatable material disposed to LLWR without significant volume reduction. Part of the reason for this may be the perceived difficulty of opening new routes, lack of authorisations, and absence of financial incentives compared to disposal.

The main facility in the UK for disposal for LLW is the LLWR near Drigg in Cumbria. A smaller on-site disposal facility for LLW and VLLW is to be constructed at Dounreay. A commercial landfill facility at Clifton Marsh is able to accept relatively significant quantities of VLLW (and small quantities of LLW) from Springfields and Capenhurst. There are a small number of other landfills around the UK able to accept small quantities of VLLW from nuclear and non-nuclear industry sites. A number of sites are considering future options for enhanced capability such as characterisation and forecasting, sorting and segregation, decontamination (wet & dry), metal recycling (decontamination & melting), incineration, on-site VLLW disposal and on-site LLW disposal.

This information has been 'rolled-up' to provide a national perspective for the nuclear industry as a whole. The baseline can be used as a benchmark for measuring the effectiveness of potential improvements to LLW management, however it is recognised that there are a number of areas of uncertainty that need to be addressed, the most significant being the LLW inventory. Furthermore the baseline review process has highlighted a number of potential inconsistencies between cost and inventory data within LTPs.

The LLW baseline has been evaluated to identify where opportunities and synergies exist to reduce NDA's cost liabilities of £9.87 billion by more than 10% through integration of waste management on a national, regional or multi-site basis. This has included a detailed cross-cutting review of LLW opportunities identified within LTPs, IWSs, Technical Baseline Underpinning Research & Development (TBURDs), WATs for each SLC to identify common themes and issues.

To ensure consistency with the NDA's LLW Strategy development process the opportunities and synergies identified have been grouped according to the structure outlined in the draft LLW Topical Strategies as follows:

- Application of the waste management hierarchy:
    - Waste Avoidance/Minimisation
    - Waste Characterisation
    - Waste Segregation/Categorisation
    - Waste Treatment
    - Recycle/Reuse
    - Waste Disposal (Exempt/VLLW/LLW)
- Waste Packaging
- Waste Transportation
- Waste Tracking/Inventory Management

Fifty-four potential strategic initiatives have been identified which could provide significant synergies or opportunities to reduce liabilities below the baseline. These initiatives have been qualitatively evaluated using strategic criteria such as the ease of implementation, potential timescales, and the magnitude of the cost-benefits and are mapped onto the matrix below.

Economic Cost-Benefit		Long (>10yrs)	Medium (5-10yrs)	Short (<5yrs)
	High (>£200m)	*Medium Priority* 28, 29, 34, 54	*High Priority* 1, 5, 12, 16, 22, 26, 27	*Very High Priority* 3, 11, 13, 14, 15, 19, 25
	Med (£50-£200m)	*Low/Medium Priority* 30	*Medium Priority* 17, 21, 23, 33, 35, 37, 38, 40	*High Priority* 8, 18, 24, 36, 39
	Low (<£50m)	*Low Priority* 31, 47	*Low/Medium Priority* 9, 32, 41, 45, 52	*Medium Priority* 2, 4, 6, 7, 10, 20, 42, 43, 44, 46, 48, 49, 50, 51, 53
Ease of Implementation: Blue = Straight-forward, Orange = Medium, Red = Difficult		*Timescale to Implement*		

Based on the qualitative evaluation, opportunities have been prioritised and separated into potential 'quick-wins' (i.e. the initiative could be implemented relatively easily and quickly) and those that require significant further work to assess and/or determine how to implement the opportunity. Potential Quick-wins are shown in the table below.

No.	Initiative	Cost Benefit	Priority
3	Incentivise waste minimisation	>£200m	Very High
11	Incentivise segregation of wastes	>£200m	Very High
13	Incentivise treatment of wastes	>£200m	Very High
14	Develop metal treatment routes	>£200m	Very High
15	Develop incineration routes	>£200m	Very High
19	Consolidate R&D on orphan and hazardous wastestreams	>£200m	Very High
25	Develop alternative routes for VLLW disposal	>£200m	Very High
18	Improve efficiency of existing NDA metal decontamination facilities	£50m - £200m	High
24	Develop alternative routes for exempt waste disposal	£50m - £200m	High
36	Use of reusable containers for transport of LLW	£50m - £200m	High
2	Improve consistency of application of NICoP	<£50m	Medium
4	Identify and share waste avoidance and minimisation best practices	<£50m	Medium
6	Consolidate R&D on characterisation	<£50m	Medium
7	Identify and share characterisation best practices	<£50m	Medium
10	Develop guidance on segregation best practices	<£50m	Medium
20	Identify and share re-use and recycling best practices	<£50m	Medium
48	Improve waste forecasting	<£50m	Medium
49	Development of UK LLW Strategy	<£50m	Medium

Collectively implementation of these initiatives could produce a step-change improvement in LLW management practices across the UK and contribute significant savings of over £1 billion to the LLW baseline. In order to realise maximum benefits from these initiatives NDA may need to consider portfolio management of LLW funds. There are a number of initiatives that require further study or consideration which are shown in the table below.

No.	Initiative	Cost Benefit	Priority
1	Standardise waste avoidance and minimisation programmes	>£200m	High
5	Standardise characterisation programmes	>£200m	High
12	Standardise design of waste segregation facilities	>£200m	High
16	Supply chain provide new treatment facilities, capacity and capabilities.	>£200m	High
22	Re-use/recycle waste in new construction projects in nuclear industry	>£200m	High
26	On-site/Near-Site disposal of VLLW on existing NDA sites	>£200m	High
27	On-site/Near-Site disposal of LLW on existing NDA sites	>£200m	High
8	Centralised provision of characterisation equipment and/or SQEP resource	£50m - £200m	High
39	Introduce small modular containers for segregated wastes	£50m - £200m	High
28	Disposal of some LLW to Deep Geological Repository (e.g. long-lived isotopes)	>£200m	Medium
29	Disposal of short-lived ILW in near-surface facilities	>£200m	Medium
34	In-situ management of contaminated land	>£200m	Medium
54	Introduce risk-based classification of radioactive substances and waste	>£200m	Medium
17	Improve efficiency and utilisation of existing incinerators at nuclear sites	£50m - £200m	Medium
21	Develop mechanism for co-ordination of supply and demand for materials	£50m - £200m	Medium
23	Re-use/recycle in new construction projects outside nuclear industry	£50m - £200m	Medium
33	Decay storage of short-lived LLW	£50m - £200m	Medium
35	Develop methods and tools for improving waste packaging efficiency.	£50m - £200m	Medium
37	Introduce inner disposal liners for non-compactable waste	£50m - £200m	Medium
38	Introduce puck overpacks for compacted waste	£50m - £200m	Medium
40	Introduce reinforced bags for VLLW	£50m - £200m	Medium
42	Increased use of rail transport	<£50m	Medium
43	Integration of LLW and spent fuel rail shipments	<£50m	Medium
44	Transport of large components whole	<£50m	Medium
46	Improved waste quality assurance processes	<£50m	Medium
50	Preparation of national strategic option assessments	<£50m	Medium
51	Enhance communications within LLW management community	<£50m	Medium
53	Develop strategy to optimise use of current/future NDA assets	<£50m	Medium
30	Alternative Vault Designs	£50m - £200m	Low/Medium
9	Re-estimate wastestream characterisation	<£50m	Low/Medium
32	Disposal of NORM to alternative facilities	<£50m	Low/Medium
41	Use of transport hubs	<£50m	Low/Medium
45	Simplify waste consignment processes	<£50m	Low/Medium
52	Establish Principles for Decontamination and Decommissioning	<£50m	Low/Medium
31	Optimise closure of LLWR	<£50m	Low
47	LLW records consolidation and archiving	<£50m	Low

Implementation of some or all of these initiatives has the potential to reduce the LLW baseline costs by several £billion, extend the life of LLWR, and have significant environmental and sustainability benefits. It should be noted that a low priority rating in this Strategic Review scoring system does not necessarily mean that the initiative is not important or should not be progressed, merely that it may take longer to realise benefits compared to other initiatives.

The status of these issues should be kept under regular review as the changing funding, regulatory and strategic environment may impact on priorities going forward. Each initiative has been assigned a preliminary 'owner' based on the strategic vehicle or entity from the table below that is most likely to successfully progress the initiative towards the point of implementation in the short-term.

Owner	Description
NDA	NDA develops solution on behalf of its Site Licence Companies (SLCs). This could be delivered via NDA's direct funded work portfolio and frameworks for consultancy and Research and Development (R&D). NDA also has the ability to strategically influence and incentivise its SLC's through funding allocation, contract specifications, Performance Based Incentives (PBIs), and other financial mechanisms.
LLWR	LLWR develops and implements the solution via its consignor support organisation and service contracts. LLWR can influence consignor behaviours through it's pricing strategy and Conditions for Acceptance.
LLW Strategy Group Sub-Committee	A sub-group of the National LLW Strategy Group is formed to work towards developing and implementing the initiative.
Existing Industry Working Group	An existing industry working group is tasked with developing and implementing the initiative. This approach has proven successful with the Nuclear Industry Code of Practice for Clearance and Exemption (NICoP) developed by the Clearance and Exemption Working Group.
Lead Site	Lead site (or sites) are nominated to develop and/or deploy certain solutions on behalf of other NDA sites. This approach has been used successfully within Magnox sites for projects such as melting of ILW pond skips, rail transport trials, and development of on-site disposal proposals.
Individual Site/SLC	Individual site is responsible for developing and implementing initiatives on its own site(s).
Supply Chain	Supply chain funded or appropriately incentivised using market forces to provide the solutions either directly or indirectly to NDA or its SLCs.

These owners are not exclusive and that for some initiatives several (or all) of the entities listed will be required. Alternatively one entity may progress an initiative part of the way and then hand over to a more suitable entity for further development or implementation. It is intended that these arrangements will be consulted with relevant stakeholders via the National LLW Strategy Group and that this forum will be used to report and track progress of key initiatives on a periodic basis.

At this stage, potential cost savings from implementing these initiatives have been qualitatively assessed to aid prioritisation. However, where appropriate, more detailed modelling will be undertaken to underpin and quantify lifecycle savings. A methodology is being developed by LLWR to quantify the costs of implementation and benefits realised at LLWR and its successor in order to support business cases going forward. For those initiatives classified as potential ‘Quick-wins’ the proposed next steps are as follows:

1. Consultation via the National LLW Strategy Group that these represent viable quick-wins
2. Development of implementation plans by the initiative ‘owner’
3. Subject proposal to appropriate stakeholder consultation
4. Develop and submit Business Cases (where applicable) for NDA approval
5. NDA and regulator agreement as required
6. Implementation in LLW Management Plan

These initiatives have been assigned preliminary owners responsible for developing implementation plans in accordance with NDA’s Value Framework process, site funding levels and LLW Policy, legal and planning frameworks at a national, regional and local level. These implementation plans will be documented in the National LLW Management Plan which will set out how the NDA LLW Strategy will be implemented.

For those initiatives that require further study or review, a range of approaches may be used with the depth of consideration and assessment tailored to the scope and objectives of the study. An “Integrated Waste Management” (IWM) process has been developed to provide a structured, flexible, robust and transparent decision-making framework for the development and evaluation of preferred solutions from a national perspective. It is recommended that more detailed consideration is given to the programme, priorities, roles and responsibilities for studying the initiative. These implementation plans and forward programmes will be documented in the LLW Management Plan which will set out how the LLW Strategy will be implemented.

The LLW Topical Strategies will be updated to take into consideration stakeholder comments and the output from this LLW Strategic Review. The updated Topical Strategies will inform the basis of NDA’s Draft LLW Strategy to be published in March 2009 and the associated LLW Management Plan.

The status of these issues should be kept under regular review as the changing funding, regulatory and strategic environment may impact on priorities going forward. It is currently intended that the LLWR SLC will undertake LLW Strategic Reviews every two years in order to revisit earlier conclusions in light of developments within the wider industry decommissioning programmes and changes in the waste management policy and regulatory framework.

Glossary

AGR	Advanced Gas-cooled Reactor
AWE	Atomic Weapons Establishment
BAT	Best Available Techniques
BPEO	Best Practicable Environmental Option
BPM	Best Practicable Means
BSS	Basic Safety Standards Directive
C&M	Care and Maintenance
CEWG	Clearance and Exemption Working Group
CFA	Conditions for Acceptance
CLESA	Calder Landfill Extension Segregated Area
D&D	Decommissioning & Demolition
DEFRA	Department of Environment, Food and Rural Affairs
DfT	Department for Transport
DOE	Department of Energy (United States)
DRS	Direct Rail Services
DV	Detailed Volumes
EA	Environment Agency
EARWG	Environment Agency Requirements Working Group
EO	Exemption Orders
ESC	Environmental Safety Case
EU	European Union
EW	Exempt Waste
FHISO	Full-Height ISO Container
FSC	Final Site Clearance
GBq	Gigabecquerel
GRA	Guidance on Requirements for Authorisation
HFC	High Force Compaction
HHISO	Half-Height ISO Container
HLW	High Level Waste
HVLA	High-Volume Low-Activity waste
HVVLLW	High-Volume Very Low Level Waste
ILW	Intermediate Level Waste
IP	Industrial Package
ITT	Invitation to Tender
IWM	Integrated Waste Management
IWS	Integrated Waste Strategy
LLW	Low Level Waste
LLWR	Low Level Waste Repository
LTP	Lifetime Plan
M&O	Management and Operations
MADA	Multi-Attribute Decision Analysis
MBq	Megabecquerel

MoD	Ministry of Defence
MRF	Metal Recycling Facility
NDA	Nuclear Decommissioning Authority
NI	National Inventory 2007
NICoP	Nuclear Industry Code of Practice for Clearance and Exemption
NNL	National Nuclear Laboratory
NORM	Naturally Occurring Radioactive Materials
OU	Operating Unit
OSD	On-Site Disposal
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)
PBI	Performance Based Incentive
PBO	Parent Body Organisation
PCM	Plutonium Contaminated Material
POCO	Post-Operational Clean-Out
PPE	Personal Protective Equipment
PSWBS	Programme Summary Work Breakdown Structure
R&D	Research and Development
RCA	Radiological Controlled Area
RP89	EC Recommended Radiological Protection Criteria for the Recycling of Metals
RSA	Radioactive Substances Act 1993
SEPA	Scottish Environmental Protection Agency
SLC	Site Licence Company
SNIFFER	Scotland & Northern Ireland Forum For Environmental Research
SQEP	Suitably Qualified and Experienced Person
SSG	Site Stakeholder Group
TBURD	Technical Baseline Underpinning Research & Development
THISO	Third-Height ISO Containers
TRL	Technical Readiness Level
UK	United Kingdom
UKAEA	United Kingdom Atomic Energy Authority
UKNWM	UK Nuclear Waste Management Ltd
US	United States
VLLW	Very Low Level Waste
W&NM	Waste and Nuclear Materials Management
WACM	Winfrith Abrasive Cleaning Machine
WAMAC	Waste Monitoring and Compaction Facility
WAT	Waste Accountancy Template
WCS	Waste Categorisation Study
WIDRAM	Waste Inventory Disposition Route Assessment Model
WMF	Waste Management Facility
WMT	Waste Management Technology Ltd.
WRACS	Waste Receipt Assay Characterisation and Supercompaction facility

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1 Introduction

UK Nuclear Waste Management (UKNWM) Ltd. undertook a Preliminary Strategic Review as part of preparation of the Low Level Waste Repository (LLWR) tender in 2006. The review identified a number of potential opportunities to improve solid Low Level Waste (LLW) management across the UK resulting in extension of the lifetime of the LLWR and reductions in overall liability cost to the Nuclear Decommissioning Authority (NDA).

From these opportunities, a number of preliminary LLW Topical Strategies have been developed to initiate the consultation process between consignor sites, regulators, and numerous stakeholders involved with or affected by solid LLW management. The Topical Strategies set out potential strategic approaches to improve the application of the waste management hierarchy, waste packaging, transportation and inventory management across the UK.

Given that the Preliminary Strategic Review was undertaken in 2006, there is a need to update this analysis based on the current situation or 'baseline' in 2008 for LLW management. Once a revised 2008 baseline has been established it will become the new benchmark for measuring the effectiveness of potential improvements to LLW management.

The aims and objectives of this LLW Strategic Review are as follows:

- Establish a credible 2008 UK LLW baseline
- Use the UK LLW baseline to identify where opportunities and synergies exist for integration of waste management on a national, regional or multi-site basis
- Identify ways to help the NDA to reduce LLW costs across its sites by 10% below the baseline

This strategic analysis will inform NDA's strategic decision-making and the development of the Nuclear Industry LLW Strategy and the associated LLW Management Plan. Whilst the objective of this Strategic Review is to identify potential ways to reduce NDA's liabilities by more than 10% it is recognised that this is just one factor that needs to be considered in the context of the overall national LLW strategy. Therefore it is important to recognise impacts in other relevant areas such as the environment, safety, stakeholder acceptance and preservation of the LLWR capacity as a national resource.

This LLW Strategic Review should be read in conjunction with the *Process for Developing a UK Nuclear-Industry Low Level Waste Strategy* [1] and the *Topical Strategies for LLW Management* [2] consultation documents. This report focuses on the management of solid radioactive wastes. The management of liquid and gaseous radioactive wastes will be considered as part of a separate process by NDA.

2 Background

2.1 UKNWM Preliminary Strategic Review

UKNWM undertook a Preliminary Strategic Review in 2006 as part of preparation of the LLWR tender, which covered critical elements of UK LLW management, including:

- The draft (now published) Government Solid LLW Policy[3];
- Current UK policy and regulatory frameworks for LLW management.
- NDA guidance on waste management;
- Critical examination of UK LLW inventory up to 2129;
- Preliminary strategies for solving the capacity gap and Environmental Safety Case (ESC)[4] based on historical site knowledge and consultant input;
- Potential for application of waste treatment technologies;
- Potential innovations in categorisation, segregation and packaging;
- Current and possible future infrastructure and assets for transportation and disposal.
- Stakeholder engagement requirements;
- Summaries of information learned through attendance at LLWR Site Stakeholder Group (SSG) meetings and UK LLW seminars and conferences;

The review identified a number of potential opportunities to improve LLW management across the UK resulting in extension of the lifetime of the LLWR and reductions in overall liability cost to NDA.

From these opportunities, a number of preliminary LLW Topical Strategies were developed to initiate the consultation process between consignor sites, regulators, and numerous stakeholders involved with or affected by LLW management.

2.2 Formulation of Topical Strategies

Radioactive waste management can be divided into a number of specific aspects or topics. For each topic a strategy or strategic direction can be defined (known as a '*Topical Strategy*') to achieve the NDA's strategic objectives. The approach for solving the LLWR capacity gap was integrated with the approaches for applying the waste management hierarchy at consignors' sites and opening up more fit-for-purpose disposal routes, consistent with revised UK Solid LLW Policy.

The opportunities identified in the Preliminary Strategic Review were divided into a number of draft 'Topical Strategies' which set out strategic direction on various aspects of LLW management. These topics include:

- Application of the waste management hierarchy:
    - Waste Avoidance/Minimisation
    - Waste Characterisation
    - Waste Segregation/Categorisation
    - Waste Treatment
    - Recycle/Reuse
    - Waste Disposal (Exempt/VLLW/LLW)
- Waste Packaging
- Waste Transportation
- Waste Tracking/Inventory Management

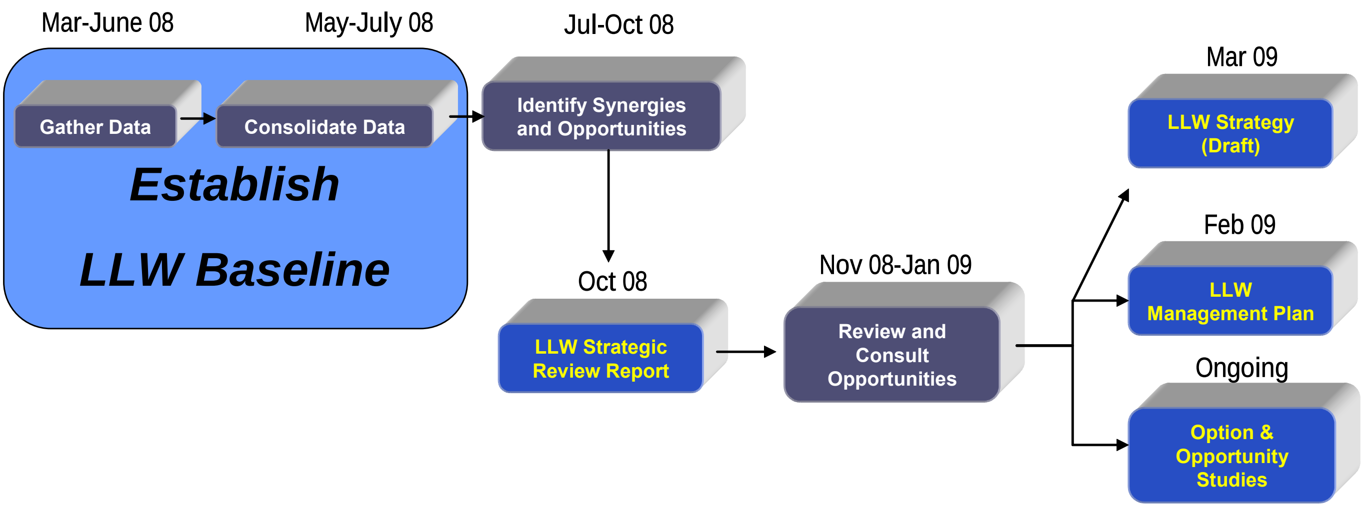
The Topical Strategies were consulted via the National LLW Strategy Group and on the LLWR website during April and May 2008. Comments on the consultation were received from a wide range of organisations including Consignors (NDA and non-NDA), Regulators, NDA Government and Local Authorities. In general the comments were very positive that the Topical Strategies represented a sound strategic way forward, however it was highlighted there may be issues when it comes to detailed implementation of some areas which may require further evaluation and consultation.

A fundamental part of the LLW Strategic review is to consider the impact of implementing the waste management strategies outlined in the Topical Strategies.

3 Strategic Review Process

This process for undertaking the LLW Strategic Review and the links to other parts of the LLW strategy development process is shown in Figure 1 below:

FIGURE 1 – STRATEGIC REVIEW PROCESS



The basic activities at each stage of this process are summarised in Table 1 below:

TABLE 1 – STRATEGIC REVIEW ACTIVITIES

	Activity	Description
1	Gather Data	Collect information and data on LLW management in the UK from a wide range of sources including: o National Inventory 2007 o Integrated Waste Strategies o LTP Technical Baselines o LLW cost data o Option studies/Best Practicable Environmental Option (BPEO) assessments o Various NDA sponsored LLW technical studies
2	Consolidate Data	Information is consolidated to form the UK LLW Baseline for all sites in terms of : o Current site LLW management strategies o LLW Inventory Arisings o Costs and liabilities associated with LLW management o Assets and infrastructure (existing and planned) for LLW management This part of the process also identifies any gaps and commonalities/disparities within the data. Each site was requested to review the baseline to check its completeness and to ensure their data has been correctly interpreted.

3	Identify Synergies and Opportunities	The LLW baseline is then evaluated to identify where opportunities and synergies exist for integration of waste management on a national, regional or multi-site basis and consider the impact of implementing the waste management strategies outlined in the Topical Strategies. Where opportunities were identified a preliminary assessment of feasibility/implementability is made. A list of opportunities and recommendations to save NDA 10% of LLW liability is then compiled and Published in this LLW Strategic Review Report.
4	Review and Consult Opportunities	These recommendations will be consulted with the National LLW Strategy Group. The review has highlighted a number of 'quick-win' opportunities for which the next steps are to: o Develop implementation plans o Subject to appropriate stakeholder consultation o Develop and submit Business Cases for NDA approval o NDA and regulator agreement o Implementation in LLW Management Plan Some solutions could take many forms or have of major significance (e.g. cost or environmental impact) and therefore these issues will be subjected to further optioneering.

Following the LLW Strategic Review the Topical Strategies will be updated to take into consideration stakeholder comments and the output from this LLW Strategic Review. The updated Topical Strategies will form the basis of NDA's Draft LLW Strategy to be published in March 2009.

The LLW Strategic Review will also inform development of the LLW Management Plan which will document in more detail how, when, and where the LLW Strategy is to be implemented. The Draft LLW Management Plan will be developed in parallel with the LLW Strategy and is due to be published in February 2009).

4 LLW Baseline

4.1 Definitions

Low Level Waste is defined in Government Policy[3] as *"radioactive waste having a radioactive content not exceeding four gigabecquerels per tonne (GBq/te) of alpha or 12 GBq/te of beta/gamma activity"*.

Very Low Level Waste (VLLW) is a sub-category of LLW that comprises:

- Low Volume VLLW ('dustbin loads') - wastes that can be safely disposed of to an unspecified destination with municipal, commercial or industrial waste, each 0.1 cubic metre of material containing less than 400kBq (kilobecquerels) of total activity, or single items containing less than 40kBq of total activity. There are different limits for carbon-14 and tritium in wastes containing these radionuclides.
- High Volume VLLW (bulk disposals) – wastes with maximum concentrations of 4MBq (megabecquerels) per tonne of total activity that can be disposed of to specified landfill sites. There is a different limit for tritium in wastes containing this radionuclide.

The principal difference between the two VLLW categories is the need for controls on the total volumes of high volume VLLW being deposited at any one particular landfill site. Low Volume VLLW is generated principally by "small users", while most High Volume VLLW is produced at nuclear sites.

The policy also notes that the definition of LLW might change in future if a new national disposal facility were developed with acceptance criteria different from those for the current LLW Repository (LLWR) near Drigg in Cumbria.

The UK government, in conjunction with the environmental regulators, is currently undertaking a review of the Exemption Order (EO) regime under the Radioactive Substances Act 1993 (RSA 93). Government are considering moving towards a system of radionuclide specific limits in line with the European approach. A formal public consultation will be undertaken by Government during 2009.

In response to the Policy the Environment Agency (EA) and Scottish Environmental Protection Agency (SEPA) are currently developing more detailed guidance on how disposals of LLW and VLLW will be authorised.

4.2 Approach to Baseline Compilation

The UK LLW Baseline can be described in terms of several interrelated aspects namely:

1. Current site LLW management strategies
2. LLW Inventory
3. Costs and liabilities associated with LLW management
4. Assets and infrastructure (existing and planned) for LLW management

The baseline has been measured at 1st April 2008 which coincides with the submission of Lifetime Plans (LTPs) from each Site Licence Company (SLC) and NDA's annual financial reports and accounting conventions.

These baseline aspects have been summarised for each site in the nuclear industry from information provided in Lifetime Plan (LTP) 2008 submissions and/or the National Inventory 2007[5] returns, as appropriate.

The baseline information presented was initially compiled by NDA and LLWR on behalf of each site. Each site was requested to review the baseline to check its completeness and to ensure that the information from LTPs or National Inventory submissions has been correctly interpreted. This understanding of the underpinning data and assumptions was a critical step to provide confidence that the LLW baseline is robust, complete, and can provide a sound basis for analysis in the strategic review.

This information has then been 'rolled-up' to provide a national perspective for the nuclear industry as a whole. The key findings from compilation of the LLW baseline are described in more detail in Sections 4.3 to 4.7 below for each aspect. It should be noted that a number of potential issues and inconsistencies between different data sets were identified during the review process which are discussed in the relevant sections below.

4.3 Current Site LLW Management Strategies

Site LLW strategies have been summarised for each NDA site by extracting the relevant sections for LLW from the Integrated Waste Strategies (IWS) submitted with the 2008 LTPs. This includes a summary of proposed projects and improvements for LLW Management and the top 3 LLW issues for the site. LLW strategies for non-NDA sites have been summarised, where available, from other sources such as IWS's, quinquennial reviews or equivalent documents. These are included for each site in Appendix A.

All NDA sites reference application of the waste management hierarchy principles as a core part of their waste strategy. A number of sites have (or have access to) treatment facilities to reduce waste volumes prior to disposal, such as high-force compaction and incineration. Some sites have also undertaken trial projects with overseas facilities using waste treatment processes such as incineration and melting.

For the majority of sites however, the current baseline disposal strategy for LLW generated from operations and decommissioning is high-force compaction (where applicable) followed by disposal to the LLWR near Drigg in Cumbria. This still remains the 'default' route for most LLW and Very Low Level Waste (VLLW), although many sites are investigating the option of VLLW disposal to a 'specified' landfill in accordance with the broader options now available under the Government's Solid LLW Policy.

Some sites such as Springfields and Capenhurst already have historic authorisations to send VLLW (and some limited quantities of LLW) to the Clifton Marsh landfill. A few sites have other authorisations to send small quantities of VLLW to local 'unnamed' landfills.

Many sites such as Dounreay, Magnox, Springfields, Sellafield and Harwell have been evaluating a range of alternative disposal strategies over the past few years including the potential to dispose of some decommissioning waste on-site.

Some LLW wastestreams do not currently have an available waste disposition route. In addition there are some LLW wastestreams that are currently assumed to be disposed to UK's the deep geological repository. This is principally because the waste radionuclide content or physical/chemical properties do not meet the current LLWR Conditions for Acceptance (CFAs)[6] or contains radionuclides that present particular problems for the LLWR ESC (e.g. carbon-14). Examples include graphite, ion exchange resins, zinc bromide and other orphan wastes.

4.4 LLW Inventory

4.4.1 Introduction

LLW inventory information is currently collected and managed in several databases. These include the UK National Radioactive Waste Inventory and Waste Accountancy Template (WAT) data used to underpin the NDA LTPs / IWS submissions. The Waste Inventory Disposition Route Assessment Model (WIDRAM)[7] (managed by the National Nuclear Laboratory (NNL)) is an integrated dataset for LLW, sourced from the UK National Inventory dataset and WAT submissions from NDA sites.

A detailed analysis of the 2006 LLW inventory in WIDRAM was undertaken as part of the tender process for the LLWR M&O contract. This inventory analysis was updated and revised in 2007 based on the 2007 WAT submissions from NDA sites to evaluate any changes in the data and assess the potential impact on the future capacity of the LLWR under a number of scenarios.

The WIDRAM inventory was extensively updated in 2008 to form the current baseline. The baseline UK LLW inventory measured as at 1st April 2008 has been developed into the latest version of WIDRAM from two key data sources:

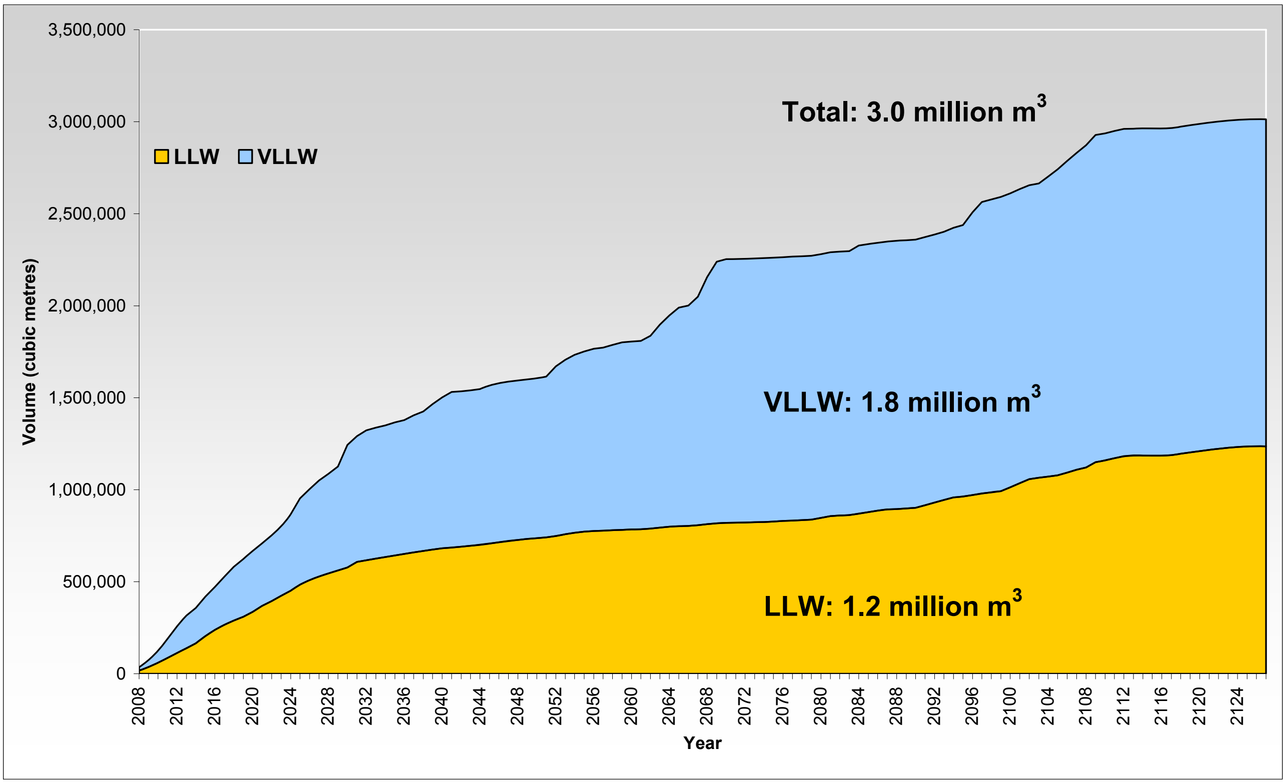
- The 2007 UK National Inventory (NI2007)
- The LTP08 Waste Accountancy Templates (WATs)

A detailed description of the process used to compile the 2008 inventory is included in Appendix B. The inventory is described further in following sections below in terms of volumes, material types, activity levels and disposition routes.

4.4.2 Volumes

The cumulative raw arisings of LLW and VLLW between 2008 and 2129 from the UK nuclear industry are shown in Figure 2 The figure shows that there is a total volume around 3 million m^3 of LLW and VLLW is forecast to be generated up to 2129. Once conditioned and packaged this is expected to increase to 3.1 million m^3. The most significant period of LLW generation is between 2008 and 2031, shown by a steeper slope to the chart. The rate of LLW arisings then slows until about 2090 when the rate of annual LLW arisings increases associated with final site clearance activities on a number of NDA sites.

FIGURE 2 – CUMULATIVE FORECAST RAW ARISINGS OF UK LLW AND VLLW

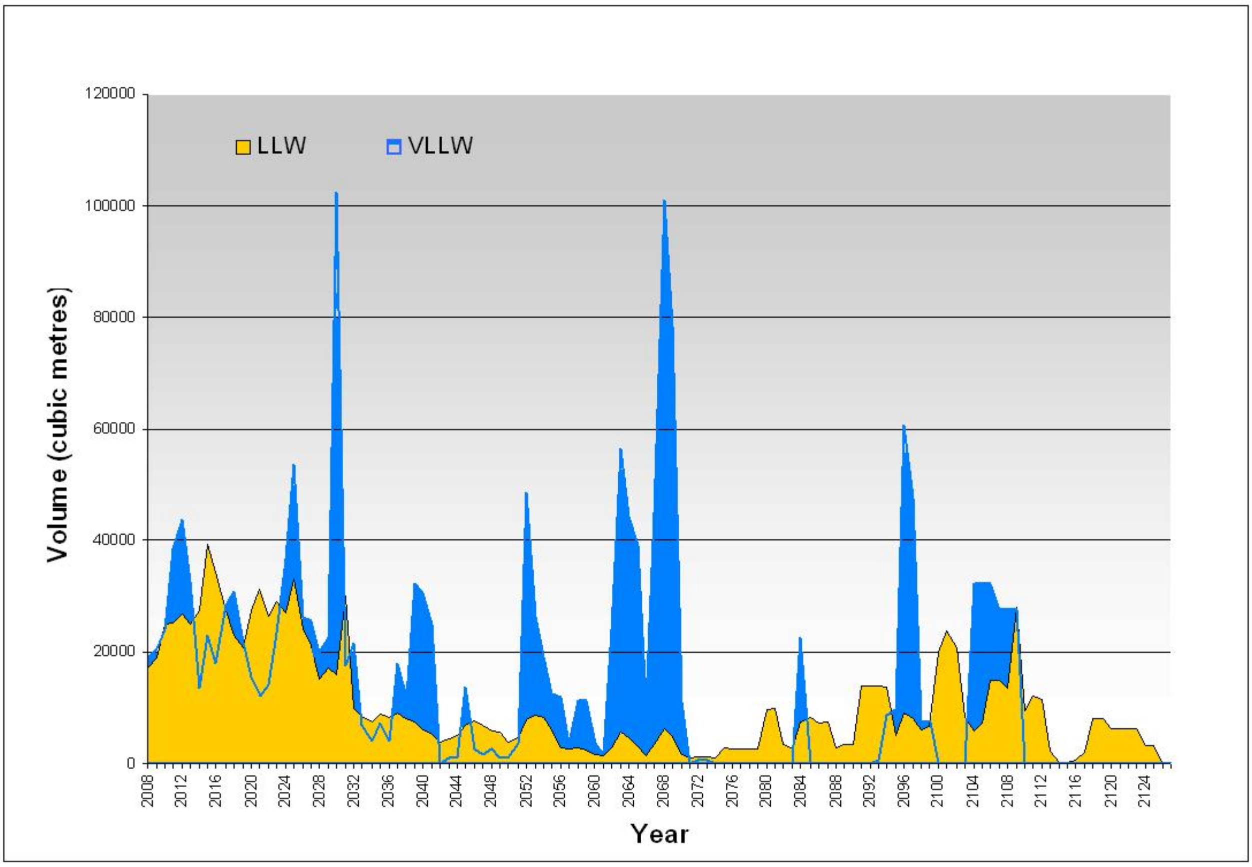


Around 1.8 million m^3 (58%) of the inventory is declared by the waste producer as VLLW. This may include a significant proportion of mixed VLLW/LLW which reflects the historic label of High Volume Low Activity (HVLA) material (<1Bq/g alpha and 40Bq/g beta/gamma) used in the nuclear industry. This aspect is considered further in Section 4.4.4.

It should be noted that the LLW inventory forecast does not include much of the contaminated land at Sellafield (potentially up to 13 million m^3) which is yet to be characterised[8]. The inventory does not include any waste arising from potential new nuclear power stations or the raw stock volume of 155,959 m^3 (194,949m^3 packaged) included in NI2007 for wastes already emplaced into Vault 8 at the LLWR.

Figure 3 shows the raw annual arisings for LLW and VLLW. Over the next 20 years the rate of LLW generation is expected to be between 20,000 and 40,000m^3 per year. Between 2030 and 2080, LLW arisings reduce to approximately 5,000 cubic metres per year, corresponding with the extended periods of reactor care and maintenance. Subsequent peaks of LLW arisings occur due to final decommissioning and site clearance, before tailing off to zero at 2129. For VLLW, the trend is similar to LLW up to 2030 beyond which several peaks of VLLW arisings are expected due to decommissioning activities at Sellafield.

FIGURE 3 – ANNUAL RAW ARISINGS OF UK LLW AND VLLW



The total raw volumes of both LLW and VLLW for each Site Licence Company (SLC) are shown in the Figure 4 and Figure 5 below.

FIGURE 4 – WASTE ARISINGS OF UK LLW PER SLC

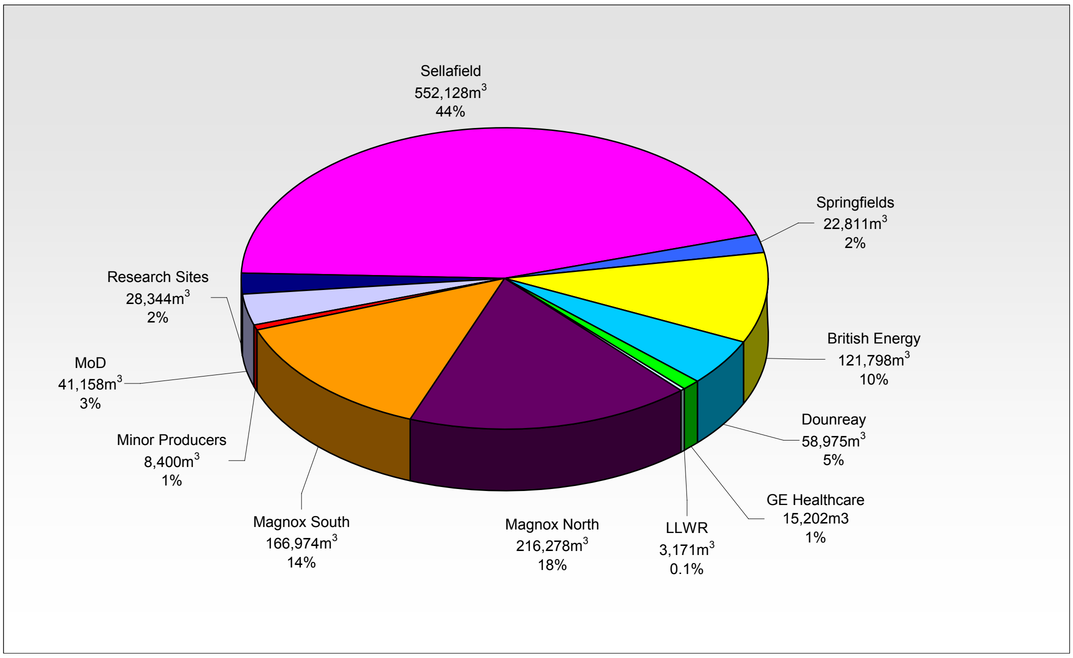
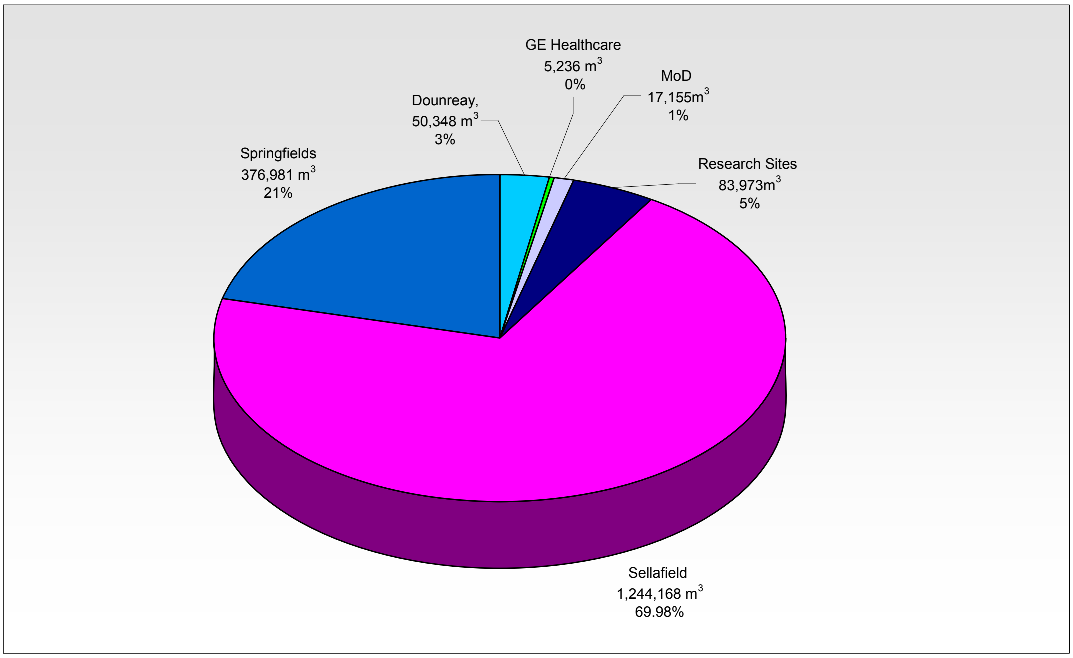


FIGURE 5 – WASTE ARISINGS OF UK VLLW PER SLC



Sellafield Ltd (including Capenhurst) is forecast to contribute just under half of the total LLW and around two-thirds of the total VLLW. There are also notable arisings of VLLW from Dounreay, Research Sites and Springfields. Magnox sites do not currently specify any wastes as VLLW within their inventories although it is expected that in reality, some proportion of the declared LLW will turn out to be VLLW during decommissioning.

4.4.3 Material contents

LLW streams comprise a broad spectrum of materials including concrete, rubble, soils, plastics, ferrous and non-ferrous metals and cellulosic materials. These materials can be classified according to the potential for volume reduction into broad categories of metals, compactables, incinerables and un-compactables. In some cases where waste streams are labelled as 'general' in the WIDRAM database, assumptions about material composition have been inferred from corresponding detailed waste data sheets in the NI2007.

Figure 6 shows the basic proportion of materials to be found in the LLW arisings. Metals (40%) and soil/rubbles (30%) constitute the majority of the material found in LLW.

FIGURE 6 – MATERIAL PROPORTIONS IN RAW LLW ARISINGS (M^3)

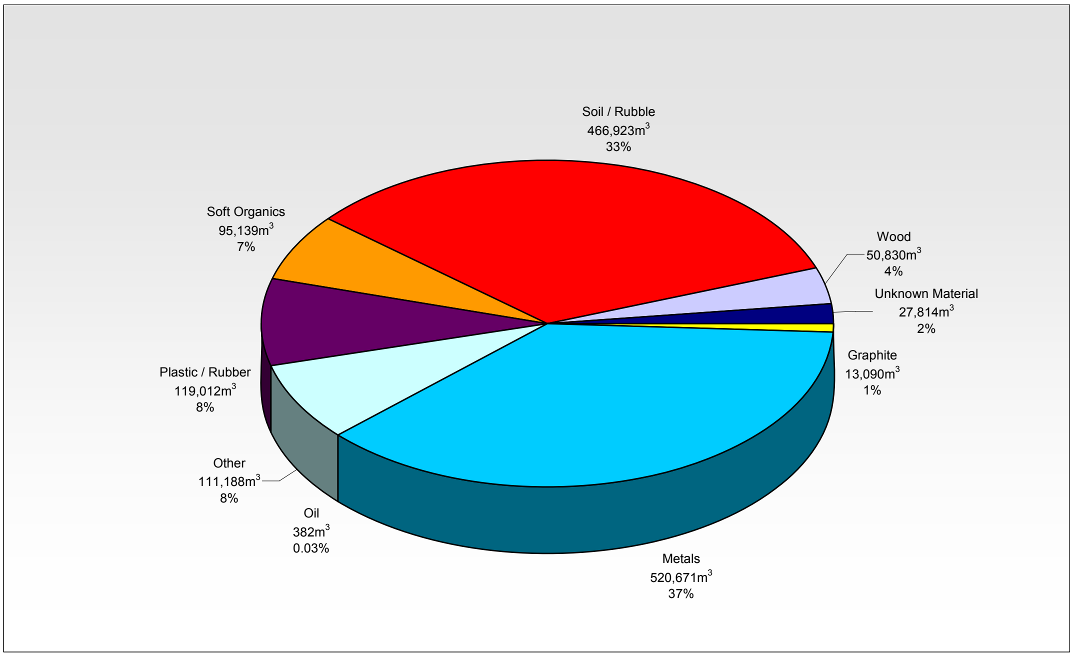


Figure 7 shows the arising of materials in LLW over bands of years. From the Figure it can be seen that the majority of each material group arises over the period 2008 to 2030. Therefore the near-term strategy needs to specifically address these diverse material types.

FIGURE 7 – LLW MATERIALS ARISINGS BY TIME PERIOD

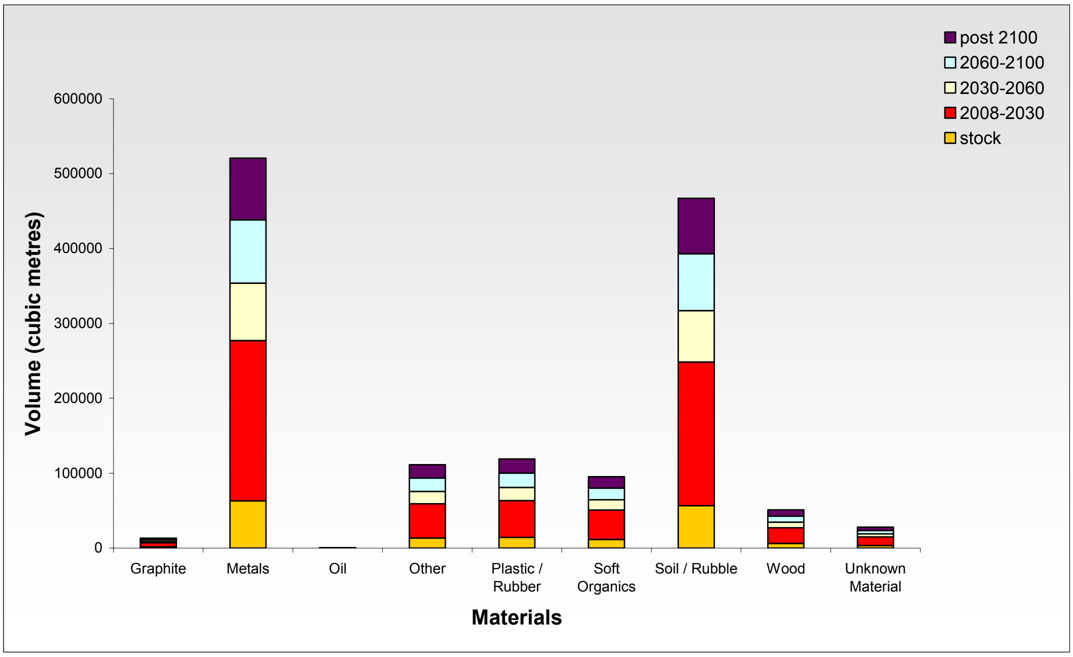


Figure 8 shows the relative proportions of materials in the VLLW arisings. The majority of the VLLW is soil and rubble with metal comprising about a quarter of the waste. Plastics and rubbers represent 5% of the waste and all other remaining materials each constitute less than 1% each of the total volume.

FIGURE 8 – MATERIAL PROPORTIONS IN RAW VLLW ARISINGS (M^3)

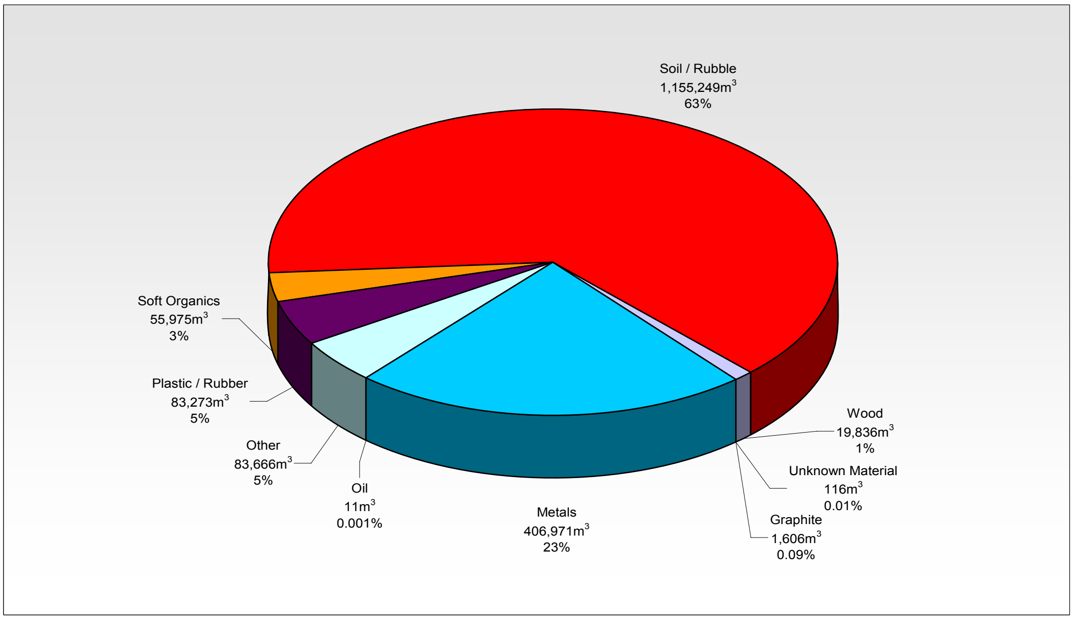
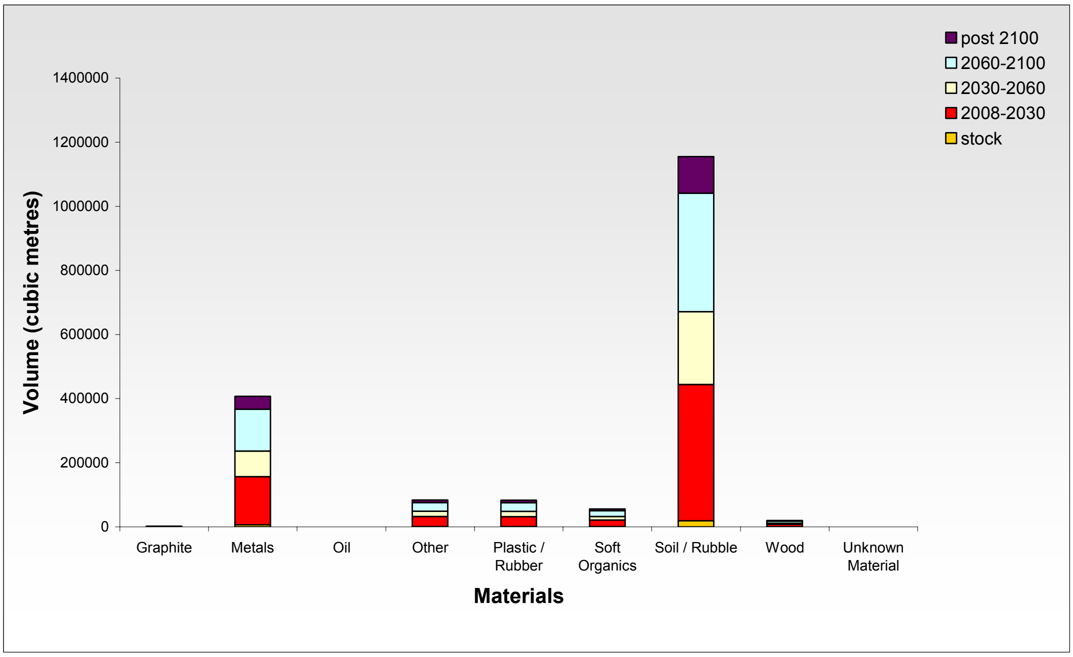


Figure 9 shows the arising of materials in VLLW over bands of years. A significant quantity of VLLW will arise during the period 2008 to 2030. As would be expected, large volumes of soil and rubble are due to be produced post 2060 when final site clearance takes place. A significant quantity of VLLW metals are expected to arise in the short term, suggesting early action to optimise the management of this material by application of the waste management hierarchy

FIGURE 9 – VLLW MATERIALS ARISINGS BY TIME PERIOD

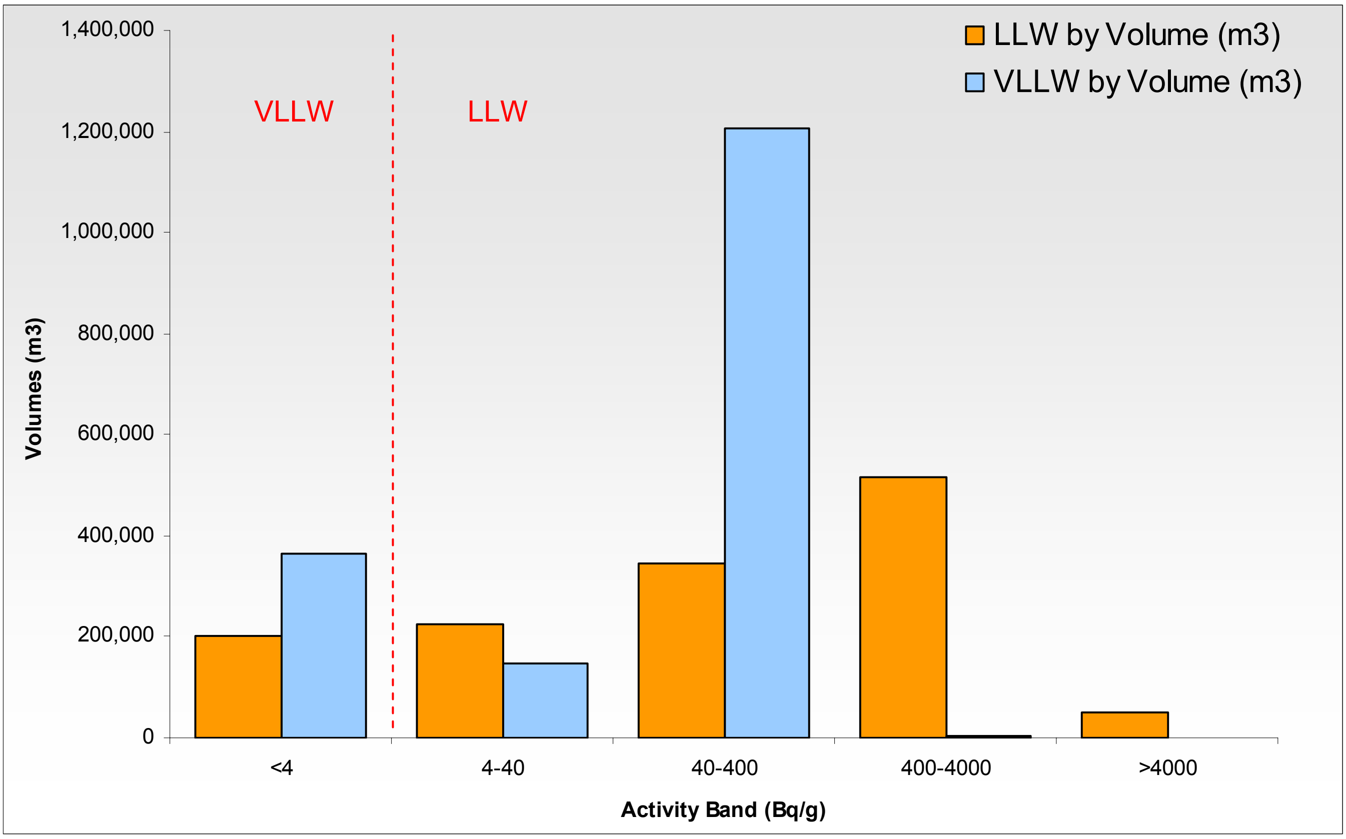


4.4.4 *Activity Distribution*

LLW is defined as radioactive waste having a radioactive content not exceeding 4,000 Bq/g alpha and 12,000 Bq/g beta/gamma. VLLW is defined in the Policy as having less than 4 Bq/g total activity. In addition to volume and material data, waste producers are required to provide radiological data on the activity content of each wastestream. This is reported as 'Total Activity by stream' and is split into specific radionuclides by stream. It should be noted that for some LLW streams no activity information was provided in the WATs and where necessary the corresponding data from NI2007 has been used to complete the dataset.

Analysis of the reported activity data has highlighted significant inconsistencies and some waste streams declared as LLW are in fact VLLW and vice versa. Figure 10 below shows large quantities of waste declared as VLLW, but with total activity values of 4-40Bq/g. Over 1,200,000 m^3 of waste declared by consignors as VLLW lies in the 40-400MBq/g total activity band.

FIGURE 10 – ACTIVITY DISTRIBUTION OF LLW AND VLLW VOLUMES



Furthermore, based on the specific activity declared by consignors in the inventory around 0.2 million m^3 of LLW has activity levels less than 4Bq/g and hence should be classified as VLLW. At face value, the activity data in the inventory would suggest only 0.36 million m^3 of the VLLW inventory is truly VLLW rather than the 1.8 million m^3 declared.

For VLLW, all but 4 wastestreams currently classified as VLLW have specific activities in the inventory of more than 4 Bq/g. Historically the nuclear industry has used an 'unofficial' classification of High-Volume Low-Activity waste (HVLA) which was typically defined as LLW with activity of <1Bq/g Alpha and <40Bq/g Beta/Gamma to represent low-activity decommissioning/site remediation wastes. Although this has now been superseded by the 'official' definition of high volume VLLW in the Policy (i.e. <4Bq/g total activity) it is possible that a number of these HVLA wastestreams which effectively straddle the new Policy definition have been labelled as VLLW.

There may be several reasons for this, such as the lack of detailed characterisation, current lack of specific route for VLLW, or the fact that some wastestreams may be partly LLW and partly VLLW, but are declared as either LLW or VLLW.

Based on experience of actual decommissioning projects both internationally and in the UK, it is expected that there will be large volumes of VLLW arising from decommissioning and much of the volume currently classified as LLW will ultimately turn out to be VLLW or exempt. Given the current discrepancies within the inventory it is difficult to estimate these proportions with a high degree of confidence.

4.4.5 Disposition Routes

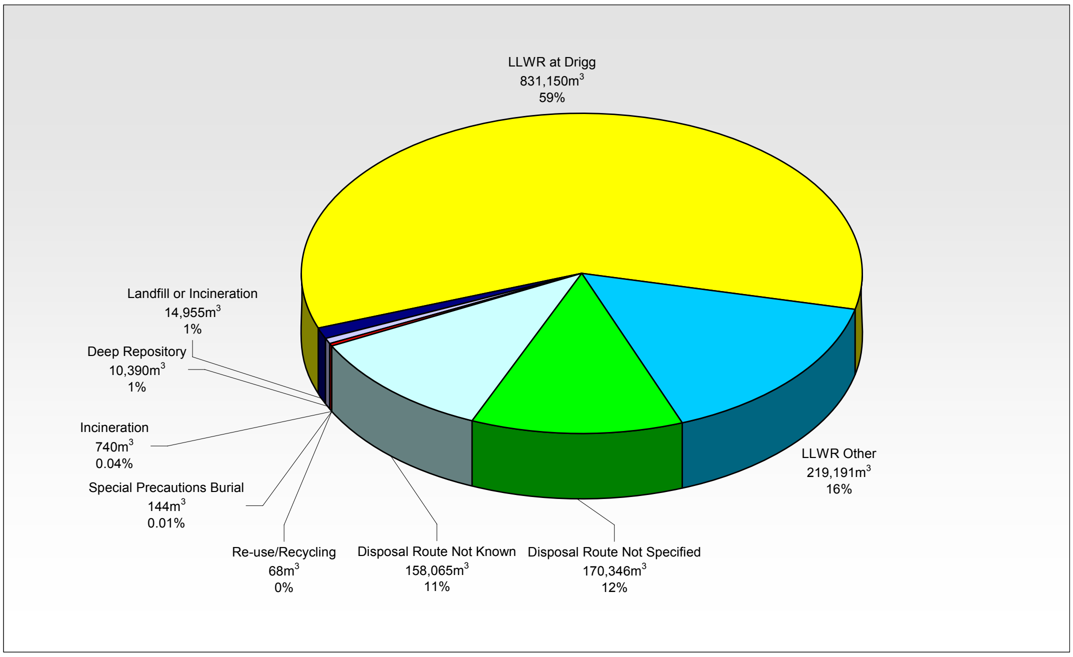
Within the WATs and the NI2007 the waste producer has a range of options to specify the disposition routings for each wastestream. Not all LLW is destined for disposal at the LLWR. Some waste is planned to be sent to landfill such as Springfields and Capenhurst waste, Dounreay waste is destined for an on- or near-site repository and some wastes are scheduled for disposition at an incineration facility. The routings used in WIDRAM are shown in Table 2 below along with the types of wastes that are typically included under each category.

TABLE 2 – EXAMPLE WASTE ROUTINGS SPECIFIED BY WASTE PRODUCERS

Disposal Route Category	Includes
LLWR at Drigg	Existing LLWR or replacement LLWR (where waste arises after 2050)
LLWR Other	Suitable for LLWR at Drigg, but arises beyond 2050 so waste producer has assumed will go to replacement LLWR
	Dounreay disposals to new LLWR facility at or near Dounreay
	Identified as not suitable for disposal to LLWR at Drigg but no other route determined
	Potentially will go to a local, purpose-built LLWR (e.g. in-situ at reactor site)
Disposal Route Not Specified	Disposal route left blank in WAT or NI by waste producer
Deep Repository	Disposal to National ILW repository
Disposal Route Not Known	Disposal route identified by waste producer as 'Not Known'
Incineration	Incineration at a named or unspecified site
Landfill or Incineration	Waste producer has identified two potential routes
	Landfill at unspecified site
	Capenhurst disposals to Clifton Marsh
	Sellafield disposals to Calder Landfill Extension Segregated Area (CLESA)
Re-use/Recycling	Will be reused or recycled
Special Precautions Burial	Springfields disposals to Clifton Marsh
Controlled Burial	Dounreay disposals to new LLWR facility at or near Dounreay
	Harwell disposals to unspecified landfill site

Figure 11 shows the proportion of packaged LLW volume currently specified for each disposition route.

FIGURE 11 – TOTAL LLW VOLUME (M^3) TO EACH DISPOSITION ROUTE (PACKAGED)



Of the total forecast packaged LLW volume of 1.3 million m^3, over half is currently labelled as disposed to 'LLWR at Drigg'. Some of this waste arises after 2050. It should be noted however that the waste labelled as 'LLWR Other' represents a wide range of routes including:

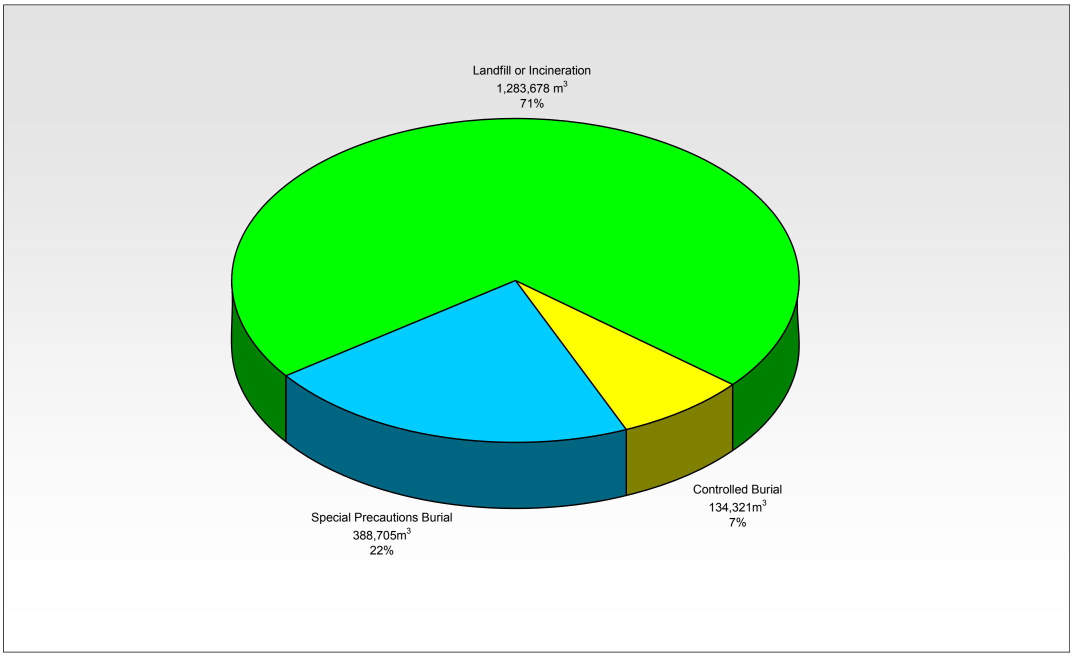
- Waste suitable for LLWR at Drigg, but arises beyond 2050 so waste producer has assumed will go to replacement LLWR
- Dounreay disposals to new LLWR facility at Dounreay
- Identified as not suitable for disposal to LLWR at Drigg but no other route determined
- Potentially will go to a local, purpose-built LLWR (e.g. in-situ at reactor site)

The majority of the waste labelled as 'Disposal Route Not Known' is contaminated land or waste from final decommissioning and clearance of Magnox and British Energy reactor sites.

This suggests that a significant proportion of the waste declared as 'LLWR Other' and 'Disposal Route Not Known' could potentially be destined for LLWR or its successor national repository facility in the absence of an alternative management strategy. The strategic implications of this are discussed further in Section 4.4.7 in terms of impact on LLWR capacity.

Figure 12 shows the disposition route for VLLW arisings. The UK National Inventory uses a single qualifier to denote either Landfill or incineration and this detail cannot therefore be split for the figure. None of the VLLW identified in the baseline has LLWR as the disposition route.

FIGURE 12 – TOTAL VLLW VOLUME (M^3) TO EACH DISPOSITION ROUTE (PACKAGED)



The Government's Solid LLW Policy published in April 2007 allowed disposal of VLLW to specified landfills where this is the BPEO. In response, a number of sites changed their waste routing assumptions from LLWR to the 'Landfill or Incineration' route in 2008. Presumably this was in expectation that a change to authorisations would be forthcoming in early 2008. The Environment Agencies are developing guidance on how this route is to be regulated and hence only a limited number of historic authorisations to dispose of VLLW to landfill currently exist.

It is therefore appropriate to adjust the baseline VLLW disposition routings to reflect the real status of site authorisations at April 2008. The strategic implications of this are discussed further in Section 4.4.7 in terms of impact on LLWR capacity.

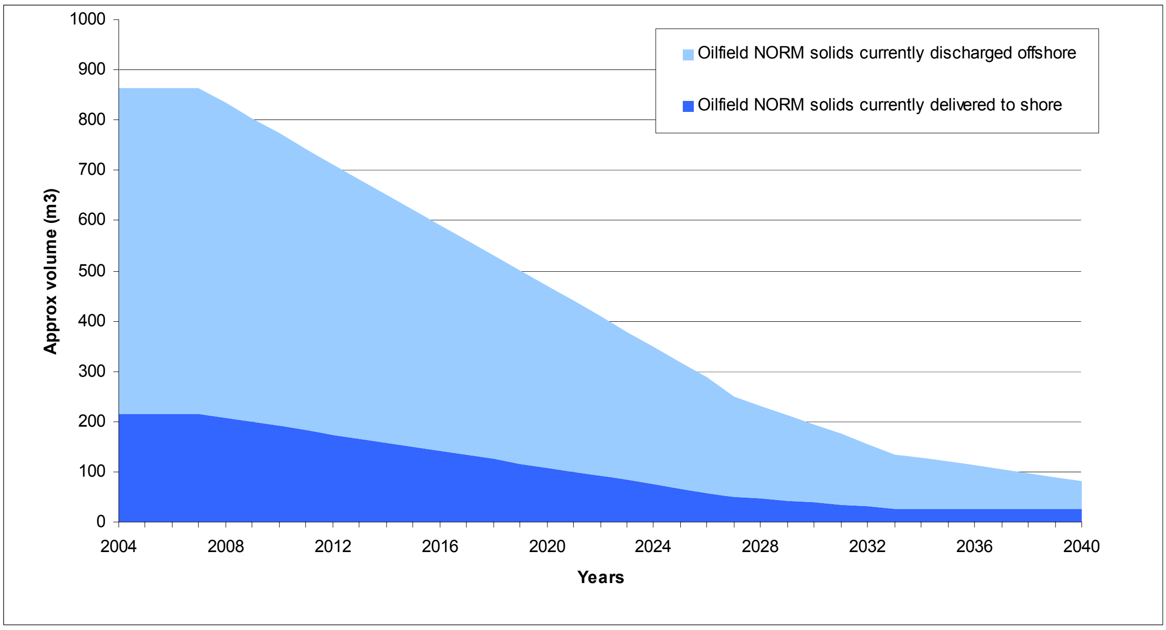
4.4.6 Non-Nuclear Industry Volumes

Smaller quantities of LLW and VLLW are generated from numerous of non-nuclear industry users of radioactive materials, including hospitals, pharmaceutical, research and educational organisations, and the oil and gas industries. These organisations use a range of treatment and disposal routes including incineration, landfill and LLWR. Wastes from these organisations do not arise in significant volumes.

A recent SNIFFER report[9] estimated that in 2005 approximately 3,600 tonnes of 'primary' VLLW was produced by non-nuclear organisations (excluding the oil and gas industry). The vast majority of the activity (>86%) in primary VLLW is associated with short-lived radionuclides with half-lives less than 30 years. A survey of these VLLW producers indicated that 52% of VLLW was incinerated and 48% sent for landfill. Incineration produces approximately 20,000 tonnes of 'secondary' VLLW consisting of ash and off-gas treatment residues which are sent to landfill. The reason for this increase in mass from primary to secondary is thought to be associated with the addition of other non-radioactive wastes for co-incineration.

The oil and gas industry is another significant producer in the non-nuclear industry which produces wastes contaminated with Naturally Occurring Radioactive Material (NORM). This is typically in the form of scale within the internals of pipework and equipment used to extract oil. A report commissioned by the NDA in 2008 reviewed NORM waste volumes and the potential impact such volumes may have on the LLWR[10]. Figure 13 shows the approximate volume of oilfield NORM solids forecast to arise in the UK from 2004 up to 2040, beyond which time it is expected that arisings will be minimal. These wastes are generally unsuitable for compaction and therefore disposal volumes could be up to 2 times greater.

FIGURE 13 – NORM WASTE ARISINGS OVER TIME



Currently most NORM waste is discharged to sea; however future changes to the regulatory regime may require more of this waste to be disposed to an appropriate solid waste management facility. A recent ruling from the Scottish Government has concluded that discharge to sea is not the BPEO. Thus, new arrangements to manage NORM waste will be required in the future. Although all this waste is presumed to be LLW, between 17% and 47% of the NORM scale waste disposed of at the Scotoil facility in the years 2000-2005 would have been classed as exempt.

Options for disposing of solid NORM are currently very limited. The management of NORM wastes at LLWR may have significant implications due to the relatively high radium and thorium levels. These nuclides present particular challenges to the LLWR ESC.

The UK Government is currently developing a strategy for management of non-nuclear industry LLW. In some cases the non-nuclear strategy may look to utilise the capabilities and capacity of waste management facilities within nuclear industry, such as the LLWR.

4.4.7 Impact of Volumes on LLWR Capacity

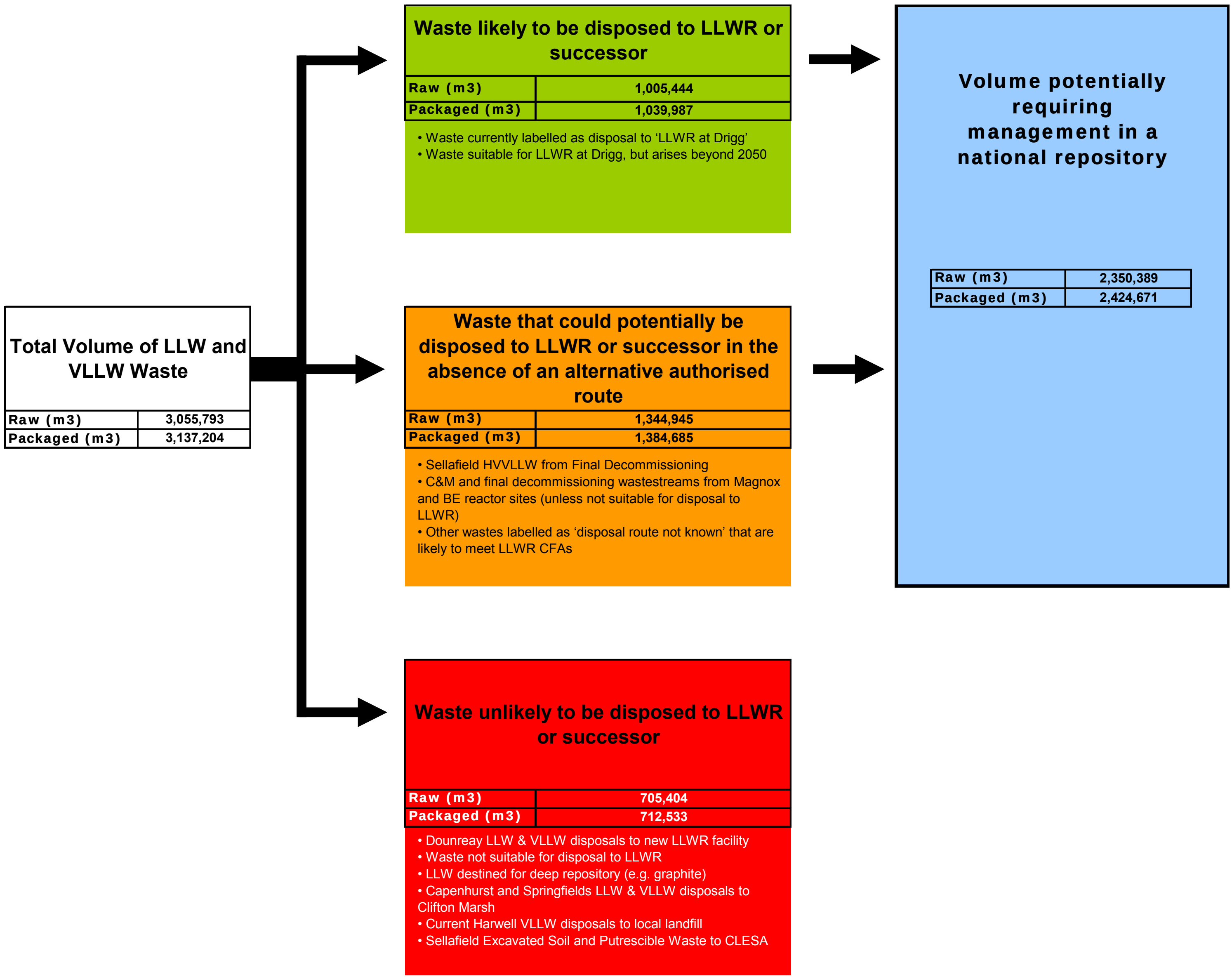
Over 60% of the forecast LLW inventory is currently labelled as disposal to 'LLWR at Drigg'. As discussed in Section 4.4.5 above, there are several LLW wastestreams labelled as 'LLWR Other' and 'Disposal Route Not Known' that may not currently have definitive alternative management strategies other than disposal to a national LLW repository. For the purposes of this baseline analysis, it is therefore appropriate to plan on the basis of accommodating some of these wastes in LLWR or a successor national repository. For VLLW, it is necessary to re-visit the waste routings specified in Figure 12 to reflect the real baseline situation at March 2008 with regard to site authorisations (i.e. that in the absence of an authorised route the waste is assumed to be disposed to LLWR). From a baseline perspective, this will remain so until appropriate alternative routes are secured for these wastestreams.

In order to understand the potential impact of LLW and VLLW arisings on the capacity at LLWR and its successor facility the disposition routes of each wastestream have been re-categorised as follows:

- Waste unlikely to be disposed to LLWR or successor
- Waste that could potentially to be disposed to LLWR or successor in the absence of an alternative authorised route
- Waste likely to be disposed to LLWR or successor

The total packaged volume for all LLW and VLLW waste of around 3.1 million m^3 has been classified according to its likelihood of being disposed as shown in Figure 14 below. This includes examples of the types of wastestreams classified under each assumed disposition route. It should be noted that this classification requires a certain degree of judgement with respect to the certainty of an alternative management strategy being in place at March 2008.

FIGURE 14 – ASSUMED DISPOSITION ROUTES



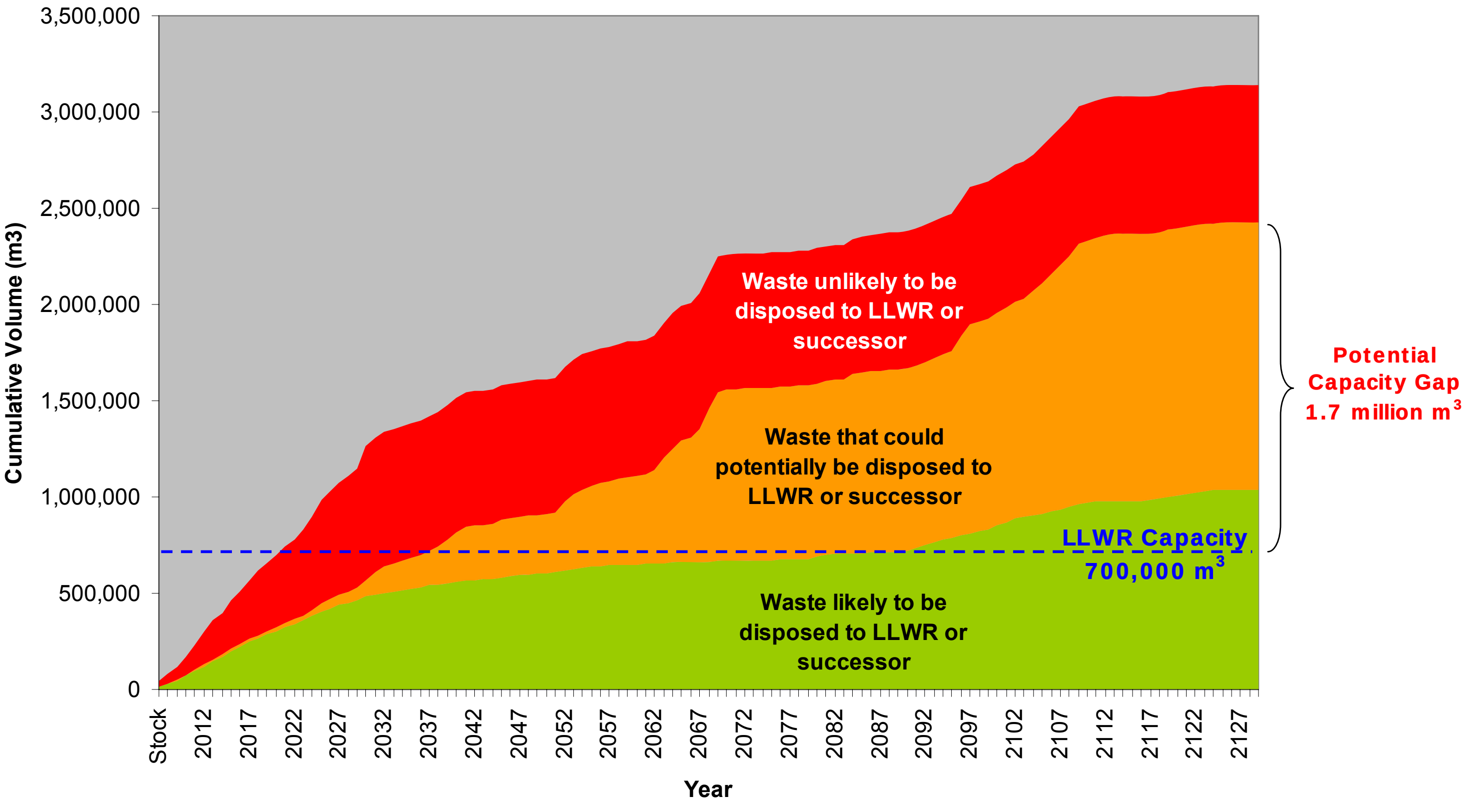
Note: The assumed routes are subject to authorisations being granted/extended

For the purposes of the baseline analysis, it is therefore assumed that 2.4 million m^3 potentially will require management at LLWR or a new national LLW repository.

In comparison to the forecast 2.4 million m^3, the remaining volumetric capacity at LLWR is around 0.7 million m^3, subject to planning and regulatory approvals for Vaults 9-15 and sufficient radiological capacity. The total forecast volume of LLW significantly exceeds the remaining volumetric capacity of the

LLWR and therefore the remaining 1.7 million m^3 must be accommodated in a new repository. The profile of waste arisings over time is shown in Figure 15 below:

FIGURE 15 – BASELINE PACKAGED VOLUME ARISINGS AND LLWR CAPACITY



Analysis on the updated inventory shows the LLWR could be full as soon as 2037 under the 'business-as-usual' scenario (i.e. minimal implementation of the waste management hierarchy and limited use of alternative waste disposal routes). This would require all ESC issues to be fully resolved and planning permission be obtained for Vaults 9 through 15. The vaults would also need to be constructed in time to accommodate the waste. If the waste currently destined for on-site disposal at Dounreay and waste disposed to Clifton Marsh was to be disposed to LLWR, the facility could be full before 2020. Once the LLWR is full, an alternative route such as a new LLW repository (or repositories) will be required to accommodate the remaining inventory.

4.4.8 Inventory Issues

As mentioned previously, LLW inventory information is currently collected and managed in multiple datasets. These include the UK Radioactive Waste Inventory, WIDRAM (managed by NNL) and data used to underpin the NDA LTPs / IWS submissions. These datasets are not always consistent due to different reporting formats, timescales and underpinning assumptions. It should be noted that the comparison of the 2008 WATs with the NI2007 showed a larger number of differences between the two data-sets than was originally anticipated prior to the receipt of the data sources. The original assumption was that the volume and structure of wastestreams in the WATs would be similar to NI2007 and only a small number of significant changes would be observed. Upon receipt of all of the information it was clear that there were very significant variations between the NI2007 and the WATs.

This variance was particularly marked within the Sellafield data. Following consultation with Sellafield it was agreed that the WIDRAM 2008 baseline would be most realistically represented by combination of wastestreams sourced from the WAT 2008 and NI2007. It should be noted that the Sellafield wastestream specific data in WIDRAM does not take into account the impact of the planned waste treatment plants.

Although recently the WAT and national inventory datasets have been converging, further work is needed in order to improve and refine the LLW dataset that can be used to improve the accuracy of short-term forecasting, liability estimating and strategic planning.

The review of the activity levels assigned to specific waste streams has identified that over 1 million m^3 of waste specified as VLLW actually appears to be LLW. Conversely over 0.2 million m^3 of LLW streams appear to state VLLW activity levels. This highlights a need to improve consistency in the categorisation or characterisation of wastes within the baseline.

There are a number of materials that are not currently included in the LLW inventory the most significant of which is potentially contaminated land. A significant amount of further characterisation is necessary across a number of NDA sites to define the potential size of the problem. The ultimate quantity declared as LLW or VLLW (potentially up to 13 million m^3) and subsequent management strategy will significantly impact on LLW strategy. A report was produced which discusses radioactive materials not included in NI2007 in more detail[8].

The move towards an integrated LLW inventory data source containing accurate and appropriate information will enhance confidence in the strategic analysis of improvements of treatment/disposal practices. This is discussed further in the Section 5.5 of Synergies and Opportunities.

It is currently unclear what impact the ongoing Government EO review will have on the LLW inventory. Government are considering moving towards a system of radionuclide specific limits in line with the European approach. This may result in some material currently classified as LLW becoming exempt, whilst some material currently below the exemption threshold of 0.4Bq/g may fall within LLW.

4.5 Costs and Liabilities

A LLW management cost baseline for 2008 has been established to inform NDA's strategic decision-making. The costs and liabilities faced by NDA for LLW management includes the full lifecycle costs for management and disposal of solid LLW and VLLW generated by operations and decommissioning of NDA's sites.

This includes the design, construction, operation, decommissioning of any solid LLW management facilities required in addition to the cost of treatment (characterisation, packaging, conditioning, etc), transport and waste disposal itself. The costs associated with the in-situ management of contaminated land and groundwater remediation have not been included, although the cost associated with the management and disposal of any material treated as LLW are included.

The NDA's standard Programme Summary Work Breakdown Structure (PSWBS) [11] has been used to identify areas where these LLW costs are likely to reside within the LTPs of all NDA all sites. The baseline primarily focuses on identifiable solid LLW and VLLW costs residing within every NDA site's LTP08. It is possible however that other LLW costs may be embedded elsewhere (e.g. in decommissioning projects) and hence are not currently included in the LLW baseline. A detailed description of the process used to compile the 2008 cost baseline using the NDA's PSWBS Dictionary[12] and is included in Appendix C.

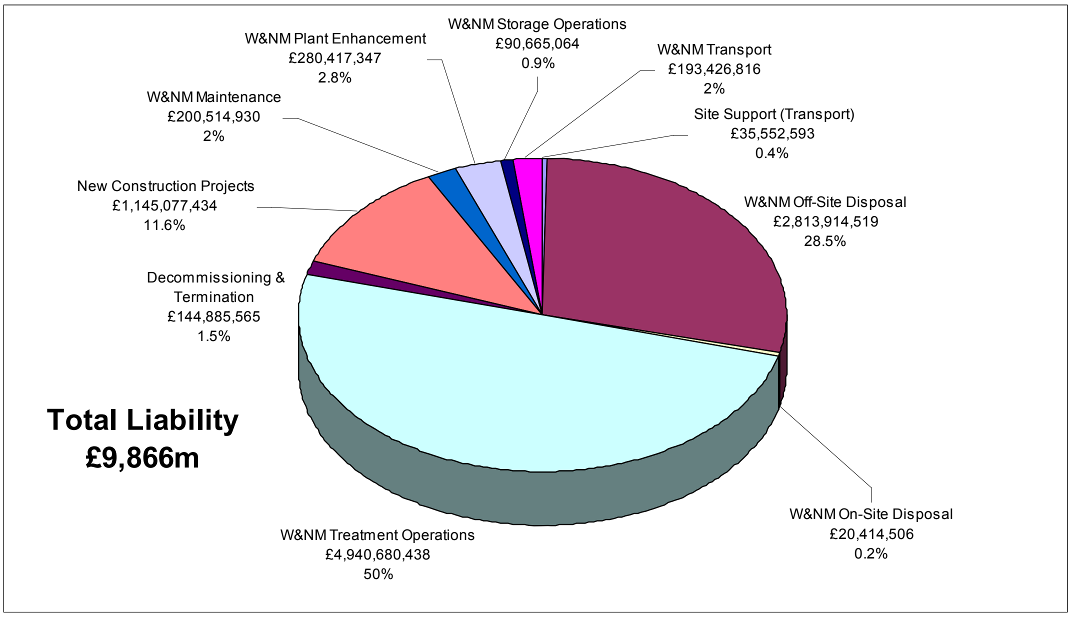
In compiling the costs for each site, some preliminary judgements were made to assess the relevance of particular facilities to LLW management (for example, where facilities may have a shared role with other waste types such as exempt, non-hazardous, hazardous, ILW, etc). When reviewing this data, sites were requested to highlight any areas where they feel such facilities should not be included in the LLW baseline. The cost baseline is described further in the following sections below.

4.5.1 LLW Costs by PSWBS Area

The undiscounted costs for management and disposal of solid LLW generated by operations and decommissioning of NDA's sites is currently estimated at around £9.87 billion. This is the cost of LLW management currently included within the LTPs the NDA's waste producing sites and therefore does not include the costs of LLWR or a replacement LLWR facility. This aspect is discussed further below.

Table D1 in Appendix D shows how this cost is distributed by NDA's PSWBS across different sites. This is summarised in Figure 16 below. Over 50% (£4.9 billion) of costs are associated with Waste and Nuclear Materials Management (W&NM) Treatment Operations. This category typically includes operational aspects of LLW management including costs for characterisation, size-reduction, sorting, segregation, packaging, and volume reduction (e.g. compaction). In reality this is likely to be an underestimate of the true treatment and pre-processing costs as there may be significant costs for these LLW management elements embedded within decommissioning projects which have not been captured.

FIGURE 16 – TOTAL LLW LIABILITY BY PSWBS CATEGORY



Over £1.1 billion is associated with new construction projects for LLW management facilities on NDA sites. These projects include a range of waste handling and treatment facilities and on-site disposal facilities. A further £145 million is required to then decommission these LLW facilities. In addition to the cost of construction, a further £20 million has been included to operate these on-site disposal facilities at Dounreay and Harwell.

A number of differences have been observed as to the extent to which different categories of the PSWBS are interpreted on different sites. A number of projects have been identified where several different elements have been combined under a single PSWBS category (e.g. combining treatment operations, transport and off-site disposal under a single heading of off-site disposal). This makes precise comparisons of the different elements challenging because the costs cannot be isolated with a high degree of confidence.

The data indicates that approximately 2% of overall costs are allocated to W&NM Transport however it should be noted that some sites such as Sellafield include their LLW transport costs under the W&NM Treatment Operations and Site Support categories so in reality the proportion is actually higher.

4.5.2 LLW Disposal Costs

The costs of Off-site Disposal of LLW are accounted for in NDA's overall liabilities in two parallel ways. The costs of operating LLWR appear explicitly in the LTP for the current LLWR facility near Drigg. These costs also appear implicitly in the LTPs for waste producers through the unit price payable to LLWR for the waste disposal service. NDA's LTP Guidance Note EGG01 Summary Requirements[13] requires sites to cost all categories of LLW at a standard rate for the LLWR disposal facility unless:

- An approved alternative disposition route exists, or
- A route exists but is only for a fixed contract duration and it could be expected that future rates will vary; or
- Alternative plans, specifically approved by regulators are in place; or
- A robust, defensible argument for using an alternative rate can be made.

Therefore for the purposes of this 2008 LLW baseline double-accounting is avoided by only including the costs of off-site disposal from the waste producers LTP's (i.e. 1.1.X.XX.14.43.xxxxx.xxxxx.46) in the £9.8 billion total rather than actual costs associated with LLWR's LTP and its successor in the baseline.

Therefore approximately £2.8 billion (less than 30%) of the total LLW management costs in consignors LTPs are associated with actual disposal of waste. This would appear to concur with studies in the US Department of energy (DOE) and other markets which have shown the true lifecycle cost of waste management can be more than 10 times the actual price of disposal[14].

It should be noted that the LLWR's current pricing structure is designed to recover disposal costs over a certain fixed period (based on forecast inventory volumes) and therefore does not necessarily represent the true lifecycle cost liability of LLWR or its successor. This approach, adopted for consignor LTP costing purposes, assumes that the current LLWR gate price will also be sufficient to cover the costs of a replacement facility. A different approach is therefore required in order to estimate the cost of a successor LLWR as described in Appendix H.

The current LLWR LTP08 is around £1.5 billion based on extending the site lifetime to 2070 by applying the waste management hierarchy. In 2007, NDA commissioned a study on 'uncontracted liabilities' which estimated the costs of constructing, operating and closure of a new LLWR facility, under a range of scenarios, to be between £1.4 and £2 billion[15]. It should be noted that the study did not consider aspects such as costs for planning and permitting, community benefit or other risks associated with provision of a new facility.

4.5.3 LLW Costs Over Time

Figure 17 shows the profile of spending per year on LLW management and Figure 18 shows the cumulative cost profile. This yearly profile shows that expenditure on LLW management is due to rise over the next few years from £75 million/year to over £100 million/year at 2020. A considerable proportion of this is attributable to new construction projects such as LLW treatment plants at Sellafield (£165 million), new LLW disposal facilities at Dounreay (£69 million) and Care and Maintenance (C&M) preparation waste facilities at various Magnox stations (£37 million).

By contrast the cost of treatment operations remains relatively stable at £30-£37 million/year until 2026 when the cost falls to £15-25 million/year through to 2040. There is big increase from £15 million/year to

£47 million/year in 2047 associated with the start of Sellafield contaminated land remediation activities which alone account for approximately £32 million per year.

The cost profile shows some large peaks of £150-£225 million/year between in 2080 and 2120 primarily associated with Final Site Clearance (FSC) at Magnox sites.

FIGURE 17 – ANNUAL LLW COSTS BY PSWBS

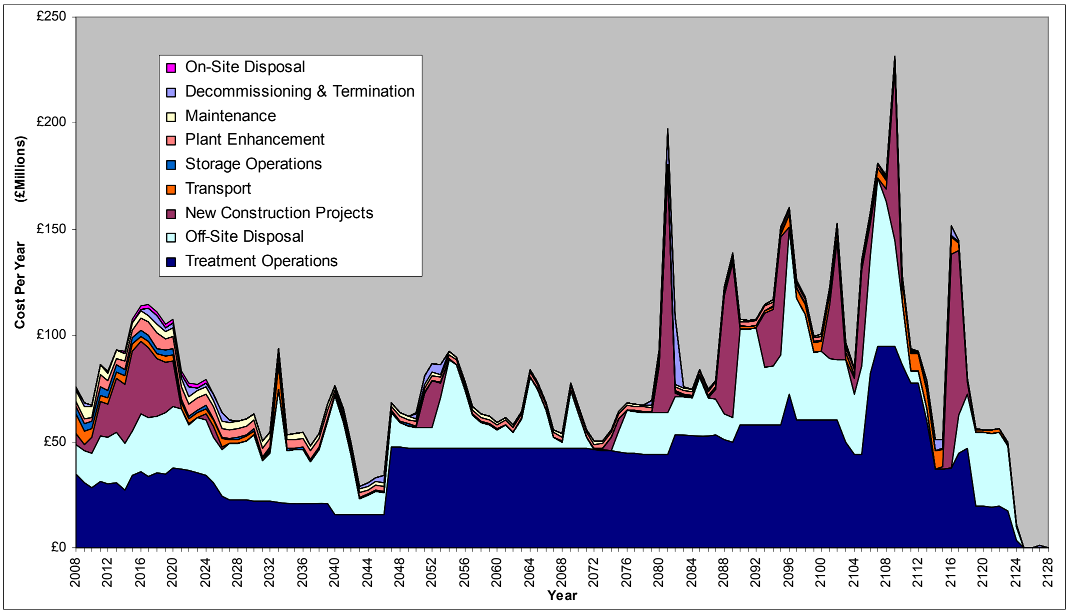
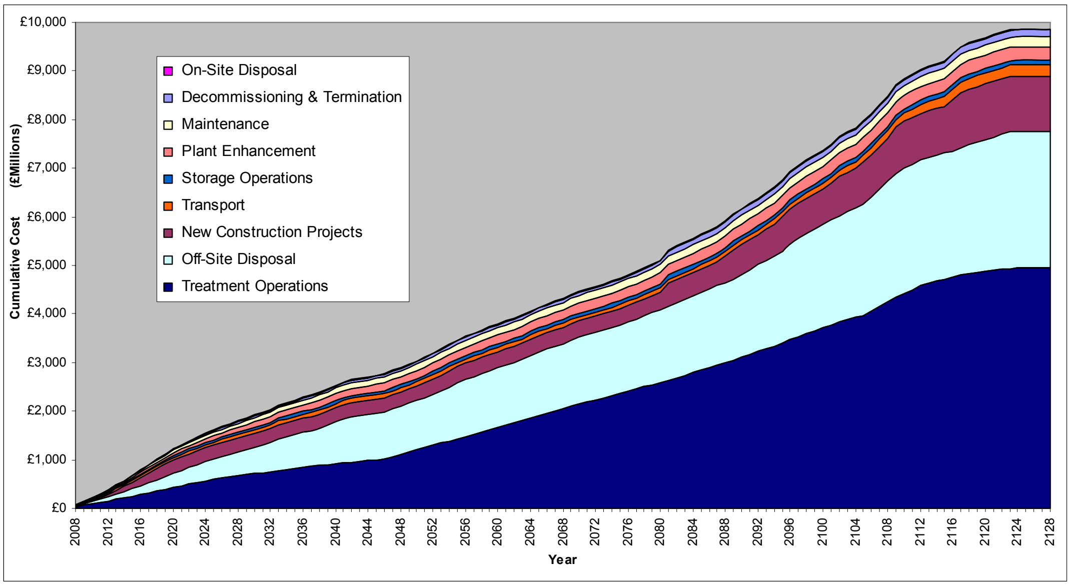


FIGURE 18 – CUMULATIVE LLW COSTS BY PSWBS



4.5.4 LLW Costs by SLC

Figure 19 shows how this cost is distributed within NDA's SLC's. Over 63% (£6.3 billion) of costs are located at Sellafield. This is consistent with Sellafield being the largest producer of waste. A further £3.2 billion (32%) is associated with LLW management at the 10 Magnox sites. Springfields, Dounreay and Research Sites combined account for less than 5% of the total liability.

FIGURE 19 – LLW COSTS BY SLC

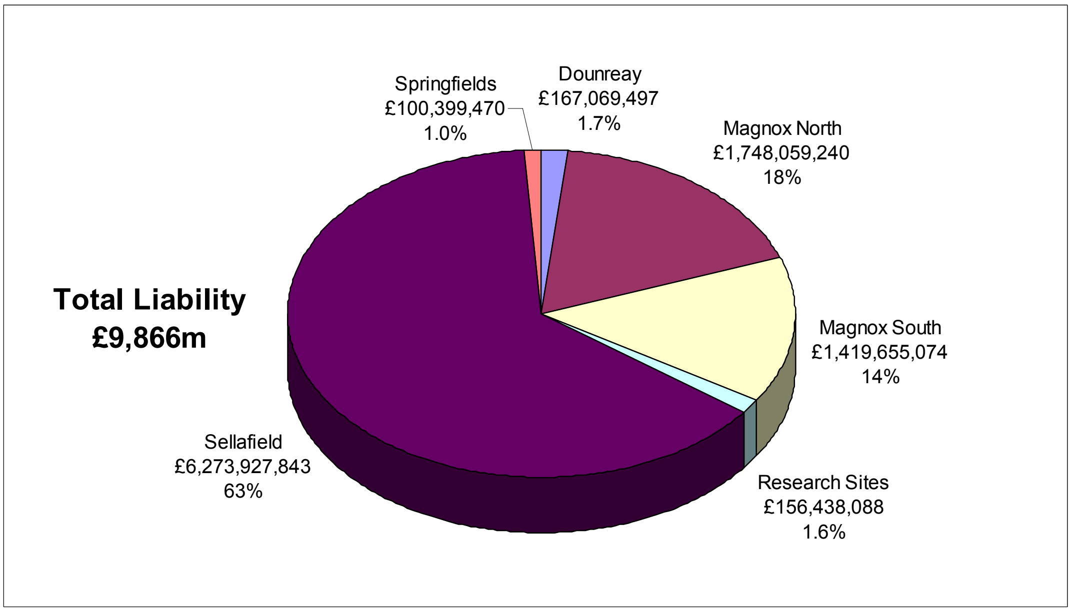


Table 3 shows a more detailed breakdown of costs for each SLC by PSWBS category.

TABLE 3 – PSWBS COSTS PER SITE

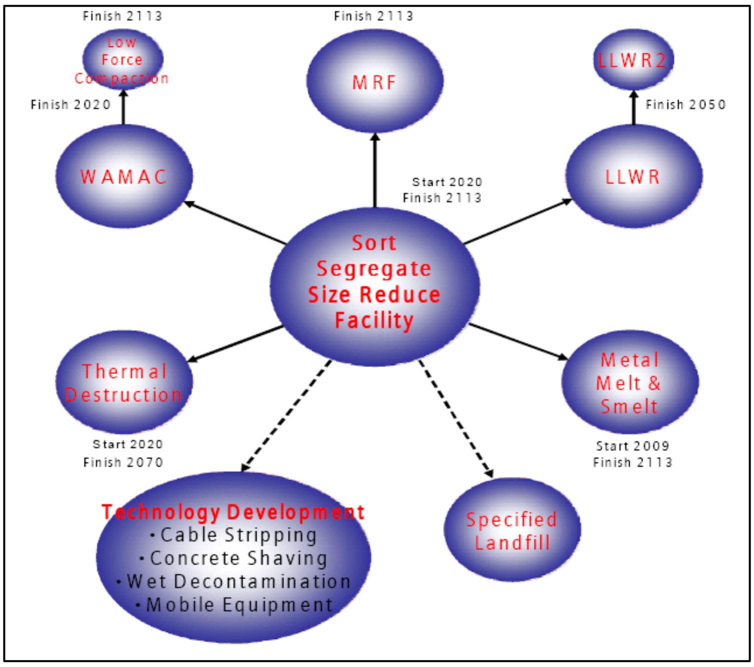
Category		Dounreay	Magnox North	Magnox South	Research Sites	Sellafield	Springfields	Grand Total
New Construction Projects		£78.6m	£504m	£283m	£8m	£271m		£1,145m
Waste & Nuclear Materials Management	Treatment Operations	£40.4m	£471m	£288m	£36.9m	£4,104m		£4,941m
	Storage Operations	£2.9m	£32.5m		£3.5m	£51.7m		£91m
	Maintenance	£6m	£5.4m	£3.3m	£14.7m	£171m		£201m
	Plant Enhancement	£11m	£28.4m	£0.8m		£240m		£280m
	Transport	£4.9m	£86m	£56.8m	£4,7m	£41m		£193m
	On-Site Disposal	£16.6m		£0.2m	£3.7m			£20.4m
	Off-Site Disposal		£609m	£699m	£85m	£1,320m	£100m	£2,814m
Waste & Nuclear Materials Management Total		£81.7m	£1,232m	£1,049m	£148m	£5,928m	£100m	£8,540m
Site Support (Transport)				£36m				£36m
Decommissioning & Termination		£6.7m	£11.5m	£52.5m		£74.2m		£145m
Grand Total		**£167m**	**£1,748m**	**£1,420m**	**£156m**	**£6,274m**	**£100m**	**£9,866m**

4.5.5 Significant LLW Costs

4.5.5.1 Sellafield

Sellafield are currently developing a LLW management strategy due in 2009 which will form part of the wider Integrated Waste Strategy for the site. The draft LLW Strategy[16] under development for the Sellafield site centres around a 'Hub and Spoke' model shown in Figure 20 below.

FIGURE 20 – PROPOSED SELLAFIELD HUB AND SPOKE MODEL



Sellafield LTP08 includes provision for a LLW sort and segregation facility which is assumed to become operational in 2020 along with the following waste treatment plants:

- Continued use of WAMAC for high force compaction of compactable LLW until 2020
- New build thermal treatment capability from 2020 up-to the end of site decommissioning, currently scheduled to be 2113
- New build melt / smelt capability for LLW metals from 2020 up-to 2113
- New build low-force compaction capability for compactable LLW from 2020 up-to 2113
- Continued use of mechanical decontamination in the form of the wheelabrator for the decontamination of metals up-to 2113
- Continued use of direct emplacement of non-compactable items into ISO freight containers
- Disposal of LLW to the LLWR until 2050 and to a future LLW disposal facility that has not yet been specified

Over 63% of the total cost liability is associated with Sellafield. This proportion is broken down further to a project level in Table 4 below. The largest cost is associated with Sellafield is £2.3 billion for the Soil Decontamination Plant. This project includes the excavation, washing of large quantities of LLW and VLLW contaminated land and disposal to LLW vaults and VLLW cells on the Sellafield site. It should be noted that since March 2008 Sellafield have revisited their contaminated land remediation strategy which may lead to a reduction in this cost in future iterations of the Sellafield LTP.

TABLE 4 – COST BREAKDOWN FOR SELLAFIELD

Sites	Facility/Sub Unit	New Construction Projects	Waste & Nuclear Materials Management	Decommissioning & Termination	Grand Total
Sellafield	Waste Monitoring & Compaction Plant	£70m	£1,574m	£25m	£1,669m
	92700 Metals Recycling	£11m	£319m		£330m
	LLW Metals Melt & Smelt Facility	£31m	£146m	£7m	£184m
	LLW Sort Segregate & Size Reduction Facility	£82m	£313m	£20m	£415m
	LLW Thermal Destruction Facility	£61m	£146m	£20m	£227m
	90100 Waste Tasks		£154m		£154m
	Calder Hall Waste Management	£16m	£212m	£2m	£230m
	Calder Landfill (CLESA)		£58m		£58m
	Clearance & Characterisation		£443m		£443m
	Functional Support		£1m		£1m
	Waste Handling Facility		£217m		£217m
	Soil Decontamination Plant		£2,300m		£2,300m
Sellafield Site Total		£271m	£5,882m	£74m	£6,227m
Capenhurst Site Total			£18m		£18m
Windscale Site Total			£28m		£28m
Sellafield SLC Total		**£271m**	**£5,928m**	**£74m**	**£6,274m**

Around £1.7 billion is associated with the operation (and replacement) of the current Waste Monitoring and Compaction Facility (WAMAC). In addition, over £826 million is included within the Sellafield LTP for construction, operation and decommissioning of LLW sort and segregation, metal melt and thermal destruction facilities. A further £330 million is associated with the continued operation (and replacement) of the current metal recycling (Wheelabration) facilities. Sellafield have developed a specialist department for Clearance and Characterisation which represents around 7% (£443 million) of the total LLW costs for the site.

It should be noted that although provision for these facilities has been included in the 'unapproved' LTP08 for Sellafield it has not yet been determined if this represents the optimised UK LLW management approach. The final Sellafield LLW Strategy is currently under development, in parallel with development of NDA's national LLW strategy. It will be important that the final Sellafield LLW strategy is suitably flexible and reflects the optimised national LLW strategy (i.e. the *"what should we do"*) and UK LLW Management Plan (the *"when, where, and how should we do it"*).

4.5.5.2 Magnox

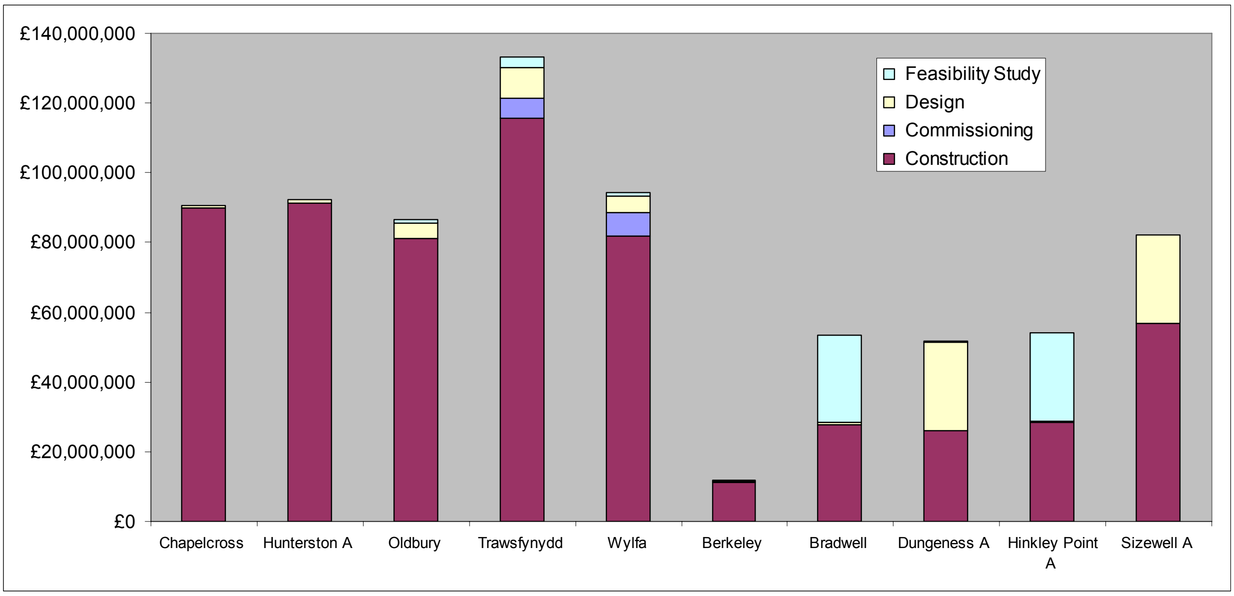
Magnox sites account for 32% (£3.2 billion) of the total liability for LLW management. The majority of this cost (£2.6 billion) is associated with the FSC phase where the highest volumes of LLW are generated. Table 5 below shows the final site clearance costs for each site under each phase.

TABLE 5 – MAGNOX FSC COSTS

SLC	Sites	New Construction Projects	Waste & Nuclear Materials Management	Decommissioning & Termination	Grand Total
Magnox North	Chapelcross	£91m	£216m	£1m	£308m
	Hunterston A	£92m	£179m	£1m	£272m
	Oldbury	£87m	£100m	£1m	£188m
	Trawsfynydd	£133m	£309m	£1m	£443m
	Wylfa	£94m	£137m	£1m	£232m
Magnox North Total		£498m	£941m	£5m	£1,443m
Magnox South	Berkeley	£12m	£122m	£41m	£174m
	Bradwell	£53m	£143m	£1m	£197m
	Dungeness A	£52m	£221m	£1m	£274m
	Hinkley Point A	£54m	£233m	£1m	£288m
	Sizewell A	£82m	£165m	£1m	£248m
Magnox South Total		£253m	£884m	£45m	£1,182m
Magnox Total		**£750m**	**£1,825m**	**£50m**	**£2,625m**

There are considerable variations in the costs of FSC for different Magnox stations which may partly reflect the different waste volumes and particular challenges found at each site. A significant proportion of the overall FSC costs (£750 million) are associated with the design and construction of new FSC waste management facilities across all 10 sites for sorting, segregation, treatment and packaging of LLW from FSC. Figure 21 below shows how theses costs compare across the different Magnox Sites. A more detailed breakdown of these costs are included in Table J1 in Appendix J.

FIGURE 21 – COMPARISON OF FSC CONSTRUCTION COSTS



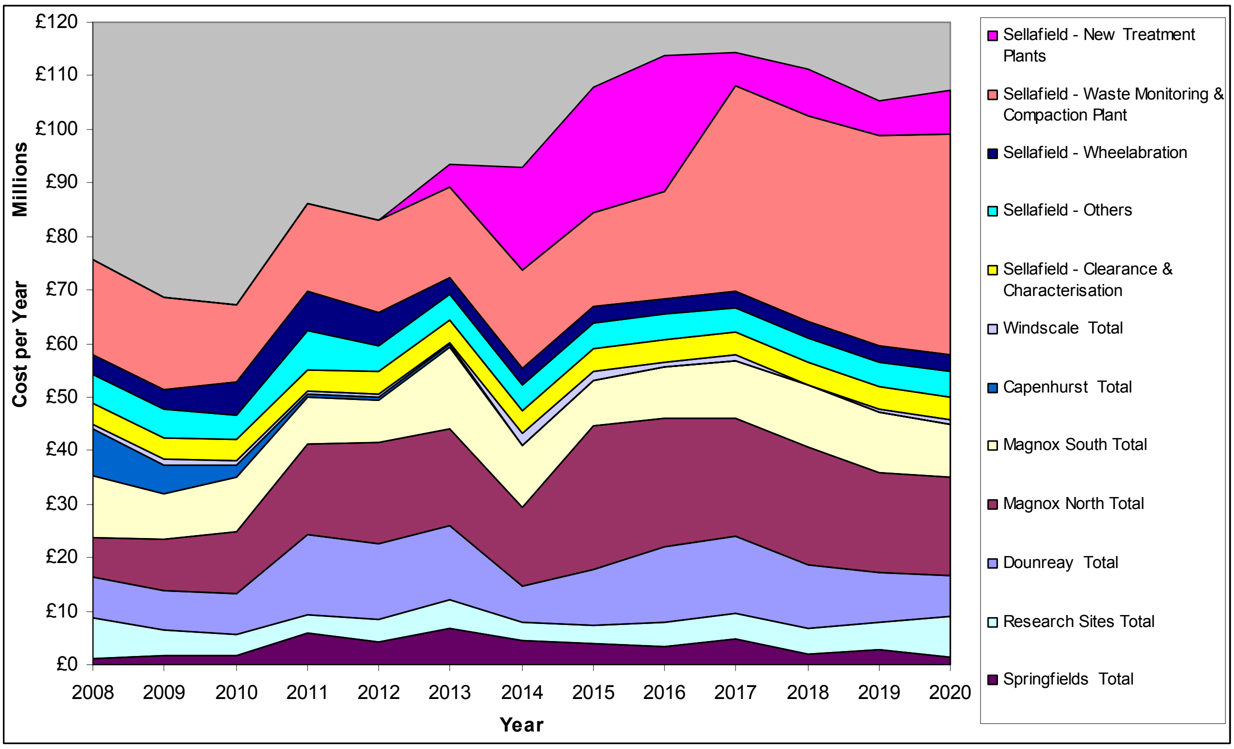
On average FSC facilities for Magnox North sites would appear to be almost twice as expensive as the equivalent facilities for Magnox South. Magnox North sites have much lower costs for the design and feasibility studies (ranging between <£1 million and £11 million) compared to most Magnox South sites which typically include about £26 million for the same tasks. However, in contrast to the other Magnox south sites, Berkley has estimated only £0.7 million for design and feasibility.

Within the Magnox South sites there appears to be a marked difference in the way cost are allocated across the PSWBS. For example, Bradwell and Hinkley Point estimate £25 million for the feasibility study and a much lower amount for design whilst the exact opposite is true of Dungeness and Sizewell. Only Trawsfynydd and Wylfa separate out cost of commissioning from other costs.

4.5.6 Near-term LLW Costs

Whilst many of the significant costs associated with final site remediation costs occur in the longer term in the near term (between 2008 and 2020) over £1.2 billion is due to be spent on LLW management on NDA sites. The distribution of annual cost for each SLC is shown in Figure 22 below. The large proportion of cost occurs at Sellafield and hence these costs are shown in more detail.

FIGURE 22 – LLW COSTS TO 2020



The LLW management costs over the near-term are relatively constant for sites such as Windscale and the Research Sites. The annual costs at Dounreay rise from 2010 onwards associated with the £72 million construction of the new on-site disposal facilities.

The costs at some Magnox North and South sites are also due to rise significantly over the period as decommissioning increase during the C&M preparation phase. The cost for construction of the new Sellafield LLW treatment plants can clearly be seen post 2013. Costs associated with WAMAC are also set to increase due a combination of increased waste volumes from decommissioning and the construction of a new replacement WAMAC facility in 2018. The total cost during the period 2008-2020 is shown in Table 6 below for each aspect.

TABLE 6 – TOTAL COST 2008-2020

Sites	Facility/Sub Unit	Total Cost (2008-2020)
Sellafield	New Treatment Plants	£102m
	Waste Monitoring & Compaction Plant	£312m
	Wheelabration	£52m
	Others	£65m
	Clearance & Characterisation	£54m
Sellafield Total		£585m
Windscale Total		£11m
Capenhurst Total		£18m
Magnox South Total		£136m
Magnox North Total		£228m
Dounreay Total		£141m
Research Sites Total		£63m
Springfields Total		£44m
Period 2008-2020 Total		**£1,226m**

4.5.7 'Non-NDA' Nuclear Industry Sites

There are a number of non-NDA sites which produce LLW and VLLW. These include private entities such as GE Healthcare and British Energy and government consignors such as MoD. These organisations are responsible for their own LLW liabilities and consequently this baseline analysis currently only includes liabilities associated with NDA-owned sites.

These organisations utilise a number of NDA assets for treatment and disposal of LLW waste on a commercial basis.

4.6 Assets and Infrastructure

This section of the report presents an overview of the UK and international treatment and disposal facilities currently available to manage LLW and VLLW from the UK Nuclear Industry. It also discusses some of the key facilities which are at the planning and development stage.

From the 1950's to 1988 virtually all LLW from the UK nuclear industry was disposed at the Low Level Waste Repository near Drigg by tumble-tipping into trenches. Vault disposals began operation in 1988 and subsequently high-force compaction was introduced in 1995 and is still the primary means to reduce LLW volumes prior to disposal. Following compaction, the resultant waste pucks are encapsulated in larger containers for disposal in near-surface engineered vaults. Waste that cannot be compacted, such as masonry and large items of equipment, are placed in large containers and encapsulated with a cementitious grout.

In recent years the focus of waste management has evolved, with many waste producers pursuing improved application of the waste management hierarchy in line with the Government's Solid LLW Policy. Waste producers are responsible under the Radioactive Substances Act 1993 (RSA93) to use the Best Practicable Environment Option (BPEO) and Best Practicable Means (BPM) to manage their radioactive waste. Appendix A provides an overview of all nuclear licensed sites current waste management strategies and their future plans.

4.6.1 Pre-treatment facilities

The majority of UK nuclear facilities have their own, small-scale facilities which provide varying degrees of scale and capability in waste segregation, size reduction, decontamination and packaging activities depending on the site's requirements. At some of the sites there may be some spare operational capacity that could potentially be used for managing wastes from other sites, subject to planning and regulatory authorisation.

As sites move from operations into the decommissioning phase many of these facilities will require modification or additional capacity to be provided in new facilities. Some sites including Chapelcross and Hinkley Point A, have invested in dedicated waste sorting and packaging facilities which have allowed non-compactable wastes to be loaded more efficiently. Cutting devices are used to size reduce items and lay down areas are used to store items to allow more effective packing regimes to be devised. A number of other Magnox sites, whom are in the earlier stages of decommissioning or are still operating, have plans for new waste management facilities of varying degrees of complexity, some with decontamination and size reduction facilities and others more simply for the more efficient packing of non-compactable waste into large containers.

Many LLW producers have small-scale shredding or baling equipment and low force compactors to reduce the volume of waste sent for onward processing and disposal. Additionally sites have also invested in various decontamination equipment predominantly for scabbling concrete and decontaminating metal. Examples here include high pressure water jetting, shot blasting, acid baths and machining and grinding equipment. Many of these smaller facilities or equipment can be bought “off-the-shelf” from numerous UK and overseas companies.

4.6.2 Sorting and Segregation

Most sites have the ability to sort and segregate compactable from non-compactable wastes. A number of sites also segregate combustible waste, where they have access to an on-site or off-site incinerator. Sites use a range of characterisation, assay and measurement equipment, underpinned by various procedures, methodologies and IT data management systems. These infrastructures also support the segregation of wastes by activity and fissile content, with varying degrees of sophistication.

As more treatment and disposal options are made available, it is expected that sites will improve the amount of segregation undertaken. Sellafield Ltd has a new £82 million Sort and Segregation facility which is expected to be operational by 2020. This facility will provide a large-scale sort and segregate service to segregate wastes from decommissioning activities by type and by activity, before sending the waste to alternative treatment and disposal routes.

4.6.3 High-Force Compaction Facilities

The LLW inventory contains a number of “operational” or “soft” wastes such as paper, plastics, clothing, and small items of metal that are suitable for compaction. This method of treatment has historically been the main volume reduction technology used for LLW in the UK for operational wastes. The 2008 inventory predicts that around 22% (172,000m^3) of all waste expected to arise by 2020 is potentially suitable for compaction. In contrast, post 2020, 11% (248,000m^3) of waste is expected to be compactable. It should be noted that much of this waste may also be suitable for alternative processes such as incineration. As more sites move into the decommissioning phase the nature of the waste arisings change towards increasing proportions of less compactable materials such as metal, rubble and soil.

High Force Compaction (HFC) or Supercompaction involves compressing metallic drums or boxes with a hydraulic ram using 500 metric tons or more compaction force. Achievable volume reduction efficiencies typically are in the range of 4:1 to 10:1 depending on the wastestream characteristics. The compaction process eliminates void spaces and also increases the mechanical strength of the final package for disposal. The compressed ‘pucks’ are then placed into a larger container such as a Half-Height ISO Container (HHISO) for disposal.

Four super-compaction facilities are currently operational in the UK. These include WAMAC at Sellafield and the Waste Receipt Assay Characterisation and Supercompaction facility (WRACS) at Dounreay. In addition there are two mobile supercompaction services available via the supply chain operated by Waste Management Technology Ltd. (WMT) based at Winfrith and Studsvik UK Ltd. based at Lillyhall in Cumbria.

All facilities can compact waste in 200litre drums. In addition to drums, the WAMAC facility can receive loose compactable waste in skips from Sellafield plants and external consignors for loading into 1m^3 boxes prior to compaction. The WAMAC, WMT and Studsvik compactors are fully available to other waste producers on a commercial basis whilst the WRACs facility is used exclusively for Dounreay waste. In contrast to WAMAC and WRACS, the WMT and Studsvik compactors are suitable for compaction of asbestos.

4.6.4 Metal Treatment Facilities

Metal arises at nuclear sites from the dismantling of buildings, equipment and other redundant assets. There is over 500,000m^3 of metal in the LLW inventory and a further 400,000m^3 of metallic VLLW. This metal is often treated on site by utilising various local size reduction and decontamination techniques to either reduce the volume of waste for further treatment (cutting out hot spots), alter the geometry to improve packing or reduce the levels of contamination for onward management. Many different techniques exist to support these activities, most of which have been adapted for use in the nuclear industry in order to improve the collection of secondary waste arisings and to reduce dose uptake to operators.

A number of NDA sites operate their own larger-scale decontamination facilities including the Wheelabrators (two of) at Sellafield and the Winfrith Abrasive Cleaning Machine (WACM) at Winfrith. These facilities process ferrous metals with relatively low levels of contamination and simple geometries by grit-blasting the surface of the metal to reach exemption levels. The secondary wastes (primarily blasting residues) are then disposed of via the normal LLW route. The two Sellafield Wheelabrators currently have a combined capacity of around 1,000 tonnes of metal per year[17]. Currently any material failing to meet the 'exemption' criteria after processing is sentenced as LLW to the LLWR.

A new commercial Metal Recycling Facility (MRF) is currently being constructed by Studsvik at Lillyhall in Cumbria. This facility is expected to be operational in early 2009 and will utilise a number of size reduction and decontamination technologies. This MRF facility will be capable of processing a wider range of metals and higher levels of contamination than the current facilities.

Metals that cannot easily be decontaminated by blasting alone can be recycled by melting. Metal melting is a well-proven mature technology that has been operated around the world for over 20 years. Metal is melted in an induction or electric-arc furnace where the majority of the radioisotopes concentrate into the floating slag layer which can be collected and returned to the customer for final disposal as LLW. The homogenised metal is then cast into an ingot or block which can be more easily assayed, handled, stored and recycled in the conventional steel industry or can be cast into components for the nuclear industry such as shielding or waste transport and disposal containers. Melting can allow up to 95% of the original metal to be recycled.

Several commercial metal melting facilities are currently operated around the world. These include EnergySolutions in the USA, Siempelkamp in Germany and Studsvik in Sweden. These facilities are all licensed to accept international material (including UK wastes) and their use is supported by the Government's Solid LLW Policy. Other metal melting treatment facilities are also in operation in France and Russia however these are largely limited to their own domestic wastes only and are not currently commercially available for UK wastes. A small metal melter was operated a Capenhurst for a number of years but has since been decommissioned meaning there are no melting facilities in the UK at present. Sellafield currently has plans to build and operate a metal melting facility by 2020 to supplement the existing Wheelabration technology.

4.6.5 Incineration facilities

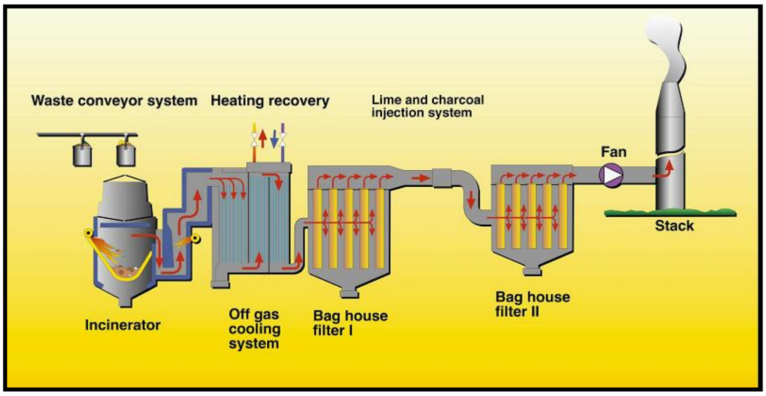
Incineration is a widely used and well developed waste treatment technology used both internationally and within the UK for radioactive and non-radioactive wastes. Incineration reduces waste volumes by up to 98% by burning combustible solid and liquid wastes and breaking down the reactive compounds and organics to create a stable homogenous waste form for disposal.

Incineration is applicable to a broad range of dry solid wastes including paper and other cellulose compounds (clothes), plastics, rubber, paper, cartridge filters and also liquid waste such as oils. The 2008 inventory includes 425,000 m^3 (15%) of potentially combustible LLW and VLLW waste from the UK nuclear industry. Almost half of this is expected to arise within the next 10 years. Currently only a very small proportion of the potential combustible waste is actually planned to be incinerated under current site strategies.

A number of Magnox and British Energy stations operate incineration facilities to treat their own waste and that of the adjacent power stations (where applicable) as shown in Table 7 below.

TABLE 7 – CURRENT AUTHORISED INCINERATORS ON NUCLEAR SITES AND EXAMPLE SCHEMATIC OF AN INCINERATOR

NDA Sites	Non-NDA Sites
Dungeness A	Hinkley Point B
Oldbury	Heysham
Sizewell A	Hartlepool
Wylfa	Sizewell B



The Capenhurst site also has an incinerator which is currently mothballed. This facility could potentially process waste from other sites but would require some investment to bring up to modern standards and requires re-authorisation become operational again. Sellafield has plans for a new thermal treatment facility post 2020.

Two commercially operated incinerators (Pyros near Fawley and Grundons near Slough) currently treat radioactive waste (primarily oils) from a number of nuclear and non-nuclear industry sites. A further 9 RSA authorised incinerators across the UK are operated SRCL (formerly White Rose Environmental). There are a number of other hazardous and non-hazardous waste incinerators around the UK that may, subject to authorisation, be capable of processing radioactive wastes.

It should be noted that there are significant differences between these different facilities with regard to the quantity, type of radioactivity and physical nature of waste (e.g. solids and/or liquids) that can be accepted. For example, most incinerators in the UK have very strict limits on activity (Pyros and Grundons) and some prohibit any alpha emitting radionuclides (e.g. SRCL incinerators). Many of these commercial incinerators are also used by the non-nuclear industry such as hospitals.

Although some UK incinerators may have some spare capacity, some are ageing and have reliability issues. The Government's Solid LLW Policy recognises the diminishing incineration capacity available for radioactive wastes from the nuclear and non-nuclear industries.

Several companies provide incineration services to international customers around the world. For example, since 1976 Studsvik has successfully been providing customers from Sweden, UK and Germany with incineration services for oils and solid LLW. It is understood that EnergySolutions operates a similar incineration service in the US. A very small volume (<3%) of ash and filter dust would be returned to the UK for disposal as LLW. The international incinerators can typically accept higher activity wastes than the current UK commercial incinerators (Pyros and SRCL) as the current UK commercial incinerators are constrained by the activity limits of the VLLW ash disposal route.

4.6.6 Other Treatment Facilities

4.6.6.1 Drying

Drying processes can be used to treat some LLW wastes that do not meet the LLWR conditions for acceptance due to their high liquid content. In the drying process low temperature heat (typically hot air or steam) is applied to evaporate water from aqueous or non-aqueous liquids, sludges and slurries to leave a dry residue that will typically contain the majority of the radioactivity. In the UK, WMT operate a mobile drying plant for drummed liquid waste where drums are placed within a container unit and heated to drive off liquid.

4.6.6.2 Sellafield Concrete crusher

A large volume of bulk rubble from building demolition is due to arise in the nuclear industry, some of which will be VLLW or even LLW. In order to improve the packing of such waste into disposal containers it is often advisable to crush the concrete. Sellafield possesses a concrete crusher for such operations.

4.6.6.3 NORM treatment and disposal

Historically, the majority of pipe-work and equipment contaminated with NORM from UK oil and gas operations has been decontaminated by Scotoil Services in Aberdeen using high-pressure water jetting to remove NORM. The decontaminated components are typically re-used in the oil and gas industries and the remaining NORM waste is macerated and then discharged to sea. In 2006, SEPA undertook a review to establish whether this practice still represented BPM and was consistent with UK Government policy on minimising discharges of radioactive waste to the environment under the OSPAR convention.

A recent Scottish Government ruling means that the company must now seek alternative treatment and disposal options for the majority of the solid NORM waste resulting from its operations. In the absence of alternative disposal solutions, such as landfill, it is possible that this waste may have to be managed at LLWR which could have significant implications for the LLWR ESC.

4.6.7 LLW Disposal Sites

The majority of LLW generated in UK from both nuclear and non-nuclear industries is currently disposed of at the LLWR near Drigg in Cumbria. LLW has been disposed of to the LLWR since 1959. Waste streams are accepted for disposal at the LLWR based on the availability of sufficient volumetric and radiological capacity. LLW arrives at the LLWR in containers of varying sizes, either following processing mainly in the WAMAC facility at Sellafield or directly from the consignors. Containerised wastes are then grouted and placed into the engineered concrete vaults.

The current operational vault at the LLWR, Vault 8, is scheduled to reach full capacity in early 2009 and Vault 9 is currently under construction which will be initially authorised for 'storage' pending resolution of the LLWR ESC. A further series of vaults were historically planned which would have provided an additional capacity of 700,000m^3 in Vaults 9-15. It should however be noted that the LLWR's LTP08 now includes provision for fewer vaults based on the projected reduction in volumes following implementation of volume reduction initiatives.

This compares with future arisings of around 3 million m^3 of LLW and VLLW. Around 2.4 million m^3 of this LLW and VLLW may potentially need to be disposed to a national repository in the absence of alternative management routes. Once the LLWR is full, a new LLW repository (or repositories) would be required to accommodate the remaining inventory. There are a number of potential cost, technical, social and programmatic risks associated with the siting and development of new repository facilities and these will need to fully understood and underpinned with robust analysis before any decisions can be taken about new facilities.

Historically there have also been some limited disposals to pits and trenches on other UK nuclear sites such as Harwell, Dounreay, Springfields and Sellafield. Some of these facilities may require remediation prior to site closure potentially generating LLW. A new facility on the Dounreay site, similar to that of the LLWR in Cumbria, is planned to dispose of any remaining LLW at Dounreay. Sellafield have included £2.3 billion in LTP08 for on-site disposal of contaminated land in engineered vaults at Sellafield.

Other nuclear licensed sites are investigating the potential to locate disposal facilities on their sites following BPEO study recommendations. Magnox South have progressed this option significantly, with plans for an on-site LLW disposal facility at Hinkley Point A. Magnox are currently preparing a full business case justification for submission to NDA.

4.6.8 VLLW Disposal Sites

VLLW is defined in the LLW Policy and was developed to reflect the lower risks posed by wastes with such low levels of radioactivity. Whereas historically most of this material would have been disposed to the LLWR, the Policy introduced a wider range of options for management and disposal of VLLW that could be considered including disposal to specified landfills. Approximately 1.8 million m^3 of VLLW is expected to arise with over 350,000m^3 forecast to arise before 2020.

At present the most significant VLLW disposal site in the UK is the commercial landfill at Clifton Marsh operated by SITA. Springfields and Capenhurst currently have authorisations for disposal of VLLW (and some limited quantities of LLW) to this facility. The site is expected to have a remaining operating life of around 10 years, but this could be significantly extended (or reduced) subject to authorisations and planning permission. The facility also offers a specialist asbestos disposal service in purpose built mono cells. There is however currently uncertainty surrounding authorisation for continued use of Clifton Marsh post-2012. There are other commercial landfills around the UK which receive small quantities of VLLW from the nuclear industry (e.g. from GE, Devonport, Harwell and Winfrith) and from the non-nuclear industry.

A number of other commercial landfill operators are considering VLLW disposal opportunities ranging from expansion of existing sites to new dedicated VLLW facilities; however, there is currently some uncertainty with regard to the authorisation regime that may be applied to these facilities. The Environment Agencies' Guidance on Requirements for Authorisation (GRA) for near-surface disposal facilities indicates that high-volume VLLW facilities may (or may not) need an RSA authorisation supported by an appropriate Environmental Safety Case or risk assessment.

Historically Sellafield have disposed of VLLW/HVLA excavated soil to the on-site South Landfill and Calder Landfill. Both facilities are now non-operational. The Calder Landfill Extension Segregated Area (CLESA) which has a capacity of 100,000m^3 is currently being used for the temporary storage/accumulation of waste pending disposal authorisation from the Environment Agency[17]. Some nuclear licensed sites, such as Harwell and Dounreay have plans for VLLW/HVLA disposal facilities on their sites. A number of other sites are currently considering options for such facilities including LLWR. The LLWR LTP08 includes provision for a VLLW facility at LLWR, subject to national strategy.

4.6.9 Infrastructure Summary

The UK nuclear industry LLW producers have access to a wide range of treatment and disposal assets. Historically the main volume reduction technology has been supercompaction and some use of incineration. With the changing nature of wastes from decommissioning, many sites are increasingly evaluating the use of more effective volume reduction technologies including incineration, metal decontamination and melting. The LLWR in Cumbria is the main disposal facility for LLW in the UK and is available to most LLW producers with the exception of Dounreay which has plans for its own facilities.

The Table 8 below summarises the key infrastructure for management of the UK's LLW and VLLW, highlighting both commercial facilities that are able to manage waste from many sites and those facilities currently for their own on-site use only. Figure 23 shows the geographical distribution of these assets.

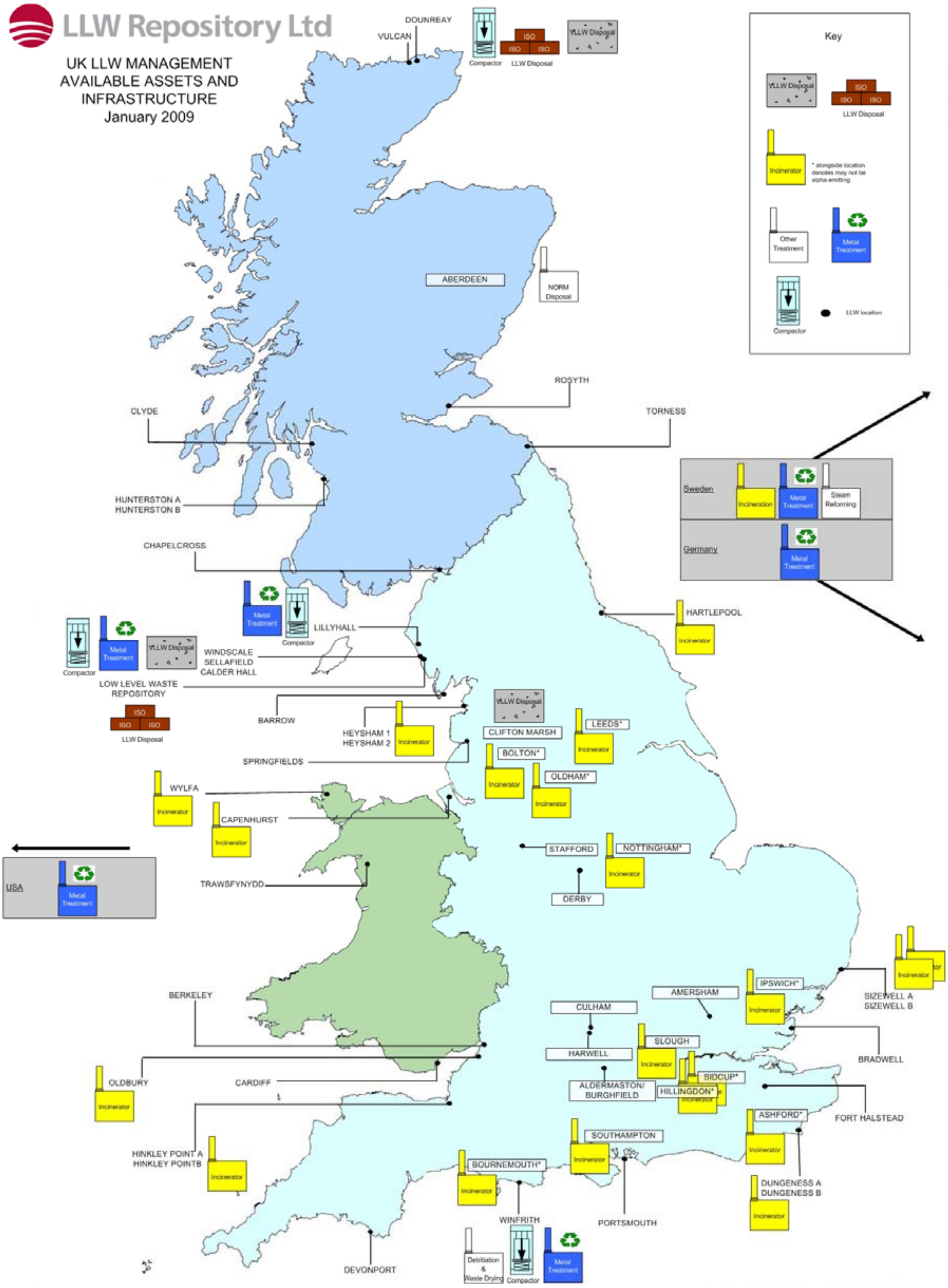
TABLE 8 – MATRIX OF CURRENT ASSETS AND INFRASTRUCTURE IN THE UK

Organisation	Location	LLW Disposal	VLLW Disposal	Super-compaction	Incineration	Metal Treatment	Other
British Energy	Hartlepool				∆		
British Energy	Heysham 1&2				∆		
British Energy	Sizewell B				∆		
British Energy	Hinkley Point B				∆		
Magnox North	Wylfa				∆		
Magnox North	Oldbury				∆		
Magnox South	Sizewell A				∆		
Magnox South	Dungeness A				∆		
Research Sites	Winfrith					∆	
Sellafield	Sellafield		∆	▲		∆	∆
Sellafield	Capenhurst				∆*		
DSRL	Dounreay	∆	∆	∆		∆	
LLWR	LLWR, Cumbria	▲					
WMT	Winfrith			▲			▲
Studsvik UK	Lillyhall			▲		▲	
Pyros	Fawley				▲		
SRCL	Various				▲**		
Grundons	Slough				▲		
SITA	Clifton Marsh		▲				
Scotoil	Aberdeen						▲
Studsvik	Sweden				▲	▲	
Siempelkamp	Germany					▲	
EnergySolutions	USA					▲	

▲ Commercial facilities available to all producers
∆ Facilities for on-site waste only

* Capenhurst incinerator is currently mothballed
** 9 incinerators across England (do not accept alpha contaminated waste)

FIGURE 23 – CURRENT RSA AUTHORISED WASTE MANAGEMENT ASSETS AND INFRASTRUCTURE



4.7 Transport and Packaging

4.7.1 Packaging

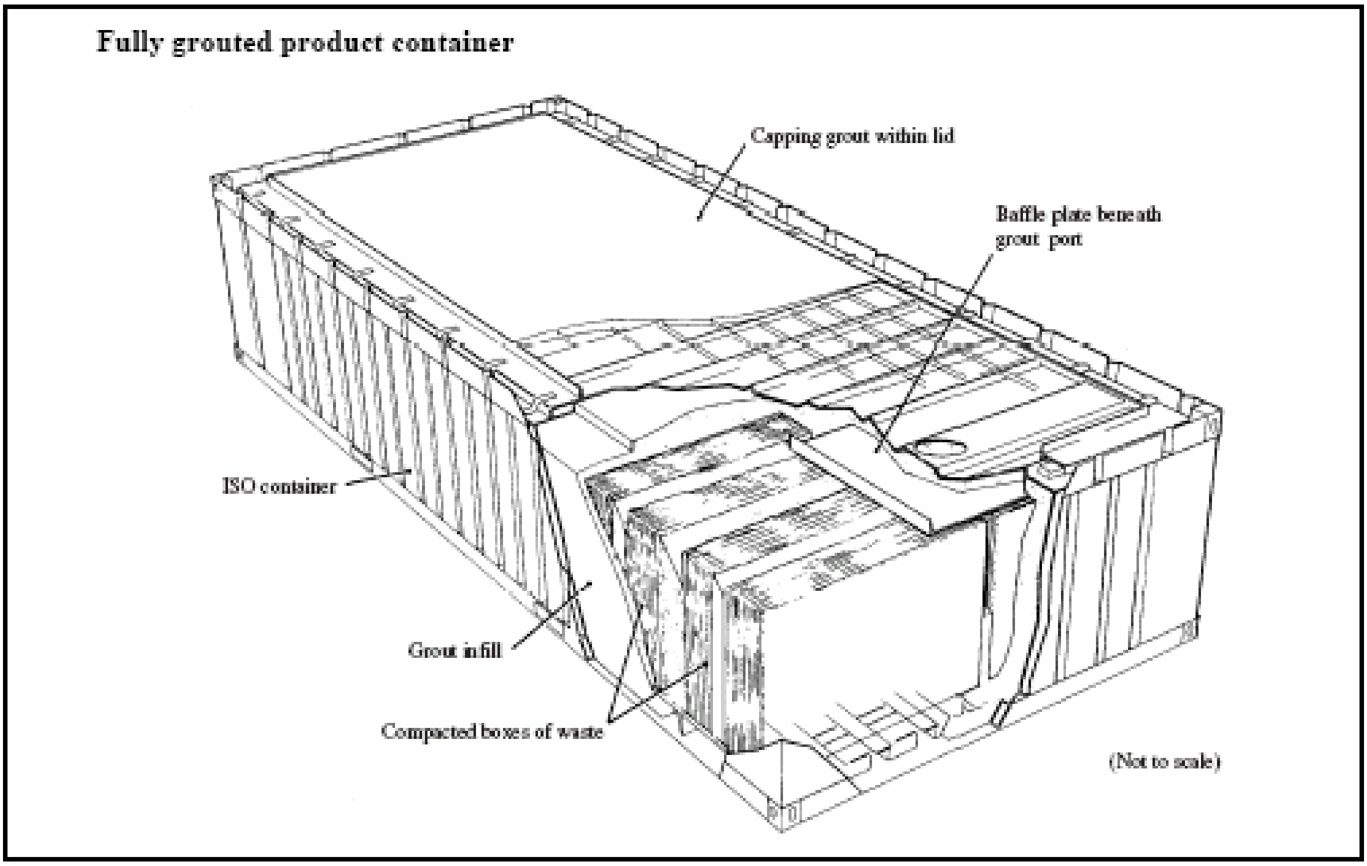
The LLWR CFAs currently specify a number of standard waste packaging requirements for disposal. Common containers used for LLW management include:

- Full height ISO containers – Transport of drummed waste to WAMAC
- Half height ISO containers – Disposal at LLWR
- Third height ISO containers – Disposal of dense material at LLWR
- Nominal 200 litre drums – Compaction or Direct disposal in HHISO
- Reusable IP2 0075 Skips – Transport to WAMAC for compaction
- 1m^3 Box – Filled and Compacted at WAMAC

The main container currently used is the HHISO. Third-Height ISO Containers (THISO) are also sometimes used to dispose of dense material. The design of the steel containers is based on ISO standards but includes a number of modifications to the top, base and side panels as shown in Figure 24. These modifications to the design were made to:

- Ensure good grout flow during filling
- Minimise voidage associated with the ISO container structure
- Enable the loads in a stack of ISO containers to be distributed through the waste form and container structure, rather than just through the container
- Provide a more uniform load distribution across the base in order to reduce point loads acting on the vault base slab

FIGURE 24 – ILLUSTRATION OF A HHISO CONTAINER



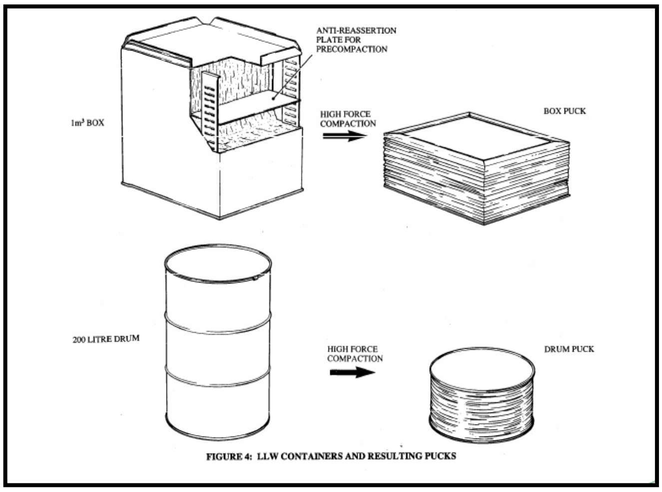
These containers are typically licensed for single-use only which provides limited flexibility. A range of other transport packages such as re-useable Industrial Package (IP) 2 ISO 0075 Skips for loose waste, and IP2 Full-Height ISO Container (FHISO) containers for drummed waste are often used to transport waste to WAMAC for compaction.

The majority of the compactable LLW that arises from nuclear sites other than Sellafield is packed in to nominal 200 litre drums. The drums are mostly standard drum with no IP classification designed to the BS standards 15750-1 and 209:2000. There are some drums with IP classification used for transport when no over pack is used. These drums are then sent to WAMAC for compaction.

The $1m^3$ boxes are used for loose compactable waste originating at Sellafield or consigned in 0075 Skips for compaction of wastes. They are designed to optimise volume to weight ratios in half height ISO containers rather than in drums. The boxes also have the option of using anti springback plates. These are used when material with the potential of springback, such as plastics, are being compacted.

Figure 25 shows the schematic of the drum and box before and after compaction. Compacted pucks are loaded into HHISO containers for disposal.

FIGURE 25 – COMPACTABLE WASTE PACKAGES



HHISOs or THISOs are received at LLWR, grouted and placed in an engineered vault for storage. The use of HHISO containers as an IP2 transport and disposal container is relatively costly and inevitably introduces a significant amount of additional voidage that occupies valuable disposal space in the vault.

For example, the internal volume of a HHISO is $15.5m^3$, however this occupies around $19.5m^3$ of disposal space in the vault. Historically the packaging efficiency for HHISOs is less than 60%, although recently many consignors have shown significant improvements.

There are several other containers that are often used for the purpose of transporting radioactive materials. The majority of these are based on a 20-ft ISO container and are available in IP1, IP2, IP3 and Type A ratings depending on design and application. Some of theses containers are specially designed for different applications, for example, shipment of large bulky items or containers specially fitted with a rail system for loading pallets.

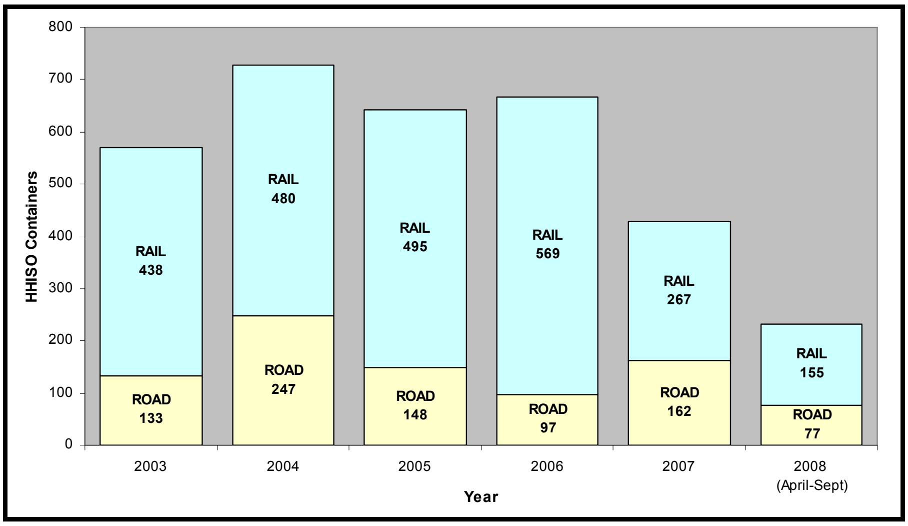
4.7.2 Transport

The movement of radioactive waste in the UK is governed by the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2007 (Statutory Instrument 1573)[18] and regulated by the Department for Transport (DfT). These regulations have recently been introduced in the UK to provide a harmonised approach within the EU for the safe transport of dangerous goods including radioactive materials.

The UK has an established road and rail infrastructure with annual road freight totalling 150 billion tonne kilometres and rail freight totalling 50 billion tonne kilometres. Moreover, half a million packages of radioactive material are shipped within the UK each year, with the nuclear industry making up only a small proportion of this total.

The LLWR currently receives between 500 and 700 HHISO containers per year in addition to occasional large items for disposal. Most of this waste (~75-80%) is delivered to LLWR by rail from Sellafield as shown in Figure 26 below. This waste is typically either generated at Sellafield or received at Sellafield by road. This is an effective operation with scheduled rail moves accommodating multiple LLW containers per shipment.

FIGURE 26 – LLWR DELIVERIES TO LLWR BY ROAD AND RAIL



Virtually all non-Sellafield LLW is transported from the producing site to either Sellafield or LLWR by road. It is estimated that currently around 20-25% of waste shipments are received at LLWR directly by road. Bulk construction materials are largely delivered to the LLWR by road, however, where possible, deliveries for Vault 9 construction are planned to be received by rail.

Consignors have historically organised their own transport using services provided by commercial carriers or other SLCs. There are currently only a small number of hauliers licensed to transport Class 7 Dangerous Goods (radioactive material) in the UK. Only two of the ten Magnox sites have facilities for loading or unloading containers directly from road vehicles. This means that the containers normally have to be collected and delivered on side-loading semi trailers. With one exception, all of the 7 British Energy and 11 Magnox stations have railheads within 2 km to 25 km of the site however these are principally used for transport of spent fuel only and not for LLW.

The key nuclear rail freight company is Direct Rail Services (DRS) (now owned by NDA) which was established in 1995 to provide BNFL with a strategic rail transport service. Its main focus was handling the specialist transportation of spent nuclear fuel from the UK's nuclear power stations to the Sellafield reprocessing facility in Cumbria, but it now offers a range of commercial services and is currently the only organisation involved with LLW rail transport. DRS has operating depots at Carlisle, Crewe, Sellafield, in Scotland and in the South-East of England.

It is recognised that transport of waste and bulk materials to LLWR is a significant stakeholder issue, particularly for residents of the surrounding communities. However with the exception of local stakeholder issues at certain sensitive sites, the transportation of LLW is not considered to be a major impact on the UK's transport infrastructure when considered in the context of other transport activities. It is however noted that the quantity of material to be transported will increase over the next few years as a result of NDA's decommissioning activities.

4.8 Key Analysis Assumptions

NDA publishes a guidance note on assumptions to be used by SLCs for waste and nuclear materials aspects of LTPs (EGG01 Summary Requirements – August 2007)[13]. Based on this guidance the following assumptions were made when compiling the site LLW strategy, waste inventory and cost data from LTP submissions:

1. That there is a reasonable level of consistency between the different data sources within the same LTP (i.e. the IWS, the WATs and the cost estimates are aligned)

2. Assumed baseline waste routings specified in the WATs are realistic (i.e. that the waste route will be available within the timescale required) and represent the current baseline strategy

3. Sites have made appropriate provision in their LTP for disposal costs based on the disposition route specified in the WATs for each wastestream

4. Where this route is currently assumed to be the LLWR near Drigg, or a successor national repository, it is expected that the pricing rates set out in the current LLWR contracts have been used as a basis for costing

The validity of these assumptions is critical to providing confidence that the LLW baseline is robust, complete, and can provide a sound basis for analysis in the strategic review. Once again, sites are requested to highlight any areas where their LTPs are not consistent with these assumptions.

The baseline information presented was initially compiled by NDA and LLWR on behalf of each site and each site was requested to review the baseline to check its completeness and to ensure that the information from LTPs or NI2007 submissions has been correctly interpreted. The feedback from SLCs highlighted the following potential issues regarding the consistency of data within the LTP08 submissions:

- Sellafield - Cost estimates include the new waste treatment plants post-2020 however the detailed wastestream inventory data in WIDRAM were compiled from a combination of WAT08 and NI2007 and hence do not reflect the reduced volumes for disposal
- Magnox South - There are variances at a number of sites between the phasing of costs and waste volumes. This was primarily a result of a re-scheduling of work programmes to reflect funding limits
- Magnox North - A number of issues with the underpinning WAT data were identified including miscalculations between the different worksheets within the WATs.
- Springfields - Inventory arisings in the LTP08 WAT reflect NI2007 values whilst costs are based on different more up to date volume estimates

As noted in Section 4.4.5 above, a number of sites have assumed VLLW will be disposed to landfill as part of their 'baseline' strategy. In reality only a limited number historic authorisations to dispose of VLLW to landfill currently exist (at October 2008) and hence this should be considered as an 'opportunity' until authorised routes have been put in place.

In addition to the identified inconsistencies within LTPs a number of sites indicated that their waste strategies or inventory volume projections had already changed since LTP submission in March 2008. These should be reflected in 2009 LTP submissions.

4.9 LLW Baseline Summary

The 2008 LLW baseline has been compiled for each site in the nuclear industry from data provided in 2008 LTP submissions and/or the NI2007 returns, as applicable. This information has been 'rolled-up' to provide a national perspective for the nuclear industry as a whole. The key findings from compilation of the LLW Baseline are summarised in Table 9 below for each aspect.

TABLE 9 – LLW BASELINE SUMMARY

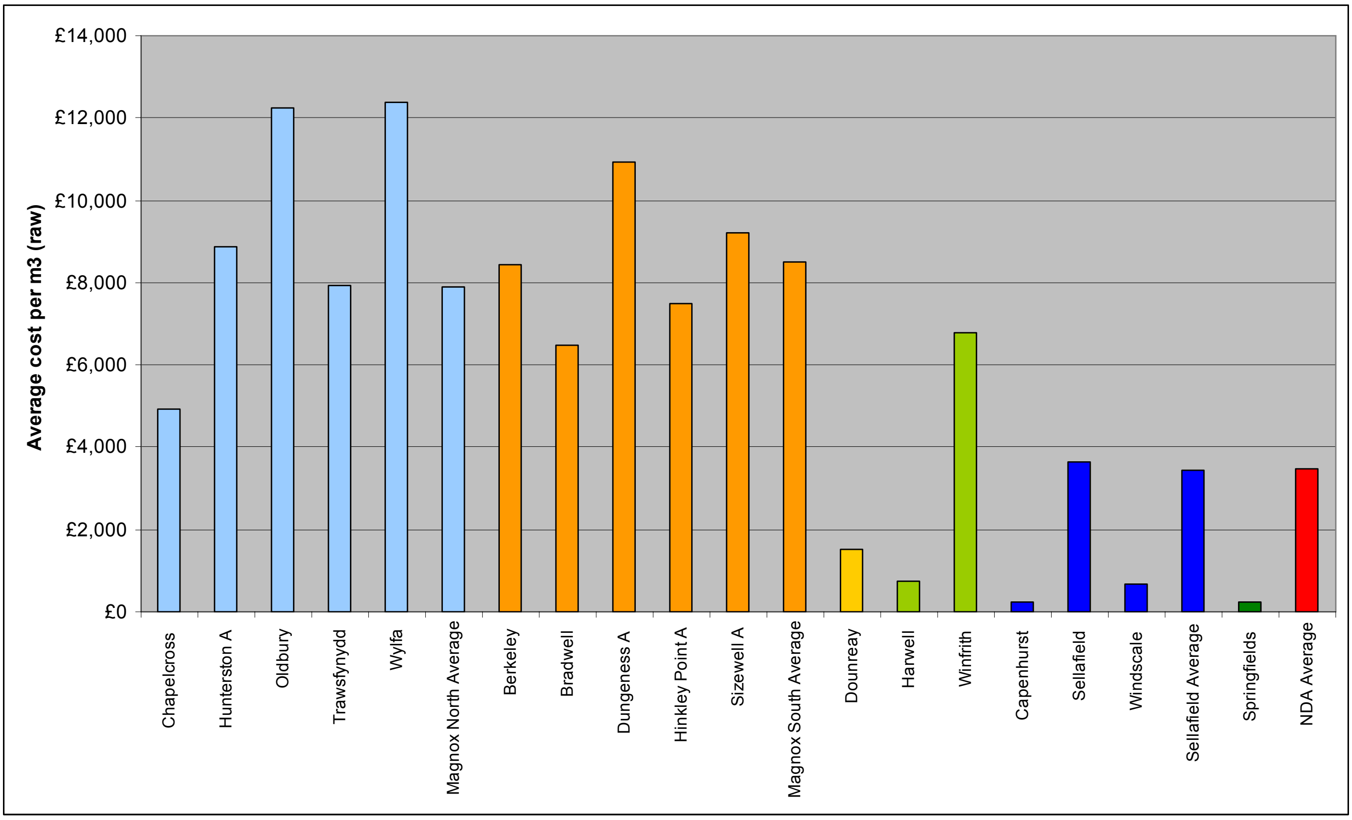
1	Current site LLW management strategies	All NDA sites reference application of the waste management hierarchy principles as a core part of their waste strategy. A number of sites have (or have access to) treatment facilities to reduce waste volumes prior to disposal, such as high-force compaction and incineration. Some sites have also undertaken trial projects with overseas facilities using waste treatment processes such as incineration and melting. Some sites already have historic authorisations to send VLLW to landfill and Dounreay are planning to dispose of LLW and VLLW to an on-site facility. For the majority of sites however, the current baseline disposal strategy for LLW generated from operations and decommissioning is high-force compaction (where applicable) followed by disposal to the LLWR near Drigg in Cumbria.
2	LLW Inventory	The estimated raw arisings of LLW up to 2129 are estimated at 3 million m^3. Of this total approximately 1.8 million m^3 is VLLW or mixed LLW/VLLW. Once packaged, the estimated total volume increases to around 3.1 million m^3. LLW waste streams comprise a broad spectrum of materials including concrete, rubble, soils, plastics, ferrous and non-ferrous metals and cellulosic materials. Sellafield Ltd is forecast to contribute just under half of the total LLW and around two-thirds of the total VLLW. It should be noted that this inventory forecast does not include much of the contaminated land at Sellafield (potentially up to 13 million m^3) which is yet to be characterised. Nor does the inventory include any waste arising from potential new nuclear power stations.

3	Costs and liabilities	A LLW management cost baseline for 2008 has been established to inform NDA's strategic decision-making. The undiscounted costs in NDA's LTPs for management and disposal of solid LLW generated by operations and decommissioning of NDA's sites is currently estimated at around £9.8 billion. This includes the design, construction, operation, decommissioning of any solid LLW management facilities required in addition to the cost of treatment (characterisation, packaging, conditioning, etc), transport and waste disposal itself. There is £2.8 billion included within the LTP's of waste producers for off-site disposal. As this is based on the LLWR tariff price this value does not represent the true lifecycle cost of disposal at LLWR and its successor facility.
4	Assets and infrastructure	Typically all nuclear industry sites have some small-scale sorting & size reduction processes and equipment in addition to monitoring equipment and facilities for loading and packing of HHISOs or other containers. Most sites also have low-force compaction (e.g. in-drum) equipment and/or access to a High Force Compaction service at Sellafield for compactable waste via the LLWR contracts. In addition to compaction, some sites employ other wet or dry decontamination equipment ranging from small-scale mobile equipment to larger industrial-scale fixed plants such as the Wheelabrators at Sellafield. A number of NDA and non-NDA sites including Dungeness, Oldbury, Wylfa, Sizewell A, Hartlepool, Heysham and Hinkley Point B have operational incinerators, primarily for their own waste or the adjoining reactor station. A number of commercial LLW treatment facilities are currently available to waste producers both in the UK and overseas. These services use technologies such as supercompaction, incineration and metal melting. The main facility in the UK for disposal for LLW is the LLWR near Drigg in Cumbria. A smaller on-site disposal facility for LLW and VLLW is to be constructed at Dounreay. Inert VLLW from Sellafield decommissioning activities is currently disposed to the on-site Calder Landfill. A commercial landfill facility at Clifton Marsh is able to accept relatively significant quantities of VLLW (and small quantities of LLW) from Springfields and Capenhurst. There are a small number of other landfills around the UK able to accept small quantities of VLLW from nuclear and non-nuclear industry sites. A number of sites are considering future options for enhanced capability such as characterisation and forecasting, sorting and segregation, decontamination (wet & dry), metal recycling (decontamination & melting), incineration, on-site VLLW disposal and on-site LLW disposal.

A number of potential issues and inconsistencies between different data sets have been identified which could have significant implications in terms of uncertainty within the baseline. The baseline highlights that a number of sites are beginning to consider the waste management hierarchy as a key part of their LLW management operations, however, there are significant differences between the approach and extent to which these principles have been adopted between different sites.

The average cost of waste management, per m^3 for each site is shown in Table D2 in Appendix D and Figure 27 below.

FIGURE 27 – AVERAGE COST OF LLW MANAGEMENT PER SITE (£/M^3 RAW WASTE)



The average cost of LLW management across all NDA sites is around £3,500/m^3, however, there are significant differences between the average cost per m^3 between individual sites. The figure above indicates that the highest average costs for LLW management are at the Magnox North and South sites. Costs range from around £5,000/m^3 at Chapelcross to over £12,300/m^3 at Oldbury and Wylfa. The average at Magnox North sites is £7,900/m^3 compared to around £8,502/m^3 at Magnox South sites. The costs for Sellafield are around £3,500/m^3 which is close to the NDA average. This is not unexpected as Sellafield has the largest proportion of LLW and VLLW wastes of all NDA sites and therefore benefits from economies of scale. Springfield and Capenhurst have the lowest average costs (both around £245/m^3) which is primarily reflects the lower costs associated with their established VLLW disposal route to Clifton Marsh.

Caution should be used in the interpretation of these figures as there may be significant upstream costs (e.g. decommissioning activities) or other site overhead and support costs which have not been captured in the LLW baseline at this stage. Furthermore, a significant component of these overall costs is the LLWR gate price which, as discussed in Section 4.5.2, is not representative of the true lifecycle cost of LLW disposal.

5 Synergies and Opportunities

5.1 Approach

The LLW Baseline described in Section 4 has been used as a basis to identify potential synergies and opportunities by considering LLW management from a national perspective. An integrated analysis has been undertaken of the site LLW strategies, assets and infrastructure, inventory and cost data to identify and evaluate potential initiatives. This process is similar to the approach used for the UKNWM Preliminary Strategic Review in 2006 which also identified a number of potential opportunities to improve LLW management across the UK. These opportunities could result in a significant extension to the lifetime of the LLWR and substantial reductions in overall liability cost to NDA, principally by driving waste up the waste management hierarchy.

5.1.1 Structure of Opportunities

The 2008 Strategic Review analysis has been undertaken in context of evolving Topical Strategies\LLW Strategy[2] and the LLWR Initial Operational Strategy[19]. To ensure consistency with the NDA's LLW Strategy development process the opportunities and synergies identified have been grouped according to the structure outlined in the draft LLW Topical Strategies as follows:

- Application of the waste management hierarchy:
    - Waste Avoidance/Minimisation
    - Waste Characterisation
    - Waste Segregation/Categorisation
    - Waste Treatment
    - Recycle/Reuse
    - Waste Disposal (Exempt/VLLW/LLW)
- Waste Packaging
- Waste Transportation
- Waste Tracking/Inventory Management

5.1.2 Review of SLC Documentation

To inform this integrated analysis, a detailed cross-cutting review has been undertaken of LLW opportunities identified within LTPs, IWSs, Technical Baselines Underpinning Research & Development (TBURDs), WATs for each SLC. Appendix E summarises the purpose and scope of each of the documents. There are marked differences between the way different sites present LTP and strategy information. Therefore a degree of interpretation has been used to categorise the specific opportunities into the themes identified above. These opportunities and Research and Development (R&D) requirements are listed in detail in Appendix F for each site. Figure 28 below summarises the findings of the exercise, illustrating the frequency of opportunities identified for each site against the high level categories as presented.

FIGURE 28 – TBURD AND IWS OPPORTUNITIES BY SITE AND TYPE

Site	Waste Minimisation / avoidance	Characterisation / Monitoring	Categorisation / segregation	Waste Treatment				Re-cycle /Re-use/ Exempt	Waste Disposal		Waste Packaging	Transport	Tracking/ Inventory Management	Other
				Decontaminate	Incineration	Other Size Reduction	Orphan Wastes		Waste Disposal	Decay				
Magnox North	✓	✓					✓✓	✓	✓✓✓✓	✓	✓	✓	✓	✓✓
Chapelcross		✓✓	✓	✓✓✓	✓	✓	✓✓	✓✓	✓		✓	✓		✓
Hunterston A				✓										✓
Oldbury		✓✓	✓✓✓	✓✓✓		✓✓	✓✓✓✓✓	✓✓	✓✓✓	✓✓✓✓ ✓✓	✓		✓	✓✓✓✓✓
Trawsfynydd		✓✓✓✓✓		✓✓	✓		✓✓✓✓✓✓ ✓✓✓	✓✓	✓✓✓✓✓	✓✓✓✓	✓			✓✓
Wylfa		✓✓✓	✓✓		✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓			
Magnox South	✓	✓✓✓		✓	✓✓	✓	✓✓✓✓	✓	✓✓		✓✓	✓✓		✓✓✓✓✓
Berkeley Centre							✓							
Bradwell				✓				✓	✓	✓				
Dungeness A														
Hinkley Point A		✓					✓✓	✓	✓✓	✓				✓
Sizewell A			✓						✓					
Sellafield	✓	✓✓✓✓✓✓	✓✓✓✓	✓✓✓✓✓✓ ✓✓	✓	✓✓✓✓	✓✓✓✓	✓			✓			✓✓✓✓
Calder Hall		✓					✓							
Windscale									✓				✓	✓
Capenhurst		✓✓			✓	✓					✓			
Springfields	✓						✓		✓✓✓					
Culham		✓									✓			
Dounreay		✓		✓					✓		✓			✓
RSRL				✓										
Harwell														
Winfrith									✓					✓
LLWR		✓										✓	✓	
NDA Spent Fuel Services		✓												
TOTAL Occurances	4	30	11	22	8	11	34	13	27	15	12	5	3	24

The review highlighted several common key themes across many sites including opportunities and/or R&D requirements for characterisation/monitoring, orphan wastes such as oils, decontamination, segregation, metal recycling, packaging and disposal.

NDA has also sponsored a series of Waste Categorisation Studies (WCS) over the last few years which have identified specific areas where improvements to LLW management could be made on different sites. The WCS process is summarised in Appendix G. These studies have been reviewed to highlight the most significant opportunities to improve LLW management from a national perspective.

5.1.3 Synergy and Opportunity Analysis

The objective of this LLW Strategic Review is to use the 2008 baseline to identify ways to reduce LLW costs across NDA sites by 10% below the baseline. From the review of baseline and the various WCS, IWSs, TBURDs, WATs, a large number of potential synergies and opportunity initiatives have been identified under each topical area. These candidate initiatives can be qualitatively evaluated using strategic criteria in order to assess aspects such as the ease of implementation, potential timescales and the magnitude of the benefits. The assessment criteria are described further in Table 10 below.

TABLE 10 – EVALUATION CRITERIA

Criteria	Score	Description
Ease of Implementation	Straight-forward	Minimal changes required to current infrastructure, funding, authorisations, or legal framework
	Medium	Some new infrastructure required or moderate changes to current infrastructure required. Some changes required to site funding, authorisations, or legal framework
	Difficult	Significant new infrastructure required. Significant or fundamental changes required to site funding, authorisations, or legal framework
Timescale to implement	Short	Can be implemented immediately or within less than 5 years
	Medium	Can be implemented within 5-10 years
	Long	Implementation would take 10 years or more
Economic Cost-Benefit	Low	Cost neutral or positive lifecycle benefit less than £50 million
	Medium	Positive lifecycle benefit between £50 million - £200 million
	High	Positive lifecycle benefit in excess of £200 million
Other impacts	LLWR capacity preservation	
	Safety and environmental protection	

At this stage the economic cost-benefits have been qualitatively estimated using a degree of judgement based on knowledge the LLW baseline and experience of similar initiatives in the UK and internationally. This approach has been used to prioritise which issues to take forward for more detailed evaluation and/or business case development where appropriate. A methodology is being developed by LLWR to quantify the costs of implementation and benefits realised at LLWR and its successor in order to support business cases going forward. This is described further in Appendix H.

Whilst the objective of this Strategic Review is to identify potential ways to reduce NDA's liabilities by more than 10% it is recognised that this is just one factor that needs to be considered in the context of the overall national LLW strategy. Therefore it is important to recognise impacts in other relevant areas such as the environment, safety, stakeholder acceptance and preservation of the LLWR capacity as a national resource. This is consistent with the Value Framework process that NDA is currently developing to inform its decision-making[20].

Following evaluation the initiatives can be mapped onto the matrix shown in Figure 29 below to prioritise those areas where further effort and resources should be focussed in order to inform NDA's decision-making.

FIGURE 29 – SYNERGY AND OPPORTUNITY MATRIX

Economic Cost-Benefit				
	High (>£200m)	*Medium Priority*	*High Priority*	*Very High Priority*
	Med (£50-£200m)	*Low/Medium Priority*	*Medium Priority*	*High Priority*
	Low (<£50m)	*Low Priority*	*Low/Medium Priority*	*Medium Priority*
		Long (>10yrs)	**Medium (5-10yrs)**	**Short (<5yrs)**
		Timescale to Implement		

Where synergies and opportunities are identified a preliminary judgement has been made whether the initiative represents a potential 'quick-win' (i.e. could be implemented relatively easily and quickly) or whether significant further work is required to assess and/or determine how to implement the opportunity. In either case further work could include commissioning working groups, feasibility studies or business cases as appropriate.

5.2 Application of the Waste Management Hierarchy

Government Solid LLW Policy requires that the principles of the waste management hierarchy are applied to LLW management. In part, this is in recognition of the capacity issues associated with the existing LLW disposal route to the Low Level Waste Repository (LLWR) near Drigg; however application of the waste management hierarchy is fully consistent with the Government's approach to non-radioactive waste management. Extending the life of LLWR also results in significant cost savings. The method being developed to quantify these savings is discussed further in Appendix H.

The objective is to deal with waste at the highest practicable level of the hierarchy. Application of improved waste characterisation, segregation and categorisation to avoid or minimise waste and channel wastes down the most appropriate treatment and disposal routes are key enablers to implement the waste management hierarchy principles.

The following sections identify and evaluate a number of potential opportunities to reduce the baseline by implementing initiatives at each stage of the waste management hierarchy.

5.2.1 Waste Avoidance / Minimisation

5.2.1.1 Current Status

Avoiding the generation of waste provides significant benefits by eliminating any requirement for future management. Where waste cannot be practicably avoided, steps can be taken to minimise the volume and activity of the arisings as far as practicable. The greatest scope for avoidance and minimisation is for those wastes yet to be generated, compared to legacy wastes (e.g. when designing new plants/processes /practices to 'build' waste avoidance and minimisation in from the start).

Increasingly some sites are implementing the Nuclear Industry Code of Practice (NICoP) principles for Clearance and Exemption[21] which aims to increase the quantities of material that can be released as exempt waste; however the application of such principles is not uniform. Other examples of waste minimisation practices include:

- Limit quantities of materials entering active areas (e.g. removal of excess packaging)
- Reduction in Personal Protective Equipment (PPE) usage from work planning and area re-classification
- Use of Exempt or ‘green’ waste routes

Every nuclear industry site references waste avoidance and minimisation as part of their integrated waste strategies and most sites have working procedures in place to minimise waste. However there appears to be significant differences in the extent and approaches implemented between (and sometimes within) sites based on what is considered to be ‘practicable’ at a local level. There is currently no ‘standard methodology’ with regard to waste minimisation practice across different sites. This probably reflects the individual approaches adopted by each site in response to local site circumstances.

5.2.1.2 Potential Initiatives

A number of potential waste minimisation initiatives have been identified and evaluated in Appendix I. The key measures are summarised in Table 11 below.

TABLE 11 – WASTE MINIMISATION INITIATIVES

No.	Title	Benefits	Ease of implementation	Timescale	Cost Benefit
1	Standardise waste avoidance and minimisation programmes	Large potential benefits but requires short-term implementation costs at each site for a standardised programme. Reduced waste volumes can be achieved at the highest level of the waste management hierarchy with corresponding environmental, cost and LLWR capacity preservation benefits. Contributions to wider positive waste management culture are possible, which can generate further ideas.	Medium	Medium Term (5-10yrs)	>£200m
2	Improve consistency of application of NICoP	Greater application of NICoP principles is expected to increase quantities of waste cleared and exempted with corresponding environmental, cost and LLWR capacity preservation benefits.	Straight-forward	Short Term (<5yrs)	<£50m
3	Incentivise waste minimisation	Encourages further investment in waste minimisation programmes and culture change with corresponding environmental, cost and LLWR capacity preservation benefits. Cost savings could be recycled back into further waste minimisation or hazard reduction activities.	Straight-forward	Short Term (<5yrs)	>£200m
4	Identify and share waste avoidance and minimisation best practices	Improved access to best practices developed on other sites will reduce overall costs. NDA doesn't have to fund same learning twice.	Straight-forward	Short Term (<5yrs)	<£50m

There is a range of potential strategic initiatives which could improve waste avoidance and minimisation that could be implemented relatively easily and within a short space of time for a relatively low investment. Some examples are shown in Appendix I. Whilst it is difficult to predict the ultimate scale of the potential benefits across all NDA sites without further detailed consideration of specific measures, many of these small-scale improvements could also provide cumulative benefits at other levels of the waste management hierarchy.

It is likely that some measures may only be appropriate to specific sites and some sites may already be more advanced than others. It is likely, however, that all sites have some scope for improvement and could benefit from mutual sharing of best practices with other sites. An important factor in the success of waste minimisation initiatives is likely to be a framework of appropriate incentives.

5.2.2 Waste Characterisation

5.2.2.1 Current Status

The majority of the benefits associated with managing the waste management hierarchy are realised before waste is generated and packaged. Correct and accurate waste characterisation coupled with monitoring and sentencing facilitates optimal application of the waste management hierarchy. Sites currently use a range of characterisation, assay and measurement equipment, underpinned by various procedures, methodologies and IT data management systems.

Historically large volumes of waste have been characterised under a single waste fingerprint satisfying the conditions for acceptance for processing and disposal. This has frequently resulted in the declaration of higher-than-actual activity levels on waste consignments and utilisation of finite radiological capacity at LLWR (so-called “phantom activity”). It is also likely that current industry practices for characterisation and categorisation lead to a significant degree of conservatism in the sentencing of wastes and hence potentially unnecessarily disposal in engineered vaults at LLWR. More fit-for-purpose waste management routes could potentially be utilised (e.g. “clean routes” or exempt) if waste could be characterised with a higher degree of confidence.

There is a significant programme of characterisation ongoing across the NDA estate (and wider nuclear industry) with particular focus on decommissioning and contaminated land waste estimates. It appears that each site adopts an individual approach. It should be noted that the extent to which wastes have been fully characterised is also variable across different sites and there are still some considerable uncertainties associated with the volume and activity declarations in the inventory.

For most sites it is difficult to isolate the exact cost of characterisation in the LTPs because the costs are likely to be one sub-component of the W&NM Treatment Operations PSWBS category and/or distributed across budgets for decommissioning projects. Sellafield has developed a specialist department for Clearance and Characterisation which represents around 7% (£443 million) of the total LLW costs for the site. The value of characterisation research and development across the NDA Sites, as identified in the TBURD documents, relating to all wastes is between £16 million and £61 million.

5.2.2.2 Potential Initiatives

A number of potential characterisation improvement initiatives have been identified and evaluated in Appendix I. The key measures are summarised in Table 12 below.

TABLE 12 – WASTE CHARACTERISATION INITIATIVES

No.	Title	Benefits	Ease of implementation	Timescale	Cost Benefit
5	Standardise characterisation programmes	Improved waste characterisation enables greater use of alternative fit-for-purpose management and disposal routes (e.g. lower unit cost for ILW -> LLW, LLW -> VLLW, VLLW -> EW). Accurate activity estimates will help prolong LLWR radiological capacity. There are large potential benefits, but with initial short-term implementation costs at each site for a standardised programme.	Medium	Medium Term (5-10yrs)	>£200m
6	Consolidate R&D on characterisation	Reduced R&D costs will mean that each site doesn't have to 're-invent the wheel'.	Straight-forward	Short Term (<5yrs)	<£50m
7	Identify and share characterisation best practices	Improved access to best practices developed on other sites will reduce overall costs. NDA doesn't have to fund same learning twice.	Straight-forward	Short Term (<5yrs)	<£50m
8	Centralised provision of characterisation equipment and/or SQEP resource	Improved access to equipment and knowledge of efficient characterisation processes. A standard approach can be adopted across all sites with associated benefits from potential economies of scale from procurement of these services.	Difficult	Short Term (<5yrs)	£50m - £200m
9	Re-estimate wastestream characterisation	Will reduce uncertainty in volumes and activity estimates in inventory. Improved waste characterisation enables greater use of alternative fit-for-purpose management and disposal routes (e.g. lower unit cost for ILW -> LLW, LLW -> VLLW, VLLW -> EW). Accurate activity estimates will help prolong LLWR radiological capacity.	Medium	Medium Term (5-10yrs)	<£50m

A certain level of characterisation takes place irrespective of the level of waste management hierarchy application. An improved focus in this area on all sites is likely to realise benefits that outweigh any additional investment. This has been borne out by project experience in the UK and overseas which has demonstrated that small investments in additional characterisation can yield large savings by moving waste into lower categories such as VLLW or exempt wastes (EW).

5.2.3 Waste Segregation / Categorisation

5.2.3.1 Current Status

The majority of UK nuclear facilities have their own, small-scale facilities which provide varying degrees of scale and capability for segregation of waste by material type (e.g. metal, combustible, compactable from non-compactable wastes, etc) and activity (e.g. EW, VLLW, LLW, etc).

Historically UK waste has only been segregated to a limited extent such as compactable/non-compactable waste in line with the available routes. Where sites have access to an incinerator combustible waste has also been segregated. There are potentially a number of real (and perceived) constraints associated with current facilities, lack of space and flexible containers at some sites. The responses to the Topical Strategy consultation also cited lack of alternative routes as a reason current segregation is limited.

Some sites including Chapelcross and Hinkley Point A, have recently invested in dedicated waste sorting and packaging facilities which allow improved segregation and packaging of different types of waste. Other sites have used temporary waste sorting and sentencing areas for specific decommissioning projects. Sellafield Ltd has planned for a new £82 million Sort and Segregation facility (the 'hub') which is expected to be operational by 2020. This facility will provide large-scale sort and segregation services for wastes from decommissioning activities by type and activity, before sending the waste to alternative treatment and disposal routes.

5.2.3.2 Potential Initiatives

A number of potential segregation and categorisation improvement initiatives have been identified and evaluated in Appendix I. The key measures are summarised in Table 13 below.

TABLE 13 – WASTE SEGREGATION INITIATIVES

No.	Title	Benefits	Ease of implementation	Timescale	Cost Benefit
2	Improve consistency of application of NICoP	Greater application of NICoP principles is expected to increase quantities of waste cleared and exempted with corresponding environmental, cost and LLWR capacity preservation benefits.	Straight-forward	Short Term (<5yrs)	<£50m
10	Develop guidance on segregation best practices	Improved access to best practices developed on other sites will reduce overall costs. NDA doesn't have to fund same learning twice.	Straight-forward	Short Term (<5yrs)	<£50m
11	Incentivise segregation of wastes	Encourages further investment in waste segregation programmes and culture change. Segregated waste can then be processed and disposed via the most appropriate route with corresponding environmental, cost and LLWR capacity preservation benefits.	Straight-forward	Short Term (<5yrs)	>£200m
12	Standardise design of waste segregation facilities	Reduce costs across construction, feasibility, design of new facilities. Lessons can be learnt and adapted for next facility build more easily. The application of this approach for Magnox Final Site Clearance Waste Management Facilities is discussed in Appendix J.	Difficult	Medium Term (5-10yrs)	>£200m
39	Introduce small modular containers for segregated wastes	Enhances segregation by enabling containers to get closer to the workface. This also mitigates space constraints at a number of sites.	Medium	Short Term (<5yrs)	£50m - £200m

The more waste can be segregated by material type and activity; the more management options are potentially available. Segregation is a key enabler to the optimum use of waste management routes. As more treatment and disposal options are made available, it is expected that sites will improve the amount of segregation undertaken to match the available routes. These opportunities would be most successful if supported by an appropriate financial, regulatory, and technical incentivisation regime.

5.2.4 Waste Treatment

5.2.4.1 Current Status

Waste treatment includes a wide range of processes to reduce the volume of waste requiring disposal by changing the physical form of the waste or by removing contamination. Analysis of the inventory indicates that over 60% of LLW and 32% of VLLW could potentially be treated using a variety of techniques to reduce volumes.

All NDA sites reference application of the waste management hierarchy principles as a core part of their waste strategy. The current baseline treatment technology for most LLW generated from operations and decommissioning is high-force compaction (where applicable) followed by encapsulation (by grouting) prior to disposal. A range of decontamination techniques such as high pressure water jetting, shot blasting, chemical decontamination, and machining and grinding equipment have also been used to minimise volumes requiring disposal. Over 50% (£4.9 billion) of LLW costs are associated with W&NM Treatment Operations.

A number of sites have (or have access to) larger scale treatment facilities to reduce waste volumes prior to disposal, such as high-force compaction and incineration. Some sites have also successfully undertaken trial projects with overseas facilities using waste treatment processes such as incineration and melting. As described in Section 4.5.5, Sellafield currently has plans to spend over £173 million constructing substantial new waste treatment infrastructure by 2020 including a new WAMAC (£70 million), wheelabrator (£11 million), metal melting (£31 million) and thermal destruction (incineration) facility (£61 million), subject to this being the optimised solution.

Despite the availability of techniques, facilities, and a supportive regulatory regime under the LLW Policy there are still large volumes of potentially treatable material disposed to LLWR without significant volume reduction. Part of the reason for this may be the perceived difficulty of opening new routes, lack of authorisations, and absence of financial incentives compared to disposal.

Not all of the current incineration facilities run at full capacity and therefore there may be scope to make more efficient use of these existing assets, subject to authorisations. There is a significant amount of treatment capacity (compaction, incineration and melting) currently within the supply chain that could be further utilised. It is expected that increased market demand for waste treatment services will result in investment in further capacity within the supply chain.

5.2.4.2 Potential Initiatives

A number of potential waste treatment improvement initiatives have been identified and evaluated in Appendix I. The key measures are summarised in Table 14 below.

TABLE 14 – WASTE TREATMENT INITIATIVES

No.	Title	Benefits	Ease of implementation	Timescale	Cost Benefit
13	Incentivise treatment of wastes	Encourages consignors to segregate wastes to allow processing in accordance with the waste management hierarchy. Segregated waste can then be processed and disposed via the most appropriate route with corresponding environmental, cost and LLWR capacity preservation benefits.	Straight-forward	Short Term (<5yrs)	>£200m
14	Develop metal treatment routes	Provides high volume reduction for metallic wastes and allows more material to be recycled. There may be considerable attainable market value from sale of metal with corresponding environmental, cost and LLWR capacity preservation benefits. This may also stimulate investment in new UK capabilities and capacity.	Medium	Short Term (<5yrs)	>£200m
15	Develop incineration routes	Provides high volume reduction for combustible wastes. This may also stimulate investment in new UK capabilities and capacity and NDA could avoid £70m investment in new WAMAC facility.	Medium	Short Term (<5yrs)	>£200m
16	Supply chain provide new waste treatment facilities, capacity and capabilities.	Supply chain facilities are likely to be significantly cheaper and more efficient than equivalent facilities on NDA sites. NDA could potentially avoid over £200m in capital investments.	Difficult	Medium Term (5-10yrs)	>£200m
17	Improve efficiency and utilisation of existing incinerators at nuclear sites	Optimise life and use of current incineration assets. Future costs can be reduced by better joined up thinking at a national level rather than site by site.	Difficult	Medium Term (5-10yrs)	£50m - £200m
18	Improve efficiency of existing NDA metal decontamination facilities	Significantly increases overall metal recycling rates with corresponding reduction in secondary waste & non-exemptable material consigned for disposal. Facility throughput would also be increased as less blasting cycles are required.	Straight-forward	Short Term (<5yrs)	£50m - £200m
19	Consolidate R&D on orphan and hazardous wastestreams	Reduced R&D costs so that each site doesn't have to 're-invent the wheel'. Allows an optimised UK solution to be developed for each stream (e.g. oils, asbestos, lead, resins, sludges, mercury, zinc bromide, graphite, etc) which can then be deployed at all sites.	Straight-forward	Short Term (<5yrs)	>£200m

A number of the waste treatment initiatives outlined above have been under consideration for some time and could be implemented within a very short timescale (less than 1 year). It is likely that development of treatment routes in the short-term could also facilitate other initiatives such as improved efficiency of NDA metal decontamination facilities and investment by the supply chain. An important factor in the success of waste treatment initiatives is likely to be a supportive framework of appropriate technical, regulatory, and financial incentives.

The Environment Agency is currently developing proposals to change the wording of some site authorisations to facilitate the treatment of waste. The regulation of radioactive substances is planned to be brought under new the Environmental Permitting Regulations in due course. This may streamline the process of inter-site transfers of waste for treatment.

5.2.5 Recycle/Reuse and Exempt Waste

5.2.5.1 Current Status

The Government Policy recognises that there are opportunities for industry-wide initiatives for increased re-use and recycling of some forms of waste which could result in significant environmental and economic benefits. There are significant quantities of potentially reusable or recyclable material in the inventory, including over 1.5 million m^3 of soil and rubble and 0.9 million m^3 of metal. These materials are currently classified as LLW or VLLW but with increased focus on characterisation it is possible that much of this material could ultimately be sentenced as a lower category of waste such as VLLW or exempt.

Most sites have arrangements in place to re-use and recycle wastes and contaminated equipment where practicable. Examples of re-use and recycling practices include:

- Surface decontamination of metals
- Re-use of lead shielding blocks
- Re-use of demolition wastes for hard-core and site roads
- 'Hot' tool stores
- Re-cycled work-wear through active laundries

Over 1,000 tonnes of metal is processed through the two Sellafield Wheelabrators each year and recycled as conventional scrap. Currently any material failing to meet the 'exemption' criteria after processing is sentenced as LLW to the LLWR. Whilst a number of other sites have metal recycling listed as a potential 'opportunity', full advantage of this capability is not being utilised or not fully reflected in the inventory. For example, only 27m^3 of metal from Hinkley Point A is designated in the baseline WIDRAM inventory to be recycled.

Exempt wastes such as soil and rubble are often re-used within the same nuclear site where the material can be put to immediate use, such as filling voids. This approach has been successfully used on a number of sites. Where there is no immediate use for LLW or VLLW soil/rubble these are typically sentenced as waste and disposed.

There are very few examples of co-ordinated approaches where materials are transferred to other sites for re-use or recycling. There is significant scope for increased co-ordination of recycling between sites which may help find appropriate end uses for suitable material being generated.

5.2.5.2 Potential Initiatives

A number of potential re-use and recycling improvement initiatives have been identified and evaluated in Appendix I. The key measures are summarised in Table 15 below.

TABLE 15 – REUSE AND RECYCLING INITIATIVES

No.	Title	Benefits	Ease of implementation	Timescale	Cost Benefit
2	Improve consistency of application of NICoP	Greater application of NICoP principles is expected to increase quantities of waste cleared and exempted with corresponding environmental, cost and LLWR capacity preservation benefits. .	Straight-forward	Short Term (<5yrs)	<£50m
14	Develop metal treatment routes	Provides high volume reduction for metallic wastes and allows more material to be recycled. There may be considerable attainable market value from sale of metal with corresponding environmental, cost and LLWR capacity preservation benefits.	Medium	Short Term (<5yrs)	>£200m
18	Improve efficiency of existing NDA metal decontamination facilities	This could significantly increase overall metal recycling rates with corresponding reduction in secondary waste & non-exemptable material consigned for disposal. Facility throughput would also be increased as less blasting cycles are required.	Straight-forward	Short Term (<5yrs)	£50m - £200m
20	Identify and share re-use and recycling best practices	Improved access to best practices developed on other sites will increase likelihood of finding an alternative use for the material.	Straight-forward	Short Term (<5yrs)	<£50m
21	Develop mechanism for co-ordination of supply and demand for materials	Improved likelihood of finding an alternative use for the material. Reductions in waste could occur that would otherwise have been disposed to LLWR or landfill with cost and environmental benefits. Significant environmental and sustainability benefits from resource conservation may be possible.	Medium	Medium Term (5-10yrs)	£50m - £200m
22	Re-use/recycle waste in new construction projects in nuclear industry	Reduces waste that would otherwise have been disposed to LLWR or landfill with cost and environmental benefits. This also avoids cost of virgin construction materials. Significant environmental and sustainability benefits from resource conservation can be achieved.	Difficult	Medium Term (5-10yrs)	>£200m
23	Re-use/recycle waste in new construction projects outside nuclear industry	Reduces waste that would otherwise have been disposed to LLWR or landfill with cost and environmental benefits. Cost saving would depend on attainable market value of the material but there are also potentially significant environmental and sustainability benefits from resource conservation.	Difficult	Medium Term (5-10yrs)	£50m - £200m

When coupled with improved characterisation and segregation, there is huge potential to improve recycling rates of a number of materials at NDA and non-NDA sites with significant financial and environmental benefits. Critical to realising these opportunities will be establishment of diverse (and robust) routes both within and outside of the nuclear industry and that stakeholders have appropriate confidence in the integrity of the overall process.

5.2.6 Waste Disposal (Exempt / VLLW / LLW)

5.2.6.1 Current Status

The majority of LLW generated in UK from both nuclear and non-nuclear industries is currently disposed of at the LLWR near Drigg in Cumbria. Under the baseline ‘business-as-usual’ scenario, it is estimated that 2.4 million m^3 of waste will require management at LLWR or a new national LLW repository once LLWR is full. This total forecast volume of LLW significantly exceeds the remaining capacity of the LLWR. Furthermore, the Environment Agency’s assessment of the 2002 LLWR Environmental Safety Case[4] identified a number of issues and uncertainties regarding the short-term and long-term viability of the LLWR site for disposal which need to be resolved. This process will define the LLWR's ultimate radiological capacity.

A further 0.7 million m^3 of the inventory is currently planned for disposal to alternative facilities such as on-site disposal at Dounreay or VLLW to Clifton Marsh. Other nuclear licensed sites are investigating the potential to locate disposal facilities on their sites.

Approximately £2.8 billion is currently included within consignor LTPs for off-site disposal of LLW and VLLW, however, as discussed in Section 4.5.2 this may not necessarily represent the true lifecycle cost liability of LLWR and LLWR2 that NDA will ultimately incur.

Of the 1.8 million m^3 of VLLW in the inventory around 0.7 million m^3 currently has a landfill disposal route via historic authorisations to Clifton Marsh from Springfields and Capenhurst or other commercial landfills around the UK which receive small quantities of VLLW from GE, Devonport, Harwell and Winfrith. At the sites where VLLW routes are available it would appear that considerable effort is focussed on characterisation, decontamination and sentencing in order to stream appropriate material via this route in preference to LLWR.

The remaining 1.1 million m^3 of VLLW does not have alternative authorised routes and hence is currently assumed to be destined for disposal to LLWR. Apart from historic authorisations, VLLW disposal options available to other nuclear industry sites are currently very limited; however a number of commercial landfill operators are considering VLLW disposal developments ranging from expansion of existing sites to new dedicated VLLW facilities, subject to clarification of the regulatory regime.

5.2.6.2 Potential Initiatives

It is expected that there will be large volumes of VLLW arising from decommissioning and much of the volume currently classified as LLW will ultimately turn out to be VLLW or exempt. A number of potential disposal improvement initiatives have been identified and evaluated in Appendix I. The key measures are summarised in Table 16 below.

TABLE 16 – DISPOSAL INITIATIVES

No.	Title	Benefits	Ease of implementation	Timescale	Cost Benefit
2	Improve consistency of application of NICoP	Greater application of NICoP principles is expected to increase quantities of waste cleared and exempted with corresponding environmental, cost and LLWR capacity preservation benefits.	Straight-forward	Short Term (<5yrs)	<£50m
24	Develop alternative routes for exempt waste disposal	This would reduce overall costs both for disposal and preserve capacity at LLWR	Straight-forward	Short Term (<5yrs)	£50m - £200m
25	Develop alternative routes for VLLW disposal	Disposal costs reduced. If local landfills can be found for each site there may be opportunities for reduced waste transportation.	Difficult	Short Term (<5yrs)	>£200m
26	On-site/Near-Site disposal of VLLW on existing NDA sites	Disposal costs reduced. Transport distances could be reduced with on-site and regional facilities.	Difficult	Medium Term (5-10yrs)	>£200m
27	On-site/Near-Site disposal of LLW on existing NDA sites	Disposal costs could be reduced but this will be dependant on design, wasteform and packaging solution adopted. Transport distances could be reduced with on-site and regional facilities.	Difficult	Medium Term (5-10yrs)	>£200m
28	Disposal of some LLW to Deep Geological Repository (e.g. long-lived isotopes)	LLWR radiological capacity could be preserved for a considerably longer time. The extra benefit at LLWR would have to be balanced against extra cost of disposal in the deep repository.	Difficult	Long Term (10+yrs)	>£200m
29	Disposal of short-lived ILW in near-surface facilities	Considerable overall cost saving to NDA from disposal of short-lived ILW at LLWR compared to deep repository. There is potential to accelerate hazard reduction activities at sites if route for such material can be provided.	Difficult	Long Term (10+yrs)	>£200m
30	Alternative Vault Designs	Reduce impact on the environment, reduce installation and maintenance costs, and improve waste disposal efficiencies	Difficult	Long Term (10+yrs)	£50m - £200m
31	Optimise closure of LLWR	Reduce cost of new materials and operational costs	Difficult	Long Term (10+yrs)	<£50m
32	Disposal of NORM to alternative facilities	LLWR radiological capacity could be preserved for a considerably longer. time	Difficult	Medium Term (5-10yrs)	<£50m
33	Decay storage of short-lived LLW	Preserves capacity at LLWR with consequential cost savings. Cost of long-term storage and legacy management would have to be balanced against reduction in disposal costs.	Difficult	Medium Term (5-10yrs)	£50m - £200m
34	In-situ management of contaminated land	Preserves capacity at LLWR with consequential cost savings. Reductions in overall risks to the LLW strategy from large waste volumes currently outside the inventory can be achieved. Cost of in-situ management, ongoing monitoring, etc would have to be balanced against reduction in disposal costs.	Difficult	Long Term (10+yrs)	>£200m

These disposal initiatives represent a diverse range of potentially challenging but very significant opportunities. A number of these initiatives would take a significant amount of investment in time and money for further study in order to assess overall viability and/or define the details of implementation. Many of these initiatives would also require significant amounts of stakeholder consultation at national, regional and local levels and may also have interfaces with NDA's overall Strategy and waste strategies (e.g. for ILW and contaminated land). Whilst demanding, many of these initiatives could have significant benefits and hence may be worthy of further consideration.

5.3 Waste Packaging

5.3.1.1 Current Status

The main containers used for LLW disposal at LLWR are HHISO and THISO containers in combination with drums or boxes for compactable waste. HHISOs or THISOs are received at LLWR, grouted, and placed in an engineered vault for storage. Compaction provides additional volume reduction which enables around 5 times more raw waste to be packaged into a single disposal container.

Historically the average packaging efficiency of HHISO has been less than 60%. For non-compactable waste, this means that typically less than $10m^3$ of raw waste can be packaged inside a container which has an external envelope volume of $19.5m^3$.

Higher packaging efficiencies are usually possible, depending on the nature of the waste; however, there comes a point at which the effort required to segment and carefully package waste into the container outweighs the packaging efficiency benefits. Although there have been advances in some of these areas, there still remain significant opportunities yet to be realised throughout the nuclear industry.

In addition to being a disposal container, the HHISO container is an IP2-rated approved transport package. These containers are typically licensed for single-trip only which provides limited flexibility. The use of HHISO containers as an IP2 transport and disposal container is relatively costly and inevitably introduces a significant amount of additional voidage that occupies valuable disposal space in the vault.

VLLW and exempt wastes do not necessarily require the same packaging solutions as LLW but currently VLLW is often packaged in HHISO containers.

5.3.1.2 Potential Initiatives

A number of potential packaging improvement initiatives have been identified and evaluated in Appendix I. The key measures are summarised in Table 17 below.

TABLE 17 – PACKAGING INITIATIVES

No.	Title	Benefits	Ease of implementation	Timescale	Cost Benefit
35	Develop methods and tools for improving waste packaging efficiency.	Small improvements in packaging efficiency can lead to significant benefits at LLWR.	Medium	Medium Term (5-10yrs)	£50m - £200m
36	Use of reusable containers for transport of LLW	Allows containers to be reused, reducing overall packaging costs.	Straight-forward	Short Term (<5yrs)	£50m - £200m
37	Introduce inner disposal liners for non-compactable waste	Lower cost disposal container, less voidage and grout, and more efficient use of vault space.	Difficult	Medium Term (5-10yrs)	£50m - £200m
38	Introduce puck overpacks for compacted waste	Lower cost disposal container, less voidage and grout, and more efficient use of vault space.	Difficult	Medium Term (5-10yrs)	£50m - £200m
39	Introduce small modular containers for segregated wastes	Enhances segregation by enabling containers to get closer to the workface. This also mitigates space constraints at a number of sites.	Medium	Short Term (<5yrs)	£50m - £200m
40	Introduce reinforced bags for VLLW	Lower cost disposal container, less voidage and grout, and more efficient use of disposal space.	Difficult	Medium Term (5-10yrs)	£50m - £200m

There are considerable opportunities to optimise, the transport and disposal packages in order to make better use of the capacity at LLWR. Furthermore, there are opportunities to introduce simple and cost-effective new packaging solutions for segregated wastes such as metals, incinerables and compactables which will enhance the effectiveness of other treatment and disposal initiatives.

5.4 Waste Transportation

5.4.1 Current Status

When preparing waste management plans for LLW, the Government Policy requires appropriate consideration of the proximity principle and waste transport issues. It is stated in the policy that while the use of centralised facilities, such as the LLWR near Drigg in Cumbria, or any similar future facility, may be the appropriate point of disposal for much LLW, other options should be considered using the proximity principle as a point of reference. The policy recognises that although the desire to avoid excessive transportation of materials is an important consideration, it must be balanced with all the other relevant factors on a case-by-case basis. The social and environmental impacts of waste transport are a function of the number of movements, the distance travelled and the mode of transport utilised. The overall risks to public safety for nuclear waste shipments have been demonstrated to be extremely small.

The cost baseline indicates that approximately 2% of overall costs are allocated to transport. It should be noted that some sites, such as Sellafield, include their LLW transport costs under other categories that were not captured in this LLW baseline so in reality the proportion is actually higher. Transports of LLW may potentially increase in future as larger volume of low activity wastes are generated by decommissioning.

The LLWR currently receives between 500 and 700 HHISO containers per year, with around 75% delivered by rail from Sellafield. Virtually all non-Sellafield LLW is transported from the producing site to either Sellafield or LLWR by road. With one exception, all of the AGR and Magnox stations have railheads within 2 km to 25 km of the site. Three of the AGR stations have rail facilities on site, although these facilities are not currently used for LLW transport. Existing railheads, currently set up for flask movements, could be made suitable for dealing with ISO containers. There may also be some "mothballed" railheads that have the potential to be returned to operational status.

Virtually all UK LLW is transported in ISO containers. Limited transport of large contaminated metallic items has been undertaken in the UK. For example, four heat exchangers, each weighing 190te, were transported by road from UKAEA Windscale to LLWR in 1995 and more recently in 2007 several large 50te contaminated components from the steel industry were shipped to LLWR. There are several dozen large Magnox boilers weighting over 200 tonnes each that already have been or will be decommissioned in the near future.

With the exception of local stakeholder issues at certain sensitive sites, the transportation of LLW is not considered to be a major impact on the UK's transport infrastructure when considered in the context of other transport activities.

5.4.2 Potential Initiatives

A number of potential transport improvement initiatives have been identified and evaluated in Appendix I. The key measures are summarised in Table 18 below.

TABLE 18 – TRANSPORT INITIATIVES

No.	Title	Benefits	Ease of implementation	Timescale	Cost Benefit
41	Use of transport hubs	Reduced cost of transport, less stakeholder concern, and environmental impact from rail and sea transport.	Difficult	Medium Term (5-10yrs)	<£50m
42	Increased use of rail transport	Possible reduction in cost, environmental impact, and traffic congestion on the roads	Medium	Short Term (<5yrs)	<£50m
43	Integration of LLW and spent fuel rail shipments	Significant cost savings, reduced number of rail shipments, and better integrated waste loading and transport to appropriate facilities.	Medium	Short Term (<5yrs)	<£50m
44	Transport of large components whole	The transport of larger items can have a number of advantages including the safety benefits and cost savings from avoiding the need for bespoke size reduction and packaging facilities at the waste producing site. There are likely to be significant safety, environmental and cost benefits from undertaking this type of work in purpose-built facilities. These advantages would likely outweigh the inconvenience and cost of transporting the large item.	Medium	Short Term (<5yrs)	<£50m

Whilst transport may not represent a significant proportion of overall LLW liability compared to other costs, when combined with other waste management hierarchy initiatives, optimising waste transport would likely bring positive environmental benefits and reduce the concerns of transport with local stakeholders.

5.5 Waste Tracking/Inventory Management

5.5.1 Current Status

The management process to consign waste to LLWR is currently a largely paper-based system. This includes activities such as assuring compliance with the CFAs, waste stream characterisation, supply of packaging and associated quality assurance and commercial arrangements. The operation and administration of this system is often both resource and time intensive. The current system only provides limited capability to perform analysis and forecasting. The current practice for waste data management systems therefore offer a number of significant opportunities to automate and streamline the system resulting in cost efficiencies.

As mentioned in Section 4.4.8, LLW inventory information is currently collected and managed in multiple datasets at present which creates a number of issues in terms of data quality and consistency. LLW inventory is tracked by different bodies in different formats, over different timescales, and for different purposes. There are a number of issues associated with the current situation of diverse datasets such as:

- Different types of information in each dataset (volume/material type/time)
- Reporting differences and assumptions between sites
- Data is difficult to access/analyse
- Reporting burden for sites
- Difficult for LLWR to forecast waste arisings
- Different definitions for High-Volume Low Activity waste and high-volume VLLW (Government Solid LLW Policy)

Historically, the actual receipts of waste at LLWR have been significantly lower (sometimes half) compared with the forecast arisings in the inventory. Not only does this make strategic planning difficult, this uncertainty creates additional challenges in terms of managing LLWR's income, expenditure and cost-recovery. In addition, the presence of changeable high-volume waste streams make long-term planning and cost liability management difficult, particularly with regard to capacity provision (e.g. planning for future vaults and a successor repository) and environmental safety cases.

5.5.2 Potential Initiatives

A number of potential waste tracking and inventory management improvement initiatives have been identified and evaluated in Appendix I. The key measures are summarised in Table 19 below.

TABLE 19 – TRACKING AND INVENTORY INITIATIVES

No.	Title	Benefits	Ease of implementation	Timescale	Cost Benefit
45	Simplify waste consignment processes	Reduced time and effort required to consign waste for treatment and disposal will improve efficiency at consignors' sites and LLWR resulting in reduced cost and resource requirements. Lower incidence of non-compliances may also occur.	Difficult	Medium Term (5-10yrs)	<£50m
46	Improved waste quality assurance processes	Benefits from improved consistency in meeting the LLWR CFAs and can enable more effective oversight of authorisations by regulators.	Medium	Short Term (<5yrs)	<£50m
47	LLW records consolidation and archiving	Some efficiency across the UK could be achieved through centralised and electronic records management subject to regulatory agreement.	Difficult	Long Term (10+yrs)	<£50m
48	Improve waste forecasting	Improves short-term forecasting which allows more efficient operational and capacity planning at LLWR. Reduction in long-term uncertainties is vital for NDA's strategic planning and decision-making.	Straight-forward	Short Term (<5yrs)	<£50m

There are a range of initiatives that can improve overall waste management and consignment processes resulting in increased efficiency and regulatory compliance.

Although improving the data may not necessarily save significant costs in itself, development of the inventory into a robust dataset by reducing uncertainty in key areas is important to enable NDA to manage capacity, liabilities, and save cost in other areas. Improving the accuracy of waste forecasting in the LLW inventory is a vital strategic issue to inform NDA's overall Strategy and may have significant interfaces with other waste management strategies, such as ILW and contaminated land.

5.6 Other

A number of potential initiatives have been identified and evaluated in Appendix I which do not fit into one of the above categories. These are summarised in Table 20 below.

TABLE 20 – OTHER INITIATIVES

No.	Title	Benefits	Ease of implementation	Timescale	Cost Benefit
49	Development of UK LLW Strategy	Provide strategic direction and focus to Government, waste producing sites, regulators and planning authorities on LLW management.	Straight-forward	Short Term (<5yrs)	<£50m
50	Preparation of national strategic option assessments	Development of strategic national optimised solutions will mitigate against sub-optimal decision-making at site or project level. It will also minimise duplication of optioneering (e.g. BPEO) effort and provides guidance for consignors undertaking their own studies.	Medium	Short Term (<5yrs)	<£50m
51	Enhance communications within LLW management community	Mitigates against stakeholder fatigue by improving consultation and communication and provides added transparency of decision-making. This also helps mitigate against potential inconsistency in decision-making at different sites by NDA, waste producers and regulators.	Medium	Short Term (<5yrs)	<£50m
52	Establish principles for decontamination and decommissioning	Improved use of the waste management hierarchy within decommissioning projects, reduced costs and impact on the environment. It will provide stepping stones on which to build effective decommissioning projects aimed at avoiding and reducing the generation of all wastes	Medium	Medium Term (5-10yrs)	<£50m
53	Develop strategy to optimise use of current/future NDA assets	Optimise life and use of current assets. The strategy can also reduce future costs by better joined up thinking at a national level rather than at a site-by-site level. Use of supply chain to provide new facilities could result in significant cost savings to NDA.	Medium	Short Term (<5yrs)	<£50m
54	Introduce risk-based classification of radioactive substances and waste	Potentially significant savings by classifying and managing waste by a direct numerical assessment of risk to health and environment.	Difficult	Long Term (10+yrs)	>£200m

These initiatives are mainly of a programmatic nature and act as a framework within which waste management takes place. These initiatives have the potential to support or influence implementation of a multitude of other initiatives at all levels of the waste management hierarchy.

5.7 Synergy and Opportunity Summary

Potential synergies and opportunities to improve LLW management have been identified and evaluated in the previous sections. These have been mapped onto the matrix shown in Figure 30 below.

FIGURE 30 – SYNERGY AND OPPORTUNITY MATRIX (POPULATED)

Economic Cost-Benefit				
	High (>£200m)	*Medium Priority* 28, 29, 34, 54	*High Priority* 1, 5, 12, 16, 22, 26, 27	*Very High Priority* 3, 11, 13, 14, 15, 19, 25
	Med (£50-£200m)	*Low/Medium Priority* 30	*Medium Priority* 17, 21, 23, 33, 35, 37, 38, 40	*High Priority* 8, 18, 24, 36, 39
	Low (<£50m)	*Low Priority* 31, 47	*Low/Medium Priority* 9, 32, 41, 45, 52	*Medium Priority* 2, 4, 6, 7, 10, 20, 42, 43, 44, 46, 48, 49, 50, 51, 53
Ease of Implementation: Blue = Straight-forward; Orange = Medium; Red = Difficult		**Long (>10yrs)**	**Medium (5-10yrs)**	**Short (<5yrs)**
		Timescale to Implement		

The figure shows that there are a number of measures that would be relatively straight-forward to implement within a short timescale. These are likely to only need minor changes to current systems and infrastructure to implement. These are summarised in Table 21 below and are considered potential 'quick-wins'.

TABLE 21 – POTENTIAL 'QUICK-WINS'

No.	Initiative	Cost Benefit	Priority
3	Incentivise waste minimisation	>£200m	Very High
11	Incentivise segregation of wastes	>£200m	Very High
13	Incentivise treatment of wastes	>£200m	Very High
14	Develop metal treatment routes	>£200m	Very High
15	Develop incineration routes	>£200m	Very High
19	Consolidate R&D on orphan and hazardous wastestreams	>£200m	Very High
25	Develop alternative routes for VLLW disposal	>£200m	Very High
18	Improve efficiency of existing NDA metal decontamination facilities	£50m - £200m	High
24	Develop alternative routes for exempt waste disposal	£50m - £200m	High
36	Use of reusable containers for transport of LLW	£50m - £200m	High
2	Improve consistency of application of NICoP	<£50m	Medium
4	Identify and share waste avoidance and minimisation best practices	<£50m	Medium
6	Consolidate R&D on characterisation	<£50m	Medium
7	Identify and share characterisation best practices	<£50m	Medium
10	Develop guidance on segregation best practices	<£50m	Medium
20	Identify and share re-use and recycling best practices	<£50m	Medium
48	Improve waste forecasting	<£50m	Medium
49	Development of UK LLW Strategy	<£50m	Medium

Collectively implementation of these initiatives could produce a step-change improvement in LLW management practices across the UK and contribute significant savings of over £1 billion to the LLW baseline. Further detailed consideration will have to be made on the practicability of some initiatives based on the current funding allocations. Whilst it is considered that these initiatives are implementable within the overall level of funding for LLW management, NDA may have to consider portfolio management of LLW funds in order to realise maximum benefits.

It should be noted that not all of these initiatives are mutually exclusive and in some cases the impact of initiatives may overlap. For example, incentivising treatment will yield maximum benefits when coupled with opening up treatment routes. Depending on the interaction, certain initiatives may enhance (or possibly even negate) the cost-benefit of others. This would have to be considered further when defining more detailed implementation plans and/or business cases.

There are a number of initiatives that require further study or consideration which are shown in Table 22 below. These initiatives are likely to take longer to realise tangible benefits or require further evaluation to determine the best means of implementation.

TABLE 22 – INITIATIVES TO BE STUDIED FURTHER

No.	Initiative	Cost Benefit	Priority
1	Standardise waste avoidance and minimisation programmes	>£200m	High
5	Standardise characterisation programmes	>£200m	High
12	Standardise design of waste segregation facilities	>£200m	High
16	Supply chain provide new treatment facilities, capacity and capabilities.	>£200m	High
22	Re-use/recycle waste in new construction projects in nuclear industry	>£200m	High
26	On-site/Near-Site disposal of VLLW on existing NDA sites	>£200m	High
27	On-site/Near-Site disposal of LLW on existing NDA sites	>£200m	High
8	Centralised provision of characterisation equipment and/or SQEP resource	£50m - £200m	High
39	Introduce small modular containers for segregated wastes	£50m - £200m	High
28	Disposal of some LLW to Deep Geological Repository (e.g. long-lived isotopes)	>£200m	Medium
29	Disposal of short-lived ILW in near-surface facilities	>£200m	Medium
34	In-situ management of contaminated land	>£200m	Medium
54	Introduce risk-based classification of radioactive substances and waste	>£200m	Medium
17	Improve efficiency and utilisation of existing incinerators at nuclear sites	£50m - £200m	Medium
21	Develop mechanism for co-ordination of supply and demand for materials	£50m - £200m	Medium
23	Re-use/recycle in new construction projects outside nuclear industry	£50m - £200m	Medium
33	Decay storage of short-lived LLW	£50m - £200m	Medium
35	Develop methods and tools for improving waste packaging efficiency.	£50m - £200m	Medium
37	Introduce inner disposal liners for non-compactable waste	£50m - £200m	Medium
38	Introduce puck overpacks for compacted waste	£50m - £200m	Medium
40	Introduce reinforced bags for VLLW	£50m - £200m	Medium
42	Increased use of rail transport	<£50m	Medium
43	Integration of LLW and spent fuel rail shipments	<£50m	Medium
44	Transport of large components whole	<£50m	Medium
46	Improved waste quality assurance processes	<£50m	Medium
50	Preparation of national strategic option assessments	<£50m	Medium
51	Enhance communications within LLW management community	<£50m	Medium
53	Develop strategy to optimise use of current/future NDA assets	<£50m	Medium
30	Alternative Vault Designs	£50m - £200m	Low/Medium
9	Re-estimate wastestream characterisation	<£50m	Low/Medium
32	Disposal of NORM to alternative facilities	<£50m	Low/Medium
41	Use of transport hubs	<£50m	Low/Medium
45	Simplify waste consignment processes	<£50m	Low/Medium
52	Establish Principles for Decontamination and Decommissioning	<£50m	Low/Medium
31	Optimise closure of LLWR	<£50m	Low
47	LLW records consolidation and archiving	<£50m	Low

Implementation of some or all of these initiatives has the potential to reduce the LLW baseline costs by several £billion, extend the life of LLWR, and have significant environmental and sustainability benefits. As with the quick-win initiatives, there will inevitably be significant interactions between different initiatives which may enhance (or possibly even negate) the cost-benefit of others.

It should be noted that a low priority rating in this scoring system does not necessarily mean that the initiative is not important or should not be progressed, merely that it may take longer to realise benefits compared to other initiatives. Furthermore, the cumulative impact of many small changes can have significant positive incidental benefits in other areas of LLW management.

The status of these issues should be kept under regular review as the changing funding, regulatory and strategic environment may impact on priorities going forward. This could be achieved through routine discussion and/or assignment of actions at the National LLW Strategy Group, allowing an integrated approach to LLW management in the UK. This would have to be considered further in more detailed studies and as part of the development and optimisation of the LLW Strategy and Management Plan.

5.8 Implementation

In order to realise these initiatives it is necessary consider strategic vehicles or entities that could successfully progress the initiative towards the point of implementation in the short-term. A range of potential delivery mechanisms or owners to take initiatives forward have been considered as shown in Table 23 below.

TABLE 23 – POTENTIAL DELIVERY MECHANISMS/OWNERS

Owner	Description
NDA	NDA develops solution on behalf of its SLCs. This could be delivered via NDA's direct funded work portfolio and frameworks for consultancy and R&D. NDA also has the ability to strategically influence and incentivise its SLC's through funding allocation, contract specifications, PBIs, and other financial mechanisms.
LLWR	LLWR develops and implements the solution via its consignor support organisation and service contracts. LLWR can influence consignor behaviours through it's pricing strategy and Conditions for Acceptance.
LLW Strategy Group Sub-Committee	A sub-group of the National LLW Strategy Group is formed to work towards developing and implementing the initiative.
Existing Industry Working Group	An existing industry working group is tasked with developing and implementing the initiative. This approach has proven successful with the NICoP developed by the Clearance and Exemption Working Group.
Lead Site	Lead site (or sites) are nominated to develop and/or deploy certain solutions on behalf of other NDA sites. This approach has been used successfully within Magnox sites for projects such as melting of ILW pond skips, rail transport trials, and development of on-site disposal proposals.
Individual Site/SLC	Individual site is responsible for developing and implementing initiatives on its own site(s).
Supply Chain	Supply chain funded or appropriately incentivised using market forces to provide the solutions either directly or indirectly to NDA or its SLCs.

It should be noted that in many cases these owners are not exclusive and that for some initiatives several (or all) of the entities listed will be required in order for implementation to be successful. It is also possible that one entity may progress an initiative part of the way and then hand over to a more suitable entity for further development or implementation. Each potential initiative has been assigned a 'preliminary' owner which could progress the initiative in the short-term as shown in Table 24 below.

TABLE 24 – POTENTIAL OWNERSHIP FOR CARRYING FORWARD INITIATIVES

Ownership	No	Initiative	Priority	Classification
NDA	3	Incentivise waste minimisation	Very High	Quick-win
	11	Incentivise segregation of wastes	Very High	Quick-win
	13	Incentivise treatment of wastes	Very High	Quick-win
	1	Standardise waste avoidance and minimisation programmes	High	Study further
	28	Disposal of some LLW to Deep Geological Repository (e.g. long-lived)	Medium	Study further
	29	Disposal of short-lived ILW in near-surface facilities	Medium	Study further
	34	In-situ management of contaminated land	Medium	Study further
	49	Development of UK LLW Strategy	Medium	Quick-win
	53	Develop strategy to optimise use of current/future NDA assets	Medium	Study further
	54	Introduce risk-based classification of radioactive substances and waste	Medium	Study further
	32	Disposal of NORM to alternative facilities	Low/Medium	Study further
	47	LLW records consolidation and archiving	Low	Study further

LLWR	14	Develop metal treatment routes	Very High	Quick-win
	15	Develop incineration routes	Very High	Quick-win
	24	Develop alternative routes for VLLW disposal	Very High	Quick-win
	5	Standardise characterisation programmes	High	Study further
	8	Centralised characterisation equipment and/or SQEP resource	High	Study further
	33	Use of reusable containers for transport of LLW	High	Quick-win
	36	Introduce small modular containers for segregated wastes	High	Study further
	17	Improve efficiency and utilisation of existing incinerators at nuclear sites	Medium	Study further
	21	Develop mechanism for co-ordination of supply and demand for materials	Medium	Study further
	23	Re-use/recycle in new construction projects outside nuclear industry	Medium	Study further
	35	Develop methods and tools for improving waste packaging efficiency.	Medium	Study further
	37	Introduce inner disposal liners for non-compactable waste	Medium	Study further
	38	Introduce puck overpacks for compacted waste	Medium	Study further
	40	Introduce reinforced bags for VLLW	Medium	Study further
	42	Increased use of rail transport	Medium	Study further
	44	Transport of large components whole	Medium	Study further
	46	Improved waste quality assurance processes	Medium	Study further
	48	Improve waste forecasting	Medium	Quick-win
	50	Preparation of national strategic option assessments	Medium	Study further
	30	Alternative Vault Designs	Low/Medium	Study further
	41	Use of transport hubs	Low/Medium	Study further
	45	Simplify waste consignment processes	Low/Medium	Study further
	31	Optimise closure of LLWR	Low	Study further
National LLW Strategy Group Sub-Committee	4	Identify and share waste avoidance and minimisation best practices	Medium	Quick-win
	10	Develop guidance on segregation best practices	Medium	Quick-win
	20	Identify and share re-use and recycling best practices	Medium	Quick-win
	51	Enhance communications within LLW management community	Medium	Study further
	52	Establish Principles for Decontamination and Decommissioning	Low/Medium	Study further
Existing Industry Working Group	2	Improve consistency of application of NICoP	Medium	Quick-win
	7	Identify and share characterisation best practices	Medium	Quick-win
Lead Site	19	Consolidate R&D on orphan and hazardous wastestreams	Very High	Quick-win
	12	Standardise design of waste segregation facilities	High	Study further
	26	On-site/Near-Site disposal of VLLW on existing NDA sites	High	Study further
	27	On-site/Near-Site disposal of LLW on existing NDA sites	High	Study further
	6	Consolidate R&D on characterisation	Medium	Quick-win
	33	Decay storage of short-lived LLW	Medium	Study further
	43	Integration of LLW and spent fuel rail shipments	Medium	Study further
Individual Site/SLC	18	Improve efficiency of existing NDA metal decontamination facilities	High	Quick-win
	22	Re-use/recycle waste in new construction projects in nuclear industry	High	Study further
	24	Develop alternative routes for exempt waste disposal	High	Quick-win
	9	Re-estimate wastestream characterisation	Low/Medium	Study further
Supply Chain	16	Supply chain provide new waste treatment facilities, capacity and capabilities.	High	Study further

It is intended that these arrangements will be consulted with relevant stakeholders via the National LLW Strategy Group and that this forum will be used to report and track progress of key initiatives on a periodic basis. Although a preliminary 'owner' has been assigned to drive the initiative forward it is recognised that in some cases there are likely to be several mechanisms by which an initiative could be delivered and the roles/interactions with other entities will require further consideration.

At this stage potential cost savings from implementing these initiatives have been qualitatively assessed to aid prioritisation however, where appropriate, more detailed modelling will be undertaken to underpin lifecycle savings.

6 Recommendations

For those initiatives classified as potential 'Quick-wins' the proposed next steps are as follows:

1. Consultation via the National LLW Strategy Group that these represent viable quick-wins
2. Development of implementation plans by the initiative 'owner'
3. Subject proposal to appropriate stakeholder consultation
4. Develop and submit Business Cases (where applicable) for NDA approval
5. NDA and regulator agreement as required
6. Implementation in LLW Management Plan

Implementation plans for work packages will take into account a number of factors including NDA's Value Framework process[20], site funding levels and LLW Policy, legal and planning frameworks at a national, regional and local level.

It is therefore recommended that 'quick-win' initiatives are assigned owners responsible for developing implementation plans and securing the necessary approvals. These implementation plans will be documented in the National LLW Management Plan which will set out how the NDA LLW Strategy will be implemented.

For those initiatives that require further study or review, a range of approaches may be used with the depth of consideration and assessment tailored to the scope and objectives of the study. In general, studies of large scope and reach will undergo a more detailed, formally-defined optimisation process. An "Integrated Waste Management" (IWM) process[1] has been developed to provide a structured, flexible, robust and transparent decision-making framework for the development and evaluation of preferred solutions from a national perspective.

The process utilises decision-analysis tools to aid and inform the waste management decision-making process. These could include Sustainability Appraisal, Best BPEO, Multi-Attribute Decision Analysis (MADA), Best Available Techniques (BAT) and BPM assessments as appropriate.

In a smaller study, assessment processes may be implicit or merged together (with documented justification). Relatively straightforward or low impact decisions can be subjected to a simplified fit-for-purpose evaluation process while more time and resources can be focussed on the more significant or challenging decisions.

For those initiatives classified as requiring further study it is recommended that more detailed consideration is given to the programme, priorities, roles and responsibilities for studying the initiative. This forward programme of further study will be documented in the LLW Management Plan.

7 Conclusions

This LLW Strategic Review has established a 2008 LLW baseline in terms of LLW management strategies, LLW Inventory Arisings, costs and liabilities associated with LLW management and assets and infrastructure (existing and planned) for LLW management.

The baseline can be used as a benchmark for measuring the effectiveness of potential improvements to LLW management, however it is recognised that there are a number of areas of uncertainty that need to be addressed, the most significant being the LLW inventory. The baseline review process has also highlighted a number of potential inconsistencies between cost and inventory data within LTPs.

The LLW baseline has been evaluated to identify where opportunities and synergies exist to reduce NDA's cost liabilities of £9.87 billion by more than 10% through integration of waste management on a national, regional or multi-site basis. This has included a detailed cross-cutting review of LLW opportunities identified within LTPs, IWSs, TBURDs, and WATs for each SLC to identify common themes and issues.

Fifty-four potential strategic initiatives have been identified which could provide significant synergies or opportunities to reduce liabilities below the baseline. These initiatives have been qualitatively evaluated using strategic criteria such as the ease of implementation, potential timescales and the magnitude of the cost-benefits. Based on the qualitative evaluation, opportunities have been prioritised and separated into potential 'quick-wins' (i.e. the initiative could be implemented relatively easily and quickly) and those that require significant further work to assess and/or determine how to implement the opportunity.

Collectively implementation of 'quick-win' initiatives could produce a step-change improvement in LLW management practices across the UK and contribute significant savings of over £1 billion to the LLW baseline. Implementation of the longer-term initiatives has the potential to reduce the LLW baseline costs by several £billion, extend the life of LLWR and have significant environmental and sustainability benefits. It should be noted that the impact of many initiatives may overlap which could enhance (or negate) the cost-benefit of others. This would have to be considered further when defining more detailed implementation plans and/or business cases. A methodology is being developed by LLWR to quantify the costs of implementation and benefits realised at LLWR and its successor in order to support business cases going forward (see Appendix H).

In order to realise these initiatives a preliminary 'owner' or delivery mechanism has been assigned to progress the initiative towards the point of implementation. It is intended that these arrangements will be consulted with relevant stakeholder via the LLW Strategy Group and that this forum will be used to report and track progress of key initiatives on a periodic basis.

It is therefore recommended that implementation plans and business cases (if appropriate), are prepared for the consulted 'quick-win' initiatives with a view to securing the necessary NDA and regulatory agreements for implementation. For those initiatives requiring further study it is recommended that more detailed consideration is given to the programme, priorities, roles and responsibilities for studying the initiative. These implementation plans and forward programmes will be documented in the LLW Management Plan which will set out how the LLW Strategy will be implemented.

The status of these issues should be kept under regular review as the changing funding, regulatory and strategic environment may impact on priorities going forward. It is currently intended that the LLWR SLC will undertake LLW Strategic Reviews every two years in order to revisit earlier conclusions in light of developments within the wider industry decommissioning programmes and changes in the waste management policy and regulatory framework.

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Appendix A – Site Summary Data

Sellafield

Summary of Proposed LLW Site Strategy

Sellafield's overall Integrated Waste Strategy vision is stated as follows:

An Integrated Waste Strategy will deliver an operating site that has minimised waste generation and where waste is generated, it is contained in a manner that achieves sustainability; where sustainability is waste in a form that requires ideally nil, but probably minimal, management to safely protect people and environment including the remediation of historical impacts.

LLW and VLLW is generated at Sellafield from a wide range of operations across the site. The waste typically comprises of secondary wastes from plant operations such as redundant equipment, tools and used protective clothing and items. Quantities of this waste are projected to increase significantly as the site moves towards clean up and decommissioning.

Recent site initiatives have focussed on reducing the amount of material which is taken into active areas and hence becomes potentially contaminated (known as 'deemed' waste). Other methods such as "red to green route" sentencing and increased usage of Low Resolution Gamma Spectroscopy (LRGS) have proven successful. Additionally the formation of a new clearance and characterisation team has enabled a reduction in LLW arisings by providing a centralised pre-demolition characterisation assessment profile which then informs segregation in order to maximise free release and lower category waste yields.

Compactable LLW that meets the Conditions for Acceptance (CFA) of the Low Level Waste Repository (LLWR) is routed to the Waste Monitoring And Compaction (WAMAC) plant where it is loaded into boxes or 200 litre drums and pre-compacted. This is then subjected to High Force Compaction and the resultant pucks are loaded into Iso-freight containers and grouted at the LLWR.

Non-compactable LLW that meets the CFA of the LLWR is directly emplaced in Iso-freight containers and grouted at the LLWR. Large items such as the Windscale AGR heat exchangers have been transported and directly grouted in the vault at the LLWR. Surface contaminated LLW metals that are suitable for abrasive decontamination are currently processed through either of the two site "wheelabrators". The material undergoes abrasive surface decontamination and monitoring to vouchsafe consignment as "free release" to an external contractor. Excavated soil above the Substances of Low activity (SoLA) limit but below 37 Bq/g has previously been disposed of to the South landfill and Calder Landfill. Both facilities are now non-operational. The Calder Landfill Extension Segregated Area (CLESA) is currently being used for the temporary storage/accumulation of waste below 3.7Bq/g pending disposal authorisation from the Environment Agency.

The current scope of the future LLW strategy covers all LLW generated on the Sellafield licensed site (excluding the Calder Hall). The future strategy currently assumes that material arising from management of the contaminated ground which has an activity less that 40 Becquerel/gram (Bq/g) will not be disposed to LLWR or equivalent but be left in-situ. The LLW management strategy is associated primarily with the passivation and restoration phases of the Sellafield site, as described in the Sellafield site summary. It should be noted that as a result of the strategy post 2050 there is a strong interdependence with the Sellafield contaminated land and decommissioning strategies and the plant and facilities they require. The endpoint of this strategy is the suitable and optimal disposal of the LLW generated by the Sellafield site.

Current LLW operational and activities (Waste Handling Tasks, Waste Treatment Tasks, Metal Recycling Facility, Clearance and Characterisation) have been extended up to the end of the final decommissioning phase, currently assumed to be 2113/14. The WAMAC operation is planned to operate until 2113/14 during which time it will continue to process LLW from site and external consignors. The timing is planned in conjunction with the completion of demolition waste activities. In the shorter term the strategy across the Operating Unit (OU), i.e. excluding Calder Hall, is to minimise arisings of LLW, reduce the volume of that which does arise and recycle greater volumes of material for re-use or disposal to lower cost waste streams.

The overall strategy for LLW is to provide the most cost effective and environmentally preferred route for waste generated from Sellafield and external clean up operations by minimising waste volume and maximising free release. The strategy is also to improve waste forecasting during clean up of UK Sites, including Calder, which commenced in 2006 under an SLA contract.

Proposed Projects and Improvements for LLW Management

The LLW OU is developing the site's LLW Strategy for issue in January 2009. The strategy will be informed by the recent series of public workshops that covered such Low-Level Wastes as oils, metals, process waste, etc. The LLW strategy, as described in LTP07, has since been updated and now includes a suite of new build treatment facilities, these are all assumed to commence operations in 2020. The facilities are to provide a greater degree of volume reduction than that which currently exists on the site and hence will minimise the overall quantities for disposal to the LLWR or successor facility. The LLW strategy is summarised below:

- Continued use of WAMAC for high force compaction of compactable LLW until 2020;
- New build thermal treatment capability from 2020 up-to the end of site decommissioning, currently scheduled to be 2113;
- New build melt / smelt capability for LLW metals from 2020 up-to 2113;
- New build low-force compaction capability for compactable LLW from 2020 up-to 2113;
- Continued use of mechanical decontamination in the form of the wheelabrator for the decontamination of metals up-to 2113;
- Continued use of direct emplacement of non- compactable items into ISO freight containers;
- Disposal of LLW to the LLWR until 2050 and to a future LLW disposal facility that has not yet been Specified.

Processing assumptions such as the proportion of waste that are suitable for various processes and the resultant volume reduction achieved is included in LTP08. A comparison is made between the LTP08 strategy and the LTP07 strategy with the same (LTP08) data-set showing that LTP08 treatment facilities contribute towards a reduction of around 19,300 HHISOs. Work is ongoing to understand the range of uncertainty on the waste estimates as well as the cost and environmental benefit of the new treatment facilities.

A number of recommendations made in the IWS 2007 pertains to LLW management and progress has been made against them, including:

- Develop and trial a structured process for waste management hierarchy application within decommissioning mandates;
- Establish robust characterisation and capability to sort and segregate LLW and ILW waste from decommissioning;
- Ensure the re-use and recycling of materials such as high volume VLLW and cables;
- Increase the Sellafield waste volume reduction capability;
- Widen the envelope of the current LLW decontamination facility;
- Carry out a Decontamination Option Study including assessment of electro-chemical techniques;
- Ensure that equipment re-use is considered when developing decommissioning plans;
- Investigate the options for re-use of waste and materials rendered from decommissioning and demolition.

Top 3 LLW Issues for the Site

The main challenges to the Sellafield site strategy for waste are:

- If it were required that material of less than 37 Bq/g be containerised and sent to LLWR or a new VLLW facility, then this could represent an increase of at least 800,000 m^3 from contaminated land alone. Upper estimates of this contaminated land volume are of the order of 20,000,000 m^3.

- Uncertainties from potential changes to LLW disposal requirements at LLWR and other repositories, including modifications to the pricing structure (activity or volume), CFA requirements, potential changes in the DEFRA definitions of LLW/ VLLW / Exempt wastes, and changes to regulatory requirements at Sellafield may affect future LLW disposal strategies.

- The National LLW disposal facility post 2050 may be remote from Sellafield resulting in considerable additional transport costs.

Across the site orphan wastes are now included within each OU together with a fund to support eventual treatment. It is envisaged that the Waste Facility will take responsibility for the site orphan wastes and develop the expertise to treat / dispose of them. As these opportunities are developed, these will be reflected in Lifetime Plan.

Springfields

Summary of Proposed LLW Site Strategy

The following waste strategies are adopted at the Springfields site:

Eliminate: To implement a variety of measures to prevent the creation of waste. Examples include:

- The use of Transfer Islands allows uncontaminated items to be retained at a control barrier to ensure potential waste doesn't pass into the controlled area unless necessary.
- A programme of workforce education to improve awareness in environmental issues.
- Monitoring and Review of progress occurs through the Environmental Improvement Committee.

Reduce: To critically examine potential radioactive waste generation processes using appropriate tools such as BPEO/BPM studies to ensure that radioactive waste quantities and their environmental impact is minimised. Examples include:

- Selection of more efficient cleaning methods (e.g. kimtex wipes).
- Reduction of hazard potential by moving from repository to special precautions disposal.
- Design of processes (e.g. specimen samples from Nexia Solutions radioassay unit) to minimise sample size.
- Development and deployment of improved measurement devices for radioactive contamination of waste.

Re-use: To clean radioactively contaminated wastes that are unavoidably created, through suitable treatment methods, to a contamination level which enables re-use of the material. Examples include:

- Re use of drums that have stored uranium ore.
- Re-use of cylinders containing hex after-heels that have been removed through washing.

Recycle: To maximise the amount of waste radioactive material recycled, having regard to the balance of costs involved in doing so. Examples include:

- Cleaning and recycling of valuable scrap metal.
- Collection of unavoidably-generated radioactive residues/wastes and re-treatment through the processing lines (e.g. EURRP concept).
- Improved segregation and more exact assessment allowing some waste material to be reclassified.

Dispose: To dispose of unavoidable wastes in a safe manner in accordance with the requirements of relevant disposal authorisations / regulatory requirements, avoiding the necessity to dispose of LLW, where possible. A further strategy is to steadily reduce reliance on Clifton Marsh by establishing alternatives and moving more waste into exempt category (i.e. classed as non-radioactive). This is applicable for all waste types. Examples include:

- The majority of waste consigned to Clifton Marsh is potentially contaminated with uranium and is categorised as radioactive waste under the RSA Authorisation. Some solid waste that is not radioactive is sent for recycling (e.g. used fluorescent tubes, batteries).
- The largest bulk weight of non-radioactive waste is demolition spoil (concrete/brick rubble) which is crushed and reused on site for backfill.
- With the uncertainties surrounding the use of Clifton Marsh post 2012, the options for dealing with waste are being reviewed. It may be that additional assessment work will enable more routine waste arisings to be categorised as 'clean' and/or potentially suitable for on site burial. A review of solid waste disposal options is underway, but at this stage it is not possible to forecast exactly how this will affect the disposition of solid waste arisings. Examples of compliance measures include the Clifton Computer system to record and track disposals, SITA procedures and protocols, and Waste DoC (Duty of Care) Management.

Springfields authorised radioactive waste disposals can contain up to 100Bq/g alpha activity (100MBq/te). LLW as defined can contain up to 4x106 MBq/te alpha activity. High volume VLLW can contain up to 4 MBq/te total activity. At the permitted limit, Springfields authorised disposals are at the bottom end of the LLW spectrum. Typical material disposed of to local landfill under 'special precautions' procedure contains much less than this. For example, over the last 5 years, the site's total disposed radioactive waste typically contained between 3 – 9 MBq/te uranium alpha activity annual average. However, the site's waste is disposed of by category. Category averages in the decade from 1990 – 2000 were 0.19% uranium for process residues and 0.005% for general waste, equivalent on a natural uranium basis to ~ 47MBq/te and ~ 1.3MBq/te.

Proposed Projects and Improvements for LLW Management

Springfields' main strategy is to develop robust alternatives to the current way in which the local authorised disposal site is used for Springfields' wastes, which can be deployed should additional capacity not become available at Clifton Marsh. Some options could involve utilising Clifton Marsh in a different way, for example by reclassifying some waste currently defined as 'radioactive' as 'clean/exempt', and additionally, a firm of consultants has been engaged to carry out a feasibility study of on-site disposal.

An opportunity for further consideration relates to extending the use of Springfields residue treatment facilities to process other uranic residues, originating at other NDA owned UK sites. The benefits arising from any proposals would include obtaining more value / use from the residues and therefore preventing potential disposal at the LLWR, or other NDA funded disposal facilities, of all or part of the material. These residues include those that may be costly or impracticable to treat at other sites (e.g. due to quantities, or lack of processing capacity) but where Springfields already has the facilities and the experience of dealing with the material. Springfields is a unique site in the UK in having the only large scale processing capability for un-irradiated uranium. A small scale facility for pre-processing problematic uranium residues is also available for testing.

Top 3 LLW Issues for the Site
The main issue and challenge for the site (but also an opportunity) arises from the uncertainty about the continued availability of the local disposal facility (Clifton Marsh landfill) after the current contract ends in 2012. The facility takes much local domestic and industrial waste, and Springfields' disposals currently account for less than 10% of the total. Planning permission for the current facility will expire in 2012. If the life of the facility was not extended, for whatever reason, significant changes (and costs) for Springfields' waste disposal could result. Particularly the bulk waste arisings, from continuing plant operations and from the site decommissioning programme, would have to be dealt with in an alternative manner. Opportunities for decommissioning waste reduction are currently being investigated, in particular an option for residual very low level waste to be disposed of on-site. A "precautionary approach" has historically been adopted in regard to the very low uranium content, high volume wastes produced on site, for example from the demolition of old process buildings. The philosophy was that the adverse consequences, in terms of public concern, if material sent for recycling reuse or disposal as ordinary waste proved to be mis-sentenced were too great compared to the benefits. Segregation of waste into truly very low level radioactive and clean or 'exempt' waste is now the appropriate strategy preferred, as in line with the 'Waste Management Hierarchy' principles as more reuse or recycling could be achieved and the quantities going for disposal as radioactive waste would reduce. In order to allow material into the public domain for reuse/recycle/ordinary landfill, it is necessary to prove that material is clean from contamination by a reliable and repeatable method of monitoring. Therefore, a key need is to develop sustained confidence in appropriate monitoring to clear material as 'Exempt' waste. Investment in improved monitoring equipment (Active Waste Monitors (AWM)) has been made for assessing bagged (low density) waste for disposal to Clifton Marsh under the authorisation for disposal of radioactive waste. This has proved a big step forward in allowing more material to be reliably monitored as being suitable for Clifton Marsh disposal. However the AWM, whilst giving promising results, has not yet been certified as suitable for classifying / sentencing material to destinations other than Clifton Marsh. In addition, it has been found that AWMs are unlikely to be capable of clearing higher density material, unless it is in a fixed, simple shape such as a drum of known dimensions. However, as such material tends often to have only surface contamination, and traditional monitoring instruments can be used to sentence this material to Clifton Marsh. Unfortunately, these traditional methods also are not capable of clearing items to the very low levels required for clearance as 'exempt'. There is a requirement for Transport Regulations to be met for UK transport of both wastes and residues, and for this Approved Packages are required. For the LLWR and other UK destinations, this can present a problem if enriched uranic materials are present. The simplest way for materials to be approved is if particular criteria are met. If these criteria are not met, there can be problems and finding a suitable transport package can be very onerous. The likelihood is that approved containers may not exist and obtaining the necessary approvals can be complex and time-consuming. Although SFL disposals to the LLWR are small, some delay has been experienced with the current consignments due to transport clearance issues. In addition it is noted that a proportion of the waste material which potentially may require disposal at the LLWR is slightly enriched. This could also face difficulties with conforming to transport and packaging regulations, as a suitable container has not been cleared for such movements under the latest transport regulations. Furthermore, when considering alternative options for the processing of historic residues, it has become apparent that options involving the transfer of low enriched residues (>0.725%U235) to other sites for treatment is currently not viable. This therefore currently restricts any chosen options to existing treatment facilities on site, or bringing a new technology onto site at Springfields.

Magnox South Sites

Summary of Proposed LLW Site Strategy

Magnox South Baseline Strategy

The current strategy for non-combustible solid LLW produced during C&M Preps is disposal to the LLWR. The waste is received at dedicated on-site LLW waste management facilities and sorted by dedicated teams to exclude items that are not permitted under the Conditions for Acceptance at the LLWR. Non-compactable waste is sent in HHISO and THISO containers directly to LLWR, where grout is added to the container and the container is placed in the vault.

Compactable waste is compacted into 210 litre drums by low-force compaction on-site. It may then be transferred to Sellafield for supercompaction at the Waste Monitoring and Compaction facility (WAMAC). It is then grouted and placed in the vault at the LLWR. All Magnox South sites are now authorised to use the supercompaction facilities at the Winfrith nuclear licensed site for processing LLW. Combustible LLW (oil and oil contaminated solids, paper, mixed trash etc.,) is wherever possible incinerated either on or off-site.

It has been assumed that a LLWR remains available throughout the lifetime of the decommissioning programme with no discontinuity in the commissioning of proposed vaults or the establishment of alternative facilities if the current repository reaches capacity.

Current Processing / Disposal Routes

	Incinerator at Hythe	WAMAC/ LLWR	Processing at Winfrith prior to LLWR	B station Incinerator	Recycling via Metal Melting	Incineration on the premises	VLLW to Landfill
Berkeley	✓	✓		NA			
Bradwell	✓	✓	✓	NA			
Dungeness A		✓	✓	B station use A site incinerator		✓	
Hinkley Point A	✓	✓	✓	Route available	✓ pond skips		
Sizewell A		✓	✓	✓	✓	✓	

Processing/ Disposal Route Used		Processing/ Disposal Route Not Currently Used		Route in development

Proposed Projects and Improvements for LLW Management

Good Practices

Magnox South sites have initiated a number of techniques and arrangements that are considered Good Practices and are listed below. Ongoing assessment of good practices and sharing at waste manager peer groups assist in the identification process.

- Fit for purpose Waste Management teams with a high level of SQEP. Standardised post profiles developed and implemented at MxS sites in 2008.
- Inspection/Screening of the contents of every LLW waste drum to ensure all waste is compliant
- A number of LLW drums that have already been sorted are routinely selected at random and inspected prior to disposal
- Use of appropriate coloured / labelled drums to permit segregation of waste streams/types at source
- Use of the Rados Drum Monitor for assay of large items, without the need for size reduction.
- Use of software based Waste Management Schedule Tool (P3e) for dynamic waste planning
- Minimum manual handling of processed drums – ergonomically designed equipment.
- Bespoke air handling system for HHISO loading to reduce potential exposures.
- The Magnox South Waste Management Group has initiated a Waste Minimisation Focus Group made of waste management representatives from all of five sites and DSO. The purpose of this group is to share current waste minimisation practises currently being employed at the different sites and to identify new

opportunities

Alternative Strategies

The NDA has asked Magnox South to consider alternative LLW disposal strategies. Those under current consideration include projects on:

On-Site Disposal

An assessment of LLW disposal options at all sites (excluding Berkeley site where volumes of LLW are judged insufficient to make on-site disposal viable) in 2006 received positive feedback from stakeholders on the possibility of disposing of LLW at the sites where it is produced. Hinkley Point A is taking the lead in developing a design and seeking planning approval for an on-site disposal facility. The planning application and Environmental Statement are ready for submittal and will occur during the 2008 financial year. LTP08 includes feasibility reviews for Bradwell, Sizewell A and Dungeness A with Bradwell being the next identified priority site. The Strategy Insertion Point for On-Site Disposal is 2011.

Overseas Metal Melt

Hinkley Point A has recently started sending LLW shipments of pond skips to the US for recycling into shield blocks for use in the international nuclear industry. There is potential to expand this route to accept LLW metals from all Magnox South sites.

Sizewell A is has opened a route for smelting to Germany and will be sending metals for smelting by early September. The metals will be used to produce waste boxes (ILW mini-stores) that will be used to pilot the concept of ILW mini-stores.

Issues / Opportunities

Facilities are available at the Magnox South sites for size reduction and decontamination of LLW to minimise the volume transferred to the LLWR (thereby conserving this resource). The facilities at Bradwell and Dungeness A are limited and significant facility enhancement programmes are underway at both sites to optimise waste minimisation. Opportunities for further optimisation to include:

- Packing efficiency of disposal containers
- Clearance and exemption to allow disposal as exempt waste

Overseas metal melting is currently being utilised by Hinkley Point A for disposal to recycle Pond Skips and both Bradwell and Sizewell A hope to commence similar operations in the near future subject to authorisation. Sizewell A has also opened an overseas route for smelting metals. The metals will be used to produce waste boxes.

If LLWR was unable to take LLW due to capacity issues / delays in opening new disposal vault/s, then LLW may need to be accumulated on-site subject to regulatory approval. Most sites are small and additional storage space is limited. This could significantly impact decommissioning work.

Magnox South sites are decommissioning in parallel not only with themselves, but with other SLCs and other nuclear installations. There is therefore a potential constraint due to the ability of the LLW support services contractor to provide sufficient transport for all sites when required, and for disposal facilities with their own authorisation limits to comply with, to be able to support the necessary volumes of waste material e.g. incineration of oils. Magnox

It can take between 3 and 12 months to receive a variation to a RSA93 Authorisation (depending on the complexity of the application). At Bradwell, because of the delay in submitting applications to vary authorisations, the annual activity limit on the transfer of radioactive LLW to the LLWR are such that only a very small amount of the encapsulated sludge retrieved can currently be sent to the LLWR each year before a variation required to allow prompt disposal can be sought. Magnox South would welcome the NDA to lead discussions with the Environment Agency to improve the efficiency of this process, to facilitate the speed of which the sites can then progress with the role of decommissioning.

NDA funding restrictions will have an impact on the progress of decommissioning and waste management during 2008. In particular, the construction and refurbishment of LLW facilities to aid the site during C&M Preps will be delayed. Facilities should provide decontamination capabilities, size reduction and be able to handle complex wastes and increases in processing capability. Significant improvements cannot be made until new or enhanced facilities are available (applies to Berkeley, Bradwell, Dungeness and Sizewell A).

There is a potential to optimise strategy implementation by gaining flexibility in the transfer of waste between sites and facilities to allow different types of waste treatment/processing to be undertaken. The scenario will require a steer from local stakeholders to support the establishment of these centres of excellence, pending development of specific business cases and approval by the NDA.

Use of conventional landfill for either VLLW or Controlled Burial requires authorisation under RSA93. Government Policy in Cm2919 discouraged the use of these routes for the disposal of LLW from nuclear sites, although some sites do have access to such facilities. The recent policy on solid LLW has been reviewed and a more flexible risk-based approach to LLW disposal is now permitted. It is therefore possible that greater use of these disposal routes could be made in the future. However, as landfill capacity is generally reducing in the UK, this might not provide a great benefit in the longer term.

The increased VLLW limits have presented the opportunity to dispose of a significant amount of tritiated waste that would have normally gone to LLWR. Sizewell A has sampled and diverted a significant amount of tritiated lagging waste from disposal at Drigg and is currently working on opening a route for disposal of the waste as VLLW at local landfill sites.

Top 3 LLW Issues for the Site

Key Issues for Each Site

Berkeley

Issues:

1. Orphan wastes (BNLS does not have any as it is far down the decommissioning routes, but this may be an issue at most sites. LLWR may be able to share industry learning.
2. Single point of contact as a one-stop shop at LLWR. This front man needs to be technical but not necessarily the expert.
3. Waste management hierarchy - some industry wide guidelines on applying the principle from LLWR point of view, to provide some joined up thinking
4. Waste packaging- sites strive for packing efficiencies, but this may not reflect the total picture. LLWR was stating problems with grouting when the packing fraction is high, this needs some guidance.

Best Practices:

1. Use of the RADOS two door drum monitor for waste clearance monitoring of large items. This resulted in 26.49 Tonnes of free release in financial year 2007/8.
2. Use of THISO for non-compactable waste to LLWR
3. Use of coloured drums for waste segregation (red for non-compactable and yellow for compactable)

Bradwell

Issues:

1. Lack of storage & processing facilities. (until the completion of the new LLWMF)
2. Insufficient level of RSA Authorisation Limits, leading to a potential backlog of wastes waiting to leave site for final processing and disposal.(6B vault waste)
3. Uncertainty regarding availability of space at LLWR in outer years.

Opportunities.

1. Open up a Metal Melt waste route to the USA, to allow the sites ponds skips and other metals to be recycled as shielding blocks. (the same route as Hinkley Point A)
2. Open up VLLW routes to significantly reduce the volume of waste currently sent to the LLWR.
3. The ability to further increase the volume of SoLA exempt waste leaving site, through more aggressive decontamination and size reduction techniques once the new fit for purpose LLWMF is fully commissioned.

Dungeness A

Issues:

1. Loss / compromise of LLWR disposal route

- Changes in LLWR CfA
- LLWR capacity
- Changes in LLWR contract
- Operational problems at LLWR

2. Loss of site incinerator
   - Technical / equipment failings or regulatory issues
3. Lack of adequate EA authorisation
   - Failure to gain authorisation for increased waste arisings during decommissioning
   - EA policy decision to decrease site authorisations

Opportunities:

1. Open up a route for VLLW and make every effort to segregate out VLLW.

2. Provision of on-site disposal facility has been considered for Dungeness, but is currently on hold due to funding restrictions. Benefits would include:

   - Reduced transport
     - o Lowered cost
     - o Reduced environmental impacts
   - Reduced business risk (once facility commissioned)
     - o Assured capacity
     - o Control over disposal costs
   - Possible reduced packaging requirements
     - o No need for transport containers
     - o Risk assessment and facility safety case may well indicate reduced packaging requirements, esp for lower activity wastes
     - o Leading to cost and environmental (resource use) benefits

3. Further substantial improvements would be gained by adoption of a range of more modest opportunities Including

   - Improved size reduction facilities
   - Improved monitoring (clearance) capability
   - Improved decontamination techniques and capability

Hinkley Point A

Issues / Opportunities

On-site disposal is the main issue for Mx sites (admittedly does not fall specifically under the remit of LLWR, but as a waste diverting exercise, must be pursued with stakeholders)

Opportunities

Open up a route for VLLW and make every effort to segregate out VLLW. A specific example is tritium contaminated asbestos waste stream currently stored in eight full height ISO's.

Sizewell A

Issues / Opportunities

1. Progressing safety case for dissolution of FED to allow it to replace prompt encapsulation and storage as ILW in the lifetime plan.
2. Completing first shipment of contaminated metals to Siempelkamp to support ILW mini-store project.
3. Opening route for disposal of tritium contaminated lagging as VLLW. This cannot be completed until RSA authorisation is granted upon exit from shadow working.
4. Opening route for incineration of biological waste. This cannot be completed until RSA authorisation is granted upon exit from shadow working.
5. Completing the installation of a waste shredder.

Chapelcross

Summary of Proposed LLW Site Strategy

Operational LLW

Operational waste is a mixture of historic drummed waste and large bespoke items, wrapped and stored in a temporary building. There are also some 210 litre drums of activated charcoal currently stored within hangar 39. The waste is stored currently stored in new, good quality temporary buildings. The wastes have been accumulated in a wide variety of different containments (drummed, plastic wrapped, bagged etc.). The wastes are made up of varying materials and are likely to include metal, wood, plastics, cellulosics.

Decommissioning LLW

Instances of LLW are being identified on site whereupon the waste is processed in the on-site LLW Processing Facility and the processed waste is stored in a custom built temporary storage facility prior to offsite disposal.

These purpose built facilities have been provided on North site for the centralised processing and sentencing of wastes, with a core waste management team in place to run the facilities and provide waste management guidance to the decommissioning projects. It is envisaged that this approach will result in the best practicable application of the waste management hierarchy and subsequent efficiencies in waste recycling, packaging and disposal.

Following categorization, the waste will be conditioned and packaged and placed in interim storage pending transfer via approved routes for disposal. Where appropriate radioactive materials will be decontaminated; examples of these decontamination processes are wipe down, water jetting, shot blasting, scabbling and chemical decontamination.

LLW is processed by the Chapelcross site waste team that was put in place following the implementation of the post operational safety case (POSC) and streamed into the following categories:

Combustible LLW:

Organic liquid LLW wastes are comprised of radioactively contaminated oils and other liquid within a designated area within the North Site. The aspiration is to dispose of organic LLW via transfer to a commercial incinerator pending SEPA authorisation. Should authorisation be granted, organic LLW would be removed by tanker to Fawley, Hampshire for treatment by incineration.

Active oil is considered as an orphan awaiting authorizations for discharges or disposal to the Incinerator at Fawley.

- Mobile LLW - Mobile LLW wastes are either treated for authorised discharge or shipped to incineration facilities for authorised discharge by the operator of the incineration facility. Concerning the mobile LLW, Chapelcross Hanger 39 on the North Site was historically the handling and storage area for activities associated with the treatment and conditioning of wet Low Level Waste (LLW), such as sludges and contaminated oils
- Tritiated LLW

Non-Combustible LLW

The Site waste team is responsible for categorising LLW into the following types:

- Compactable LLW are placed in 200L drums which are transported by road to Sellafield for supercompaction at the WAMAC facility. They are then repacked and transported by rail to the LLW repository near Drigg for grouting and disposal.
- Non-compactable LLW is packed directly into either Half Height (HHISO) or Third Height (THISO) containers and shipped to the LLWR. The ISO containers are grouted upon receipt at the LLWR. Some non-compactable wastes are packed into 200L drums and these are loaded into HHISO's for disposal direct to the LLWR. This is usually carried where it is operationally efficient to package the waste in this manner. Large items of LLW are handled separately by special arrangement.
- Asbestos LLW; the site has 3 streams of asbestos: Tritiated, Mixed Radioactive Contamination and Clean. Tritiated asbestos and fission-product contaminated asbestos currently has to be disposed to the LLWR near Drigg with the other LLW. All active asbestos could go to landfill as VLLW, if a route is developed, because levels of fission products are so low (~2 Bq per g). CHX use a 1m^3 plastic box and a box monitor for asbestos. Best guess is 20% asbestos will be clean. This might increase as characterisation is done.

Good practice

Examples of good practice in LLW management at Chapelcross are:

- Dedicated LLW team with a high level of SQEP
- The contents of every LLW waste drum are screened to ensure all waste is compliant with the Conditions for Acceptance at the LLWR
- Appropriately labelled drums are available to permit segregation of waste streams/types at source
- Minimum manual handling of processed drums
- Decontamination and free release

Proposed Projects and Improvements for LLW Management

New LLW handling facility

The current LLW strategy for C&M Preps is to construct a LLW handling facility within one of the RUBB buildings situated at the North end of site. This facility will process all of the LLW arisings from decommissioning activities, which are significantly higher in volume than generation operations. Hence, new facilities are required to appropriately process and package LLW in a manner that ensures compliance with the LLW repository acceptance criteria since current LLW management arrangements will be insufficient to manage the elevated volumes of LLW arising during decommissioning. The new facility will be designed to ensure that processed and packaged LLW will meet the Drigg Conditions for Acceptance (CFA) to enable the packages to be transported to the LLW repository at Drigg for disposal. The facility will also enable more cost effective LLW management, maximizes packing efficiencies (saving cost and preserving disposal capacity) and will comply with the disposal requirements for the LLW repository near Drigg.

The conversion of the Large Rubb Building to create a facility for processing and packaging LLW prior to onward shipment to the LLWR, is ongoing. The intention was to create a facility to carry out limited dry decontamination of lightly surface contaminated solid items to enable Chapelcross to divert waste from the LLW stream to exempt materials and ease some of the burden for disposals of LLW. The facility was originally erected in 1999 at the northern area of the Chapelcross site and had been previously been used for storing a mixed Low Level Waste and potentially clean, free release waste.

Opportunities

The following opportunities are relevant to Chapelcross:

- Soil remediation technology such as soil washing could be used to minimise the amount of LLW sent to the LLWR, however R&D would be required to determine the feasibility and cost effectiveness of this option; and
- Opportunities for extensive, intrusive Land characterisation to underpin current assumptions – sooner rather than later.

Optimisation of Waste Management Organisation

A feasibility assessment to identify ways to optimise team structure and provide greater flexibility and coverage is planned for 2008. There is also an intention to expand the team so that it includes specialist areas such as planning, cost estimation and contract management.

Optimisation of Waste Management Arrangements

The lessons learnt from the optimisation process for disposal of significant quantities of asbestos are being applied to other projects on site.

LLW Minimisation

The Site is enhancing its facilities for decontamination and size reduction. However, there are opportunities for further optimisation to include:

- Packing efficiency of disposal containers;
- Use of incineration route; and
- Clearance and exemption to allow disposal as exempt waste.

Optimisation of LLW Assay Techniques

The current techniques used for the assay of LLW are time consuming. There is an opportunity to improve waste processing efficiency by enhancing waste assay technique and also improving the Chapelcross laboratory facilities.

Alternative Disposal options

On-site Disposal- The On-Site Disposal project has benefited from a comprehensive approach to stakeholder engagement. A number of workshops have been held at national level to maximise consultation and information sharing.

Top 3 LLW Issues for the Site	
1.	Large quantities of asbestos have low activities (predominantly tritium). Significant benefit would be gained if this could be disposed as VLLW, should this be feasible.
2.	The site is very large and has both radioactive and chemical land contamination. There are two very long pipelines that are contaminated with low level radioactivity. Surveying and characterisation will be important. Soil washing and other remediation techniques could be worthwhile to minimise waste volumes.
3.	Much greater volumes of demolition LLW than on other sites are expected during Care and Maintenance Preps. This is due to low levels of tritium throughout the site. The availability of VLLW disposal would be useful, particularly since the limit for tritium is higher than other nuclides.

Oldbury

Summary of Proposed LLW Site Strategy

Current Site LLW Arrangements

LLW arisings on site are segregated at source into combustible and non combustible and by area of arising (to aid in waste fingerprint streaming). Wastes are routed to a Waste Sorting and Assay Facility where further sorting and monitoring takes place, resulting in segregation into non radioactive, incinerable, compactable non combustible and non-compactable non combustible streams.

Combustible LLW

Combustible LLW (including active oil) is incinerated on site in a purpose built incinerator. The associated activity essentially remains in the ash, which then itself requires disposal as LLW – incineration is seen as a size reduction method rather than a disposal mechanism.

Non-Combustible LLW

Current arisings typically consist of miscellaneous rubbish (metal, plastics, paper, rubber and cloth), redundant equipment and redundant personal protective equipment (clothing) and incinerator ash. Wastes are sorted, assayed and size reduced as appropriate prior to being packaged in drums or placed directly into ISO containers, for disposal to the LLWR. Where required to meet disposal acceptance criteria, further conditioning may be undertaken on site prior to despatch. Oldbury typically consigns 1 each of FHISO and HHISO per year.

- Compactable wastes are placed in 200 litre drums that are placed in FHISO for transport, via WAMAC, to the LLWR
- Non-compactable wastes are placed in HHISO and shipped direct to the LLWR

Oldbury LLW comprises several distinct UK Radwaste Inventory waste streams; individual ISO containers will contain a mixture of streams but each stream arising will have been assayed separately.

LLW Arising from Decommissioning (waste arisings expected c2019 onwards)

Decommissioning will see a significant change in LLW arisings and hence in LLW management on site.
The volumes of waste will increase dramatically. The nature of wastes will also change, resulting in increased waste arisings at both ends of the LLW activity spectrum:

- Bulk demolition wastes expected to be at the lower end of the radioactive characterisation for LLW and will comprise large quantities of loose rubble and building materials
- Higher activity items (incl previously inaccessible plant items and 'difficult' higher dose items whose

disposal had previously been deferred)

- Stored operational wastes currently designated ILW in UK Inventory but during retrieval and / or processing may be recategorised as (higher end) LLW – these would be additional arisings not currently identified as LLW in waste inventories.

The overall LLW strategy will build on the current arrangements at Oldbury:

- Optimising segregation of wastes into activity category (ILW, LLW, non active)
- Decontamination of solid wastes and size reduction of large items where practicable
- LLW to be packaged in drums or HHISOs for disposal to the LLWR
- Default assumption for LLW is disposal to the LLWR (on site disposal of LLW is a potential option (subject to required consents) which is planned to be explored further)

Recent BPEO studies have confirmed the following strategy hierarchy to be adopted:

1. Decontamination and/or segregation and clearance under SoLA where possible, leading to recycling/disposal as clean waste
2. On site incineration of combustible wastes
3. Metal melting to allow clearance under SoLA where possible, leading to recycling as clean material
4. Disposal on site in an appropriate LLW disposal facility
5. Disposal of vLLW in an off site vLLW facility (assumed to be large purpose built regional / national facility)
6. Disposal to LLWR

Clearly application of this hierarchy is dependant on the feasibility of decontamination of wastes, and on the future availability of alternative disposal options. Currently efforts are made to decontaminate and segregate wastes where practicable with current facilities, following which all active wastes are routed to LLWR.

Key opportunities associated with delivery of this optimised strategy include:

- Improvement of site facilities for decontamination, size reduction, segregation and monitoring
- Opening up routes to metal melting facilities
- Construction of an on site disposal facility (if feasible)
- Availability of national / regional vLLW facilities

Proposed Projects and Improvements for LLW Management

Optimisation of Waste Management Arrangements

The current waste management arrangements are largely based upon those of an electricity producing site, producing relatively small waste volumes. Arrangements for decommissioning will be expanded in a number of ways.

- New, larger, facilities will be commissioned to handle the greater waste throughputs. These will include decontamination facilities as well as enhanced monitoring facilities to effectively sentence waste as active or non active.

- Changes to waste strategy to reflect the greater opportunities applicable to the wider range and greater volume of wastes:
  - Improved decontamination, segregation and size reduction of wastes is expected to minimise ILW and LLW volumes
  - Melting of active metal wastes may give various benefits including increased decontamination and size reduction.
  - For disposal of LLW, alternatives to the LLWR, if available, may prove to be appropriate.
    - BPEO study ranked on site disposal above equivalent off site disposal for all waste categories considered, based mainly on transport (nuisance, resource use and safety) and proximity principle considerations.
    - Other alternatives may include commercial VLLW routes if these were to become available.
  - Alternatives under consideration for FED include segregation and disposal of relevant waste as LLW.
  - Alternatives for ILW sludge include the potential to sentence as LLW following simple conditioning in grout
  - Alternative treatment strategies for desiccant may include decay storage or processing to LLW.

LLW Minimisation

The Site is enhancing its facilities for decontamination and size reduction. However, there are opportunities for further optimisation.

- All detailed plans for segregation and decontamination of wastes will be developed with consideration to BPEO (including the waste management hierarchy), BPM, the company procedures for the management, control and clearance of material and inter industry experience and good practice as promoted by CEWG and elsewhere.
- The decontamination` and size reduction techniques listed above, including metal melting, are particularly appropriate for LLW.

Optimisation of LLW Assay Techniques

The current techniques used for the assay of LLW are time consuming. There is an opportunity to improve waste processing efficiency by enhancing waste assay techniques.

It is intended that pre-monitoring of plant and facilities will be used where appropriate to identify waste arisings with the highest potential to be active or inactive, allowing segregation at source and increasing the ability to accurately sentence wastes. This would be supported by sampling and monitoring of the wastes once generated.

Experience gained by other sites in assay techniques and use of monitoring equipment will be used to optimise the facilities and procedures deployed at Oldbury.

Top 3 LLW Issues for the Site

Top 3 LLW related risks in the LTP are:
 	
• Loss / compromise of LLWR disposal route
  o Changes in LLWR CfA
  o LLWR capacity
  o Changes in LLWR contract
  o Operational problems at LLWR
• Loss of site incinerator
  o Technical / equipment failings or regulatory issues
• Lack of adequate EA authorisation
  o Failure to gain authorisation for increased waste arisings during decommissioning
  o EA policy decision to decrease site authorisations
 	
Top 3 opportunities:
• Provision of on on-site disposal facility is considered the top LLW opportunity for Oldbury. Benefits would include:
  o Reduced transport
    ▪ Lowered cost
    ▪ Reduced environmental impacts
  o Reduced business risk (once facility commissioned)
    ▪ Assured capacity
    ▪ Control over disposal costs
  o Possible reduced packaging requirements
    ▪ No need for transport containers
    ▪ Risk assessment and facility safety case may well indicate reduced packaging requirements, especially for lower activity wastes
    ▪ Leading to cost and environmental (resource use) benefits
 	
• Alternatively, significant opportunities could be offered by the availability of off site VLLW facilities
  o Assumed reduced packaging requirements
  o cost and environmental (resource use) benefits
  o Assumed reduced cost
  o Assumed (as new build) sufficient capacity for wastes
 	
• Further substantial improvements would be gained by adoption of a range of more modest opportunities including
  o Improved size reduction facilities
  o Improved monitoring (clearance) capability
  o Improved decontamination techniques and capability

Hunterston A

Summary of Proposed LLW Site Strategy

Decommissioning LLW

The waste management team are responsible for the packaging and consignment of LLW and decontamination.

Combustible LLW:

- Liquid Organic wastes will be disposed at an off-site commercial incineration at a licensed location; this is dependent on formalisation of the multimedia discharge authorisation. Batches are sized to ensure no breach of RSA 93 authorised transfer limits.

Non-Combustible LLW:

The Site waste team is responsible for categorising LLW into the following types:

- Compactable LLW are processed via the Low Level Waste Processing Facility and are placed in 200 litre drums that are subsequently transferred to the WAMAC facility at Sellafield Ltd before transfer to the LLWR near to Drigg.
- Non-compactable LLW is processed via one of the two Non Compactable Waste Processing Facilities at Hunterston A where the majority is packed directly into either Half Height ISO (HHISO) or Third Height ISO (THISO) containers and shipped to the LLWR. The ISO containers are grouted upon receipt at the LLWR. However, some non-compactable wastes are packaged in 200 litre drums and loaded into HHISO's for disposal direct to the LLWR where it is operationally efficient to package waste in this manner. ISO containers are loaded at various locations around the RCA.
- Asbestos LLW is stored on-site to allow reduction of activity levels before disposal to the LLWR.

Good Practices

Examples of good practice in LLW management at Hunterston 'A' are:

- Dedicated LLW team with a high level of SQEP;
- The contents of every LLW waste drum are screened to ensure all waste is compliant with the Conditions for Acceptance at the LLWR; and
- Minimum manual handling of processed drums.

Proposed Projects and Improvements for LLW Management

Opportunities

The following opportunities are relevant to Hunterston:

- Soil remediation technology such as soil washing could be used to minimise the amount of LLW sent to the LLWR, however R&D would be required to determine the feasibility and cost effectiveness of this option;
- Disposal of VLLW soils to alternative locations; and
- Increased use of supercompaction to reduce disposal volumes.

Optimisation of Waste Management Organisation

The site has a project based waste management system and the environmental co-ordinator acts as the waste manager. Additional waste management responsibility also lies with personnel in the EHS&Q department. This division of responsibility means that there is a potential that waste management practices and sharing of best practice and equipment may not be as efficient as it could be.

Optimisation of Waste Management Arrangements

The waste management arrangements are largely based upon those of a generating site. In recognising that waste management is a key part of the Site's business in decommissioning, the site has modified the waste management arrangements to better integrate compliance. Further work is planned to enhance these arrangements, these include the completion of process maps to document the operation of each waste route.
The key requirement for future development is to provide a more detailed strategic review to underpin future operations. This will include:

- Identification of opportunities for improving waste management – improving statistics on recycling and increased segregation of wastes.
- Reducing environmental impact – driving home the principles of the waste management hierarchy.
- Continuing the highest safety standards. – to Dec 2007, Hunterston A has enjoyed over 6 years without a lost time accident.
- Sharing our ideas for the NDA National Waste Strategy
- Optimising costs – minimising LLW, increasing recycling and lessening site reliance on expensive landfill.
- Further work to underpin the confidence in the magnitude of future waste volumes; timing of dispatches; buffer storage opportunities and the identification of disposal routes for all orphan wastes.
- Further work to manage assumptions, uncertainties, risks and opportunities
- Further development of technical baselines and identification of research & development opportunities.
- Further development of the FSC decommissioning strategy and management of wastes arising from it (potential utilisation of ILW store etc).
- Improvements in BPEO/BPM and other option arrangements. – Formalise normal/annual reviews of BPEO/BPM
- Periodic reviews every 4 to 5 years to include technology reviews.
- Fundamental reviews – at major changes of process.

- The Waste Accountancy Template has identified gaps and it is necessary to carry out further characterisation and quantification of the LLW and non radioactive hazardous and toxic wastes. The correction of errors also needs to be carried out.
- Measures to improve waste minimisation, segregation and packaging with a view to reducing the quantities of LLW despatched to LLWR.
- The final End State of the site remains under consultation and may be modified from the current assumed end state.

LLW Minimisation

The Site is enhancing its facilities for decontamination and size reduction. However, there are opportunities for further optimisation to include:

- Packing efficiency of disposal containers;
- Use of incineration route for oil;
- Clearance and exemption to allow disposal as exempt waste;
- Segregation of metallic waste; and
- Segregation of soil.

Optimisation of LLW Assay Techniques

The current techniques used for the assay of LLW are time consuming. There is an opportunity to improve waste processing efficiency by enhancing waste assay techniques.

Alternative Disposal options

On-site Disposal- The suitability of on-site disposal has not yet been considered further.

Top 3 LLW Issues for the Site

Uncertainty of LLWR as a disposal route

There is uncertainty regarding the LLWR near Drigg including its closure date, future vaults, location, capacity and availability. The LLWR has a finite capacity. It will not be able to accommodate all of the UK's decommissioning wastes and may be unable to take LLW from 2008 onwards due to delays in opening a new disposal vault.

Inadequate Waste Characterisation

An event or non-conformance involving a ISO despatched from this or another site, which is outside the control of Hunterston A may result in a potential ban on transfer of ISO containers.

'Orphan' Wastes

There is a strategy for orphan wastes currently being developed at Hunterston A which will consider definition, treatment and disposal routes for these wastes. Orphan wastes identified at HNA include:

- Low Level Waste Oil that exceeds the radioactivity limits for commercial incineration at Fawley, Hampshire; and
- Low Level Waste Oil-contaminated sludge unsuitable for incineration;

Work is ongoing to fully identify the total inventory of orphan wastes at Hunterston A. It is intended that, as part of the overall clean up strategy, all orphan wastes within facilities other than the AWV's will be transferred to the AWV's for ongoing management and preparation for disposal.

Research and Development activities will address the missing technologies for the disposal of orphan wastes. Once a treatment and disposal route has been identified for a waste stream, its designation will change to Wastes Requiring Additional Treatment (WRAT).

Resources

There may be insufficient suitably qualified and experienced personnel (SQEP) available to deliver the commitments of the LTP. Lack of SQEP could result in inappropriate solutions, extended schedules and increased costs. Mitigating actions include retention and recruitment of staff; training programmes and succession management procedures. Skills Maintenance and Resource Enhancement plans have been produced by HR. An integrated resource strategy to explore SLC development, agency provision and tier 2 enhancement is in place. Site HR is working with identified regional skills academy to develop decommissioning training packages to allow provision of SQEP personnel in line with NDA strategy. A Skills Development Manager is to be appointed.

Trawsfynydd

Summary of Proposed LLW Site Strategy

Decommissioning LLW

Trawsfynydd LLW is processed and size reduced at the location where it is produced or at dedicated waste management facilities on site. Trawsfynydd LLW arises during specific project related deplanting and decommissioning work activities and during more general operational work. Project related bulky LLW may be packed directly into a HHISO in the project work area. HHISO packing in the project work area will take place if large volumes of LLW are being produced or if the work is within a contamination controlled area. Smaller quantities of bulky LLW may be transferred to the HHISO Loading facility where the wastes may be co-mingled to maximise packing rates. Size reduction will also be considered to maximise packing rates, subject to ALARP, BPM and ALARA considerations. Smaller items of LLW are taken to the Active Waste Handling Area (at the south end of the Active Waste Vaults Building) for monitoring and segregation of any non-compliant wastes.

Depending on the waste type, compaction, processing or size reduction (for example by sawing) may be considered to maximise packing rates. Solid LLW arisings from the fuel route and associated operations were stored in the AWV. The wastes consist of varying materials such as metal, wood and plastics that have been accumulated in a variety of different containments (drummed, plastic wrapped, bagged etc).

In addition to those wastes already stored and treatment of additional arisings, there are a number of specific decommissioning projects that will give rise to significant quantities of LLW, much of which will be in the form of concrete scabblings or spoil, e.g. the post operational clean out (POCO) and decommissioning of ILW storage facilities.

In general, LLW is segregated into the following categories:

Combustible LLW:

- There is currently no authorisation for incineration of LLW oils.
- Sludges are dried or solidified in a solid matrix as most appropriate. Cementitious slurries have previously been solidified in grout before dispatch to the LLWR.

Non-Combustible LLW:

The Site waste team is responsible for categorising LLW into the following types:

- Compactable LLW is packed in yellow 200 litre LLW drums and if appropriate the waste is further compacted within the drums. The waste packed into the drums is segregated according to its radionuclide fingerprint (as determined by the provenance of the waste). The packed drums are monitored in a Drum Assay System that produces a detailed inventory of the radionuclide content of the drum before the waste is packed in full height ISO containers (FHISOs) for transfer to the Waste Management and Compaction (WAMAC) facility at Sellafield Ltd where drums are supercompacted. The supercompacted pucks are then transferred to the LLWR near to Drigg.
- Non-compactable LLW is packed into Half Height ISO containers (HHISOs) for despatch to LLWR near to Drigg; wherever possible the wastes are co-mingled to maximise packing rates. The HHISO containers are filled with grout once delivered to the LLWR in the purpose built grouting facility. Then, after grouting, they are placed in the vault.
- Asbestos LLW is consigned to the LLWR near to Drigg in compliance with LLWR's Conditions for Acceptance.

Good practice

The appointment of an experienced LLW Engineer during 2007 has led to significant optimisation of LLW management at Trawsfynydd. Examples of good practice in LLW management at Trawsfynydd are:

- Optimised AWV Pantograph Canister and SWC Packing; and
- Identification of a disposal route and a simple drying system for D/C Sludge.

Proposed Projects and Improvements for LLW Management

Opportunities

The following opportunities are relevant to Trawsfynydd:

- Establish 'generic toolkit' on how to manage last 10% of waste type where the Technical Baseline (TBL) is not suitable (Lead and Learn);
- Establish safety case of for in-situ disposal of contaminated land under ponds;
- Opportunity to reduce LLW active waste quantities via waste reduction initiative;
- Drive to reduce unnecessary wastes being taken into the Radiological Controlled Area (RCA);
- Opportunity to maximise the use of the annual site limit of 500m^3 of LLW waste. Not currently using the annual site volume / activity limit; and
- Potential acceleration of disposal. Clear buffer store area for future use. Avoidance of possible future cost increases / more stringent CFA.

Establishment of the Waste Compound and a Site Waste Management Plan

Opportunities exist to:

- Improve non-radioactive waste segregation;
- Improve waste management through the development of the site waste management plan (including the establishment of the waste management subcommittee); and

- Reduce the total volumes of non-radioactive waste produced through increased reuse and recycling. The establishment of targets for reducing the levels of waste production and increasing the level of recycling.

Optimisation of Waste Management Organisation

The site has a project based waste management system and does not have a single decommissioning waste manager. Additional waste management responsibility also lies with personnel in the EHS&Q department. This division of responsibility could potentially give rise to a risk of inefficiencies in the sharing of best waste management practices. To ensure this does not occur, a Technical Strategy Steering Group is to be developed. A Site Waste Management Plan will also be developed for the management of non-radioactive waste.

Optimisation of Waste Management Arrangements

The waste management arrangements were largely based upon those of an electricity producing site until the Project Delivery Organisations (PDOs) were developed. The development of the PDOs has produced a clear management structure for the project management of ILW project work. Significant expansion of the Engineering Department is planned and this should contribute to further optimisation of ILW management. The development of the Wet Waste Strategy will also contribute to optimisation of wet ILW management.

In addition, since the development of the PDOs the site has modified the waste management arrangements for LLW and an experienced LLW Engineer has been appointed. Some further work is planned to enhance these arrangements.

The development of a waste compound and site waste management plan together with the operation of the waste compound by dedicated staff under the supervision of the new Facilities Manager should significantly improve these arrangements.

LLW Minimisation

The Site has chosen not to upgrade its facilities for LLW decontamination and size reduction as it is considered that this would not be cost effective for the LLW that will be produced in the next few years. However, other opportunities for further optimisation include:

- Maximising the packing efficiency of disposal containers;
- Use of any new incineration route and other routes identified as UK LLW management strategy is developed by the NDA and Site Licence Companies (SLCs); and,
- Enhancement of clearance and exemption systems to allow increased clearance of RCA wastes as exempt waste

Top 3 LLW Issues for the Site	
1.	Opportunity to maximise the use of the annual site disposal authorisation limit of 500m^3 of LLW . The site is not currently using the annual site volume / activity limit and there is potential for the acceleration of disposal.
2.	Maximising the packing efficiency of disposal containers;
3.	Use of any new incineration route and other routes identified as UK LLW management strategy is developed.

Wylfa

Summary of Proposed LLW Site Strategy

Operational LLW

Relatively small quantities of operational arisings will continue for the remainder of generation and defuelling (including POCO activities). This waste is routinely despatched to the LLWR or incinerated as appropriate. Retrieval of the waste will occur as part of site operations. However the wastes will be segregated at source by the site personnel carrying out the work and placed into dedicated collection skips or drums. The wastes will be placed into interim storage in ventilated, air filled conditions prior to processing/disposal to allow sufficient volumes for processing.

The LLW streams are generally contact handleable and require little if any bespoke retrieval equipment. The waste is routed to a Waste Sorting and Assay Facility where the waste is assayed and sorted such that the waste is sorted into non-radioactive, incinerable, compactable and non-compactable waste streams.

Combustible LLW:

- Combustible solids are burnt on site in a purpose built incinerator. The remaining ash is consigned to the compactable LLW streams and disposed at the LLWR.
- Liquid organic wastes (oils) are sent to a commercial incinerator at Fawley, Southampton.
- Sludge will be retrieved and transferred to a Sludge Dewatering Unit where it will be dewatered and the liquid effluent routed to the AETP for treatment prior to discharge. Resultant sludge will be solidified by cementation in 200 litre drums within a cementation unit. Drums will subsequently be loaded into half height ISO (HHISO) containers.

Non-Combustible LLW:

Non-combustible solids are sorted, assayed, reduced in volume where practicable and packaged for disposal to the LLWR:

- Compactable LLW is placed in 200 litre drums that are placed in Full Height ISO (FHISO) freight containers for transport to WAMAC for supercompaction and subsequent disposal to the LLWR. The use of 9.3m^3 skips is being introduced at Wylfa. These will be used to transport bagged waste for shredding and compaction at the WAMAC.
- Non-compactable LLW is placed in Half Height ISO (HHISO) containers and shipped direct to the LLWR.
- Asbestos LLW is placed in bags and drums as appropriate and sorted within the LLW sorting and assay facility. Following storage, waste is packaged in 200 litre drums and transferred to the super-

compaction facility at Winfrith in full height ISO (FHISO) containers prior to final disposal at the LLWR.

Decommissioning LLW

In addition to the general storage of operational LLW and treatment of additional arisings there are a number of specific decommissioning projects that will give rise to significant quantities of LLW. Much of this will be in the form of concrete scabblings or spoil that are too active to be disposed of via non-radiological waste routes. In addition to those identified, the POCO and decommissioning of ILW storage facilities is also likely to lead to additional arisings of LLW.

The waste will be routed to the proposed Active Waste Management Facility within the RCA where the waste will be assayed and sorted.

Good practice

- Dedicated LLW team with a high level of SQEP
- The contents of every LLW waste drum are screened to ensure all waste is compliant with the Conditions for Acceptance at the LLWR
- A number of LLW drums that have already been sorted are routinely selected at random and inspected prior to disposal
- Appropriately labelled drums are available to permit segregation of waste streams/types at source
- Minimum manual handling of processed drums
- Decontamination and free release.
- Development of waste management strategies across all Magnox North sites is described in the Main IWS Document.
- Wylfa is actively seeking to adopt Best Practice identified by WRAP, SAFEGROUNDS and SD:SPUR initiatives.

A Wylfa study has been completed using the WRAP/ICE demolition protocol for the Turbine Hall and Administration Block. The output will be considered by the new Waste Management Section. The creation of the Waste Strategy and Technical Support work stream within the new Waste Management Section will improve adherence to the guidance from SD:SPUR and SAFEGROUNDS.

Proposed Projects and Improvements for LLW Management

Opportunities

The following opportunities are relevant to Wylfa:

- Use of a commercial incinerator for contaminated organic liquid waste disposal. This may involve the use of International facilities;
- Investigate a range of available technologies (e.g. Surface Decontamination, Shredding, Partitioning, Smelting etc) that will reduce the total disposal volumes of radioactive waste;
- The options for disposal of LLW and VLLW at site are being investigated with activities primarily focused on Stakeholder Engagement;

- Use of the Wylfa Incinerator as a regional facility for other NDA sites; and
- A number of the opportunities above support generic opportunities as outlined in the main Magnox North IWS.

Optimisation of Waste Management Organisation

The formation of the Waste Management Department in 2007 was a key development in waste management at the Site. On-going review and operational feedback will be used to ensure that the waste management department structure is optimised to deliver the agreed strategy of radioactive and non-radioactive waste management.

Optimisation of Waste Management Arrangements

The former waste management arrangements were largely based upon those of an electricity producing site. In recognising that waste management is a key part of the Site's business in decommissioning, the site has modified the waste management arrangements to better integrate compliance. Further work is planned to enhance these arrangements.

LLW Minimisation

The Site is enhancing its facilities for decontamination and size reduction. However, there are opportunities for further optimisation to include:

- Packing efficiency of disposal containers
- Use of incineration route
- Clearance and exemption to allow disposal as exempt waste

Optimisation of LLW Assay Techniques

The current techniques used for the assay of LLW are time consuming. There is an opportunity to improve waste processing efficiency by enhancing waste assay techniques.

Alternative Disposal Options:

On-site disposal- The suitability of on-site disposal of contaminated concrete and building rubble has been confirmed through a series of BPEO and BPM studies. Scoping opinion has been sought from the planning authority and a planning application was submitted in November 2007.

Top 3 LLW Issues for the Site
N/A

Harwell

Summary of Proposed LLW Site Strategy

Since a large proportion of the Low Level Waste (LLW) at Harwell is or will be consigned to the LLW Repository (LLWR), the strategy is to minimise the volumes of LLW by application of the waste management hierarchy and waste minimisation using best practicable means. The wastes to be consigned to the LLWR consist mainly of the following:

- Solid waste routinely consigned to the LLW Repository (LLWR) near Drigg;
- Waste sent off-site for incineration;
- High volume low activity (HVLA) waste.

The volumes of LLW assume that all exempt waste has been segregated from the LLW sent to the LLWR. The exempt waste is characterised and consigned in accordance with the Nuclear Industry Code of Practice on Clearance and Exemption (NICoP).

LLW arising on-site is either collected in drums for processing or packaged directly into half height ISO disposal containers (HHISOs). Non-compactible LLW collected in drums is packaged directly into HHISOs. Compactible waste in drums is sent to the Waste Monitoring and Compaction (WAMAC) facility at Sellafield or the supercompactor owned by WMT Ltd. at Winfrith. Supercompacted pucks are placed in HHISOs and transferred to the LLWR for grouting and disposal. Supercompaction reduces the disposal volume and produces an improved waste form.

LLW liquids, containing higher levels of activity than standard LLW effluents, are collected in containers known as carboys. The liquids, together with floc from the treatment of standard LLW effluents, are solidified and conditioned by immobilisation in a lost-paddle cementation plant at the LETP. Drums containing conditioned cemented waste are placed in HHISOs with other bulk waste and consigned to the LLWR.

There are a number of drums of stabilised waste arising from the remediation of the Western Storage Area that contain radioactivity at levels too high to be consigned as exempt hazardous waste. They have been stabilised by solidification in cement to produce a monolithic waste form and leach tests are currently being carried out to determine whether the waste form is suitable for disposal at the LLWR.

An additional LLW disposal route for Harwell wastes is incineration at a commercial incinerator with an RSA Authorisation. Wastes consigned via this disposal route include LLW organic liquids and graphite from the GLEEP reactor. LLW organic liquids, such as oils and solvents, are collected in carboys, filtered and analysed before transfer off-site for incineration. Graphite from decommissioning the GLEEP reactor has been crushed and placed in recycled plastic drums and the whole package is incinerated. The recommendation from the site waste BPEO study was to continue with incineration of these waste streams. Plans are being developed to incinerate woodwork, such as doors, arising from decommissioning that cannot be consigned as exempt wastes.

HVLA waste, such as building rubble and soil from decommissioning and site remediation, has activity levels at the lower end of LLW. Due to the significantly large volumes of HVLA, a key assumption for LTP08 is that an alternative disposal route for this waste is available from 2013 onwards. The majority of this waste will arise after 2013 during the remediation of the LETP and environmental remediation and restoration of the rest of the site.

Proposed Projects and Improvements for LLW Management

The Strategy is to minimise the production of LLW by application of the waste management hierarchy. Examples include:

- Decontamination of lead, by planing, to re-use or recycle;
- Use of a bag monitor for wastes which may be characterised as exempt waste;
- Use of a “blast and vacuum” technique to decontaminate building surfaces;
- Use of an abrasive cleaning machine at Winfrith (WACM) to decontaminate metal for recycling.

A project is also in progress to develop a sustainable management option for HVLA waste which involves a formal BPEO study with stakeholder consultation. Results from the options assessment and stakeholder engagement have concluded that disposal to a new on-site HVLA waste disposal facility is the BPEO. This is a change from the previous strategic assumption for disposal to an existing off-site landfill. Further work is required, including seeking planning and other regulatory approvals, in order to achieve this option.

Top 3 LLW Issues for the Site

In order for the LLW strategy to be fully implemented, the following key risks or issues must continue to be resolved or mitigated:

- The availability of an HVLA waste disposal route by 2013. The current assumption has been changed to on-site disposal;
- The LLWR continues to remain open and accepting LLW from Harwell;
- MoD also owns over 100 sea disposal drums stored in the Harwell sea disposal drums store. To date, 40 drums have been characterised as LLW and have been consigned to the LLWR. Core sampling of the remaining 75 drums is required to be successfully performed to determine suitability for LLW disposal.

Winfrith

Summary of Proposed LLW Site Strategy

The impact of the new Solid Low Level Waste (LLW) Policy on LTP08 and the Winfrith waste strategy is under consideration and is not encompassed within this current version of the IWS. The policy will most likely impact on the strategy for the lower activity LLW, within the new category high volume Very LLW (VLLW) and for the UKAEA classified High Volume Low Activity (HVLA) waste. A disposal route for HVLA waste may be explored under the risk based approach suggested in the new policy.

In the site wide BPEO study, the solid LLW was broken down into four categories: solid non-combustible LLW, solid combustible LLW, solid VLLW and HVLA wastes. Although the current strategy is to send both combustible and non-combustible LLW to the LLWR, these wastes were differentiated in the study as there may be an alternative strategy for the combustible LLW (e.g. incineration) in the future. The VLLW and HVLA wastes were differentiated from the rest of the LLW as there are potential alternative disposal opportunities to the LLWR for these wastes.

Solid low level radioactive waste (LLW) is generated on the Winfrith site from routine operations, the decommissioning of redundant nuclear facilities and the removal of contaminated land. The volumes involved vary depending on the type of operation undertaken and include change-room waste associated with the routine access/egress to active areas, secondary wastes unavoidably generated during operations and materials that become waste at the end of their useful life. The wastes will be in the form of waste residues, extract filters, scrap equipment, contaminated protective clothing, and redundant plant and equipment. In developing its LLW management strategy, Winfrith takes cognisance of the Industry Code of Practice on Clearance and Exemption and where possible, segregates and decontaminates low level wastes to allow part to be treated as exempt waste. Cutting is carried out on certain large items of solid LLW and surface removal of contaminated plant and equipment is also undertaken to remove the surface contamination to enable disposal of the bulk of the item as exempt waste.

Where LLW items cannot be decontaminated, the current practice is to collect the wastes from the on-site facilities and deliver them to the A58 Complex for supercompaction. Drums of similar LLW are also consigned from UKAEA Harwell for supercompaction. Following supercompaction, pucks are placed in a half height ISO (HHISO) freight container, which is then transferred to the LLWR for disposal. Bulk LLW is placed directly into HHISOs and third height ISOs (THISOs) at source for transfer to the LLWR. The site wide BPEO Study identified two potential options for the management of the non-combustible LLW generated at Winfrith: disposal to the LLWR (as per current practice) and on-site disposal. However, only disposal to the LLWR was identified as being practically feasible for the more radioactive low level wastes. The end state for the Winfrith site is a de-licensed site and it was considered that on-site disposal of LLW would not be compatible with the NII de-licensing criteria. However, it was recognised that it might be a practicable option for HVLA wastes.

Of the 33 fully grouted sea disposal drums (SDDs) remaining in storage at Winfrith, seven of the eight 1804 type and 18 of the 1803 type have been recharacterised as LLW and will be loaded into HHISOs for disposal at the

LLWR. Three fully grouted 1803s have not been identified as ILW but require further investigation to establish whether quantities of uranium will prohibit LLWR disposal. There are also four loose lid 1803 SDDs which have also been re-characterised and will be suitable for LLW disposal following some minor conditioning/processing. One contains ion exchange resin and will be processed through Winfrith East Treatment Plant (WETP). Four tritium ion exchange columns (LLW) currently stored in A58.1 will be conditioned through WETP. Although disposal to the LLWR is a well established and existing disposal route, Winfrith recognises that the future availability of the facility is a risk; however, it is considered that this is a wider industry issue that will require higher level decision making by the NDA.

Combustible solid LLW, such as soft wastes, may potentially arise from any activities within the radiation and contamination controlled areas on the site. The solid LLW consists of general waste materials, secondary wastes and redundant items. Combustible LLW is currently not differentiated from non-combustible LLW and these wastes are not segregated at source. Mixing hard and soft wastes in this manner aids the high-force compaction process used for minimising the volumes of waste disposed to the LLWR by controlling the amount of re-assertive wastes present and also helps to meet weight limits on containers.

The site wide BPEO Study considered alternative management options for Winfrith's combustible LLW including incineration on and off-site. However, the volumes involved are too small to make an on-site incinerator a practicable option and UKAEA Winfrith has only a limited authorisation for the consignment of waste to the off-site incinerator at Fawley. Given that the Fawley incinerator is only currently used for problematic wastes for which there is no other readily available practicable alternative disposal route, it would not be sensible to use up the allocation on solid waste, for which a robust disposal route already exists.
For these reasons, continued consignment of combustible solid LLW waste to the LLWR in conjunction with the non-combustible solid LLW remains the baseline strategy. This choice is reinforced by the threat that if the combustible solid LLW was disposed by another route, the re-assertive nature of the remaining non-combustible LLW may preclude it from highforce compaction. This would lead to a higher volume of waste needing to be disposed of or potentially the LLWR SLC not allowing the disposal of the waste if it does not meet the compressive strength requirements detailed in the LLWR Conditions for Acceptance.

Significant quantities of VLLW will be produced as a result of the decommissioning activities at UKAEA's Winfrith site. The previous strategy for the management of these wastes was disposal to the LLWR as LLW. A BPEO study concluded that the option of direct disposal of VLLW to landfill should be developed and implemented by UKAEA. In 2006, the Environment Agency (EA) granted authorisation to dispose of VLLW to a licensed landfill site.

HVLA wastes may also be produced during decommissioning and from the removal of contaminated land. There is currently no waste route for this waste (other than as LLW). However, it could be disposed of in a manner analogous to VLLW or could be disposed on-site subject to the agreement of the NII and EA. There is currently ongoing consultation by CIRIA (SD SPUR) on sustainable use of construction resources which in part addresses HVLA waste. UKAEA will be taking cognisance of this guidance in developing their site IWS. Some HVLA wastes could be reused within the Nuclear Industry, as recommended by CIRIA. Further evaluation of HVLA waste management options will come from a BPEO study on HVLA wastes underway at Harwell, the results of which will be used to help determine HVLA waste management policy at Winfrith.

A variety of radioactive sludge type wastes are generated on the Winfrith site. Sludges have arisen from previous reactor operations, such as those generated on SGHWR from the storage of spent resins used for reactor primary coolant treatment. Other sludges are generated through the processing of active liquid effluents either through

materials entering the effluent plant systems or from sewage effluent treatment.
The sludges from the SGHWR are being held in storage tanks pending processing in the site WETP, which commenced operations recently. These sludges are LLW, but due to the LLWR restrictions on the acceptance of some radionuclides, they will be managed as ILW. These arisings are legacy wastes and no further quantities of this specific type will be generated.

Immobilisation of the SGHWR sludges is identified as the highest priority project on the site. Work has started on the encapsulation of the sludges in a cementitious matrix inside Nirex 500 litre drums within the WETP facility. The encapsulated drums are stored inside the Treated Radwaste Store before final transfer to the national Deep Waste Repository (DWR). Winfrith made a submission and has obtained a Final Letter of Compliance for encapsulation of the SGHWR sludge from NDA RWMD. However there will be some further work required on the sludge in the heels of the tanks.

The remaining organic sludge arisings comprise mainly of sewage sludges from the Active Liquid Effluent System (ALES), which are used to treat active foul water arisings prior to sea discharge. These wastes are currently segregated, dewatered and packaged prior to incineration at an off-site facility. There is an ongoing generation of these wastes. The relatively small volumes of active sludge wastes from the ALES plant means that there is currently no practicable viable alternative to the existing strategy of incineration at Fawley. Given the close geographical location of this facility and the high levels of abatement fitted to the incinerator, use of an on-site incinerator (permanent or mobile plant) as an alternative would offer no benefits. The EA's recent decision to grant Winfrith an authorisation for the disposal of VLLW to local landfill could potentially open up an alternative cheaper viable disposal route for the organic sludges, if they were shown to be of acceptably low activity and suitable other characteristics. However, this management strategy would have to be investigated in detail and it is uncertain at this time whether the sludge would be accepted.

Some items of SAFER equipment are still in use and will not be disposed of until the end of the lease agreement in 2009/10. It is proposed that the majority of the work will be carried out by the tenant using their existing plant and equipment. The proposed processing methodology and disposal routes are both well established and currently in use.

Proposed Projects and Improvements for LLW Management

The use of the waste management hierarchy and Best Practicable Means (BPM) to minimise the volume of waste arisings. Waste is segregated into the lowest appropriate radiological and non-radiological hazard categories for disposal or long term storage. Once waste exists then the strategy is to use existing disposal routes or to make wastes passively safe for long term storage.

UKAEA Winfrith has an authorisation for the consignment of its organic wastes and some hazardous wastes to the incinerator at Fawley.

LLW arising during the site programme will be consigned to the LLW Repository (LLWR) near Drigg. During decommissioning, Winfrith will also generate large volumes of VLLW and HVLA wastes. Although the baseline strategy at Winfrith is to send these wastes to the LLWR, Winfrith recognises that this is not BPEO and has applied for, and been granted, an authorisation from the Environment Agency to dispose of its VLLW to an authorised

landfill site. There may also be an opportunity to dispose of HVLA wastes in an analogous manner.
This issue will be common to other NDA sites and could be considered by the NDA as a potential opportunity in developing their national strategy.

Top 3 LLW Issues for the Site

The main challenges to the Winfrith site strategy for waste are:

- The availability of a store for reactor decommissioning ILW; some of this waste may be characterised as LLW and disposed at the LLWR;
- The provision of a high volume low activity (HVLA) waste disposal facility/route;
- Disposal of orphan waste streams, including sodium wastes currently categorised as LLW.

Approximately 25 tonnes of sodium metal, in a number of different containers, has been stored within a store on the Dragon Reactor Complex. The inventory comprises sodium coupons and bulk sodium. A previous strategy option of transfer to the sodium disposal plant at Dounreay was not allowed by the Scottish Environmental Protection Agency.

A BPEO study for the sodium coupons identified incineration to be the optimum method for the disposal of this waste and the coupons were subsequently opened and the sodium metal sent for incineration at Fawley.
A second BPEO study was undertaken for the bulk sodium metal and also determined incineration to be the optimum disposal method. Due to funding constraints, the sodium will now remain in storage at Winfrith and a processing route identified during the Interim End State. Winfrith has responsibility for the processing of ~133,000 sodium coupons returned from Cadarache in France. Options for these coupons are still under discussion, including opening and incineration as this is a proven technique on similar items.

Dounreay

Summary of Proposed LLW Site Strategy

Solid Low Level Waste (LLW) arises from routine operations and decommissioning at Dounreay and consists of a wide range of materials, including metal wastes, such as ducting or vessels, and soft wastes such as laboratory materials or disposable protective suits. There will also be bulk materials such as benches or large items of equipment where it is not ALARP to size reduce them.

Historically, Dounreay disposed of LLW on-site, but started to store its waste in containers when the capacity became exhausted. Although work was undertaken to open a route for the transfer of LLW to the LLW Repository near Drigg, this option was closed off following a decision by the Scottish Executive. However, UKAEA were already pursuing its reference strategy for the management of Dounreay's LLW through a stand-alone BPEO study. This has gone through stakeholder consultation with the selected option being that of on-site disposal in a new facility at the Dounreay site. Work is ongoing to deliver this solution.

The proposed new disposal facility will offer containerised storage in concrete-lined vaults, but will also have the capability for disposal of high volume low active (HVLA) waste, which is essentially contaminated soil in 1 tonne bags.

Where appropriate, LLW from operations and decommissioning on the Dounreay site is packaged in 200 litre drums. The waste volume arising is minimised by use of the Waste, Receipt, Assay, Characterisation and Supercompaction (WRACS) facility. The supercompacted drums are placed into half-height ISO freight containers and transferred into interim on-site storage.

Large items (not suitable for 200 litre drums), or bags of contaminated soil (HVLA) are separately loaded, at the source facility, directly into HHISOs for interim storage in one of 2 interim LLW stores. Part of the forward LLW strategy, Dounreay has converted an existing building to undertake segregation and/or size reduction of LLW from exempt and clean waste to ensure the best use of available capacities both on and off-site. This facility is currently undergoing inactive commissioning. The facility will also offer a monitoring station for exempt wastes.

As stated earlier, Dounreay disposed of its own LLW in a series of pits excavated from the rock along the northern coast of the site. It is assumed that UKAEA will not be able to make a post closure safety case for this facility and therefore a strategy is in place to remove and dispose of waste, repackage into HHISOs, and then re-dispose of the materials to the new LLW disposal facility. This is currently scheduled between 2019 and 2023. Current predictions estimate that this work will produce around 1300 HHISOs of waste.

Dounreay has areas of contaminated land. These are currently managed through a Contaminated Land safety case against risk criteria. Estimates of contaminated land, which will potentially be excavated, are included in the

Dounreay Radioactive Waste Inventory (DRWI) estimates of LLW, HVLA and exempt. Whilst Dounreay already has estimates of contaminated ground, LTP08 clearly sets out that further characterisation work will be undertaken with a considerable effort focused on when buildings are due to be demolished. This is supplemented by "at source segregation" which assists in correctly sentencing material as it is packaged. Dounreay is also looking at initiatives such as bio remediation as a method for reducing the volumes of contaminated materials to be disposed of. Current arisings of this type of waste are held in 1 tonne bags within HHISO containers.

Proposed Projects and Improvements for LLW Management

Dounreay have undertaken a considerable amount of work in the past year looking at improving waste data for the next 2 years, through the production of Project Specific Waste Plans. This has been aimed at improving the quality of the "near term" volume data in DRWI. Work identified in the LTP for the next 2 years will be focused on the writing of Building Waste Plans. These will become the strategic document for a facility and will detail the expected waste to be generated during the full lifecycle of the facility. These will be supplemented with improved facility wiring diagrams. Improvements in LLW management include:

- Continued initiatives to improve facility and waste characterisation will lead to better defined treatment, packaging and disposal strategies.
- Whilst every attempt has been made to put in place a reference strategy for a number of smaller waste streams these still require to be underpinned with specific strategy documents. This will be an important focus in the coming years to ensure the data generated from the production of the Building Waste Plans are formally assessed for their impact on the reference strategies, the identification of gaps, and undertaking the work to address those gaps.
- Ongoing tasks to characterise facilities to underpin the reference strategies and associated development work.
- The consultation process on Site End Points has been completed and the outcome advised to the NDA. It will still require acceptance by the Government and therefore results in a potential challenge to the reference IWS position in future years.
- Having produced a clean and exempt strategy in the past year, further work is still required in refining the non-radioactive waste strategy at Dounreay in order to maximise the opportunities for re-use and recycling of waste on site as part of the site remediation. Work is also required to better understand the capacity of non-radioactive waste routes and facilities and demonstrate BPM.
- Opportunities for the transfer of materials off-site will still be investigated as waste strategies are developed. However, Dounreay's IWS currently plans to treat, package, and dispose all Dounreay-generated LLW on-site; conditioned ILW will be stored on-site awaiting the availability of a national strategy for its long-term management.
- NDA-led Consultation where one or more SLCs are investigating waste management opportunities.
- Improved communication and information sharing between SLCs in areas such as:
  - Waste package design to offer potential savings;
  - Waste packaging plant design and equipment

- Availability of historical development work
- Sharing of letters of compliance
- Sharing of Lessons learned
- Early notification of Facility or Process Plant visits to allow other SLCs a chance to express and interest or influence specification of potential work
- Visibility of the full NDA portfolio of work/tasks to better understand where Dounreay's requirements can be addressed or where Dounreay may be best to lead.
- Clarity on the capabilities of the National Laboratory
- Innovative decommissioning techniques.
- Publishing list of key SLC contacts in areas of expertise.
- NDA schedule of "national" waste management initiatives such as graphite etc.
- Ensuring that Dounreay gets the best out of NDA-led groups such as the Nuclear Waste Research Forum, NWRF, and LSG.

Top 3 LLW Issues for the Site

- Waste Services Unit has completed the production of a clean and exempt waste strategy for the Site. Work is still required in the coming year to ensure that the waste routes identified in the strategy can be implemented and those available can be secured.

- Working with SEPA to allow retention of clean/exempt spoil for more than 3 years where a future use can be demonstrated.

- There will be requirements to produce individual Building Waste Plans, waste BPM or option studies. Possible constraints on the approval/implementation of such strategies may be through elongated Engineering reviews by the NDA or delays due to UK-wide strategies not being available to implement on timescales required by Dounreay. Also if the options are deemed contentious in any way, then there may be a requirement for stakeholder consultation.

AWE

Summary of Proposed LLW Site Strategy

Introduction

AWE operates on two sites with long term futures. There are plans to replace aging facilities and this is leading to a significant decommissioning programme which will take several decades. The main site is Aldermaston which generates the majority of the waste. Contaminants includes Pu, DU, HEU and tritium. Burghfield situated five miles from Aldermaston produces only very limited quantities of radioactive waste.

Presently, AWE does not produce a Life Time Plan as such but instead meets the requirements of Government Command 2919 and produces a review of its strategies to remediate all nuclear liabilities on its sites. This is updated every five years (the so called Quinquennial Review) and includes the technical strategy for remediating the sites, a costed programme and a forecast of waste volumes. This is based on existing facilities, processes and technologies.

AWE consist of a range of medium sized facilities support by some smaller buildings.

Baseline Strategy (the current position)

LLW at AWE is packaged either into 200 litre drums or as wrapped packages packed into half height iso freight containers (HHISO). For off site transport drums are placed in full height iso freight containers (FHISO).

Waste is packed into drums at the facility where it is produced. This is against a quality control plan before being collected by AWE's Waste Management Group (WMG). There is an audit programme and approximately 10% are radiographed to confirm they meet LLWR Conditions for Acceptance. Drums are used for compactable wastes. Soft waste from change rooms is generally either low force compacted or vacuumed packed to reduce volume. Increasingly more and more soft waste such as coveralls is being laundered off site and returned for re-use.

Wrapped packages consists of hard waste which has generally been size reduced at the facility where it has been produced to be man handleable. It is wrapped in PVC and collected by WMG. Again this is against a quality control plan. WMG then load the packages into HHISO at a central facility. Sometimes, particularly for decommissioning projects, HHISO are delivered directly to the facility, who then also pack the containers. If the container is positioned inside a controlled area, packages need not be wrapped.

Once a consignment is ready drummed waste is normally transported to WAMAC at Sellafield for compaction and grouting into containers for the LLWR. AWE does have the option of using the compactor at Winfrith instead of WAMAC. At the moment AWE only uses this route for waste that does not conform to the condition of acceptance for WAMAC. This includes radioactive waste contaminated with asbestos, beryllium and also filters.

At present HHISO are always sent directly to the LLWR near Drigg. Some tritiated waste including some oils and soft wastes are sent to a commercial incinerator at Hythe.

Once material has entered or formed part of a controlled contamination area and is no longer required, it is normally considered as LLW, unless its provenance is well known. The exception is material that is laundered. Therefore waste from decommissioning operations or the re-equipment of facilities is usually classed as LLW.

There are a small number of waste streams which do not have a defined disposal route. Those thought to be LLW or VLLW are:

- The redundant Pangbourne Pipeline (PPL), which is thought to be VLLW,
- Bulk wastes such as soil again which are thought to VLLW.

Opportunities

If a VLLW disposal route and an incineration route were available for waste from AWE, the opportunity to reduce the quantity of LLW disposed off to the LLWR should exceed 50%. Our baseline work (see below) will help to support this view.

Proposed Projects and Improvements for LLW Management

Strategy Development

During 2007 AWE prepared its own Integrated Waste Strategy (IWS). This has now been endorsed by AWE's Executive Board. Included in the IWS is a commitment to develop an improved LLW strategy for AWE. Fortuitously, this development is to run in parallel with the development of a new UK LLW strategy.

The areas that will be developed will include:

- Baseline – where the information supplied to the UK National Inventory (Nirex returns) will be / is being reviewed. This to include / has included volumes and activity and the likely stream volumes (compactable, non compactable, incinerable, VLLW etc).
- Waste Characterisation - where the aim is to reduce the conservatism and so sentence waste correctly. This by (i) improved assay (difficult for plutonium), (ii) by improved assessment procedures and (iii) cultural changes. A trial has been arranged in one facility and the successfully aspects of the trial will be rolled out across AWE during 2009. This will assist AWE to claim that BPM for waste assay has been achieved as required by our RSA Authorisations.
- LLWR Contract – Presently the MoD holds the contract with LLWR and meets the cost of disposal. Therefore there is no financial incentive for AWE to reduce LLW volumes. As part of the new strategy it is intended that the contract will be transferred to AWE prior to the start of FY 2009/10 (subject to MoD {accepted in principle} and LLWR agreement).

- BPEO – AWE will redevelop its BPEOs for LLW (during 3rd and 4th qrt 2008). This will look at options for streaming and treatment of LLW and VLLW both on site and off site and the disposal options for LLW and VLLW. In is expected that by April 2009 some options will be implemented and this will tie in with the proposed transfer of the LLW disposal contract to AWE.
- BPM - During 2009 facilities will be asked to update their BPM to ensure they are minimising their waste volumes. As a “Quick win” AWE will endeavour to increase the quantity of material that is laundered.

Top 3 LLW Issues for the Site

Key Three Issues:

- Assay and characterisation of waste contaminated with very low levels of Pu and other contaminants (hard and soft waste).
- A VLLW route for waste contaminated with Pu, HEU and other contaminants.
- Availability of an incinerator that can take LLW and VLLW contaminated with or potentially contaminated with Pu, HEU and other contaminants.

Additional Issues:

- Availability of a cost effective decontamination facility and metal recycling operation for LLW and VLLW.
- Staff culture. For decades staff have been training to minimise risk to staff and the public to the exclusion of other matters.
- Possible lack of facilities and staff to stream waste (the significance of this to be established).
- Possible management support for the prioritisation of LLW developments including the commitment of expenditure (the significance of this to be established).
- Effort and time to obtain new or amended RSA Authorisations for transfer of LLW (and VLLW) to alternative treatment and/or disposal sites.

Appendix B – Process for Compiling the 2008 Inventory

The baseline UK LLW inventory measured as at 1st April 2008 has been developed into the latest version of WIDRAM from two key data sources:

- The 2007 UK National Inventory (NI2007)
- The LTP08 Waste Accountancy Templates (WAT)

Description of Inventory Data Sources

The 2007 UK National Radioactive Waste Inventory contains volumetric, radiological, material, conditioning and disposal data for radioactive wastes arising in the UK. The national inventory comprises all radioactive materials currently classified as 'waste' including High Level Waste (HLW), Intermediate Level Waste (ILW) and Low Level Waste (LLW). It should be noted that there are a number of radioactive materials which are not currently included in the inventory such as separated plutonium, uranium and uncharacterised contaminated land which are not currently classified as 'waste' but potentially could be at some point in the future. Data is presented by waste stream. Waste streams are generally uniquely identified as arising from a particular plant or process. The stock date for NI2007 is 1st April 2007, with future raw volumetric arisings provided for individual years up to 2130. Material content data is given by weight percent for each waste stream, for a wide range of materials. Radionuclide fingerprint data is provided for each waste stream in Terabecquerels per cubic metre of raw waste.

The LTP08 WATs were produced by NDA sites to provide waste inventory data for ILW, LLW, HVLA, VLLW, EW and non-active wastes. Data is presented by waste stream, but it should be noted that the waste streams may be subdivisions of those presented in NI2007. The stock date for these is 1st April 2008. The NDA SLCs have a formal contractual obligation to complete the WATs on an annual basis. Data provided in the WATs includes volumetric stocks and arisings, plans for treatment and conditioning, total activities, material content, packaged volumes and associated uncertainty factors. Activity and material content data are provided at a lower level of detail than in NI2007; radionuclide data are not provided and material contents are given only as 'rolled up' groups.

Forecast volumetric arising data in the WATs is split into four categories in each year: In-Situ; In Process, In Storage and Disposed. Volumes are quoted such that the total of the volumes across all four categories is the same every year for a waste stream, and the movement of waste from In-Situ to Disposed can be tracked over time.

An understanding of the timing of the production of NI2007 and the WATs is of particular importance in developing the baseline inventory. The data-gathering exercise for the NI2007 began at the start of the 2007 calendar year and continued to the end of the 2007 calendar year. The data-gathering exercise for the WATs began in September 2007, towards the end of the production of the NI2007. It was determined by the NDA that the volumetric forecasts from the NI2007 would be used as the baseline for the WATs, such that the additional, more detailed waste stream materials and activity data in the National Inventory could be readily linked across.

It was recognised that changes in estimates and strategies made in the period between developing the NI2007 volumetric estimates and completing the WATs, would lead to misalignment of the waste stream volumes in the respective documents. It was agreed that SLCs would provide explanatory text to enable the two datasets to be reconciled.

Inventory Development Methodology

The methodology for developing the baseline LLW inventory can be summarised as follows:

1. Process NI2007 data to resolve data gaps and inconsistencies;
2. Derive NI2007 material breakdown by volume percent;
3. Format NI2007 data to enable import to WIDRAM;
4. Compare NI2007 data with LTP08 WAT data to identify data differences;
5. Process LTP08 WATs to resolve data gaps and inconsistencies;
6. Format LTP08 WATs to enable import to WIDRAM;
7. Decide, on a stream-by-stream basis, which data source to use, dependent on results of data comparison and other available information; and
8. Process data in WIDRAM to derive site templates.
9. Produce Baseline Output

The methodology is discussed in more detail below:

Initial assessment of the NI2007 showed there to be a number of inconsistencies and omissions in the waste stream data. In particular, it was found that the material contents for each waste stream, which are quoted by weight percent, often did not add up to 100%. Therefore there was a requirement to identify where material data were omitted or double-counted and adjustments were made accordingly. In many cases the inconsistencies in the material data could be resolved by reference to the text descriptions of stream material contents given elsewhere in NI2007. Where positive identification of ‘missing’ material contents could not be found, the remaining weight percentage was assigned to default ‘unknown material’. Sometimes it was possible to identify materials as falling into a particular broad category (e.g. plastics) but not to identify the specific material type within that category (e.g. non-halogenated plastics). In such cases, the remaining weight percentage was assigned to a default ‘unknown material’ encompassing that broad category (e.g. unknown plastics). Decision-making on the assigning of ‘missing’ material weight percentage was recorded on a spreadsheet. Where material weight percentages added up to more than 100% and the discrepancies could not be resolved by reference to the textual descriptions, then some judgment was required to bring the total down to 100%.

Waste stream material compositions are held within the NI2007 by percentage weight. In order to determine the impacts of treatment and disposition routings on waste stream volumes, it is necessary to derive waste stream material compositions by percentage volume. Having established the complete material contents by percentage weight for each waste stream (step 1), material contents by percentage volume were produced by calculating the total mass of each material in each waste stream, then dividing each material mass by an assumed material bulk density. It was found that the sum of the calculated volumes of the waste stream material components often did not equal the total volume of the waste stream due to inconsistencies in overall waste stream densities. This was corrected on a stream-by-stream basis through adjustment of the assumed material bulk densities within an acceptable range.

The relational database structure of WIDRAM is not consistent with the manner in which the data is presented within the NI2007, requiring some formatting was required to enable the data to be imported directly into WIDRAM. It should be noted that the formatting process altered the structure of the data such that it could be linked together, but not the content.

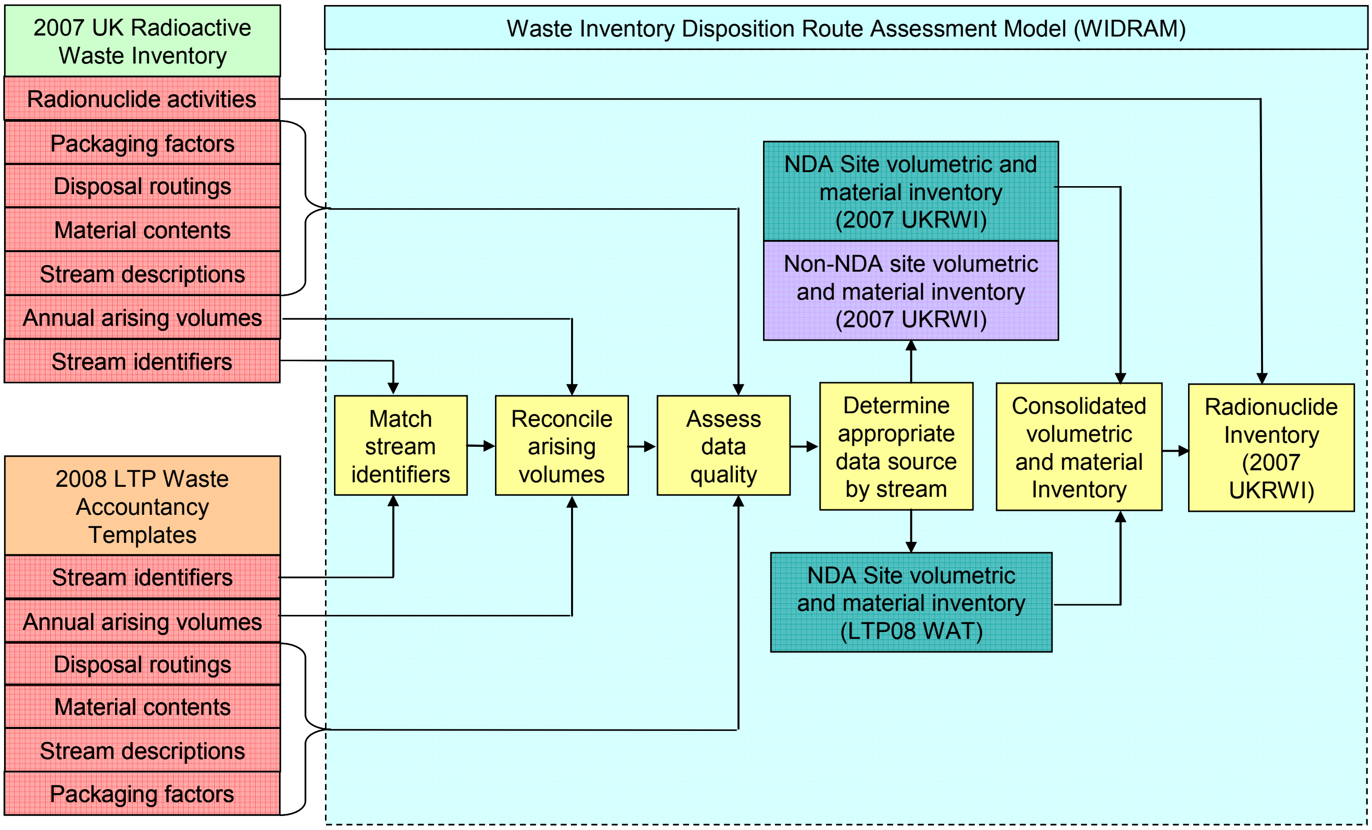
Assessment of the LTP08 WAT returns showed there to be significant variation in the quality and extent of the inventory data across the NDA sites. In a few instances the data was either non-existent or not of sufficient quality to be of use in the baseline inventory calculation. A comparison of the waste stream identifiers and volumes in the LTP08 WATs with those in the NI2007 was first undertaken to determine any data differences. Good correlation was found, with the large majority of waste streams and arising volumes consistent between the two datasets. This provided confidence that the additional, more-detailed information in NI2007 (e.g. radionuclides and material contents) could be read across to the WATs to provide a complete dataset. Where significant differences in waste stream identifiers or arising volumes were found then further information was sought, either directly from the waste producers or from additional documentation (e.g. Lifetime Plans), to reconcile these differences.

The WAT waste streams and volumes were given priority as representing the most up-to-date position and were therefore taken forward to WIDRAM for the inventory calculation in all but a small number of cases. For all non-NDA sites, and for NDA sites and waste streams where the WATs had not been completed satisfactorily, NI2007 volumes were chosen.

The strong correlation between the WAT and NI2007 waste streams enabled links to be made with the detailed waste stream material contents data (calculated as described above) in the NI2007. Similarly, the radionuclide fingerprint information held for each waste stream in the NI2007 was linked through to the waste streams in the WAT to provide a radionuclide inventory.

Figure B1 presents the calculation of the baseline inventory in diagrammatic form.

FIGURE B1 – METHODOLOGY OF APPROACH FOR THE CALCULATION OF THE BASELINE INVENTORY



Appendix C – Programme Summary Work Breakdown Structure Dictionary

The NDA's standard PSWBS[11] has been used to identify areas where these LLW costs are likely to reside across all sites. The LLW baseline costs have primarily been collected from the following NDA PSWBS areas:

- Waste and Nuclear Materials –
  - LLW Operations - 1.1.X.XX.14.43
    - Treatment Operations
    - Storage Operations
    - Maintenance
    - Plant Enhancements
    - Transport
    - On-site Disposal
    - Off-site Disposal
  - VLLW Operations - 1.1.X.XX.14.44
    - Treatment Operations
    - Storage Operations
    - Maintenance
    - Plant Enhancements
    - Transport
    - On-site Disposal
    - Off-site Disposal
- New Construction Projects –
  - Waste and Nuclear Materials - 1.1.X.XX.11.12
    - LLW management or disposal facilities
- Decommissioning and Termination –
  - Initial, C&M, Final Decommissioning - 1.1.X.XX.13.XX
    - LLW management or disposal facilities

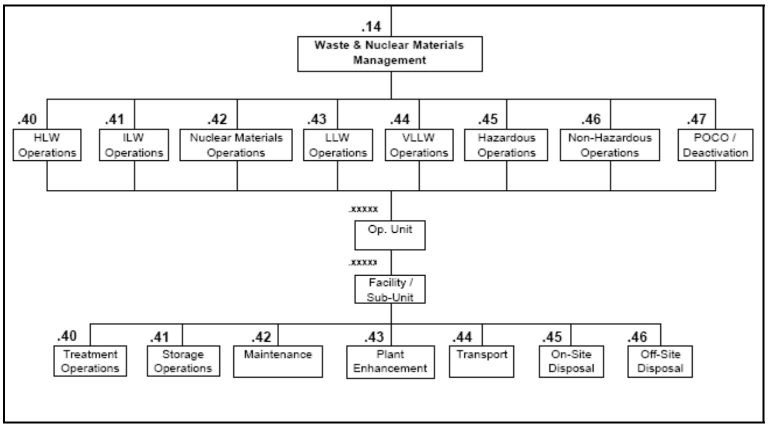
The LLW baseline costs exclude:

- The management of what is currently assessed as exempt or non-radioactive waste
- The management of contaminated land and groundwater remediation (although the costs associated with the management and disposal of any material treated as LLW are included)
- Decommissioning projects (except for decommissioning LLW management facilities)
- Liquid effluent treatment
- Gaseous effluent treatment

A full description of the relevant of the relevant areas used to compile the LLW cost baseline is provided below based on the NDA's PSWBS Dictionary and Guidelines provided in PCP-01-01[12]. This guidance is provided by NDA to each site to ensure a level of consistency in cost accounting across all sites.

Level 5 - Waste & Nuclear Materials Management (1.1.X.XX.14)

Includes all activities performed at a site, which relate to the treatment, storage, transportation and on-site (where applicable) disposal of solid low level waste (LLW),very low level waste (VLLW),



Level 6 - Low Level Waste Operations (1.1.X.XX.14.43)

Activities associated with the management of low level wastes containing less than 4 $x10^9$ Bq per tonne of alpha activity or less than 12 x 10^9 Bq per tonne of beta/gamma activity. Typically, this will include solid LLW arising from operational, waste management and decommissioning activities and Low Active Effluents. This element should also include High Volume Low Activity Waste (HVLA) and similar LLW subsets.

Level 6 - VLLW Operations (1.1.X.XX.14.44)

Activities associated with the management of wastes with a lower radioactive content than LLW but remain subject to regulatory disposal conditions and can only be disposed of at certain locations (e.g. Clifton Marsh)

Level 9 - Treatment Operations (1.1.X.XX.14.XX.xxxxx.xxxxx.40)

Activities associated with the treatment and conditioning of wastes, effluents and Nuclear Materials to render them passively safe and hence suitable for long term interim safe storage. Activities also included are the treatment of liquid effluents such that, subject to discharge authorisations, they can be discharged to the environment. Processes include vitrification, encapsulation, immobilisation, decay cooling, extraction of radionuclides from the wastes etc. Where applicable these activities include size and volume reduction by, e.g. compaction and evaporation.

Level 9 - Storage Operations (1.1.X.XX.14.XX.xxxxx.xxxxx.41)

Activities associated with the storage of raw wastes and effluents prior to treatment and the storage of conditioned, passively safe wastes, prior to final disposal. Also includes activities and costs relating to Nuclear Materials storage.

Level 9 - Maintenance (1.1.X.XX.14.XX.xxxxx.xxxxx.42)

Costs associated with maintenance activities to support plant operations e.g. routine, preventative, corrective etc.

Level 9 - Plant Enhancement (1.1.X.XX.14.XX.xxxxx.xxxxx.43)

Activities and costs of non-routine asset care and asset enhancement initiatives. Typically these will be to enhance the performance of a plant, to maintain the performance of a plant or to satisfy increased environmental or safety requirements.

Level 9 - Transport (1.1.X.XX.14.XX.xxxxx.xxxxx.44)

This element describes the activities associated with the transportation of wastes and Nuclear Materials, either between sites for treatment / storage at that location or from sites to final disposal locations (e.g. to Nirex). This activity does not include the costs of transportation of spent fuel to and from sites which is included under Commercial Operations.

Level 9 - On-Site Disposal (1.1.X.XX.14.XX.xxxxx.xxxxx.45)

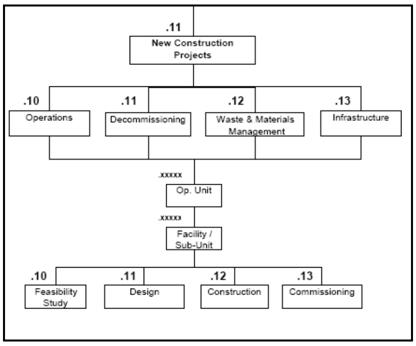
This activity is concerned with the on-site disposal of wastes where this occurs and it is anticipated that this will be confined to LLW and VLLW.

Level 9 - Off-Site Disposal (1.1.X.XX.14.XX.xxxxx.xxxxx.46)

This PSWBS element captures the activities and costs associated with wastes disposed of at off-site locations, including LLWR and ILW & HLW repositories. In addition, this will relate to non-radioactive wastes (hazardous and non-hazardous) but could also apply to any future additional disposal sites.

Level 5 - New Construction Projects (1.1.X.XX.11)

Includes all activities and costs (feasibility, design, construction and commissioning) associated with a new construction project or a group of related projects.



Level 6 - Waste & Materials Management (1.1.X.XX.11.12)

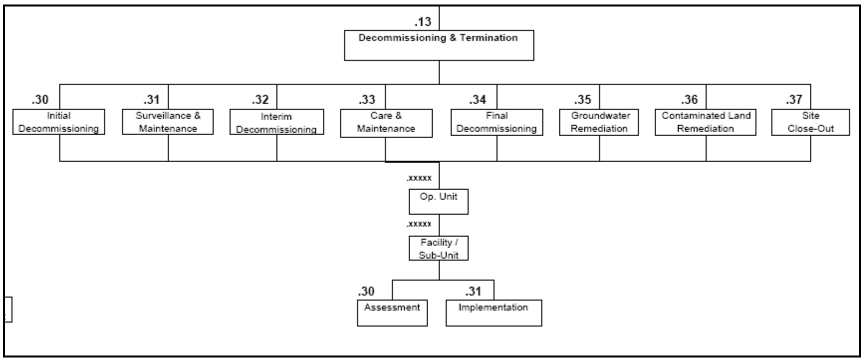
These new facilities are for the treatment, storage and on-site disposal (where applicable) of wastes which are either generated on the site or transferred from other sites (e.g. Windscale to Sellafield). This PSWBS element also includes facilities dedicated to the treatment and storage of materials which, whilst not of commercial value are not classified as wastes (e.g. Nuclear Materials).

Examples would include:

- Waste handling facilities
- Waste treatment facilities
- Stores

Level 5 - Decommissioning & Termination - (1.1.X.XX.13)

Includes all activities undertaken on a site to decommission LLW facilities starting from the end of Post-Operational Clean-Out (POCO)/defueling, through to the agreed or assumed end state for the facilities and the site.



Appendix D – LLW Cost Summary Tables

TABLE D1 – PSWBS COSTS PER SITE

Category		Dounreay	Magnox North	Magnox South	Research Sites	Sellafield	Springfields	Grand Total
Decommissioning & Termination		£6.7m	£11.5m	£52.5m		£74.2m		£145m
New Construction Projects		£78.6m	£504m	£283m	£8m	£271m		£1,145m
Site Support (Transport)				£36m				£36m
Waste & Nuclear Materials Management	Maintenance	£6m	£5.4m	£3.3m	£14.7m	£171m		£201m
	Off-Site Disposal		£609m	£699m	£85m	£1,320m	£100m	£2,814m
	On-Site Disposal	£16.6m		£0.2m	£3.7m			£20.4m
	Plant Enhancement	£11m	£28.4m	£0.8m		£240m		£280m
	Storage Operations	£2.9m	£32.5m		£3.5m	£51.7m		£91m
	Transport	£4.9m	£86m	£56.8m	£4,7m	£41m		£193m
	Treatment Operations	£40.4m	£471m	£288m	£36.9m	£4,104m		£4,941m
Waste & Nuclear Materials Management Total		£81.7m	£1,232m	£1,049m	£148m	£5,928m	£100m	£8,540m
Grand Total		**£167m**	**£1,748m**	**£1,420m**	**£156m**	**£6,274m**	**£100m**	**£9,866m**

TABLE D2 – AVERAGE LLW MANAGEMENT COST PER SLC

SLC	Sites	Total Cost	LLW Volume (m^3)	VLLW Volume (m^3)	Total Volume (m^3)	Average Cost per m^3
Magnox North	Chapelcross	£401m	81,690		81,690	£4,915
	Hunterston A	£296m	33,385		33,385	£8,868
	Oldbury	£294m	23,970		23,970	£12,246
	Trawsfynydd	£463m	58,540		58,540	£7,914
	Wylfa	£294m	23,707		23,707	£12,390
Magnox North Total		**£1,748m**	**221,292**		**221,292**	**£7,899**
Magnox South	Berkeley	£196m	23,215		23,215	£8,445
	Bradwell	£255m	39,399		39,399	£6,476
	Dungeness A	£309m	28,258		28,258	£10,941
	Hinkley Point A	£336m	44,860		44,860	£7,479
	Sizewell A	£288m	31,242		31,242	£9,226
Magnox South Total		**£1,420m**	**166,974**		**166,974**	**£8,502**
Dounreay		**£167m**	**58,975**	**50,348**	**109,322**	**£1,528**
Research Sites	**Harwell**	**£74m**	**16,327**	**83,973**	**100,300**	**£735**
	Winfrith	**£83m**	**12,167**		**12,167**	**£6,795**
Sellafield	Capenhurst	£18m	63,823	10,088	73,912	£245
	Sellafield	£6,227m	451,498	1,251,168	1,702,666	£3,657
	Windscale	£28m	41,917		41,917	£679
Sellafield Total		**£6,274m**	**557,238**	**1,261,256**	**1,818,494**	**£3,450**
Springfields		**£100m**	**22,811**	**388,705**	**411,516**	**£244**
Grand Total		**£9,866m**	**1,055,783**	**1,784,282**	**2,840,065**	**£3,474**

Appendix E – Definitions of LTP Supporting Documents Reviewed

LTP	The Lifetime Plan (LTP) is an integrated plan describing the totality of the activities in terms of scope, schedule and cost to be undertaken at each site to transition from the current state to the proposed end state. Submitted annually from the sites to the NDA.
IWS	The Integrated Waste Strategy (IWS) document summarises the key waste management issues and opportunities. A variety of radioactive and non-radioactive wastes need to be managed on NDA sites. They should be managed in an integrated way in terms of their treatment, packaging, storage and eventual disposal. The NDA believe that such an integrated approach would ensure that sites: • Protect the environment and respond to stake holder's concerns. • Make the most effective use possible of limited waste disposal resources. • Provide value for money to the UK taxpayer. To achieve these aims, the NDA requires the SLCs to base their Lifetime Plans on informed, optimised and integrated strategies; these strategies are required to cover solid, liquid and gaseous radioactive and non-radioactive wastes and the management of nuclear materials. To support this expectation, the NDA have produced a specification defining the content of the Integrated Waste Strategy Document that pulls together policy, legislative and regulatory requirements. Refer to Environmental Guidance Note ENG - 01 'Specification for the Content and Format of a Site Integrated Waste Strategy Document' together with the accompanying ENG – 02 'Companion Document to the Site Integrated Waste Strategy Specification.
WAT	The Waste Accountancy Template (WAT) comprises a series of inter-related spreadsheets used for the collection of waste stream inventory and treatment data. It is expected that the template will be used at the lowest level of data compilation, incorporating the requirements of the IWS specification. The generic nature of the template allows it to be used for data collection and tracking at all levels within a site and subsequently for consolidation into a site production deliverable aligned to the baseline.

TBURD	The Technical Baseline Underpinning Research & Development (TBURD) is a site-specific document which provides an overview of the site's technical baseline and research and development work that supports the approach to decommissioning for the remainder of the site's lifecycle. The waste management process must be supported by the site's technical approach to decommissioning as detailed in the Technical Baseline document. The Technical Baseline also identifies gaps and inconsistencies in strategies which are then picked up as required in the research and development (R&D) plan. Each proposed technique or process is assessed against the NDA Technical Readiness Level (TRL) Scale. Where a TRL of 9 (actual system proven through successful operations) cannot be justified, the gap is identified as a research and development requirement. This development work will then support improvement of the technology maturity categorisation and the subsequent reduction in risk. This also supports continual improvement in the sites' technical performance with respect to identifying, developing, implementing and sharing good practice for innovations and opportunities to improve the current site baselines in terms of time and cost, safety and environmental impact.
Waste Categorisation Study	Nexia Solutions (now The National Nuclear Laboratory) were commissioned by the NDA to undertake a series of waste reviews at all NDA sites in order to supplement the information provided by SLCs to NDA with qualitative information relating to the execution of waste treatment exercises on sites. The process adopted comprised the collation, analysis and review of relevant waste data, including both forecasted volumes and waste characteristics. This was followed initially by reviewing sites integrated waste strategies and then subsequently visiting the sites, interviewing a wide range of personnel dealing with waste including Waste teams, Project teams, Strategy teams, Health Physics etc. Recommendations were captured in a series of reports designed to assist with site operational and waste strategy improvements, including the sharing of best practice across SLCs.

Appendix F – IWS and TBURD Review

Each NDA site is required to produce Integrated Waste Strategy (IWS) and Technical Baseline and Underpinning Research Documents (TBURD) on an annual basis to underpin the LTP submission for the site. A separate review of existing TBURDs has recently been commissioned by NDA in order to identify work packages for the NDA R&D framework. This LLW Strategic Review builds on some of this existing analysis. Each table illustrates a group of opportunities that have been presented in the TBURDs and IWSs with the corresponding detail provided by each site.

Site	Waste Minimisation / avoidance	Reference
Magnox North	Produce report on optimisation of waste minimisation	Magnox North IWS 2008
Magnox South	Opportunities at all sites to improve loading of waste into containers to maximise packing efficiencies, to optimise the use of incineration routes and to enhance techniques to enable clearance and exemption of radioactive waste	Magnox South IWS 2008
Sellafield	Waste avoidance and minimisation together with characterisation and appropriate disposal will save money.	Sellafield IWS 2008
Springfields	Improve the way landfill is used by utilising waste management hierarchy principles, increasing attention on eliminating and reducing waste	Springfields IWS 2008

Site	Waste Characterisation	Reference
Magnox North	Develop prioritisation for future waste characterisation	Magnox North IWS 2008
Chapelcross	Pond sludge could be LLW not ILW	Pond Sludge-CHX/R&D/096
Chapelcross	Opportunities for extensive, intrusive land characterisation to underpin current assumptions	Chapelcross IWS 2008
Oldbury	Optimisation of LLW assay techniques - currently time consuming	Oldbury IWS 2008
Oldbury	Use experience gained from other sites in assay techniques and use of monitoring equipment to optimise the facilities and procedures deployed at Oldbury.	Oldbury IWS 2008
Trawsfynydd	Explore Opportunity that Aloxite & Anthracite sludge could be LLW	28/20025/RD002
Trawsfynydd	Volume of LLW generated during C&M preps not fully underpinned	28/29008/RD/009
Trawsfynydd	Characterisation of LLW Oils. Need to sample oils for radionuclide content and check CFA's.	28/22008/RD01
Trawsfynydd	Complete characterisation of potential extent of contamination under the cooling ponds complex and across site. Undertake BPEO and develop BPM. Submit Addendum to baseline safety case and obtain regulator feedback.	28/22005/RD007
Trawsfynydd	Characterisation of combined waste stream of Magnox sludge, FED Nimonic (springs), ILW and LLW MCI has not been completed.	28/20020/RD002

Site	Waste Characterisation	Reference
Wylfa	Characterise PVCW system to establish quantity of LLW.	WYA/R&D/028
Wylfa	Characterisation of orphan mobile waste, full and robust strategy required.	WYA/R&D/040
Wylfa	Characterisation of oils and investigation of contingency plans.	WYA/R&D/042
Magnox South	Produce waste characterisation guidance	Magnox South IWS 2008
Magnox South	Review data and undertake additional sampling, testing, analysis and modelling where required to provide increased confidence in waste volumes	Magnox South IWS 2008
Magnox South	Optimisation of LLW assay techniques - currently time consuming	Magnox South IWS 2008
Hinkley Point A	Characterisation following backwashing (sand), characterisation of sludge, orphan waste inventory, generally improving characterisation techniques	HNA/R&D/030 / HNA/R&D/035 / 2.3.1 Orphan waste inventory
Culham	Characterisation of ISO contents	WYA/R&D/042
Dounreay	Highly Enriched Uranium (HEU) waste from future D1203 operations and past operations need to be assessed for appropriate conditioning. (1203/1)	1203/G04 Fuel project & inventory management
Sellafield	Technical justification & methodology determination for all waste stream processing. In order to understand and quantify waste stream generation (volumes, radioactive inventory etc) (achieve TRL 9)	35225_TB2_RD2, (Also supports 35225_TB8, TB13 & TB17)
Sellafield	There is no methodology to assay waste items	35145_TB16_RD1
Sellafield	Level 2 Monitoring equipment remains fit for purpose (Technical justification) (achieve TRL 9) LLWR still require this service as part of their Authorisation (EA Requirement). Disposal route available for neutron generator tubes.	35225_TB5_RD1
Sellafield	Technical justification and evaluation on the derivation of a suitable monitoring technique for miscellaneous hard wastes. (achieve TRL 7)	35225_TB13_RD2
Sellafield	Technical Evaluation for appropriate radiometric instrumentation for ‘Clearance & Exemption’ monitoring. Increased range of fingerprinting probes to extend feed envelope for the metals recycling programme. Alpha contamination potentially masked from within	35225_TB7_RD1 (Also supports 35225_TB11 & TB18)
Sellafield	Technical justification of acceptability of background activity in man-made mineral fibres Man-made mineral fibre is potentially inherently radioactive. Final monitoring must be undertaken within lowest background practicable to achieve NICOP levels.	35225_TB13_RD1
Calder Hall	Full characterisation of relevant wastes and development of disposal routes to enable disposal during C&M Preparation Phase. Develop compaction capability to enable lagging disposal. TRL 9 to be achieved for disposal routes.	35245_TB3(iii)_RD1 35.14.43.35245.31245.-08483 Orphan Waste disposal Calcium

Site	Waste Characterisation	Reference
		Silicate lagging
Capenhurst	Completion of contaminated land survey and application of safeguards guidance and the HSE safety assessment principles to develop an approach for characterisation and management of contaminated land	Capenhurst IWS 2008
Capenhurst	Characterisation of oily residues to determine the most appropriate disposal route	Capenhurst IWS 2008
LLWR	Improved waste characterisation techniques to ensure declared inventory is not over pessimistic	N/A
NDA Spent Fuel Services	Characterisation of waste and criticality assessment	35830_TB1(xvii)_RD1 LLW package design

Site	Categorisation / segregation	Reference
Chapelcross	Improved segregation of LLW from ILW	Chapelcross IWS 2008
Oldbury	FED sampling and analysis. Investigate feasibility of segregation of springs from splitters.	OLA/R&D/017
Oldbury	Optioneering study, feasibility study, BPM,	OLA/R&D/028
Oldbury	Review feasibility of sludge re-categorised as LLW following cementation	OLA/R&D/074
Wylfa	ILW to LLW, detritiated, desiccant	WYA/R&D/019
Sizewell A	FED: re-categorise to LLW and dispose as such.	5.1) ILW Retrieval and Processing On hold
Sellafield	Recategorisation of PCM to LLW during crate size reduction	35090_TB3_RD1
Sellafield	Methods for the recategorisation of PCM to LLW. Current assay techniques are insufficiently sensitive and/or reliable to enable material at the detection limit to be routed to Drigg.	35090 _TB1.2_RD1
Sellafield	Radiometric Segregation & Sorting facility (achieve TRL 6) Radiometric segregation & physical sorting technical justification and Safety Case Improved segregation equipment	35225_TB2_RD1
Sellafield	Further development and validation of the proposed waste segregation technique using a collimated probe is required.	35055_TB3_RD1
Wylfa	Opportunity that DSC4 waste is LLW.	WYA/R&D/013

Site	Waste Treatment – Decontamination	Reference
Bradwell	Remove the top 50 mm of concrete from cooling pond and transfer tunnels - removing the contamination (assumed to have penetrated 40 mm)	R&D 11 - NEED
Chapelcross	Ponds furniture not decontaminated to LLW to reflect the opportunity/Other opportunities to reduce ILW to LLW	Ponds Furniture and MAC (wet)- CHX/R&D/078/ CXPP Cave Line CHX/R&D/053
Chapelcross	Surface decontamination of MCI arising during FSC	Chapelcross IWS 2008
Chapelcross	Soil remediation technology such as soil washing could be used to minimise the amount of LLW sent to the LLWR, however R&D would be required to determine the feasibility and cost effectiveness of this option	Chapelcross IWS 2008
Hunterston A	Extend DSO contaminated metal project to other metals (e.g. contaminated boilers sections) - using decontamination methods	Magnox North IWS 2008
Oldbury	Some material cannot be decontaminated to LLW - this will increase package numbers for ILW. Estimation of ILW volumes should be determined by HP water jet.	OLA/R&D/61
Oldbury	Decontamination or size reduction of MCI to maximise disposal as LLW	Oldbury IWS 2008
Oldbury	Commission new larger facilities to handle greater waste throughputs. To include decontamination facilities as well as enhanced monitoring facilities to effectively sentence waste as active or non-active.	Oldbury IWS 2008
Trawsfynydd	Decontamination of MSV steel liner	28/20015/RD008
Trawsfynydd	Potential that Walnut shells maybe LLW. Shells were used as abrasive media for contamination removal, it is considered that the shells themselves could be recovered and disposed of as LLW.	28/20024/RD016
Magnox South	Decontaminate pond skips from ILW to LLW for disposal	Magnox South IWS 2008
Bradwell	Decontaminate Pond Furniture to Free Release	Ponds Decommissioning Fuel Skips and mobile ponds furniture. 3.4
Dounreay	Chemical decontamination techniques to be investigated to enable the determination of whether medium active side of D1208 can be reduced to LLW for sentencing (1208/4)	D1208/G02 Liquid Effluent Complex
RSRL	Design, development and trialling of equipment to decontaminate emptied tubes as part of tube stores decommissioning (B462 DEC/4)	99.2.10.B1009/T1 B462 Tube decontamination
Sellafield	No decontamination strategy should VLLW present itself as LLW	35020-TB53_RD1
Sellafield	Limited experience of the success and deployment of aggressive decontamination techniques	35020_TB6_RD1
Sellafield	Source decontamination chemicals and methods to increase amount of ductwork sent as LLW.	35020_TB19_RD1
Sellafield	Determination of depth of contamination in steelwork: Decontamination of steel using abrasive techniques is attractive but is	35225_TB20_RD8

Site	Waste Treatment – Decontamination	Reference
	dependent on knowledge of the extent and location of sub-surface contamination. (achieve TRL 6)	
Sellafield	Supercritical CO2 extraction: There are currently moderate volumes on site of PCM contaminated soils/silts which require treatment. Future arisings indicate that there may be significant quantities of PCM contaminated rubble. Technology has the potential to enable suitable PCM to be declassified to LLW. (achieve TRL 6)	35225_TB20_RD6
Sellafield	Explore decontamination options to reduce PCM to LLW.	35205-TB15_RD2
Sellafield	Provide / develop suitable decontamination capability for contaminated items.	35050_TB17_RD5
Sellafield	Significant increase in decontamination if chemical techniques are employed	Sellafield IWS 2008

Site	Waste Treatment – Incineration	Reference
Chapelcross	Use of Studsvik incinerator (Sweden) for contaminated oils with repatriation to the UK for disposal to LLWR	Chapelcross IWS 2008
Trawsfynydd	Closure of incineration facility at Fawley (or variation to RSA93 authorisation) which would prevent oil processing. Resulting in schedule delay and associated costs incurred. Identify alternative options and develop contingency plan.	28/22008/RD02
Wylfa	Expand utilisation of on site incinerators by incinerating combustible wastes from other nuclear licensed sites unable to.	WYA/R&D/032
Wylfa	Closure of incineration facility at Fawley (or variation to RSA93 authorisation) which would prevent oil processing. Resulting in schedule delay and associated costs incurred.	WYA/R&D/045
Magnox South	Trials on heat treatment techniques, which will also potentially benefit Magnox North and may result in reclassification of desiccant and catalyst to LLW.	Magnox South IWS 2008
Magnox South	Opportunities at all sites to improve loading of waste into containers to maximise packing efficiencies, to optimise the use of incineration routes and to enhance techniques to enable clearance and exemption of radioactive waste	Magnox South IWS 2008
Sellafield	LLW incineration: Currently the volumes of 'soft' combustible LLW going to Drigg are a significant percentage of the total. As Drigg capacity is limited incineration would give the greatest volume reduction for these wastes (achieve TRL 6)	35225_TB20_RD5
Capenhurst	Trials to confirm most appropriate method for disposal of high uranic content incinerator ash to LLWR	Capenhurst TBURD 2008

Site	Waste Treatment – Other size reduction	Reference
Capenhurst	Trials on incinerator ash containing high levels of uranium to determine whether recovery of uranium is effective.	Capenhurst IWS 2008
Chapelcross	Increased use of supercompaction to reduce disposal volumes	Chapelcross IWS 2008
Oldbury	Investigate a range of available technologies (e.g. surface decontamination, shredding, partitioning, smelting etc)	Oldbury IWS 2008
Oldbury	Commission new larger facilities to handle greater waste throughputs. To include decontamination facilities as well as enhanced monitoring facilities to effectively sentence waste as active or non-active.	Oldbury IWS 2008

Site	Waste Treatment – Other size reduction	Reference
Wylfa	Determine the availability of supercompaction facilities.	WYA/R&D/035
Wylfa	WAMAC potentially unavailable after 2020. Full and robust strategy required. Preparation of contingency plans.	WYA/R&D/034
Magnox South	Opportunities at all sites to improve loading of waste into containers to maximise packing efficiencies, to optimise the use of incineration routes and to enhance techniques to enable clearance and exemption of radioactive waste	Magnox South IWS 2008
Sellafield	Size reduction of non compactable material (achieve TRL 6) Alternative routings and processes for non-compactable	35225_TB3_RD1
Sellafield	Technical regarding size reduction methodology applied to (oxy acetylene, plasma, partner saw & grinder etc), for a dedicated size reduction facility with a dedicated and appropriate ventilation system. (achieve TRL 9)	35225_TB6_RD1
Sellafield	Opportunities include techniques such as segregation and characterisation, chemical decontamination, cracking and crushing concrete and cable stripping.	Sellafield IWS 2008
Sellafield	Decontamination and volume reduction of bulk metals to reduce disposal volumes, costs and apply the waste management hierarchy more effectively.	Sellafield IWS 2008

Site	Waste Treatment – Orphan wastes	Reference
Magnox North	FED - disposal as LLW or dissolution	Magnox North IWS 2008
Magnox North	Encapsulation of oils and non-aqueous phase liquids	Magnox North IWS 2008
Chapelcross	Feasibility of using Chapelcross Production plant as a detritiation facility	Magnox North IWS 2008
Chapelcross	Assessment of alternative treatments of tritiated desiccants to introduce new disposal methods / routes	Chapelcross IWS 2008
Oldbury	The project is to survey and assess systems for adsorption onto inert material for subsequent cementation encapsulation (e.g.NoChar). Such systems shall be examined with a view to sorption of ILW (and LLW) liquids for waste transport, further treatment if	N02/07
Oldbury	Handbook of the processing and immobilisation of organic IX resin wastes - The handbook of the processing and immobilisation of Magnox IX resin shall provide a comprehensive listing of all aspects of potential options for all Magnox ILW and LLW IX resins.	S30/07
Oldbury	Alternative treatment strategies for desiccant	Oldbury IWS 2008
Oldbury	Transfer of Asbestos waste to WMT Winfrith for compaction and disposal.	OLA/R&D/93
Oldbury	Identify impact on site decommissioning strategy - Asbestos supercompaction	OLA/R&D/90
Trawsfynydd	Investigation of feasibility of detritiating desiccant utilising WMT. Solid waste disposed of as LLW.	28/20024/RD018
Trawsfynydd	R&D required to determine if it is possible to use single procedure for treatment and disposal of all LLW sludges.	28/22008/RD05

Site	Waste Treatment – Orphan wastes	Reference
Trawsfynydd	Development of permissions for transfer of contaminated oils to Studsvik.	28/22008/RD08
Trawsfynydd	Methods for disposing of LLW oil from MSV need investigating. MSV oils are above UK incinerator limits therefore current baseline is solidification and disposal to the LLWR near Drigg.	28/20024/RD001
Trawsfynydd	Detailed analysis of samples will give early identification of oil characteristics prior to commencement of design	28/20024/RD03
Trawsfynydd	Develop an interim conditioning step for disposal of contaminated concrete slurry wastes from civil enabling works to enable disposal to LLWR.	28/22008/RD009
Trawsfynydd	Sorption systems for encapsulation of radioactively contaminated oil and problem liquid wastes – The project is to survey and assess systems for adsorption onto inert material for subsequent cementation encapsulation (e.g.NoChar).	N02/07
Trawsfynydd	Develop an interim conditioning step for disposal of contaminated concrete slurry wastes from civil enabling works to enable disposal to LLWR.	28/22008/RD009
Trawsfynydd	Produce handbook of the processing and immobilisation of organic IX resin wastes - The handbook of the processing and immobilisation of Magnox IX resin shall provide a comprehensive listing of all aspects of potential options for all Magnox ILW and LLW IX resin	S30/07
Wylfa	Sorption systems for encapsulation of radioactively contaminated oil and problem liquid wastes – The project is to survey and assess systems for adsorption onto inert material for subsequent cementation encapsulation (e.g.NoChar).	N02/07
Wylfa	Produce handbook of the processing and immobilisation of organic IX resin wastes - The handbook of the processing and immobilisation of Magnox IX resin shall provide a comprehensive listing of all aspects of potential options for all Magnox ILW and LLW IX resin	S30/07
Wylfa	Send LLW oils to Wylfa (or Oldbury) for incineration rather than to Fawley to reduce cost	Magnox North IWS 2008
Magnox South	Wet waste - exploring opportunities for thermal treatment of wet waste, rather than baseline grouting technique	Magnox South IWS 2008
Magnox South	Review options for desiccant management due to uncertainties in discharge authorisations	Magnox South IWS 2008
Magnox South	Opportunity to develop strategy and undertake R&D into improve graphite management options	Magnox South IWS 2008
Magnox South	IonSiv pre/post filters to be decontaminated to LLW by back washing with water	Magnox South IWS 2008
Berkeley Centre	Aloxite retrieval and solidification trials. Trials to underpin that the waste can be retrieved placed in containers and disposed.	R&D 6 Task 2.4 CRP Decommissioning (1.1.5.21.14.43.21225.34100.200 61)
Hinkley Point A	Sorption systems for encapsulation of radioactively contaminated oil and problem liquid wastes – for transport, further treatment and storage	N02/07

Site	Waste Treatment – Orphan wastes	Reference
Hinkley Point A	Handbook of the processing and immobilisation of organic IX resin wastes - The handbook of the processing and immobilisation of Magnox IX resin shall provide a comprehensive listing of all aspects of potential options for all Magnox ILW and LLW IX resins.	S30/07 / 1.5.10 Handbook of the processing and immobilisation of organic IX resin wastes
Sellafield	Mercury treatment: Technologies are required for the treatment and recovery or disposal of mercury contaminated to LLW or ILW levels (achieve TRL 6)	35225_TB20_RD2
Sellafield	Technologies and routes for oil disposal: There are substantial volumes on site of contaminated oils, of various descriptions, with no demonstrated treatment and disposal route. (achieve TRL 6)	35225_TB20_RD4
Sellafield	Drying of putrescible materials: There are issues with the disposal of roof wastes and putrescible materials until the CLESA is operational. This waste could be dried and used as infill in Drigg containers. In addition, there is some trace active sludge/	35225_TB20_RD7
Sellafield	Asbestos treatment: There are large quantities on site of potentially contaminated asbestos with no treatment and disposal route (achieve TRL 6)	35225_TB20_RD1
Calder Hall	Further develop non-landfill options to inert the asbestos, to mitigate against unavailability of landfill sites, and that >1% of asbestos arisings are LLW.	35245_TB3(ii)_RD1 35.14.45.35245.31245.-08484 Asbestos disposal (HZW) & 35.14.43.35245.31245.-08483 LLW management
Springfields	For residues categorised as Category C or orphan residues the treatment route is uncertain and work has been commissioned for suitable treatment routes to be developed	Springfields IWS 2008

Site	Recycle/Re-use/Exempt	Reference
Magnox North	Contaminated and activated metals - establish routes for smelting and reuse	Magnox North IWS 2008
Chapelcross	Extend DSO contaminated metal project to other metals (e.g. contaminated boiler sections) - using volume reduction (smelting)	Magnox North IWS 2008
Chapelcross	Melting of contaminated metals to segregate out the heavier radionuclide contaminants and free release of the remaining metal	Chapelcross IWS 2008
Oldbury	Metal melting opportunity to use both USA, European and build new facility in UK for metal recycling (potential for up to 90% of steel recycled (either outside or within the nuclear industry) presents a strong opportunity.) Opportunity to utilise lead sites for preparatory / logistics / inter-site transfers to support recycling.	Contaminated and Activated Metals Project ref No: 39/39055
Oldbury	Use of temporary buildings such as rubb tents as cost savings opportunities which include the reuse of redundant portable buildings from other sites	Oldbury IWS 2008
Trawsfynydd	Opportunity - metal melting of pond skips	Contaminated and Activated Metals Project ref No: 39/39055
Trawsfynydd	Undertake trials to underpin the execution of alternative strategies to the LLWR for metal, building on the positive precedents set by HPA with consignment of metal overseas. In particular seek options to deliver a UK solution	Contaminated and Activated Metals Project ref No: 39/39055
Wylfa	Metal waste, LLW to exempt, Pond furniture, Pond skips, recycling	Contaminated and Activated Metals Project ref No: 39/39055
Wylfa	Smelting of LLW metals - waste management hierarchy	WYA/R&D/036
Magnox South	Investigating recycling of metals via melting	Magnox South IWS 2008
Bradwell	Cooling Ponds wastes and Fuel Skips - investigate into sending the material overseas	R&D 10
Hinkley Point A	Looking at Metal Melting in Europe, implementation of Waste Management Hierarchy. Also investigating melting contaminated metal. Stores on site holding metal are close to capacity	Contaminated and Activated Metals Project ref No: 39/39055 / 3.4.3 Contaminated and Activated Metals / 3.4.1 Metal Melting
Sellafield	Reuse and recycle of HVLLW	Sellafield IWS 2008

Site	Waste Disposal	Reference
Magnox North	Strategy to address lack of disposal capacity for contaminated oil disposal	Magnox North IWS 2008
Magnox North	Disposal of VLLW to conventional landfill	Magnox North IWS 2008
Chapelcross	Investigate opportunities for source disposal	Chapelcross IWS 2008
Oldbury	Alternative commercial disposal of VLLW	Oldbury IWS 2008
Trawsfynydd	Secure RSA93 authorisation variation and ensure that Asbestos waste meets the CFA for WMT and Drigg	28/29008/RD/001
Trawsfynydd	Determine site LLW transfer requirements during C&M preps. Make application to EA for new transfer route/limits as required.	28/29008/RD/002
Trawsfynydd	Scope change may be needed. Stock pile of LLW on site potentially breaching site licence conditions.	28/29008/RD/006
Magnox South	Investigating alternatives to disposal to LLWR inc. VLLW to landfill	Magnox South IWS 2008
Magnox South	Opportunity to quicken the RSA authorisation process to open up new disposal routes quicker	Magnox South IWS 2008
Hinkley Point A	In conjunction with examination of alternative Final Site Clearance opportunities, Magnox South proposes to examine innovative, alternative disposal solutions across the globe focussing on ILW whilst also exploring alternatives for LLW.	Alternative Disposal Options Project ref No: 10.39.35.39/39050/ HNA/R&D/001
Springfields	Understand LLWR disposal requirements – 90.02	Waste Management-TB5
Springfields	Investigate alternatives disposal options in light of potential Clifton marsh closure in 2012	Springfields IWS 2008 Decommissioning-TB12
Windscale	Development of disposal route for HVLA wastes	Windscale IWD 2008
Dounreay	D1203 Thorium tank decommissioning. (1203/4)	1203/G02 Fuel project & inventory management
Winfrith	The provision of a HVLA waste disposal facility / route	Winfrith IWS 2008
Magnox North	On-site disposal of LLW - an alternative to LLWR disposal	Magnox North IWS 2008
Magnox North	Opportunity for on-site disposal of LLW	Magnox North IWS 2008
Bradwell	Licensing a section of site for on site disposal	R&D V
Hinkley Point A	Looking at alternatives to the disposal of LLW to Drigg, specifically on site disposal	On-site disposal of Low Hazard Waste Project ref No: 39/39035 / HNA/R&D/038 / 3.2.5 OSD HPA Review
Oldbury	Validate on-site disposal of LLW	OLA/R&D/100a

Site	Waste Disposal	Reference
Oldbury	BPEO has determined that On Site Disposal appears to be the preferred solution for HPA, BWA, DNA and SZA. HPA now leading on project working towards demonstrating both the technical viability and stakeholder/regulator acceptance of on-site disposal at HPA.	On-site disposal of Low Hazard Waste Project ref No: 39/39035
Sizewell A	Understand on-site disposal enablers.	4.1) Conventional Plant Area Deplant & Demolition On hold
Springfields	Investigate options for on-site disposal	Springfields IWS 2008
Trawsfynydd	Feasibility study, early liaison with regulators.	28/29008/RD/010
Trawsfynydd	Use BPEO/BPO to determine alternatives to the LLWR. BPEO showing on-site disposal as favourable with requirement for early engagement of stakeholders and regulators. On-site disposal facilities will use 'contained demolition' techniques which will generate considerable reductions in worker dose uptake and further significant cost and schedule savings.	On-site disposal of Low Hazard Waste Project ref No: 39/39035
Wylfa	Potential to use VLLW as backfill.	WYA/R&D/061
Wylfa	Use BPEO/BPO to determine alternatives to the LLWR. BPEO showing on-site disposal as favourable with requirement for early engagement of stakeholders and regulators. On-site disposal facilities will use 'contained demolition' techniques which will generate considerable reductions in worker dose uptake and further significant cost and schedule savings.	On-site disposal of Low Hazard Waste Project ref No: 39/39035

Site	Waste Disposal – Decay Storage	Reference
Magnox North	Delay and decay and detritiation strategies	Magnox North IWS 2008
Oldbury	Feasibility of utilising packing strategy which would yield LLW following interim storage should be produced. Further work is required to underpin such an approach.	OLA/R&D/036
Oldbury	Feasibility of utilising packing strategy for Desiccant which would yield LLW following interim storage should be produced. Further work is required to underpin such an approach.	OLA/R&D/044
Oldbury	Conduct Sampling and analysis to underpin desiccant decay properties	OLA/R&D/122
Oldbury	Some packages may be LLW due to radioactive decay	OLA/R&D/138
Oldbury	Accelerated decommissioning may reduce LLW volumes, but increase ILW	Oldbury IWS 2008
Oldbury	Alternative strategies for FED - including dissolution, segregation and disposal as LLW	Oldbury IWS 2008
Trawsfynydd	Early results from FED radiological sample analysis has indicated that it may be possible to preferentially package Trawsfynydd FED to yield LLW over a decay period of approx. 30 years. Further work is required to underpin such an approach.	28/20016/RD011
Trawsfynydd	Some packages may be LLW due to radioactive decay	C&M/RD003

Site	Waste Disposal – Decay Storage	Reference
Trawsfynydd	Review of radionuclide data from R1 MAC waste. Determination of requirements to yield LLW from remaining MAC waste. BPEO and Safety Case justification.	28/20008/RD002
Trawsfynydd	Opportunity to take advantage of generic DSO desiccant project. Send Trawsfynydd desiccant to WMT for trials.	28/20024/RD024
Wylfa	Some packages may be LLW due to radioactive decay	WYA/R&D/066
Wylfa	Temporary requirement to store increased volumes of LLW on site.	WYA/R&D/006
Bradwell	MAC to be stored in situ until the radioactivity decays to LLW levels.	R&D Q
Hinkley Point A	Decay Storage MAC to LLW	HNA/R&D/041

Site	Waste Packaging	Reference
Magnox North	Product a report on optimisation of packing factors	Magnox North IWS 2008
Chapelcross	Optimise LLW packing to reduce number of packages to LLWR	Magnox North IWS 2008
Oldbury	Review of available techniques - Skips could be placed into HHISO and filled with other wastes to maximise waste loading, Also investigate size reduction.	OLA/R&D/62
Trawsfynydd	Determine realistic LLW packaging efficiency and revise LLW arising estimates.	28/29008/RD/004
Wylfa	Determine realistic LLW packaging efficiency and revise LLW arising estimates.	WYA/R&D/001
Wylfa	Mildly contaminated rubble suitable for infill of voids.	WYA/R&D/048
Magnox South	report on optimisation of packing factors and improvements in packing efficiencies	Magnox South IWS 2008
Magnox South	Opportunities at all sites to improve loading of waste into containers to maximise packing efficiencies, to optimise the use of incineration routes and to enhance techniques to enable clearance and exemption of radioactive waste	Magnox South IWS 2008
Culham	Development of a 2m box for packaging of tritiated ILW. Opportunity to develop an inner package that can be sent to Drigg at a later date, when the ILW decays to become LLW.	TMS/1 Development of a 2m box
Dounreay	UKAEA needs to develop simpler packages for on-site disposal of LLW and HVLA wastes. (LLWIS/1)	New Low Level Waste Facilities Design / Build
Sellafield	Soil Infill problem (Technical justification) (achieve TRL 5) Technical evaluation of moisture and packing integrity of waste Outcome of work in this area will also be applied to Waste Handling – Container Despatch (35225_TB15) and Task Team - Disposal and Sentencing (35225_TB19)	35225_TB4_RD1
Capenhurst	Encapsulation of tank sludge, ion exchange resin and acid dissolution and filtration and the repackaging and transportation of materials	Capenhurst IWS 2008

Site	Waste Transportation	Reference
Magnox North	Study to investigate the transport of LLW by train to LLWR	Magnox North IWS 2008
Chapelcross	Possibility of transport CHX skips to Sellafield for processing with B30 skips	Chapelcross IWS 2008
Magnox South	Reducing the number of lorry loads on the countries roads and associated vehicle emissions	Magnox South IWS 2008
Magnox South	Develop optimised waste transport plan for radioactive waste	Magnox South IWS 2008
LLWR	Feasibility for the intermodal transport of half height and third height LLW ISO containers that involves their nominated rail partner and road transport subcontractor	Magnox South IWS

Site	Tracking/Inventory Management	Reference
Magnox North	Improve the accuracy of waste inventory for FSC	Magnox North IWS 2008
Oldbury	Waste data review and update	OLA/R&D/97
Windscale	Request projects to review the waste volumes and arisings, types of packages and report on new inventories for input into IWS and WAT.	Windscale IWS 2008

Site	Other	Reference
Magnox North	Opportunity: adopting a regional approach to waste treatment, storage and disposal for ILW and LLW	Magnox North IWS 2008
Magnox North	Establish Magnox North policy relating to application of waste management hierarchy	Magnox North IWS 2008
Chapelcross	Manage MAETP such that Cartridges are LLW	IONSIV Cartridges-CHX/R&D/165
Hunterston A	Investigate strategy opportunities: Lead site for MN: Back to bioshield to reduce costs for weather shield and C&M maintenance costs	Magnox North IWS 2008
Oldbury	Identification of alternative options for LLW management	OLA/R&D/98
Oldbury	Review of other sites' experience and LLW processing	OLA/R&D/132
Oldbury	Identify impact on site decommissioning strategy, identify RSA93 requirements.	OLA/R&D/89
Oldbury	Reuse of key equipment from other NDA sites e.g. scabblers, TWSDU and TILWISP	Oldbury IWS 2008
Oldbury	Optimisation of waste management organisation and waste management arrangements	Oldbury IWS 2008
Trawsfynydd	Identification of alternative options for LLW management. Revision of work scope for AWV project – may result in cost savings against project duration and number of packages produced – may also yield benefits in reduction of P&E provision.	28/29008/RD/008
Trawsfynydd	Establish "generic toolkit" on how to manage last 10% of waste type where technical baseline is not suitable (lead and learn)	Magnox North IWS 2008

Site	Other	Reference
Magnox South	Investigating transfer of wastes between sites	Magnox South IWS 2008
Magnox South	Report on optimisation of waste minimisation across sites.	Magnox South IWS 2008
Magnox South	Develop common waste metrics for all sites	Magnox South IWS 2008
Magnox South	Optimise waste management organisation and arrangement	Magnox South IWS 2008
Magnox South	Implement a sustainable development strategy - incorporating sustainability into decommissioning design and optimise reuse and recycling of plant and structures	Magnox South IWS 2008
Hinkley Point A	Looking at accelerated FSC	14.0.1 Final Site Clearance
Sellafield	Technical Justification for explosion mitigation for various process streams required development. (achieve TRL 6)	35225_TB9_RD1
Sellafield	Potential for treatment plants to become available earlier than scheduled in LTP 2008 if a private finance initiative arrangement is used	Sellafield IWS 2008
Sellafield	Demonstrate that current high activity levels are due to historic operations within legacy reprocessing plant - filter disposal	35230_TB10_RD1
Sellafield	Identify an appropriate disposal route for LLW MEBs.	35165-TB3-RD4
Windscale	Obtain early commercial agreement with Sellafield to accept future hand-offs	Windscale IWS 2008
Dounreay	Opportunity for improved communication and information sharing between SLCs numerous areas	Dounreay IWS 2008
Winfrith	NDA to provide assistance with the development of sites strategies for the management of HVLA waste	Winfrith IWS 2008

Appendix G – Overview of Waste Categorisation Study Process

Overview

The Waste Categorisation Study (WCS) programme has been sponsored by NDA over the last few years to identify opportunities to reduce waste arisings through the application of best practice techniques for waste prevention, reuse, recycling, segregation, categorisation, volume reduction and processing. The work programme undertaken by Nexia (now NNL) has both qualitatively reviewed waste management documentation and views of key personnel and also quantitatively assessed different options using current and potential future techniques against volume reduction and cost.

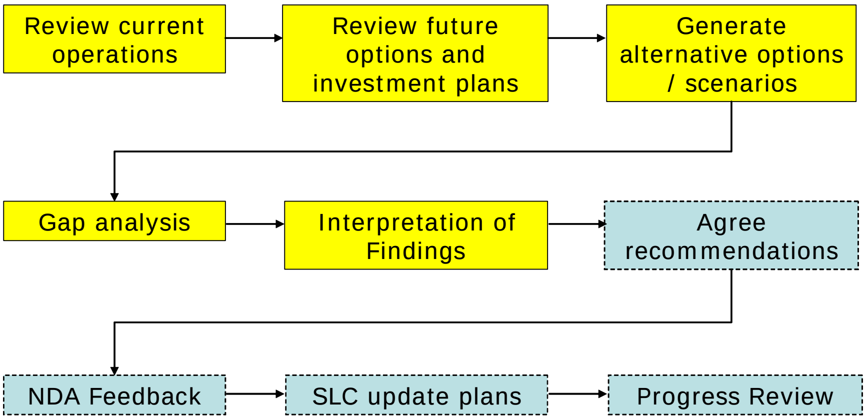
All NDA sites have been reviewed and savings in terms of reductions in disposal costs have been presented to the sites. Re-visits have also been undertaken to assess progress against recommendations. For the Magnox sites, waste volumes prior to the end of C&M preps were reviewed, whereas for Sellafield and UKAEA total waste volumes were assessed. This appendix summarises both the qualitative and quantitative findings from the collection of studies.

WCS Process

The WCS process, shown in Figure G1 below, aims to review current waste management operations (Low Level Waste [LLW], Intermediate Level Waste [ILW], Plutonium Contaminated Material [PCM] at a particular site with the aim of identifying opportunities to improve the operations and thus reduce waste volumes and costs. This is achieved by working closely with the personnel from the site being considered in order to review future plans and generate alternative options / scenarios. A gap analysis is then completed to help identify initiatives / techniques that provide the greatest opportunities. A series of recommendations are then proposed to the site under consideration.

Underpinning the results from the review is a database repository for the information collected and scenarios developed. This database allows the financial benefits of existing and future scenarios to be quantified by varying the underpinning data, which will include process utilisations, waste forecast estimates, manpower costs, etc.

FIGURE G1 – WCS PROCESS



The focus of the studies was to support individual sites in revising their waste management plans in light of good practice observed both in the UK and internationally. Although the project identified synergies and opportunities where sites could share resources, assets and experience it did not assess UK Inventory as a whole and thus did not attempt to recommend investment in UK assets and infrastructure.

Waste Management Hierarchy

Following the ethos of the Department for Environment, Food and Rural Affairs (DEFRA) Waste Management Hierarchy, and building on other hierarchy concepts, Nexia have developed a more detailed waste management hierarchy for the WCS studies. This is applicable to LLW, PCM and ILW wastes, incorporating best practice and allowing a more comprehensive modelling analysis. It should be noted that interim storage can be applied at any stage after prevention. The WCS hierarchy is shown in Figure G2 below and is used extensively in modelling scenarios.

FIGURE G2 – THE WCS WASTE MANAGEMENT HIERARCHY

1	Prevent
2	Reuse / recycle
3	Decontaminate / Concentrate
4	Segregate / Re-categorise
5	Reduce size / Pre-process
6	Reduce size / Major Process
7	Pack Preparation
8	Dispose / Store

Summary of qualitative findings

A summary of common features throughout the reviews are detailed below:

- Waste forecasts were reviewed in many cases and multiple occurrences with differing volumes found. It was generally accepted that forecasting was poor and that centralisation and standardisation of the process and results would be beneficial.
- Most sites would accept that they could save at least 10% of compactable LLW by waste minimisation through a number of chosen initiatives and re-direct more waste to alternative disposal routes.
- Decontamination was limited on the sites at WCS project inception, 2004, however since then sites have begun to accept that many proven techniques exist which could support waste management and thus both allow reuse of materials but also allow re-categorisation of wastes to more appropriate disposal routes.
- Many sites claimed that they had little space to hold waste to support better packing of ISOs, however on closer inspection numerous opportunities existed, including using current space better, using existing facilities and constructing Rubb tents.
- Opening up new disposal routes for different categories of waste was being pursued in many cases.
- Softer issues were identified which focussed on stakeholders, communication and systems to support more cost effective waste management

Summary of quantitative findings

Savings are assessed against a base case which includes utilisation of current assets and onward disposal to the LLWR at current packaging factors. Examples of the indicative savings identified in various reports consist of:

- A review of all of the Magnox sites WCS reports highlighted cumulative potential opportunities of the order of £280 million [22].
- The latest Sellafield review highlighted approximately £900 million of potential opportunities. Some these scenarios overlap therefore the actual savings are likely to be around 30% less than this at around £600 million conservatively[23].
- The Harwell and Winfrith review highlighted opportunities exceeding £25 million[24].

The total savings identified in these studies are therefore of the order of £1 billion.

Summary of suggested Improvements across all sites

These tables provide a summary of the suggested improvements.

Waste Avoidance / Minimisation

Technique	Description
Prevention	Waste minimisation campaign
	Establish a green route for exempt wastes
	Improve forecasting
	Eliminate entry into an area – zero in, zero out
	Implement measure to reduce filter usage e.g. pre-filters
	Increased policing of waste collection areas
	Bag-less transfer
People & management	Best practice groups
	Waste management Improvement team
	Team briefs to publicise information about waste
	Walk-arounds
	Improved maintenance planning
	Incentivisation
PPE reduction initiatives	Reusable gloves
	Eliminate tape, surgical gloves, cotton liners and disposable booties, ambidextrous gloves and covers
	Reduce the number and size of controlled areas
Negotiation	Re-negotiate discharge authorisations
Monitoring	Monitor waste out of controlled areas
	Increase amount of monitoring equipment
	Desktop re-classification, reducing pessimisms / deminimis / background limits and associated risk
	Re-classify finger prints

Waste segregation / categorisation

Technique	Description
Segregate	Segregate at source – different coloured bins / packages for different waste types and categories
	Segregate centrally - simply structured areas used for improved management of different waste types and categories
Cutting / size reduction	Concrete shaving
	Cutting out hot spots
Decontamination	Wiping and scrubbing more items clean
	Acid baths / chemical washing
	Expand use of media /abrasive blasting – maximise utilisation of current techniques
	High pressure water jetting
Monitoring	Monitoring at source, reduces onward handling costs
	Accurate bag monitoring

Waste Treatment

Technique	Description
Compaction	Pre-compact wastes where possible
	Divert non-compactable to compactable route where possible
Incineration	Utilise incinerators on adjacent nuclear sites
	Utilise incinerators close by e.g. Trawsfynydd utilise Wylfa incinerator
	Incinerate waste oil
Melting	Metal melting overseas
Other	Shredding
	Asbestos destruction

Reuse / Recycle

Technique	Description
Reuse	Store / reuse scaffolding / tools / mop buckets, tape etc – implement spares cabinets
	Use metal / plastic pallets instead of wood
	Wash Windscale suits
	Use launderable substitutes e.g. Use washable mop heads, clothes, bags, PPE and barriers
	Reuse redundant facilities instead of building new ones
Decontamination	Decontaminate filter elements (when practicable) and return them to service e.g. wash

Waste Packaging

Technique	Description
Packaging	Cutting to size reduce
	Innovative mobile platform solutions to support manual packing
	Minimise void space

Typical Quantification parameters

Some of the suggested improvements were quantified. The table below demonstrates typical parameters used in the modelling assessment. It could therefore be suggested that these values could be equally applied to the UK inventory in the same manner in order to identify savings to disposal costs.

The table headings are mainly self explanatory, however utilisation describes the percentage in terms of waste volumes of the waste type and waste group which can be applied to that specific technique and the volume reduction is that which is obtained from the utilised volume. Each site had different assumptions, these have been put together as what could be anticipated across all areas if resources were shared.

Technique Type	Waste Type	Waste Group	Utilisation	Volume Reduction
Waste Minimisation (culmination of techniques)	All	All	100%	10%
Segregate as VLLW / exempt	All	All	100%	34% VLLW
Cutting out hot spots and size reduction	All	Non-compactable	30%	30%
Light Decontamination	All	All	10%	90%
Metal Decontamination	Metal	Non-compactable	30%	90% Ex
Concrete shaving and other volume reduction methods	Soil / rubble	Non-compactable	50%	50% Ex
Super-compaction	All	Compactable	100%	62%
Incineration	All	Compactable	78%	95%
	All	Non-compactable	5%	95%
Metal Melting	Metal	All	60%	94% Ex
Improved packing	All	Non-compactable	100%	~15% **

*Ex means waste becomes exempt

** Based on increasing the packing fraction from 60% to 70%

Appendix H – Quantifying Benefits of Initiatives

Introduction

The costs of Off-site Disposal of LLW are accounted for in NDA's overall liabilities in two parallel ways:

1. Costs of Off-Site Disposal appear in the LTP of each waste producer based on volume arising and the unit price currently charged by LLWR for the waste disposal service.

2. The costs of operating LLWR appear explicitly in the LTP for the current LLWR facility near Drigg. NDA also holds a separate additional provision (known as 'uncontracted liability') to cover the cost of a successor repository (LLWR2).

For the purposes of the 2008 LLW baseline described in Section 4, double-accounting is avoided by only including the current visible costs of off-site disposal included in the waste producers LTP's which currently amounts to around £2.8 billion. It is important to note that the LLWR's current pricing structure is designed to recover operational disposal costs over a certain fixed period (based a forecast inventory volume) rather than the true lifecycle cost of operating and closing the facility.

The consignor LTP cost provisions are also based on an implicit assumption that the same tariff rate will be sufficient to cover the costs of a new LLWR2 facility once LLWR is closed. The actual lifecycle costs of LLWR2 will depend on a number of factors including the size of the facility required to accommodate the remainder of the inventory.

The provision currently within NDA's consignor's LTPs therefore may not necessarily represent the true lifecycle cost liability of LLWR and LLWR2 and it would therefore be inappropriate to use £2.8 billion as a benchmark for lifecycle cost saving comparisons. As a general principle, evaluation of initiatives based on comparisons with the LLWR gate price should not be regarded as representative of the true lifecycle cost saving to NDA. The relationship between lifecycle cost and volume is not linear and therefore a methodology is required to estimate the true lifecycle costs of LLWR and LLWR2 under the current baseline scenario and then evaluate the impact of initiatives.

Estimation of Lifecycle LLW Disposal Costs

LLWR

The cost of operating and closure of the current LLWR is estimated in the LLWR LTP. For the purposes of analysis LLWR costs can be classified as follows:

- Fixed costs associated with operating LLWR
- Variable costs associated with disposal of waste at LLWR
- The capital costs of extending capacity at LLWR

These costs are underpinned by detailed estimates of every task in the LTP up to and including site closure and remediation legacy facilities.

LLWR2

An estimate is also required of the costs of a new repository facility (LLWR2) to take the remainder of the inventory following LLWR's closure. NDA commissioned a study in 2007[15] which estimated the costs of a new facility under a range of scenarios. The costs associated with constructing a new facility will include a significant up-front outlay on the following aspects:

- Site Selection
- Land purchase
- Planning and authorisation
- Site infrastructure
- Vault construction

There would then be ongoing cost of operations and ultimately site closure costs. The cost of a new facility will be estimated using a combination of the previous NDA study in 2007 and the underpinned LLWR costs as appropriate. The previous study did not consider costs of planning, regulatory permitting or community benefit which could be significant issues for a new national LLW repository.

Volumes

As described in Section 4.4.7 the volume of waste potentially requiring management at LLWR or a new national LLW repository is around 2.4 million m^3 under the current baseline compared to a remaining volumetric capacity at LLWR of around 0.7 million m^3, subject to planning and regulatory approvals. The remaining 1.7 million m^3 would therefore need to be accommodated in a new repository.

Evaluating impact of Initiatives

Potential cost savings in the LLW management strategy arise from a more effective use of LLWR, primarily through reducing demand upon the volumetric capacity. This reduction in demand will result in a number of lifecycle cost benefits at LLWR, but may require some expenditure to allow it to occur. The net benefit to the strategy will therefore be determined by the difference between costs of implementation and potential savings. Cost savings at LLWR are expected to arise from strategic initiatives in four broad areas:

- Waste avoidance/minimisation - Avoiding the need to provide disposal capacity
- Waste treatment - Treatment of wastes to reduce the volume to be disposed of in LLWR
- Waste diversion - Diverting materials such as LLW, VLLW and exempt wastes away from LLWR to more appropriate disposal routes.
- Improved packaging - Improved packaging arrangements leading to reduced costs for the package and/or better use of space in LLWR

The effect of implementing the above initiatives compared to a baseline 'business-as-usual' scenario can be quantified in terms of the elements in Table H1 below.

TABLE H1 – IMPACT OF INITIATIVES ON LLW LIFECYCLE COSTS

Cost Element	Impact
Fixed costs associated with operating LLWR and any replacement facility	Fixed costs are those that do not vary significantly with waste volume. These include aspects such as site management, labour, site support, maintenance, regulatory compliance, etc. For the purposes of this comparative analysis it is assumed that the fixed operating costs of LLWR and any replacement facility would be approximately the same under different scenarios. The total timeframe over which both facilities must operate does not change (i.e. 2008-2129), therefore even if LLWR lifetime is extended, the total spend on fixed operating costs would not change significantly. The proportion associated with the new facility is however lower in the case where LLWR lifetime is extended.
Variable costs associated with operating LLWR and any replacement	Extending the lifetime of the current LLWR by reducing the quantity of waste destined for LLWR or its successor reduces the total spend on variable costs, as the quantity of waste to be emplaced will fall. Both undiscounted and discounted variable costs will be reduced in the case where LLWR life is extended.
Capital costs of extending capacity at LLWR	Extending the lifetime of LLWR by reducing the quantity of material disposed defers the costs associated with extending the capacity at LLWR (i.e. building new vaults). Whilst these costs will remain the same in constant money (undiscounted) terms, the benefits of deferral are apparent when the total is discounted, as the later the spend occurs, the greater the extent to which costs are discounted.
Capital costs associated with constructing a replacement for LLWR	Extending the lifetime of LLWR defers the costs associated with a replacement facility. However, in this case the costs themselves will also fall, because the quantity of material to be emplaced, and hence the size of facility required will be smaller or may even be entirely eliminated. In this case, therefore, there is a double benefit to be obtained.

Conclusion

The net lifecycle benefit of extending the life of LLWR to NDA can therefore be determined by the difference between costs of implementation and potential reduction in costs at LLWR and LLWR 2. As discussed above this relationship is not linear with waste volumes.

To demonstrate the impact of implementing these initiatives LLWR Ltd is currently developing a tool to model the impact of candidate initiatives on LLWR/LLWR2 costs in detail. To recognise fully the benefits associated with reduced waste volumes to LLWR, it will be appropriate to show discounted costs to recognise the time value of money.

This is important as the costs for implementing some of the measures associated with volume reduction will occur well in advance of the benefits being realised. This approach is entirely consistent with the Treasury's Green Book approach[25]. This tool is currently under development and will be used, where appropriate, to support business cases.

Appendix I – Synergies and Opportunities

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
Waste Avoidance / Minimisation										
1	Standardise waste avoidance and minimisation programmes	Create a standardised programme for waste minimisation to be implemented consistently across all NDA sites. Shared learning from experience across UK sites and internationally will support the development of comprehensive programme of best practice techniques, equipment, protocols and procedures for waste avoidance and minimisation. Would require changes to waste management practices and procedures across all sites. Some amount of flexibility would be required to suit local site circumstances however waste minimisation programme could be encouraged through a range of mechanisms such as NDA's SLC contracts or regulatory requirements.	Large potential benefits but requires short-term implementation costs at each site for a standardised programme. Reduced waste volumes can be achieved at the highest level of the waste management hierarchy with corresponding environmental, cost and LLWR capacity preservation benefits. Contributions to wider positive waste management culture are possible, which can generate further ideas.	Medium	Medium Term (5-10yrs)	>£200m	LLWR Capacity preservation, Environmental	High	Study Further	NDA
2	Improve consistency of application of NICoP	Improve consistency of application of NICoP on all nuclear industry sites. The CEWG has developed a Nuclear Industry Code of Practice (NICOP) to provide a consistent safe, responsible and sustainable approach to clearance and exemption of LLW. Membership of the CEWG is drawn primarily from the large nuclear organisations AWE, British Energy, Sellafield, DML, DSTL, GE Healthcare, Magnox Electric, NPL, UKAEA. These different organisations interpret the NICOP guidance in different ways and to different extents therefore there are significant differences when it comes down to implementation between sites.	Greater application of NICoP principles is expected to increase quantities of waste cleared and exempted with corresponding environmental, cost and LLWR capacity preservation benefits.	Straight-forward	Short Term (<5yrs)	<£50m	LLWR Capacity preservation, Environmental	Medium	Quick-win	Existing Industry Working Group

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
3	Incentivise waste minimisation	Introduce financial incentives and targets for waste minimisation to drive improvements in behaviour, preferably cascaded to projects at the point of generation. Currently waste minimisation investments are typically sanctioned against the cost of available alternatives such as LLWR disposal. On some sites the cost of waste management is covered as a site overhead and not accountable to individual projects generating the waste. Increased incentives would allow each site flexibility to find the most efficient way of making improvements. Internationally, the implementation of incentive and fee earning schemes has significantly reduced waste volumes and improved waste management culture.	Encourages further investment in waste minimisation programmes and culture change with corresponding environmental, cost and LLWR capacity preservation benefits. Cost savings could be recycled back into further waste minimisation or hazard reduction activities.	Straight-forward	Short Term (<5yrs)	>£200m	LLWR Capacity preservation, Environmental	Very High	Quick-win	NDA
4	Identify and share waste avoidance and minimisation best practices	Improve identification and sharing of waste avoidance and minimisation best practices consistently across industry. Knowledge of best practices (and how to implement them) must be suitably cascaded within each site to projects and the workface. Although a range of mechanisms currently exist such as forums, websites (e.g. EARWG), industry working groups, tool-box talks, etc, it would appear that the acquisition and use of knowledge is still an issue. There is often a reluctance to share knowledge between different SLCs and with supply chain on grounds of commercial confidentiality.	Improved access to best practices developed on other sites will reduce overall costs. NDA doesn't have to fund same learning twice.	Straight-forward	Short Term (<5yrs)	<£50m	LLWR Capacity preservation, Environmental	Medium	Quick-win	LLW Strategy Sub-Committee

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
Waste Characterisation										
5	Standardise characterisation programmes	Define standards, objectives, and guidance on characterisation, monitoring and sentencing to be implemented consistently across sites. Shared learning from experience across UK sites and internationally will support the development of comprehensive programme of best practice techniques, equipment, protocols and procedures. Consider development of a NICoP for characterisation including guidance on optimum sampling, and analysis of common waste streams and 'difficult' wastestreams such as oil, asbestos, contaminated land, etc. Would ultimately require changes to waste management practices and procedures across all sites. Some amount of flexibility would be required to suit local site circumstances however waste characterisation programme could be encouraged through a range of mechanisms such as NDA's SLC contracts, LLWR CFAs or regulatory requirements.	Improved waste characterisation enables greater use of alternative fit-for-purpose management and disposal routes (e.g. lower unit cost for ILW -> LLW, LLW -> VLLW, VLLW -> EW). Accurate activity estimates will help prolong LLWR radiological capacity. There are large potential benefits, but with initial short-term implementation costs at each site for a standardised programme.	Medium	Medium Term (5-10yrs)	>£200m	LLWR Capacity preserva tion	High	Study Further	LLWR
6	Consolidate R&D on characterisation	Consolidation of R&D activities by reducing duplication of characterisation work within different site TBURDs. In some cases the problem may have already been solved at another site already or there may be scope to nominate an appropriate lead site or sites to undertake the R&D on behalf of all sites. This may be particularly applicable to 'difficult' wastestreams.	Reduced R&D costs will mean that each site doesn't have to 're-invent the wheel'.	Straight-forward	Short Term (<5yrs)	<£50m	LLWR Capacity preserva tion	Medium	Quick-win	Lead Site

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
7	Identify and share characterisation best practices	Improve identification and sharing of characterisation current best practices consistently across industry. Knowledge of best practices (and how to implement them) must be suitably cascaded within each site to projects and the workface. Although a range of mechanisms currently exist such as forums and industry working groups it would appear that the acquisition and use of knowledge is still an issue. There is often a reluctance to share knowledge between different SLCs and with supply chain on grounds of commercial confidentiality.	Improved access to best practices developed on other sites will reduce overall costs. NDA doesn't have to fund same learning twice.	Straight-forward	Short Term (<5yrs)	<£50m	LLWR Capacity preservation	Medium	Quick-win	Existing Industry Working Group
8	Centralised provision of characterisation equipment and/or SQEP resource	Centrally procure and deploy characterisation equipment such as assay systems/box counters. These would be leased to consignors for the duration of projects. Systems would be used to assist consignors in waste characterisation and segregation as they implement improved application of the waste management hierarchy. Box counter systems could also be employed at the LLWR to validate consignor characterisation results prior to treatment or disposal. Training and/or SQEP resource could also be provided to assist waste producers to operate equipment.	Improved access to equipment and knowledge of efficient characterisation processes. A standard approach can be adopted across all sites with associated benefits from potential economies of scale from procurement of these services.	Difficult	Short Term (<5yrs)	£50m - £200m	LLWR Capacity preservation	High	Study Further	LLWR
9	Re-estimate wastestream characterisation	Re-examine and/or re-estimate the characterisation data for previously characterised wastestreams. If necessary re-forecast wastes to more appropriate routes (e.g. lower unit cost, ILW -> LLW, LLW -> VLLW, VLLW -> EW).	Will reduce uncertainty in volumes and activity estimates in inventory. Improved waste characterisation enables greater use of alternative fit-for-purpose management and disposal routes (e.g. lower unit cost for ILW -> LLW, LLW -> VLLW, VLLW -> EW). Accurate activity estimates will help prolong LLWR radiological capacity.	Medium	Medium Term (5-10yrs)	<£50m	LLWR Capacity preservation	Low/Medium	Study Further	Individual Site/SLC

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
			Segregation / Categorisation							
2	Improve consistency of application of NICoP	Improve consistency of application of NICoP on all nuclear industry sites. The CEWG has developed a Nuclear Industry Code of Practice (NICOP) to provide a consistent safe, responsible and sustainable approach to clearance and exemption of LLW. Membership of the CEWG is drawn primarily from the large nuclear organisations AWE, British Energy, Sellafield, DML, DSTL, GE Healthcare, Magnox Electric, NPL, UKAEA. These different organisations interpret the NICOP guidance in different ways and to different extents therefore there are significant differences when it comes down to implementation between sites.	Greater application of NICoP principles is expected to increase quantities of waste cleared and exempted with corresponding environmental, cost and LLWR capacity preservation benefits.	Straight-forward	Short Term (<5yrs)	<£50m	LLWR Capacity preservation, Environmental	Medium	Quick-win	Existing Industry Working Group
10	Develop guidance on segregation best practices	Develop guidance based on a collation of best practice in support increased segregation by material type and activity. Sites to review planned / existing procedures against best practice to determine if greater segregation is possible. Experiences in waste management and sharing of lessons-learned by sites already conducting facility D&D need to be disseminated more effectively across the UK.	Improved access to best practices developed on other sites will reduce overall costs. NDA doesn't have to fund same learning twice.	Straight-forward	Short Term (<5yrs)	<£50m	LLWR Capacity preservation	Medium	Quick-win	LLW Strategy Sub-Committee
11	Incentivise segregation of wastes	Introduce incentives and/or targets for segregated waste based on segregation by activity and material type. By increasing incentives each site would have flexibility to find the most efficient way of segregating waste (e.g. segregation at source vs. centralised segregation). Incentives could be a mix of financial (e.g. LLWR pricing hierarchy) and technical/regulatory (e.g. LLWR Conditions for Acceptance)	Encourages further investment in waste segregation programmes and culture change. Segregated waste can then be processed and disposed via the most appropriate route with corresponding environmental, cost and LLWR capacity preservation benefits.	Straight-forward	Short Term (<5yrs)	>£200m	LLWR Capacity preservation	Very High	Quick-win	NDA

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
12	Standardise design of waste segregation facilities	In a number of cases there are significant similarities between waste management and segregation facilities planned to be built at NDA sites (particularly Magnox stations). Reductions in design and construction costs for new waste management facilities at NDA sites could be achieved using a modular approach to accommodate differences in functional requirements in response to specific site circumstances (e.g. if one site has more significant quantities of a particularly problematic or a unique waste stream). Because most of these facilities will only operate for a short period of time there is scope for use of mobile or semi-mobile structures and equipment such as Rubb-tents. The application of this approach for Magnox Final Site Clearance Waste Management Facilities is discussed in Appendix J.	Reduce costs across construction, feasibility, design of new facilities. Lessons can be learnt and adapted for next facility build more easily. The application of this approach for Magnox Final Site Clearance Waste Management Facilities is discussed in Appendix J.	Difficult	Medium Term (5-10yrs)	>£200m		High	Study Further	Lead Site
39	Introduce small modular containers for segregated wastes	Introduction of small modular containers for segregated wastes (e.g. metals, combustibles, compactables, etc). This would include modular inner-packaging solutions to be used in conjunction with HHISOs and FHISOs for transport to treatment facilities. The design of these containers would need to be consistent with transport regulations and agreed with consignors based on requirements for lifting points, handling equipment, etc.	Enhances segregation by enabling containers to get closer to the workface. This also mitigates space constraints at a number of sites.	Medium	Short Term (<5yrs)	£50m - £200m	LLWR Capacity preservation	High	Study Further	LLWR

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
Waste Treatment										
13	Incentivise treatment of wastes	Introduce incentives and/or targets for treatment waste based on volume reduction achieved. Current consignor behaviour is strongly influenced by the LLWR gate price which is less than true lifecycle cost. Incentives could be a mix of financial (e.g. LLWR pricing hierarchy) and technical/regulatory (e.g. LLWR Conditions for Acceptance).	Encourages consignors to segregate wastes to allow processing in accordance with the waste management hierarchy. Segregated waste can then be processed and disposed via the most appropriate route with corresponding environmental, cost and LLWR capacity preservation benefits.	Straight-forward	Short Term (<5yrs)	>£200m	LLWR Capacity preservation	Very High	Quick-win	NDA
14	Develop metal treatment routes	Develop metal treatment routes using technologies such as decontamination and melting to significantly reduce volume of LLW metals requiring disposal. Maximise use of the available capacity in supply chain, both in UK and overseas. It is expected that over 95% of metal could be recycled.	Provides high volume reduction for metallic wastes and allows more material to be recycled. There may be considerable attainable market value from sale of metal with corresponding environmental, cost and LLWR capacity preservation benefits. This may also stimulate investment in new UK capabilities and capacity.	Medium	Short Term (<5yrs)	>£200m	LLWR Capacity preservation	Very High	Quick-win	LLWR
15	Develop incineration routes	Develop incineration routes to significantly reduce volumes and provide stabilisation for combustible LLW. Maximise use of the available capacity in the supply chain, both in UK and overseas.	Provides high volume reduction for combustible wastes. This may also stimulate investment in new UK capabilities and capacity and NDA could avoid £70m investment in new WAMAC facility.	Medium	Short Term (<5yrs)	>£200m	LLWR Capacity preservation	Very High	Quick-win	LLWR

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
16	Supply chain provide new waste treatment facilities, capacity and capabilities.	Supply chain to provide new waste treatment facilities, capacity and capabilities. This would avoid the need for NDA to invest in new waste facilities. Supply chain may need sufficient market confidence in order to justify investment.	Supply chain facilities are likely to be significantly cheaper and more efficient than equivalent facilities on NDA sites. NDA could potentially avoid over £200m in capital investments.	Difficult	Medium Term (5-10yrs)	>£200m		High	Study Further	Supply Chain
17	Improve efficiency and utilisation of existing incinerators at nuclear sites	Improve utilisation of existing nuclear site incinerators by integrating operations, authorisations and waste volumes. Several incinerators at nuclear power station sites are currently only run for very short campaigns (e.g. few days per month) due to lack of waste feed. The Capenhurst site also has an incinerator which is currently mothballed due to lack of waste. There may be scope to make considerably better use of these existing assets as permitting of new incinerators may be a lengthy process and present a number of challenges due to stakeholder perception.	Optimise life and use of current incineration assets. Future costs can be reduced by better joined up thinking at a national level rather than site by site.	Difficult	Medium Term (5-10yrs)	£50m - £200m	LLWR Capacity preservation, Environmental	Medium	Study Further	LLWR
18	Improve efficiency of existing NDA metal decontamination facilities	Improve efficiency of existing Wheelabration facilities by using a more flexible operating model where material that cannot be easily decontaminated to exempt level is routed for melting. It is very difficult to exempt some metals using grit-blasting techniques alone because of material type, amount and type of contamination, geometry, etc and inappropriate use can result in large volume of secondary waste and/or non-exemptable material being disposed to LLWR. Using blasting as a pre-treatment, followed by melting, can allow a much wider envelope of material to recycled.	Significantly increases overall metal recycling rates with corresponding reduction in secondary waste & non-exemptable material consigned for disposal. Facility throughput would also be increased as less blasting cycles are required.	Straight-forward	Short Term (<5yrs)	£50m - £200m	LLWR Capacity preservation, Environmental	High	Quick-win	Individual Site/SLC

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
19	Consolidate R&D on orphan and hazardous wastestreams	Consolidation of R&D activities for different orphan and hazardous wastestreams by reducing duplication of work within different site TBURDs. Orphan wastestreams are those that do not have an underpinned final disposition route in their current form. This is typically because they do not currently conform to the CFA at the LLWR by virtue of their physio-chemical properties. There are significant quantities of orphan wastes in the current LLW inventory including materials such as oils, asbestos, lead, mercury, zinc bromide, resins, sludges and graphite. In some cases the problem may have already been solved at another site already or there may be scope to nominate an appropriate lead site or sites to undertake the R&D and/or develop a solution on behalf of all sites.	Reduced R&D costs so that each site doesn't have to 're-invent the wheel'. Allows an optimised UK solution to be developed for each stream (e.g. oils, asbestos, lead, resins, sludges, mercury, zinc bromide, graphite, etc) which can then be deployed at all sites.	Straight-forward	Short Term (<5yrs)	>£200m	LLWR Capacity preserva tion	Very High	Quick-win	Lead Site

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
Recycle/Reuse and Exempt										
2	Improve consistency of application of NICoP	Improve consistency of application of NICoP on all nuclear industry sites. The CEWG has developed a Nuclear Industry Code of Practice (NICOP) to provide a consistent safe, responsible and sustainable approach to clearance and exemption of LLW. Membership of the CEWG is drawn primarily from the large nuclear organisations AWE, British Energy, Sellafield, DML, DSTL, GE Healthcare, Magnox Electric, NPL, UKAEA. These different organisations interpret the NICOP guidance in different ways and to different extents therefore there are significant differences when it comes down to implementation between sites.	Greater application of NICoP principles is expected to increase quantities of waste cleared and exempted with corresponding environmental, cost and LLWR capacity preservation benefits. .	Straight-forward	Short Term (<5yrs)	<£50m	LLWR Capacity preservation, Environmental	Medium	Quick-win	Existing Industry Working Group
14	Develop metal treatment routes	Develop metal treatment routes using technologies such as decontamination and melting to significantly reduce volume of LLW metals requiring disposal. Maximise use of the available capacity in supply chain, both in UK and overseas. It is expected that over 95% of metal could be recycled.	Provides high volume reduction for metallic wastes and allows more material to be recycled. There may be considerable attainable market value from sale of metal with corresponding environmental, cost and LLWR capacity preservation benefits.	Medium	Short Term (<5yrs)	>£200m	LLWR Capacity preservation	Very High	Quick-win	LLWR
18	Improve efficiency of existing NDA metal decontamination facilities	Improve efficiency of existing Wheelabration facilities by using a more flexible operating model where material that cannot be easily decontaminated to exempt level is routed for melting. It is very difficult to exempt some metals using grit-blasting techniques alone because of material type, amount and type of contamination, geometry, etc and inappropriate use can result in large volume of secondary waste and/or non-exemptable material being disposed to LLWR. Using blasting as a pre-treatment, followed by melting, can allow a much wider envelope of material to recycled.	This could significantly increase overall metal recycling rates with corresponding reduction in secondary waste & non-exemptable material consigned for disposal. Facility throughput would also be increased as less blasting cycles are required.	Straight-forward	Short Term (<5yrs)	£50m - £200m	LLWR Capacity preservation, Environmental	High	Quick-win	Individual Site/SLC

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
20	Identify and share re-use and recycling best practices	Improve identification and sharing of re-use and recycling best practices consistently across industry. Knowledge of best practices (and how to implement them) must be suitably cascaded within each site to projects and the workface.	Improved access to best practices developed on other sites will increase likelihood of finding an alternative use for the material.	Straight-forward	Short Term (<5yrs)	<£50m	LLWR Capacity preservation, Environmental	Medium	Quick-win	LLW Strategy Sub-Committee
21	Develop mechanism for co-ordination of supply and demand for materials	A mechanism for co-ordination of supply and demand of materials could be developed to enable nuclear sites to better co-ordinate activities. Exempt wastes such as soil and rubble could re-used at another nuclear site for construction, capping, in-fill, etc). Could consider waste storage at an appropriate location until a final use is available.	Improved likelihood of finding an alternative use for the material. Reductions in waste could occur that would otherwise have been disposed to LLWR or landfill with cost and environmental benefits. Significant environmental and sustainability benefits from resource conservation may be possible.	Medium	Medium Term (5-10yrs)	£50m - £200m	LLWR Capacity preservation, Environmental	Medium	Study Further	LLWR
22	Re-use/recycle waste in new construction projects in nuclear industry	Reuse and recycle EW (and possible VLLW) waste materials for construction projects in nuclear industry (e.g. recycling rubble as aggregate for new site roads, waste stores, new power stations, LLWR vaults, capping material, etc)	Reduces waste that would otherwise have been disposed to LLWR or landfill with cost and environmental benefits. This also avoids cost of virgin construction materials. Significant environmental and sustainability benefits from resource conservation can be achieved.	Difficult	Medium Term (5-10yrs)	>£200m	LLWR Capacity preservation, Environmental	High	Study Further	Individual Site/SLC

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
23	Re-use/recycle waste in new construction projects outside nuclear industry	Reuse and recycle EW waste materials for new construction projects outside nuclear industry (e.g. recycling rubble as aggregate for new roads, runways, sea defences, void in-fill, etc). Recycling of metals into new products. Appropriate routes would need to be set up with organisations willing to take the material.	Reduces waste that would otherwise have been disposed to LLWR or landfill with cost and environmental benefits. Cost saving would depend on attainable market value of the material but there are also potentially significant environmental and sustainability benefits from resource conservation.	Difficult	Medium Term (5-10yrs)	£50m - £200m	LLWR Capacity preservation, Environmental	Medium	Study Further	LLWR

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
Waste Disposal										
2	Improve consistency of application of NICoP	Improve consistency of application of NICoP on all nuclear industry sites. The CEWG has developed a Nuclear Industry Code of Practice (NICOP) to provide a consistent safe, responsible and sustainable approach to clearance and exemption of LLW. Membership of the CEWG is drawn primarily from the large nuclear organisations AWE, British Energy, Sellafield, DML, DSTL, GE Healthcare, Magnox Electric, NPL, UKAEA. These different organisations interpret the NICOP guidance in different ways and to different extents therefore there are significant differences when it comes down to implementation between sites.	Greater application of NICoP principles is expected to increase quantities of waste cleared and exempted with corresponding environmental, cost and LLWR capacity preservation benefits.	Straight-forward	Short Term (<5yrs)	<£50m	LLWR Capacity preservation, Environmental	Medium	Quick-win	Existing Industry Working Group
24	Develop alternative routes for exempt waste disposal	Develop routes for exempt waste disposal to alternative routes in the non-nuclear industry. Improved segregation and sentencing of wastes will allow wastes to be routed down more appropriate disposal routes and avoid co-disposal with LLW at LLWR.	This would reduce overall costs both for disposal and preserve capacity at LLWR	Straight-forward	Short Term (<5yrs)	£50m - £200m	LLWR Capacity preservation, Environmental	High	Quick-win	Individual Site/SLC
25	Develop alternative routes for VLLW disposal	Develop alternative VLLW management and disposal routes (for example, to landfill) for appropriate material as an alternative to LLWR vault disposal. Maximise use of the available capacity in the supply chain if possible although interest may depend on regulatory regime.	Disposal costs reduced. If local disposal solutions can be found for each site there may be opportunities for reduced waste transportation.	Difficult	Short Term (<5yrs)	>£200m	LLWR Capacity preservation, Environmental	Very High	Quick-win	LLWR

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
26	On-site/Near-Site disposal of VLLW on existing NDA sites	Develop fit-for-purpose On-site/Near-Site disposal facilities for VLLW on a site specific, regional or national basis. A number of NDA sites already have plans for new VLLW on-site disposal facilities. Not all sites may be suitable for such facilities therefore a combination of regional and/or national VLLW facilities may be necessary, subject to stakeholder acceptance. Opportunities also exist to learn from disposal practices in Europe where lower activity wastes are disposed of in sacks which minimise void space. The AREVA Morvilliers VLLW facility offers French consignors a low cost, high-volume disposal capacity for VLLW. The optimum locations, capacity and transportation considerations would have to be considered further as part of the LLW Strategy and Management Plan.	Disposal costs reduced. Transport distances could be reduced with on-site and regional facilities.	Difficult	Medium Term (5-10yrs)	>£200m	LLWR Capacity preservation, Environmental	High	Study Further	Lead Site
27	On-site/Near-Site disposal of LLW on existing NDA sites	Develop fit-for-purpose On-site/Near-Site disposal facilities for LLW on a site specific, regional or national basis. A number of NDA sites already have plans for new LLW on-site disposal facilities. Not all sites may be suitable for such facilities therefore a combination of regional and/or national LLW facilities may be necessary, subject to stakeholder acceptance. The optimum number of facilities, locations, capacity and transportation considerations would have to be considered further as part of the LLW Strategy and Management Plan. It should be noted that small on-site facilities are typically more expensive per unit volume than larger disposal facilities such as LLWR however upstream LLW management costs are often lower due to lesser packaging and transportation requirements. There may a case for a lead site to develop the concept and roll-out to other suitable sites. OSD at Magnox sites is discussed further in Appendix J.	Disposal costs could be reduced but this will be dependant on design, wasteform and packaging solution adopted. Transport distances could be reduced with on-site and regional facilities.	Difficult	Medium Term (5-10yrs)	>£200m	LLWR Capacity preservation, Environmental	High	Study Further	Lead Site

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
28	Disposal of some LLW to Deep Geological Repository (e.g. long-lived)	Disposal of some LLW wastestreams to the Deep Geological Repository. These may include some long-lived LLW or wastestreams with radionuclides that present particular challenges to the Environmental Safety Case (ESC) at LLWR (e.g. Cl-36 and C-14). Safe interim storage of these wastes would be required until the deep repository becomes available.	LLWR radiological capacity could be preserved for a considerably longer time. The extra benefit at LLWR would have to be balanced against extra cost of disposal in the deep repository.	Difficult	Long Term (10+yrs)	>£200m	LLWR Capacity preserva tion	Medium	Study Further	NDA
29	Disposal of short-lived ILW in near-surface facilities	Disposition of short-lived ILW in near-surface facilities such as LLWR would avoid disposal to the deep geological repository. This approach is commonly used internationally. The feasibility of this approach would require further study to determine the impact on the ESC and operational safety case at LLWR and would be subject to considerable stakeholder consultation.	Considerable overall cost saving to NDA from disposal of short-lived ILW at LLWR compared to deep repository. There is potential to accelerate hazard reduction activities at sites if route for such material can be provided.	Difficult	Long Term (10+yrs)	>£200m		Medium	Study Further	NDA
30	Alternative Vault Designs	Review the design, size, and location of future vaults at LLWR optimise use of LLWR site. This may include different grades of vault commensurate with different types and activities of waste. Options include different types of vaults, silos or cells and shallower or deeper designs.	Reduce impact on the environment, reduce installation and maintenance costs, and improve waste disposal efficiencies.	Difficult	Long Term (10+yrs)	£50m - £200m	LLWR Capacity preserva tion Environ mental	Low/Medi um	Study Further	LLWR
31	Optimise closure of LLWR	Optimise closure of LLWR by considering implementation of innovative options for construction of a more efficient closure cap; integrating design features with future decommissioning plans; and designing post-closure monitoring and surveillance.	Reduce cost of new materials and operational costs.	Difficult	Long Term (10+yrs)	<£50m	Environ mental	Low	Study Further	LLWR
32	Disposal of NORM to alternative facilities	Disposal of NORM to facilities other than LLWR. Disposal of significant quantities of NORM at LLWR may have detrimental impacts on ESC. Options include disposal to local landfills or other NDA on-site disposal facilities. Much of the UK's NORM will be generated in Scotland (Aberdeen) therefore there may be potential to utilise the new OSD facilities at Dounreay subject to regulatory and stakeholder acceptance.	LLWR radiological capacity could be preserved for a considerably longer. time.	Difficult	Medium Term (5-10yrs)	<£50m	LLWR Capacity	Low/Medi um	Study Further	NDA

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
33	Decay storage of short-lived LLW	Decay storage of short-lived LLW until material reaches exempt levels. Wastes containing short-lived isotopes is stored within appropriate storage facilities until sufficient decay has occurred to allow the material to then be disposed down exempt waste routes. This may require storage of waste for several decades in an appropriately monitored and maintained facility. This approach is currently being used at Capenhurst for certain tritiated wastes. It is unclear what proportion of the LLW inventory would be suitable for this approach.	Preserves capacity at LLWR with consequential cost savings. Cost of long-term storage and legacy management would have to be balanced against reduction in disposal costs.	Difficult	Medium Term (5-10yrs)	£50m - £200m	LLWR Capacity preservation	Medium	Study further	Lead Site
34	In-situ management of contaminated land	In-situ management and disposal of contaminated land at the site of arising. This is a key strategic issue for NDA as there is potentially up to 13 million m^3 of contaminated land at UK nuclear sites, the majority at Sellafield. Options for contaminated land management are typically management in-situ or removal and management as waste. Much of the contaminated land is not fully characterised and there is considerable uncertainty over how much will ultimately need to be managed as waste. Sellafield have included £2.3bn in the current LTP08 to remove, decontaminate and then dispose of large quantities of contaminated land to on-site LLW vaults. In-situ management at Sellafield and other sites could reduce these costs significantly however the feasibility of in-situ management would have to be assessed on a case-by-case basis and be compatible with the ultimate site end-state.	Preserves capacity at LLWR with consequential cost savings. Reductions in overall risks to the LLW strategy from large waste volumes currently outside the inventory can be achieved. Cost of in-situ management, ongoing monitoring, etc would have to be balanced against reduction in disposal costs.	Difficult	Long Term (10+yrs)	>£200m	LLWR Capacity preservation Environmental	Medium	Study further	NDA

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
Waste Packaging										
35	Develop methods and tools for improving waste packaging efficiency.	Develop methodology, tools and site guidance for estimating and improving packing efficiencies in waste containers. Based on evaluations of different waste streams/waste types, new packaging innovations, and existing experience in the nuclear industry, standardised approaches for estimating and increasing packing efficiencies can improve forecasting future waste volumes for disposal across the UK.	Small improvements in packaging efficiency can lead to significant benefits at LLWR.	Medium	Medium Term (5-10yrs)	£50m - £200m	LLWR Capacity preservation	Medium	Study Further	LLWR
36	Use of reusable containers for transport of LLW	Use of re-usable containers (Type0075 Skips, HHISOs and FHISOs) as the approved transport container for moving materials between consignor sites, treatment facilities and LLWR. Currently HHISO and THISO containers are used once and then disposed. Uses existing container designs however some relicensing and modification of procedures could be required.	Allows containers to be reused, reducing overall packaging costs.	Straight-forward	Short Term (<5yrs)	£50m - £200m	LLWR Capacity preservation	High	Quick-win	LLWR
37	Introduce inner disposal liners for non-compactable waste	Use of inner disposal liners for non-compactable waste. Currently waste is disposed of in HHISO and THISOs at LLWR. The liner or box would act as the ultimate disposal container and the transport container would be re-used. Liner would be designed to meet requirements of LLWR ESC and transport regulations.	Lower cost disposal container, less voidage and grout, and more efficient use of vault space.	Difficult	Medium Term (5-10yrs)	£50m - £200m	LLWR Capacity preservation	Medium	Study Further	LLWR
38	Introduce puck overpacks for compacted waste	Puck overpacks for compacted waste as alternative to current disposal in HHISOs. The design of these containers would need to be consistent with ESC requirements, transport regulations and agreed with consignors based on requirements for lifting points, handling equipment, etc.	Lower cost disposal container, less voidage and grout, and more efficient use of vault space.	Difficult	Medium Term (5-10yrs)	£50m - £200m	LLWR Capacity preservation	Medium	Study Further	LLWR

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
39	Introduce small modular containers for segregated wastes	Introduction of small modular containers for segregated wastes (e.g. metals, combustibles, compactables, etc). This would include modular inner-packaging solutions to be used in conjunction with HHISOs and FHISOs for transport to treatment facilities. The design of these containers would need to be consistent with transport regulations and agreed with consignors based on requirements for lifting points, handling equipment, etc.	Enhances segregation by enabling containers to get closer to the workface. This also mitigates space constraints at a number of sites.	Medium	Short Term (<5yrs)	£50m - £200m	LLWR Capacity preserva tion	High	Study Further	LLWR
40	Introduce reinforced bags for VLLW	Introduce reinforced bags for VLLW as alternative to current disposal in HHISOs. The design of these containers would need to be consistent with transport regulations and agreed with consignors based on requirements for lifting points, handling equipment, etc. Similar containers are in widespread use internationally for VLLW transport and disposal.	Lower cost disposal container, less voidage and grout, and more efficient use of disposal space.	Difficult	Medium Term (5-10yrs)	£50m - £200m		Medium	Study Further	LLWR

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
Waste Transportation										
41	Use of transport hubs	Use of transport hubs to transfer waste and materials between different modes of transport including road, rail and sea. Hubs could also store wastes for a short term in order to obtain economies of scale for onward travel. Investigation in optimising the transportation of LLW across the UK and beyond would need to consider both the current and future facilities capacities and locations and also the volumes of waste expected. Potential options include existing rail facilities located at Crewe and the Port of Workington. Opportunities exist in the transportation of materials to the LLWR, in terms of bulk construction materials (e.g. vault aggregate) and also consumables which could be transported by rail rather than road.	Reduced cost of transport, less stakeholder concern, and environmental impact from rail and sea transport.	Difficult	Medium Term (5-10yrs)	<£50m	Environmental	Low/Medium	Study Further	LLWR
42	Increased use of rail transport	Increased use of rail transport. Currently LLW transported by rail is predominantly over relatively short distances between LLWR and Sellafield. Most AGR and Magnox stations have railheads within 2 km to 25 km of the site although these facilities are not currently used for LLW transport. Pilot projects involving rail transport of LLW over longer distances from sites in the South of England have been undertaken (e.g. Magnox) which shown that the economics, relative to road transport alterative, are principally dependant on the number of containers shipped per rail movement.	Possible reduction in cost, environmental impact, and traffic congestion on the roads	Medium	Short Term (<5yrs)	<£50m	Environmental	Medium	Study Further	LLWR
43	Integration of LLW and spent fuel rail shipments	Integration of rail shipments for LLW, spent fuel, ILW, and/or other materials for transport. Integration of transport can make better use of rail capacity by maximising waste per shipment.	Significant cost savings, reduced number of rail shipments, and better integrated waste loading and transport to appropriate facilities.	Medium	Short Term (<5yrs)	<£50m	Environmental	Medium	Study Further	Lead Site

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
44	Transport of large components whole	Transport of large components whole. This particularly large items arising from decommissioning such as boilers or reactor pressure vessels by road or sea. This option has historically seldom been used in the UK but is common practice in other European countries and the US where items such as steam turbines in excess of 500te have been transported by sea and road to metal recycling facilities. Most of the UK power reactors are situated at coastal sites, but none of which have any kind of significant port or harbour facility. It is understood that several feasibility studies have already been undertaken on transportation of Magnox boilers to treatment facilities.	The transport of larger items can have a number of advantages including the safety benefits and cost savings from avoiding the need for bespoke size reduction and packaging facilities at the waste producing site. There are likely to be significant safety, environmental and cost benefits from undertaking this type of work in purpose-built facilities. These advantages would likely outweigh the inconvenience and cost of transporting the large item.	Medium	Short Term (<5yrs)	<£50m	Environ mental	Medium	Study Further	LLWR

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
Tracking/Inventory Management										
45	Simplify waste consignment processes	Simplify and improve the process for consigning and scheduling wastes for disposal at LLWR. Implementation of improved processes will include waste consignor services to facilitate effective planning and management, automated documentation, simplified waste transport approval, and electronic or web-based systems at LLWR and consignor sites.	Reduced time and effort required to consign waste for treatment and disposal will improve efficiency at consignors' sites and LLWR resulting in reduced cost and resource requirements. Lower incidence of non-compliances may also occur.	Difficult	Medium Term (5-10yrs)	<£50m	Regulatory compliance	Low/Medium	Study Further	LLWR
46	Improved waste quality assurance processes	Improved waste quality assurance processes and standardisation of requirements for waste consignors	Benefits from improved consistency in meeting the LLWR CFAs and can enable more effective oversight of authorisations by regulators.	Medium	Short Term (<5yrs)	<£50m	Regulatory compliance	Medium	Study Further	LLWR
47	LLW records consolidation and archiving	LLW records consolidation and archiving could be centralised to ensure a consistent approach. Waste consignors and treatment/storage/disposal facilities are required to maintain and control waste records and information for long periods of time as a requirement of their regulatory authorisations. Some sites have limited secure storage space for records. This is a particular issue for sites entering long care and maintenance periods. Record management could be centralised in a secure electronic and paper archive.	Some efficiency across the UK could be achieved through centralised and electronic records management subject to regulatory agreement.	Difficult	Long Term (10+yrs)	<£50m		Low	Study Further	NDA

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
48	Improve waste forecasting	Improved waste inventory forecasting managed within one definitive inventory dataset with more accurate short, medium and long-term forecasting.	Improves short-term forecasting which allows more efficient operational and capacity planning at LLWR. Reduction in long-term uncertainties is vital for NDA's strategic planning and decision-making.	Straight-forward	Short Term (<5yrs)	<£50m		Medium	Quick-win	LLWR

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
			Other							
49	Development of UK LLW Strategy	Development and implement a National LLW Strategy and LLW Management Plan.	Provide strategic direction and focus to Government, waste producing sites, regulators and planning authorities on LLW management.	Straight-forward	Short Term (<5yrs)	<£50m		Medium	Quick-win	NDA
50	Preparation of national strategic option assessments	Preparation of strategic option assessments and national option and opportunity studies. Studies will be undertaken to develop and engage on preferred LLW management solutions optimised from a national strategic perspective. The level of detail will be proportionate to the scope of the management opportunity and will be influenced by our stakeholder engagement. Outputs from these studies will act as a framework to support consignors when they undertake more detailed option and implementation studies at a site level.	Development of strategic national optimised solutions will mitigate against sub-optimal decision-making at site or project level. It will also minimise duplication of optioneering (e.g. BPEO) effort and provides guidance for consignors undertaking their own studies.	Medium	Short Term (<5yrs)	<£50m		Medium	Study Further	LLWR
51	Enhance communications within LLW management community	Improve communications between consignors, treatment and disposal facilities, appropriate stakeholders, and regulators. Improved communication methods for LLW management that standardise messages, provide timely notification, and provide the appropriate level of technical detail need to be evaluated and integrated. Provisions for simultaneous communication tools, including electronic websites, standardised distribution lists, and other telecommunication methods could be implemented.	Mitigates against stakeholder fatigue by improving consultation and communication and provides added transparency of decision-making. This also helps mitigate against potential inconsistency in decision-making at different sites by NDA, waste producers and regulators.	Medium	Short Term (<5yrs)	<£50m		Medium	Study Further	LLW Strategy Sub-Committee

No.	Title	Description	Benefits	Ease of implementation	Timescale	Cost Benefit	Other Benefits	Priority	Classification	Ownership
52	Establish principles for decontamination and decommissioning	Establish standardised, waste management principles for nuclear facility decontamination, decommissioning, and demolition. Develop these into a guidebook of good practices, tools and techniques for implementing D&D projects to prevent or minimise the generation of waste, improve waste characterisation, enhance segregation of waste streams, and integrate waste management efficiencies throughout the project can save significant costs and prevent unnecessary re-work and redundancy.	Improved use of the waste management hierarchy within decommissioning projects, reduced costs and impact on the environment. It will provide stepping stones on which to build effective decommissioning projects aimed at avoiding and reducing the generation of all wastes	Medium	Medium Term (5-10yrs)	<£50m	LLWR Capacity preservation Environmental Safety	Low/Medium	Study Further	LLW Strategy Sub-Committee
53	Develop strategy to optimise use of current/future NDA assets	Development of a strategy to optimise the use of current assets and future planned facilities at NDA facilities based on best overall value to NDA. Develop a further understanding how the existing and planned capacity at a site level could contribute towards meeting national needs, including waste treatment, storage, and disposal capacity. Where possible encourage the supply chain to provide such facilities.	Optimise life and use of current assets. The strategy can also reduce future costs by better joined up thinking at a national level rather than at a site-by-site level. Use of supply chain to provide new facilities could result in significant cost savings to NDA.	Medium	Short Term (<5yrs)	<£50m		Medium	Study Further	NDA
54	Introduce risk-based classification of radioactive substances and waste	Risk based classification and regulation of radioactive substances is more closely aligned with the European Basic Safety Standards Directive. This could include aspects such as radionuclide specific categorisation based on risk (e.g., BSS, RP89), redefinition of LLW, sub-categorisation (e.g., ILW, LLW, VLLW, EW, short-lived, long-lived and hazardous, etc). Would significantly re-draw the boundaries of UK waste classifications.	Potentially significant savings by classifying and managing waste in a manner commensurate with risk to health and environment.	Difficult	Long Term (10+yrs)	>£200m	LLWR Capacity preservation Environmental Safety	Medium	Study Further	NDA

Appendix J – Analysis of Magnox FSC Cost-Saving Opportunities

The similarities between Magnox sites may present significant opportunities for synergies. Magnox sites account for 32% (£3.2 billion) of the total liability for LLW management. The majority of this cost (£2.6 billion) is associated with the Final Site Clearance (FSC) phase where the highest volumes of LLW are generated. The detailed volumes (DVs) associated with Magnox FSC waste management activities have been reviewed to understand the scope and in the associated costs across all 10 Magnox sites with a view to identifying possible areas for synergy.

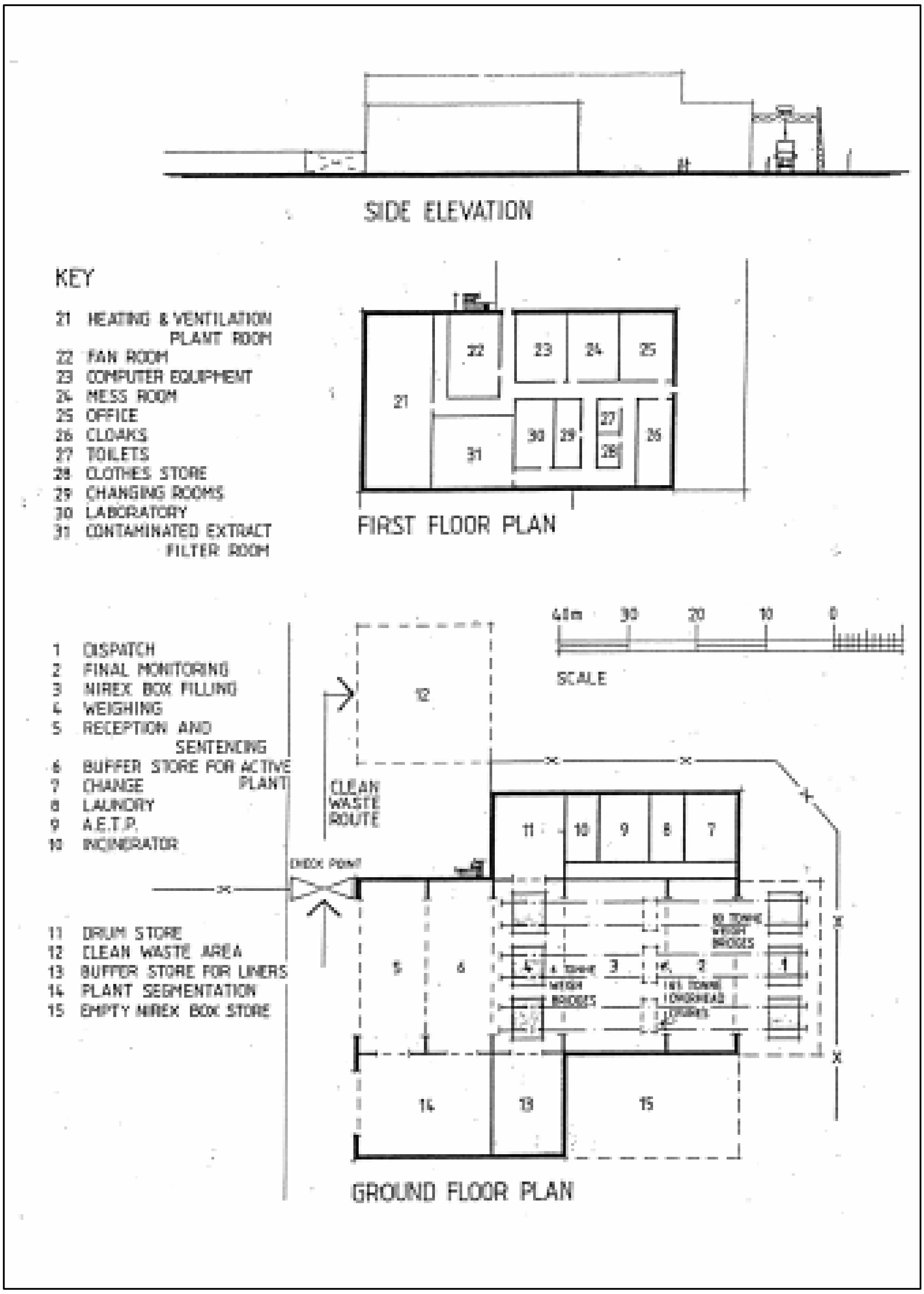
FSC New construction Projects

Each site includes scope for construction of a new FSC Waste Management Facility (WMF) to manage decommissioning wastes arising during this period. These facilities incorporate the management of LLW, non-radioactive wastes and small quantities of ILW. The design of FSC WMF's in all cases was described as conceptual in the LTPs. All plans did however include a description of the areas within the facility as follows:

- Reception & Sentencing Area
- Active Plant Buffer Store and Decontamination Area
- Plant Segmentation Area
- Weighing Area
- Liner Buffer Store
- Drum Buffer Store
- Incinerator Area
- Active Effluent Treatment Plant
- Active Laundry
- Waste Disposal Box Filling Area
- Waste Disposal Box Buffer Store
- Waste Box Grouting Area
- Waste Curing and Despatch Area
- Grout Mixing Area
- Final Monitoring Area
- Despatch Area
- Miscellaneous
- Building Services and Ventilation

A floor plan of the facility is also shown in three of the sites DVs including Berkeley, Chapelcross and Oldbury as shown in Figure J1 below.

FIGURE J1 – EXAMPLE FSC WASTE MANAGEMENT FACILITY LAYOUT



FSC WMF Construction Costs

There are considerable variations in the costs of FSC for different Magnox stations which may partly reflect the different waste volumes and particular challenges found at each site. A significant proportion of the overall FSC costs (£750 million) are associated with the design and construction of new FSC waste management facilities as shown in Table J1 below.

TABLE J1 – MAGNOX FSC CONSTRUCTION COSTS

SLC	Sites	New Construction Projects				Grand Total
		Commissioning	Construction	Design	Feasibility Study	
Magnox North	Chapelcross	£0	£89,883,443	£667,819	£166,880	£90,718,142
	Hunterston A	£0	£91,421,292	£830,575	£207,645	£92,459,512
	Oldbury	£0	£81,036,817	£4,552,685	£1,138,172	£86,727,674
	Trawsfynydd	£5,849,797	£115,641,299	£8,774,722	£2,924,922	£133,190,740
	Wylfa	£6,860,969	£81,827,386	£4,597,100	£1,149,275	£94,434,730
Magnox South	Berkeley	£0	£10,998,340	£567,367	£141,839	£11,707,546
	Bradwell	£0	£27,691,400	£552,175	£25,138,045	£53,381,620
	Dungeness A	£0	£25,943,040	£25,518,653	£129,663	£51,591,356
	Hinkley Point A	£0	£28,274,851	£584,908	£25,146,228	£54,005,987
	Sizewell A	£0	£56,733,827	£25,398,895	£99,724	£82,232,446
Grand Total		£12,710,766	£609,451,695	£72,044,899	£56,242,393	£750,449,753

Because the scope of the proposed FSC facilities at Magnox sites appears to be very similar it might be expected that there would be relatively little variation between the costs of design, feasibility study and construction however there appears to be very significant variations (up to +/- £100 million) in total costs between different sites.

Design Costs

Whilst there are some differences between Magnox sites in terms of waste types and volumes it may be possible to standardise the design and feasibility studies for these FSC facilities to a significant degree. A modular approach could be used to accommodate differences in functional requirements in response to specific site circumstances (e.g. if one site has more significant quantities of a particularly problematic or a unique waste stream).

If a standard design and feasibility study could be developed and made sufficiently flexible to accommodate the requirements of all sites then it is possible that the total cost for all sites could potentially be reduced from a total of £128 million to less than £25 million (this represents the upper end of design costs at a single site - most sites are less than half this cost). This could therefore represent a £100 million lifecycle saving to NDA.

Construction Costs

The FSC periods for Magnox stations occur at different times under the current baseline decommissioning programme. The construction costs range from £11 million up to £115 million per site (over £100 million difference) and amount to a total of £609 million.

Given that these facilities will operate for a maximum of 5-10 years there may be opportunities to consider the use of mobile or 'fit-for-purpose' temporary buildings for the FSC period including such as Rubb tents or other similar mobile/semi-mobile structures and equipment which could lead to significant savings. This approach is already being successfully adopted at Chapelcross for C&M preparation waste management activities.

Furthermore, due to the difference in time phasing between FSC on different sites it may actually be feasible to decontaminate, dismantle, transport and re-assemble the waste management facility at the next site. Assuming four 'mobile' facilities would be required, at a cost of around £50 million each, the total cost for all sites could potentially be reduced from a total of £609 million to less than £200 million. This could represent a £400 million lifecycle saving to NDA.

FSC LLW Operations and Disposal

In addition to construction of a WMF each site includes costs of LLW operations as shown in Table J2 below.

TABLE J2 – W&NM MANAGEMENT COSTS FOR MAGNOX FSC

SLC	Sites	Waste & Nuclear Materials Management			Decommissioning & Termination Total	Grand Total
		Treatment Operations	Transport	Off-Site Disposal		
Magnox North	Chapelcross	£77,777,817	£5,455,366	£133,040,505	£916,854	£217,190,542
	Hunterston A	£61,039,294	£4,532,033	£113,379,315	£1,049,412	£180,000,054
	Oldbury	£39,361,490	£60,824,492		£711,514	£100,897,496
	Trawsfynydd	£102,786,237	£9,271,719	£196,715,406	£787,503	£309,560,865
	Wylfa	£46,213,783	£4,061,378	£86,460,041	£1,219,998	£137,955,200
Magnox South	Berkeley			£121,602,282	£40,984,740	£162,587,022
	Bradwell	£54,840,849		£88,104,480	£957,928	£143,903,257
	Dungeness A	£87,941,659	£11,341,793	£121,757,835	£903,317	£221,944,604
	Hinkley Point A	£65,792,163	£35,236,517	£131,923,373	£1,011,252	£233,963,305
	Sizewell A		£9,212,034	£156,004,574	£1,005,781	£166,222,389
Grand Total		£535,753,292	£139,935,332	£1,148,987,811	£49,548,299	£1,874,224,734

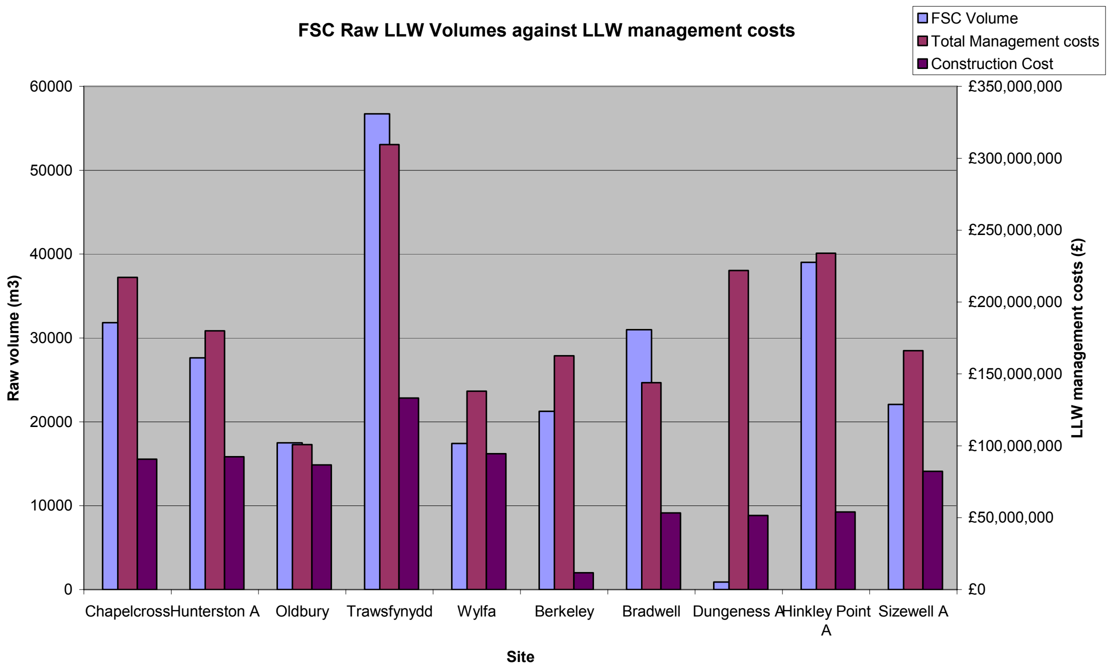
The W&NM Treatment Operations category typically includes operational aspects of LLW management including costs for characterisation, size-reduction, sorting, segregation, packaging, and volume reduction (e.g. compaction). All sites exclude graphite from their LLW operations DVs and suggest that some decontamination of waste would be undertaken at source prior to management within the facility.

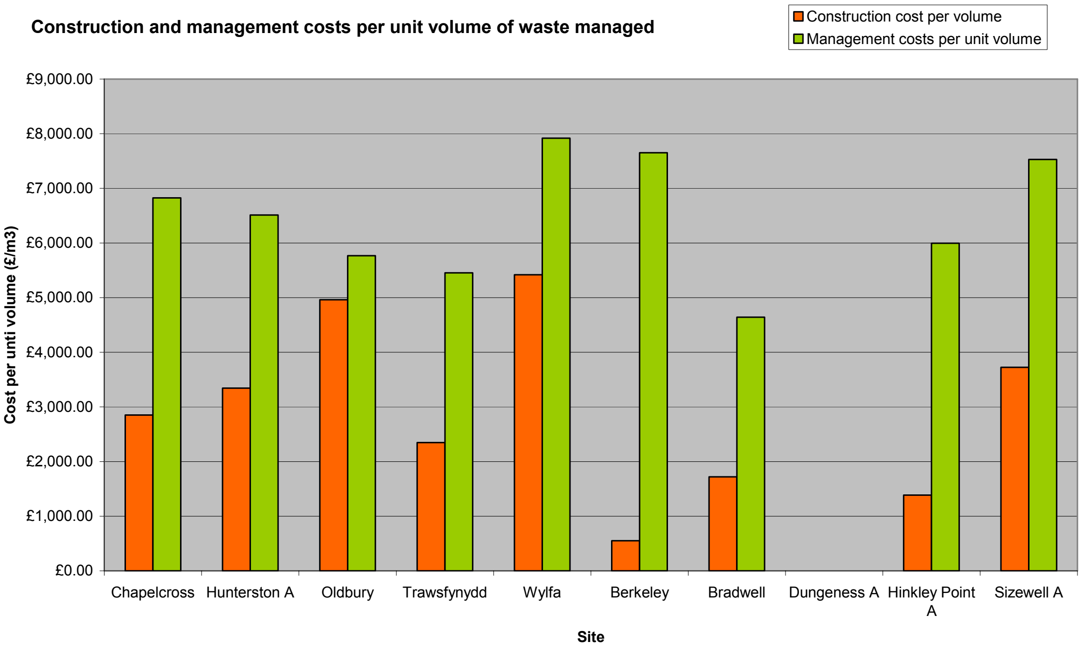
It should be noted that in the case of Berkley and Bradwell the Off-site Disposal category also includes transport and for Oldbury the cost of Off-site disposal is included in Treatment Operations and Transport Categories. There are considerable differences (up to £200 million) between costs on different sites. This may be due to the following:

- Differences in waste volumes between sites
- FSC waste management activities span different categories of waste and hence there may be significant differences in the way costs are allocated across PSWBS areas between different sites.
- Some DVs are more detailed than others, meaning that some may have undertaken more in-depth investigation into costs
- Some sites state that the WMF will be managed by contractors, others will be managed in-house
- It is not clear whether costs include management of large volumes of non-radioactive wastes in LLW Operations costs

An analysis of FSC construction and LLW operational and disposal costs and LLW is shown in Figure J2 below. The graphs below the construction and management costs with the raw waste volumes in FSC.

Figure J2 – FSC LLW Costs and Volumes





Management costs per unit volume range from £4,600 to nearly £8,000 per m^3. Both Wylfa and Sizewell A show the highest unit LLW costs when compared with their waste volumes. The range of construction costs per unit volume is much greater when considering total overall costs, ranging from just over £400 per m^3 to nearly £5,000 per m^3. The highest relative costs are again at Wylfa, whereas the lowest is at Berkeley and Sizewell A.

The Oldbury and Wylfa sites appear to expect similar waste volumes, however Wylfa waste management costs are over £36 million more than Oldbury's costs. A similar picture is shown for Berkeley and Sizewell A volumes, where costs at Sizewell A are over £40 million greater than Berkeley. One reason for this may be that Wylfa have the lowest total volumes in FSC and therefore fixed costs may play a larger role.

The graph shows that although the Trawsfynydd construction, management costs and volumes are the highest in all cases, the actual costs per unit volumes are not. The graph shows that Dungeness A do not appear to have forecasted significant volumes of waste at FSC, however their costs are higher than would be expected. This could appear to highlight a potential issue in the forecasted inventory for this site in this final period.

Whilst there appears to be some relationship between FSC costs and volumes on some Magnox sites there are some significant exceptions to be above. The reasons for this are currently unclear, for example, it could be because costs or waste volumes are labelled under other categories that were not captured by this top-down analysis.

Given the apparent lack of correlation between costs and volumes on different sites no attempt has been made to quantify areas for synergy however it is recommended that a more thorough evaluation is undertaken of costs and volume estimating across different Magnox sites to ensure a consistent approach is adopted.

On-Site Disposal

In total around £140 million has been included for transport and £1,150 million for off-site disposal to LLWR across the 10 Magnox sites. Magnox has been evaluating a range of alternative strategies over the past few years including the potential to dispose of some decommissioning waste from C&M preparations and FSC to on-site disposal (OSD) facilities. Implementation of OSD for VLLW or LLW could potentially result in significant savings in terms of avoiding transport costs and possibly lower disposal costs, depending on facility design, waste-form, inventory and packaging.

There remains some degree of uncertainty over the inventory and engineering approach (and hence costs) that may ultimately be required to implement these proposals. Given the uncertainties associated with these aspects, the potential savings from OSD compared the true variable costs of disposal to LLWR and offset of capital are difficult to quantify in advance of the full business case.

Magnox are currently preparing a detailed business case for an on-site disposal facility and have chosen Hinkley Point A as the lead site for development of an OSD facility in order to provide a ‘proof of concept’. If approved this concept could be rolled out across other suitable Magnox sites on a phased basis to accommodate C&M preparations wastes and potentially FSC wastes.

Wastes arising during FSC are potentially significant in LLWR capacity terms; however these wastes will not arise for another 60 or 70 years under current decommissioning programmes. There is therefore some time available for NDA to consider the optimum disposal strategy for these wastes. Given the economies of scale of larger disposal facilities, there may also be some enhanced value to NDA of a shared or regional approach to such facilities subject to stakeholder acceptance.