

Position Paper of NDA Research Board NDARB020

Review of NDA's Higher Activity Waste Pre-Disposal Treatment R&D Issue 1

December 2015

About the Independent NDA Research Board

Despite its title, the Research Board has terms of reference which cover the Research and Development (R&D) interests for waste management and decommissioning of the UK, not just the that of the NDA. Given the scale of the NDA's work in this sphere however, much of its time is dedicated to the NDA's own programme. Although the Board works cooperatively with the NDA, which provides the secretariat, it is independent. Neither its programme of work or published opinions have to be agreed with the NDA. Its membership comprises experts in the field and senior representatives of key stakeholder organisations such as Government departments and regulatory bodies. Its role is advisory only, reporting to the main NDA Board and to Government departments via their Chief Scientific Advisors. Further information on the Research Board can be found on the NDA website (www.gov.uk/nda).

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1. Introduction

The reader is asked to note that this Position Statement is based on information provided to the independent Research Board up to the date of its meeting of October 2014. Any R&D developments after that date are not part of the considerations presented here.

Higher Activity Waste (HAW) includes High Level Waste (HLW), Intermediate Level Waste (ILW) and a relatively small amount of Low Level Waste (LLW) that is unsuitable for disposal in current LLW facilities¹. The NDA separates its work into six strategic themes², one of which is Integrated Waste Management (IWM). This is a very large theme; in order to make the scope of this review manageable it covers only the R&D activities associated with the NDA's directly funded programme on pre-disposal treatment of higher activity wastes. The NDA's Strategic Theme of Integrated Waste Management covers more related areas (to which the Research Board may return at some future date). The reader is asked to bear this in mind when considering the extracts from the NDA's Integrated Waste Management section of its overall strategy document³ below, some of which may be more appropriate to other waste aspects.

Information on quantities and the nature of radioactive waste is available from the UK Radioactive Waste Inventory (UKRWI). NDA are responsible for production and reporting of the UKRWI on behalf of DECC and it is currently collected and published every three years. The most recent UKRWI was published in 2014 based on a stock date of 1st April 2013.

2. The NDA's Strategy for HAW – Information extracted and restructured from NDA Strategy

The high level NDA strategy for Higher Activity Wastes is: "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."

Underlying support for this high level strategy is provided by:

- Informing strategic decisions about waste management by the following key principles:
 - Risk reduction is a priority.

¹ See Implementing Geological Disposal, 14D/235, Department of Energy & Climate Change, 24 July 2014

² Site Restoration, Spent Fuels, Nuclear Materials, Integrated Waste Management, Business Optimisation, Critical Enablers.

³ Strategy, effective from April 2011, <http://www.nda.gov.uk/publication/nda-strategy-effective-from-april-2011/>

- Centralised and multi-site approaches should be considered where they may be advantageous.
 - Waste should be minimised.
 - The Waste Hierarchy should be used as a framework for waste management decision making, enabling an effective balance of priorities including value for money, affordability, technical maturity and the protection of health, safety, security and the environment.
- Taking a UK wide view of waste management opportunities, risks and practical developments (e.g. by investigating opportunities to share waste management infrastructure across the estate and with other waste producers where there is benefit). The NDA takes a multi-site and, where appropriate, a UK wide view, including its own sites and the operations of other waste producers, including EDF Energy and MoD.
 - Requiring its own sites to deliver an Integrated Waste Strategy (IWS). These IWSs are strategic documents which aim to communicate how wastes will be managed, now and over the site lifetime, and what challenges, including technical challenges, lie ahead and when they need to be addressed.
 - Tracking international developments (a standing item on the internal R&D Board agenda) as a benchmark and collaborating with other countries on waste management opportunities to share good practice.
 - Encouraging innovation and open market solutions, and sustaining R&D matched to the challenges of waste management both by direct investment and indirectly through the programmes of the SLCs.

Within this overall framework the NDA goes on to note:

- The priority is to achieve risk reduction by dealing with waste in ageing storage facilities (for example legacy facilities at Sellafield) and placing it into safer modern storage conditions. At facilities where the immediate priority is near term risk reduction the NDA is prepared to retrieve wastes and provide containerisation knowing that further treatment steps will be necessary prior to disposal.
- There are opportunities for a more flexible approach in the management of waste that is close to category boundaries. Decay storage of ILW may make the use of LLW treatment and disposal routes feasible.
- There are possibilities for developing alternative waste treatment capabilities that will help provide a more flexible and cost-effective approach. These include:
 - Thermal treatment for volume reduction.
 - Near surface disposal of some reactor decommissioning wastes.
- The NDA recognises the impact of the UK New Build Reactor programme and will supply advice and information to the utilities involved as required. This will promote an integrated approach such that its facilities can plan effectively for the future.

3. Five Year Research and Development Plan⁴

The NDA's approach to R&D is that, where possible, site specific research should be conducted by the SLCs; where appropriate NDA carries out R&D affecting several SLCs or to enable NDA to develop and deliver strategy. NDA directly funded research is managed through the Direct Research Portfolio (DRP)⁵. Research in the area of waste management is dominated by Higher Activity Waste tasks that mainly cover the following areas:

- Informing Strategy – underpinning technical work that supports NDA strategy development.
- Delivering innovation – cross industry/multi-SLC technical opportunities or alternatives to established technologies.
- Maintaining technical skills in key areas.

A number of strategy related tasks are also being undertaken by Radioactive Waste Management Ltd (RWM) under the Upstream Optioneering work programme⁶. These tasks are often information gathering or scoping studies that feed into and supplement the work delivered through the DRP. These two portfolios of work (i.e. that of the DRP and that of Upstream Optioneering) are coordinated via RWM's membership of the internal NDA R&D Board and through the NDA IWM Strategic Authority. The Strategic Authority (a person) manages the RWM client specification, which sets out that work which RWM is to deliver, and is also a member of the internal NDA R&D Board.

In December 2013 the NDA published its R&D plan for the period FY2014-15 to FY2018-19. For HAW this states that the R&D objectives are:

- To support the NDA in its development and analysis of strategic options for HAW management.
- To enable the NDA to act as an informed strategic body by sponsoring R&D activities that allow the NDA to:
 - Respond to decisions on government policy and
 - Oversee SLC activities with regard to HAW retrieval, treatment, storage and disposal.

⁴ See Research and Development, 5 Year Research and Development Plan, Issue 1, EDMRS No. 2080915, NDA December 2013, <http://www.nda.gov.uk/publication/research-and-development-5-year-plan-2014-to-2019/>

⁵ See Technology / Research Investment Process, EGPR04 Rev5, NDA, August 2013

⁶ The RWM Upstream Optioneering work derived from considerable engagement with the SLCs and the wider industry via stakeholder workshops and publications.

- To support the development of innovative technologies for the retrieval, treatment, storage and disposal of HAW.

The report goes on to set out the key Direct Research Portfolio R&D topics for the period as:

- Application of the Waste Hierarchy:
 - Development of Technologies to improve the application of the Waste Hierarchy (e.g. waste characterisation technologies, sorting and segregation technologies, understanding technical barriers to material reuse).
- Alternative Waste Treatment, with particular focus on volume reduction:
 - Understanding and, where appropriate, addressing the technical barriers to implementation of new thermal, mechanical and chemical treatment technologies across the NDA estate.
 - Understanding and, where appropriate, addressing the technical barriers to implementation of mobile and/or modular treatment technologies.
 - Technologies that may lead to better treatment of unique waste streams at an NDA estate-wide level (e.g. contaminated oils and solids).
- Alternative Encapsulants:
 - Consolidate work and understanding on improving existing encapsulation technology (e.g. use of superplasticisers).
 - Understand options and technical barriers to implementation of alternative encapsulants (e.g. alternative cements or polymers).
- Underpinning of interim storage:
 - Material and design of package (e.g. improve fundamental knowledge of relevant underpinning science).
 - Store environments and their impact on long-term interim storage.
 - Understanding the evolution of waste packages during long-term interim storage.
 - Technologies for monitoring waste packages and stores.
 - Technologies for remediating damaged ILW packages.
- Alternative disposal approaches:
 - Understanding and, where appropriate, addressing the technical barriers to implementation of alternative disposal approaches (e.g. decay storage, near surface).

A useful condensed summary of the specific tasks in the current programme was provided to the Board in Paper NDARB018⁷; this is reproduced in Appendix 1

As noted earlier, the R&D work on IWM comes in two separate but related sets, that managed by the NDA IWM team and that managed by RWM under the Upstream

⁷ R&D Programme with respect to Pre-disposal Treatment of Higher Activity Wastes, Issue 1, October 2013, NDARB018.

Optioneering work programme. While the relationship between these contributing parties appears to work very comfortably at present, RWM has recently become a wholly owned subsidiary of the NDA and there is the intention that, at some point in the future, RWM will become a separate SLC.

Recommendation: The NDA should consider carefully the relationship between NDA Strategy sponsored R&D tasks and the RWM Upstream Options programme, particularly at a time when RWM has recently become a wholly owned subsidiary of the NDA.

4. Research Board's Questions

In conducting this review the Research Board set out to answer a number of questions as follows.

On the basis of the evidence available to the Research Board

Question 1: *Is the programme soundly based?*

Question 2: *Are the mechanisms for review adequate?*

Question 3: *Is the programme adequately communicated to stakeholders?*

Question 4: *Is the programme robust to future change?*

Question 5: *Are there areas which members would like to investigate further?*

The Board received paper NDARB018 from NDA responding to these questions and providing broader information and a further paper reviewing the progress of the Nuclear Waste Research Forum and its working groups, which contained, inter alia, information on the Waste Packaging and Storage Working Group and the Characterisation Working Group, each supporting NDA's IWM work. At its October 2014 meeting the Board had the opportunity to discuss these matters with the NDA's Head of Integrated Waste Management, Higher Activity Waste Strategy Development Manager and Head of Technology and also with RWM Ltd.'s Head of Research. In preparing this Position Statement the Board also reviewed a range of supporting NDA publications.

5. Question 1. Is the Programme Soundly Based?

The high level R&D programme was initially developed from an analysis of the combined R&D needs, risks and opportunities resulting from integrating the individual SLC TBuRD (Technical Baseline Underpinning R&D)⁸ documents. This analysis was undertaken jointly by the DRP Framework Contractors (National Nuclear Laboratory, UKAEA Technical Services Group, Serco and Hyder Consulting). The analysis process included an industry wide workshop using the membership of the Nuclear Waste Research Forum (NWRP) at

⁸ The NDA requires each of its Site Licence Companies to provide these documents setting out the research and development needs for it to carry out the SLC's lifetime plan.

which the attendees could comment on the process used, highlight R&D areas worthy of further investigation and participate in the prioritisation process.

More recently the R&D programme has developed further by the introduction of the IWM Strategy Development Programme⁹, which identified some underpinning R&D tasks. Ongoing engagement with the NWRf and in particular the Working Group on Waste Packaging and Storage (WP&SG) has generated a list of high priority technical issues.

The current five year R&D plan has been prepared by the NDA R&D team based upon information supplied by the Integrated Waste Management Team and the NWRf. The final plan was reviewed by the NDA's Internal Review Board and approved by the NDA's Head of Technology. The development of the programme is also discussed at the IWM Theme Overview Group (ToG), which includes Government and Regulators. The ToG is informed of the programme, scope development, progress and outcomes of the R&D tasks, providing the opportunity to discuss the work and provide feedback.

The Board notes and commends that the intention with much of the programme is to produce guidance documents on particular topics. It was particularly impressed that an Integrated Project Team (SLCs, RWM, EDF Energy, MoD, AWE and the supply chain organisations for the DRP) was assembled to produce the Industry Guidance on the Storage of Packaged HAW¹⁰.

5.1. Research Board's Position

In its earlier meetings the RB explored how other organisations identify and prioritise their R&D programmes and compared this to the NDA's TbuRD process in an independent study¹¹. This found that the TbuRD process was best in class, with no parallel elsewhere. Hence, the derivation of the IWM R&D programme from the analysis of the SLC TbuRD returns gives confidence that it is soundly based. This is further reinforced by the cross-industry workshop held as part of that process. The NDA's internal review process then examines the programme, bringing in expertise from outside the immediate IWM team and the ToG enables input from regulators and Government departments. The Board is also impressed by the highly interactive nature of the relationship with the NWRf WP&S WG, which continues to engage those at the "coal face" with the R&D programme. The Board is therefore of the opinion that the programme is soundly based

⁹ Integrated Waste Management Strategy Development Programme, Final, May 2012, SMS/TS/D-IWM/002: <http://www.nda.gov.uk/publication/integrated-waste-management-strategy-development-programme-final-may-2012/>

¹⁰ Industry Guidance – Interim Storage of Higher Activity Waste Packages – Integrated Approach November 2012: <http://www.nda.gov.uk/publication/industry-guidance-interim-storage-of-higher-activity-waste-packages-integrated-approach-november-2012/>

¹¹ Summary of Independent Peer Review and Analysis of SLC TbuRD Submissions 2012: <http://www.nda.gov.uk/publication/summary-of-independent-peer-review-and-analysis-of-slc-tburd-submissions-2012/>

6. Question 2. Are the Mechanisms for Review Adequate?

At the broader level the full DRP is regularly reviewed by the NDA Research Manager to ensure that the portfolio is balanced across the key themes and that any synergies with other R&D programmes are identified. This oversight role also includes the publication of annual reviews of the DRP looking at the value and nature of the work placed and the status of the framework contracts used to deliver the R&D.

The NDA's Internal R&D Board meets on a monthly basis to discuss current proposals, future plans and the delivery of ongoing projects. On a quarterly basis it discusses the overall delivery of the programme. The DRP process is managed by the NDA's Research Manager with the NDA Head of Technology having overall accountability.

With respect more specifically to IWM, the Head of IWM is accountable for ensuring that the IWM strategy is developed and underpinned, which may include a requirement for R&D. Together with the NDA Research Manager, the Head of IWM defines the R&D scope and then acts as the sponsor for the project through the DRP process including reviewing any deliverables. NWRP Working Groups, principally WP&S, may also propose relevant multi-SLC R&D projects for funding through the DRP. For these projects, they will define the R&D scope and act as the sponsor for the project through the DRP process. Where appropriate, the NWRP Working Groups are also involved in reviewing R&D scopes, contractor proposals, commenting on deliverables and communicating the results to the wider SLC community. This aims to ensure continued close engagement with the end user group.

The Board also commends the invitation of the International Atomic Energy Agency (IAEA) to peer review the Industry Guidance on the Interim Storage of HAW Packages. This is an excellent way to draw on international experience in validating the quality of the guidance.

6.1. Research Board's Position

The NDA's review processes include scrutiny of the programme internally and with external input via the ToG and the NWRP WP&S WG. The end users are kept fully engaged via the NWRP and specifically the WP&S WG. The NDA's processes therefore seem to be effective for reviewing the continuing appropriateness of the programme and the validity of the output products.

Observation: Where a significant guidance document is a result of the programme, international peer review, as used for the Industry Guidance on the Interim Storage of HAW Packages, is an excellent way to draw on international experience to validate the guidance content.

7. Question 3. Is the Programme Adequately Communicated to Stakeholders?

There are two sets of stakeholders that need special consideration, those that will use the outcomes of the R&D and those in the supply chain that may be able to contribute to the R&D work itself.

As noted in the sections on Q1 and Q2 above, the NWRF WP&S WG has aided development of the programme and follows the progress of the R&D projects. Clearly the SLCs form the most important of the key stakeholder groups for this work as they will be the implementers of any successful outcomes. In addition, where considered of value the NDA holds specially arranged workshops. The Board notes and commends the NDA for holding a workshop to launch the Industry Guidance on the Storage of Packaged HAW. The Board also notes and commends the symposium organised by Sellafield Ltd and the University of Sheffield on thermal treatment of radioactive waste¹².

External communication of specific outputs of the NDA's directly funded R&D projects is determined on a project by project basis. Tenders include an option for contractors to propose tasks that will support raising the impact of the project, such as presentations to relevant SLC technical experts or at international conferences. Contractors are required to provide a summary document that can be shared with external stakeholders.

The IWM ToG also provides the facility to keep Government and the Regulators up to date with the R&D strategy, the R&D five year plan and the content and results of the IWM components of the R&D programme. As in the section on Q2 above, the publication of annual reviews of the DRP is a good practice which contributes to the communication with stakeholders, both users and potential R&D suppliers. These reviews include the publication of the value and the nature of the work placed and the status of the framework contracts. Regular articles on R&D are included in the NDA's stakeholder magazine, Insight and on the website. Similarly, SLCs publish information on their R&D programmes in their own stakeholder magazines.

As indicated to the Board at the end of NDARB018, the NDA IWM team is aware that persuading the SLCs to employ the outcome of R&D is not always easy. The RB has previously been made aware of this same difficulty elsewhere by its French CEA member. Contractors may prefer to continue with technology that they regard as tried and tested, rather than take on board a new approach which they may see as inherently risky to their programme and costs. The CEA has sometimes found it necessary in the past to pay

¹² Thermal treatment of radioactive wastes 2013: research, development and demonstration
<http://www.sheffield.ac.uk/materials/news/thermaltreatmentsymposium-1.384659>

contractors to employ these new approaches via paid for demonstration projects on the clean-up sites.

In terms of preserving the information for future use, outputs from R&D projects are stored centrally within NDA and recorded on a searchable database.

7.1. Research Board's Position

The NDA goes to great lengths to provide stakeholders with information on its programme and the outcome results. The Board is satisfied that the programme and its results are adequately communicated to stakeholders.

Observation: The Board commends:

- The use of workshops when appropriate to aid the wide dissemination of R&D results.
- The practice and intention of providing documents summarising the R&D outcomes and/or guidance documents when the work on specific topics has matured to an appropriate stage.

Recommendation: Where R&D results indicate significant benefit could be gained to NDA but SLC's are reluctant to adopt the technology, NDA could consider an incentive payment, as has been employed by the French CEA.

8. Question 4. Is the Programme Robust to Future Change?

The TBuRDs are updated annually and the SLC Integrated Waste Strategies triennially unless the NDA asks an SLC for an earlier update. The close engagement of the WP&S WG in the establishment, prioritisation and ongoing monitoring of the programme means that the NDA should be very quickly aware of the impacts of any previously unforeseen change. The NDA has informed the Board that the HAW R&D programme "is live" and although it is based on the five year plan it is also adapted in response to fresh proposals and task findings. In this way the programme remains current and is less vulnerable to adverse impacts.

An interim store for packaged HAW is a robust engineered facility with a design life of typically 100 years and robust storage arrangements provide high confidence that packages will be disposable at the end of the storage period, unaffected by any variation in the nature of or availability of disposal routes. While encapsulation of wastes would be expensive to reverse and reengineer, should this ever become necessary, it is unavoidable if the objective of immobilising potentially mobile waste is to be achieved. If this were to become necessary, the robustness of the storage arrangements should provide plenty of time for such technologies to be developed and the RB does not believe that research in this area is warranted.

8.1. Research Board's Position.

The Board concludes that the programme is robust to future change.

9. Question 5. Are there Areas that Members Would Like to Investigate Further?

There is a great deal of excellent work ongoing or planned. The RB would like to use this section to discuss, not only those elements that might be missing, but to give additional emphasis to some that are already in the programme:

- The RB is aware of concerns raised by SLCs about the escalating costs for site remediation programmes from monitoring, segregation and treatment of wastes that are employed to push waste up the waste hierarchy. While the RB acknowledges these concerns it is also aware of wider more strategic factors that affect the overall cost of radioactive waste management including the availability of waste disposal capacity. In order to ensure that the application of the waste hierarchy across the industry is effective and efficient the RB encourages continued work in this area including R&D into characterisation, segregation and pre-treatment methods.
- The NDA has in its programme work to clarify the life cycle cost of a unit volume of waste. The Board takes the view that this is essential if the value of R&D work to reduce disposed waste volumes (e.g. by improving packing factors, reducing volumes of raw waste by treatment or using the waste hierarchy more effectively) is to be judged for whether it is worth pursuing and when it is needed.
- The programme of environmental restoration work across the Magnox, the former UKAEA and Sellafield sites is advancing rapidly with respect to the retrieval and packaging of operational wastes. The Board is concerned that some of the technologies under development with applicability to this topic area of Higher Activity Waste Pre-disposal Treatment (e.g. thermal treatment, use of mobile plants) may not be available in time to be of real value. Many of these operational waste streams already have facilities dedicated to their management. The Board would like to see more attention paid to the Technology Readiness Levels of those technologies under development in this area and the insertion points in the programme that are required for them to prove their value. These two factors are important both for the overall restoration programme and for reviewing where the majority of R&D work should be focussed. The Board recognises that decommissioning wastes from plant dismantling will continue to be generated well into the future, but operational wastes present a more urgent issue. The Board will be considering this wider area as part of a future meeting focussed on technical baselines.

- If there is an element missing in the overall R&D programme it may be in the field of waste retrieval. In order to manage any waste stream the standard steps are:
 - Retrieval
 - Predisposal treatment (e.g. packaging)
 - Interim storage (unless, as in the case of low level waste, a disposal route is already available.)
 - Transport and disposal.

It appears that the NDA has R&D programmes addressing the latter three, but not the first of these. Over the years many and diverse retrieval systems have been developed, some more successful than others. Is there merit in collecting this experience and producing a guidance document or, as with the concern expressed above with respect to volume reduction, is it too late to have any real benefit?

Work is planned to examine the merits of changes to the UK classification system of wastes, recognising that a more nuanced approach, managing wastes according to the hazard they present, has provided benefits internationally. Alongside this is the work to consider other “disposal” routes, such as decay storage and near surface on site or near site disposal. While such changes may well prove contentious, the Board is fully supportive of the NDA’s work in this area which would hopefully provide a factual basis for a rational debate across all interested parties at national level.

9.1. Research Board’s Position

The manner in which the R&D programme is built up from the TBuRD submission and then is reviewed internally, via the ToG with its external members and via the WP&S WG, make it unlikely that any significant element is missing. However, the Board would like to see consideration of the insertion points for positive R&D outcomes in the overall restoration programme, alongside assessment of the future value of the results. This, together with assessment of the Technology Readiness Levels, should show whether the work will deliver in time for real benefits to be gained.

The Board would also like to see an assessment of whether there is any benefit in R&D on retrieval technology, leading to a guidance document. The Board recognises that such technology may be too site specific and again the timeliness of any results needs to be part of the assessment.

Observations: The Board supports the NDA’s work to examine the merits of:

- moving the UK’s management approach for wastes to one that is based on the hazard that the waste presents;
- employing decay storage where appropriate;
- employing near surface disposal and disposal at or near site when appropriate; and
- The Board encourages this development of a factual basis for a rational debate amongst all interested parties at national level, recognising that some of these matters may prove contentious.

- The board notes that some of these issues may require R&D to develop and implement future strategies.

Recommendations:

- The evaluation of the life cycle cost of a unit of waste is a key input to evaluating the potential value of R&D and should be prioritised by NDA.
- The NDA and SLCs should assess and publish the Technology Readiness Levels of the technologies under development in the R&D programme.
- The NDA should assess the possible insertion points for new technologies into the overall site remediation programme to establish whether they will be available in time to be of real benefit. This would also help prioritise R&D spend. This is of generic relevance, not just the IWM programme, but it appears to the Board that IWM opportunities may be closing fast.
- The NDA should continue to sponsor R&D tasks that support the effective implementation of the waste hierarchy including characterisation techniques, segregation and pre-treatment methods.
- The NDA should consider whether there is merit in adding some work on waste retrieval, collecting and refining the evidence accumulated, with a view to producing a guidance document on best practices.

10. Short Summary of Conclusions

The reader is asked to note that this Position Statement is based on information provided to the independent Research Board up to the date of its meeting in October 2014. Any R&D developments after that date are not part of the considerations presented here. The Board has reviewed the NDA's R&D programme for the pre-disposal treatment of higher activity radioactive waste against a set of questions and these and a summary of its conclusions are set out below. The reader is directed to the main text for more detail and for the associated observations and recommendations.

Q1. Is the programme soundly based?

The derivation of the IWM R&D programme from the analysis of the SLC TBUrd returns gives confidence that it is soundly based. This is further reinforced by the cross-industry workshop held as part of that process. The NDA's internal review process then examines the programme, bringing in expertise from outside the immediate IWM team and the ToG enables input from regulators and Government departments. The Board is also impressed by the highly interactive nature of the relationship with the NWRF WP&S WG, which continues to engage those at the "coal face" with the R&D programme.

The Board is therefore of the opinion that the programme is soundly based.

Q2. Are the mechanisms for review adequate?

The NDA's review processes include scrutiny of the programme internally and with external input via the ToG and the NWRP WP&S WG. The end users are kept fully engaged via the WP&S WG.

The Board concludes that NDA's processes are effective for reviewing the continuing appropriateness of the programme and the validity of the output products.

Q3. Is the programme adequately communicated to stakeholders?

The NDA goes to great lengths to provide stakeholders with information on its programme and the outcome results.

The Board is satisfied that the programme and its results are adequately communicated to stakeholders.

Question 4. Is the programme robust to future change?

The close engagement of the WP&S WG in the establishment, prioritisation and ongoing monitoring of the programme means that the NDA should be very quickly aware of the impacts of any previously unforeseen change. The NDA has informed the Board that the HAW R&D programme "is live" and although it is based on the five year plan it is also adapted in response to fresh proposals and task findings. In this way the programme remains current and is less vulnerable to adverse impacts.

The Board concludes that the programme is robust to future change.

Question 5. Are there areas which members would like to investigate further?

The manner in which the R&D programme is built up from the TBuRD submission and then is reviewed internally, via the ToG with its external members and via the WP&S WG make it unlikely that any significant element is missing. However, the Board would like to see consideration of the insertion points for positive R&D outcomes in the overall restoration programme, alongside assessment of the future value of the results. This, together with assessment of the Technology Readiness Levels, should show whether the work will deliver in time for real benefits to be gained.

The Board would also like to see an assessment of whether there is any benefit in R&D on retrieval technology, leading to a guidance document. The Board recognises that such technology may be too site specific and again the timeliness of any results needs to be part of the assessment.

Appendix 1

Summary table showing the current relevant DRP and RWM (in italics) work packages.

5 year plan R&D Topic	Work Package	R&D Driver
1. Application of the Waste Hierarchy	Waste Acceptance Criteria for Existing and Planned Treatment Plants <i>ILW/LLW Boundary wastes</i> <i>Cost norms – value of volume reduction</i> <i>Centralised and mobile treatment plant</i> <i>Disposability of decontamination agents</i>	Informing Strategy
2. Alternative Waste Treatment - with a particular focus on volume reduction - Understanding and, where appropriate, addressing the technical barriers to implementation of new thermal, mechanical and chemical treatment technologies across the NDA estate	Graphite Behaviour (phase 2b & 2c) Refinement of strategy for HAW treatment Nature and Quantity of contaminated oil <i>Packaging for spent sealed sources</i> <i>Mercury waste disposability</i>	Informing Strategy Informing Strategy
2. Alternative Waste Treatment - with a particular focus on volume reduction - Technologies that may lead to better treatment of unique waste streams at an NDA estate-wide level	Orphan Wastes - Timings of Treatment <i>Guidance on the packaging of filters</i> <i>Gate A paper on Optimised management of orphan waste</i>	Informing Strategy
3. Alternative Encapsulants - Understand options and technical barriers to implementation of alternative encapsulants	Low Dose Rate Irradiation Testing of Piles Candidate Polymers <i>Collating R&D on the use of polymers</i>	Innovation
3. Alternative Encapsulants - Consolidate work and understanding on improving existing encapsulation technology	New uses of cementitious grouts (Reactive Encapsulants) Solubility Studies in the Presence of Bespoke	Informing Strategy / Innovation / Maintaining key skills Innovation

5 year plan R&D Topic	Work Package	R&D Driver
	Superplasticisers	
4. Underpinning of Interim Storage - Technologies for monitoring waste packages and stores	SMART Coupons (phase 4)	Innovation
4. Underpinning of Interim Storage - Material and design of package	Waste Packaging Database <i>Value Engineering waste containers</i>	Informing Strategy / Maintaining key skills
5. Alternative disposal Approaches	<i>Expanding LLW treatment capability</i> <i>ILW/LLW Boundary wastes</i> <i>HLW lifecycle options</i> <i>Gate A paper on decay storage</i>	