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Strategic Review 2013

NWP/REP/047 – Issue 2 – May 2014

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National Waste Programme

Strategic Review 2013

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Executive Summary

Low Level Waste (LLW) is defined as radioactive waste having radioactive content not exceeding 4 GBq/te alpha or 12 GBq/te beta/gamma activity. It is generated by a diverse range of industries including the nuclear industry, the defence sector and non-nuclear users of radioactive material including hospitals, universities, research institutions, the pharmaceutical industry and the oil and gas industry.

The aims and objectives of the 2013 Strategic Review are:

- To update the UK LLW baseline for 2013.
- To 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.
- To provide a knowledge base to inform the NDA review of the UK LLW Strategy in 2014.

The Strategic Review describes the status of the Low Level Waste management environment in the UK; the document intends to provide stakeholders with information on how LLW is managed in the UK at a given time and how management of LLW has changed since the previous Strategic Review. The first LLW Strategic Review (reflecting the 2008 baseline) was published in January 2009, and was a major milestone in the development of the UK Nuclear Industry LLW Strategy providing a baseline of LLW management practice in 2008/09. The 2008 Strategic Review provided the first comprehensive view of LLW management in the UK, described in terms of waste management strategy, infrastructure, volumes and costs to inform Nuclear Decommissioning Authority (NDA) strategic decision making and the development of the UK LLW Strategy. A further review was published in 2010, to update the position at 2010 and to identify synergies and opportunities across the estate. This document updates the 2010 Strategic Review to reflect the LLW management baseline for 2013. It is expected that this document will provide an input to the update of the UK LLW Strategy planned for publication in 2015; will support NDA and Site Licence Company (SLC) strategic decision making; and will act as an information source to a range of stakeholders.

The LLW baseline is described in terms of a range of interrelated aspects: current SLC LLW management strategy, waste inventory, research and development, assets and liabilities (existing and planned) available for LLW management, waste management performance (in terms of diversion and disposal performance) and costs/liabilities.

A review of the UK's LLW inventory shows that the total forecast volume of LLW arising between 2013 and 2120 is 4.2 million m^3. This includes 1.1 million m^3 of LLW and 3.1 million m^3 of VLLW. Approximately 90% of this total inventory will be generated by NDA estate SLCs, and Sellafield Ltd is the dominant waste generator in the UK. The LLW stream is dominated by metals; whilst unknown wastes (from the 2D148 waste stream) and rubble is the greatest constituent of the VLLW inventory. The UK Radioactive Waste Inventory (UKRWI) 2013 has continued the trend observed in the 2010 Strategic Review in the increasing accuracy and quality of LLW data, although further improvements are required. There has been a small reduction in the LLW inventory from the 2010 UKRWI and the 2013 edition which is attributed to the incorporation of improved forecasts particularly for decommissioning wastes.

NDA sites are expected to produce an Integrated Waste Strategy (IWS) in accordance with NDA Specification ENG01. This specification was revised in October 2012 and a new format IWS has been produced by NDA estate SLCs in 2013. The IWS documents articulate the LLW management strategy for the NDA estate SLCs. A review of the LLW management strategy within the IWS documents has been

undertaken against the strategic principles within the UK LLW Strategy to understand how SLC waste management strategy aligns with the national strategy. The review demonstrated that generally the IWS documents meet the revised ENG01 specification and that there is strong alignment of the SLC LLW management strategy with the strategic principles of the UK LLW Strategy. There was strong reference to the principles of the Waste Hierarchy and the importance of waste diversion away from disposal at the LLW Repository, with descriptions of how this is undertaken at a tactical level, reflecting the relative maturity of strategy implementation within the NDA estate. A strategic principle of the LLW Strategy is that waste management decisions should be supported by sound business cases and robust decision-making processes; and there is a related success criterion in the IWS Specification (ENG01) that the IWS will be implemented and how it factors into business decisions. Based on observations of the SLC IWS, it is evident that SLCs could do more to demonstrate that business cases are used to underpin their decision making. A key difference was observed in the IWS for Dounreay Site Restoration Ltd (DSRL) relative to the other SLC IWS documents, in that the default waste management strategy for LLW is disposal (to the Dounreay near-site disposal facility).

Waste management performance, in terms of waste diversion versus waste disposal, has been reviewed through interrogation and analysis of waste actuals data and projections contained within the September 2013 iteration of Joint Waste Management Plans (JWMP) for the NDA estate and (where data was available) for the non-NDA estate. Since the routine reporting of waste metric data was established in April 2011, approximately 15,000m^3 of waste has been diverted away from LLWR, exceeding the volume of waste disposed. This demonstrates progress in the successful implementation of the Waste Hierarchy, and the UK LLW Strategy, within the UK. Waste diversion has been dominated by the disposal of VLLW/LA-LLW to specified landfill, with combustible waste treatment representing the smallest component. This can be attributed to the relatively low volume of waste diversion via the combustible route by Sellafield Ltd, as a consequence of restrictions to their Environmental Permit. The majority of metal treatment is undertaken on-site (by Sellafield Ltd and RSRL). Off-site supply chain infrastructure dominates VLLW/LA-LLW (if the use of the CLESA facility by Sellafield Ltd is excluded) and combustible routes. It is projected that waste diversion will continue to increase over the forthcoming five year period, with greater use being made of the off-site routes.

Research and development (R&D) is a key activity for waste generators to assist in the identification and implementation of innovative approaches and waste management solutions. A review of the Technical Baseline and Underpinning Research and Development (TBuRD) documents, which the NDA requires SLCs to produce, was undertaken to identify R&D relating to LLW management. Relatively little R&D relating to LLW management is captured within the TBuRDs (where most R&D is focussed on management of Higher Activity Waste (HAW)). The R&D that is formally identified in this mechanism is predominantly needs-driven (i.e. related to a specific project or waste stream) and predominantly development work at a high technology readiness level (TRL), such as technology transfer from the non-nuclear sector to a nuclear application. There is no R&D at a fundamental or applied level, reflecting the maturity of LLW management routes and the good level of understanding of the characteristics and challenges that LLW poses from a waste management perspective. The September 2013 iteration of the Joint Waste Management Plans[1] (JWMP) have also been reviewed to identify any R&D related activities not formally captured in the TBuRD. Four

[1] These are produced on a six monthly basis as a plan of the delivery, transformational and opportunity activities being undertaken by SLCs to implement the UK LLW Strategy.

activities were identified (relating to new waste management route development for specific wastestreams that cannot be managed by standard waste management routes), again reflecting the needs-driven and development nature of R&D relating to LLW management.

A review has been conducted of the existing and planned assets and infrastructure available in the UK for the management of LLW. There have been significant changes in this since the 2010 Strategic Review. There have been developments since 2010 in the range of assets and infrastructure available for LLW management. One new commercial incinerator (the Veolia facility at Ellesmere Port) has received an Environmental Permit; and a number of on-site incinerators (predominantly the fleet of incinerators at Magnox Ltd) have closed owing to the impact of the Industrial Emissions Directive. Three commercial facilities for the disposal of Very Low Level Waste (VLLW) and Low Active LLW (LA-LLW) received Environmental Permits and planning permission in 2011. DSRL has made significant progress in the design and construction of a near-site disposal facility for LLW, which is expected to be operational in 2014. There have been significant developments made in the development and use of a diverse range of new packaging to support the use of these new routes. A transport service has been established by LLWR, through partnership with Direct Rail Services, to increase the utilisation of rail for the transport of LLW. The range of assets and infrastructure available in the UK for management of LLW directly supports the implementation of the UK LLW Strategy by facilitating and enabling the diversion of LLW away from disposal at the LLWR.

Costs and liabilities faced by NDA for LLW management include the full lifecycle costs for management and disposal of solid LLW and VLLW generated by operations and decommissioning of NDAs sites. This includes the design, construction, operation and decommissioning of any solid LLW management facilities as well as the cost of treatment, transport and disposal. A review of cost information from 2013 has shown the Nuclear Provision (NP) for LLW management is £7.60Bn, a reduction of £1.3Bn from the 2010 baseline. This has arisen from a reduction of costs associated with off-site disposal. Magnox Ltd is a significant contributor to the total costs and liabilities in 2013, possibly as a consequence of increases to the projected volume of LLW requiring management at final site clearance (FSC). The profile of annualised LLW costs across the NDA estate broadly follows the profile in the 2010 baseline, particularly in the post 2070 horizon. Costs in the period 2013 to 2070 follow the same profile as in 2010 but at a reduced cost.

One of the significant developments in the LLW management baseline since 2010 has been the establishment of the LLW National Programme. This National Programme enables coordination of the efforts within the NDA estate with regards to implementation of the UK LLW Strategy, and facilitates collaboration between waste producers, service providers and other stakeholders to enable the sharing of best practice and the optimisation of waste management practice. The National Programme has introduced the JWMP to take forward the previous LLW Management Plan and Acceleration of Element 2 Strategy (ACCELS) programme described in the 2010 Strategic Review, as a SLC focussed plan. A review of the ACCELS initiatives that remained incomplete in 2010 has been undertaken, and this demonstrates that 20 of the 29 initiatives were translated into the first (and where appropriate subsequent) iteration of the JMWP, and that the vast majority of these have been completed. The type of activities and initiatives has changed since 2010, reflecting the increasing maturity of arrangements within SLCs for the management of LLW and the fact that most SLCs have now opened and are actively using metal recycling, thermal treatment and VLLW routes. Activities in 2013 focus on optimising arrangements for these routes and managing specific non-standard wastestreams. This also reflects how waste diversion, one of the overriding themes of the UK LLW Strategy, has essentially become routine within the majority of the NDA estate. Waste diversion is predicted, on the basis of current operational and decommissioning plans, to yield cost avoidance of £164M over the next five year period compared to if the waste had been disposed of at LLWR.

The 2013 Strategic Review has demonstrated that good progress has been made in the UK LLW management community since 2010 in terms of strategy implementation and the adoption of more effective LLW management arrangements. A number of related issues, challenges and threats remain including: supply chain fragility; the loss of on-site LLW management infrastructure particularly in the Magnox and EDF fleet; inventory and waste forecast data quality; nuclear liability channelling arrangements for high volume VLLW (HV-VLLW) and LA-LLW; and ongoing uncertainties in LLW disposal capacity whilst the applications for the Environmental Permit and planning consent are reviewed and determined. Further work is being undertaken to manage these issues and threats in order to further improve and optimise LLW management arrangements in the UK.

Glossary

Term / Acronym	Definition
ACCELS	Acceleration of Element 2 Strategy
ADR	Carriage of Dangerous Goods Regulations 2009 (as amended)
AM	Asset management
BAT	Best Available Technique
Bn	Billion
BPEO	Best Practicable Environmental Option
BPM	Best Practicable Means
BS	British Standard
C&M	Care and maintenance
CLESA	Calder Landfill Extension Segregated Area
DOG	Delivery Overview Group
DRS	Direct Rail Services
DSRL	Dounreay Site Restoration Ltd
EA	Environment Agency
EPR10	Environmental Permitting Regulations 2010 [as amended]
ESC	Environmental Safety Case
EU	European Union
FSC	Final site clearance
FY	Financial year
HAW	Higher activity waste
HFC	High Force Compaction
HHISO	Half-height isofreight container
HVLA	High-volume low-activity waste
HV-VLLW	High-volume very low level waste
ILPDG	Integrated LLW Policy Development Group
ILW	Intermediate Level Waste
IPT	Integrated Project Team
IWS	Integrated Waste Strategy
JWMP	Joint Waste Management Plan
LFC	Low Force Compaction
LLW	Low Level Waste
LLWR	Low Level Waste Repository
Low Activity Low Level Waste (LA-LLW)	This is a waste classification not formally described in legislation or policy; describing a sub-category of LLW with a maximum concentration of radionuclides bounded by the upper definition of HV-VLLW (4 MBq/te) and the upper threshold of the Waste Acceptance Criteria for specified landfill sites (this is typically 200 MBq/te). There is a different limit for tritium in wastes containing this radionuclide. This is waste predominantly produced by the Nuclear Industry.

Term / Acronym	Definition
Low level waste (LLW)	Radioactive waste having radioactive content not exceeding 4 GBq/te alpha or 12 GBq/te beta/gamma.
LTP	Lifetime Plan
LTP10	Lifetime Plan 2010
LTP13	Lifetime Plan 2013
LV-VLLW	Low-volume very low level waste
M	Million
MEB	Multi Element Bottle
MRF	Metal Recycling Facility
NDA	Nuclear Decommissioning Authority
NORM	Naturally Occurring Radioactive Materials
NP	Nuclear Provision
NWP	LLW National Programme
OSD	On-site Disposal
ONR(RMT)	Office for Nuclear Regulations Radioactive Materials Transport Team
Out-of-scope waste (exempt waste in Scotland)	An article or substance that is not radioactive under the Environmental Permitting Regulations 2010 (as amended) for England and Wales, and the Radioactive Substances Exemption (Scotland) Order 2011.
PAS55	Publicly Available Specification 55
PCM	Plutonium contaminated material
PSWBS	Programme Summary Work Breakdown Structure
R2A2	Roles, responsibilities, authorities and accountabilities
R&D	Research and Development
RSA93	Radioactive Substances Act 1993
RSRL	Research Site Restoration Ltd
RWMD	Radioactive Waste Management Directorate
SED	Safety and Environmental Detriment
SEPA	Scottish Environmental Protection Agency
SLC	Site Licence Company
SQEP	Suitably Qualified and Experienced Person
SSSR	Sort, segregate and size reduction
TBuRD	Technical Baseline and Underpinning Research and Development
TFS	Trans-Frontier Shipment
TRL	Technology Readiness Level
UK	United Kingdom
UKRWI	UK Radioactive Waste Inventory

Term / Acronym	Definition
Very Low Level Waste (VLLW)	Low-volume VLLW (LV-LLW) is a sub-category of LLW (otherwise known as “dustbin loads”) including wastes that can be safely disposed of to an unspecified destination with municipal, commercial or industrial waste, each $0.1m^3$ of material containing less than 400kBq 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. This is principally generated by small users. High-volume VLLW (HV-VLLW) is a sub-category of LLW (otherwise known as “bulk disposals”) including wastes with a maximum concentration of 4MBq/te of activity that can be disposed of to specified landfill sites. There is a different limit for tritium in wastes containing this radionuclide. This is principally generated by the nuclear industry.
WAC	Waste Acceptance Criteria
WACM	Winfrith Abrasive Cleaning Machine
WAMAC	Waste Monitoring and Compaction Facility
WIDRAM	Waste Inventory Disposition Route Assessment Model
WRACS	Waste Receipt Assay Characterisation and Supercompaction Facility

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1. Introduction

The Strategic Review describes the baseline of the LLW management environment in the UK; to provide stakeholders with information on how LLW is managed in the UK at a given time and how management of LLW has changed since the previous Strategic Review. These are produced on a three yearly basis to align with the UK Radioactive Waste Inventory production cycle. The first Strategic Review (Strategic Review 2008) [Ref. 1] was published in January 2009 providing a comprehensive, up-to-date and robust assessment of the LLW baseline including potential challenges and opportunities. The Strategic Review 2008 provided the foundation for the development of the UK Nuclear Industry LLW Strategy [Ref. 2] and associated LLW Management Plan [Ref. 3]. A second Strategic Review [Ref. 4] was published in March 2011, providing an update to the Strategic Review 2008 and setting the LLW management baseline at the time of Strategy publication. This document is the third Strategic Review providing a "state of the nation" view of LLW management practice in the UK in 2013.

The period 2010-2013 has seen significant change in LLW management practices within the UK; primarily as a consequence of efforts to implement the National LLW Strategy [Ref. 2]. SLC waste strategy has changed, to reflect different practices following implementation of the National LLW Strategy and, owing to a range of new waste routes becoming available via the supply chain, waste diversion has become routine across the NDA estate, except for DSRL where restrictions imposed by their current RSA93 Authorisation and their default waste management option of disposal to a near-site disposal facility precludes waste diversion. There have been improvements in inventory management and inventory derivation, reflected in changes to the UK Radioactive Waste Inventory (UKRWI) [Ref. 5]. The period 2010-2013 has also seen significant change through the introduction of the LLW National Programme, led by LLW Repository Ltd on behalf of NDA, to coordinate activities across the NDA estate relating to LLW management and to maximise opportunities for collaboration between waste producers and stakeholders. This LLW Strategic Review aims to reflect these changes to the LLW management baseline. This review has expanded the analysis undertaken in 2008 and 2010 in that it has widened the number of "waste management aspects" considered by the review to incorporate a review of research and development pertaining to LLW management, as well as a comprehensive review of the trends in actual waste management practice within the UK nuclear industry in terms of performance in waste disposal and waste diversion.

The aims and objectives of the 2013 Strategic Review are:

- To update the UK LLW baseline for 2013.
- To 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.
- To provide a knowledge base to inform the NDA review of the UK LLW Strategy in 2014.

This report focuses on the management of solid radioactive wastes from the NDA and non-NDA estate. Some elements of the report (notably LLW strategy, cost baseline and research & development) are considered on a purely NDA estate basis owing to the paucity of available information for these elements for the non-NDA estate. Land contamination, contaminated groundwater and liquid and gaseous discharges are excluded from the review.

2. Background

2.1. The Strategic Review

The LLW Strategic Review provides a comprehensive national baseline describing LLW management strategies, assets and infrastructure, research and development, inventory, waste management performance, and cost/liabilities. The Strategic Review informs the NDA's strategic decision making, the development of Nuclear Industry LLW Strategy and its associated implementation plans; as well as providing a key source of information on LLW management in 2013 to a range of stakeholders such as regulators, planning authorities and the supply chain. This document is the third iteration of the Strategic Review (following earlier iterations published in 2009 [Ref. 1] and 2011 [Ref. 4]).

2.2. UK Nuclear Industry LLW Strategy

The UK Nuclear Industry Low Level Waste Strategy [Ref. 2] was developed between 2008 and 2010 by NDA in partnership with LLWR and involved consultation with government, waste producers, regulators, planning authorities and other key stakeholders.

The Strategy, and its accompanying Strategic Environmental Assessment [Ref. 6], was published for consultation in June 2009. Following this consultation, the strategy was updated and approved by Government in August 2010. The key themes of the strategy were application of the waste management hierarchy, making best use of existing assets and the opening of new fit-for-purpose waste management routes.

The 2010 Strategy focussed entirely on the nuclear industry. Other LLW management strategies have been developed since 2010. A LLW management strategy for the non-nuclear industry (excluding Naturally Occurring Radioactive Material (NORM)) was developed and published by Government in March 2012 [Ref. 7]. This strategy advocates appropriate application of the Waste Hierarchy and making optimum use of the existing network of waste management facilities in the UK. A strategy for the management of NORM has been developed and is undergoing consultation; it is anticipated that this will be published in 2014 [Ref. 8].

2.3. National LLW Programme

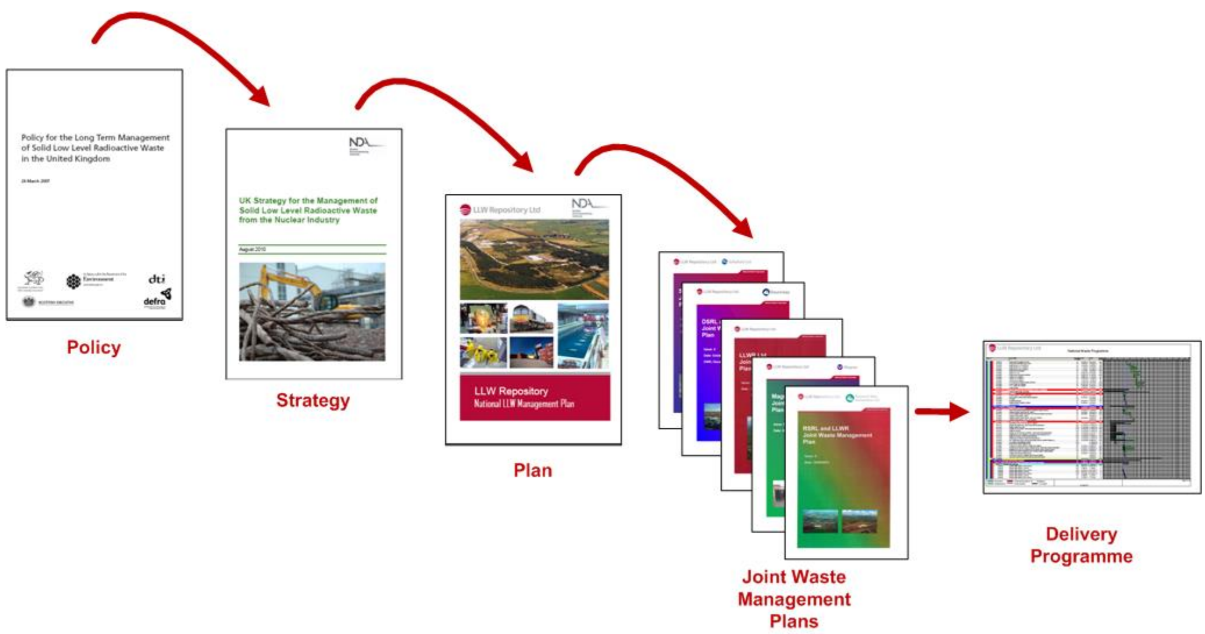
LLW Repository Ltd, as a component of its first contract with the NDA, played a key role in the development of the UK Nuclear Industry Low Level Waste Strategy during 2008 and 2009. In 2009, the NDA requested that LLW Repository Ltd enhance its role as the "UK Integrator" for LLW management within the NDA estate. In response to this, LLWR developed and implemented the ACCELS programme, representing a programmatic approach to the implementation of the National Strategy in the UK (as described in the 2010 Strategic Review [Ref. 4]). This programmatic approach was further enhanced in April 2011 when the NDA established a formal LLW National Programme, which is led on its behalf by LLW Repository Ltd. The National LLW Programme builds on its predecessor (the ACCELS programme), to support implementation of the UK LLW Strategy in a timely and cost effective manner to optimise and prolong the lifetime of the LLWR site, ensuring sufficient capacity for the management of the UK's LLW. The vision for the National LLW Programme is to deliver a reduction in the multi-billion pound Nuclear Provision and to avoid the necessity for construction of a second LLWR site.

2.4. Evolution of the National LLW Management Plan

A National LLW Management Plan [Ref. 3] was developed in parallel with the National LLW Strategy in 2008 – 2009. The National LLW Management Plan was first issued in 2009; and comprised a set of initiatives to begin to transform management of LLW in the UK nuclear industry. It was structured to reflect the Waste Hierarchy.

Over time, the National LLW Management Plan has evolved into a series of plans (the Joint Waste Management Plan (JWMP)) which deliver the ongoing strategy implementation activities and operations of LLW consignors. The first iteration of these JWMPs, produced collaboratively by the LLW consignors within the NDA estate and LLW Repository Ltd, were published in August 2011 and further iterations have subsequently been published on a six-monthly basis thereafter. The JWMP provides a rolling five year look-ahead; structured into seven sections including delivery (business-as-usual) activities, transformational activities, opportunities, flywheel projects, a five year waste forecast, a benefits map and a summary of the projected costs/benefits associated with the plan. These sections are organised using a common work breakdown scheme (described in Ref. 9). Recently, the JWMP has been developed into a three-tier approach such that the level of the JWMP can be appropriately tailored to the needs of organisations of differing size and complexity. For example, smaller organisations generating less waste have a much less detailed plan compared to larger generators.

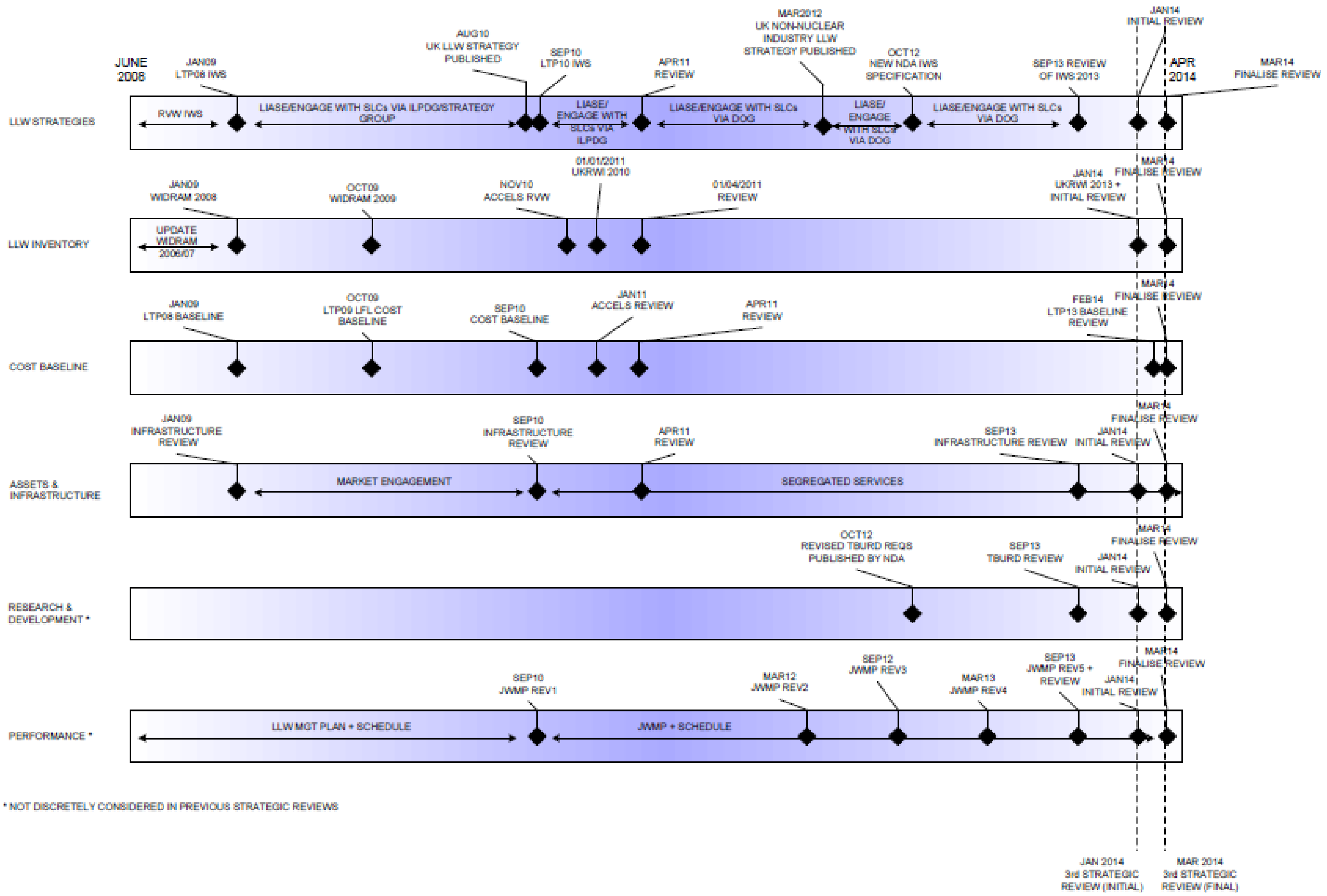
Figure 1 – Evolution of the LLW Management Plan to JWMP



3. Strategic Review Process

Figure 2 provides a timeline of the evolution of each of the LLW Strategic Review elements.

Figure 2 – The evolution of the LLW Strategic Review Elements



As illustrated in Figure 2, a range of activities have been undertaken by NDA estate SLCs and LLWR to support implementation of the National Strategy. There has been significant engagement with SLCs and other stakeholders via the Delivery Overview Group (formerly the LLW Strategy Group and the Integrated LLW Programme Development Group (ILPDG)) and the Regulatory Liaison Group.

The 2013 Strategic Review will inform ongoing implementation of the National LLW Strategy through the National LLW Programme and SLC-specific Joint Waste Management Plans (JWMP), as well as providing a a baseline to inform the next iteration of the National LLW Strategy, which is programmed for publication in summer 2015.

4. Baseline

4.1. Approach to baseline compilation

The UK LLW baseline is described in terms of the following interrelated elements:

- Current site LLW management strategies (integrated waste management strategy)
- Projected waste arisings within the LLW National Inventory
- Costs and liabilities associated with LLW management
- Waste management performance (in terms of diversion vs. disposal)
- Research and development plans
- Assets and infrastructure (existing and planned) for LLW management

The UK LLW generators included within the scope of this review are summarised in Table 1 below.

Table 1 – Summary of sites included within scope of Strategic Review 2013

SLC / Organisation	Site	Relevant Baseline Elements
Sellafield Ltd	Sellafield	All aspects
Magnox Ltd	Berkeley	All aspects
	Bradwell	
	Chapelcross	
	Dungeness A	
	Hinkley Point A	
	Hunterston A	
	Oldbury	
	Sizewell A	
	Trawsfynydd	
	Wylfa	
Research Sites Restoration Ltd (RSRL)	Harwell	All aspects
	Winfrith	
Dounreay Site Restoration Ltd (DSRL)	Dounreay	All aspects
LLW Repository Ltd	LLWR	All aspects
Non-NDA estate	Capenhurst (Capenhurst Nuclear Services and Urenco)	Inventory; Waste Management Performance; Assets and Infrastructure. Information pertaining to the other aspects is not sufficiently available to enable detailed analysis in this document.
	Springfields (Westinghouse)	
	AWE Aldermaston (AWE/MoD)	
	Clyde, Rolls Royce, Devonport, Rosyth (MoD)	
	Torness, Hinkley Point B, Sizewell B, Hunterston B, Dungeness B, Hartlepool, Heysham (EdF Energy)	
	Other small producers	

No data has been included for new nuclear power stations as the size, number and location are still somewhat uncertain and subject to investment decisions over the coming years. No data has been included for small generators of NORM or LLW outside of the nuclear industry, other than where the volumes are already included within the UKRWI.

The baseline aspects described have been summarised for each site in Table 1 from key sources of information. This information has been "rolled up" to provide a national perspective for the NDA estate and/or NDA/non-NDA estate as required. The key findings from the compilation of the LLW baseline are described in more detail in sections 4.2 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.

4.2. LLW Inventory

The reporting of Low Level Waste (LLW) information is required by various international obligations. A United Kingdom Radioactive Waste Inventory (UKRWI) is generated every three years to satisfy the following requirements:

- European Commission (EC) periodic reporting on radioactive waste, spent fuel quantities, summary of national strategies and other pertinent information.
- International Atomic Energy Agency (IAEA) joint convention on the 'Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management'.

LLW inventory information reported is used by strategic authorities such as the NDA, to implement government policy on the management of radioactive waste and to underpin plans for the clean-up and decommissioning of civil nuclear facilities. Waste forecasts are also used by the supply chain to inform investment decisions. Waste producers are the primary users of UK LLW inventory data in support of site safety cases, planning applications and operations planning; as well as informing other bespoke assessments and programmes of work.

4.2.1. Review Approach

An analysis of the LLW inventory for the UK has been undertaken through a review of the UKRWI 2013 [Ref. 5, 10-11]. This review has focussed on: volumes; inventory composition; regional distribution; activity distribution; and retrospective analysis against UKRWI 2010 [Ref. 12]. As part of the 2013 UKRWI LLW inventory analysis presented in this section, volume, radioactivity and materials data has been categorised into the 'LLW' or 'VLLW' category based on each individual waste streams' total activity (with VLLW classified as waste with specific activity less than 200Bq/g). However, the formally published 2013 UKRWI document suite presents the data as categorised by each contributing waste organisation. Consideration has also been given to the inventories of particular sub-sets of the inventory notably waste arising from management of land that has been contaminated, orphan waste, ILW/LLW cross boundary wastes and NORM. General issues with data quality and data granularity identified during the review have been identified and are discussed as part of this review.

4.2.2. Summary of findings

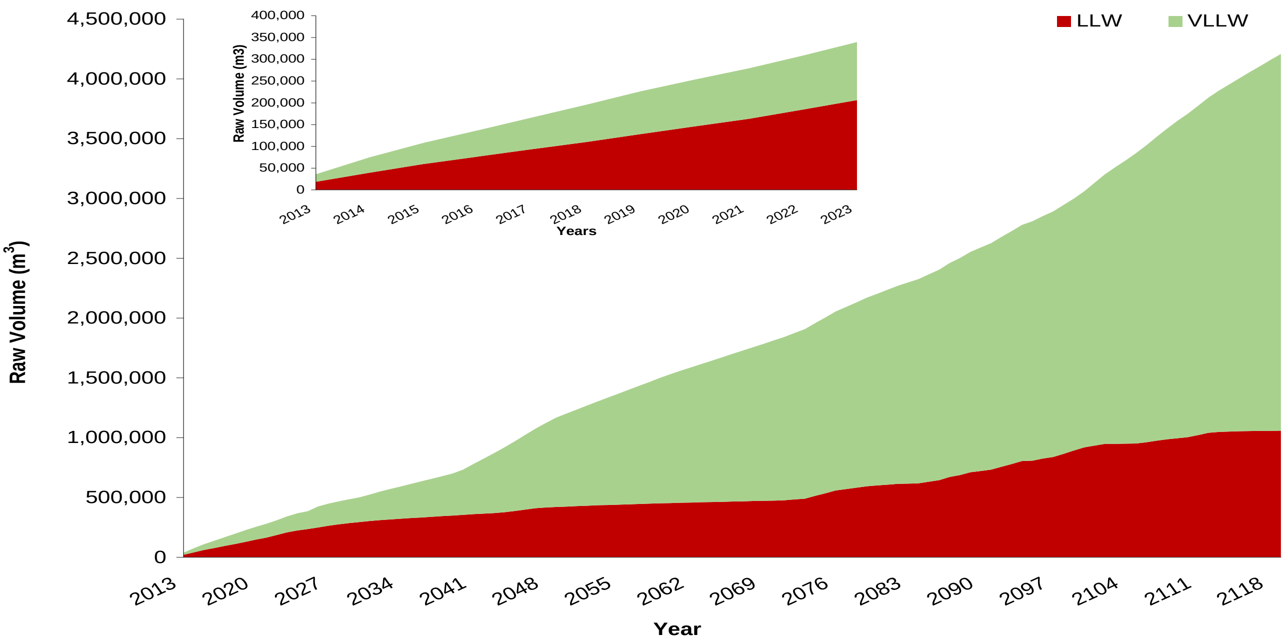
4.2.2.1 Volumes

There is a total raw volume of around 4.2 million m^3 LLW/VLLW forecast to be generated up until 2120, the current end date of the NDA's decommissioning programme (shown in Figure 3). Around 90%, or 3.78 million m^3 of this forecast will be generated by NDA SLCs, with the largest volume arising at Sellafield Ltd (3.1 million m^3).

The most significant period of waste generation is forecast to occur between 2040 and 2050 from increased decommissioning activities at the Sellafield and Springfields sites. Waste is then produced gradually until about 2080 when the rate of annual waste arisings increases as a result of final site clearance work on a number of Magnox Ltd sites.

It should be noted that 88%, or 2.76 million m^3, of the total Sellafield Ltd LLW inventory is associated with one large decommissioning waste stream (ID Reference 2D148) which is scheduled to start arising in 2021 for approximately 100 years. In order to maintain alignment with the 2013 UKRWI inventory report, 2D148 has been retained within the analysis carried out in this section. However, for information purposes Appendix A of this report provides the same inventory figures excluding this waste stream.

Figure 3 –Cumulative (stacked) forecast raw arisings of UK LLW and VLLW



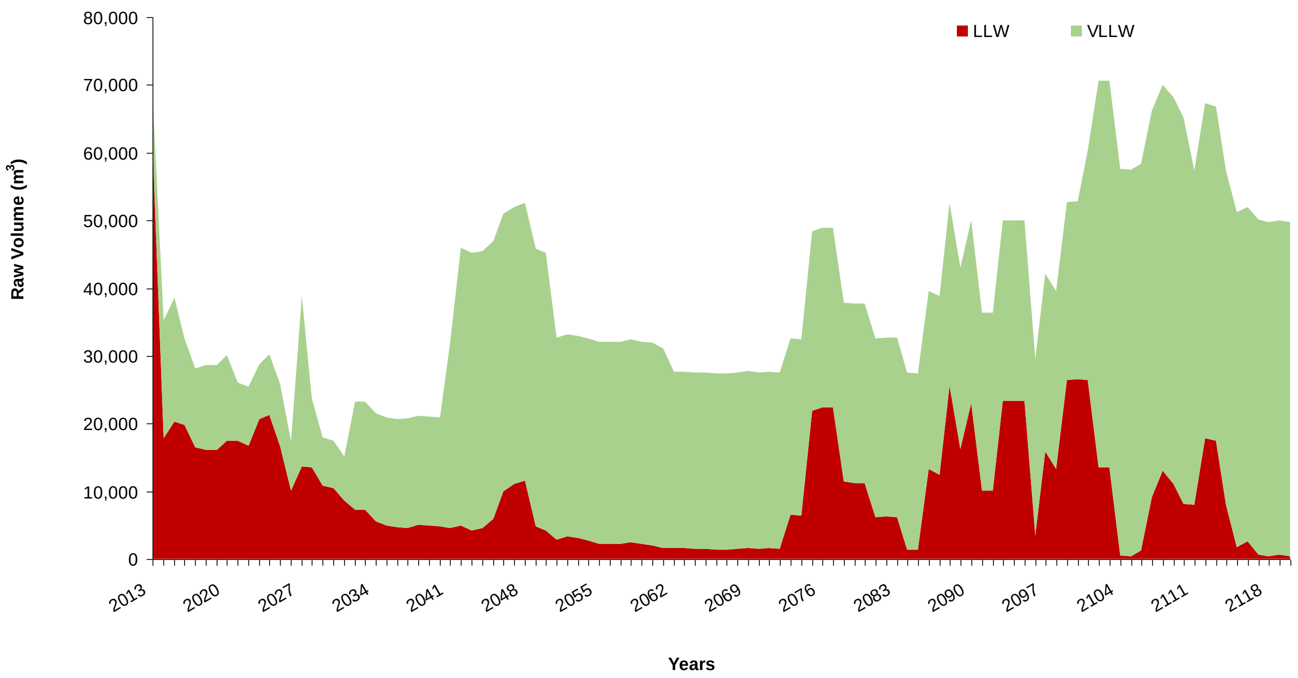
As can be seen from the smaller graph inset in Figure 3, arisings over the period 2013 to 2023 are dominated by LLW volumes as opposed to VLLW, which dominates over the lifetime of the inventory. Approximately 350,000 m^3 of waste is forecast to be generated over the next 10 years, with the main contributors being Dounreay and several Magnox Ltd sites who are entering the Care & Maintenance phase of their decommissioning lifecycle. It should be noted that waste produced at the Dounreay site will not be consigned to the LLWR but will be disposed in the Dounreay near-site LLW repository.

Figure 4 shows the raw arisings of LLW and VLLW over time.

The rate of LLW generation is expected to average around 10,000 m^3 per annum over the next 40 years. Between 2040 and 2050 LLW arisings average 5,000 m^3 per year, peaking at 11,500 m^3 in 2047 due to decommissioning work at Sellafield and Sizewell A. Waste arisings between 2050 - 2070 decline to volumes around 2,000 m^3 because of a reduction in decommissioning activity. Between 2070 - 2120 LLW arisings are sporadic and linked to final site clearance at several Magnox Ltd sites, as well as decommissioning activities at Sellafield Ltd.

There is a broad correlation between the peaks, which correspond to key decommissioning activities around the estate (particularly for Springfields and Sellafield decommissioning activities); with the exception of a broad plateauing of LLW volumes between 2050 and 2075, but a more gradual series of step changes in VLLW volumes during this horizon. The 2D148 waste stream is responsible for the large volumes forecast between 2040 and 2050, and post 2090.

Figure 4 – Annual (stacked) raw arisings of UK LLW and VLLW



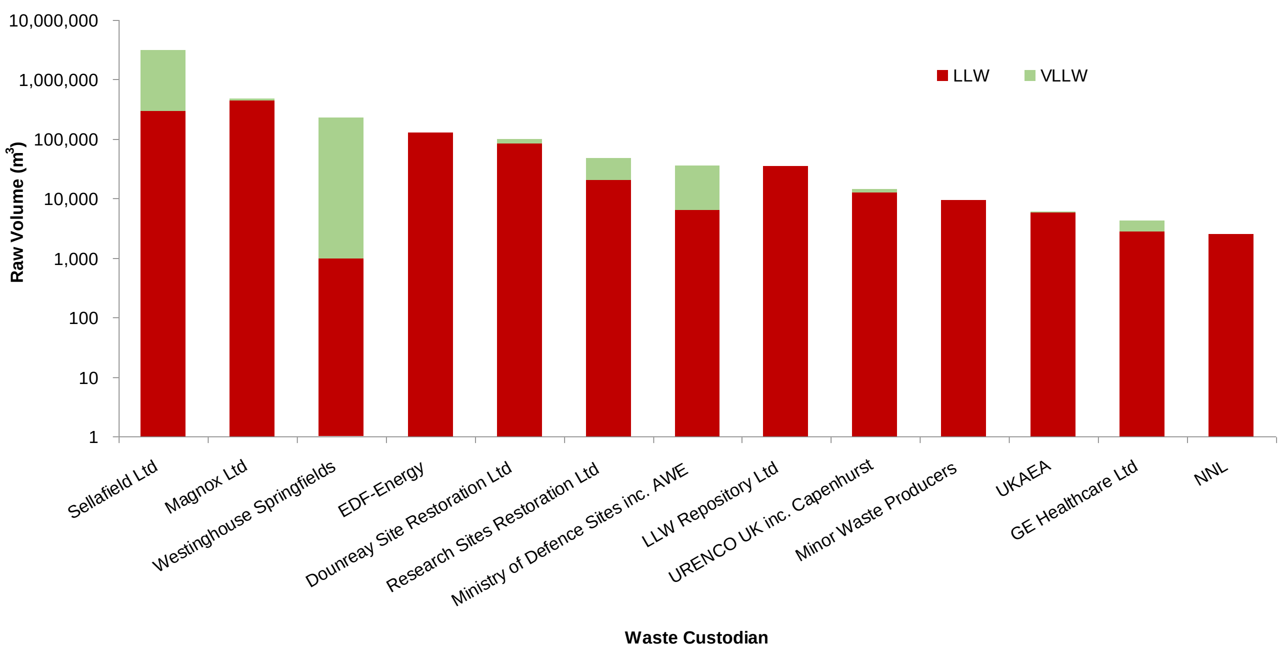
The collective raw volume of United Kingdom LLW and VLLW by waste producer is shown in Figure 5. Sellafield is the major waste producer, generating 3.1 million m^3. Magnox Ltd is the second largest generator, with over 470,000 m^3 and indeed, if waste stream 2D148 is not included, Magnox Ltd would be the largest producer of LLW and VLLW. Magnox are also forecast to contribute the greatest amount of LLW, some 453,207 m^3 between 2013 and 2120.

When considering the forecasts for VLLW, Westinghouse Springfields is forecasting to generate the second largest volume of VLLW (after Sellafield Ltd), amounting to around 220,000 m^3 over the lifetime of the inventory. As noted earlier in this section, the Sellafield Ltd VLLW inventory is dominated by waste stream 2D148 which projects arisings in the order of 2.76 million m^3.

It is anticipated that VLLW volumes will increase further for the majority of UK waste producers as improvements are made to sites' waste characterisation and segregation practices.

Overall the NDA estate contributes around 84% or 890,984 m^3 of the total LLW/VLLW inventory. Non-NDA sites such as EDF-Energy, Westinghouse Springfields, URENCO and Ministry of Defence (MoD) also collectively forecast significant volumes of LLW and VLLW.

Figure 5 – Raw (stacked) waste arisings of UK LLW and VLLW by Waste Custodian (note the logarithmic scale)



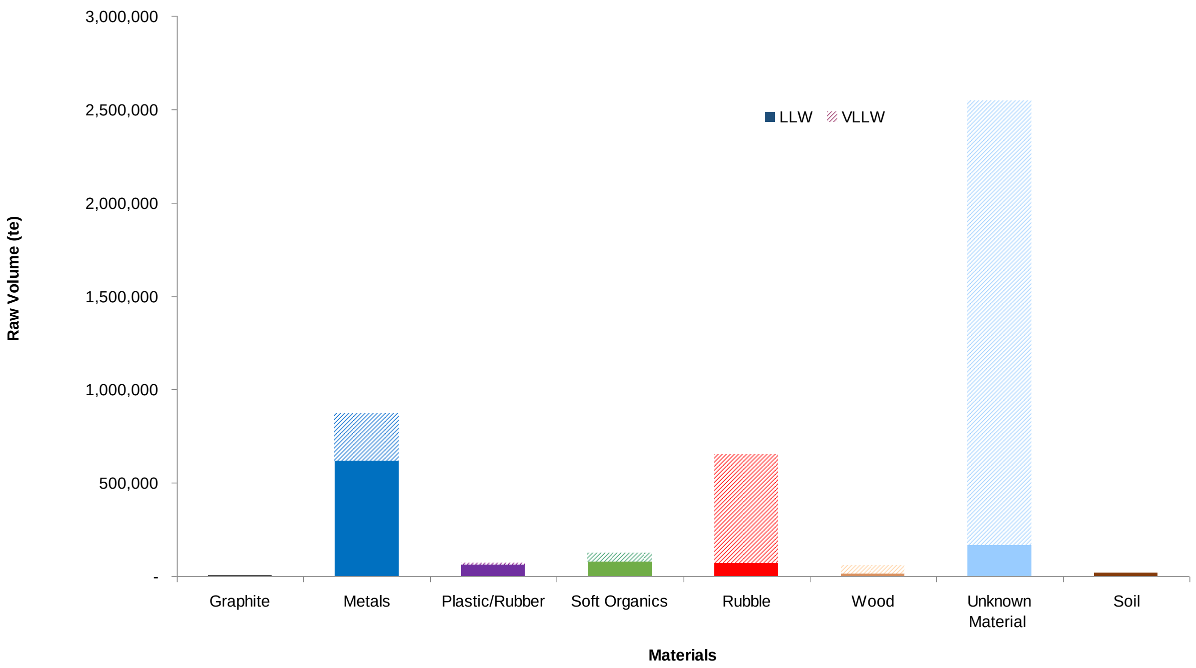
4.2.2.2 Inventory Composition

The total LLW and VLLW volume reported in the 2013 UKRWI amounts to some 4,2 million m^3, which is broadly equivalent to 4,3 million (te) when converted to mass based on the reported densities for each waste stream. The waste is made up of a broad spectrum of materials including concrete, rubble, soils, plastics, ferrous and non-ferrous metals, cellulosic materials and unknowns for all waste streams. Figure 6 shows the total inventory composition.

Of the total reported mass, the NDA estate SLCs forecast 2.5 million te of arisings. From the Non-NDA estate, EDF-Energy has the largest forecast, of around 33,000 te.

Within these numbers, arisings of LLW are dominated by metals arising from certain Magnox sites (Trawsfynydd, Bradwell and Oldbury) and Sellafield Ltd.
VLLW is dominated by the UKRWI 'unknown materials' category (2.3m te material), principally from Sellafield and Springfields[2]. As decommissioning programmes mature, this waste will be better characterised, either causing an increase in the other composition categories or becoming out of scope/exempt. Rubble is the second largest category of VLLW with Sellafield and RSRL generating the largest amount (532,609 and 33,174 tonnes respectively). The forecasts indicate that 99.5% of VLLW will come from the NDA estate, with the Ministry of Defence making up the remaining 0.5%.

Figure 6 – Raw waste arisings of UK LLW and VLLW by Waste material (te)



The arisings of LLW by material content over time are shown in Figure 7, showing that the majority of waste will be metals, with also some varying amounts of unknown material to be characterised later.

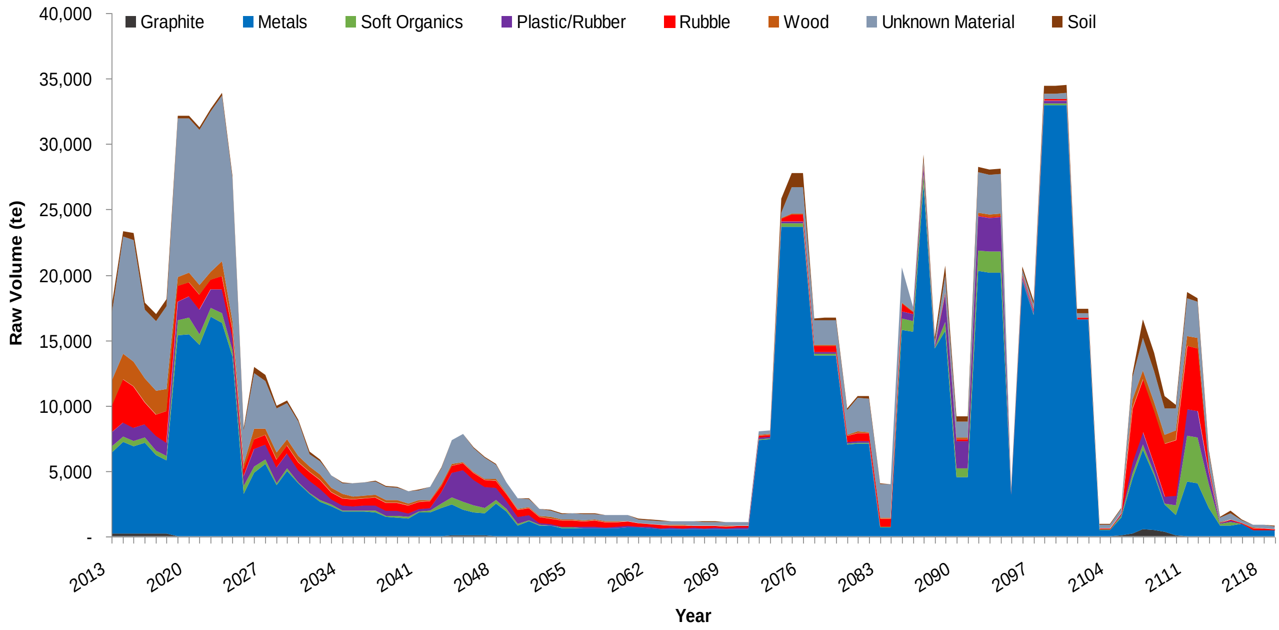
The trend of metal arisings over time reflects the phasing of decommissioning projects. Almost 160,000 te arise between 2013 and 2033 (8,000 te per annum). The rate of metals then gradually slows to 831 te per annum until rising to a peak of 10,830 te per annum in the period between 2064 and 2100. These peaks align with the Sellafield and Magnox decommissioning programmes.

Combustible materials, including plastics and rubber, soft organics and wood show a similar trend over the time period, with higher average annual volumes between 2013 and 2033 (2,700 te per annum); then a reduction after this time to 752 te per annum.

[2] 'Unknown materials' are those which are not characterised adequately to enable categorisation or those which have been broadly characterised but are not divisible into specific waste types.

The trend for soil and rubble arisings again reflects the decommissioning programmes for the site, with higher volumes generated between 2013 and 2033 (a total of 30,915 te, averaging at 1,545 te per annum); slowing to 440 te per annum over the following period 2034 to 2063. There is a sharp increase in rubble arisings after 2105, when there will be final demolition of buildings at sites.

Figure 7 – Annual LLW arisings only by material content (te)

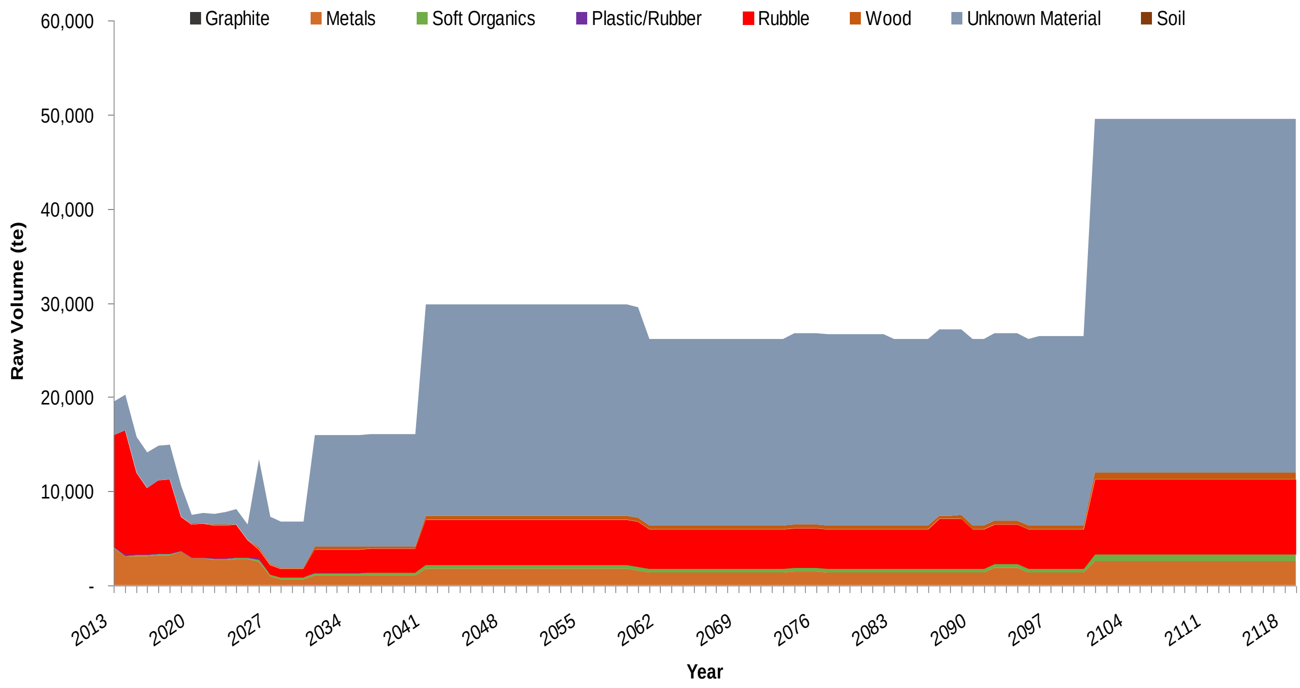


*Note: This figure assumes that the annual waste arisings for each waste stream have a standard composition.

The arisings of VLLW by material content over time is shown in Figure 8. The most significant proportion of VLLW will be generated post 2040 when final site clearance is occurring at the Magnox sites and decommissioning at Sellafield is increasing pace.

In terms of VLLW, the overwhelming category throughout the period is ‘unknown material’ Rubble is the second largest contributor to VLLW volumes, with a forecast arising during period after 2100 of 143,175 te, or 7,158 te per annum.

Figure 8 – Annual VLLW arisings only by material content (te)



*Note: This figure assumes that the annual waste arisings for each waste stream have a standard composition.

4.2.2.3 Regional Distribution of LLW and VLLW

LLW and VLLW are widely distributed throughout the United Kingdom due to the geographical distribution of nuclear sites. The majority of waste is held at sites owned by the NDA on behalf of the UK government. However, there are also significant volumes of waste at Ministry of Defence (MOD) and sites managed by commercial operators such as EDF Energy. The UK regional distribution of both LLW and VLLW raw volumes for the lifetime of the inventory are shown in Figure 9.

Over 42% of material arisings are from the North West (mainly categorised as unknown), with the second and third largest contributors seen to be the South West and Scotland respectively.

4.2.2.4 Activity Distribution

In the United Kingdom LLW is defined as radioactive waste having a radioactive content which does not exceed 4 GBq/te of alpha or 12 GBq/te of beta/gamma activity. VLLW is defined as having less than 4 Bq/g total activity and LA-LLW not greater than 200 Bq/g total activity (note that LA-LLW is not a formal definition). In addition to the volume and material data provided by waste producers, radiological data on the activity of each waste stream is also required within inventory submissions. This is reported as ‘Total activity by stream’; and is then split into specific radionuclides for each waste stream.

Figure 9 – UK Regional Distribution of Raw LLW and VLLW Volumes (2013 – 2120)

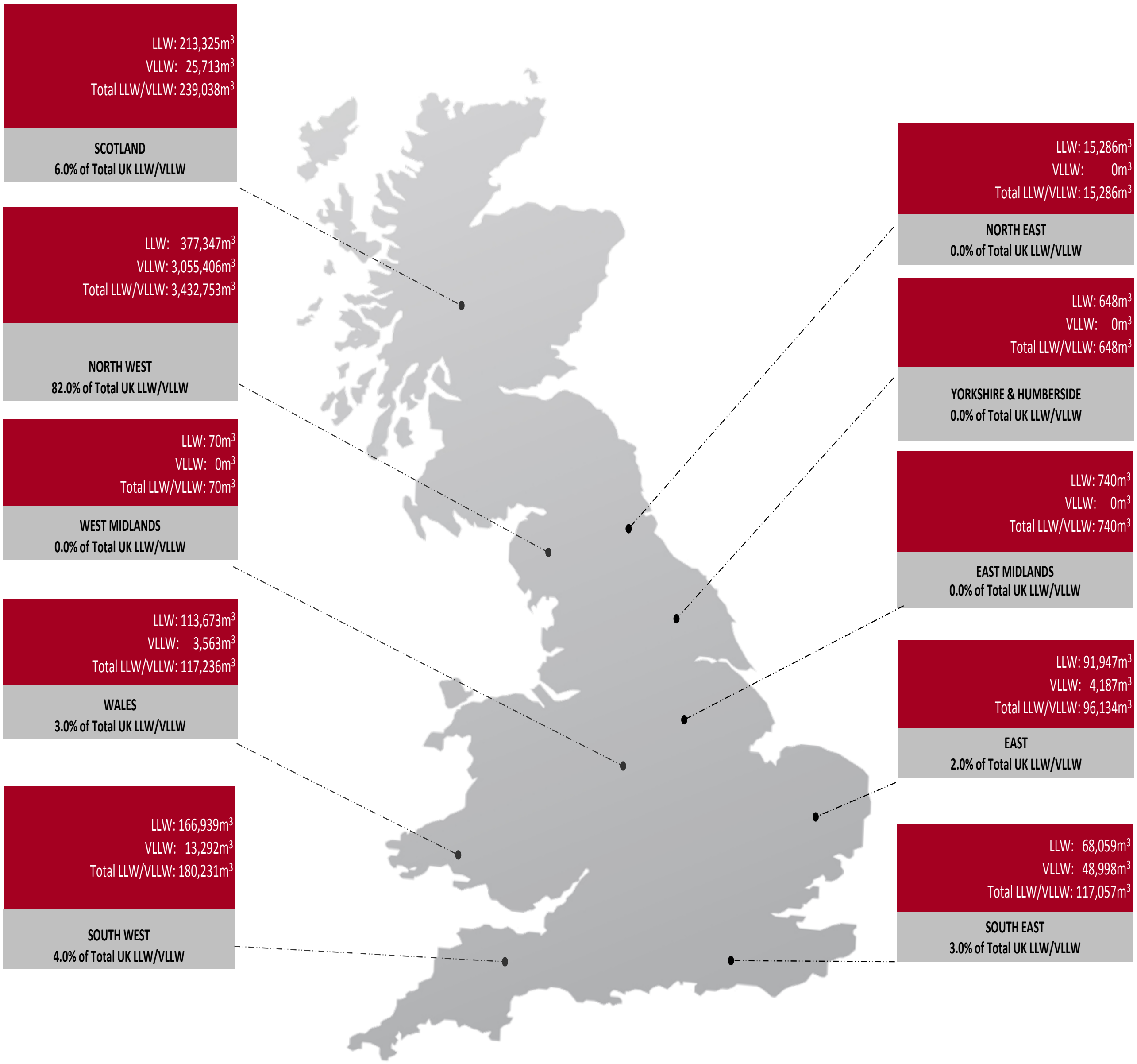
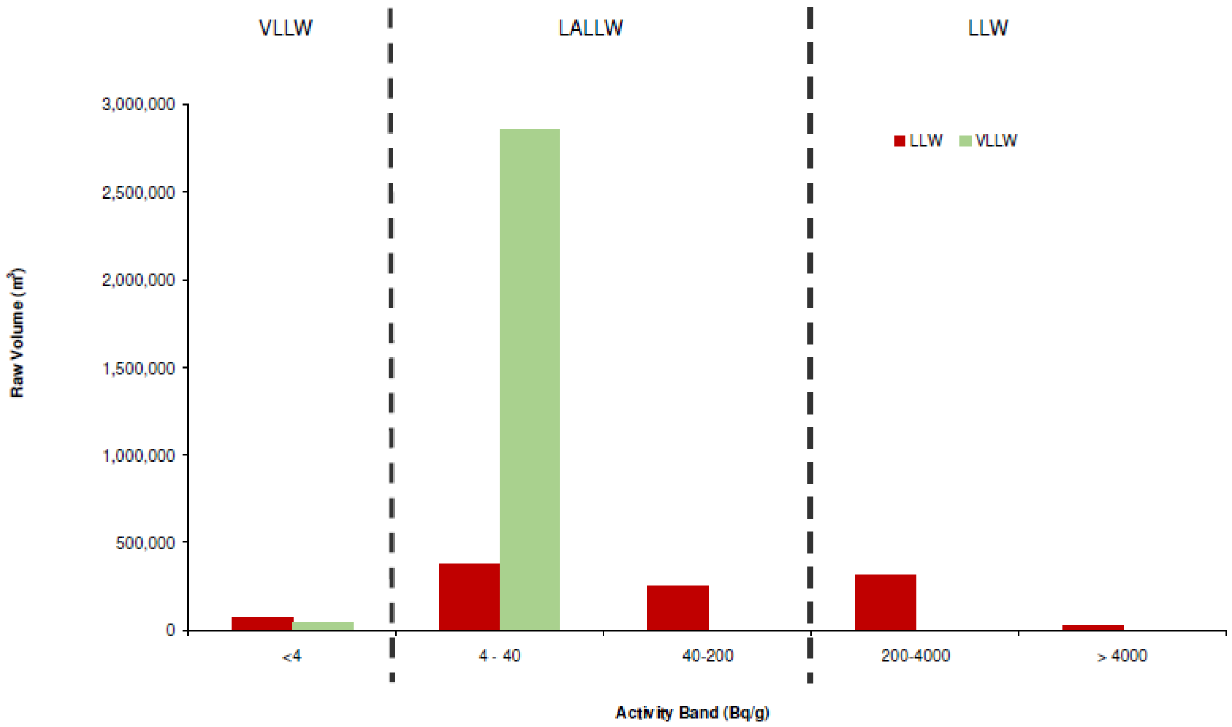


Figure 10 shows the activity distributions of LLW and VLLW volumes. Some LLW waste streams have activity levels below both the LA-LLW and VLLW limits; whereas 2.85 million m^3 of the VLLW volume is identified as over the VLLW limit, but within the LA-LLW limit (so this waste would still be suitable for disposal at an appropriately permitted landfill site). The bulk of this volume is the 2D148 waste stream.

Figure 10 – Activity distribution of LLW and VLLW volumes



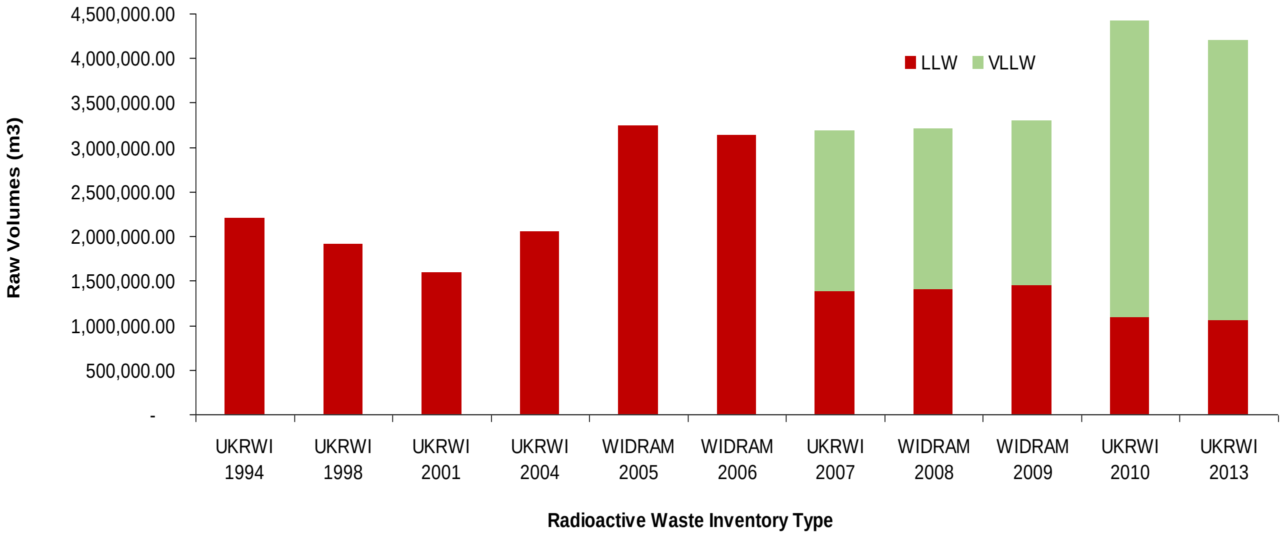
It should be noted that 5 of the 655 waste streams did not provide any activity information as well as stock/future arising volumes in the 2013 UKRWI, which will result in slightly underestimated results. Nonetheless, based on the provenance of these wastestreams, it is believed that this activity remains a very small fraction of the total activity from all wastes.

4.2.2.5 Retrospective volume analysis of the 2010 UK Radioactive Waste Inventory against previous inventories

Forecast LLW volumes have varied significantly since the first UKRWI in 1984 and continue to do so. Compared with the 1994 UKRWI there has been a 1.14 million m^3 reduction in the LLW volumes in the 2013 UKRWI; and there has also been a reduction between the 2010 UKRWI and the 2013 edition (of 35,000 m^3). LLW volumes in the 2013 inventory are at their lowest - at close to 1 million m^3 - since records began. This reduction in LLW inventory volumes can probably be attributed to the improved data sets derived using innovative inventory derivation/validation techniques (e.g. the Magnox Ltd SMART inventory process), improved forecasting methods and recategorisation of waste as VLLW.

Since the introduction of VLLW as a category in 2007 UKRWI, and owing to ongoing waste management, the LLW proportions have decreased significantly with VLLW volumes accounting for at least 50% of the overall LLW inventory. For the 2013 UKRWI, VLLW is closer to 75% of the total inventory. Figure 11 shows the LLW and VLLW volumes recorded by the 2013 UKRWI compared against previous inventories.

Figure 11 – Overview of Radioactive Waste Inventories since 1994



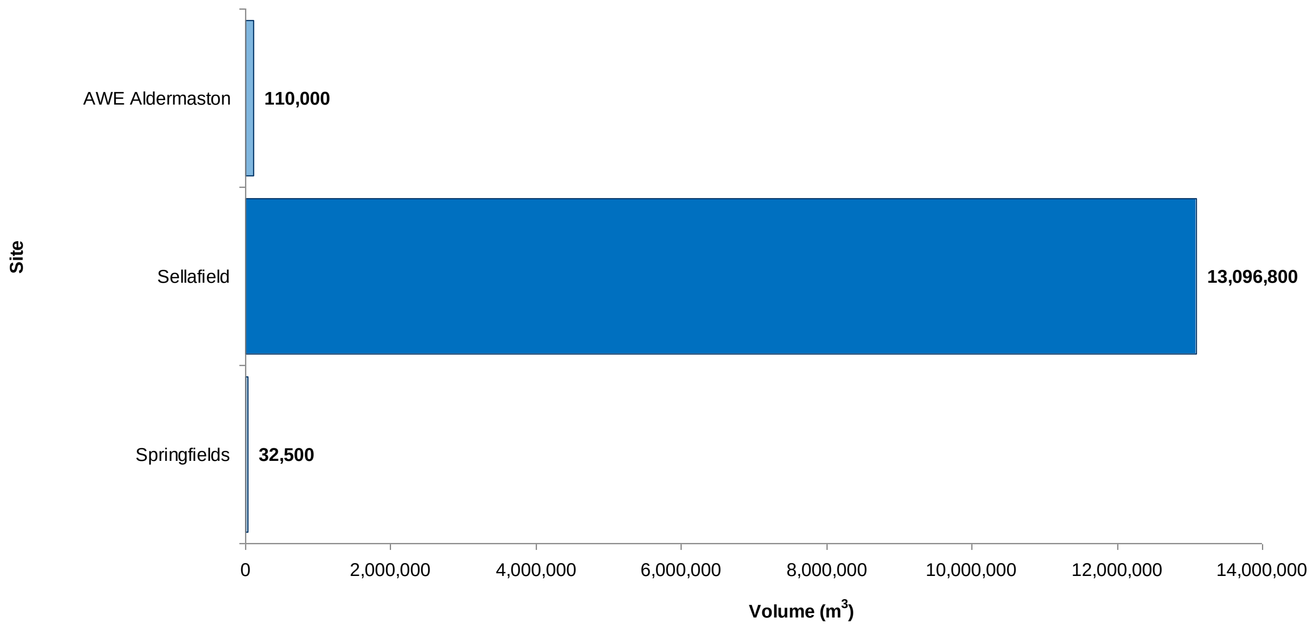
4.2.2.6 Potentially contaminated land

A supplementary report to the 2013 UKRWI describes the volumes of potentially contaminated land in the UK [Ref. 13].

1.4 million m^3 of potentially contaminated land has been identified by waste producers. As can be seen in Figure 12, the North West region accounts for 98% of the UK's contaminated land, linked to the Sellafield waste stream 2D154 (11.8 million m^3 of HV-VLLW Contaminated Soil from Site Clearance). The management of potentially contaminated land at Sellafield is still under development, with large waste streams likely to be re-characterised and diverted from the LLW Repository.

It is important to note that Springfield and AWE Aldermaston arisings are based on limited analysis and further work is required to give improved estimates.

Figure 12 – Potentially Contaminated Land Stock and Future Arisings from 2010–2120 (m^3)



4.2.2.7 Orphan wastes

Orphans, or problematic wastes, are those which cannot be managed via standard, conventional waste management routes as a consequence of their physical, chemical and/or radiological properties. The UK RWI includes information on the national inventory of such orphan/problematic LLW, with an overall volume of 10,936m^3 arising from 19 wastestreams [Ref. 14]. There is evidence that this does not reflect the total orphan waste inventory in the UK, and further work is required with SLCs to identify "informal" inventories of such wastes to produce a clearer understanding of the nature and extent of the LLW orphan waste inventory in the UK.

4.2.2.8 ILW / LLW cross boundary wastes

A category of waste which is of increasing interest within the UK nuclear industry is that of ILW/LLW cross boundary waste. This waste is that with activities close to the boundary between ILW and LLW; and that potentially may be managed as ILW or LLW subject to appropriate characterisation and conditioning. Such wastes could, if managed as LLW, contribute to an increase in the total volume of waste disposal at the LLWR site but would reduce the volume of waste to be disposed of to the Geological Disposal Facility (GDF). Such wastes described above are typically currently classified as ILW in the 2013 UKRWI but may contribute to the total volume disposed at LLWR. As a result, further work may be required to identify these waste streams. It was found that several waste streams had calculated activities that would be considered as ILW prompting an urge to re-evaluate such streams. These include 9B960 (Bradwell) and 9C950 (Dungeness A) with activities of 171 and 671 MBq/g. An initial study into establishing an inventory of such cross-boundary waste identified an upper bound volume of 1,416,00m^3 [Ref. 15], although this was based on an analysis of UKRWI 2010 [Ref. 12]. A number of work streams are currently being progressed by LLW Repository Ltd and the Radioactive Waste Management Limited Upstream Optioneering project to develop an improved, bounded inventory assessment for such cross-boundary wastes.

There will be a proportion of LLW (expected to be relatively small) which is not suitable for management as LLW and will require management as higher activity waste.

4.2.2.10 NORM Waste

It is recognised that NORM waste arisings are predominantly not included within the UKRWI 2013. DECC and the Scottish Government are currently developing a strategy for the management of NORM waste for the UK [Ref. 8], and this should provide information regarding the nature and volume of the NORM inventory for the UK.

4.2.2.11 Inventory Issues

During the collation of information for this review, several areas have been identified to improve data reporting and to strengthen the baseline data.

LLW inventory information is currently collated and managed using several data sets. These include the UKRWI, Waste Inventory Form (WIF) data and bespoke data sets used by sites. The issue with using multiple data sets is that they have different reporting formats, timescales and assumptions which result in a lack of alignment between data sets. Although progress is being made to merge and strengthen some of these data sets, further work is required to improve and refine the LLW dataset. This would improve the short and long term forecasting, liability estimating and strategic planning.

As already noted, the 2D148 waste stream has been included in the analysis; despite its high volume impacting the results. Appendix A provides the analysis of the inventory data without the waste stream. It is expected that this waste stream will be re-characterised and may be declared as out of scope in future inventories. Better characterisation of all waste streams and application of the waste hierarchy will encourage SLCs to improve disposal estimates, as well as to identify methods of diverting waste from the limited space at the LLW Repository Ltd.

There were found to be numerous issues with the initial UKRWI data sets with the majority resolved once identified in a UKRWI gap analysis:

- Five waste streams were found to have no stock or future arising volumes.
- When analysis was completed on the potential activities of waste streams it was found that several recorded activities higher than LLW limits. These waste streams will have to be reviewed, since they could not currently be sent to LLWR without treatment.
- Some waste streams identified as LLW had activities which were VLLW and vice versa.
- Some waste streams had material contents above or below 100%

Data quality and data analysis would be improved if SLCs and waste producers took action to resolve these issues.

4.3. LLW Management Strategy

4.3.1. Review Approach

SLCs within the NDA estate are required by the NDA to produce and maintain an Integrated Waste Strategy (IWS) in accordance with the specification contained in ENG01 [Ref. 16]. The Integrated Waste Strategy is defined in ENG01 as a strategy which describes how a site (SLC) optimises its approach to the management of all waste arisings over the short, medium and long term up to the point of site end state by specifying:

- How the site optimises its approach to waste management in an integrated way
- The waste streams and discharges expected from current and future operations
- Actions that are required to improve the sites' approach to waste management.

A review of the IWS documents for the NDA estate from the 2013 iteration (mandated following publication of the revised ENG01 specification by NDA in October 2012) [Ref. 17 – 21] has been undertaken to identify and understand the current baseline LLW management strategy at each of the SLCs.

The IWS components for LLW management strategy have been reviewed against a series of strategic principles outlined in the UK Nuclear Industry LLW Strategy. These are summarised in Table 2 below. An identifier (A-H) has been used in the review tables (presented in the IWS summaries in Appendix B).

Table 2 – LLW Strategy Principles for review of the IWS

ID	LLW Strategy Principle
A	High standards of health, security, environmental protection and public acceptability are central to development of appropriate waste management plans and their implementation.
B	Waste prevention should be implemented by all producers of LLW wherever practicable.
C	Effective characterisation and segregation of waste and material that will become waste is critical to flexible management of LLW.
D	Given the diverse physical, chemical and radiological nature of LLW, the availability of proportionally regulated waste management routes is essential.
E	The development of new waste routes or approaches to the management of LLW requires early and proactive engagement with local and national stakeholders.
F	Availability of flexible waste management routes is essential for hazard reduction and decommissioning and the continued operation of the nuclear and non-nuclear industries.
G	Integration of strategies for all wastes (both radioactive and conventional) is important nationally and at a site level; waste plans will be consistent with, and complement, national strategy and Government Policy.
H	Waste Management decisions should be supported by sound business cases and demonstrate the use of robust decision-making processes to identify the most advantageous option.

It should be acknowledged that this review of IWS against these NDA strategic principles has been undertaken solely by examination of the IWS documentation provided by the site licensees. It is recognised that sites may indeed operate in alignment with LLW strategy principles and that the IWS document may not articulate actual practices sufficiently clearly.

A summary data sheet has been prepared for each SLC in Appendix B describing the following aspects:

- Summary of LLW strategy
- Status
- Waste volumes
- Origin of waste
- Current waste routes
- Organisation and management
- Opportunities for improvement
- Principal LLW issues for the SLC (risks)

4.3.2. Summary of findings

The review of the Integrated Waste Strategies for the NDA estate SLCs has shown good alignment of the strategies with the NDA requirements specified in the revised ENG01 noting that Sellafield Ltd are in the process of producing a formal IWS to meet the requirements of the October 2012 revision of ENG01. Introduction and use of the revised NDA specification (ENG01 Revision 3) has driven significant improvement in the clarity and granularity of waste management strategy pertaining to LLW in these documents. Adoption of the revised IWS specification has clearly driven a more standardised approach to the format, content and quality of the IWS across the NDA estate; and has simplified and streamlined the approach relative to earlier IWS iterations.

Table 3 provides a high-level summary of how the LLW strategy principles (described in Table 2) have been incorporated into the IWS for the NDA estate SLCs.

Table 3 – A summary of the incorporation of LLW strategy principles in 2013 IWS for NDA estate SLCs

Strategy principle ID	DSRL	LLW Repository Ltd	Magnox Ltd	RSRL	Sellafield Ltd
A – EHS Principles					
B – Waste Avoidance					
C – Characterisation and segregation					
D – Waste route availability					
E – Stakeholder engagement					
F – Flexibility					
G – Integration					
H – Decision making and business cases					

Note – a Red-Amber-Green scale has been used where green represents distinct incorporation of the strategic principle with detail of how it is incorporated into strategy; amber represents incorporation of the strategy principle at a high level with limited detail on execution; red represents that there is limited evidence that the strategy principle is incorporated into the strategy.

All SLCs have provided a clear statement of their waste management strategy relating to LLW. There is recognition and understanding of the Waste Hierarchy demonstrated in all the IWS, and a commitment from all SLCs to the application of the Waste Hierarchy. There is consistent acknowledgement that waste avoidance and minimisation are the preferred strategic options (demonstrating alignment with strategic principle B). Three SLCs (LLW Repository Ltd, RSRL and Sellafield Ltd) provide description of how waste avoidance is undertaken at their sites, with the other SLCs dealing with waste avoidance at a principles level.

The importance of waste characterisation and segregation (strategic principle C) is formally recognised by all the SLCs; with LLW Repository Ltd providing the clearest description of how this is undertaken at a tactical level. A significant change from the waste management strategies reviewed for Strategic Review 2010 [Ref. 4] has been a distinct increase in the range of waste routes routinely employed by SLCs (except DSRL) demonstrating a definite move away from a strategy where disposal to LLWR was the default option. This reflects the diverse range of waste management solutions now readily available via the supply chain and the continued use of on-site infrastructure where it is available; and demonstrates incorporation of strategic principles D and F. DSRL note that there are potential benefits from the use of alternative waste management routes but maintain a default waste management option of disposal, to their own near-site disposal facility rather than LLWR, citing the challenge posed by restrictions within their current RSA93 Authorisation and the cost of using alternative routes relative to disposal. The IWS recognise – across the NDA estate – that waste management strategy is driven by a range of factors such as ensuring the health and safety of workers and the public, environmental protection and public acceptability (showing incorporation of strategic principle A). There was a strong theme in all the IWS of the need for stakeholder engagement on waste management strategy (strategic principle E).

The specification for IWS [Ref. 16] requires that SLCs optimise their approach to waste management in an integrated way; for example by describing the key interrelationships between wastestreams to demonstrate overall integration and optimisation. The 2010 Strategic Review identified some weaknesses in this area, and these persist into the 2013 iterations of the IWS. In general terms, all waste types have been identified and discussed in the strategies, albeit at variable levels of detail, but there continues to be limited consideration of the interrelationships between different wastestreams and their relevant waste management strategies.

The 2010 Strategic Review identified weakness in the IWS documents reviewed in terms of the depth of consideration that waste diversion has or could have on final disposal volume. For the most part, there has been improvement in this area in the 2013 IWS. LLW forecasts projecting over the lifetime of the IWS (up to 2018) broken down by waste route are included by Magnox Ltd and RSRL, demonstrating for these organisations how the diversity of waste routes has been adopted and the impact this has on the volume of waste requiring disposal. LLW Repository Ltd includes similar information but on a total diversion vs. total disposal level, and does not show how individual waste routes contribute. This is not reflected by either DSRL or Sellafield Ltd. However, all SLCs demonstrate some level of success in the diversion of waste away from disposal within their strategies. Waste diversion is reported as routine, business-as-usual activity by Magnox Ltd, RSRL and Sellafield Ltd at an SLC level for all waste routes, whilst LLW Repository Ltd and Sellafield Ltd both identify that improvements in this area are required for some waste routes in the future. It is recommended that all sites adopt the approach of Magnox Ltd and RSRL in demonstrating the projections for waste routing over the lifetime of the IWS to demonstrate the impact of the adoption and routine use of diverse, flexible waste routes where these are used. This could be further augmented by consideration of waste forecasts broken down by waste route over a longer time period.

The revised IWS specification [Ref. 16] includes a requirement for the production and annual review of IWS action plans, to support the delivery of the necessary actions to ensure the IWS is appropriately implemented. These action plans [Ref. 17, 21 - 24] have been reviewed as part of this strategic review and this has demonstrated a level of repetition within these documents (for example, implementation of the

JWMP is a common action across many of the IWS Action Plans). However, generally these Action Plans reflect the relatively mature status of the SLCs with regard to implementation of the National LLW Strategy. There may be an opportunity for collaboration on common estate wide actions, and this could be managed via the LLW National Programme.

A key strategic principle from the Nuclear Industry LLW Strategy is the availability of appropriate waste management routes given the diversity of the physical, chemical and radiological characteristics of SLC LLW inventories. There is – with the exception of the DSRL and RSRL IWS – minimal consideration of any non-standard wastes which would not be compatible with existing waste management routes; although Sellafield Ltd acknowledge the challenge posed by problematic and orphan wastes. It is recommended that SLCs give consideration of any such potentially problematic wastestreams within their IWS and to identify their approach to management of these risks; which would provide a mechanism for improved integration of the IWS with other strategies (such as the TBuRD) and support raising the visibility of these issues which would assist in driving efforts to identify and implement waste management solutions.

There is a requirement in the LLW strategic principles (notably principle H) that waste management solutions should be supported by sound business cases and demonstrate the use of robust decision-making processes. This is reflected in the IWS Specification ENG01 [Ref. 5] through a criterion that a successful IWS will show how the strategy will be implemented and how it factors into business decisions. As in 2010, all sites reference the use of mature and proven decision making processes such as BAT/BPM; and DSRL references the use of the NDA Safety Environment Detriment (SED) process to assist prioritisation. However, again reflecting the trend in 2010, few SLCs other than RSRL make any discrete reference to waste management decisions being supported by business cases or reference how the strategy integrates with business decision making. SLCs could do more to demonstrate how business cases are used to underpin waste management decision making.

4.4. Waste Management Performance

A key area of change since Strategic Review 2010 has been the take-up and utilisation of waste diversion routes by the majority of the NDA estate SLCs. This section provides an overview of the waste management performance within the NDA estate since 2010, identifying the key trends in waste management during this time, and the projected waste management performance over the next four years. Waste management performance is a clear indicator of the progress made by waste generators within the nuclear industry in the implementation of the UK LLW Strategy.

4.4.1. Review Approach

The waste management performance of waste generators within the UK has been established by interrogating and analysing a range of data sources reporting actual waste metrics and waste forecasts.

The data for this review is valid to December 2013 (YTD), and originates from these sources:

- Actual waste metrics from the monthly LLW National Programme metric dashboards from August 2011 to March 2014 for NDA and non-NDA estate producers [Ref. 25 - 50];
- Planned diversion and disposal for the complete FY 2013/14 using the waste metrics summaries provided in the October 2013 Monthly Progress Report on the NWP for NDA estate producers [Ref. 51];

- 5 year forecasts of waste diverted and disposed from NDA consignors from the start of the 2nd contract term (FY 2013/14-FY 2017/18) provided in the Joint Waste Management Plans provided from the SLCs (using the current revisions to the forecasts in the September 2013 versions of the JWMPs) [Ref. 52 - 56].

Note that, consistent with the reported and forecast volumes from the SLCs, all data for LLW disposals is presented here as the final, packaged volume based on the number of containers filled, assuming a packaging of 10te or $10m^3$ per container. Performance with respect to supercompaction has been specifically excluded from this analysis, to avoid double counting with disposal, since there is a direct link between the supercompaction and disposal routes.

Sellafield Ltd exhibit positive waste management performance through diversion of some VLLW and LA-LLW to their on-site landfill. Waste management performance relating to the use of this on-site facility is not included in the general analysis but is presented as a discrete set of data, owing to its nature.

Waste management performance for the non-NDA estate has been included in the analysis where data was available through the LLWR waste dashboard and / or managed via the LLWR waste treatment frameworks. It is recognised that this non-NDA data set provides an underestimate of the volume of waste diverted by these organisations as it does not inlcude volumes of waste managed via direct contracts with the supply chain.

It is recognised that waste generating organisations undertake significant effort, in line with the Waste Hierarchy, to utilise the clearance and exemption regime introduced by the pertinent legislation (EPR10 and RSA93 (Scotland) 2011). A significant volume of waste is managed via this mechanism (as out-of-scope or exempt waste), which reduces the volume of LLW requiring management. Where data on such activities has been reported to LLWR and the National LLW Programme, this has been included in this analysis. It is howevere recognised that this available data underestimates the volume of waste managed via this mechanism.

Waste management performance for the NDA estate and non-NDA organisations, where available, is expressed in terms of the quantity of waste diverted from disposal at the LLWR site (through application of the Waste Hierarchy and use of metallic treatment, thermal treatment, disposal of VLLW and LA-LLW to specified landfill and the re-classification of waste to enable management at a lower waste classification).

4.4.2. Summary of findings

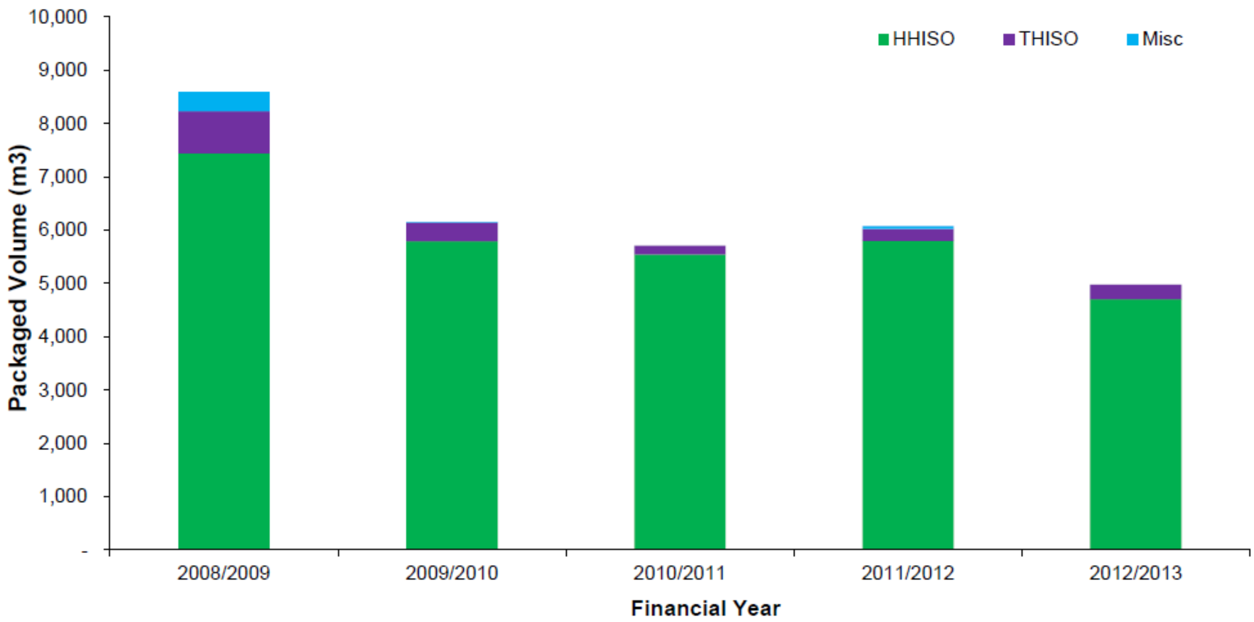
4.4.2.1 Analysis of historic waste disposals to the LLWR 2008-2013

Between the April 2008 and March 2013, LLWR received 1,668 containers from both the nuclear and non-nuclear industries.

As shown in Figure 13 below, the majority of the containers arrived in the form of an Industrial Package (IP) IP-2 approved Half Height ISO (HHISO) with the number of receipts declining from 372 in 2008/2009 to 229 in 2012/2013. This decline has strong links with the improvements in recent years in waste management across the NDA estate which is a result of: application of the Waste Hierarchy; improved characterisation; improved segregation; implementation of alternative waste routes; and improved waste awareness.

Despite the reduction in the number of container receipts, HHISO's have been consistently utilised and represent about 86% of annual container receipts received at the LLW Repository site. Third Height ISO containers (THISO) are also used in some cases for dense materials to comply with container and transport limits. A number of other miscellaneous packages are sometimes used to dispose of 'non-standard' wastes or direct disposal of large items. It can be noted that no Full Height ISO containers were consigned over the period shown. The majority of all consignments received to LLWR come under the consigner code 1WAM or 1S for WAMAC and Sellafield respectively, reflecting the fact that most consignors transport containers via Sellafield in some way.

Figure 13 - Packaged Volume Receipts at the LLW Repository since 2008



A total of around 31,500 m^3 of waste has been received at site which equates to an average of 6,300 m^3 of packaged volume per annum. This is 3,700 m^3 of packaged volume per annum less than recorded in the 2010 URKWI. The direct cause of this is due to improved characterisation and use of the waste hierarchy. Between the years 08/09 and 12/13, packaged volume received for disposal at LLWR can be seen to have decreased by 42%, with the consequent benefit that vault capacity is increased in Vault 9.

Of the 1,668 containers received by LLWR during the period April 2008 to March 2013, over 60% had specific activities less than 200 Bq/g of which, 50 containers had an average activity of less than 4 Bq/g.

4.4.2.2 Waste Management Performance FY2011/12 to FY2013/14 YTD

Waste management performance for the period FY2011/12 to FY2013/14 YTD has been analysed for the NDA estate with the exception of DSRL (who are currently storing solid LLW pending the availability of their near site disposal facility).

In overall terms, as illustrated by Figure 14 and Table 4, the volume of waste disposal at the LLWR site has decreased since 2008/09, whilst the volume of waste diverted to alternative treatment and disposal routes has increased since 2009/10 (when the initial route via the LLW Repository Ltd waste management frameworks, the metallic route, was opened). The progressive year-on-year decrease in disposal combined with the increase in diversion reflects that progress has been made by SLCs in the implementation of the UK LLW Strategy and that reporting of waste management performance has improved during this period. The rate of waste diversion increased sharply in 2010, late 2011, early 2012 and during 2013/14; corresponding with the opening of the metallic, combustible and VLLW routes via the LLW Repository Ltd waste management frameworks. This provides evidence that the provision of easier commercial access to off-site, supply-chain waste management infrastructure (a recommendation of the UK LLW Strategy) has had a positive impact on the rate of waste diversion and the implementation of the UK LLW Strategy within the NDA estate.

Figure 14 – Overall trends in waste diversion and waste disposal for the UK from FY2008/09 to FY2013/14

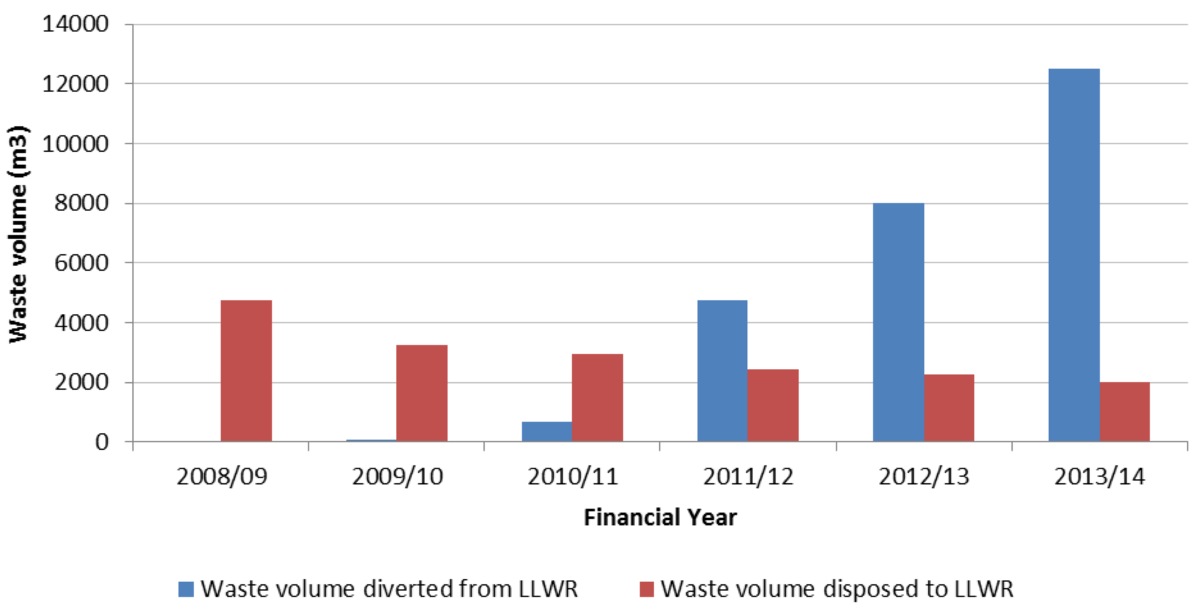


Table 4 – Summary of total waste volumes for the UK by waste route for the period 2008/09 to 2013/14

LLW Stream	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	TOTAL
Metal (te)	0	65	664	3,915	3,568	3,489	11,701
Combustible[3] (m^3)	0	0	23	527	782	2,766	4,098
VLLW/LA-LLW (m^3)	0	0	0	323	3,658	6,242	10,223
TOTAL DIVERSION (m^3)	0	65	687	4765	8008	12497	26,022
Disposal to LLWR (est. m^3)	4,760	3,230	2,930	2,440	2,270	2,020	17,650
TOTAL LLW (m^3)	4,760	3,295	3,617	7,205	10,278	14,517	43,672

[3] Combustible data prior to 2012/2013 does not account for incineration undertaken using on-site facilities, as no data is available, although it is acknowledged that this has contributed to waste diversion.

Whilst there is evidence, as demonstrated by Figure 14 and Table 4, that waste diversion and hence implementation of the UK LLW Strategy has progressed significantly since 2010, there has been variation in the take-up and utilisation of different waste managemenent routes by different waste generators. Figure 15 illustrates the performance of waste diversion and waste disposal over time as a function of waste generator.

Figure 15 reinforces the trend illustrated in Figure 14 that there has been a gradual decrease in the volume of waste disposed of at the LLWR site since FY2011/12. Waste disposals by Sellafield Ltd dominate the overall disposal volumes and has remained relatively static over this time period. This can be attributed to the relative immaturity of the thermal treatment route at Sellafield and the volumetric restrictions imposed upon it through its Environmental Permit (although it is noted that Sellafield Ltd worked fully upto the volumetric restrictions imposed by the permit); as its waste disposals to the LLWR site are dominated by the disposal of soft, compactable waste. Waste disposals from Magnox Ltd have increased marginally over the time period, reflecting the increased decommissioning activity at its accelerated sites generating larger volumes of LLW (some of which can only be managed by disposal). As a proportion of its waste arisings, however, Magnox Ltd has a 9 fold reduction in its waste sent for disposal. Disposals of waste from RSRL have fallen sharply over the period, reflecting the take-up and use of alternative waste management practices.

Figure 15 – Waste disposal and diversion performance by waste generator from FY2011/12 to FY2013/14

As detailed in Section 4.6.8, Sellafield Ltd utilises an on-site disposal facility (the Calder Landfill Extension Segregated Area) for disposal of predominantly inert VLLW / LA-LLW and certain putrescible VLLW / LA-LLW wastes unsuitable for disposal to the LLWR. Disposal of these wastes to CLESA enables Sellafield Ltd to divert a significant proportion of waste away from disposal at LLWR, as summarised by Table 5.

Table 5 – Summary of total waste volumes disposed of by Sellafield Ltd to the CLESA facility 2008 – 2013 [on a calendar year basis]

Calendar Year	Volume of waste (m^3)
2008	2679
2009	2370
2010	7990
2011	10904
2012	3303
2013	4484

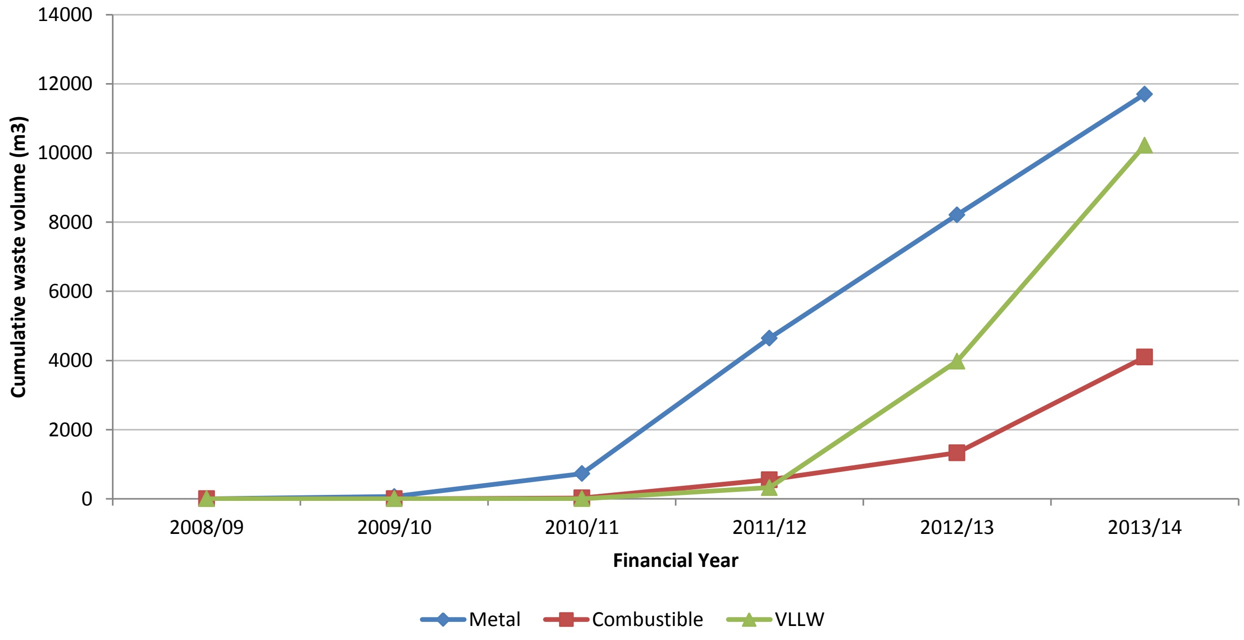
Waste diversion has strongly increased over the period 2008/09 to 2013/14, particularly for Magnox Ltd and Sellafield Ltd. Sellafield Ltd has particularly strong performance in the diversion of metallic waste (accounting for some 60% of the total volume of metals diverted during this period) through the use of its on-site infrastructure and the LLW Repository Ltd waste management frameworks. Magnox Ltd has demonstrated good performance in the utilisation of thermal treatment (again using a combination on on-site and off-site infrastructure), contributing to 79% of the total combustible waste diverted. A particularly significant achievement was the removal to Sweden for recycling of around 4,650 te of steel from Berkeley's redundant heat exchangers. Growth in waste diversion is not consistently increasing for RSRL, reflecting the nature of the waste being generated, but still shows strong performance, particularly for the disposal of VLLW/LA-LLW (contributing 67% of the total VLLW/LA-LLW diverted).

This variation in the usage of the different alternative waste management routes can also be seen in overall terms. This is described by Figure 16.

There has been a consistent upward trend for all three waste diversion routes since April 2011. Cumulative arisings of metallic waste has grown at a consistent rate over this time period, demonstrating the progressive maturation of arrangements for metallic waste treatment within the NDA estate through the use of on-site infrastructure and the supply chain.

Arisings of waste managed as VLLW/LA-LLW via disposal at specified landfill were relatively small prior to September 2012. This reflects efforts made by RSRL prior to the opening of the VLLW/LA-LLW route through LLW Repository Ltd under the waste management framework in April 2012 and initial trials of the route by a range of waste producers between April and September 2012. There was a rapid spike in waste arisings managed via the VLLW/LA-LLW route in late 2012, corresponding with the transfer from "trial" loads to more routine usage of the route with larger volumes of waste. Subsequently, there has been a rapid increase in the usage of this route as a consequence of the maturing of the route (e.g. opening up access to more than one landfill site) and the transfer to business-as-usual activity across much of the NDA estate.

Figure 16 – Cumulative arisings of diverted waste as a function of waste route over time for the period FY2008/09 to FY2013/14



The usage of thermal treatment for combustible waste is significantly less than for metallic and VLLW/LA-LLW waste, and has increased at a steadier rate. This reflects a steady, progressive adoption of the thermal treatment route across the NDA estate. As previously noted, a contributing factor to the comparitively lower use of the combustible route has been the performance of Sellafield Ltd, who are the largest generator of soft, compactable (combustible) waste in the NDA estate. Sellafield Ltd's performance has been restricted by limitations imposed by their Environmental Permit; these restrictions have subsequently been lifted in January 2014 and it is anticipated that Sellafield Ltd will divert a greater proportion of combustible waste in the future. New thermal treatment facilities – e.g. Veolia at Ellesmere Port – have become available during this period.

4.4.2.3 Projected Waste Management Performance FY2013/14 to FY2017/18

A key element of the JWMPs is a forward projection over five years of the expected waste diversion and disposal. Figure 17 and Table 6 describe the projections for waste diversion and disposal made by the NDA estate SLCs for the period 2014/15 to 2017/18.

Figure 17 – Overall cumulative projected trends in diversion and disposal within the NDA estate FY2014/15 to FY 2017/18

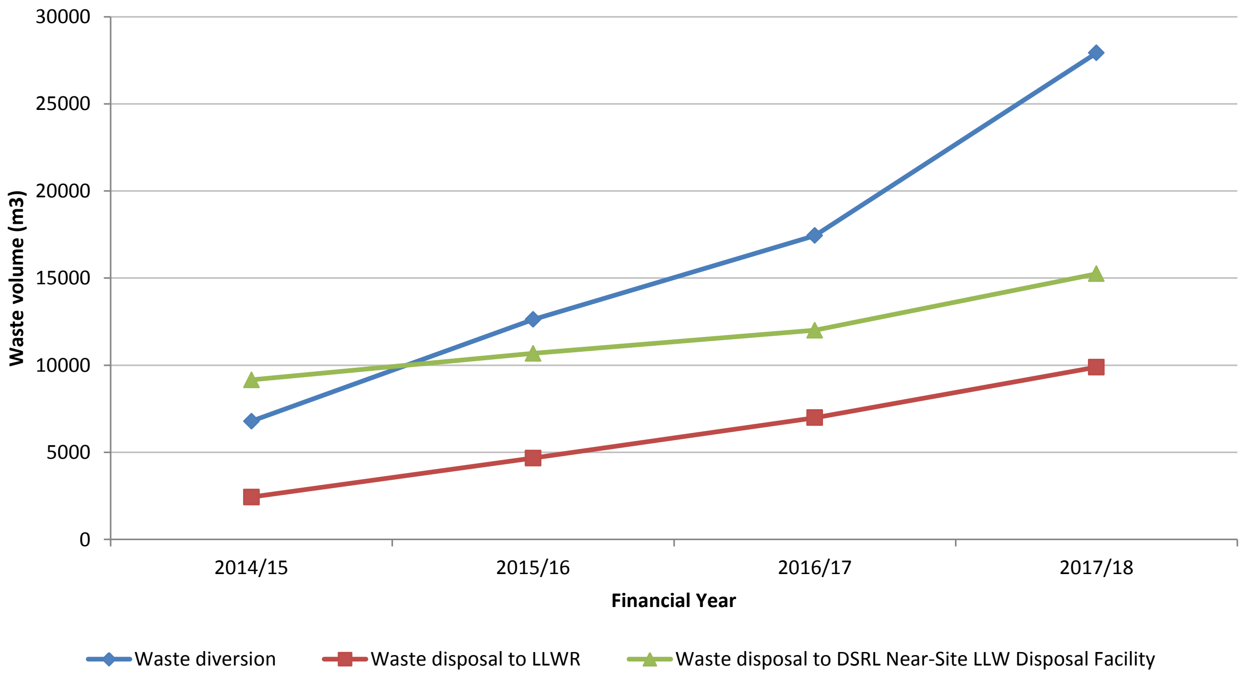


Table 6 - Summary of projected total waste volumes within the NDA estate by waste route for the period FY2014/15 to FY2017/18

LLW Stream	2014/15	2015/16	2016/17	2017/18	TOTAL
Metal (te)	2,322	3,356	2,246	2,372	12,720
Combustible (m^3)	2,054	1,576	1,763	2,894	10,352
VLLW/LA-LLW (m^3)	2,408	908	846	5,217	14,690
TOTAL DIVERSION (m^3)	6,784	5,840	4,815	10,483	37,762
Disposal to LLWR (est. m^3)	2,430	2,240	2,320	2,900	11,920
Disposal to DSRL near-site facility (est. m^3)	9,160	1,520	1,330	3,240	15,280
TOTAL DISPOSAL (est. m^3)	11,590	3,760	3,650	6,140	27,200
TOTAL LLW (m^3)	24,759	12,961	13,906	22,064	89,381

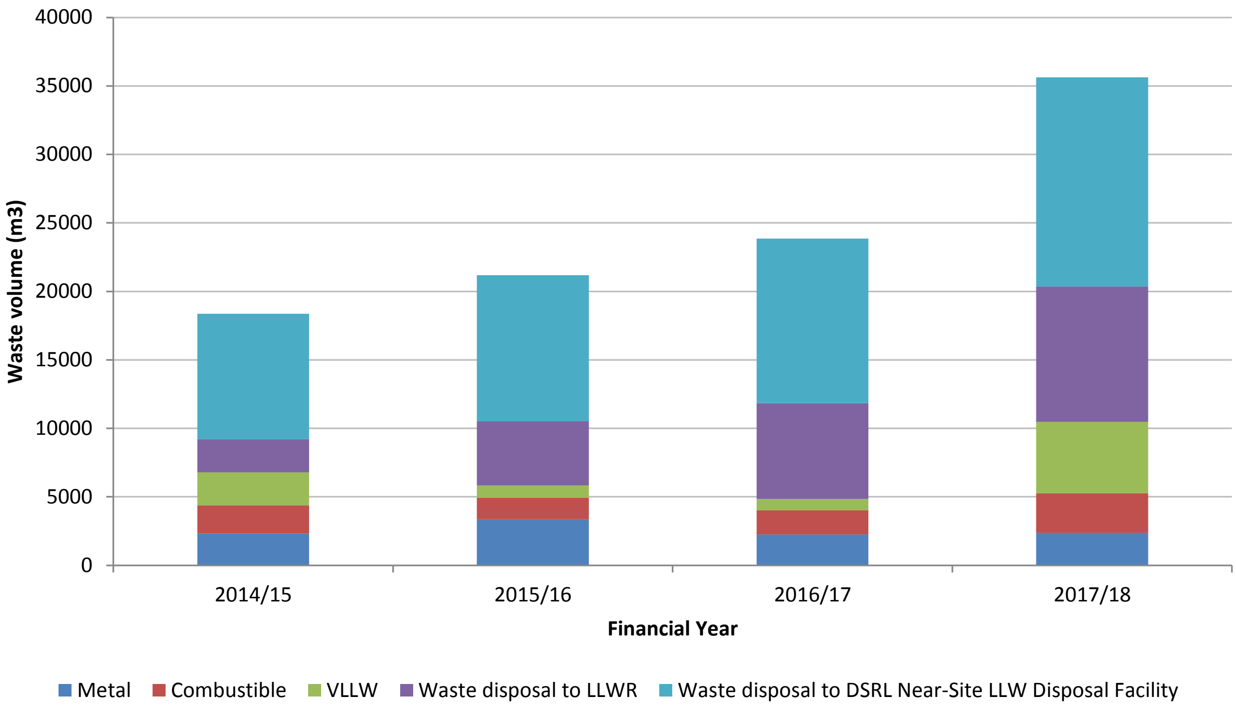
Figure 17 illustrates that disposal to the LLWR is expected to remain significantly lower than waste diversion over the period, with a small increase in volumes by 2017. This reflects a ramp up in decommissioning activity within the NDA estate – particularly for RSRL Winfrith, which is scheduled to reach an interim end state in 2021, and activity within the Magnox Ltd estate with C&M preparations – and a corresponding increase in the volume of waste that requires disposal.

The volume of waste diversion decreases between 2013 and 2016; this can be attributed to the cessation of decommissioning operations at the two accelerated Magnox Ltd sites (Bradwell and Trawsfynydd), who will enter C&M during this time period. Waste diversion is projected to strongly increase again in 2017 as a consequence of increased decommissioning activity at RSRL Winfrith and further C&M preparations work within the Magnox Ltd estate. There is greater waste diversion activity than waste disposal projected during this period, demonstrating that the cultural shift in waste management made during 2010 to 2013 with implementation of the UK LLW Strategy is being sustained within the NDA estate.

Waste disposal by DSRL is expected to occur and increase over the period 2014 to 2017/18, as a consequence of the availability of the near-site LLW disposal facility at Dounreay (anticipated to open in 2014) and the management of a backlog of waste which is currently being stored.

The projected trends in diversion and disposal are illustrated on a waste route basis in Figure 18. This demonstrates the overall estate-wide totals as described in Figure 17, but also demonstrates that the greatest contribution to the projected decrease in waste diversion between 2013 and 2016 can be attributed to a decrease in disposal of VLLW/LA-LLW. The volume of metallic waste and combustible waste diversion is projected to remain relatively stable over the time period, but there is a marked decrease in VLLW/LA-LLW disposal until 2017/18. This again is reflective of the activities within the wider NDA decommissioning programme, particularly for the Magnox Ltd estate.

Figure 18 – Projected waste disposal and diversion performance by waste route from the NDA estate for the period FY2013/14 to FY2017/18



4.5. Research & Development

4.5.1. Review Approach

Research and Development (R&D) is defined by the NDA as creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of individuals, culture and society and the use of this stock of knowledge to devise new applications [Ref. 57]. R&D is a term covering three activities:

- **Fundamental (sometimes called basic or pure) Research** – original, exploratory investigation involving either experimental or theoretical work undertaken primarily to acquire new knowledge and understanding of the underlying foundation of phenomena and observable facts, without any immediate application or use in view.
- **Applied Research** - investigation directed primarily towards a specific practical aim or objective that may involve using existing knowledge and understanding or acquiring new knowledge.
- **Development** - systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed towards the production or substantial improvement of materials, products or devices, or to the design and development of processes, systems and services.

There is a requirement by the NDA for UK nuclear sites, using the specification defined in EGG 10 [Ref. 58] to develop and maintain a suite of documents under the heading of 'Technical Baseline and Underpinning Research and Development' (TBuRD) [Ref. 59-63].

TBuRDs typically contain process wiring diagrams, technology maps and research and development tables; and identify where SLCs need to undertake R&D to fill in gaps in technology or technical approaches. These have been reviewed in order to provide a summary of the R&D planned to support the management of LLW at nuclear sites across the UK, and provides a baseline of the LLW related R&D activities within the NDA estate in 2013.

In addition, the Joint Waste Management Plans for NDA estate organisations (the September 2013 iteration) have been interrogated to identify any potential research and development activities, or opportunities, relating to LLW management that are not captured within the TBuRD documents.

4.5.2. Summary of Findings

Overall, R&D helps support technical underpinning of a baseline plan and typically includes development needs that have been identified to increase the Technology Readiness Levels of a baseline strategy, activities for risk mitigation and technical opportunities to improve upon, or enhance the baseline plan [Ref. 58]. This helps to provide confidence, visibility and demonstration of the coordination and prioritisation of the work programmes.

In the UK, as described in Appendix C, research and development associated with LLW management is predominantly needs-driven (i.e. associated with the management of a specific waste type or associated with a specific project); although for some organisations (notably Magnox Ltd and RSRL) R&D is specifically related to opportunities and threats. There is a clear distinction between the R&D activities being undertaken by LLW Repository Ltd and that within the rest of the NDA estate; with a greater diversity of R&D activities being undertaken by LLW Repository Ltd. Albeit that the majority of these are focussed on delivery of the 2011 Environmental Safety Case and optimisation of the LLWR site, rather than more generic R&D relating to the waste management lifecycle. R&D activities for the remainder of the NDA estate are focussed on specific wastestreams, projects and/or specific waste management routes. Research and development relating to LLW management in 2013 is focussed on development rather than research; involving technologies that are at high TRL (TRL 6 – 9). This is a consequence of the relative maturity of technologies for LLW and the relative ease of "nuclearising" technologies for wastes at the lower end of the radiological spectrum compared to higher activity waste (HAW).

Interrogation of the September 2013 iteration of the Joint Waste Management Plans [Ref. 52 – 56] identified one transformational activity not declared within the TBuRD and three opportunity activities that are related to R&D or that have an R&D component. These are summarised in Table 7.

Table 7 – Summary of R&D and opportunity R&D projects identified from September 2013 JWMP

SLC	Activity Type	Description
RSRL	Opportunity (Joint Project with LLWR/other SLCs)	Establish new routes for radioactive asbestos via the supply chain, if required, based on quantities and activity level from SLCs.
RSRL	Opportunity (Joint Project with LLWR/other SLCs)	Establish route for contaminated mercury, recognising work that DSRL is already doing in this area.

Table 7 demonstrates further the preference for needs-driven, development focus of R&D relating to LLW management identified as a key trend in the TBuRD review.

The 2013 TBuRDs for the NDA estate do not reflect any significant cross-estate R&D pertaining to LLW management, although there are opportunities for collaborative working identified in JWMPs (as summarised in Table 7). There is some R&D being undertaken by SLCs or their supply chain partners on the management of so-called orphan and problematic wastes; such as the work being undertaken by DSRL on the management of mercury and Magnox Ltd on problematic oils, but this reflects a limited range of problematic/orphan wastes.

There is an opportunity for a more joined up, collaborative approach on R&D activities relating to LLW management such as the development or "nuclearisation" of technology for characterisation or the management of more non-standard waste types that cannot be managed via existing routes. It is recommended that development of a collaborative, needs-driven R&D plan for LLW management, particularly in the area of non-standard waste, is considered by the LLW National Programme. This would assist in the timely execution of R&D activities and the adoption of/access to new technologies to support timely and cost-effective waste management within the UK.

4.6. Assets and infrastructure

4.6.1. Review approach

This section presents an overview of the UK and international treatment and disposal facilities currently available to manage LLW and VLLW from the UK nuclear industry. This section has been developed through review and analysis of information from waste generators, supply chain organisations and LLWR on the varied asset and infrastructure architecture within the UK.

4.6.2. Background

Disposal to the LLWR was historically the predominant route for the management of LLW within the UK. From the 1950s to 1988, virtually all LLW from the UK nuclear industry was disposed at the LLWR near the village of Drigg by tumble-tipping into trenches. Vault disposal operations began in 1988 and subsequently high-force compaction was introduced in 1995 (see Section 4.6.4) as a mechanism 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 (see Section 4.6.7). 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 hierarchy in line with the Government Policy and the UK Nuclear Industry LLW Strategy. Waste producers are responsible for following legal requirements under the Radioactive Substances Act 1993 (RSA'93), now subsumed into the Environmental Permitting Regulations 2010, (EPR'10 as amended 2013) for England and Wales. A key provision of these regulations is the requirement for waste producers to use BAT (or BPEO & BPM in Scotland) to manage their radioactive waste, which involves consideration of the environmental consequences of particular waste management options. A summary of the waste management strategy for the NDA estate SLCs is described in Appendix B.

4.6.3. Waste Treatment Enabling Facilities

The majority of UK nuclear facilities have their own, small-scale treatment facilities. These provide varying degrees of scale and capability in waste segregation, size reduction, decontamination, and packaging activities depending on the site's requirements. For example:

- **Size reduction facilities:** 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. Many LLW producers have small-scale shredding, baling and low force compaction equipment to reduce the volume of waste sent for onward processing and disposal.
- **Sorting and segregation facilities:** 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, as required by site and facility requirements. As more treatment and disposal options are made available, it is expected that sites will improve the amount of segregation undertaken.

- **Decontamination facilities:** sites have also invested in other pre-treatment equipment such as methods for scabbling concrete and decontaminating metal. Other decontamination examples include high pressure water jetting, milling, sponge-jetting, shot blasting, acid baths and grinding equipment. There are commercial decontamination facilities at Studsvik MRF facility near Workington in Cumbria; and Tradebe Inutec[4] at Winfrith, which focuses on the decontamination of materials contaminated with tritium and carbon-14. Further information on use of decontamination for metals is provided in Section 4.6.5.

[4] Since November 2013, there has been a change of ownership and the Inutec Group is now owned by Tradebe.

- **Drying facilities:** drying can be used to treat some LLW wastes that do not meet the LLWR waste acceptance criteria (WAC) 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, Tradebe Inutec operated a mobile drying plant for drummed liquid, sludge or wet waste where drums are placed within a container unit and heated to drive off liquid. Despite the excellent performance of the technology, there is currently insufficient industry demand for the waste drying service to justify the cost of upkeep and periodic refurbishment of the wet waste drum drier. Therefore this facility is considered to be mothballed and future use is not currently planned. Nevertheless, Tradebe Inutec are regularly reviewing the situation and demand for a centralised drying service, but it is not expected that demand for the service will increase in the short term.

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. Many of these waste treatment enabling facilities are also offered by commercial LLW treatment centres such as the Tradebe Inutec and Studsvik UK facilities.

As sites move from operations into the decommissioning phases, many of these facilities will require modification or additional capacity to be provided in new facilities. A number of Magnox sites, which 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 [Ref. 19]. For example, 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.

4.6.4. Compaction Facilities

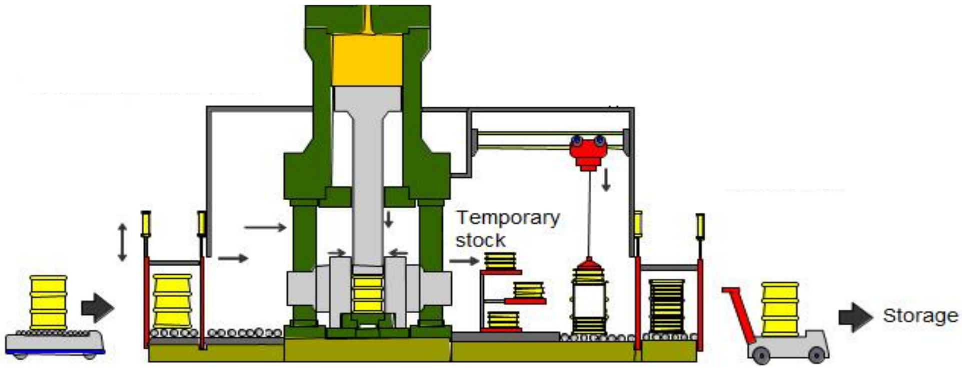
The LLW inventory contains a number of “operational” or “soft” wastes such as paper, plastics, clothing, and small items of light-gauge metals that are suitable for compaction. This method of treatment has historically been the main volume reduction technology used for LLW in the UK for operational wastes. It should be noted that much of this waste may also be suitable for alternative processes such as incineration, and a recent strategic study has determined that the BAT for combustible LLW is incineration [Ref. 65]. As more sites move into the decommissioning phase, the nature of the waste arisings changes towards increasing proportions of less compactable materials, such as metal, rubble and soil, as buildings and facilities are dismantled.

Low Force Compaction (LFC) is typically applied to the compression of bags of waste, in order to facilitate packaging for transport either to a waste treatment facility, where further compaction might be carried out, or to a storage/disposal facility. It ranges from manual to slightly mechanical techniques and has been previously undertaken at some Magnox Ltd and RSRL sites.

High Force Compaction (HFC) or “super-compaction” involves compressing metallic drums or boxes with a hydraulic ram using 500 metric tonnes or more compaction force. Achievable volume reduction efficiencies typically are in the range of 2:1 to 10:1 depending on the wastestream characteristics. The compaction process eliminates void spaces and increases the mechanical strength of the final package for disposal. The resulting compressed ‘pucks’ are then placed into a larger container for disposal.

Figure 19 provides an illustration of the process a waste package undertakes at a super-compactor facility.

Figure 19 – Illustration of waste package super-compaction at a super-compactor facility [Ref. 66]



Two super-compaction facilities are currently available in the UK. These include the Waste Monitoring and Compaction Facility (WAMAC) at Sellafield and the mobile super-compaction service operated by Tradebe Inutec at Winfrith. These super-compaction facilities can compact waste in 200 litre drums. In addition to drums, the WAMAC facility can receive loose compactable waste in skips from Sellafield plants and external consignors for loading into 1 m^3 boxes prior to compaction. Compacted drums and boxes are then placed inside an ISO freight container and transported, mainly by rail, to the LLWR. The schedule will see the completion of activities at the WAMAC facility at Sellafield in 2026. The WAMAC and Tradebe Inutec compactors are fully available to other waste producers on a commercial basis. In contrast to WAMAC, the Tradebe Inutec compactor is also suitable for compaction of asbestos and beryllium contaminated wastes.

The original LLW super-compactor at Dounreay was removed from the site's Waste Receipt Assay Characterisation and Super-compaction (WRACS) facility in December 2012 following an inspection in 2011 that found it was beyond economic repair [Ref. 67]. Installation of a new super-compaction unit will be complete in April 2014 [Ref. 68]. In the meantime, backlogs of LLW drums that need super-compacting is building up and are being stored on-site.

There is another super-compactor facility owned by Studsvik UK based at Lillyhall in Cumbria. This facility is currently not in use and there are no plans to install and operate the facility in the near term. Nevertheless, this facility provides a potential contingency should any serious operational problems happen to the WAMAC or Tradebe Inutec super-compactors.

4.6.5. Metal Treatment Facilities

Decontamination Techniques

Metal arises at nuclear sites from the dismantling of buildings, equipment and other redundant assets. This metal is often treated on-site by size reduction and decontamination techniques (as described in Section 4.6.3) either to reduce the volume of waste for further treatment (cutting out hot spots), to alter the geometry to improve packing efficiency; or to reduce the levels of contamination for onward management, as illustrated in Figure 20.

Figure 20 – Photograph of metallic waste prior to and following surface decontamination at the Studsvik UK MRF facility

Hunterston A Site treats some of its metallic LLW on-site using a 'sponge jetting' decontamination technique [Ref. 69]. Spongejet is a mechanical surface decontamination technique which uses a shot abrasive enclosed within sponge media [Ref. 70]. The material is jetted at high speed against the surface of the contaminated item, and on impact the sponge structure flattens to expose the abrasive. Upon leaving the surface of the item, the sponge media expands and creates a vacuum that entraps the contamination (which would have otherwise become airborne). The media can be recycled typically up to ten times. The process is typically operated remotely, within a containment shield, to provide protection to operators. The secondary waste produced by the process is a dry solid waste - the spent sponge jet media – and is managed as LLW.

Two NDA sites operate their own larger-scale decontamination facilities (which currently do not accept wastes from other sites): a "Wheelabrator" facility at Sellafield; and the Winfrith Abrasive Cleaning Machine (WACM) at Winfrith. These facilities process metals by grit blasting the surface in order to reach levels of contamination that remove the waste from the scope of regulations governing them as radioactive. The Sellafield Ltd Wheelabrator facility can accept ferrous materials with coated and/or rust surfaces, with surfaces contaminated up to 50cps alpha (by DP6 probe or equivalent) and 1500cps beta [Ref. 71]. The WACM facility is restricted to ferrous metals only. It can accept painted and/or rusty surfaces, with surfaces contaminated up to 4 Bq/cm^2 alpha activity and 40 Bq/cm^2 other nuclides [Ref. 72]. The secondary wastes (primarily blasting residues) are then disposed of from both facilities via the normal LLW route. Currently any material failing to meet the criteria for 'out of scope' wastes after processing is sentenced as LLW to the LLWR or to metal recycling via melting or else as VLLW.

A commercial Metal Recycling Facility (MRF) has been constructed by Studsvik at Lillyhall, near Workington in Cumbria and has been in operation since 2009. This nuclear licensed facility utilises sorting and grit blasting techniques to achieve decontamination. The Studsvik MRF accepts a wide range of ferrous and non-ferrous metals for recycling in containerised form, as well as larger components and items.

Metal melting facilities

Metals that cannot easily be decontaminated by the methods described above can be recycled by melting. Metal melting is a well-proven mature technology. Metal is melted in an induction or electric-arc furnace where the majority of the radioisotopes concentrate into the floating slag layer which can subsequently be collected and returned to the customer for final disposal as LLW or VLLW, as illustrated by Figure 21. The homogenised metal is then cast into an ingot which can be easily assayed, handled, stored and recycled. Such material is appropriate for wider distribution, but is ideally suited to further use in the nuclear industry, as shielding or waste transport and disposal containers. The process of metal melting can allow up to 95% of the original material to be recycled.

Figure 21– Metal melting at the Siempelkamp facility, Germany [Ref. 73]

LLWR Ltd offers a range of service providers and facilities for the treatment of metallic waste (see Table 8). The metallic waste treatment service was introduced in the Waste Service Contract on 1st April 2010 and several customers have now used this service to reduce waste disposal volumes at the LLWR. These facilities are all licensed to accept material from international consignors (including UK wastes) and their use is supported by UK Government Policy and the LLW Strategy. All sites within England and Wales now have access to these facilities as a result of a global variation to authorisations undertaken by the Environment Agency (EA); and by the Chapelcross and Hunterston A sites in Scotland. There are three principal metal melting facilities used by UK waste generators – the Studsvik AB facility in Sweden; the Bear Creek facility operated by Energy Solutions in the USA; and the Siempelkamp facility in Germany.

A small-scale metal melting facility was operated at Capenhurst for a short period, but this has since been decommissioned. Consequently, there are no metal melting facilities in operation in the UK at present. The overseas treatment of UK LLW is subjected to authorisation under the Transfrontier Shipment (TFS) of Radioactive Waste and Spent Fuel Regulations 2008 and consideration of the BAT/BPM and BPEO.

Metal recycling for DSRL is limited to the use of local recyclers for “outside the scope of regulations” and “clean” material. The Scottish Environment Protection Agency (SEPA) are going through their due process to approve Dounreay’s new RSA’93 authorisation; until this approval is granted DSRL are limited in the routes available to treat/recycle metal wastes [Ref. 17].

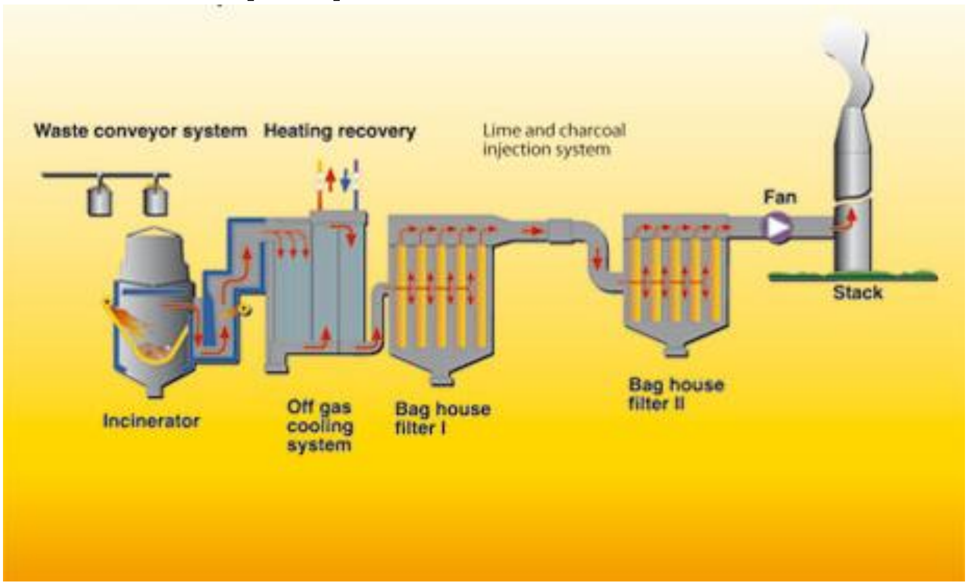
Table 8 – Metal treatment services offered through the LLWR Services Framework

Supplier, facility name (and location)	Acceptance limits	Examples of use
Studsvik Studsvik Metal Recycling Facility (Lillyhall, UK)	The facility can only treat surface contaminated metal within the UK LLW definition. Radioactivity for a single item must not exceed 500Bq/g. Alpha contamination must be less than 25 Bq/cm^2 and beta contamination must be less than 250 Bq/cm^2. The types of metal that can be treated are limited to carbon steel, stainless steel, cast iron, aluminium, copper, lead and brass [Ref. 74].	To date, 254 multi-element bottles (MEBs) – equating to 726 te - from the Sellafield Ltd THORP facility have been treated via shot-blasting at the Studsvik MRF facility. The treatment and removal of these MEBs is a significant project for Sellafield Ltd.
Studsvik Studsvik AB (Nyköping, Sweden)	This facility has a licensed capacity of 5,000 tonnes per year of which no more than 1,000 tonnes can be lead. The technical capacity for the melting plant is around 8,000 tonnes per year. The average activity over a container must not exceed 500Bq/g [Ref. 75].	Studsvik successfully removed, transported to the Nyköping site and treated fifteen boilers from the Magnox-owned Berkeley site in 2012 and 2013. The boilers were 20 m long and weighed over 300 tonnes each. The removal and treatment of the boilers is a significant milestone for the UK nuclear industry in the decommissioning of UK legacy sites [Ref. 76].
EnergySolutions Siempelkamp GmbH (CARLA plant, Krefeld, Germany)	This facility has a licence for an annual melting quantity of 4,000 tonnes and can treat various metals including carbon steel (coated, uncoated and galvanised), stainless steel, alloys, aluminium, copper, brass and lead. Specific total activity must be less than 1,000 Bq/g [Ref. 77].	Since starting operation, 25,000 tonnes have been melted in the CARLA plant. From this quantity, 9,000 tonnes was decontaminated in a way so that a release for further use as secondary raw material in metal recycling was possible. 14,500 tonnes did not conform to the conditions for release and were instead applied in the production of cast iron containers, which were used for transport and final storage of radioactive wastes [Ref. 77]. This facility has also been used to open up and make available a route for treatment of galvanised steel in 2011.
EnergySolutions Bear Creek (Oak Ridge, Tennessee, USA)	The dose impact from metal recycling must be less than 200 micro Sieverts at contact with the waste. Alpha contamination must be less than or equal to 1 Bq/cm^2 and beta-gamma contamination less than or equal to 8 Bq/cm^2. This contamination can be either fixed or removable [Ref. 77].	This route has been used for the recycling of Hinkley Point A skips. The shipments were sent from Hinkley to Liverpool docks where they were transported via ship (Halifax - Nova Scotia to Portsmouth – Virginia), and onwards by road to the Bear Creek smelting facility in Tennessee [Ref. 78].
Nuvia (via Vinci) Socodei (Centraco, France)	This facility requires alpha activity to be less than 370 Bq/g per package and beta-gamma activity less than 20,000 Bq/g per package. All metals are accepted except mercury [Ref. 79].	This facility is not currently available following an accident in 2011; regardless this route has never been trialled due to a lack of an inter-governmental agreement between the UK and France. It is therefore unlikely that this facility will be used by a UK producer in the near or medium term.

4.6.6. 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 (ash) for disposal.

Figure 22 – Process of incineration [Ref. 75]



Incineration is applicable to a broad range of dry solid wastes including paper and other cellulose-based compounds (cloth and other textiles), plastics, rubber, paper and cartridge filters; and also liquid waste such as oils and dessicants.

A number of Magnox nuclear power stations operated incineration facilities to treat their own waste and that of the adjacent power stations (where applicable). The remaining Magnox Ltd incinerators were shut down in early 2014 following a change in the gaseous emissions requirements in the Industrial Emissions Directive (2010/75/EU). Continued operation of these incinerators would have required significant upgrading of the air effluent systems and the cost of upgrading could not be justified by the benefit gained.

One EDF nuclear power station – Hartlepool – has operational on-site incinerators to treat their own waste. Three EDF on-site incinerators (at Heysham, Hinkley Point B and Sizewell B) have been mothballed since the 2010 Strategic Review.

The Capenhurst site also has an incinerator which is currently mothballed. This facility could potentially process waste from other sites but would require significant investment to bring the facility up to modern emissions standards, and would require re-authorisation to become operational again.

LLWR Ltd introduced a Combustible Waste Treatment Service in December 2010 as part of an amendment to the Waste Services Contract. Under the new framework agreements, LLWR Ltd offers the following service providers and facilities for the treatment of combustible waste:

1. Abbott Nuclear Consulting, using the Veolia facility (Ellesmere Port, Cheshire, UK);

2. Nuvia, using the facility at Socodei (Centraco, France) [although there is no intergovernmental agreement between the UK and France which precludes its timely use and the facility has been closed since an industrial accident in 2011];
3. Energy Solutions, using the following facilities:
    a. Bear Creek (Oak Ridge, Tennessee, USA);
    b. Belgoprocess (Mol-Dessel, Belgium) [although there is no intergovernmental agreement between the UK and Belgium which precludes its ready use];
    c. Tradebe Inutec (Winfrith, Dorset, UK);
    d. Grundon (Colnbrook, Slough, Berkshire, UK);
4. Studsvik using the following facilities:
    a. Studsvik AB (Nyköping, Sweden);
    b. Tradebe (Fawley, Hampshire, UK).

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 (see Table 8). These factors, as well as the proximity principle and the waste consignors' BAT, are taken into account when deciding which incinerator to use. Additionally, the absence of inter-governmental agreements limits some international treatment routes (e.g. Socodei and Belgoprocess). Figure 23 provides images of the UK operated Grundon and Fawley incinerators.

Figure 23 – Image of Grundon incinerator (left), Tradebe Fawley incinerator (middle) and Veolia Ellesmere Port incinerator (right)

There are also a number of incinerators across the UK authorised to burn small quantities of radioactive waste, arising primarily from hospitals and other small users (e.g. White Rose incinerator in Lancashire). In addition to these, there are several commercial and municipal incinerators that could, subject to authorisation, be capable of processing combustible VLLW. However, such authorisations have to date not been submitted and these assets are not considered further in this report.

Table 9 - Radioactive limits for incinerators

Facility (and location)	**Capacity and limits**
Tradebe facility (Fawley, UK)	This facility can process industrial waste packaged in drums or intermediate bulk containers and on pallets. Consignment limit of 800,000 MBq for total tritium and carbon-14 [Ref. 80].

Facility (and location)	Capacity and limits
Grundon (Colnbrook, Slough, UK)	This facility has a capacity limit of 410,000 tonnes/year for all waste. It accepts wastes with up to five MBq per month alpha activity and up to 300 GBq per day beta-gamma activity (radionuclide specific) [Ref. 81].
Veolia (Ellesmere Port, Cheshire, UK)	This facility has a capacity limit of 100,000 tonnes/year for all waste. It can incinerate, on a monthly basis, 10GBq of beta-gamma activity and 200MBq alpha activity (radionuclide specific) [Ref. 82].
Socodei (Centraco, France)	This facility requires alpha activity levels to be less than 370 Bq/g per package and beta-gamma activity levels less than 20,000 Bq/g per package. Metals, aerosols, batteries, explosives and mercury are prohibited [Ref. 83].
Bear Creek (Oak Ridge, Tennessee, USA)	This facility can treat beta-gamma, alpha, LLW, ILW solid and liquid wastes and has a high throughput – 26,000 tonnes of organic waste since 1990 [Ref. 84].
Belgoprocess (Mol-Dessel, Belgium)	This facility has a nominal capacity of 100 kg/hr. An average of 150 tonnes of solid and 10 tonnes of liquid waste is incinerated at the site [Ref. 85].
Studsvik AB (Nyköping, Sweden)	This facility incinerates dry radioactive waste, mainly comprising plastic, textiles and cellulose, in the form of protective clothing, rags and paper. It has an incineration capacity of 250 kg/hr with a heat recovery of 1.2 megawatts. Surface dose rate must be less than 0.1 milli Sieverts/hour on an individual waste package and no more than 5 % of total delivery can be between 0.1 – 1.0 milli Sieverts/hour [Ref. 86].

4.6.7. LLW Repository

Since 1959, the majority of LLW generated in the UK from both nuclear and non-nuclear industries has been disposed at the LLWR near Drigg in Cumbria. 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 (via Sellafield to minimise transports through Drigg village). Containerised wastes are then grouted and placed in the engineered concrete vaults. LLW may also be disposed to specified landfill sites as LA-LLW; or to other engineered disposal facilities under ‘controlled burial’ arrangements (see Section 4.6.8).

Waste streams are accepted for disposal at the LLWR based on the availability of sufficient volumetric and radiological capacity. The current operational vault at the LLWR, Vault 8, has almost reached capacity and a very small amount of authorised disposal capacity remains (as illustrated in Figure 24). Once the existing LLWR is full a new facility would be required.

Figure 24 – Aerial photograph of Vault 8 and Vault 9 of the LLWR from 2011; remaining permitted disposal area highlighted in yellow

The LLW Strategy aims to extend the life of the existing site and thereby reduce or eliminate the need for a new LLWR facility. As part of the Environmental Safety Case (ESC) programme, LLWR Ltd is intending to implement options to increase disposal capacity. Vault 9 has been constructed and is operational but is currently permitted for storage of LLW only. Disposal at Vault 9 (and future vaults) is pending the acceptance by the EA of the ESC, LLW Repository Ltd receiving a revised EPR10 Environmental Permit from the EA and planning permission being granted by Cumbria County Council. A further series of vaults are planned that would provide an additional total capacity of 700,000 m^3 (in Vaults 9 – 14) and site optimisation works (including the higher stacking of containers in the vaults and capping of the facility) are planned, but this is also subject to planning consent. A planning application has been made by LLW Repository Ltd during 2013 for this purpose. It is anticipated that a decision on the suitability of the LLWR for continued disposals of LLW, and proposals for the future optimisation of the site, will be decided by the EA and Cumbria County Council in 2014/2015 [Ref. 87-88].

4.6.8. On-Site and Near-Site Disposal

In addition to the national facility at the LLWR, there have also been some limited historic on-site disposals (OSD) 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 end state potentially generating LLW, though the current intention on these sites is for final disposal.

Historically, Sellafield has 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 120,000 m^3, is currently being used for disposal of wastes from decommissioning and site clearance activities. Waste disposed to CLESA is primarily inert waste but the facility also accepts certain putrescible wastes unsuitable for disposal to the LLWR (as per its design intent). This facility will not however, be able to accommodate all Sellafield's waste.

A new facility adjacent to the Dounreay site, similar to that of the LLWR in Cumbria, is being developed to dispose of all remaining LLW at Dounreay, and is scheduled for operation in 2014. Excavation of the first phase of Dounreay's near-site LLW disposal facility was completed on schedule in August 2012. Following successful tests, the vault concrete walls and floor pours began in late August 2012 and were completed in both the Demolition LLW and LLW vaults in February 2013. DSRL are awaiting a revised RSA93 Authorisation from SEPA to enable use of the disposal facility.

RSRL previously considered the construction of a facility for the management of VLLW at Harwell, which would have also fulfilled the requirements of the Winfrith site. This proposal was a contingency facility in case routes to the supply chain did not open up (such as those described in Section 4.6.9), but as these routes are up and running, it was deemed to be no longer needed and removed from future site plans. Other nuclear licensed sites have also investigated the potential to locate disposal facilities on-site. Magnox South (now Magnox Limited) carried out preliminary work to investigate the feasibility of on-site disposal at Hinkley Point A. Both Magnox Ltd and RSRL have demonstrated that it is BAT to use supply chain routes for VLLW and do not intend to pursue on-site disposal for VLLW.

4.6.9. VLLW / LA-LLW Disposal Options

The Government announced a new Policy on LLW management in March 2007 [Ref. 89]. The Policy includes revised regulation around the disposal of LLW to landfill. This means the nuclear industry can now dispose of high volume VLLW and controlled burials of LLW to landfill. Historically most of this material would have been disposed of to the LLWR[5].

The EA issued a radioactive substances activity environmental permit to SITA for disposal of VLLW and LA-LLW at the company's Clifton Marsh site effective from 1 September 2012, following a positive Article 37 decision. The waste material types include decommissioning and demolition rubble, redundant plant and equipment, contaminated protective clothing and residues containing NORM [Ref. 90]. The site has a LA-LLW capacity of 210,000 m^3 (10% of total capacity) and a bulk radioactive limit of 200 Bq/g [Ref. 91]. It is expected to have a remaining operating life of around 10 years (although its current planning permission expires in 2015 unless extended), but this is subject to successful reauthorisation. The facility also offers a specialist asbestos disposal service in purpose-built mono cells.

Augean was granted a permit and planning permission to dispose of LA-LLW at the existing Kings Cliffe hazardous waste landfill site in Northamptonshire in May 2011 and have since been accepting waste from various sites including Harwell, Bradwell and Hinkley Point A [Ref. 92]. The site has a total landfill capacity of 400,000 m^3 but there is a limit of 249,000 m^3 per year for hazardous waste and LLW; and a bulk radioactive limit of 200 Bq/g [Ref. 93]. Augean has recently applied for planning permission to extend the site to dispose of more waste until 2026 and were granted a Development Control Order in July 2013 [Ref. 93]; however, a variation to their EPR permit is still required. No capacity limit is specified for LA-LLW although one may be applied under the extension.

The EA issued a permit to Waste Recycling Group (now FCC Environment) to dispose of VLLW at their landfill site in Lillyhall, Cumbria [Ref. 95]. The site can accept no more than 26,000 m^3 of high volume VLLW

[5] Some organisations have historically – as enabled by their Environmental Permits – undertaken disposals to local landfill sites.

per year. If the landfill remains operational until 2031 (their current planning permission expires in 2029), it can accept up to 582,000 m^3 of high volume VLLW in total (38% of total capacity) with a bulk radioactive limit of 4 Bq/g [Ref. 96].

Endecom UK (set up by SITA in 2009) applied for an authorisation to dispose of LA-LLW and VLLW to a new facility at Keekle Head in Cumbria (on a site of a former coal mine). The facility was designed for the disposal of 1 million cubic metres of LA-LLW and VLLW i.e. 20,000 tonnes/year waste (plus packing materials) over a 50 year period [Ref. 97]. Cumbria County Council rejected plans from Endecom UK, arguing that it would have an unacceptable impact on the area. The original decision to refuse planning permission was made in May 2012 by the County Council's Development Control and Regulation Committee. The original applicant, Endecom Ltd, submitted an appeal to the Planning Inspectorate. The planning decision was upheld by the Secretary of State for Environment in December 2013 [Ref. 98].

There are other commercial landfills around the UK that currently receive small quantities of VLLW from the nuclear industry (e.g. from Devonport, Harwell and Winfrith) and from health care and other non-nuclear industries, as detailed in Table 10.

Table 10 – UK sites holding a local disposal authorisation [Ref. 99]

Site	Disposal Route	Authorised Volume (m^3 per year)
HM Naval Base Devonport	Disposal site not named	50
Devonport Royal Dockyard Limited	Heathfield Landfill at Newton Abott or Lean Quarry at Liskeard	1,000
GE Healthcare, Amersham	Disposal site not named	490
GE Healthcare, Cardiff	Lamby Way Landfill site, Cardiff	200
GE Healthcare, Harwell	Disposal site not named	500

4.6.10. NORM Treatment and Disposal

NORM waste is generated from a range of industrial sectors within the UK; predominantly from the UK oil and gas sector but also from a diverse range of other industries such as mining, china clay extraction and manufacturing of certain pigments and compounds. NORM is treated by various means including (but not limited to) high pressure water jetting, descaling, shot blasting, chemical treatment, washing, filtration and incineration. NORM is treated to reduce the volume of waste requiring disposal. NORM is disposed of to landfill or, for certain NORM wastes generated off-shore, by discharge to sea (subject to appropriate authorisation) or re-injection to depleted wells/reservoirs from where oil and gas has been extracted. For on-shore NORM disposal, there are five landfills permitted to dispose of radioactive waste – LLWR, FCC Lillyhall, Augean ENRMF in East Northamptonshire, the SITA Clifton Marsh facility near Preston and the SITA Stoneyhill landfill in Scotland. The Stoneyhill landfill is permitted to accept NORM waste only.

DECC and the Scottish Government are leading the development of a strategy for the safe and sustainable management of NORM in the UK. This is expected to be published in quarter 2 of 2014 and was made available for public consultation by the end of February 2014. The strategy aims to identify and overcome obstacles preventing NORM waste managers from contributing to sustainable economic growth [Ref. 8].

4.6.11. Packaging

LLWR Ltd offers a range of International Atomic Energy Agency (IAEA) Industrial Package 2 (IP-2) approved re-usable and disposal containers; and consultancy services for the delivery of optimised solutions for packaging and transporting low activity wastes.

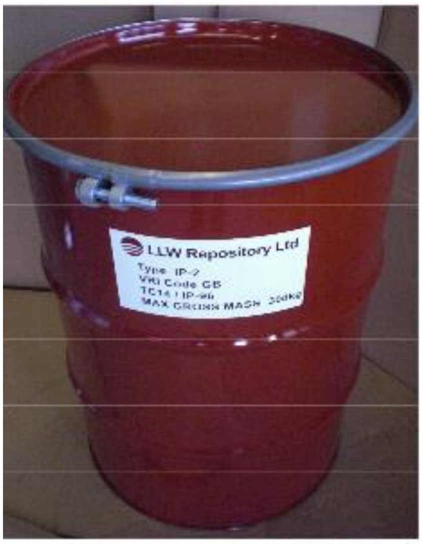
LLWR Ltd manages the entire lifecycle of all supplied package designs; from design, manufacturing, testing, license management, with additional maintenance and engineering support for re-usable package designs. The LLWR Waste Acceptance Criteria currently specifies a number of standard waste packaging requirements for disposal.

There are a number of common containers used for LLW management (as described in the LLW Repository Ltd packaging brochure [Ref. 100]). The main container currently used is the half-height ISO container (HHISO). The design of the steel containers is based on ISO standards but includes a number of modifications to the top, base and side panels. 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.

Table 11 – Types of packaging container for LLW

Package ref: name	Package details	Picture
TC-01: Half height ISO containers [Ref. 101]	This package consists of a specifically designed 6.058 long x 2.438 m wide x 1.320 high *dry* HHISO container of all welded carbon steel construction and fitted with a self-draining bolted top opening lid. They are transportable by road, rail and sea and have a gross mass limit of 35,000 kg. These packages are readily used to package, transport and dispose of waste at the LLWR.	
TC-02: Re-useable half height ISO containers [Ref. 102]	This package has the same dimensions and gross capacity as the TC-01 package. It has a carbon steel external frame and a stainless steel inner tub and floor.	
TC-03 – Third height ISO containers [Ref. 103]	This package is 6.058 m long x 2.438 m wide x 0.880 m high. It has been used to dispose of dense material at the LLWR.	
TC-05: Re-useable skips [Ref. 104]	This package measures 3.40 m long x 1.95 m wide x 1.74 m high and consists of a dry, undersize, ISO freight container of all-welded, carbon steel. The container has two loading hatches, one that is incorporated into the tipping door and one mounted in the opposite end wall. Each loading hatch features an outer bottom hinged door and a pair of inner, side hinged doors. The container also has a top lidded opening that can also be used for loading the container. This package has been used to transport wastes to WAMAC for compaction.	
TC-10: Oversize re-useable IP-2 ISO container [Ref. 105]	This package is 6.244 m long x 3.400 m wide x 3.100 m high. It has a maximum gross weight is 72,130 kg. This top-opening container is primarily designed as a multi-use package for the transport of redundant machinery.	

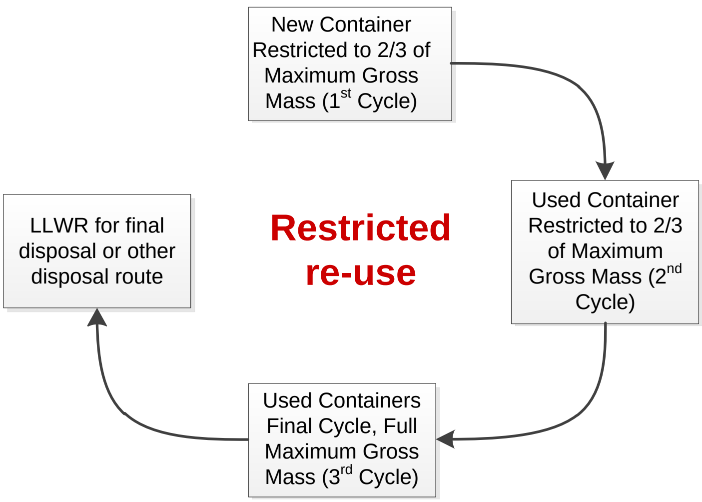
Package ref: name	Package details	Picture
TC-12: Full height IP-1/IP-2 ISO container [Ref. 106]	This package is 6.058 long x 2.438 wide and 2.591 high. It has four container listing positions, a forklift truck fork pocket and grappler pockets. It can transport approximately 35 – 70 200 litre drums.	
TC-14: 210 Litre IP-2 drum [Ref. 107]	This package has a diameter of 0.615 m and a height of 0.859 m. It has a maximum gross weight of 300 kg. It is routinely being used for the transport of solid and liquid waste to incineration facilities and MRF or solid waste for disposal. When used for the transport of solid contents the package is a single use package. When used for the transport of liquid waste the package can be used as a re-useable package subject to inspection and maintenance checks.	
TC-19: 210 litre IP-2 drum [Ref. 108]	This package has a diameter of 0.585 m and height of 0.867 m. The drum lid, which incorporate an elastometer seal are secured to the drum body by a zinc coated steel closure ring with a heavy duty nut and bolt fastening. It has a maximum gross weight of 300 kg and can be lifted using drum grabs, tongs, slings or when secured on a pallet. This package is readily used for super-compaction.	

Package ref: name	Package details	Picture
Miscellaneous containers	Waste consignors utilise a range of other (non-LLWR) containers and packagings for the management of LLW including (but not limited to): • Soft-sided packages • Metallic and plastic drums • Metallic and plastic stillages / boxes • Fibreboard kegs • Wheelie bins	 

DSRL is developing shielded concrete ISO containers as an alternative to the steel frame.

HHISOs or THISOs are received at the 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 17.8 m^3; however this occupies around 22.8 m^3 of disposal space in the vault. A new licensing regime for ISO containers has been developed by LLWR, enabling the indefinite re-use (subject to successful annual maintenance and inspection) or three uses, rather than the historical single use restriction for such containers, as described by Figure 25.

Figure 25 – The re-use of packages concept [Ref. 100]



A range of other transport packages, such as re-useable IP-2 ISO skips for loose waste, and IP2 full-height ISO containers (FHISO) 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 into nominal 200 litre drums. LLWR Ltd has recently introduced the TC-14 and TC-19 IP-2 drums which are being increasingly used for routine consignments.

The 1 m^3 boxes are used for loose compactable waste originating at Sellafield or consigned in skips for compaction of wastes. They were designed to optimise volume to weight ratios in HHISO 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.

In addition to the packaging systems described above, LLWR Ltd has developed new packaging systems including bulk bags for the transport of VLLW and re-usable ISO containers for LLW, VLLW, and metal waste for recycling and compactable wastes. The re-usable ISO containers developed by LLWR Ltd are modular and are capable of carrying several types of waste. The TC-11 (half-height VLLW IP-1) is expected to be launched by April 2014.

There are a range of alternative containers for LLW and VLLW, constructed of metal/plastic, which can be transported using the TC-02. For use in metal recycling or combustible routes, alternative containers such as Dolav boxes, fibreboard kegs and wheelie bins are also used to facilitate handling and packing within overpacks. These enable better segregation at source and offer other practical and operational advantages such as reduced dose uptake and protection from water ingress.

4.6.12. Transport

The movement of radioactive waste in Great Britain by road and rail is governed by the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (Statutory Instrument 1573) and regulated by the Office for Nuclear Regulation (ONR) Radioactive Materials Transport (RMT) team (formerly part of the Department for Transport). These regulations provide a harmonised approach within the European Union (EU) for the safe transport of dangerous goods, including radioactive materials, in particular agreements concerning the International Carriage of Dangerous Goods by Road (ADR) and Rail (RIL). These align with the IAEA Transport Regulations 2013.

The LLWR has historically received between 500 and 700 HHISO containers per year in addition to occasional large, bulky items for direct (ungrouted) disposal (there is no current provision for in situ acceptance of large items for direct disposal). Most of this waste (~75 – 80%) is delivered to the LLWR by rail from Sellafield. This waste is typically generated at Sellafield or received at Sellafield from other consignors by road for super-compaction at the WAMAC facility, or to avoid transport through Drigg village. This is an effective operation with scheduled rail moves accommodating multiple LLW containers per shipment.

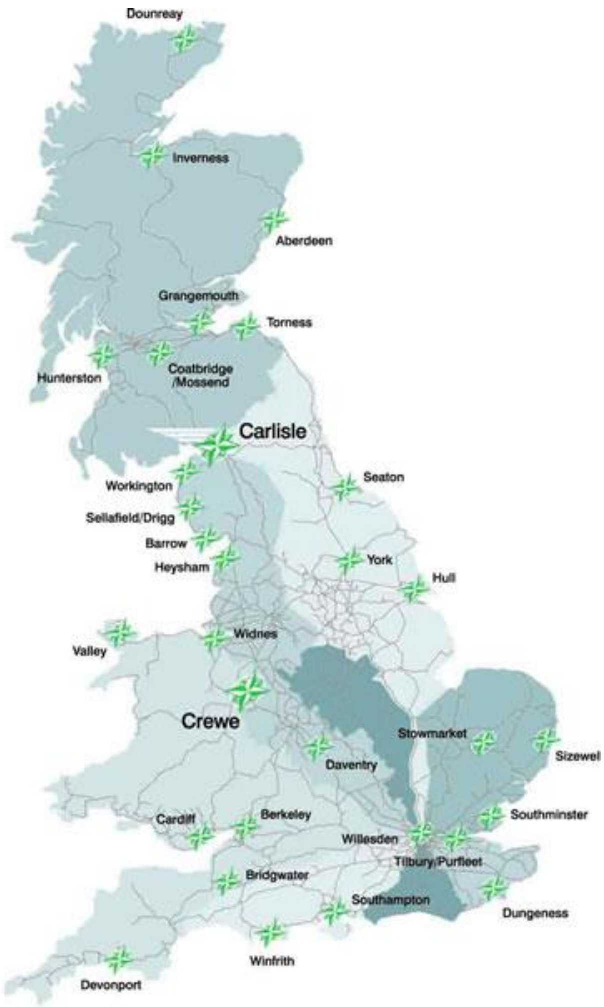
Consignors historically organised their own transport using services provided by commercial carriers or other SLCs. Before 2012, a large proportion of Sellafield waste was delivered to the LLWR by rail and virtually all non-Sellafield LLW was transported by road. A LLW Transport Hubs Assessment [Ref. 109], carried out by Entec, was undertaken by LLWR Ltd as part of a series of initiatives set within the National LLW Management Plan. The scope of the study was to assess the feasibility of using transport hubs in support of multi-modal transport solutions, including available capacity and identification of strategic sites; and to identify measurable savings that can be achieved by using rail in preference to road transport.

In 2012, LLWR Ltd launched a Transport Service, under its Waste Management Services frameworks, to provide consignors with a range of cost-effective transport services via the supply chain. This service offers waste consignors to transport radioactive waste by road, rail and sea (as required). Nevertheless, some SLCs do still organise their own transport using commercial carriers or their own transport services.

The Transport Service involves the partnering of LLWR Ltd with the Direct Rail Services (DRS). DRS was established in 1995 and is now a wholly owned subsidiary of NDA to provide the nuclear industry 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. Since 2012, DRS provides rail transport services for LLW and acts as an integrator to provide access to a framework of road hauliers (who are licensed for the transport of Class 7 radioactive waste) and sea transport providers. The transport service is multi-modal (road, rail and sea) and provides waste consignors with ready access to a range of specialist transport equipment through the supply chain [Ref. 110]. In 2012, 261 road transport services were completed and seven international multi-modal shipments were undertaken. In 2013/14, to the end of Q3, 194 shipments were made by road and three shipments were made by rail.

The rail service allows the use of potentially seven regional rail heads and ten fully approved nuclear stabling points (as illustrated in Figure 26). To date, a limited number of these rail services have been run (notably from Southminster, Winfrith and Workington). Use of rail services for LLW is restricted owing to restricted capability of the key strategic rail sidings used for the shipment of LLW (meaning that only waste with a payload of less than 15 tonnes can be shipped by rail, unless specialist carriage is hired in). Despite this, there has been demand for and good use of the rail services on offer by the LLWR Ltd Transport Service, with a range of customers within and out with the NDA estate. In 2013, virtually all waste received from Sellafield to the LLWR site has been by rail (90 containers delivered) with only a small number of containers received by road (11 containers delivered). Furthermore, there were three non-Sellafield LLWR rail shipments and three international multi-modal shipments completed.

Figure 26 – Locations of DRS depots across the UK [Ref. 111]



4.6.13. Issues

The period 2010 to 2013 has seen the realisation of a strategic threat relating to supply chain fragility through a number of examples. One example was observed for the LLW Repository Ltd combustible waste treatment framework, a capacity supply issue was experienced towards the end of financial year 2012/13 owing to activity limits being reached at commercial incinerator sites. In addition, a delivery and storage capacity shortfall occurred at the Studsvik UK MRF facility in October 2013 which caused adverse impacts to the metallic waste treatment service (albeit that the impact was mitigated for consignors using the LLWR waste services framework through diversion of waste to different suppliers, interim storage at LLWR and the deferral of some work scope by waste consignors). Work has been undertaken to increase the robustness of the supply chain moving forward – e.g. through investigating and opening routes to new suppliers, and encouraging new entrants to the market such as the Veolia Ellesmere Port incinerator – but it is acknowledged that supply chain fragility in the widest sense continues to pose a significant threat to strategy implementation and the sustained adoption of more effective LLW management practice. This is exacerbated by a reduction in resilience in terms of the ability to self-perform through the closure of on-site infrastructure such as the Magnox Ltd incinerator fleet.

As noted in Section 4.6.9, LLW Repository Ltd enables disposal of HV-VLLW and LA-LLW to specified landfill by channelling the associated nuclear liabilities. In practice this means that HV-VLLW/LA-LLW disposals can only be undertaken via the LLWR framework arrangements, undertaken via a process which is resource intensive to set up. This requirement has the potential to limit the openness of the market and act as a barrier to new supply chain entrants. Whilst liability channelling has impacted in terms of resource requirements for waste consignors and LLWR when setting up the route, and perhaps limited the market, it has not adversely impacted on the diversion of HV-VLLW and LA-LLW to specified landfill for disposal (as illustrated on Figure 16, Section 4.4.2.2).

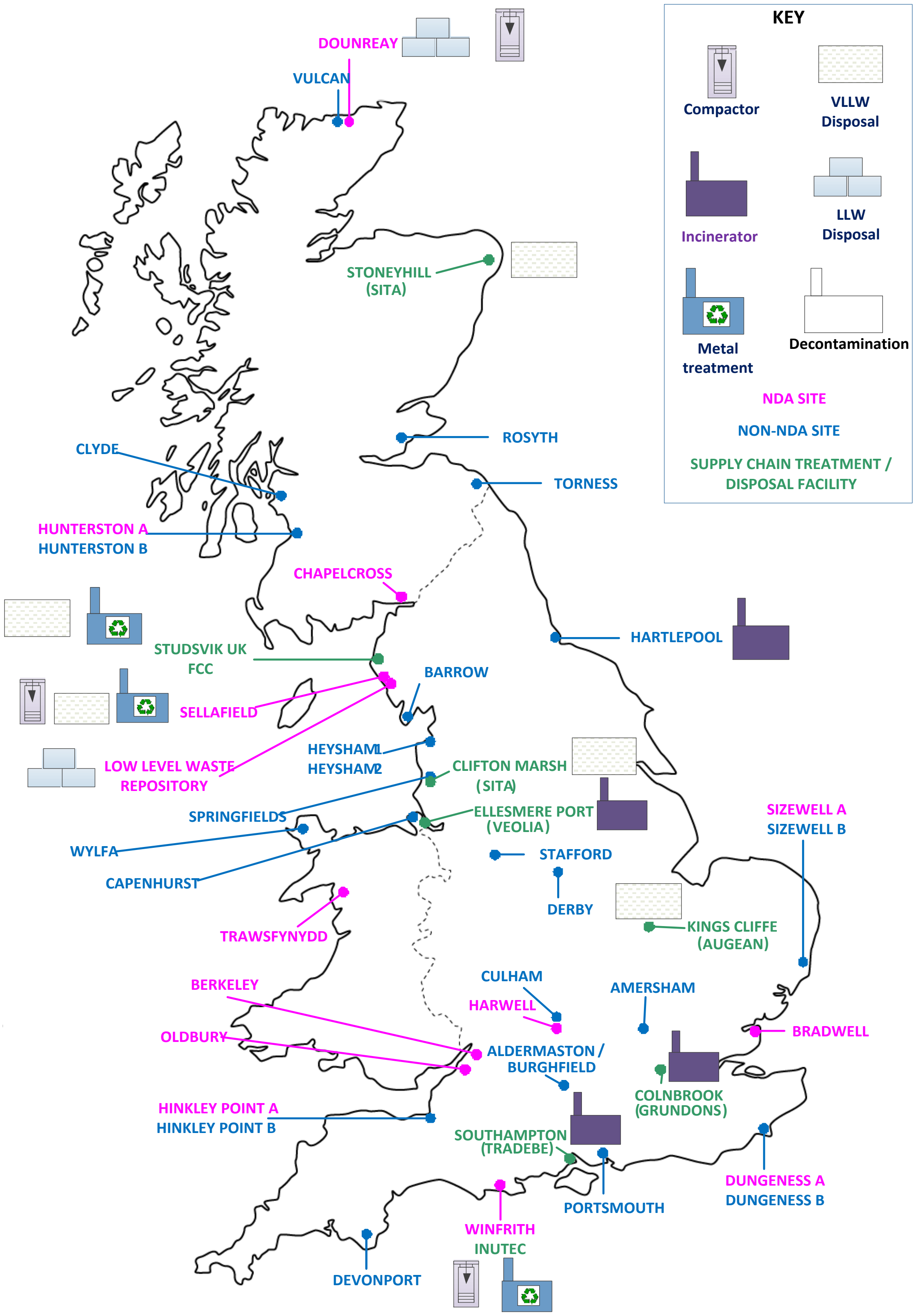
4.6.14. Infrastructure Summary

Figure 27 provides a summary of the assets and infrastructure available to manage LLW and their geographical locations.

The main changes since the 2010 Strategic Review are:

- Closure of on-site incinerators at Magnox Ltd and part of EDF.
- Mothballing of the Tradebe Inutec operated drying facility.
- The addition of the Veolia operated incinerator at Ellesmere Port, Cheshire.

Figure 27 – Illustrative summary of UK assets and infrastructure to manage LLW



4.7. Cost and liabilities

The costs and liabilities associated with LLW management form a key component of the LLW management environment, and are used to define the Nuclear Provision (NP) for LLW. The LLW cost baseline was first established in the Strategic Review 2008 and was updated in the 2010 iteration to reflect updated LTP data and refinements resulting from the ACCELS programme (a detailed description of the ACCELS programme is provided in Section 5). The cost baseline has been updated for Strategic Review 2013 to incorporate additional revised LTP data.

The costs and liabilities faced by NDA for LLW management include the full lifecycle costs for management and disposal of solid LLW and VLLW generated from the operation and decommissioning of NDA sites. These costs and liabilities arise from:

- Design, construction, operation and decommissioning of solid LLW management facilities.
- Pre-treatment (processing and packaging) costs as well as pre-processing activities such as sorting, segregation, characterisation, monitoring and assay.
- Transport and treatment/disposal

4.7.1. Review Approach

The NDA's standard Programme Summary Work Breakdown Structure (PSWBS) was used to identify areas where LLW costs are likely to reside within the LTPs (at December 2013) of all NDA sites [Ref. 112]. The baseline focuses on identifiable solid LLW and VLLW costs residing within every sites LTP. It should be noted that some other LLW costs may be embedded elsewhere in the LTP (for example, in decommissioning costs) and hence are not currently included in the baseline. In compiling the costs for each site, judgement has been used regarding both the costs held within such other descriptions (where available) and the relevance of particular facilities to LLW management. The cost baselines have been validated with each of the SLCs.

Key assumptions and exclusions for this cost and liability review include:

- The review is focussed on costs and liabilities within the NDA estate. A number of non NDA organisations generate LLW and VLLW, but these organisations are responsible for their own liabilities and on this basis are excluded from this review.
- Costs associated with the management and remediation of land which is contaminated and groundwater have been excluded, although costs associated with the management and disposal of any such material treated as LLW are included.
- Costs associated with operations at the LLWR site (estimated at £684M) have been excluded to avoid double counting of any elements as it is assumed that these cost elements are recovered by the off-site treatment budget in individual LTP. If this was being charged to SLCs it is recognised that it would account for a not insignificant proportion of the total (around 10%).
- Costs for sites that have moved to new contractual arrangements with NDA or where NDA no longer retains responsibility for certain liabilities associated with LLW (e.g. Capenhurst and Springfields) have been excluded.

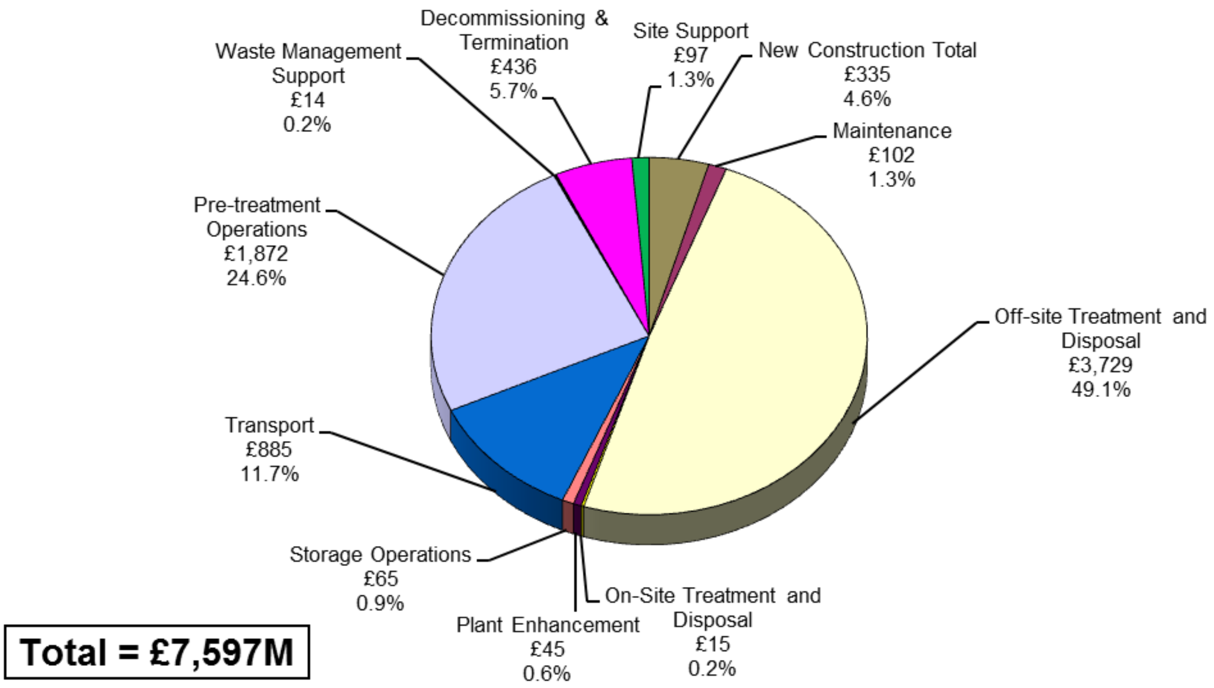
4.7.2. Summary of findings

4.7.2.1 LLW Cost Summary

The undiscounted cost of LLW management across the NDA estate in March 2014 is estimated as £7.60bn (contributing around 12% of the total NP of £62.5bn). This cost has decreased by £1.3bn from the Strategic Review 2010 baseline of £8.9bn and a reduction of £2.3bn from the original Strategic Review 2008 baseline of £9.86bn.

This is summarised, broken down by cost category, in Figure 28. Additional detail, including a comparison against the 2010 baseline on an SLC basis, is presented in Appendix D.

Figure 28 – Total 2013 Liability by Cost Category (£M)



Less than half (49%) of the overall cost baseline in 2013 can be attributed to off-site treatment and disposal (a reduction in the contribution of this cost element of 14% since 2010). This saving is a consequence of the removal of the Springfields legacy costs (£156M in LTP10) and a significant reduction of nearly £2bn since Strategic Review 2010 in Sellafield Ltd off-site disposal costs. There have been no contributions to the total 2013 liability from major additional asset or infrastructure costs.

The proportion of the cost and liabilities associated with treatment operations (such as waste characterisation, size reduction, sort and segregation, packaging and volume reduction) has increased to approximately 25% from 17% in 2010 following the expected trend from indexation of such costs over this period. In reality, some treatment and pre-processing costs for LLW will be embedded within decommissioning projects which have not been captured in this analysis.

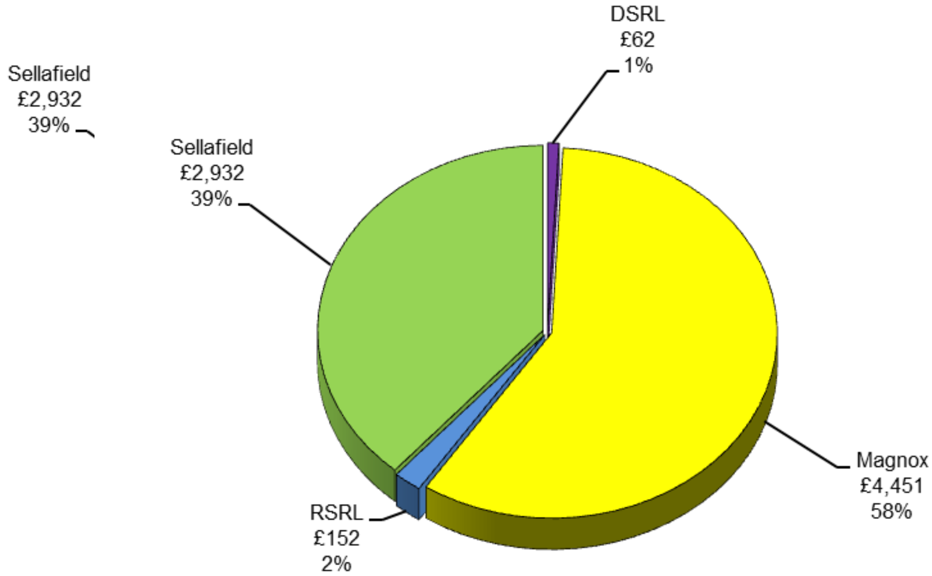
Transport costs remain broadly similar between 2010 and 2013 (9% and 12% contribution to the total respectively). It should be noted that transport costs for Sellafield Ltd have been reassigned from the LLW budget into a different programme area and thus have not been separately accounted for in this review. Transport costs remain at a similar proportion of the overall baseline for the rest of the NDA estate.

The overall cost of constructing new LLW management facilities has decreased from £0.4bn in 2010 to £0.34bn. Some of this has arisen from the transfer of costs to more fully utilise supply chain routes rather than capital expenditure in self-performing work. The most obvious change has been the removal of all construction costs relating to LLW from the RSRL budget and reductions in the costs of new infrastructure for interim LLW storage and processing at DSRL; although Sellafield Ltd within LTP13 plan capital expenditure (some £127M) in new sort, segregation and size reduction facilities.

In general, the cost of running existing LLW facilities has reduced between 2010 and 2013, with minor exceptions such as operation of the metal recycling facility and WAMAC at Sellafield Ltd.

4.7.2.2 LLW Cost by SLC

The distribution of the overall LLW liability estimate across the NDA estate is illustrated by Figure 29.



Magnox Ltd makes the greatest contribution to the total LLW liability estimate at 2013 at 58%. Sellafield Ltd has seen a significant reduction in its budget from over half the NDA estate total in 2010 (£4.46bn) to less than 40% in 2013 (£2.93bn). By contrast, Magnox Ltd has seen a significant increase by nearly £0.5bn. This is due to improved estimates of the liabilities associated with managing and disposing of LLW associated with final site clearance (FSC).

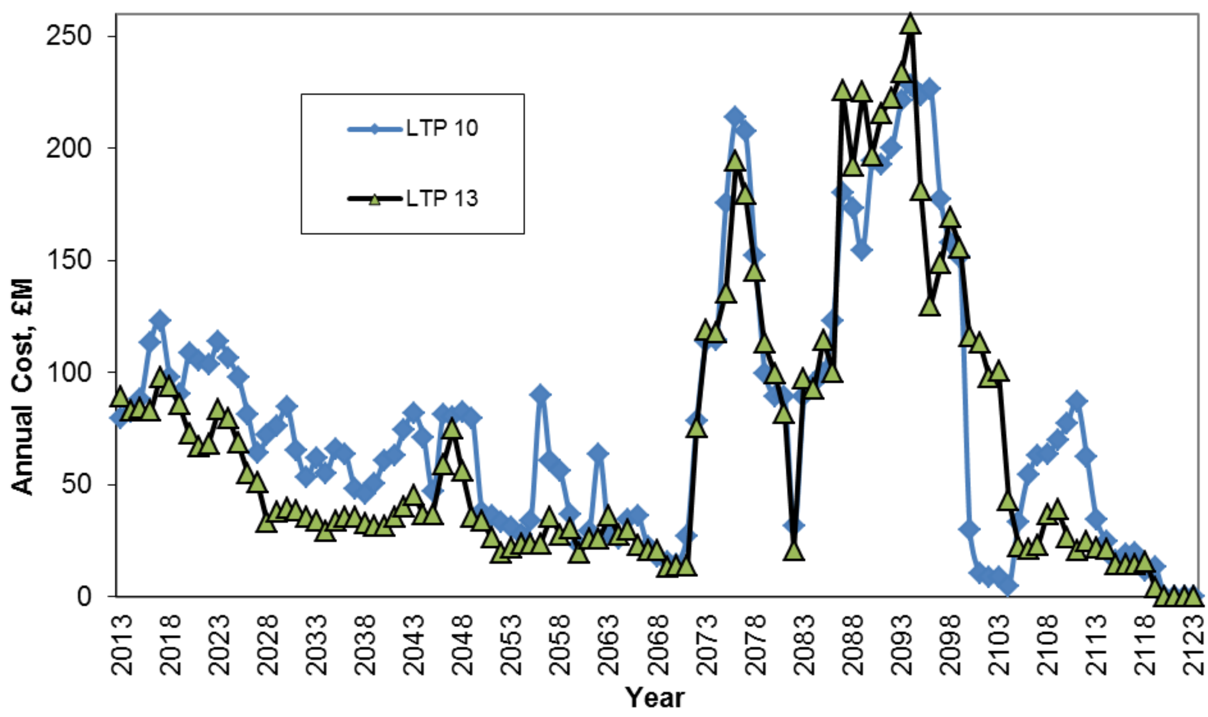
Most of the Magnox Ltd LLW baseline is covered by the FSC phase (currently scheduled for 2070 to 2104). The increased costs reflects re-estimated FSC inventories (developed using the SMART inventory review methodology and an improved understanding of decommissioning methods) resulting in an increase in total LLW volume estimates. As illustrated by Appendix D, Magnox Ltd have the largest LLW liability for decommissioning and termination across the NDA estate, followed by Sellafield Ltd (around half the Magnox Ltd total) and then DSRL and RSRL carrying minimal decommissioning costs. It is expected that estimates of decommissioning liabilities associated with LLW management at these SLCs will change in the future with more developed preparations for final decommissioning within the NDA estate.

The other major contributor to LLW costs, besides the management of Magnox Ltd FSC LLW, is disposal of packaged waste from WAMAC at Sellafield Ltd (£1.44bn). Sort, segregation and size reduction operations and characterisation programmes at Sellafield also make a sizeable contribution.

4.7.2.3 LLW cost over time

The profile of spending per year on LLW management over the period 2013 to 2120 is illustrated by Figure 30.

Figure 30 – Annual LLW liability over time for the period 2013 to 2120 (£M)



The LTP10 and LTP13 data track broadly similar profiles (which themselves demonstrate broad alignment with the projected waste generation profile illustrated by Figure 7, Section 4.2.2.1), but with a significant drop in the overall budget for the period 2013 to 2070 for LTP13. The largest element of this is attributed to a saving of over £0.8bn at Sellafield Ltd during this period. Overall, site programmes are currently expected to deliver around £90M of spend on LLW management per year until 2020, reducing on an annual basis (with an exception of a peak in the early 2040s) to £13M per year by 2070 before a significant ramp up. The out years (post 2070) budgets for LTP13 remain similar to those from LTP10, with similar peaks and troughs in activities from decommissioning and interim C&M phases, with LLW costs terminating at 2120. This shows that there has been no significant re-scheduling or accelerations of projects in the post 2070 horizon.

Issues

Whilst in total terms the Nuclear Provision associated with LLW management has decreased – demonstrating a favourable impact in implementation of the LLW Strategy since 2010, adoption of improved practices in the use of diversion over disposal and improved waste forecasting/inventory development – a number of issues remain. These issues include:

- Some SLCs continue to make conservative assumptions regarding projected waste volumes, waste classifications and waste routes.
- Some SLC baselines do not demonstrate alignment with the 2010 UK LLW Strategy (e.g. in terms of assumptions regarding waste routes).

SLCs could improve their LTP, and hence the accuracy and quality of the LLW Nuclear Provision estimate, by revisiting and challenging conservatisms in waste volumes, classifications and waste routings within their LTP. This would support improving the alignment of individual LTP with the 2010 LLW Strategy.

5. Synergies and Opportunities

Implementation of the UK National LLW Strategy has involved the identification and delivery of a range of opportunities, both SLC-specific and collaborative. In the earliest phase of strategy development and implementation, as described by the 2010 Strategic Review [Ref. 4], initiatives and opportunities were identified in the initial LLW Management Plan and were those arising from the ACCELS programme. The introduction of the LLW National Programme in 2011 has enabled the continuation of opportunity identification and implementation through the JWMP process. This section provides an update on the status of those initiatives described in the 2010 Strategic Review and also describes synergies and opportunity initiatives identified through JWMP (reflecting the post ACCELS landscape under the LLW National Programme).

5.1. LLW Management Plan and ACCELS Nuclear Provision Opportunities

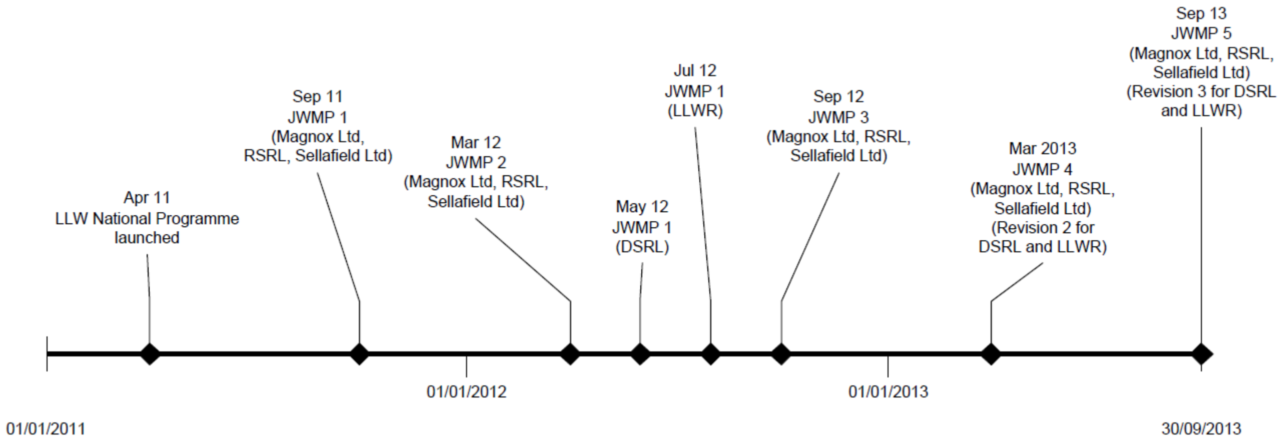
Prior to the commencement of the LLW National Programme in April 2011, a programme of work was undertaken to identify initiatives and opportunities to support implementation of the UK National LLW Strategy and hence deliver reductions to the Nuclear Provision (NP) for LLW. This was delivered through the ACCELS programme which was used as a mechanism to demonstrate that the National Strategy provides an effective, value for money approach to the management of LLW in the UK (the ACCELS programme and the LLW Management Plan is described in more detail in the 2010 Strategic Review [Ref. 4]). Opportunities and initiatives were identified during Phase 1 of the programme through interrogation of LTP08 and LTP10 data, and a series of Integrated Project Team (IPT) reviews involving personnel from LLWR, NDA and the SLCs. ACCELS Phase 2 involved the planning and implementation of the opportunities and initiatives identified in Phase 1, as well as the formal revision of SLC LTP to reflect the integration and savings in LLW management. Apppendix E provides a summary of the status of those initiatives identified as “ongoing” or "on-hold" in 2010 Strategic Review to indicate how these initiatives have been progressed through the ACCELS programme and latterly the LLW National Programme. It should be noted that these initiatives were reviewed during 2011/12, when the LLW National Programme was being established, and rationalised where appropriate into new activities reflected in the first iteration of the JWMP [Ref. 113 - 115] and LLW National Programme Schedule [Ref. 116].

Of the 29 initiatives not complete at the time of the 2010 Strategic Review, 20 initiatives were incorporated into the first (and where appropriate subsequent) iteration of the JWMP. The vast majority of these initiatives have been delivered in some form (18 of the 20 are complete), with the remaining two initiatives (SL16 and SL20) being delivered, for the former, through implementation of the output of the sort/segregate/size reduction peer assist and, for the latter, through ongoing engagement between waste management and decommissioning communities. The 9 initiatives not incorporated into JWMP were reviewed during FY11/12 and were deemed to either provide limited benefit from delivery or that were duplicates of other activities. As a result of completion of these initiatives, several parts of the original LLW NP have been removed from SLC LTPs or appropriately re-allocated from the LLW programme to other programmes within a SLC LTP (as detailed in Section 4.7).

5.2. LLW National Programme and JWMP 1-4 Synergies / Opportunities

As described in Section 2, the ACCELS programme was succeeded in April 2011 by the LLW National Programme. The LLW National Programme was established by NDA to drive implementation of the UK LLW Strategy within and outwith the NDA estate, and this is managed by LLW Repository Ltd on behalf of the NDA. A key initiative of the LLW National Programme was the introduction of JWMPs as a successor to the LLW Management Plan and ACCELS. The JWMPs are a series of proactive 5-year management plans produced by waste generators in collaboration with LLWR to improve the integration and compliance of that waste generator organisation with the UK LLW Strategy. The first JWMPs were produced by DSRL, Magnox Ltd, RSRL and Sellafield Ltd in September 2011 and have been produced on a six monthly basis since the second iteration in March 2012 as illustrated by Figure 31 (although some SLCs – notably DSRL and LLWR – have historically produced these plans on a different cycle). JWMPs allow the LLW National Programme to provide support on an individual basis to waste generators in implementation of the UK LLW Strategy as well as enabling the identification of and support to collaborative, cross-estate opportunities.

Figure 31 – JWMP Timeline



The activities and initiatives within the early iterations of the JWMPs, for SLCs other than LLWR, focussed on trialling, establishing arrangements and implementing as business-as-usual new waste management routes. They also included activities to ensure the best use is made of existing on-site infrastructure and activities to implement the necessary cultural changes within their organisations to support implementation of the LLW National Strategy. The activities for LLWR have been more varied; reflecting its status as leader of the National Programme, service broker, service provider and waste generator.

5.3. JWMP 5 Synergies and Opportunities

The fifth iteration of the JWMPs were published by NDA estate SLCs in September 2013 [Ref. 52 – 56]. These describe the activities being undertaken by the SLCs to implement the UK LLW Strategy in terms of:

- Delivery activities – those activities that deliver ongoing LLW management
- Transformational activities – those activities that will be undertaken to make a step change in LLW management practice.
- Opportunities – those activities which could be undertaken with current funding, which are opportunities for joint working or which could be undertaken if additional funding is made available, which would further optimise LLW management.
- Flywheel projects.

Delivery activities are those which are business-as-usual for SLCs in terms of LLW management practice (and often are a consequence of the successful delivery of transformational activities or opportunities that has resulted in a behavioural change). They are focussed on continued delivery of waste diversion, appropriate waste disposal, waste reclassification and inventory management. Many of these delivery activities are reflected in the SLC LTP.

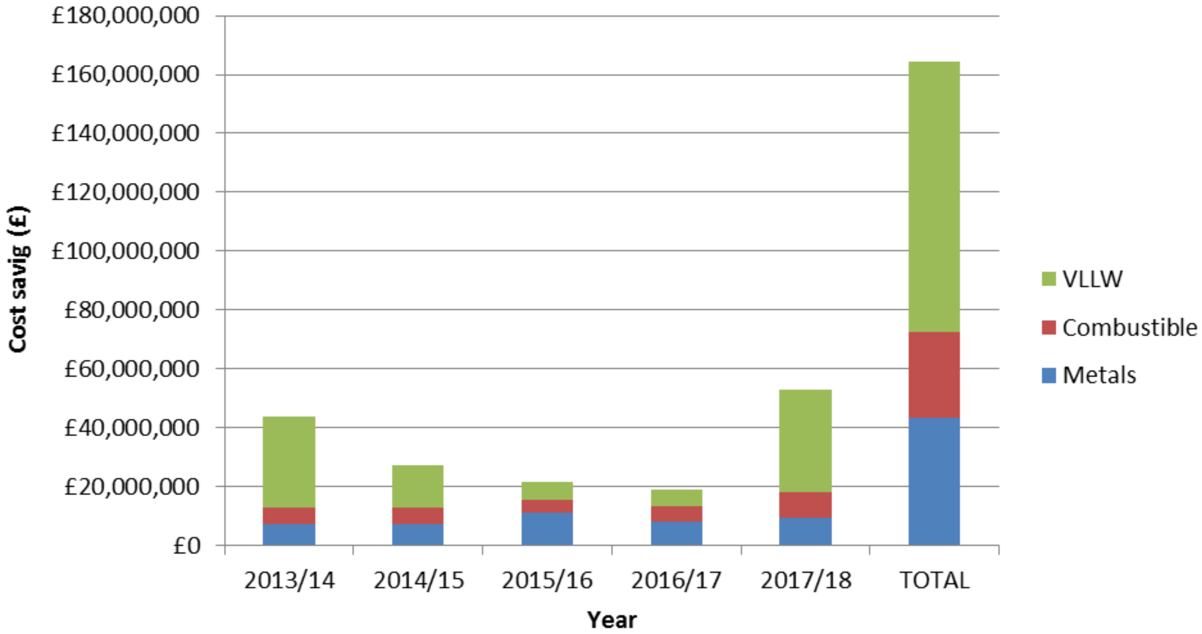
Transformational and opportunity projects are those which seek to support effecting cultural change in LLW management practice and the implementation of more effective LLW management practices. For LLWR, these also include a range of activities associated with optimising the delivery of the LLW National Programme, the use of the LLWR site and service delivery. A total of 136 transformational and opportunity projects were identified in the JWMPs (with 109 of these being transformational projects), as summarised by Appendix F. Comparison of the nature of the activities in Appendix E and Appendix F illustrates how the LLW National Programme (and the SLCs arrangements for LLW management) have matured since the introduction of the programme in 2011. Early change initiatives, as exemplified in Appendix E, focussed on the adoption of new waste routes and the necessary enabling activities around packaging, transport and characterisation. Appendix F illustrates how efforts now are focussed on optimising and improving arrangements for waste management through improving contractual mechanisms for access to services via the supply chain; training; investigating new technologies; and identifying waste management solutions for more challenging waste streams.

A key theme, and indeed a key benefit, of the LLW National Programme is the promotion and facilitation of collaboration between waste generators, LLWR and other stakeholders, as appropriate. Collaboration drives implementation of value for money (by reducing rework on common projects by waste generators) and supports the promulgation of good practice between organisations, driving improvements in LLW management practice. Appendix F shows some 26 initiatives from JWMP 5 (19% of the total) that are directly collaborative. These include: inter-SLC collaboration on subjects such as waste technologies, peer reviews, training and procurement of services; SLC-LLWR collaboration (on specific problematic wastes); and collaboration between SLCs and other stakeholder groups such as the NDA, regulators and RWMD.

Cumulatively, it is anticipated that the delivery of business-as-usual, transformational and (where funding and schedule allows) opportunity projects will continue to drive the realisation of benefits in terms of reduction to the NP. Figure 32 below illustrates the anticipated cost benefit of implementation of the JWMP for the NDA estate, as a function of the volume of waste diverted away from disposal at the LLWR, for the period 2013/14 to 2017/18.

This graph shows that it is anticipated, based on the current operation and decommissioning plans for the NDA estate, that waste diversion (facilitated by execution of the JWMP) will deliver a saving of approximately £164M across the NDA estate over the period compared to the cost of disposal of the volume. This can be attributed to the significant difference in cost between LLW disposal at LLWR, and the use of waste diversion routes. The greatest cost benefit is brought through the use of the VLLW/LA-LLW disposal route (which contributes 56% of the total savings). This predicted waste diversion would contribute to an extension of the life of LLWR of 2 years[6]. There is significant variation across the 2013/14 to 2017/18 period, with a downward trend in diversion from 2013/14 until a significant ramp-up in 2017/18. This reflects the profile in waste generation predicted during this period with the phasing of the decommissioning programme at Magnox Ltd (as Bradwell and Trawsfynydd enter Care & Maintenance, followed by ramp up in Care & Maintenance preparations at other sites) and at RSRL; as summarised in Section 4.4.

Figure 32 – Summary of cost benefits by waste route from waste diversion (JWMP implementation) for the NDA estate during 2013/14 to 2017/18



[6] It should be noted that the £164M saving is that derived from the difference in cost between planned diversion and disposal during this period, and does not reflect the value of the life extension of the LLWR.

6. Conclusions

This LLW Strategic Review has described the 2013 baseline for LLW management in the UK in terms of waste inventory, LLW management strategy, waste management performance, research and development, existing and planned assets and infrastructure, and costs and liabilities. This provides an update to the 2010 baseline provided in the Strategic Review published in 2011, reflecting the changes and progress that has been made in the UK LLW management sector to implement the UK LLW Strategy.

The key conclusions from this Strategic Review are:

- A review of the UK's LLW inventory shows that the total forecast LLW volume arising between 2013 and 2120 is 4.2 million m^3; consisting of 1.1 million m^3 of LLW and 3.3 million m^3 VLLW. Approximately 90% of this total forecast (3.78 million m^3) will be generated by the NDA estate, with Sellafield Ltd being the dominant waste generator in the UK. The LLW stream is dominated by metals; whilst VLLW is dominated by unknown material (arising from Sellafield's 2D148 wastestream) and rubble.

- The 2013 iteration of the IWS documents clearly articulate the waste management strategy relating to the management of LLW for the NDA estate SLCs. The IWS documents meet the requirements specified in the revised ENG01 specification, providing a concise, high-level overview of waste management strategy. There is strong evidence within the IWS documents of alignment with the strategic principles of the UK LLW Strategy, particularly with respect to application of the Waste Hierarchy and diversion of waste away from disposal at the LLWR site; reflecting the growing diversity and maturity of alternative waste routes since the 2010 Strategic Review where disposal was the default strategy. Further improvements to IWS documents could still be made, particularly with respect to demonstrating how business decision making integrates with the strategy/waste management decisions and the interrelationships between strategies for different waste classifications.

- Waste performance data clearly demonstrates the progress that has been made in the implementation of the UK LLW Strategy, within the NDA estate. There is clear evidence that waste diversion is becoming routine, business-as-usual activity for waste generating sites; with particularly good use made of diversion routes for VLLW/LA-LLW and metallic waste. Off-site commercial supply chain infrastructure is widely used – particularly for management of VLLW/LA-LLW, for SLCs with no on-site option, and for combustible waste; and there is use of on-site and off-site waste management capability for treatment of metallic waste. Waste diversion is predicted to increase over the period 2013 to 2018, demonstrating that changes made to organisational waste management strategies following implementation of the UK LLW Strategy will be sustained.

- A review of the TBuRD and JWMP for the NDA estate SLCs demonstrates that research and development activities are being undertaken to support LLW management practice in the UK. These activities tend to be needs-driven (related to a specific project or wastestream), associated with development rather than fundamental or applied research, and are generally at high TRL. Some research and development activities were identified solely in JWMP, demonstrating that progress could be made in fully aligning these different plans. There is limited collaborative research and development occurring in these projects, although there is potential for a more collaborative approach, particularly for issues or wastestreams that occur across the estate. This is an area where the LLW National Programme could take a lead to coordinate and champion collaborative, cross-estate efforts.

- There is a diverse range of assets and infrastructure available to waste generators in the UK for the management of LLW. This review has demonstrated some changes in the availability of assets and infrastructure in the UK, particularly for combustible waste (with the closure of on-site infrastructure at Magnox Ltd sites and the opening of a new commercial incineration facility at Ellesmere Port) and VLLW/LA-LLW (with the LLWR segregated services framework providing waste generators with access to three commercial VLLW/LA-LLW disposal facilities). There has been progress made in the development of new packaging and transport services by LLWR under the segregated services framework to support waste generators in the use of the range of off-site waste management assets and infrastructure.

- A review of cost information shows that the 2013 cost and liability baseline is around £7.60Bn. This has decreased by £1.3Bn from the previous 2010 baseline of £8.89Bn. Within this total, there have been changes in the cost of individual elements reflecting changes in scope, unit rate assumptions and underpinning inventory numbers. As in 2010, there remain several areas where site baselines are not fully aligned with the UK LLW Strategy or utilise conservative assumptions regarding waste volumes, categorisation and waste routing.

- A key development in the UK LLW management landscape since 2010 has been the establishment of the LLW National Programme in 2011. The LLW National Programme provides a mechanism for coordination of activities within the UK that support implementation of the UK LLW Strategy and supports the facilitation of collaboration between waste generators, service providers and other stakeholders. The LLW National Programme has introduced the JWMP, and associated schedule, as a replacement to the LLW Management Plan and ACCELS programme. A review of the outstanding initiatives from the ACCELS programme identified that the majority were translated into the JWMPs in 2011 and all but two of these have subsequently been delivered. The JWMP is a collaborative plan developed by a NDA estate waste producer and LLWR, covering a five year period. The most recent iteration of the JWMPs contained some 136 transformational and opportunity initiatives. The nature of these initiatives has changed since ACCELS and the first JWMP in 2010 reflecting the increased maturity of the programme and strategy implementation, with the focus now on optimising waste management arrangements and finding solutions to particular problematic wastestreams rather than on establishing new routes. The theme of collaboration is reflected in these activities, with 19% of the initiatives being directly related to collaboration. It is predicted that delivery of the September 2013 JWMP will deliver a cost benefit of £164M through waste diversion.

- Whilst this review has identified good progress in terms of strategy implementation and effective LLW management practice, it is acknowledged that a diverse range of issues remain. Strategy implementation (through application of the waste hierarchy) relies on the availability of a robust, competitive supply chain. The fragility of the supply chain remains a credible threat to the UK LLW management community as exemplified through the impacts of the delivery and storage capacity shortfall at the Studsvik UK MRF in 2013. The quality, accuracy and completeness of waste inventory and forecasting data have continued to be an issue, contributing to supply chain fragility. Changes and uncertainties in assets and infrastructure continue to be a theme. This has been demonstrated through the closure of on-site incineration infrastructure (in the Magnox Ltd and EDF fleets) and the mothballing of infrastructure (at Capenhurst and Tradebe Inutec), although this period has seen the availability of new infrastructure at the Veolia Ellesmere Port facility. The channelling of nuclear liabilities through LLWR for HV-VLLW and LA-LLW has enabled the use of the specified landfill disposal route for these wastes but has necessitated a rigorous, resource intensive process to be deployed in setting up the route at individual sites. There are also ongoing issues with LLW disposal capacity at LLWR whilst the applications for a revised Environmental Permit and planning permission are determined. In addition, LLW management and the application of the waste hierarchy in LLW management arrangements have not yet been consistently applied or optimised in the UK LLW management community.

This 2013 baseline shows that there has been significant progress made since 2010 in terms of the successful implementation of the UK LLW Strategy and the cultural change in waste management practice within the UK, through the efforts of waste producers, service providers and the LLW National Programme. Whilst it is recognised that progress has been made, further work is required to resolve the issues/threats that have been identified and to embed effective LLW management arrangements into sustained cultural change.

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Appendix A: LLW Inventory

As noted in Section 4.2, the inventory analysis presented in the body of this report reports on the entire UKRWI 2013 data set. It is recognised that 88% of the Sellafield Ltd LLW inventory is dominated by one large decommissioning wastestream (ID reference 2D148), which is scheduled to arise in 2021 and for which there is significant uncertainty in activity distribution and waste type. Presented in this Appendix is the same inventory analysis as provided in Section 4.2 but discounting the 2D148 wastestream, to illustrate the different trends in the data if this dominating wastestream is removed.

Figure A1 – Cumulative forecast raw arisings of UK LLW and VLLW Exc. Sellafield Waste Stream 2D148

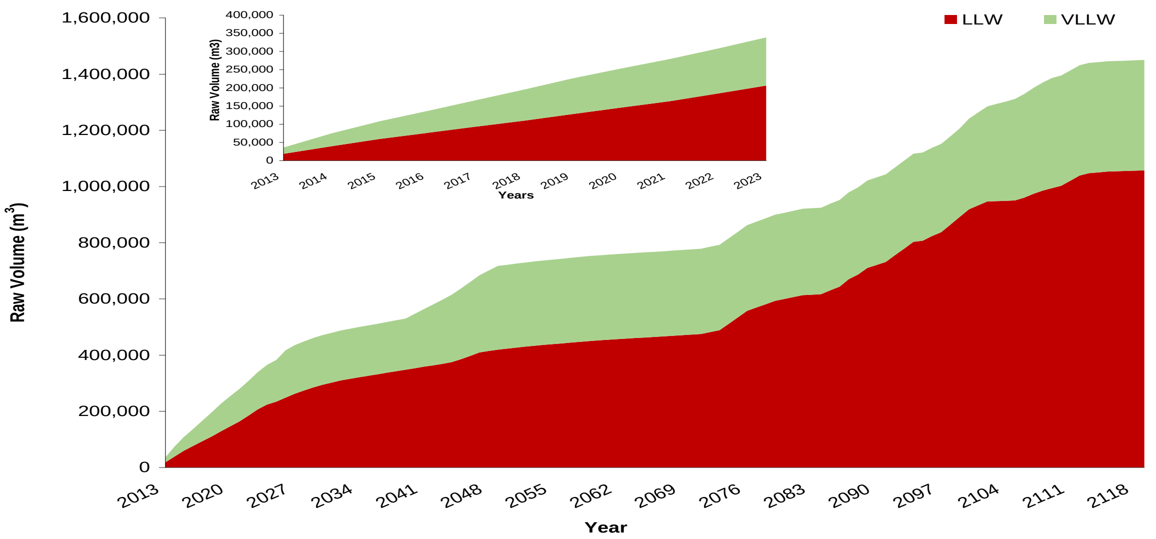


Figure A2 – Annual raw arisings of UK LLW and VLLW Exc. Sellafield Waste Stream 2D148

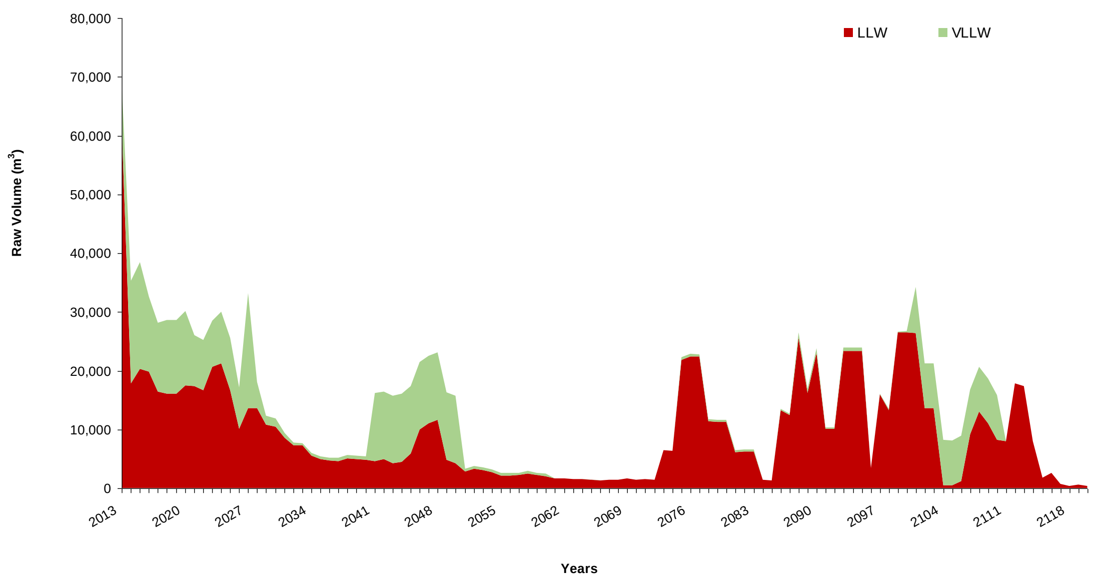


Figure A3 – Raw waste arisings of UK LLW and VLLW by Waste Custodian (m^3) Exc. Sellafield Waste Stream 2D148

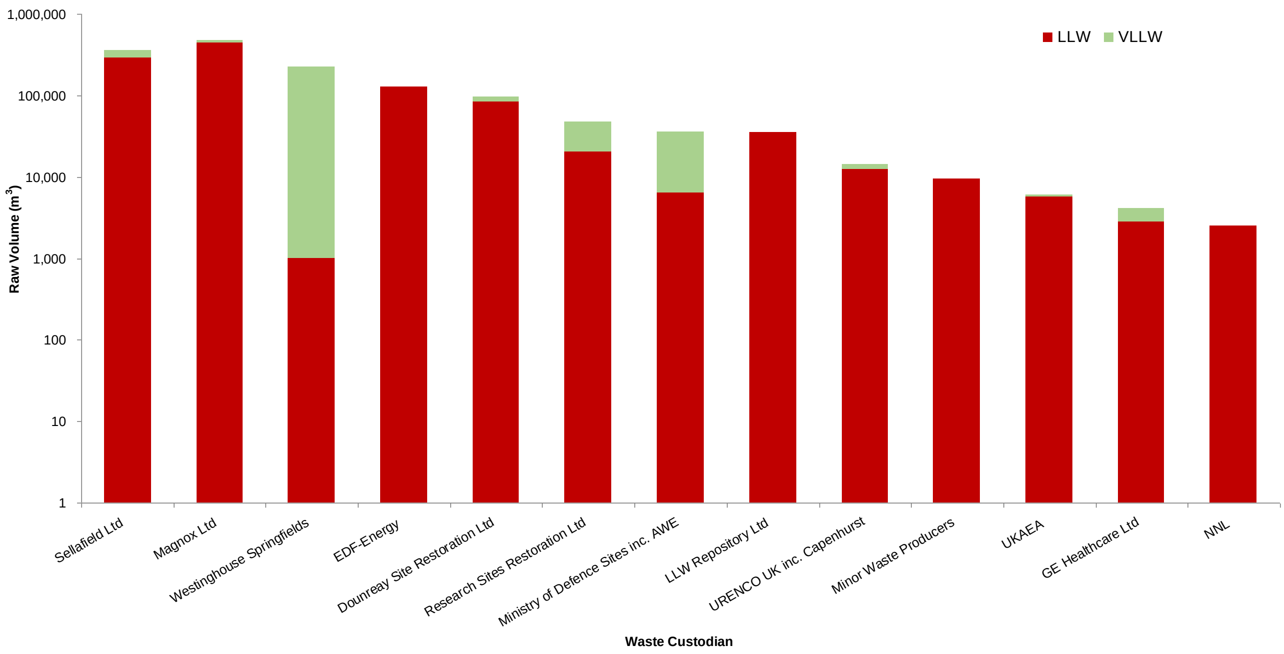


Figure A4 – Raw waste arisings of UK LLW and VLLW by Waste material (te) Exc. Sellafield Waste Stream 2D148

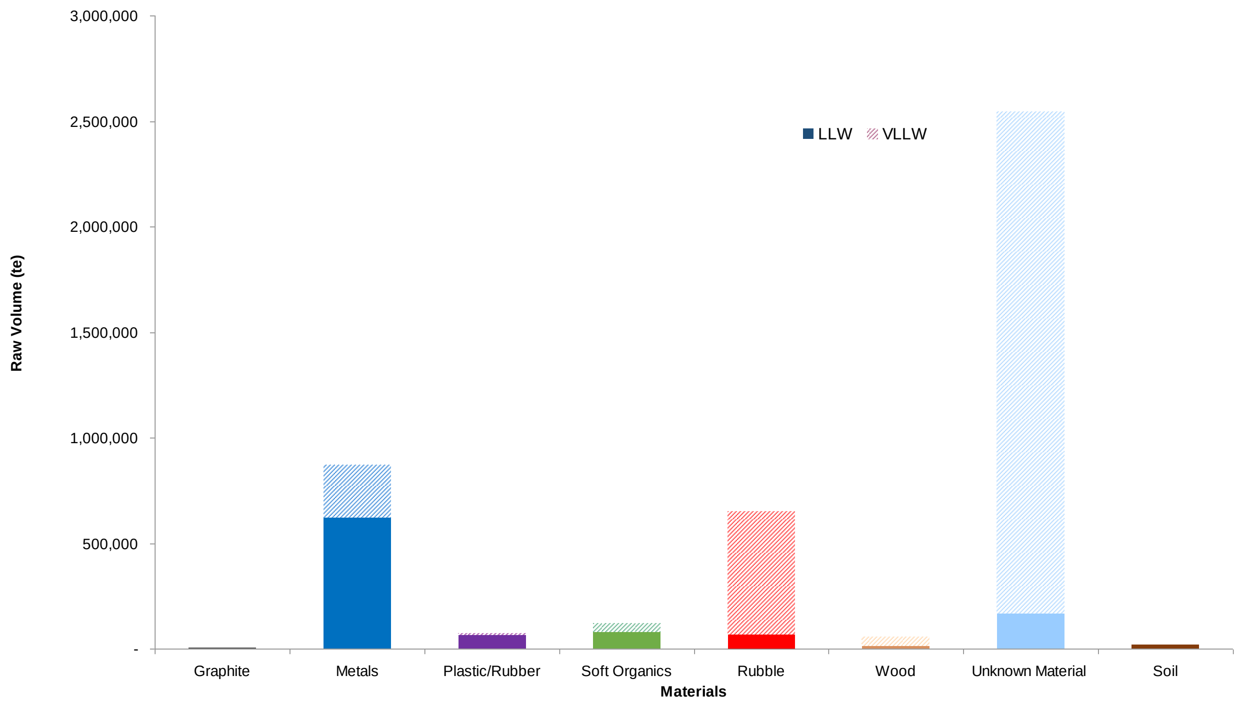


Figure A5 – Annual LLW arisings only by material content (te) Exc. Sellafield Waste Stream 2D148

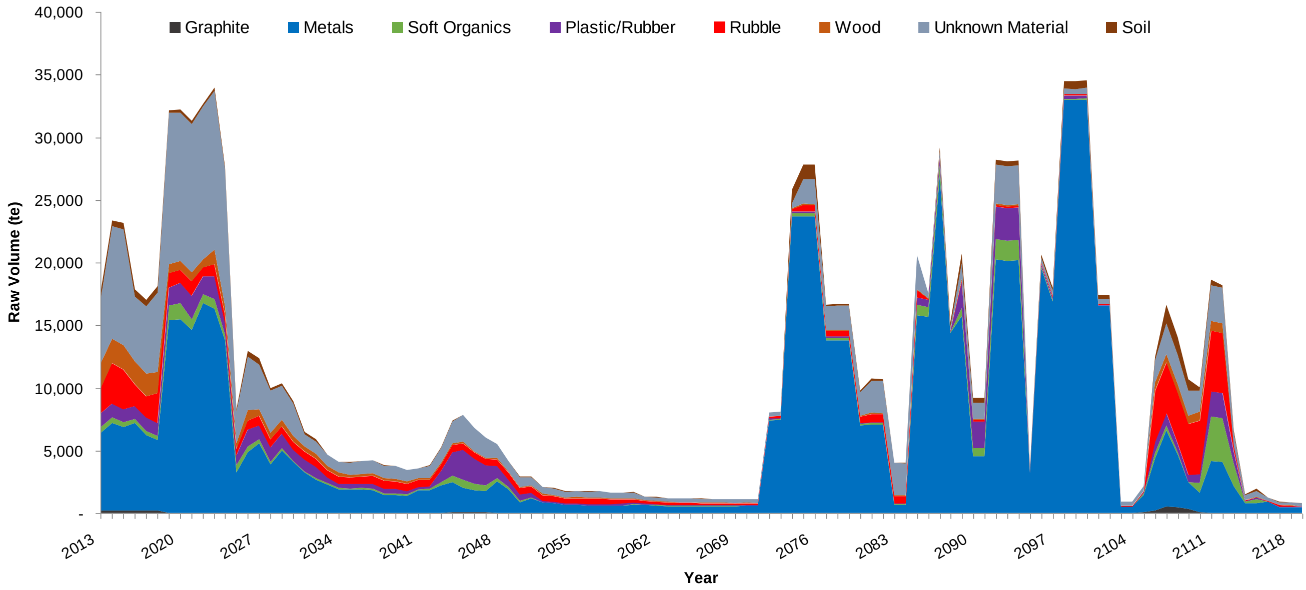


Figure A6 – Annual VLLW arisings only by material content (te) Exc. Sellafield Waste Stream 2D148

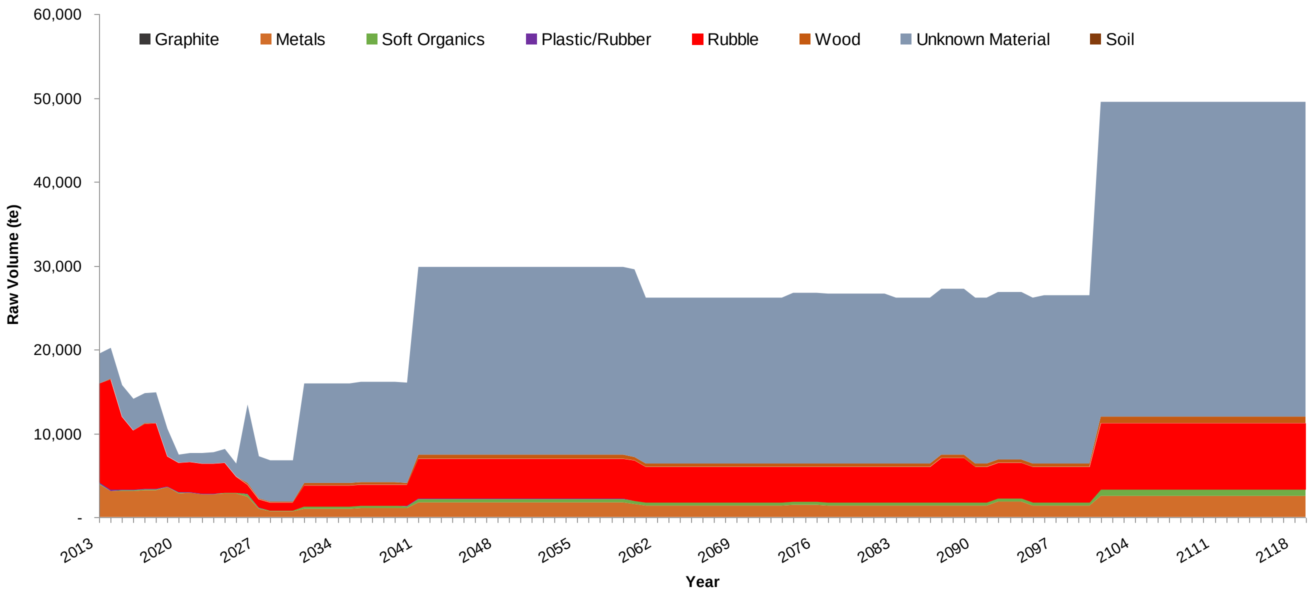


Figure A7 – UK Regional Distribution of Raw LLW and VLLW Volumes (2013 – 2120)

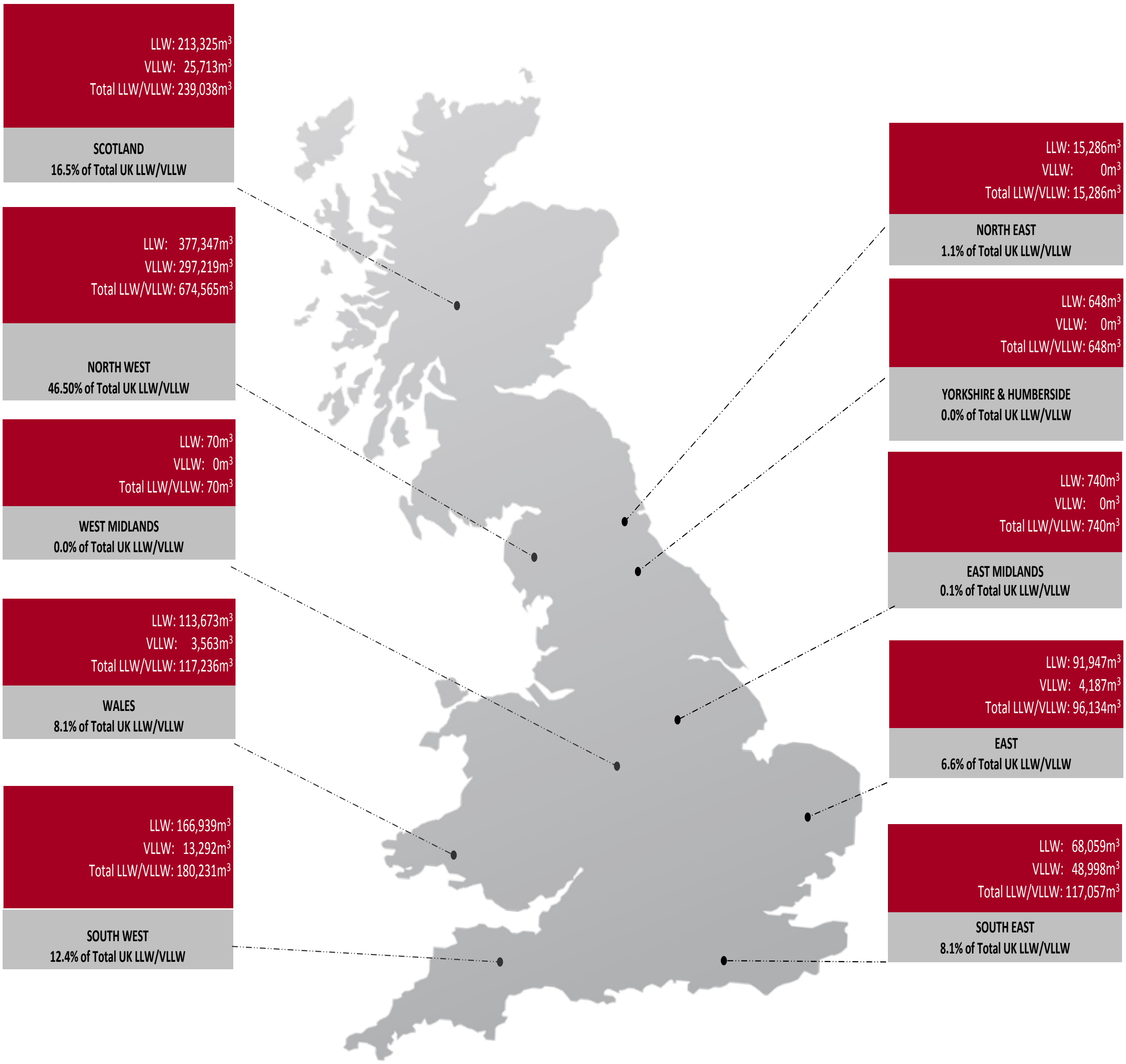
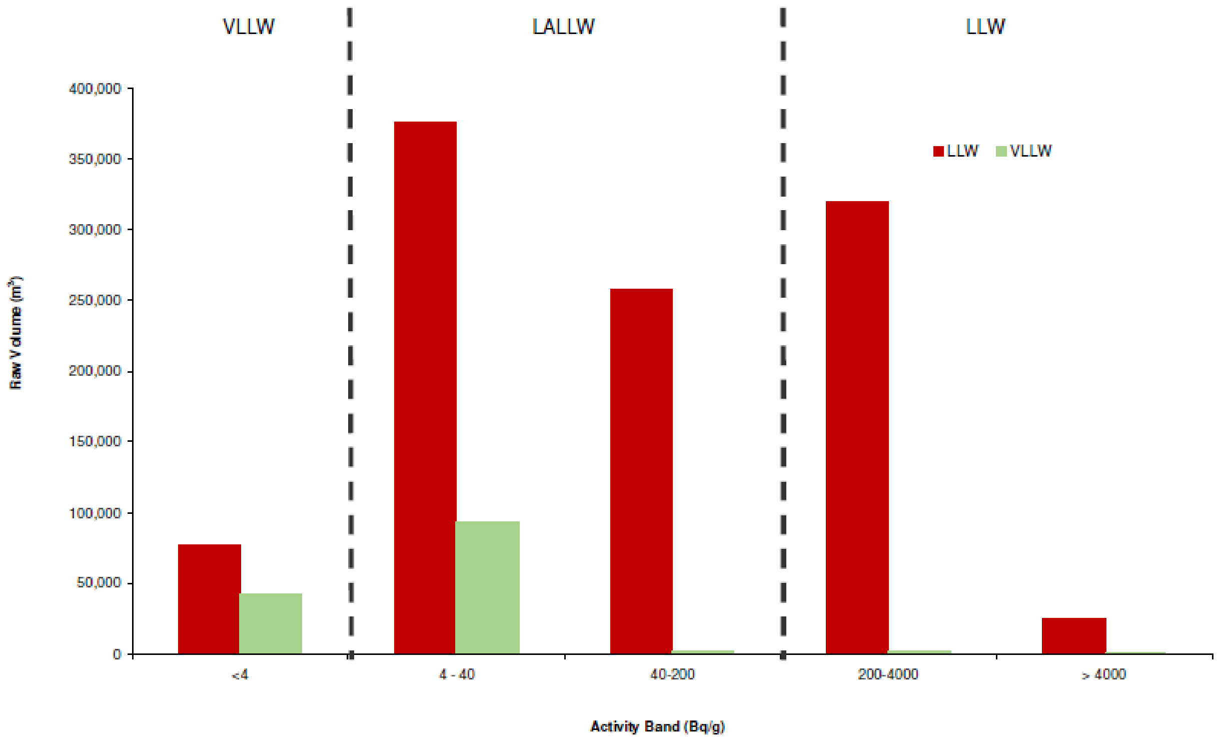


Figure A8 – Activity distribution of LLW and VLLW volumes Exc. Sellafield Waste Stream 2D148



Appendix B: Waste Management Strategies

DSRL [Ref. 17]	Dounreay Site Restoration Ltd
Summary of LLW Strategy	
DSRL's objective is to restore the Dounreay site to a publicly acceptable condition in a safe, secure, environmentally responsible and efficient manner. The overall strategy for radioactive wastes is treatment as necessary to allow removal from the site. In relation specifically to LLW, DSRL IWS states that after implementation of the waste hierarchy, and where appropriate, LLW from operations and decommissioning on the site is packaged in 200 litre drums, with the volume further minimised by use of the WRACS facility, and interim stored pending the availability (planned for 2014) of the near-site LLW disposal facility.	
Status	
Dounreay Site Restoration Ltd is the Site Licence Company that manages and operates, on behalf the NDA, the Dounreay site. DSRL is undergoing active decommissioning, with the vision of transfer to an interim end point by 2025 prior to a period of institutional control before reaching a final end state in 2033.	
Waste Volumes	
DSRL predict the following volumes of raw solid LLW will be generated during this decommissioning programme: • LLW – 72,448 m^3 • Demolition LLW – 22,852 m^3	
Origin of Waste	
LLW arises on the Dounreay site as a result of routine operations and decommissioning of redundant reactors and facilities which supported the full nuclear fuel cycle. The IWS states that LLW arisings consists of materials including: • Metallic waste e.g. ducting and vessels • Soft wastes e.g. laboratory materials or disposable clothing	
Current Waste Routes	
The IWS identifies the following waste routes for LLW: • Storage pending availability of the new near-site LLW disposal facility (D3100) Characterisation is used to identify wastes which are exempt; which are re-used where possible, recycled via specialist authorised contractors or disposed of to suitable landfills.	
Organisation and Management	
Waste management organisation within DSRL is the responsibility of the Waste Directorate (WD). The 'Project Director Waste', supported by a management team, reports directly to the DSRL Managing Director.	

Opportunities to Improve		
DSRL identified a range of opportunities for the improvement of LLW management: • Continue to research opportunities for more efficient waste packages. • Waste Department to continue to open up waste routes and further develop and underpin strategies for wastes. • Review potential opportunities to utilise waste treatment facilities outside Scotland for the possible treatment of LLW, once new RSA Authorisation has been approved. • Continue to progress the construction of the new LLW Disposal Facility.		
Principal LLW Issues		
DSRL have identified risks associated with: • Inventory accuracy • An unforeseen discovery resulting in delays to the programme • An inability to retrieve specific wastes • Political pressures resulting in strategic changes which may impact on time and cost.		
Alignment to principles identified in LLW Strategy		
A	In line with NDA's objectives, DSRL identify safety of workers and public and protection of the environment as top priorities.	✓
B	The IWS states that one of the key requirements of waste management at Dounreay is to ensure that the production and accumulation of new waste is minimised. Where creation of waste is unavoidable, it should be diverted from burial as far as is reasonable practicable. DSRL states its objective to manage waste at the highest achievable level within the waste hierarchy. Examples of how waste minimisation and the waste hierarchy are applied at Dounreay include: • Continual monitoring of opportunities to recycle material where cost-effective and practical • Re-use of material in a cost-effective and environmentally responsible manner Compaction of much of the LLW generated to minimise the volume requiring disposal. There is no specific, tactical level description of how DSRL promotes or undertakes waste avoidance within the IWS.	-
C	DSRL note the importance of characterisation to allow improved understanding of materials and the future waste treatment requirements.	✓
D	The strategy recognises the importance of segregating, size-reducing and compacting LLW to minimise volumes sent for interim storage and subsequent disposal. It is recognised that some wastestreams do not fit within the waste management model selected by DSRL (e.g. mercury and oils / solvents) and there is recognition that other waste management routes will be required for such wastes in the future.	✓
E	The IWS states that DSRL is committed to open and honest two-way communication and active engagement with all its stakeholders. The IWS recognises that it is easier to make good progress developing and implementing waste strategy when stakeholders understand the objectives and constraints of the site. There is a clear description of the process used by DSRL for interacting and engaging with	✓

	stakeholders.	
F	DSRL confirms that the purpose of the Dounreay IWS is to demonstrate how the site will assess and manage all forms of waste; both radioactive and non-radioactive arising from the site's past, present and future operations and notes the need for available, flexible waste management routes. Currently, the DSRL disposal facility is undergoing construction (and is not due to be available until 2014) and the RSA93 Authorisation prevents the use of off-site management routes, limiting the availability of waste management routes for the site. These limitations in the availability of flexible waste management routes are reflected in the IWS.	-
G	The IWS details DSRL's waste management strategy. The IWS confirms that application of the waste hierarchy is embedded into the company decision making processes; and BPEO/BPM studies are undertaken to determine optimum waste management strategies where appropriate. There is limited consideration of the interrelationship between different waste types, other than LLW and Out of scope waste. There is a clear indication of how the IWS interacts with other key strategies such as the TBuRD, decommissioning strategies for the site, Government policy, SEPA waste strategy and pertinent legislation.	✓
H	DSRL clearly use robust decision making processes to identify advantageous waste management options. The IWS refers to the application of BPM, and the consideration of BPEO/BPM in the selection of waste management options. DSRL also apply the NDA SED process to facilitate the prioritisation of projects. The IWS does not reference the NDA Business Case Methodology not indicates application. No link is drawn within the IWS between the outcome of decision making processes and business cases.	-

LLW Repository Ltd [Ref. 18, 22]	
Summary of LLW Strategy	
LLW Repository Ltd's overall strategy for management of LLW arising on the LLWR site involves application of the Waste Hierarchy and diversion of waste away from disposition at LLWR as far as practicable.	
Status	
LLW Repository Ltd is the Site Licence Company responsible for managing on behalf of the NDA the national Low Level Waste Repository (LLWR) facility in West Cumbria and for overseeing the National Waste Programme to ensure that lower activity waste arisings from the UK are managed effectively. LLW Repository Ltd performs a number of roles – management of the LLW National Programme, service provider (of LLW disposal services), waste management service broker (through the segregated service broker) and decommissioning of legacy Plutonium Contaminated Material (PCM) storage facilities on the LLWR site.	
Waste Volumes	
LLW Repository Ltd estimates that approximately 8,600m^3 of LLW (including VLLW) will be generated over the lifetime of the LLWR site, equating to approximately 24% of the total waste arisings from the LLWR site.	
Origin of Waste	
The IWS states that the majority of the LLW arisings for the LLWR site are expected to arise during the phases of site operations, PCM decommissioning and site remediation. The IWS details LLWR sites operational role in the disposition of LLW received from waste consignors across the country, although the IWS focuses on management of waste arisings from the LLWR site itself. In the near term, until 2018, waste arisings will predominantly arise from operations to decommission the legacy PCM storage facilities. Following the completion of the PCM decommissioning programme, waste from site operations and site remediation will dominate arisings.	
Current Waste Routes	
The IWS states that the following principal waste management routes are utilised by LLW Repository Ltd: • Characterisation and monitoring, and the re-classification of waste to out-of-scope for release from the site as non-radioactive material • Decontamination and metal melting (where required) of metallic waste via the supply chain • Disposal of VLLW and LA-LLW to permitted landfill sites • Supercompaction of compactable LLW at the Sellafield WAMAC facility and disposal of the compacted waste at LLWR • Disposal at LLWR	
Organisation and Management	
The LLWR site has personnel with the specific task of coordinating LLW management operations (for waste arisings at the LLWR site itself). LLW management operations are undertaken by Decommissioning and Operations personnel at the site.	

Opportunities to Improve		
LLWR identified a range of opportunities for the improvement of LLW management: • Complete SMART inventory review and update waste inventory data for LLWR. • Establish route for incineration of combustible LLW arising on the LLWR site. • Establish facilities on the LLWR site to enable enhanced segregation and management of LLW arisings from the site. • Delivery of the LLWR JWMP.		
Principal LLW Issues		
LLWR have identified risks associated with: • Withdrawal of ≥ 1 service providers from the LLWR service frameworks, reducing opportunities for diversion of waste from disposal at LLWR. • Unexpected levels and/or volumes of waste (radioactive and non-radioactive) are found prior to site remediation and decommissioning. • Sufficient LLW treatment and disposal routes – other than disposal to LLWR – remain available to support waste management activities at the LLWR site.		
Alignment to principles identified in LLW Strategy		
A	In line with NDA's objectives, LLW Repository Ltd identify safety of workers and public and protection of the environment as the main priorities of the waste strategy.	✓
B	The LLWR IWS articulates that LLW Repository Ltd applies the Waste Hierarchy to the management of all wastes, where practicable. The application of the waste hierarchy and the application of BAT are incorporated as a requirement in corporate processes and the Management System for the management of radioactive waste. There is a clear indication that waste avoidance is the preferred option and tactical level mechanisms for the avoidance of waste generation (such as the use of the NDA asset transfer scheme) are communicated within the IWS.	✓
C	LLW Repository Ltd state that 'characterisation is used to enable segregation of waste based on radiological classification and waste type to enable re-use and recycling or management as a lower category of waste'. This demonstrates recognition that characterisation and waste segregation is key to the effective management of LLW.	✓
D	There is recognition within the LLWR IWS that – given the variability in physical, chemical and radiological characteristics of LLW – the availability of a range of appropriately regulated waste management routes is important. LLW Repository Ltd uses a range of waste management routes, including: • Characterisation and monitoring, and the re-classification of waste to out-of-scope for release from the site as non-radioactive material • Decontamination and metal melting (where required) of metallic waste via the supply chain • Disposal of VLLW and LA-LLW to permitted landfill sites • Supercompaction of compactable LLW at the Sellafield	✓

	WAMAC facility and disposal of the compacted waste at LLWR • Disposal at LLWR The IWS states that, in line with the national LLW strategy, plans are in place for the utilisation of other waste management routes, such as incineration, to further performance in waste diversion.	
E	The IWS identifies LLW Repository Ltd's approach to stakeholder engagement and notes the importance of effective stakeholder engagement to delivery of its mission. This aligns with the principle in the National LLW strategy that the development of new waste options or approaches to the management of LLW requires proactive engagement with stakeholders. Examples of the mechanisms used for engagement with stakeholders (such as community open days) are provided within the IWS.	✓
F	The LLW Repository Ltd LLW waste management strategy, articulated within the IWS, identifies that application of the Waste Hierarchy is embedded into the company decision making process and that a diverse range of waste management routes are utilised by LLW Repository Ltd. The IWS demonstrates recognition by LLW Repository Ltd that the availability of a flexible range of waste management routes is necessary to meet the corporate objectives of the organisation such as decommissioning of legacy PCM facilities, site operations and, in the longer term, site remediation.	✓
G	The LLW Repository Ltd IWS clearly demonstrates the interaction of the LLW strategy within the IWS with wider decommissioning and corporate strategy, UK LLW Strategy, Government policy and legislation. The IWS confirms the strategy to apply the waste hierarchy applies to all wastes, both radioactive and non-radioactive. This is consistent with the principle of integration of strategies for all wastes; although this is not consistently applied for all waste types (i.e. the interrelationships between different types of waste are not clear within the IWS).	✓
H	The IWS notes 'how waste management decisions are made in a transparent, technically underpinned, structured and auditable manner that takes due regards of a range of factors and is based on an effective and defensible balance of priorities.' BAT is used as the principle waste decision making mechanism. The IWS does not reference the NDA Business Case Methodology not indicates application. No link is drawn within the IWS between the outcome of decision making processes and business cases.	-

Magnox Ltd [Ref. 19, 23]

Summary of LLW Strategy

Magnox Ltd is responsible for the management of 10 of the UK's Magnox power stations on behalf of the NDA; of which one is operational and the remaining facilities are either shutdown or undergoing decommissioning. The current strategies for all LLW is to treat or dispose in line with government policy and the nuclear industry LLW strategy; based on applying the Waste Hierarchy for all waste streams where practicable. The Magnox Ltd IWS details the Joint Waste Management Plans to assist implementing and integrating the UK LLW Strategy.

Status

Magnox Ltd is the Site Licence Company responsible managing 10 of the UK's Magnox power stations on behalf of the NDA. Of the fleet of Magnox power stations, only one reactor, unit 1 on the Wylfa site, remains operational; reactors on the nine other Magnox sites are all shutdown and at various stages of defueling/decommissioning. Whilst electricity generation continues at Wylfa, the main activities being undertaken by Magnox at its sites are defuelling, which is undertaken as soon as practicable after shutdown; and preparations towards Care and Maintenance (C&M) ahead of Final Site Clearance (FSC) which, in the current lifetime plan, is assumed will commence after a period of 85 years from shutdown. Two sites – Bradwell and Trawsfynydd – are on an accelerated decommissioning programme and will transfer into C&M by 2016. The remaining 8 sites will transfer into C&M by 2028.

Waste Volumes

The IWS states that LLW (including VLLW) accounts for 26% of all waste arising across the 10 Magnox sites during all phases of decommissioning.

The site predicts the following (raw) volumes of LLW (including VLLW) during each phase of decommissioning:

- C&M Preparations – 36,796 m^3
- C&M – 1,210 m^3
- Final Site Clearance – 317,160 m^3

Origin of Waste

LLW and VLLW are generated by Magnox Ltd during operations, C&M preparations and C&M as a result of active operations, maintenance activities and decommissioning work. However, it is during Final Site Clearance that the majority of waste will arise, this being largely concrete, graphite and redundant plant/equipment.

- Oil and solvents from gas circulator lubrication and maintenance
- Combustible solid LLW such as oil soaks and wood
- Soft waste such as clothing, filter and general waste
- Activated or contaminated insulating materials, including asbestos
- Metal items such as heat exchangers, pipework, tanks, pumps and motors
- Concrete and building structures
- Some sludges

Current Waste Routes		
The IWS identifies the following waste routes are used by Magnox Ltd for the management of LLW: • Incineration of combustible LLW • Decontamination, and where appropriate, melting of contaminated and activated metals • Disposal of VLLW to permitted landfill sites • Controlled burial of LA-LLW to permitted landfill facilities • Optimised disposal of LLW to the LLWR • Decontamination to enable disposal of waste as out of scope or exempt from EPR10/RSA93 The current waste management strategy for LLW utilised by Magnox Ltd involves the application of the Waste Hierarchy and the diversion of waste from disposal by burial as far as reasonably practicable. This includes the use of decontamination as required to enable reuse/recycling.		
Organisation and Management		
Each of the ten sites has a waste management team which is responsible for the day-to-day management of LLW (and other types of waste as appropriate) on the individual site. SLC wide functional support on waste management is provided by a central Waste Management team who has responsibility for maintaining waste inventories, developing waste management routes and maintaining the company's strategies, including strategic regulatory engagement.		
Opportunities to Improve		
Magnox Ltd identified an opportunity for the improvement of LLW management: • Delivery of the JWMP to embed the UK LLW Strategy within Magnox Ltd as part of a national waste programme.		
Principal LLW Issues		
Magnox have identified as a threat that following the update to the LLWR Environmental Safety Case, the facility may not be longer be able to accept certain LLW wastestreams e.g. asbestos, which would have waste management implications.		
Alignment to principles identified in LLW Strategy		
A	In line with the objectives of the NDA, the overriding aim of Magnox Ltd is the safety of the public, workforce and protection of the environment.	✓
B	The IWS recognises that where creation of waste is unavoidable, waste should be diverted from burial as far as is reasonable practicable. The principle that wastes should be diverted is implicit throughout the IWS and the waste management strategy utilised by Magnox Ltd demonstrates strong alignment with the Waste Hierarchy. There is limited tactical level information provided within the IWS as to how waste avoidance is promoted or achieved by Magnox Ltd, although the need for waste avoidance is clearly referenced.	-
C	Magnox Ltd notes the importance of characterisation in determining a reliable waste inventory upon which waste management strategy and plans can be derived. Magnox Ltd state that characterisation is used to determine the volume, physical, chemical and radiological characteristics of waste in order to produce a reliable waste inventory. The need for consistent standards in characterisation is recognised and to support this Magnox Ltd have developed a waste characterisation process.	✓

D	The Magnox Ltd IWS clearly identifies the diversity in the physical, chemical and radiological characteristics of its waste inventory; and demonstrates an appreciation that a range of available, appropriately regulated waste management routes is essential to meeting its corporate objectives. Magnox Ltd utilises the following routes for management of LLW: • Incineration of combustible LLW • Decontamination, and where appropriate, melting of contaminated and activated metals • Disposal of VLLW to permitted landfill sites • Controlled burial of LA-LLW to permitted landfill facilities • Optimised disposal of LLW to the LLWR • Decontamination to enable disposal of waste as out of scope or exempt from EPR10/RSA93	✓
E	The IWS confirms development of the strategy has been undertaken involving consultation with, and input from, regulators and other stakeholders. Magnox Ltd has clearly described their approach to engagement with the public, and other stakeholder groups. One example of public engagement described in the IWS is that of the transport off-site of the Berkeley boilers for metal recycling.	✓
F	The IWS details the Magnox Ltd waste management strategy, confirming that application of the Waste Hierarchy is embedded into the company decision making process and that a diverse range of waste management routes are utilised by Magnox Ltd. The IWS links the relationship between the need for flexible waste management routes and successful delivery of the Magnox Ltd corporate objectives (i.e. decommissioning plan).	✓
G	Magnox Ltd has developed an Integrated Waste Strategy which applies to all waste streams; although the interrelationships between different wastestreams (with the exception of LLW and out-of-scope/exempt waste) are not discretely considered. The IWS clearly illustrates the relationship between the IWS, corporate strategies, the UK LLW Strategy, Government Policy and regulation.	✓
H	The Magnox Ltd IWS confirms that the application of BAT in England and Wales/BPM in Scotland is required and that the strategies contained within the IWS are based on a strategic options assessment process as well as being subject to detailed optimisation. This demonstrates the use of robust decision making processes for waste management. The IWS references neither the NDA Business Case Methodology, nor indicates application. No link is drawn within the IWS between the outcome of decision making processes and business cases.	-

RSRL [Ref. 20, 24]

Summary of LLW Strategy

RSRL objective is to maintain high standards of safety, security and environmental performance whilst eliminating the nuclear liabilities at the lowest lifetime cost. RSRL is responsible for delivering the clean-up and restoration of the Harwell and Winfrith sites in line with the NDA mission. The RSRL LLW management strategy is to effectively manage radioactive waste arisings in a safe and cost effective manner through the application of BAT and effective application of the Waste Hierarchy.

Status

Research Sites Restoration Ltd. was formed in 2009 as the Site Licence Company to deliver the closure programmes at both the Harwell and Winfrith sites on behalf of the NDA. RSRL manages two sites – Harwell and Winfrith.

Harwell

Since the cessation of operations at the site in the early 1990s, Harwell have been progressing a programme of work to decommission redundant nuclear research reactors and other nuclear research facilities. It is predicted that the site will reach an interim end state by 2031 when the only licensed facilities remaining would be stores for packaged operational and decommissioning ILW. A final end state, when all ILW has been transferred to the GDF and the site is de-licensed, is anticipated in 2064.

Winfrith

Decommissioning of the site began in the 1990s and the last reactor was shut down in 1995. Processing of legacy waste and reactor decommissioning work is ongoing at the site, working towards a Care and Maintenance (C&M) phase, expected to be reached in 2021. Final site clearance at Winfrith is expected to be achieved in 2048.

Waste Volumes

Harwell

The following (raw) volumes of waste are predicted to be generated over the lifetime of the Harwell site:

- LLW – 10,027 m^3
- VLLW/LA-LLW – 23,997 m^3

Winfrith

The following (raw) volumes of waste are predicted to be generated over the lifetime of the Winfrith site:

- LLW – 9,405 m^3
- VLLW/LA-LLW – 2,196 m^3

Origin of Waste

LLW from Harwell and Winfrith arises from decommissioning and demolition projects associated with historic waste and fuel cycle operations as well as current active operations.

The RSRL IWS states that LLW arisings consists of materials including:

- Compactable LLW – such as disposable clothing, bags and general waste
- Metallic LLW -- such as tanks and pumps
- LA-LLW and VLLW – soil, rubble and general decommissioning waste.
- Non compactable/bulk LLW – bulk LLW for which further treatment and/or diversion from LLWR is not BAT.

• Active sludge –arising from the treatment of active effluent • SGHWR sludges – a mixture of organic resins encapsulated in cement into drums • Oils/solvents		
Current Waste Routes		
The IWS identifies that RSRL uses the following waste routes for management of LLW from both Harwell and Winfrith: • Incineration of combustible LLW off-site • Compaction and transfer of waste for disposal at LLWR • Off-site metallic treatment • On-site metallic treatment, at the Winfrith site only using the Winfrith Abrasive Cleaning Machine (WACM) • Disposal of waste (compactable and non-compactable), where appropriate, at LLWR • Disposal of VLLW and LA-LLW at specified, permitted landfill sites		
Organisation and Management		
RSRL has in place a comprehensive waste management organisation comprising a management team reporting to the RSRL Managing Director. The Harwell and Winfrith sites each have a Closure Director with responsibility for the strategic development, implementation and operation of waste processes at each site. The Winfrith Site Closure Director has overall responsibility for the RSRL waste management strategy. Senior Project Managers, a Waste Strategy Manager and Waste Policy & Compliance Manager are direct reports. There are specific teams at the sites, embedded into projects where appropriate, with responsibility for the day-to-day management of LLW.		
Opportunities to Improve		
RSRL identified a number of opportunities for the improvement of LLW management: • Progress actions listed in the JWMP • Development of alternative treatment or disposal routes for LLW • Establish the optimum disposal route for RIPPLE crates • Effective application of the waste hierarchy • SMART inventory review including the way RSRL records waste disposal routes for radioactive waste • Identify a route for WSA LLW drums.		
Principal LLW Issues		
RSRL identified a number of potential threats and issues associated with LLW management in their IWS: • Current waste disposal routes may not be available to support the current programmes • The disposal route to LLWR may not be sufficient to meet programme requirements • LLWR may not accept the Winfrith SGHWR sludges.		
Alignment to principles identified in LLW Strategy		
A	In line with NDA's objectives, RSRL objective is to maintain high standards of safety, security and environmental performance whilst eliminating the nuclear liabilities at the lowest lifetime cost.	✓
B	The RSRL IWS recognises the importance of application of the Waste Hierarchy and clearly states how RSRL effectively ensures the application of the Hierarchy in waste management decisions. In particular, the IWS recognises that if creation of waste is unavoidable, arisings should be minimised as far as is practicable. RSRL state the important role segregation has to play in waste minimisation. Specific	✓

	examples of how waste avoidance and minimisation are undertaken by RSRL are included within the IWS.	
C	RSRL state that characterisation is used to determine the volume, physical, chemical and radiological characteristics of waste in order to produce a reliable waste inventory and waste management strategy. There is reference to specific RSRL waste characterisation guidance which describes the approach to developing and implementing appropriate characterisation strategies. Examples of the use of characterisation (e.g. to identify out-of-scope wastes) are provided.	✓
D	The RSRL IWS clearly identifies the diversity in the physical, chemical and radiological characteristics of its waste inventory; and demonstrates an appreciation that a range of available, appropriately regulated waste management routes is essential to meeting its corporate objectives. RSRL utilises a range of waste routes including: • Incineration of combustible LLW off-site • Compaction and transfer of waste for disposal at LLWR • Off-site metallic treatment • On-site metallic treatment, at the Winfrith site only using the Winfrith Abrasive Cleaning Machine (WACM) • Disposal of waste (compactable and non-compactable), where appropriate, at LLWR • Disposal of VLLW and LA-LLW at specified, permitted landfill sites.	✓
E	The IWS details the RSRL approach to Stakeholder Engagement noting that the strategy is based on openness: • Ensure that stakeholders are identified and plans put in place to communicate with them • Ensure that for significant projects and major operational activities stakeholder communication plans are produced Mechanisms for stakeholder engagement on waste management strategy is clearly described including participation in local stakeholder groups and holding formal stakeholder engagement sessions on-site BPEO studies (such as engagement on the development of the VLLW/LA-LLW route).	✓
F	The IWS details the RSRL waste management strategy, confirming that application of the Waste Hierarchy is embedded into the company decision making process and that a diverse range of waste management routes are utilised by RSRL. The IWS links the relationship between the need for flexible waste management routes and successful delivery of the RSRL corporate objectives (i.e. decommissioning plan). The need for additional waste management routes to manage problematic and non-standard waste streams is clearly referenced within the IWS document.	✓

G	The IWS clearly articulates how the LLW management strategy within the IWS interacts with other policies, strategies and plans. There is a clear line-of-sight between the RSRL IWS, other corporate strategies, technical underpinning, UK LLW Strategy, Government policy and legislation. There is limited consideration of the interrelationship between different waste types, other than LLW and exempt waste.	✓
H	The IWS details RSRL's waste management process designed to ensure the consistent preparation and endorsement of waste management strategies at the Harwell and Winfrith sites. The IWS states that RSRL undertakes a variety of strategic options studies to develop and implement the waste management strategy. Historically these have comprised BPEO studies and BAT reviews for the management of wastes. This demonstrates robust decision making processes are used by RSRL. The RSRL IWS notes that the company has developed programme-level business cases for the optimisation of waste management at both the Harwell and Winfrith programmes.	✓

Sellafield Ltd [Ref. 21]	
Summary of LLW Strategy	
The Sellafield Ltd IWS identifies that a wide range of radioactive and non-radioactive wastes will be generated on the site over its lifetime as a consequence of its varied history and operations spanning fuel reprocessing to decommissioning. The Sellafield Ltd strategy acknowledges that a range of robust and fit for purpose waste management routes is essential to the safe and efficient management of the site.	
Status	
Sellafield Ltd is the Site Licence Company responsible for safely delivering decommissioning, reprocessing and nuclear waste management activities on the Sellafield site on behalf of the Nuclear Decommissioning Authority. The Sellafield site includes Windscale and Calder Hall.	
Waste Volumes	
The IWS states a total LLW volume of 3.5 million m^3 is predicted to arise from the present date until 2130, of which 2.8 million m^3 is predicted to be VLLW or out-of-scope waste. The remaining 650,00m^3 is LLW generated from current operations and future decommissioning.	
Origin of Waste	
LLW and VLLW on the Sellafield site arise from operational and decommissioning activities. These wastes arise from current operations and maintenance work, and significant volumes of such wastes are expected to be generated from decommissioning and demolition activities. Typical examples of these wastes include: contaminated PPE and general wastes; oils; asbestos, metallic items such as pumps, plant and equipment; concrete and building structures; and soils arising from the remediation of contaminated land.	
Current Waste Routes	
The IWS identifies the following routes for Sellafield LLW: • On-site decontamination of metallic waste • Off-site decontamination and melting of metallic waste via the supply chain • Off-site thermal treatment of combustible waste via the supply chain • Disposal of VLLW and LA-LLW to the on-site landfill (CLESA) • Disposal of VLLW and LA-LLW to off-site specified landfill [route in development – waste types are currently limited] • Supercompaction of compactable waste at the on-site WAMAC facility and disposal to LLWR • Disposal of non-compactable waste to LLWR	
Organisation and Management	
Sellafield Ltd has a centralised waste management organisation – the Solid Waste Operating Unit – who acts as a service provider to the rest of the LLWR site. The Solid Waste OU is responsible for establishing LLW management strategy, developing / opening and operating waste management routes, managing on-site infrastructure for waste management (such as the MRF and WAMAC) and providing guidance and advice to waste generators.	
Opportunities to Improve	
Sellafield Ltd identified a number of opportunities for the improvement of LLW management, including: • Maintain and develop portfolio of waste management routes as decommissioning progresses • Maintain and develop characterisation and sort/segregation/size reduction capability. • Work with LLWR / NDA to support the development of new fit-for-purpose waste management routes	

Principal LLW Issues		
The IWS does not specify any risks particular to LLW management. The Sellafield Ltd LLW Strategy identifies the following risks which may affect implementation of the LLW strategy: • Long-term viability of the supply chain • Inventory accuracy and future volume forecasts • Inadequately implemented waste characterisation process • Public acceptance • Funding • Policy changes • Resources		
Alignment to principles identified in LLW Strategy		
A	A strategic principle set out in the IWS is that wastes should be managed in such a manner as to minimise impact on human health, safety and the environment. This is consistent with the NDA mission.	✓
B	The IWS identifies the Waste Hierarchy as a fundamental principle and notes the importance of waste avoidance and minimisation, but notes that owing to the nature of the Sellafield site much waste already exists. Some examples of waste minimisation and avoidance are provided such as the removal of excess packaging before materials are transferred to controlled areas.	✓
C	Sellafield Ltd recognises that the ability to accurately characterise, sort and segregate wastes is a key enabler the implementation of the site LLW management strategy. The IWS indicates that characterisation methodologies are in place and that there is localised waste sorting/segregation/size reduction being undertaken on the site.	✓
D	Sellafield Ltd has articulated that delivery of their LLW management strategy, and hence the corporate objectives of the organisation, requires the availability of a diverse range of waste management routes. The IWS identifies the following routes for Sellafield LLW: • On-site decontamination of metallic waste • Off-site decontamination and melting of metallic waste via the supply chain • Off-site thermal treatment of combustible waste via the supply chain • Disposal of VLLW and LA-LLW to the on-site landfill (CLESA) • Disposal of VLLW and LA-LLW to off-site specified landfill [route in development – waste types are currently limited] • Supercompaction of compactable waste at the on-site WAMAC facility and disposal to LLWR • Disposal of non-compactable waste to LLWR Describing a change from an earlier strategy document, Sellafield Ltd also details the use of supply chain waste management solutions where they are available, cost-effective and meet the requirements of BAT. This aligns with LLW policy for strategy planning and decision making. The IWS recognises that better application of the waste	✓

	hierarchy and use of alternative waste management routes to divert waste away from disposal to LLWR will extend the life of the facility and may remove the requirement to develop a new facility in the future.	
E	The IWS specifies the approach that Sellafield Ltd has adopted to regulatory and stakeholder input and consultation. The IWS provides a number of examples of mechanisms used for stakeholder consultation including strategic optioneering, regular meetings and participation in the West Cumbria Site Stakeholder Group.	✓
F	The IWS notes that the strategy derives from detailed consideration of the management techniques that are available within the supply chain to efficiently manage wastes generated at the site. This is consistent with the principle that all practicable options should be considered for the management of LLW. The Sellafield Ltd IWS recognises that the availability of waste management routes is essential to enable Sellafield Ltd to meet its goals on hazard reduction, decommissioning and operations.	✓
G	The LLW Management Strategy demonstrates integration of this strategy with the UK LLW Strategy, Government policy and necessary legislation. There is limited consideration of the interrelationship between different waste types, other than LLW and exempt waste.	✓
H	There is a clear statement within the IWS that Sellafield Ltd employs robust and underpinned waste decision making processes, through the application of BAT. The IWS does not reference the NDA Business Case Methodology not indicates application. No link is drawn within the IWS between the outcome of decision making processes and business cases.	-

Appendix C: Research and Development

Summary of LLW management related R&D activities within the NDA estate in 2013 [Ref. 59 – 63]. Activities directly related to LLW management are highlighted in yellow.

SLC	Activity Description	Type	TRL
DSRL	Develop a water cutting technology to demolish the sphere.	Need	7
	Develop, design, trial and prove HHISO container made from concrete as an alternative to fabrication from steel.	Opportunity	8
	Perform an assessment of process cell activity content measured against current cell mass for practicality of total activity content meeting LLW criteria for total mass.	Threat	8
	Develop detailed heavy haul plan/scheme to show how heavy LLW sections will be moved to disposal facility.	Need	8
	Development of a mercury treatment process.	Need	8
	Absorption of solvents and oils with NoChar (to absorb and stabilise the solvents) to allow treatment by incineration off-site.	Need	8
LLWR	The development of placement techniques for use of VLLW in the cap over the existing vaults and trenches.	Opportunity	7→8
	Demonstration that the trench cap performance monitoring system installed can provide the information to robustly demonstrate the performance of the trench cap until the point the final cap has been installed.	Need	8→9
	The development of a new or adapted inventory model to help assess the implications of new waste materials.	Need	5→8
	Improved understanding of the distribution of carbon-14 between different materials and the nature of materials.	Need	7→8
	Research to improve the understanding of the fate of chloride-36 in reactor circuits.	Need	7→8
	The development of new modelling approaches to the near-field or adaptations of the existing model to more firmly estimate the risks associated with gases containing carbon-14.	Need	3→9
	The undertaking of column experiments to study the transport and sorption behaviour of key radionuclides through materials to simulate behaviour in hydrogeological environments and build confidence in the current conceptual model.	Need	5→5
	The development of an IT tracking system across all LLWR frameworks.	Need	7→9
	Research into an alternative super-plasticiser for use in LLW disposal.	Need	8→9
	The development of waste packages which are flexible for treatment routes to reduce the numbers of HHISOs required for treatment shipments.	Need	5→9
	The development of a new IP-2 ISO container overpack with the capability of shipping all the ISO containers that exist in the current LLWR fleet.	Need	5→9
	The design of a new disposal overpack that can be transported.	Need	5→9
	The development of disposal containers to meet the requirements of	Need	5→9

SLC	Activity Description	Type	TRL
	the ESC.		
	The design of alternative ISO containers.	Need	5→9
Magnox Ltd	Optimise disposal volumes e.g. through the co-disposal of wastes.	Opportunity	9→9
	Establish a SLC decontamination facility.	Opportunity	9→9
	Re-use scabbled/demolition concrete.	Opportunity	9→9
	Seek and implement opportunities to manage LLW according to the waste hierarchy owing to a lack of available space at LLWR.	Threat	9→9
Sellafield Ltd.	Development of tools and techniques for size reduction and consolidation of LLW items to enable realisation of disposal via a LLW route.	Need	4
	Research, development and deployment of techniques for sorting and segregation of materials from mixed waste skips.	Need	1
	Development of a removal and disposal methodology for tritiated concrete and activated rebar.	Threat	1→4
	Development of tools and technology for manual dismantling of structures including characterisation and waste conditioning/handling.	Need	5→7
	Studies and trials into the best means of achieving the free release of mild steel; including investigating smelting as a possible combined recycling and decontamination method.	Opportunity	5
	Studies and trials into best practicable size reduction of cylindrical flasks.	Need	5
	Development and deployment of in-situ and possibly mobile analytical techniques for decommissioning samples including sludges, soils, concretes and metal surfaces.	Opportunity	
	Characterisation, retrieval, disposal and management of multi-element bottles.	Need	6
	Develop suitable size reduction, decontamination and disposal methods for LWR skips and AGR pond furniture.	Need	6→9
	Development of a protocol for management and analysis of decommissioning and other atypical samples.	Need	6
	Determine a method for the disposal of zinc bromide samples.	Need	5→7
RSRL	Undertake characterisation of SGHWR sludges and submit to LLWR for assessment to determine the acceptability of the waste for management as LLW.	Opportunity	9→9
	Establish a defined, BAT method for the decontamination of the Winfrith sea pipeline.	Threat	5→9
	Produce option study and BAT assessment for grouting and in-situ disposal of the Winfrith sea pipeline.	Opportunity	9→9

Appendix D: LTP Cost Comparison across NDA sites (£M)

Category		DSRL		Magnox Ltd		RSRL		Sellafield Ltd		Total	
		LTP10	LTP13	LTP10	LTP13	LTP10	LTP13	LTP10	LTP13	LTP10	LTP13
New construction projects		89.3	26.1	187.1	182.2	3.8	0.0	123.8	127.2	404.1	335.4
Waste and Nuclear Materials Management	Maintenance	7.0	0.8	49.5	25.7	2.7	0.1	93.7	75.4	153.0	102.1
	Off-site treatment and disposal	0.0	0.0	2,032.1	2,162.0	87.1	121.6	3,406.3	1,445.5	5,525.5	3,729.1
	On-site treatment and disposal	14.8	12.6	0.1	0.0	7.9	2.4	0.0	0.0	22.8	15.0
	Plant enhancement	14.4	0.0	19.9	0.8	0.2	0.0	79.7	44.6	114.2	45.4
	Storage operations	3.6	9.4	16.8	15.8	3.4	1.2	50.9	38.7	74.7	65.0
	Transport	4.2	6.1	801.8	872.9	4.3	6.4	14.3	0.0	824.6	885.4
	Pre-treatment operations	46.8	5.9	821.4	882.7	31.6	20.3	598.4	963.4	1,498.2	1,872.3
	Waste management support	0.0	0.0	0.0	13.6	0.0	0.0	0.0	0.0	0.0	13.6
Decommissioning and termination		6.1	0.7	28.8	295.3	0.0	0.0	34.7	140.4	69.6	436.3
Site support		0.0	0.0	0.0	0.0	0.0	0.0	55.4	97.1	55.4	97.1
Total		186.2	61.5	3,957.6	4,451.0	141.2	152.0	4,457.3	2,932.1	8,742.2	7,596.7

Note: this cost analysis excludes the contribution towards the LTP10 baseline of £56M costs from Springfields and £18M from Capenhurst, now removed from NDA liabilities.

Appendix E: ACCELS Programme Initiative Status at September 2013

Initiative Ref.	Initiative Description	Status
SL10	Use the forthcoming LLWR re-usable HHISOs for treatment.	Action was translated into JWMP and is complete; packaging needs were assessed in 2011 and re-usable HHISO are in use for waste movements.
SL11	Switch to thermal treatment/supply chain compaction earlier than 2020.	Action translated into JWMP and is complete; trials conducted since FY2011/12 and work is ongoing to translate to business-as-usual delivery.
SL12	Expand use of WAMAC for sort/seg and size reduction.	Action was translated into JWMP and is complete; a Sort/Segregation/Size Reduction peer assist
SL13	Eliminate Level 2 monitoring regime.	Action was translated into JWMP and is complete; Level 2 monitoring regime has been retained (to demonstrate compliance with LLWR WAC) but streamlined.
SL14	Evaluate use of WAMAC for lower-end ILW compaction.	This was assessed in FY11/12 but not expected to be feasible. This was not included in JWMP.
SL15	Evaluate use of WAMAC for PCM crate breakdown.	This was assessed in FY11/12 but not expected to be feasible. This was not included in JWMP.
SL16	Delay decommissioning for WAMAC.	Action is ongoing as it is dependent on the outcome of other work streams (such as SL12 and SL19).
SL18	Shift to supply chain provision of metal recycling services.	Action was translated into JWMP and is complete; supply chain is used for metal recycling to augment use of on-site infrastructure.
SL19	Evaluate options for sorting and size reduction (e.g. use of WAMAC, MRF, temporary buildings etc.).	Action was translated into JWMP and is complete; a Peer Assist was held 2013 to evaluate options. Implementation of Peer Assist findings planned for F2013/14 and 14/15.
SL20	Ensure all needs for decommissioning projects, including ILW, are met or coordinated.	Action was translated into JWMP as a requirement to ensure strategies are aligned. Work to deliver this is ongoing.
SL23	Utilise LLWR transport services for off-site treatment and disposal shipments.	Action was translated into JWMP and is complete; use of LLWR transport services successfully trialled and is used on ad-hoc basis as required to support on-site capability.

Initiative Ref.	Initiative Description	Status
SL24	Implement results of LLWR integrated transport study using existing Sellafield resources.	This action was not translated into the JWMP.
SL25	Expand use of 0075s for compactable waste to WAMAC and for LLWR combustible services.	Action was translated into JWMP and is complete; 0075s used for more inter-site movements of compactable waste and for off-site moves of combustible waste (although other packaging regimes are under consideration to optimise arrangements).
SL26	Evaluate impact of LLWR service on SLC resource requirements.	This action was not translated into the JWMP.
SL27	Integration of existing LLWR consignor support resources and staffing of new Sellafield Waste OU.	This action was not translated into the JWMP.
SL28	Offer combined LLWR/Sellafield resources as part of service offering.	This action was not translated into the JWMP.
SL29	Combine LLWR and Sellafield requirements and resources for procurement of waste tracking system.	Action was translated into JWMP and is complete; the requirements translated into specification for new LLWR waste tracking system. Improvements of Sellafield waste tracking system is ongoing.
DR1	Reduce volumes requiring disposal within the new on-site disposal facility.	Action was translated into JWMP and is complete; DSRL are implementing near-site disposal of LLWR rather than use of LLWR and are using high force compaction to reduce disposal volumes.
DR2	Utilise new disposal liner developed by LLWR for onsite disposal at Dounreay.	Action was translated into JWMP and is complete; use of “disposal liner” assessed in optioneering; DSRL have selected an alternative concrete HHISO concept for use at Dounreay.
RS1	Use supply chain provision of High Volume Low Activity (HVLA)/VLLW disposal services.	Action was translated into JWMP is and is complete; supply chain provision of HVLA/VLLW disposal services in routine use.
RS2	Shift to supply chain provision of metal recycling services.	Action was translated into JWMP and is complete; supply chain provision of metal recycling services used to augment use of on-site infrastructure.
MX1	Expand Magnox Smart inventory project or extrapolate results to FSC.	Action was translated into JWMP and is complete; Magnox Ltd SMART inventory project undertaken at all Magnox sites.

Initiative Ref.	Initiative Description	Status
MX2	Investigate current scope and estimate. Evaluate potential to use temporary facilities (e.g. Rubb tent) instead of fixed facilities for FSC.	This activity was considered during FY11/12 but not translated into a formal JWMP action.
MX3	Investigate current scope and estimate. Evaluate potential to use temporary facilities (e.g. Rubb tent) instead of fixed facilities for C&M Preps.	This activity was considered during FY11/12 but not translated into a formal JWMP action.
MX5	Focus on accelerating use of off-site routes.	Action was translated into JWMP and is complete; all off-site routes in use by Magnox Ltd. A programme is in place to roll out all routes to all sites.
MX6	Expand use of 0075s for compaction and other segregated waste services.	Action was translated into JWMP and is complete; Magnox use a range of waste packaging containers.
MX7	Use of re-usable full-height and half-height ISO containers. Transport of large components such as boilers/vessels whole.	Action was translated into JWMP and is complete; Magnox use a range of waste packaging containers. Transport of large components whole has been used e.g. Berkeley boilers transfer to Sweden for treatment.
MX8	Review impacts of acceleration (e.g. Bradwell, Trawsfynydd) on resource utilisation. Specialist mobile workforce and manage waste on campaign basis. Optimise use of supply chain for on-site LLW management.	This activity was considered during FY11/12 but not translated into a formal JWMP action.
MX9	Implement waste tracking system.	Action was translated into JWMP and is complete; – waste tracking system implemented for Magnox Ltd at all sites.

Appendix F: Summary of transformational and opportunity activities in JWMP 5

Collaborative projects (transformational and opportunity) are highlighted in yellow. The information has been extracted from Ref. 52 – 56.

SLC	Activity type	Description of activity	End Date
DSRL	Transformational	Participate in the LLWR Best Practice Peer Review Process	As required
DSRL	Transformational	Obtain the necessary permissions to enable consignment of LLW for off-site treatment	March 2014
DSRL	Opportunity	Fabricate and test prototype concrete HHISOs.	Oct 2013
DSRL	Opportunity	Procure concrete HHISOs for routine use subject to successful testing/approval.	Beyond 2018
DSRL	Opportunity	Share output of mercury treatment development project with the rest of the NDA estate.	2018
LLWR	Transformational	ESC team to assess the acceptability for disposal of asbestos at the repository site.	March 2014
LLWR	Transformational	Gain approval for ESC and execute implementation plan.	September 2014
LLWR	Transformational	Prepare and submit planning application.	September 2014
LLWR	Transformational	Rewrite LTP13 post issue of environmental permit and planning approval.	March 2018
LLWR	Transformational	Develop and gain approval for site optimisation and closure works programme.	May 2013
LLWR	Transformational	Undertake standalone procurement exercise for civils framework.	April 2014
LLWR	Transformational	Complete transport study and develop integrated transport strategy for construction materials.	March 2018
LLWR	Transformational	Develop and implement a programme for the management of construction materials on-site.	March 2018
LLWR	Transformational	Develop and implement arrangements for managing the coordination and logistics of resources and transport during construction.	March 2018
LLWR	Transformational	Carry out phases 1 to 3 of the LLWR transformation and improvement programme.	March 2014
LLWR	Transformational	Agree scope and boundaries for waste handling facility.	January 2014
LLWR	Transformational	Prepare waste handling facility safety case.	October 2014
LLWR	Transformational	Implement changes to waste handling facility.	October 2014

SLC	Activity type	Description of activity	End Date
LLWR	Transformational	Revise operations strategy for site to allow bulking of waste.	May 2014
LLWR	Transformational	On-site generated waste storage facility available.	Ongoing
LLWR	Transformational	Develop LTP13 for asset refurbishment and replacement. Gain approval and funding from NDA.	March 2013
LLWR	Transformational	Execute year 1 to 3 of asset refurbishment and replacement improvements.	March 2016
LLWR	Transformational	Undertake cost/benefit analysis for LLWR ISO 55000 accreditation.	March 2014
LLWR	Transformational	Address findings and recommendations of the NDA's PAS55 maturity assessment and identify appropriate actions to include in the asset management implementation programme.	March 2014
LLWR	Transformational	Develop and implement an Asset Management (AM) Policy, AM Strategy and a suite of implementing procedures.	March 2014
LLWR	Transformational	Develop and implement additional key role R2A2s and SQEP role specifications.	March 2014
LLWR	Transformational	Raise the visibility of the LLWR AM programme.	Ongoing
LLWR	Transformational	Agree the commercial terms and place the contract for decommissioning and demolition activities.	June 2013
LLWR	Transformational	Develop, consult upon and issue new WAC to meet requirements of the ESC.	March 2014
LLWR	Transformational	Carry out ground characterisation work across the in-operational areas of the LLWR site in order to identify areas of potential concern and produce report.	March 2016
LLWR	Transformational	Conduct orphan waste review and complete orphan waste database.	December 2013
LLWR	Transformational	Identify preferred supplier multi year agreement for treatment of combustible waste.	March 2014
LLWR	Transformational	Undertake an analysis of consignor preferred packages.	October 2013
LLWR	Transformational	Develop a guide to correlate the supply chain preferred container types with waste types.	October 2013
LLWR	Transformational	Develop guidance/FAQs for packaging/waste information for consignors and place in eroom.	March 2014
LLWR	Transformational	Secure use of Geminis or alternate containers to move PCM packages.	December 2015
LLWR	Transformational	Conduct review of environmental permits.	December 2013
LLWR	Transformational	Support NDA's review of the National LLW Strategy.	March 2016
LLWR	Transformational	Develop information systems strategy and implement.	March 2016

SLC	Activity type	Description of activity	End Date
LLWR	Transformational	Complete gap analysis between current and required management systems.	March 2014
LLWR	Transformational	Overhaul management system to close gaps.	March 2016
LLWR	Transformational	Develop and implement best practice model and peer review process.	September 2013
LLWR	Transformational	Develop and implement National Programme training framework.	March 2014
LLWR	Transformational	Implement Knowledge Management process for National Programme.	March 2014
LLWR	Transformational	Develop new consolidate lifecycle LLW cost norm model.	March 2014
LLWR	Transformational	Identify and implement cost recovery mechanisms in commercial framework.	March 2014
LLWR	Transformational	Re-compete metals, combustibles and supercompaction framework.	March 2014
LLWR	Transformational	Assess the feasibility of LLWR producing a global trans-frontier shipment authorisation.	March 2014
LLWR	Transformational	Evaluate options for consignors to financially commit to forecast delivery.	March 2014
LLWR	Transformational	Undertake a review of the current waste services organisation and implement recommendations.	March 2014
LLWR	Transformational	Support the development of non-NDA estate JWMPs.	March 2014
LLWR	Transformational	Develop terms of reference for Programme Board and set up meetings calendar and process.	July 2013
LLWR	Transformational	Project to implement new website and arrangements for its management.	April 2013
LLWR	Transformational	Support NDA in the development/replacement of the British Radwaste Inventory Management System (BRIMS) and deploy.	May 2016
LLWR	Transformational	Introduction of the Waste Inventory Process Guide and Form into the Waste Services Contract.	March 2015
LLWR	Transformational	Develop Waste Inventory Service Business Case and implement.	March 2014
LLWR	Transformational	Undertake SMART review of inventory on Repository site.	March 2014
LLWR	Transformational	Implement project for web based forecasting.	March 2014
LLWR	Transformational	Support the specification and development of the LLWR capacity management tool.	March 2014
LLWR	Transformational	Support the specification and development of the LLWR ESC Projected Inventory Evaluation Routine (PIER) model successor.	March 2015
LLWR	Transformational	Revise business case for waste tracking system.	August 2013

SLC	Activity type	Description of activity	End Date
LLWR	Transformational	Implement new waste tracking system.	March 2018
LLWR	Transformational	Undertake gap analysis between UK Strategy and LLW National Programme and develop programme to close gaps.	November 2013
LLWR	Opportunity	Environmental permit amendment to allow VLLW in cap.	TBC
LLWR	Opportunity	Collaborative working with RWMD – joint project scopes.	March 2016
LLWR	Opportunity	Engage with NDA Site End States team.	Ongoing
Magnox Ltd	Transformational	Project for long term planning of demolition arisings at Magnox sites to identify suitable material for landscaping.	March 2015
Magnox Ltd	Transformational	Project to review the opportunity to dispose of short term ILW at LLWR once the new permit is in place.	March 2016
Magnox Ltd	Transformational	Explore the ability to upscale ARVIA oil processing unit. Consider the use of mobile on-site processing plant at Trawsfynydd site for high activity oil treatment, with subsequent use across other Magnox sites as required.	March 2014
Magnox Ltd	Transformational	Complete LLW Fingerprint Review. This will set out the current approach to LLW fingerprinting and consider whether improvements are needed given that new treatment and disposal routes are in use.	September 2013
Magnox Ltd	Transformational	Implement recommendations from LLW Fingerprint Review.	March 2014
Magnox Ltd	Transformational	Complete review of waste activity assessments. This will review the current methods used and establish an agreed toolkit for waste activity assessments appropriate to all waste routes.	March 2014
Magnox Ltd	Transformational	Improvements to process and protocols for clearance and exemption.	September 2014
Magnox Ltd	Transformational	Improvement to characterisation process – standards, procedures, training etc.	September 2014
Magnox Ltd	Transformational	Investigate requirements for assay of packages against current equipment, identify gaps, develop action plan and implement.	September 2014
Magnox Ltd	Transformational	Project to develop in-house capability to produce loading plans for the transportation of non-standard LLW items for treatment; based on the newly issued Nuclear Industry Code of Practice.	March 2014
Magnox Ltd	Transformational	Project to ensure alignment of new packages and site safety case requirements.	March 2014

SLC	**Activity type**	**Description of activity**	**End Date**
Magnox Ltd	Transformational	Project to consider the feasibility of co-ordinated waste consignments between participating sites across the NDA estate to enable more use of rail transport.	March 2014
Magnox Ltd	Transformational	Hold at least one peer review at a Magnox site and participate in two others across SLCs, building improvement opportunities into the JWMP.	March 2014
Magnox Ltd	Transformational	Project to put in place bulk orders and routine schedule arrangements for shipments of waste.	March 2014
Magnox Ltd	Transformational	Implement the Magnox Strategic LLW BPEO across all ten sites.	March 2014
Magnox Ltd	Transformational	Capture experience of safety cases required to permit use of all available treatment and disposal options for LLW.	March 2014
Magnox Ltd	Transformational	Activities in support of the transition of the Magnox waste function to a Waste Programme, including standardisation of processes and procedures, strengthening interfaces with Programmes, DV alignment, training, stakeholder mapping and communication plan.	March 2014
Magnox Ltd	Transformational	Transfer inventory data to eMWaste tracking tool.	March 2014
Magnox Ltd	Opportunity	Undertake a transport feasibility study for potential early removal of boilers from the Chapelcross site.	December 2013
Magnox Ltd	Opportunity	Undertake a project to obtain all historical information on Chapelcross boilers to inform future removal.	December 2013
Magnox Ltd	Opportunity	Assess the commercial routes available for LLW oil via the LLWR Waste Services Contract.	December 2013
Magnox Ltd	Opportunity	Implement an alternative treatment process for high activity oils based on the outcome of the Arvia review and options assessment on alternative treatments.	March 2015
Magnox Ltd	Opportunity	Assess use of some VLLW as capping material at the LLWR (assessment of suitability).	March 2015
Magnox Ltd	Opportunity	Potential to identify sites as a temporary hub for facilitating the use of rail transport.	Undefined
Magnox Ltd	Opportunity	Collaborate with LLWR to undertake a first shipment under a consolidated treatment procurement, aggregating demand across the NDA estate.	March 2014
Magnox Ltd	Opportunity	Aggregate bulk orders for LLW treatment/disposal, with fixed consignment schedules across the NDA estate.	March 2015
Magnox Ltd	Opportunity	Evaluate Lifetime Plan cost savings from updating RWI 2014 with new disposal and treatment routes.	January 2014

SLC	Activity type	Description of activity	End Date
RSRL	Transformational	Review waste streams within the RSRL inventory to maximise the quantities of waste that could reasonably be diverted for alternative treatment/disposal.	March 2014
RSRL	Transformational	Support regulators and the NDA to define site end state for Winfrith. Assess the availability of materials for in-filling voidage left by decommissioning activities, where the radioactive, physical and chemical properties of the waste are suitable.	March 2014/July 2014
RSRL	Transformational	Formally identify preferred suppliers, through LLWR's Combustible Framework, for the treatment of Harwell and Winfrith combustible waste in anticipation of the end of the current services.	September 2014
RSRL	Transformational	Book fixed slots for the collection of combustible waste from Harwell and Winfrith sites.	January 2014
RSRL	Transformational	Formally identify, through LLWR's VLLW Framework, preferred suppliers for VLLW and LA-LLW dispatched from Winfrith and Harwell sites.	June 2014
RSRL	Transformational	Investigate the feasibility of re-use of HV-VLLW/LA-LLW at Harwell and Winfrith.	July 2014
RSRL	Transformational	Update guidance to RSRL waste producers in line with LLWR draft WAC.	March 2014
RSRL	Transformational	Establish a call-off contract for the analysis of samples taken in support of decommissioning activities, through LLWRs Characterisation Framework.	June 2014
RSRL	Transformational	Work closely with NDA and regulators to develop a regulatory framework for the re-use of HVLLW/LA-LLW on nuclear licensed sites.	December 2014
RSRL	Transformational	Hold at least one peer review at a RSRL site and participate in two others. Build improvement opportunities arising from inter-site peer reviews into the JWMP. Actively participate in the inter-SLC post project review hosted by LLWR.	March 2014
RSRL	Transformational	Implement guidance for RSRL projects which facilitates use of established segregated waste services.	June 2014
RSRL	Transformational	Update LTP with revised waste metric/category data arising from SMART Inventory assessments.	June 2015
RSRL	Opportunity	Establish new routes for radioactive asbestos via the supply chain, if required, based on information on quantities and activity levels from SLCs (LLWR opportunity).	June 2014

SLC	Activity type	Description of activity	End Date
RSRL	Opportunity	Establish route for contaminated mercury, recognising work that DSRL is already doing in this area (LLWR opportunity).	September 2014
RSRL	Opportunity	Develop guidance on the acceptability of various commonly encountered complexing agents (LLWR opportunity).	March 2014
RSRL	Opportunity	Identify wastes in RSRL LTP (e.g. decommissioning concrete) that could be used as LLWR capping material (joint opportunity).	March 2014
RSRL	Opportunity	Work closely together in order to develop a training programme for customers characterising their own wastes (joint opportunity).	December 2014
RSRL	Opportunity	Develop an accelerated protocol for approving small discrete Winfrith legacy waste streams within plant areas (joint opportunity).	December 2013
RSRL	Opportunity	Work closely with LLWR to develop a training programme for customers consigning their own wastes (joint opportunity).	December 2014
Sellafield Ltd	Transformational	Review options for packaging metals for consignment to supply chain.	March 2014
Sellafield Ltd	Transformational	Undertake further combustible waste trials to expand range of wastes and improve logistics.	March 2014
Sellafield Ltd	Transformational	Implement combustible waste route as business as usual.	March 2014
Sellafield Ltd	Transformational	VLLW/LA-LLW landfill disposal trials.	March 2014
Sellafield Ltd	Transformational	VLLW/LA-LLW landfill route open.	Undefined
Sellafield Ltd	Transformational	Develop Sellafield Ltd on-site disposal strategy.	December 2014
Sellafield Ltd	Transformational	Review and integrate information flows between generators, Waste OU and characterisation team.	March 2014
Sellafield Ltd	Transformational	Implement output of SSSR peer assist.	March 2015
Sellafield Ltd	Transformational	Complete Waste Coordinator trials and if necessary implement training programme across site.	March 2014
Sellafield Ltd	Transformational	Rationalise/align roles of Solid Waste Advisor and Coordinator.	March 2014
Sellafield Ltd	Transformational	Continue to develop and implement the decontamination strategy for Sellafield in conjunction with the decommissioning strategy.	October 2016
Sellafield Ltd	Transformational	Obtain full EPR Permit with no volume limits.	March 2015
Sellafield Ltd	Transformational	Undertake organisation review of level of resource needed in waste team, identify and deliver training.	March 2015
Sellafield Ltd	Transformational	Collaborate with LLWR/other SLCs to undertake consolidated waste shipments as appropriate.	March 2014

SLC	Activity type	Description of activity	End Date
Sellafield Ltd	Transformational	Develop and deliver Waste Communications and Training Programme covering management system topic area roll out and LLWR familiarisation.	December 2013
Sellafield Ltd	Transformational	Develop and issue decommissioning strategy to give forecast and waste arisings profile.	October 2016
Sellafield Ltd	Transformational	Develop waste tracking systems.	March 2014
Sellafield Ltd	Transformational	Work with waste inventory coordinators to identify improvements to forecasting process and WIF process.	March 2014
Sellafield Ltd	Transformational	Programme to develop WIF process.	March 2014
Sellafield Ltd	Transformational	Address Rad Waste Inventory waste stream issues raised by RWMD/LLWR.	March 2014
Sellafield Ltd	Opportunity	LLWR to provide specification for VLLW vault profiling materials.	March 2014
Sellafield Ltd	Opportunity	Assess feasibility for reuse of VLLW as LLWR vault profiling material.	March 2015
Sellafield Ltd	Opportunity	Identify and develop potential buffer storage locations for VLLW if required.	March 2015
Sellafield Ltd	Opportunity	LLWR to provide training on loading plan development.	March 2014
Sellafield Ltd	Opportunity	Collaborate with LLWR/other SLCs to develop and publish an orphan waste strategy and implement an orphan waste database.	March 2014