Nuclear Decommissioning Authority

Higher Activity Waste

Strategic Position Paper on the Management of Waste Graphite

January 2014

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Executive Summary

The purpose of this paper is to summarise a number of pieces of work that we have undertaken to better understand the challenges of managing radioactive graphite wastes leading to an updated Nuclear Decommissioning Authority (NDA) strategic position on graphite waste management. This position statement on the management of waste graphite takes into consideration government's response to CoRWM recommendation 8 and provides the current NDA strategic position alongside circumstances where this should be reviewed. The two main documents contributing to this strategic position are:

1. Operational Graphite Management Strategy: Credible and Preferred Options (Gate A & B) [1]
2. The Long-term Management of Reactor Core Graphite Waste: Credible Options (Gate A) [2]

The paper highlights the key findings from the following work that has been undertaken to better inform this position:

- A review by the NDA Radioactive Waste Management Directorate (RWMD) [3] of the current baseline for managing radioactive graphite in England and Wales of geological disposal. The review identified some areas for optimisation and provided clarification on some aspects of the baseline, *e.g.* the assumed 'footprint' of graphite wastes for a future Geological Disposal Facility (GDF).

- Investigations into suitability of near-surface disposal options for graphite wastes. This included a review of the Low Level Waste Repository (LLWR) Ltd's new Environmental Safety Case (ESC) [4] to assess the potential for graphite disposal and a feasibility study into a near-surface disposal facility for Higher Activity Waste (HAW) graphite at the Hunterston A site.

- Continued monitoring of potential future treatment options.

- Detailed characterisation work under our Direct Research Portfolio using computer modelling and sample analysis to better understand any limitations of the current inventory data for graphite wastes.

- Graphite behaviour work under our Direct Research Portfolio to help better understand the options available for graphite waste management in the future.

The learning gained from these pieces of work has enabled us to develop our strategic position in this area. Following discussion with stakeholders it was decided that a clearer position could be expressed if two broad categories of graphite waste were considered separately:

- Near term arisings from operational activity (*e.g.* graphite sleeves from fuel assemblies)

- Other arisings from reactor decommissioning activities

Working with Magnox, and employing the NDA Strategy Management System, we have developed a Preferred Option for management of operational graphite waste and Credible Options for management of graphite waste from reactor decommissioning.

This analysis of the credible and preferred options has led to a better understanding of both the options available and the performance of the current baseline.

Our position is that at the current time no change is needed to the baseline strategy for the management of graphite in England and Wales.

For operational graphite waste, we have determined a preferred option that the waste will be managed as follows:

- Berkeley Site – to manage all the graphite waste as Intermediate Level Waste (ILW) for interim storage (in resilient, self-shielding containers) and un-encapsulated disposal to GDF.

- Hunterston A Site – to manage all the graphite waste as ILW for interim storage (in stainless steel containers) and encapsulation at final site closure prior to management in accordance with Scottish Government Policy.

- Sellafield Site – to manage all the graphite waste as ILW for interim storage (in mild or stainless steel drums) and encapsulation prior to disposal to a GDF.

Each site may implement a variation on this preferred option driven by site specific challenges, for example, at the Hunterston site the intention is to encapsulate the waste in the near term, rather than at final site clearance.

For reactor core graphite, we have not determined a case for changing the baseline strategy at the current time. Our work has demonstrated, through the identification of a number of alternative options, that the management of graphite waste by geological disposal provides a robust baseline strategy suitable for planning purposes. The extended period of quiescence that reactors are scheduled to be in means that there is sufficient time for alternative options to develop such that any future decisions on the management of radioactive graphite waste will be appropriately informed. In addition to this position we have identified factors that would drive a review of this strategic position, for example a change in site restoration strategy.

We will continue to support Scottish Government Strategy Implementation work, which could include more detailed consideration of near-surface disposal as well as long-term storage of graphite wastes.

1 Background

Graphite waste represents approximately 30% of the UK volumetric inventory of Intermediate Level Waste (ILW) [5]. Radioactive graphite waste arises in two main ways. A significant proportion of "reactor decommissioning wastes" will be graphite and will arise when reactors are decommissioned. This is mostly reactor core wastes. Waste graphite also arises from spent fuel management operations and there are further arisings from the retrieval of legacy wastes at some sites. This type of graphite waste is predominantly derived from fuel sleeves.

In the Nuclear Decommissioning Authority (NDA) Strategy published in March 2011 [6] and the 2009/12 NDA Business Plan [7] we made a commitment to explore management and treatment options for reactor graphite waste. These reflect the Committee on Radioactive Waste Management's (CoRWM) recommendation on reactor decommissioning wastes in 2006 [8] and Governments' response [9] (reproduced below), which recognised the need to examine alternative options for all wastes arising from reactor decommissioning. Most of the reactor core graphite waste will not arise until 70-100 years after fuel has been taken out of the reactors.

CoRWM Recommendation 8:

In determining what reactor decommissioning wastes should be consigned for geological disposal, due regard should be paid to considering other available and publicly acceptable management options, including those that may arise from the low level waste review.

Government's Response:

Government accepts this recommendation. The NDA will review whether a safety case could be made for other non-geological disposal of reactor decommissioning wastes, including on-site, or near-site, disposal in order to minimise transport. In doing this it will take account of the outcome of the Government's Low Level Waste management policy review, as well as public and stakeholder views. The NDA will use the outcome of these reviews, which will be published, in developing its outline geological disposal implementation plan.

1.1 Scope and Boundaries

In response to the above statements we launched the Reactor Decommissioning Wastes project in 2009 to build on our support for the EU Carbowaste project. The project was designed to examine the potential benefits and costs of options for the alternative management of reactor decommissioning waste, whilst also considering the implementation of the waste hierarchy. It focuses on Magnox reactors in the our

estate, but in considering the position with regard to the large volume estimate of waste graphite, also takes account of the eventual decommissioning of graphite moderated Advanced Gas-Cooled Reactors (AGRs) owned by EdF Energy.

This work is part of our Higher Activity Waste (HAW) strategy development programme. The HAW strategy objective therefore provides context for the work:

> "To treat and package HAW and place it in safe, secure and suitable storage facilities until it can be disposed of, or be held in long-term storage in the case of a proportion of HAW in Scotland."

An update was given on this ongoing strategic work in the 2011 NDA document Reactor Decommissioning Update – Summary of Options for Waste Graphite [10], where we outlined further work that was necessary to develop a strategic position. This paper reports on the findings of the further work that has taken place since the update was published.

Various pieces of work that have been initiated in order to better understand the graphite waste challenge are now at the stage where conclusions can be drawn and an informed position on the management of graphite waste can be produced.

1.2 Strategy interfaces

The graphite programme is a component of the overall HAW strategy and interfaces with the following topic strategies:

- Low Activity Waste (because of the potential for use of the Low Level Waste Repository (LLWR) or a similar facility for disposal and learning from the LLWR Environmental Safety Case (ESC))
- Decommissioning (because that could affect the rate and form of graphite arisings)
- Transport and Logistics (because of the potential need to move waste between sites)

1.3 Current strategy

The baseline strategy for reactor graphite is to dismantle reactor cores following a period of quiescence (typically 85 years) and package the graphite for disposal. Disposal in a Geological Disposal Facility (GDF) is the planned end point for the packaged waste in England and Wales. The Scottish Government Policy is that the long-term management of higher activity radioactive waste should be in near-surface facilities; and that those facilities should be located as near to the site where the waste is produced as possible/practicable. Developers will need to demonstrate how the facilities will be monitored and how waste packages, or waste, could be retrieved. All long-term waste management options will be subject to robust regulatory requirements.

Notable arisings of operational graphite waste are present at three sites within our estate, Berkeley, Hunterston A and Sellafield and work on operational graphite waste arisings has focused on these three sites. The baseline strategy for the management of graphite at Berkeley, Hunterston A and Sellafield is to retrieve the waste, condition (either promptly or following a period of containerised storage) and package in containers suitable for eventual disposal. The waste packages will be stored on-site prior to their eventual disposal to a future facility. For England and Wales disposal will be in a GDF, for Scotland this will be long-term management in near-surface facilities in accordance with Scottish Policy.

1.4 2011 Update paper [10]

There were a number of high level strategic options for the management of graphite laid out in the 2011 update on graphite. These are outlined below:

- Option 1 - Manage all graphite waste as ILW and ensure the geological disposal facility caters for the large volumes of material. This is the baseline option for England and Wales.
- Option 2 - Condition graphite waste to enable disposal at LLWR Ltd.
- Option 3 - Condition Low Level Waste (LLW) and/or ILW graphite waste to remove most of the contamination and release as “exempt waste” or reuse the graphite where possible.
- Option 4 - Separate disposal facility (or facilities) for graphite wastes, including a near surface disposal option and may include a pre-treatment step. This option would support Scottish Government’s HAW long-term management Policy and the development of its Implementation Strategy.

These options informed some of the work that is described in the following sections.

2 Key Findings

The following pieces of work have provided a better understanding of graphite waste management options. These have helped to inform a combined credible and preferred options paper on operational graphite management [1] and a credible options paper on reactor graphite management [2], which in turn have informed the development of our strategic position described in this paper.

2.1 Radioactive Waste Management Directorate (RWMD) GDF Baseline Review [3]

RWMD undertook a review of the baseline option for the management of graphite with a view to gaining a better understanding of the viability of implementation and investigating opportunities for optimisation. The review covered many factors in this area and some of the notable conclusions are shown here:

Footprint

The graphite contribution to the ILW inventory intended for disposal in the GDF is around 30%. Despite this, the review concluded that the impact of graphite on the GDF footprint is expected to be relatively small, around 2% of the total GDF volume/capacity.

Safety Case

A review of the safety cases found that graphite has very little impact on both the transport and operational safety cases. Additional work was highlighted as being possible to review the current assumptions around graphite in the ESC as they appear to be very pessimistic concerning carbon-14.

Costs

The study reviewed the costs associated with various stages of the management of graphite. A notable development is the use of a more detailed cost model for the GDF, which separates out fixed costs and marginal costs. The revised costs also recognise the difference in variable cost for shielded and unshielded wastes (unshielded wastes being more costly because of the remote handling requirements). Shielded packaging is the baseline packaging strategy for the majority of graphite waste and therefore the costs for disposal are lower than previously calculated.

Waste Scheduling

Graphite has little impact on the waste scheduling of the GDF. In the timeframe graphite is consigned the constraints are on the consigning sites infrastructure and not the GDF infrastructure. The length of time the GDF will be operational is not constrained by graphite. All the graphite is expected to be consigned well before Sellafield Ltd will stop consignments, the current limiting factor on site closure.

2.2 Near-Surface Disposal

Investigation of near-surface disposal options has focused on two work streams: potential disposal options using existing facilities (LLWR) and a feasibility study into new on-site facilities (Magnox – Hunterston A).

2.2.1 LLWR

Disposal of graphite at LLWR has been considered in two of the work packages that have been undertaken. This included reviews of the current Enviromental Permits and the recently submitted ESC [4] for the LLWR. The review identifies that the critical radionuclide in near-surface disposal considerations is carbon-14. The LLWR has an annual limit, a package limit and a total repository inventory limit on carbon-14 bearing wastes, such as graphite. There is significant activity, especially in the key radionuclide carbon-14, associated with operational graphite waste. Under the present permits and submitted ESC the LLWR is not considered suitable for disposal of large quantities of graphite waste. The activity of the majority of the graphite wastes is too high and the total inventory would significantly impede LLWR from undertaking its core mission of LLW management.

In adition to this the high level of carbon-14 in the graphite waste identifies that current treatments for graphite wastes to remove the carbon-14 would not be effective enough to allow disposal of them at LLWR.

2.2.2 Feasibility study into near-surface disposal

Magnox Ltd undertook a feasibility study to consider near surface disposal of operational graphite waste from the Hunterston A site.

The study included the drafting of a preliminary ESC for a facility to dispose of graphite waste from the site and the development of a high level business case. SEPA and RWMD were consulted on the developing Environmental Safety Case. The study provided valuable understanding of the near surface option for the handling of operational graphite waste. It was intended that the work would also inform the position on the management of reactor graphite.

After the initial study had been concluded a review of the project was undertaken to help understand what, if any, future actions should be taken. The review concluded that no further action should be taken for this option as the study had shown no compelling case for change at this time. The key issues highlighted by the review were:

- Regulatory risks associated with permitting the facility.
- Schedule risk - delays in the implementation could threaten the schedule for placing the site into Care and Maintenance which would be very costly.
- Cost – there is no overriding cost benefit from the alternative approach.

- The impact of a facility on site end state and the ability to de-licence the site are not well understood.

It was highlighted through this work that the factors that would determine a coherent strategy for managing operational arisings are very different to those for reactor decommissioning wastes and that progress in strategy development would be improved by separating the two.

2.3 Treatment Options

In several areas of our work we have reviewed the maturity of options for the treatment of graphite waste. It is evident that treatment options are not viable for the management of large quantities of graphite waste at the present time. A number of key factors underpin this perspective, in particular: the availability of treatment options; the pace at which graphite would be treated and the level of treatment required to deliver an alternative management solution; and finally, the challenge of managing secondary wastes.

Until these are addressed alternative treatment options are unlikely to be viable and it is recognised that further research and development would be needed to achieve this. Because the majority of graphite wastes are not scheduled to arise for many decades and because we have a viable baseline for planning purposes, research in this area is not presently a priority when compared to other challenges.

However, international progress on treatment alternatives should continue to be monitored. Any potential benefits from future collaboration should be explored and assessed when the opportunities arise.

It remains our intention to conclude the work we are undertaking on the treatment of graphite as part of our graphite behaviour project (see below) and we will make available the findings from that work.

2.4 Reactor Core Characterisation [11] [12]

A Direct Research Portfolio funded project was initiated to better understand the radiological characteristics of the irradiated reactor core graphite within the UK Radioactive Waste Inventory (UK RWI). Previously there was uncertainty around the modelling assumptions used for calculating the radiological characteristics of the core graphite and therefore the contribution to the UK RWI. The aim of the characterisation work was to increase confidence in the declared inventory by using active samples and more in-depth modelling to better understand the sensitivities of the currently used model. The project also considered whether this work could be scaled to fit the differing characteristics of all the Magnox reactors within the UK.

The characterisation work came to the following conclusions:

- The developed model and the UK RWI data were within agreement taking into account uncertainty bounds for the majority of the radionuclides studied.

- It is difficult to accurately understand the activity levels of the more highly volatile radionuclides within the graphite (*e.g.* chlorine-36 and tritium) as the active work undertaken to test the model causes these radionuclides to volatise before they can be accurately sampled.

- Faulty fuel cartridges within the Magnox reactors have not had a significant effect on the activity of the graphite.

- There is scalability between the different Magnox reactors, allowing for a more accurate understanding of the graphite within the UK RWI.

2.5 Graphite Behaviour [13]

In parallel with the graphite characterisation work, we are undertaking a research project into graphite behaviour. The purpose of this work is to assess the properties of irradiated graphite that influence the performance of treatment technologies. The work comprises: a review of treatment technologies; an experimental programme to analyse the physical and chemical properties that influence the performance of treatment technologies; and a final review to determine whether it is possible to select the best performing technology based upon this understanding.

The first step was completed some time ago, although a recent update to the review of options incorporated recent developments, including:

- the RWMD GDF baseline review;

- LLWR ESC submission and WAC review; and

- the findings of the graphite characterisation project.

In addition to this, a mini-Best Available Technique (BAT) assessment was undertaken assessing at a very high level for the treatment options available for graphite wastes. It categorised these into three main areas:

- Direct disposal (including un-encapsulated, encapsulated and vitrified waste forms)

- Decontamination followed by disposal as reclassified waste (using various thermal or chemical techniques)

- Thermal treatment and disposal into the environment and/or capture and disposal

The mini-BAT concluded that at the current time direct encapsulation was likely to be BAT for graphite waste options, mostly because thermal and chemical treatment options are not currently technically mature enough to be BAT. In addition there were various concerns about secondary waste generation, public/regulatory acceptability and complexity of the techniques.

The second part of the graphite behaviour work, the experimental programme, is currently underway and will report, along with the implications for different treatment technologies that can be determined from the analysis.

3 Strategy Development

This section discusses the conclusions from the supporting studies work outlined in Section 2 as well as Strategy Management System papers on:

- Operational Graphite Management Strategy: Credible and Preferred Options (Gate A & B)
- The Long-term Management of Reactor Core Graphite Waste: Credible Options (Gate A).

3.1 Discussion

The review undertaken by RWMD has indicated that there are no significant challenges with the baseline option for graphite management. It highlighted that the space required within the GDF is minimal (~2% of the footprint). It also noted that the disposal costs of graphite waste are not a significant portion of the overall cost of the GDF. No significant challenges are posed by waste scheduling and it is believed that a safety case can be made that includes graphite waste. The review has provided good underpinning information for the current baseline option in England and Wales, but did identify a number of areas where graphite management for disposal could be optimised.

Near-surface options for management of graphite have been initially investigated through both the LLWR ESC submission and the Hunterston A project. It is apparent that the use of LLWR for the direct disposal of a large proportion of the graphite waste is not a credible option, in the context of the current Environmental Safety Case. Any use of the LLWR for disposal of graphite would impact on the radiological capacity of the LLWR and impact on the main function of the facility, to facilitate the management of LLW.

Significant work was undertaken for the feasibility project into near surface disposal of graphite at Hunterston A. This concluded that there was no case for change at the present time due to a number of reasons including regulatory and schedule risks, cost and the potential impact on site end-state. The Hunterston A feasibility study has informed the strategy development by highlighting the importance of separating the operational and reactor core graphite strategic positions. It also further developed our understanding of some of the key issues that need to be addressed when developing an ESC for such a facility. This will be essential learning for the implementation of Scottish Government's policy for the management of HAW.

International progress on treatment alternatives should continue to be monitored and collaborations undertaken where there is a clear benefit.

The characterisation task has given confidence in the current inventory of reactor core graphite, which will be valuable to underpinning any future decision making on the management of graphite

The graphite behaviour project will also support future decision making, including any decisions on further research and development work. The recent high level mini-BAT

assessment undertaken as part of this project supports the current baseline. The maturity of current treatment technologies is shown to be low and require more work to bring up to a level where they could be compared equitably to the baseline. However, without an immediate need to manage the waste in question, careful consideration of any future work would be required.

3.2 Operational Graphite Management Strategy (Credible and Preferred Options) [1]

Magnox on our behalf have prepared the credible and preferred options for the management of operational graphite waste. The work provides a strategic framework for operators to develop the management of current arisings of operational graphite waste. Three sites in the UK were selected to represent current operational graphite waste that needs to be managed: Berkeley, Hunterston A and Sellafield and builds on some of the work outlined in section 2.

The preferred options for each of the identified sites are as follows.

- Berkeley Site – to manage all the graphite waste as ILW for interim storage (in resilient, self-shielding containers) and un-encapsulated disposal to GDF.

- Hunterston A Site – to manage all the graphite waste as ILW for interim storage (in stainless steel containers) and encapsulation at final site closure prior to management in accordance with Scottish Policy.

- Sellafield Site – to manage all the graphite waste as ILW for interim storage (in mild or stainless steel drums) and encapsulation prior to disposal to GDF.

It is not our intention to take this work forward to SMS Gate C at the NDA estate wide level. The selection of an approach to implementation will be influenced by assessment of site specific considerations, which cannot effectively be made at an NDA estate wide level.

A key factor in the selection of preferred options was avoiding constraining waste management options in the future, either treatment or disposal.

3.3 The Long-term Management of Reactor Core Graphite Waste (Credible Options) [2]

The credible options for the long-term management of reactor core graphite arising from the final decommissioning activities have been prepared. This strategic position includes reviewing options for Magnox and AGR reactors as well as Sellafield Ltd piles, Research Sites Restoration Ltd (RSRL) and Dounreay Sites Restoration Limited (DSRL) research reactors. The work to date also considers the strategic tolerances to alternative site restoration strategies, GDF availability and a high level plan for progressing potential R&D to further inform graphite decisions. The strategic position referred too much of the work outlined here including the graphite characterisation and behaviour studies, near-surface disposal options, treatment

options and the review undertaken by RWMD. These are discussed in the framework of the strategic and economic case for change.

There are 8 options outlined on the long list including disposal, treatment and recycling options. These align with the options previously outlined for graphite [10].

Disposal options

1. **GDF disposal** to the planned disposal facility for higher activity wastes arising in England & Wales

2. **Near surface disposal**[1] to a new specialised facility Permitted in line with the Near Surface GRA regulatory guidance

3. **In-situ disposal** (necessarily assumes reactor mounding is selected as an alternative site restoration and decommissioning strategy)

4. **LLWR disposal** (existing specialised facility)

5. **Permitted landfill disposal** (existing or future commercial facilities)

Treatment options[2]

6. **Treatment to make subsequent management of the waste easier**, followed by consignment to appropriate waste routes *e.g.* decontamination to remove key radionuclides

7. **Treatment to minimise the volume of solid waste for disposal**, followed by consignment to appropriate waste routes *e.g.* steam reformation, thermal treatment, etc.

Recovery for re-use or recycling[3]

8. **Recovery for beneficial re-use or recycling**

This long-list of options was assessed against a range of screening criteria developed for the study to produce a list of credible options that are legal, potentially feasible and meet strategic objectives. Credible options are identified for the five types of reactors where core graphite waste is found. Table 1 outlines the credible options and reasons for rejection where applicable.

Currently there is no strategic case for change to the baseline for the management of reactor core waste throughout our estate in England and Wales. Although the study does identify that more R&D work may be required to support Scottish Government

[1] Facility could be sited at intermediate depths up to about 100 m below ground.
[2] This option could be used in conjunction with disposal options for any remaining wastes.
[3] This option could be used in conjunction with disposal options for any remaining wastes.

Policy to look at alternative near-surface disposal options. There is no case to change the near-term Scottish strategy however, in the long-term both near-surface disposal and long-term storage options will be considered. RSRL is identified as a potential area where treatment options could be tested, although it is acknowledged that this work may have limited use in informing the wider options for reactor graphite.

Table 1 – Credible Options for Reactor Core Graphite

	Magnox waste	EDF Energy AGR waste	Sellafield waste	RSRL waste	DSRL waste
1. **GDF disposal**	✓ for England and Wales x for Scotland (Scottish policy compliance)	✓ for England and Wales x for Scotland (Scottish policy compliance)	✓	✓	x (Scottish policy compliance)
2. **Near surface disposal**	✓	✓	✓	✓	✓
3. **In-situ disposal**	✓	✓	✓ for Pile 2 waste x for WAGR & Pile 1 waste (feasibility)	✓ ? (ability to meet timescales)	✓ ? (ability to meet timescales)
4. **LLWR disposal**	x (compliance with WAC)	x (compliance with WAC)	x (compliance with WAC)	x (compliance with WAC)	x (compliance with WAC)
5. **Permitted landfill disposal**	x (compliance with WAC)	x (compliance with WAC)	x (compliance with WAC)	x (compliance with WAC)	x (compliance with WAC)
6. **Treatment to make management easier**	✓	✓	✓ for Pile waste x for WAGR waste (feasibility)	✓	✓
7. **Treatment to minimise volume**	✓	✓	✓ for Pile waste x for WAGR waste (feasibility)	✓	✓
8. **Re-use/ recycling**	✓	✓	✓ for Pile waste x for WAGR waste (feasibility)	✓	✓

4 Position Statement

As described above, we have undertaken a number of supporting studies to develop our strategic position on graphite waste management. Our position is as follows:

For operational HAW graphite waste arisings we have expressed a preferred option that retains the current approach of interim storage. Our strategic preference with respect to packaging of these wastes is that encapsulation should be deferred until the time of disposal in order to take advantage of any treatment or disposal opportunities that develop over that period. In some circumstances, Berkeley for example, an encapsulation stage may not be required.

Individual sites already have established strategies for the management of this kind of waste and it is recognised that these may differ from the preferred option expressed above as a result of site specific issues and circumstances.

With respect to reactor decommissioning graphite waste we have not determined a case for changing the baseline strategy at the current time. Our work has demonstrated that the management of graphite waste by geological disposal provides a robust baseline strategy suitable for planning purposes. The extended period of quiescence that reactors are scheduled to be in means that there is sufficient time for alternative options to develop such that any future decisions on the management of radioactive graphite waste will be appropriately informed. In addition to this position we have identified factors that would drive a review of this strategic position.

Moving forward, we will continue to support Scottish Government work on the implementation of Scottish HAW policy, which could include more detailed consideration of near-surface disposal as well as long-term storage of graphite wastes.

For the rest of the UK we do not intend to undertake further strategic work on the management of graphite wastes in the near term. This will be the case unless circumstances trigger the requirement for a review of this position, for example if the strategy for Site Restoration and/or reactor decommissioning timescales changes. Developments in the Site Restoration strategy will be monitored from this respect.

We will close out our current R&D activities and ensure that the findings of that work are disseminated. In addition, RWMD will continue to research the implications of graphite and carbon-14 on the geological disposal concept. We will also continue to monitor international developments.

In the longer term we also recognise the opportunity to gain experience from previous and relatively near term reactor decommissioning activities (RSRL, Dounreay) and will ensure that learning is appropriately captured. Where small scale testing can be carried out on reactors going into quiescence, that will assist future understanding for decommissioning, this should be considered.

5 References

[1] NDA, "Operational Graphite Management Strategy: Credible and Preferred Options (Gate A & B)," 2013.

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[9] DEFRA, "Response to the Report and Recommendations from the Committee on Radioactive Waste Management (CoRWM), UK Government and the devolved administrations," 2006. [Online]. Available: http://corwm.decc.gov.uk/media/viewfile.ashx?filetype=4&filepath=corwm/Post-Nov%2007%20Doc%20Store/Documents/Other/051010/2069-corwm-govresponse-plenary-nov-9th.pdf.

[10] NDA, “Reactor Decomissioning Update - Summary of Options for Waste Graphite,” February 2011.

[11] UKAEA, "Graphite Characterisation (Stage 1 – Define Characterisation Programme): Study for the Nuclear Decommissioning Authority Issue 1," 2010.

[12] Babcock, "Magnox Reactor Graphite Characterisation Stage 2 – Final Active Analysis Stage Issue 3," 2010.

[13] Babcock International, "DRP Lot 3 WP5 Graphite Behaviour Stage 2 Task 1 - Review of Graphite Treatment," 2013.

6 Abbreviations

AGR	Advanced Gas-Cooled Reactor
BAT	Best Available Technique
CoRWM	Committee on Radioactive Waste Management
DSRL	Dounreay Sites Restoration Ltd
ESC	Environmental Safety Case
EU	European Union
GDF	Geological Disposal Facility
HAW	Higher Activity Waste
ILW	Intermediate Level Waste
LLW	Low Level Waste
LLWR	Low Level Waste Repository
NDA	Nuclear Decommissioning Authority
RSRL	Research Sites Restoration Limited
RWI	Radioactive Waste Inventory
RWMD	Radioactive Waste Management Directorate
SEPA	Scottish Environmental Protection Agency
UK	United Kingdom
WAC	Waste Acceptance Criteria