Regulatory scrutiny of Radioactive Waste Management Limited's work on geological disposal of radioactive waste

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We would welcome your feedback on this document.

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https://www.gov.uk/government/collections/scrutiny-of-radioactive-waste-management-directorates-rwmd-work

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Foreword

This is a joint publication by the Environment Agency and the Office for Nuclear Regulation to inform others about our oversight of Radioactive Waste Management Limited's (RWM)[i] work related to geological disposal of radioactive waste. Prior to the start of formal regulation, we have established agreements with RWM to provide regulatory advice in relation to implementing geological disposal. The regulators are working together to make sure that any future facility will meet our required high standards for environmental protection, safety, security, radioactive waste transportation and safeguards.

We are engaging with RWM for two reasons. Firstly, to ensure that any future applications for a geological disposal facility (GDF) we receive will take full account of our permitting and licensing requirements. Secondly, to ensure that the advice RWM currently provides to waste producers, about how they should package their radioactive waste for future geological disposal, is appropriate.

We have no formal role in the decision-making process for selecting potential sites for a GDF. However, separate to our oversight of RWM reported here, we also provide advice and comment on matters that would be within our regulatory remits to inform that decision-making process.

As independent regulators, we are committed to making our work open and transparent. We trust that this report will be useful to others in introducing our standards and requirements for a geological disposal facility and in providing insight into how we will ensure that these will be met in any future applications.

[i] On 1 April 2014, Radioactive Waste Management Limited (RWM) was established as a wholly-owned subsidiary of the Nuclear Decommissioning Authority (NDA) taking on the responsibilities of Radioactive Waste Management Directorate (RWMD) of the NDA. For clarity and simplicity we refer to RWM throughout this report.

Executive summary

Government policy for the long-term management of higher activity waste (HAW) is by disposal to a geological disposal facility (GDF), which will be implemented alongside ongoing interim storage and supporting research. Radioactive Waste Management Limited (RWM) is responsible for implementing government policy on geological disposal of higher activity radioactive waste and for providing radioactive waste management solutions to the nuclear industry. It is currently undertaking preparatory work to plan for geological disposal - work described as "generic", as no sites have been identified yet.

We have no formal role in the decision-making process for selecting potential sites for a GDF. However, separate to our oversight of RWM reported here, we also provide advice and comment on matters that would be within our regulatory remits to inform that decision-making process.

This report summarises the work carried out by the Environment Agency and the Office for Nuclear Regulation, between April 2013 and March 2015, to scrutinise the work of RWM.

The main outcomes from our work in this reporting period are as follows:

- Our regulatory advice to RWM about our expectations and requirements for duty holders has helped it to establish itself as a stand-alone organisation. On 1 April 2014, The Nuclear Decommissioning Authority's (NDA's) Radioactive Waste Management Directorate (RWMD) became Radioactive Waste Management Limited (RWM), a wholly owned subsidiary company of NDA. As discussed with RWM, its move to subsidiary company at this stage is consistent with our expectations.
- We inspected RWM's disposability assessment and Letter of Compliance process and found it to be robust; it provides waste producers with confidence, reduces the risks associated with packaging wastes now, and helps progress decommissioning and clean-up. However, there is still potential for improvements in the process and we are continuing to engage with RWM to encourage progress of these.
- We continue to emphasise the importance of waste package records for disposability. Waste generators must establish plans to ensure appropriate records are made and managed for the long term, in order to meet future acceptance criteria for wastes disposed to a GDF. The industry now recognises the importance of adequate and appropriate information management to support geological disposal, and addressing this is now regarded as a matter of high priority. RWM and NDA have made progress through dialogue with waste producers on this matter, and RWM has initiated a project on waste package records.
- We reviewed RWM's science & technology plan, and we think it provides a good overview of the Research and Development (R&D) work that RWM plans to undertake over the next decade. It provides RWM with a good tool to use as a basis for engaging with others, to explain the R&D it plans to undertake, and the further R&D that may be required to implement geological disposal. The document should also help RWM develop a more focussed R&D programme during the generic phase, which will be useful once a site (or sites) is identified. Overall, we remain confident that RWM is progressing R&D in areas it identifies as high priority.
- We do not want progress in clean-up to be hindered by protracted deliberations where strong safety arguments can be made, for example at Sellafield. RWM needs to establish fissile material limits for waste packages via an approach that takes into account the whole waste life cycle, considering an overall balance of risk. We acknowledge RWM's demonstration that post-closure criticality carries very low risk. Consequently, we advised RWM that post-closure criticality safety should not be as significant a driver, as it has been historically, for setting waste package fissile material limits for many wastes. As a result, RWM is proposing to remove fissile material limits based on pessimistic post closure GDF evolution scenarios for the majority of wastes that instead can be shown to be consistent with a low likelihood of post-closure criticality. We support this approach.

- RWM has developed a good understanding of the permissions framework and the associated regulatory submissions required to support environmental permitting. It has adopted a sensible approach towards meeting our expectations for an initial site evaluation and preliminary environmental site evaluation. Our draft environmental permit template for intrusive investigation work at a GDF, and drafts of an application form and associated guidance to applicants, that we provided to RWM, will help RWM understand the Environment Agency's permitting requirements and help it plan any future site investigation work programme.
- RWM has made satisfactory progress towards addressing our recommendations from our review of the 2010 generic Disposal System Safety Case (gDSSC).This should help RWM improve the quality of its forthcoming update of the gDSSC and any future safety case submissions in support of a permit or licence application. In particular, we advised RWM that the update of the gDSSC (in 2016) should be more balanced in its coverage of different geological environments and concepts.

We also advised RWM on how it may improve a number of its documents that it submitted for regulatory review, and on a number of specific regulatory matters, such as: groundwater protection, climate change, safeguards requirements, and optimisation.

We are satisfied that RWM has adequate systems in place to monitor our regulatory concerns and recommendations, such that it can take them into account and implement any necessary changes and improvements in its ongoing programme towards implementing geological disposal, and that RWM is responsive to our regulatory advice.

Contents

1. Introduction

Radioactive waste arises from the UK's historic and ongoing nuclear power, research and defence programmes. To date there is no disposal route for the waste generated that is termed Higher Activity Waste (HAW). Instead, HAW is stored on nuclear sites awaiting a disposal solution. HAW continues to be produced from nuclear sites and in smaller amounts from other users of radioactive material such as, industry, hospitals and universities. New nuclear power stations, proposed for England and Wales, would add to the amount of waste produced.

The UK government policy for the long-term management of HAW is explained in the 2014 white paper [1]. Radioactive waste management is a devolved policy issue. Therefore, the Welsh government, Northern Ireland executive and Scottish government each have responsibility for this issue in respect of their areas. During the course of producing this report (May 2015) the Welsh government has decided to adopt a policy for geological disposal for the long term management of HAW [2]. Although the Welsh government has adopted a policy for geological disposal for HAW, this does not mean that a GDF will necessarily be sited in Wales. The Welsh government continues to support the policy of voluntary engagement where potential host communities are able to seek discussions, without prior commitment, about potentially hosting a GDF. The Welsh government considers that a GDF can only be built in Wales if a community is willing to host it. The Northern Ireland executive continues to support the implementation of geological disposal for the UK's HAW, recognising that it is in the best interests of Northern Ireland that these wastes are managed in the safest and most secure manner. The Scottish government does not support geological disposal; its policy is for long-term management of HAW in near-surface facilities. The 2014 white paper [1] sets out the UK government's framework for managing HAW in the long term through geological disposal, focussing on how a GDF would be implemented in England, and highlighting points of variation in respect of Wales, and Northern Ireland.

The NDA is responsible for implementing government policy on the long-term management of radioactive waste and RWM is responsible for implementing government policy on geological disposal of higher activity radioactive waste. Figure 1 illustrates the typical layout of a GDF.

The Environment Agency and the Office for Nuclear Regulation (ONR) will regulate any future GDF for radioactive waste in England[ii]. We are working together to make sure that any future facility meets the required high standards for environmental protection, safety, security, safeguards, and radioactive waste transportation. We are engaging with RWM now for two reasons. Firstly, to ensure that any future applications for the development of a geological disposal facility we receive will take full account of our permitting and licensing requirements. Secondly, to ensure that the advice RWM currently provides to waste producers, about how they should be packaging their radioactive waste for future geological disposal, is appropriate.

Prior to the start of formal regulation, we have established agreements with RWM to provide regulatory advice in relation to implementing geological disposal. As a separate but related activity, the Environment Agency, the Scottish Environment Protection Agency (SEPA) and Natural Resources Wales (NRW) work with ONR to regulate the management of HAW on nuclear licensed sites. This includes oversight of advice on disposability provided by RWM to nuclear site licensees.

Our early dialogue will enable RWM to understand our permitting and licensing requirements and to prepare any applications to us including, for example, the safety cases we require in support of permitting or licensing applications. Similarly, our scrutiny work will allow us to prepare for any applications we receive from RWM, in order to respond in an informed and timely manner.

ii On 1 April 2013, Natural Resources Wales took over the functions previously carried out by the Environment Agency Wales, the Countryside Council for Wales and Forestry Commission Wales. Natural Resources Wales is the environmental regulator in Wales but, for the foreseeable future, the Environment Agency will provide technical support for its regulation of nuclear licensed sites in Wales.

We develop an annual programme of work to scrutinise RWM's work relating to implementing geological disposal. Our scrutiny programme is organised into eight areas of work. In this document, we report on the regulatory advice we have provided to RWM during the reporting period in these eight work areas in sections 2 to 9.

This report provides an overview of the work we carried out between April 2013 and March 2015. Not all the documents we refer to are published. Where our information is not available via published reports, we strive to provide summaries of our main comments in this annual report. We will consider requests for detailed information, relating to work reported here, under the Freedom of Information or Environmental Information Regulations in consultation with the information owner.

1.1. Our role in geological disposal

The Environment Agency

In addition to many other duties, the Environment Agency is responsible for regulating disposals of radioactive waste from nuclear licensed sites, and the storage and disposal of radioactive waste from other premises that use radioactive substances. Disposals of radioactive waste include any discharges into the atmosphere, surface waters and groundwater, disposals by transfer to another site, and disposal to land including geological disposal.

The Office for Nuclear Regulation

ONR's mission is to provide efficient and effective regulation of the nuclear industry, holding it to account on behalf of the public. ONR brings together the regulatory functions for nuclear safety, nuclear security, radioactive materials transport and conventional health and safety at nuclear sites, and is also responsible for ensuring that safeguards obligations on civil nuclear sites in the UK are met. The management and storage of radioactive waste on a nuclear licensed site is regulated by ONR.

1.2. The regulatory process for geological disposal

Together, the regulators are responsible for making sure that any future GDF meets the required high standards for protecting people and the environment when it is being developed, while it is operating, and after it has closed. We will be responsible for granting the necessary nuclear site licences, permissions and environmental permits throughout this period. Regulatory control is likely to be required for many decades and possibly for more than a century.

The UK government favours a voluntarist approach, based on working with communities that are willing to participate in the process, to identify potential sites for a GDF. Regulators have no formal role in the decision-making process for selecting potential sites for a GDF. However, to inform the decision-making process, and separate to our oversight of RWM reported here, we provide regulatory advice and comment on environmental, safety, and transport matters, within our regulatory remits.

The Environment Agency will regulate the development of any future GDF under the Environmental Permitting (England and Wales) Regulations 2010 (EPR10), using a process known as 'staged regulation'. This process only applies to a GDF. Figure 2 is a simplified illustration of how staged regulation might work, up to the start of disposal operations at a GDF. Staged regulation provides regulatory control from very early in the development of a GDF and enables us to maintain regulatory control throughout each stage of development from the start of intrusive site investigation, through construction and operation, and eventually to closure. The developer would

need to satisfy our stringent requirements and gain regulatory approval before each stage of development could begin. In particular, disposal of radioactive waste would not be allowed without the appropriate environmental permit. Figure 3 shows the links between a possible development programme for a GDF and the regulatory processes.

2. Planning for implementing geological disposal

We are engaging with RWM now to ensure that any future applications for the development of a GDF we receive will take full account of our permitting and licensing requirements. This will help to avoid unnecessary delays that might result if RWM were to provide inappropriate or incomplete information in support of any licence or permit application.

2.1. Our permissioning process

We continued to provide regulatory advice to RWM on our expectations of its submissions required under the staged permitting process, and the planning of its work to produce them.

To help RWM understand our permitting requirements and assist in planning its site investigation work programme we provided it with draft copies of our environmental permit template for intrusive investigation work, our application form, and our associated guidance to applicants.

We will review our draft permit documents and, if necessary, update them before the start of any intrusive investigation work at a prospective site e.g. to include other environmental protection regimes under EPR10 such as groundwater protection.

We provided regulatory advice on RWM's developing Permissions Schedule [3,4] as follows:

- All civil nuclear materials in the UK are subject to international safeguards requirements; however, as a Nuclear Weapons State the UK can/has the right to decide to retain material outside safeguards for reasons of national security, which includes wastes containing nuclear material being consigned to a GDF. The overall aim is to agree effective and efficient safeguards arrangements before the start of construction/operation. Our objective is to have agreed reporting and verification arrangements in respect of safeguards, well ahead of first receipt of nuclear material at a GDF. We will therefore continue to engage with RWM and Euratom in respect of the development of detailed safeguards arrangements for a UK GDF. The safeguards regime doesn't include regulatory permissioning by the Euratom or IAEA inspectorates.
- ONR and the Department of Energy and Climate Change (DECC) have not yet concluded how licensing will be undertaken. ONR will inform RWM as its approach develops.
- In terms of siting, there should be some consideration of the 1988 'Hansard criteria' on demographics, in which ONR has a role. Also with respect to the Control of Major Accident Hazards Regulations 1999 (COMAH), in addition to assessing RWM's activities with respect to COMAH thresholds, ONR will also provide advice about the proximity of the GDF siting to adjacent hazardous (COMAH) facilities.
- There should be wider consideration of fire safety (for example, access and egress).
- Given that different requirements need to be met for delicensing and surrender of an environmental permit, there are risks that these activities will not be able to be coordinated.
- Overall, RWM has developed a good understanding of the permissions framework and the associated regulatory submissions required to support environmental permitting. We are pleased that RWM has taken into account advice we gave to it previously [5], on developing an initial site evaluation (ISE) and preliminary environmental site evaluation (PESE), and we consider that RWM has adopted a sensible approach towards meeting our expectations for these. We recommend that RWM continues to liaise with us to ensure that its permissions

schedule remains consistent with our regulatory expectations and to help ensure that all necessary applications are ready for submission at the appropriate implementation stage.

RWM's developing Permissions Schedule takes our comments into account [6, 7, 8].

2.2. Legislative requirements

The following subsections summarise our engagement with RWM to explain certain legislative requirements. More generally, in our review of the 2010 generic Disposal System Safety Case (gDSSC) [9], we asked RWM to explain how it will identify and respond to any new statutory requirements. We expect RWM to respond with a short summary of its general approach.

2.2.1. Groundwater (Daughter) Directive 2006

Radioactive waste containing substances with non-radiological hazardous properties must be disposed of in a manner that provides adequate protection to people and the environment. RWM must design its GDF appropriately and develop an understanding now of its waste acceptance criteria for non-radiological components of the waste. This will help ensure that packaging operations today produce disposable wasteforms and minimise the risk that reworking of packages will be required.

Previously, we recommended [9] that RWM develops restrictions on chemotoxic substances, in order to meet statutory requirements for groundwater protection (Groundwater Daughter Directive 2006 (GWDD)). We subsequently issued supplementary guidance on groundwater protection [10, 11], and provided regulatory advice for RWM on the application of GWDD considerations to a GDF for RWM, at a meeting in July 2013. In particular, we discussed the UK government guidance on the 'prevent' requirement of the GWDD for the entry of hazardous substances into groundwater, and Environment Agency guidance on receptors that require protection from pollution. We clarified our regulatory position for RWM, with respect to compliance with groundwater protection requirements [12]. Regulation 17 of EPR10 states that, if a groundwater activity is carried on as part of a radioactive substances activity, the regulator must authorise the carrying on of the groundwater activity under the same environmental permit that authorises the carrying on of the radioactive substances activity. In authorising a groundwater activity under the radioactive substances permit we would, of course, take into account groundwater provisions. We agree with RWM that, for a GDF, compliance with the legal groundwater protection requirements needs further discussion. We are currently working to establish a position that can act as a secure basis for future discussions with RWM.

We are formally tracking RWM's development of this work area through a regulatory observation (RO) [13]. We recognise that this matter cannot be addressed fully until a site is identified, and the specific GDF design developed along with waste acceptance criteria, but we expect RWM to have work in progress, or planned, to ensure that waste containing substances with non-radiological hazardous properties is being packaged and will continue to be packaged in such a way that it will be suitable for disposal in a GDF with no, or minimal reworking. We discussed with RWM its draft document [14], which sets out RWM's understanding of the requirements of the GWDD and describes part of its work in addressing the associated RO [13]. RWM has informed us that its future work programme will consider topics such as, packaging standards for substances that are non-radiologically toxic or hazardous; chemotoxic issues during the operational period; chemotoxic gas release during the post-closure period; and implications of the GWDD on the assessment of chemotoxic species.

2.2.2. Construction (Design and Management) Regulations

The Construction (Design and Management) (CDM) regulations[iii] will apply from initial GDF design concept stage; this might be when one or more candidate sites are agreed or possibly in the earlier stage when potential sites are being identified. The CDM regulations were being revised during the period covered by this report, and we will continue to engage with RWM to advise on our expectations of the regulation of conventional safety under the new regime.

2.2.3. Security and safeguards

We continued dialogue with RWM, DECC, and the Ministry of Defence (MoD) to identify safeguards and security requirements for the potential GDF inventory. We also maintained contact with the Euratom safeguards inspectorate and other national safeguards authorities on the subject of safeguards measures for geological repositories. Our input has helped inform RWM's development of its generic illustrative designs and its approach to the development of public reports on the application of safeguards and security at a GDF.

2.2.4. Lessons and requirements from other national and international programmes

2.2.4.1. Fukushima

Previously we asked [9] RWM to "consider the lessons learnt from the Fukushima disaster with respect to the assessment of external hazards for UK nuclear facilities and, if necessary, modify the standards used to assess external hazards from those currently quoted in ONR's Safety Assessment Principles (SAPs)". RWM confirmed that it has considered and taken on board lessons learnt from the Fukushima accident, and that the resulting changes are going through the change control process and will be reflected in the next revision of the gDSSC scheduled for publication in 2016. We are formally tracking RWM's response to our request [15] and we expect RWM to demonstrate how it has considered and taken on board lessons learnt from the Fukushima disaster which are relevant to the GDF.

2.2.4.2. Waste Isolation Pilot Plant in New Mexico, USA (WIPP)

In February 2014, two isolated events took place at the US the Department of Energy Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. These were:

- On 5 February, a salt haul truck caught fire. Workers were evacuated, and the underground portion of WIPP was shut down.
- On 14 February, a second, unrelated event occurred when a continuous air monitor alarmed during the night shift. The next day an above ground air monitor on the WIPP site detected very low levels of airborne radioactive contamination. Subsequent investigations indicate the release was caused by an exothermic reaction involving the mixture of the organic materials and nitrate salts inside a waste drum.

We have considered both incidents at WIPP and have noted the failings identified in the preliminary reports [16][17]. We will take account of the lessons identified in developing our joint regulatory approach for any future GDF, and we expect RWM to address any lessons learnt in

[iii] The Construction (Design and Management) Regulations 2015 (CDM 2015) came into force in Great Britain on 6 April 2015 http://www.hse.gov.uk/construction/cdm/2015/index.htm

developing its proposals. We are formally tracking our request [18] for RWM to demonstrate how it has considered, and will take on board, lessons learnt from the WIPP incidents, which are relevant to the GDF. Any further lessons from the Accident Investigation Board's Phase 2 report for the event on 14 February 2014[iv] will also be considered.

2.2.5. ONR's Safety Assessment Principles

ONR published a revised version of its safety assessment principles (SAPs) [19]. This revision of the SAPs was prompted by the Chief Inspector's report on the implications of the Fukushima accident for the UK nuclear industry which recommended a review to ensure that lessons learnt were incorporated. That review was completed and the SAPs revised accordingly. ONR has also taken the opportunity to ensure its SAPs are compatible with recent work by the International Atomic Energy Agency (IAEA), and the most recent version of the Western European Nuclear Regulators' Association Reference Levels.

2.2.6. Use of pulverised fuel ash and furnace bottom ash

Because RWM might use pulverised fuel ash or furnace bottom ash in a GDF (as a constituent of certain cementitious materials) we provided our quality protocol on the end use of these ashes [20]. The protocol was produced in consultation with Defra, the Welsh Assembly Government (WAG), industry, and other regulatory stakeholders, and it is applicable in England, Wales and Northern Ireland.

2.3. GDF programme planning

Previously, DECC had challenged RWM to show that its overall programme to develop a GDF is "optimised" with respect to delivery dates, or whether there is scope to reschedule tasks so as to deliver a GDF (or parts of it) sooner. We provided regulatory advice to RWM to ensure that it understood the details and scheduling of our permissioning processes, in particular to ensure that any options it put forward for consideration would be feasible from a regulatory perspective.

We consider the examination of programme options to be good practice. Given the lengthy development period of a GDF, we made the general points that it would be particularly important for RWM to:

- keep its options open, even if some are not currently favoured or might be implemented only under special circumstances, to maintain programme flexibility for the future
- keep good records of all options identified, including the factors that influence its option selection, the factors on which the option depends and the factors that depend on it

We also noted that care is needed in applying the term 'optimisation', to avoid confusion with radiological optimisation (which is a legal requirement).

3. Disposal system specification and design

RWM will need to demonstrate to us that its geological disposal system provides the necessary protection for people and the environment. As part of this we expect RWM to show how, at the

[iv] Available at: http://energy.gov/em/downloads/radiological-release-accident-investigation-report-phase-ii-report

early design stage, it is taking into account our requirements. This includes how the facility, and its structures, systems, and components, are identified and selected to achieve an optimised design.

3.1. Upstream optioneering

Since 2010 RWM has undertaken an upstream optioneering project on behalf of NDA. It undertakes this work in conjunction with waste producers with the aim of identifying and implementing opportunities to improve the management of HAW in the UK.

Our particular areas of interest in engaging with RWM on its upstream optioneering programme are; lifecycle optimisation of High Level radioactive Waste (HLW), optimisation of decommissioning waste management, and the benefits of decreasing time for Intermediate Level radioactive Waste (ILW) emplacement at a GDF. We noted that RWM can sometimes be perceived by industry as a blocker to decommissioning and clean-up. RWM explained that it intends to address this perception by focussing on becoming a service provider to industry, offering more pro-active early engagement and practical advice on waste packaging options. We support this from a nuclear safety and environmental protection viewpoint in order to facilitate decommissioning and clean-up and to encourage quicker and more cost effective hazard reduction and reduce environmental and safety impacts. However, we will still expect duty holders to meet our standards and requirements.

We discussed, with RWM, opportunities that could be taken through to delivery, and we recommended that early availability of the standard waste package transport container (SWTC) could facilitate wastes that are already in storage being moved, in order to optimise Site Licence Company (SLCs') waste management plans. The SWTC[v] does not yet have approval; it has gone through a review process with ONR, and it could be approved for use within a few years. Other improvements RWM is progressing include:

- a review of its packaging advice and safety cases to establish whether there are any unnecessary conservatisms that can be removed
- a new searchable waste package database is now available to help waste producers trace previous packaging advice for similar wastestreams
- in response to our concerns over a lack of transparency in how new package systems are evaluated before becoming "standard", RWM has developed, and continues to improve, its internal procedures for dealing with innovative packaging proposals [21]

We previously asked RWM and NDA to establish their position on disposal of graphite, and to address the confusion around the stated volume of reactor core graphite for disposal. RWM has clarified that while graphite accounts for around 30% of raw or packaged waste volume, this translates into only around 2% of the GDF footprint. Consequently RWM considers that further research and development on alternative management options for graphite to reduce footprint is not urgent.

We advised RWM and NDA that waste package records are important to demonstrate that waste packages are disposable and meet future waste acceptance criteria for a GDF. RWM must work with waste producers to ensure appropriate records are made and managed for the long term, and has initiated a project on waste package records.

3.2. Optimisation

RWM will need to demonstrate that a GDF is optimised for radiological protection. Previously, we have noted potential misunderstanding of aspects of this requirement. We recognise that RWM has to consider optimisation across a range of disciplines, including radiological protection and

[v] Applies to SWTC-285. Other SWTCs (70 and 150) are less advanced in terms of design, and have not been reviewed by ONR

conventional health and safety. We advised RWM that optimising for radiological protection has a specific meaning and care should be taken in using the terminology more generally [9].

We have been formally tracking our ongoing dialogue with RWM to achieve a common position and understanding [22, 23]. We have agreed with RWM the meaning and appropriate use of optimisation with respect to radiological protection.

3.3. GDF design

3.3.1. Design manual and design authority implementation plan

We informed RWM that its design manual needs significant reworking [24, 25], in particular to address the lack of information on post-closure environmental safety. In particular we asked RWM to:

- ensure post-closure environmental safety is addressed (particularly in the design process and design principles)
- clarify what constitutes the Design Authority and its role
- ensure that the design process continuously adapts, during GDF implementation, to any changes in requirements or in the information available (such as new information on the geology of a site)
- update the document to reflect the 2014 white paper [1]

As a result of our advice RWM significantly changed the manual [26]. We are content with the revised document provided that, in any future revision, RWM makes it clear that when referring to 'safety' it relates to environmental, transport, or operational safety, or some or all of these [27].

RWM intends to have in place a complete suite of safety manuals (design manual, transport safety case manual, nuclear operations safety manual, and environmental safety manual) to be used to control the assessments and safety case production, for the 2016 gDSSC. We are expecting to see these during 2015 to 2016, and will provide any regulatory advice as appropriate, through our ongoing scrutiny work.

3.3.2. Operational safety design features

We continued dialogue with RWM to enable it to progress recommendations from our review of its 2010 gDSSC [9]. We provided our views on operational design features of a GDF such as fire suppression systems, ventilation systems, heat removal, and impact testing. We also discussed RWM's plans for operating a GDF, its response to our recommendations on the generic operational safety case and design, and the development of its operational safety strategy.

3.3.3. Requirements Management and Disposal System Specification.

We provided regulatory advice on RWM's developing approach to requirements management, and its hierarchical Disposal System Specification (DSS) as follows:

- RWM will need to reflect the uncertainty associated with the environmental safety case in the Requirements Management System (RMS). We want RWM to provide assurance that the unique nature of geological disposal can be adequately captured in the RMS.
- We support RWM's proposal to separate out the requirements, assumptions, and links to the illustrative designs, when it updates the generic DSS (gDSS). RWM considers it is important to outline where the requirements come from and why it is making particular assumptions in the

gDSS. This approach will help to identify the decisions that need to be made and when they need to be made.

- With respect to RWM's business model, which depicts safety cases as an output of the assessments, we advised that safety cases need to be considered as part of the iterative process. RWM agrees that safety assessments and safety cases are part of the iterative business model.

We will continue dialogue with RWM on its RMS, in particular; to learn how requirements management is being used overseas, to understand how the RMS works, its role in terms of developing site specific safety cases, and how the regulators' requirements are translated into the RMS.

3.4. Change control

RWM continued to progress our recommendations on developing a change control process [9, 28, 29, 30] which state, for example, "RWMD should clarify how it will apply change control to the suite of documents and the statements it contains" and "Ensure that RWMD's 'management of change process' is progressively adapted to be fit for purpose for future stages of the programme so that all the different components of RWMD's work progress in parallel". We are content that RWM's proposed approach is appropriate, but consider that RWM should:

- Provide greater clarity by defining what constitutes a change to a disposal system concept, which is largely illustrative and loosely defined, or otherwise describe why defining 'change' is not practicable. RWM will clarify what constitutes a disposal system change in the next version of the procedure.
- Consider developing procedural guidance to include a list of concept-defining assumptions, or design basis parameters (whether expressed in discrete values or bounding ranges) such that those involved in evaluating the change can see immediately whether the proposed change could affect one or more of these key concept-defining parameters. This may help RWM decide the significance of changes. RWM considers it has partly addressed this recommendation by its guidance on rigour and transparency and will be fully addressed by its update of the Disposal System Specification for the 2016 gDSSC.
- Reconsider the inclusion of changes to the knowledge base (status reports) in the procedure and clarify the role of its document production procedure [31]. RWM believes that it is important to continue to include the knowledge base (status reports) within the scope of the disposal system change control process. We agree that change management is applicable for changes to RWM's knowledge base (including status reports, where knowledge underpins the concept) but we do not think it is applicable to all RWM's research publications.
- Clarify, in the document, its approach to informing regulators of changes. We are notified about change control status via RWM's change control summary spreadsheet which is produced for its Change Control Working Group and sent to regulators quarterly. We advised RWM that this is adequate at this stage in implementing geological disposal, but may need to revisit this once licensing and permitting processes are in operation. Regulators will advise RWM of any specific areas of interest, on an ongoing basis, and will include any necessary dialogue or engagement in the programme.

RWM intends to update the procedure to address regulatory advice and adapt to lessons learnt from its own internal review, to reflect good practice for quality management, and to improve its clarity. RWM has engaged with LLWR and other UK site licence companies as part of developing its disposal system change process. We suggested RWM might also consider engaging with international waste organisations at a similar stage of implementing geological disposal, with respect to disposal system change management.

Change control is of continuing interest to us, we will continue to engage with RWM on this matter. At this stage we are broadly content with RWM's progress on this. We will review RWM's revised procedure and implementation of it, in due course.

3.5. RWM's management of issues and its issues register

We recommended that RWM seeks views from all stakeholders and records and tracks any matters that might affect geological disposal. We consider that the publication of RWM's issues register is a good start towards transparent and supportable decision-making, which should improve stakeholder confidence.

We asked RWM [32] to clarify the scope of its issues register, and in particular whether and how regulatory issues would be included (noting the regulators maintain their own register of regulatory issues). We also recommended that RWM should:

- indicate the relative significance of an issue
- provide enough information to support the statements it makes
- give the individual or organisation raising the issue confidence in understanding how and when the issue will be addressed
- account for the possibility that 'issues' closed in the current context may re-emerge later in a site or concept specific context
- distinguish between general issues, which can be progressed at any time, and issues where resolution is dependent on reaching a particular stage of GDF development, for example, when a site is identified

RWM's June 2014 version took on board most of our regulatory advice [33, 34, 35]. RWM last updated its issues register in November 2014, to update the topic responses and include links to RWM's Science and Technology Plan [36] and Technical Programme [37]. RWM indicates that it intends to include specific task identification numbers in a future update, to allow stakeholders to correlate their issues to relevant research areas.

Only our formally tracked technical regulatory issues are included on RWM's issues register. The (larger proportion of) regulatory recommendations and advice that we address in our day to day work are summarised in our annual report. To improve the tracking of RWM's responses to lower tier recommendations and advice that we make during our scrutiny work, we asked RWM to maintain a list of our recommendations and its response. To start this process, we provided RWM with a list of recommendations that have arisen from our scrutiny work since the early 2000s [35]. RWM informed us that it has found this a useful tool and will maintain it as part of its arrangements for actively managing and demonstrating progress towards addressing our recommendations [38].

3.6. Inventory

In our review of RWM's 2010 gDSSC [9] we said that RWM should include a wider exploration of waste inventory uncertainty in future revisions of the gDSSC, and that it should take into account the most up to date inventory considerations in the future development of the gDSSC (recommendations 5 & 17 of [9]). We also noted that clarity of presentation is an important area for RWM to address, in particular, to help dialogue about the inventory with potential host communities.

Both DECC and NDA have recognised that there are multiple reports on the inventory, and the 2013 United Kingdom Radioactive Waste Inventory (UKRWI) scope included a redesign of the inventory website. RWM is also considering whether to incorporate information on the derived inventory and variant scenarios on its web site, so that there is a single location for inventory information.

RWM recognises one of the constraints against publishing both sets of inventory reports (the UKRWI and the UK derived inventory) is the time it takes to publish the UKRWI from a freeze date (necessary for stock take purposes) and subsequently analysing and enhancing the UKRWI data

for use in RWM's disposal system design and safety assessments. RWM and NDA are seeking to resolve this issue.

We provided regulatory advice to RWM on its plans for updating the derived inventory, as follows:

- RWM should explore a modular approach to packaging assumptions and consider key wastestreams that have a large impact on the disposal system designs (the degree to which waste packages and concepts can be changed because the waste has not been packaged yet).
- RWM should indicate (in the disposal inventory report) the likelihood that the assumptions made, will, in practice, be realised.
- One of the main changes to the content of the inventory is the increase in heat generating wastes, and this will have a large impact on potential GDF designs. RWM should clarify how the uncertainty and variability in volume and activity arises; what can be done about it; and which uncertainties and variabilities are important for a GDF. RWM has looked at which uncertainties and variabilities are important to a GDF and which radionuclides have the biggest impact. RWM has also identified the possible ways of decreasing the main uncertainties and is working with waste producers to try and reduce the uncertainty in the inventory.
- RWM should say more about the nature of the uncertainty and variability (if that is available), and highlight wastestreams that have a large impact on uncertainty and variability.
- RWM needs to improve the reporting of chemotoxic and hazardous components of the disposal inventory.

RWM confirmed that it has addressed earlier comments from regulators [39] with respect to improving the documentation, to better explain how data are enhanced for the derived inventory.

3.7. GDF site security

At a meeting with RWM, in January 2014, we discussed RWM's conceptual security arrangements for a GDF. RWM advised that its proposed security arrangements are high level and based on the National Objectives, Requirements and Model Standards (NORMS) document for the protection of material from theft. We advised RWM to also consider the threat from sabotage or malicious activity when developing security arrangements, and to look at the process used to develop the conceptual security arrangements document for the nuclear new build programme [40]. We also informed RWM of other good reference material available (for example [41] and from the International Atomic Energy Agency (IAEA) website).

4. Safety case development

Development of a safety case for a GDF is complex and it is recognised internationally that continual dialogue between the regulators and the developer, from the very early design stage, is essential.

4.1. RWM's generic disposal system safety case

We consider RWM's project initiation document [42], that sets out the scope and approach for the 2016 update of the gDSSC, is a reasonable document. We continued to discuss with RWM its plans and programme for updating the gDSSC. RWM informed us that actions to address the majority of our previous recommendations are completed or on target for completion for the 2016 gDSSC. We are satisfied with RWM's progress [43] to address recommendations related to safety case development in our review of the 2010 gDSSC [9, 44]. We noted that we would not

necessarily expect all recommendations to be fully completed (at least for a gDSSC). RWM will maintain an audit trail as to where progress has been made and what remains for future revisions.

We reminded RWM that a generic DSSC is not a regulatory requirement and we asked it to clearly state what the 2016 gDSSC is for and to say what it will not (or cannot) do. We advised RWM to present the relationship between the gDSSC and a future site-specific DSSC clearly, particularly for the benefit of a wider audience. An important aspect of the relationship is that a generic safety case develops understanding, tools and techniques, which can later be deployed on a site-specific basis as appropriate.

We expect the 2016 gDSSC update to be more balanced in its coverage of different geological environments and concepts, noting that high level safety functions may be fulfilled in different ways in different contexts. RWM informed us that this will be achieved in the updated Environmental Safety Case (ESC), by presenting the environmental safety arguments separately for different geological settings.

We have asked RWM to consider the design constraints that will be set by wastes that are already packaged and to consider lessons learnt from production of the 2010 gDSSC, in particular with respect to its assurance, quality checking, and peer review procedures.

RWM intends to have its updated gDSSC available for publication in November 2016. Our ongoing dialogue with RWM, and review of relevant documents through 2014 to 2016, should ensure that the 2016 gDSSC is fit for purpose. RWM has agreed to flag any new or potentially contentious issues early, for engagement with us.

RWM's developing 'technical safety narrative' [45] presents a qualitative explanation of the features and functions of the components of a GDF system that provide safety. It will form part of the 2016 update of the generic ESC. In the ESC, the narrative will be extended to describe how specific concept designs for generic illustrative environments provide safety, linking into design safety requirements. RWM will also use it to underpin any public facing safety-related materials needed to support the site selection process set out in the White Paper [1].

The 'technical safety narrative' is a reasonable document [46]. We consider the "top down" approach is an indispensable complement to the "bottom up" approach (based on features, events and processes (FEPs)), to produce a stronger ESC overall. We are in favour of RWM developing this approach, both technically and to help communicate environmental safety aspects of a GDF to a non-technical audience. We support RWM's approach of linking safety functions and FEPs. We asked RWM to clarify, in the document, its intention to extend the approach to include operational and transport safety functions, and to ensure that, as this approach is developed, it remains consistent with the identification of disposal system requirements. RWM also intends to develop the approach for use in evaluating packaging proposals on post-closure safety grounds, by considering which FEPs are present or absent in the proposal. We advised RWM that we wish to be kept informed of progress with this aspect.

4.2. Environmental safety case strategy report

We are satisfied that RWM took account of our earlier comments [47, 48, 49] for its published environmental safety case strategy (ESS) [50]. Since this is a live document which will be subject to revision, we advised RWM to ensure that use of parallel lines of reasoning is not lost. We noted, for example, that natural analogues may have particular value in the very long term, when rising uncertainties from numerical assessment models tend to lose the ability to provide confidence. We also advised RWM that there may be presentational problems associated with the use of the term 'safety narrative' (or 'safety story'), which RWM indicated will form part of the front end of its ESC. RWM clarified that the material from the 'safety narrative' will be presented in the updated ESC in a chapter titled 'Demonstrating post-closure safety'.

We challenged RWM's claim that the 2010 gDSSC risks are not normalised around the GRA risk guidance levels (given that text at p.55 of its generic post-closure safety assessment (PCSA) [51] states "The parameter values for the reference case have been chosen such that the total peak risk is likely to be close to the risk guidance level"). In response RWM stated that the risk calculations in the generic PCSA are only meaningful in determining whether changes (to inventory or other data) increase or decrease the calculated risk.

We reminded RWM that it needs to consider some important topic areas associated with groundwater protection and non-radiological hazards (see section 2.2.1). RWM intends to revise its disposal system specification to take better account of substances with non-radiological hazardous properties, and to make progress towards collecting better data on these aspects of the waste.

4.3. Operational safety strategy

From our review [52] of RWM's draft operational safety strategy (OSS) [53] we concluded that the OSS provides a sound basis for further development of the OSS, the associated environmental safety case strategy (ESS), and the transport safety strategy (TSS). The complexities arising from the current uncertainties (in particular, the use of generic designs) are identified, and the processes proposed appear to be well developed. We welcomed RWM's commitment to cover all aspects of safety in the Operational Safety Case (OSC), as this integration makes interactions between nuclear and conventional safety more readily identifiable and efforts to balance them more transparent.

We expect, as the OSS indicates, RWM to examine rigorously the relationships and interactions between operational parts of the GDF and areas under construction. While recognising that RWM's intent to segregate construction and operations will facilitate better control of safety for each area, we suggested that RWM will need to consider carefully the transition from construction to operations.

RWM's current exclusion of retrievability from the scope of the OSS is appropriate and consistent with Government policy, but we reminded RWM that it may need to incorporate retrievability at some point in the future. We expect RWM to clarify in the OSS the extent to which retrievability is addressed.

When it updates the OSS (and the ESS) we advised RWM [52] to:

- Consider undertaking more frequent updates of its preliminary safety report[vi], particularly in the early stages, because of the complexities associated with simultaneous construction, commissioning and operation of a GDF, and the phased nature of the emplacement of different waste forms.
- Consider developing an environmental safety manual (equivalent to the nuclear operational safety manual described in the OSS).
- Include certain sections in the OSS report that are relevant also to the ESS, either verbatim or suitably adapted, in a future update of the ESS. We provided examples in our letter [52].
- Take into account any post-closure consequences relating to foreseeable operational incidents and accidents.
- Take and present a more integrated approach to operational safety than currently presented. However, we are aware that, unlike, for example, a nuclear power station, there is no single concentrated operational hazard in a GDF, and that the hazards are various and need to be considered one by one, which may lead to an apparently fragmented approach.
- Account (in the inventory) for any material introduced to facilitate operations, such as crane rails and backfilling pipe work, that cannot be removed from a vault prior to closure, and

[vi] 'at least every ten years'

evaluate their potential effects on the long term safety of the GDF. RWM intends to do this once it has developed more detailed designs.

We advised RWM of our requirements for monitoring during the operational phase of a GDF, because of the potential effects on post closure safety and the need to establish the initial state for the post-closure safety case. RWM is developing its requirements management system to ensure that safety functions, claimed in the post-closure safety case, are delivered and hence that the required initial state for post-closure is achieved.

RWM has now published its OSS [54] which takes into account our advice.

4.4. Transport safety strategy

RWM produced a draft TSS in January 2013 for regulatory review [55]. However, due to other operational priorities of ONR transport specialists, further regulatory advice was not provided to RWM during the reporting period. RWM's published Transport Safety Strategy [56] takes into account relevant regulatory advice from our reviews of the ESS and OSS documents.

4.5. Safety Manuals - Nuclear Operations, Environmental and Transport Safety.

RWM plans to develop a suite of safety case manuals which will set out the procedures and methodologies it will apply to the production of operational, environmental, and transport safety assessments and safety cases. We advised RWM [57] with respect to development of the safety manuals [58] from the point of view of environmental safety aspects. The framework described for the safety case manuals should, if suitably implemented, help to ensure consistency both within a given safety area and between the different safety areas (operation, transport, environment). Hence, it should help to achieve and demonstrate a GDF design that is integrated in safety terms. Our guidance [59] does not specifically identify any requirement for an ESC manual. However, we consider that providing and using such a manual may help to achieve a suitable standard of quality management for the ESC, in accordance with Requirement R4 of our guidance [59], as long as RWM has formulated the manual appropriately. From the information provided [58], we cannot judge whether the structure, scope and purpose demonstrate a sufficient understanding of the requirements to be fulfilled by a manual supporting ESC production. We expect RWM [57] to:

- Ensure it fully understands any differences in approach that might be needed between post-closure and operational safety before implementing the framework for the ESC manual. We expect the ESC manual to be consistent with a post-closure environmental safety assessment approach based on FEPs and safety functions.
- Include a mechanism for dealing with interactions between the different safety areas, for example between post-closure safety and operational safety.
- Include a mechanism for making use of feedback from experience.

4.6. Transport criticality

4.6.1. Criticality safety assessment approach for the 500l drum in a standard waste transport container

We have discussed with RWM its ongoing work to determine fissile material limits for the standard waste transport container (SWTC), which is proposed to transport a range of fissile nuclide-bearing radioactive waste to a GDF. RWM explained that its approach is to develop generic compliance

rules for the waste on a graded basis: Low fissile limits with minimum Quality Assurance (QA) requirements (for example; on geometry, and presence of moderators), and more generous fissile limits with greater QA requirements.

RWM's limits have historically been based on worst case geometry (reflected and moderated spheres), which it considered were adequate since, at that time, post-closure criticality safety was considered to place the greatest constraint on waste package fissile content. Understanding of post-closure criticality has now reached a stage where it (post-closure) will not be the limiting factor for most waste streams. RWM's focus will, in future, shift towards transport limits being the most limiting factor for package contents. For further discussion of this see section 6.2.1.

4.6.2. Criticality solution of multiple water barriers for spent fuel disposal packages

We discussed with RWM its work on designing a disposal transport container for spent fuel. RWM informed us that its initial studies indicated the need for special design features to prevent criticality. RWM selected a preferred option of multiple water barriers, which was shown to be safely subcritical in routine, normal, and accident conditions of transport for legacy spent fuel. RWM has subsequently developed a design incorporating multiple water barrier features:

- The outer water barrier is the transport flask (the barrier being the steel flask body, steel bolted lid and polymer lid seal). A pre-dispatch test is required to demonstrate that a barrier is "watertight" and RWM proposes a pass criterion for gaseous leakage that is equivalent to "watertight".
- The inner water barrier is the disposal canister itself. A pre-dispatch test is required to demonstrate that the barrier is "watertight". RWM proposes that this requirement is fulfilled by rigorous NDT testing of the disposal canister body, lid and weld.

RWM considers this scheme design is optimal as it provides a high degree of independency between the manufacturing techniques, testing techniques and failure modes of the two water barriers.

4.6.3. Application for multilateral fissile exception (under the 2012 IAEA Transport Regulations)

The provision in the 2012 edition of the IAEA Transport Regulations [60] allows material to be excepted from the requirements for the transport of fissile material, notably controls on the design and approval of transport packaging for criticality safety, package accumulation control, and, implicitly, the need for additional criticality safety assessment.

Fissile exception approval requires an applicant to demonstrate that the material is safely subcritical without accumulation control in routine, normal and accident conditions of transport. Many fissile nuclide-bearing low heat generating waste materials could be potential candidates for fissile excepted approval.

RWM has completed a disposal system change proposal to update its disposal system and the packaging advice it provides to take account of the 2012 IAEA transport regulations. RWM has subsequently made an application for multilateral fissile exception, under the 2012 IAEA transport regulations.

We discussed with RWM its draft application for approval of a design of material as fissile excepted, prior to formal submission [61]. We advised RWM that:

- A generic application would fail if required to be fully deterministic (RWM informed us that some of the safety arguments are probabilistic, that is, based upon worst-credible rather than worst-conceivable situations).

- The criteria required under the terms of the specification (a concentration limit of 1g in 2000g for U-235 or 1g in 2500g for other fissile nuclides, and a maximum localised concentration of fissile nuclides of 140g of U-235 or 112g for other fissile nuclides) appear to be a coarse measure.
- The deliberate use of engineered baskets to space out fissile lumps would not be acceptable, under a Fissile Exceptions authorisation. However this would not preclude waste in drums (that may also be compacted) from consideration.
- Our initial view of RWM's non-uniformity argument[vii] is favourable.
- We support RWM's intent to apply the application, prior to its formal approval, in a risk based manner to inform its disposability advice. In this manner, wastes that do not approach the limits of the specification (i.e. that are well within the concentration and non-uniformity limits) could be considered to be demonstrated as being transportable without further evidence, whilst wastes that approach the limits of the specification would require greater scrutiny and a greater burden of evidence (judged on a case by case basis). Thereby, if RWM's application is unacceptable, waste packages would be expected to still meet the requirement to be approved as fissile exception design, albeit in a separate application specific to the waste.

5. Sustainability and environmental assessment

The Environment Agency is a statutory consultee for strategic environmental assessment (SEA) and environmental impact assessment (EIA). Through this role we will ensure that RWM's assessments adequately consider all potentially significant environmental effects.

We have previously provided regulatory advice to RWM by our active involvement in its Sustainability Advisory Group (SAG). RWM proposes to implement an expert advice or peer review group (which will not involve the regulators), and to have early engagement with statutory consultees at some point in the future, as the siting process progresses.

Article 2(2) of the Infrastructure Planning (Radioactive Waste Geological Disposal Facilities) Order 2015 (SI 2015 No. 949) amends section 14(1) of the 2008 Planning Act to extend the categories of infrastructure project which are nationally significant for the purposes of the 2008 Act [viii] by adding to them a new type of project, being development relating to radioactive waste geological disposal facilities [1]1. A national policy statement (NPS) will be produced to support the launch of the GDF siting process. We will be involved (as Statutory Consultees) when DECC consults on the draft NPS[ix] and associated appraisal of sustainability (AoS).

RWM is currently developing generic assessments: generic socio-economic assessment; generic health impact assessment; generic transport assessment; and updating the generic environmental and sustainability report. RWM is using these assessments to inform the development of generic design concepts for the disposal system, and to support stakeholder engagement and the early stages of the siting process. RWM has informed us that it will be preparing EIAs for intrusive surface-based investigations and ultimately for a GDF, but timing depends on progress with the siting process.

We have continued to engage with RWM to discuss its planned programme of work on these assessments.

[vii] limits on the material require it to be solid and combustible and leachable material must be excluded from determination of the non-fissile material mass, therefore there is no mechanism for preferential separation of the non-fissile mass or fissile material, and consequently RWM argues that it is not credible that an unsafe localised accumulation could occur.

[viii] Nationally Significant Infrastructure Projects (NSIP)

[ix] See The Infrastructure Planning (National Policy Statement Consultation) Regulations 2009 (SI 2009/1302)

5.1. Approach to climate change in design and assessment

RWM is currently developing an approach to address the potential consequences of climate change in its design and assessment work for a GDF [62]. We have previously provided regulatory advice to RWM on how it might deal with uncertainty in forecasting climate change and the range of possible outcomes it should be considering. We advised RWM to focus on the worst case emissions scenario considered by UK climate projections [63], even though this only goes up to 2100.

We discussed with RWM our latest perspective on this issue and provided regulatory advice on the types of climate change scenario it should be considering and planning for. We explained our approach to climate change for the design and assessment of large infrastructure projects and gave presentations on long term climate change scenarios and sea level rise. In particular we:

- made RWM aware of the climate ready support service managed by the Environment Agency, which aims to help organisations adapt to the effects of climate change
- explained the challenges and scenarios for long term climate change, for example, uncertainty in the projections, as these depend on emissions and climate sensitivity, and we advised RWM to consider the most likely and worst case scenarios
- explained the development of adaptive pathways (or route maps), using the Environment Agency Thames Estuary 2100 project as an example and other examples from the Rhine
- posed questions for consideration by RWM, such as 'How can uncertain change be planned for?' and 'How can the concept of adaptive pathways and route maps be used to help?'

RWM's report [62] is a high level summary of its approach to the assessment of climate change, and the impacts of climate change on a GDF in the short and longer term. It refers to work already carried out (mainly relating to the 2010 gDSSC) and discusses in general terms what RWM intends to do. From a very high level review we note and welcome RWM's commitment to limit the effect a future GDF will have on climate change, and recognition that climate change mitigation and adaptation are important considerations in the development of a GDF. We also welcome RWM's commitment to continue to keep up to date with short-term climate change via the UK Climate Impacts Programme and to carry out research in relation to longer-term climate change and the implications on geological disposal. We will further consider how RWM has addressed climate change in the 2016 gDSSC.

6. Research and development

We expect the best scientific knowledge and engineering practice to underpin any future GDF. We expect RWM to undertake a comprehensive R&D programme, informed by wider national and international research or implementation programmes. RWM should address, in a timely manner, the issues that require R&D to meet our requirements. This will help RWM to avoid unnecessary delays when requesting regulatory approval for the various stages of geological disposal.

6.1. RWM's technical programme

We have previously commented [64] on RWM's R&D programme [65]. Subsequently, we have engaged with RWM on matters such as: prioritising R&D, RWM's 'solutions focused approach', and 'benefits realisation' [9], and on its updated R&D programme overview [66] and technical programme documents [37].We advised RWM [67] that our previous observations essentially remain valid [64], as follows:

- RWM's R&D Programme Overview is commendable as an open and wide ranging summary. The scope of the R&D described in the overview is very wide, which is appropriate at this stage of implementing geological disposal.
- We are confident that RWM is progressing R&D (or has work planned) in areas it identifies as high priority.
- RWM's approach of developing its R&D programme within the framework of a range of well chosen drivers enables a systematic approach, and prioritising R&D against a range of criteria is a useful process.
- RWM's broad specification of research areas and the prioritisation process do not easily lead to identification and ranking of specific issues that are important to the programme.
- RWM needs to differentiate clearly between R&D that "must be done" from that which "would be nice to do".

Through our ongoing discussions with RWM on its developing science and technology plan (S&T plan), we advised RWM that it's planned approach for the S&T plan, and the use of 'scientific readiness levels', are likely to address some of our previous concerns (last bullet point above), and will help RWM engage with stakeholders. We advised RWM that there may be scope for work on links between non-radiological work areas and other programmes. In particular, RWM needs to understand whether there will be impact on the biosphere from the non-radionuclide component, and we recommended there is scope for R&D in this area[x]. We also advised RWM to clarify the links between biosphere work and the groundwater daughter directive.

The S&T plan [36] provides a good overview of the R&D work that RWM plans to undertake over the next decade, as part of its generic work programme. It provides RWM with a good tool to use as a basis for engaging with others, to explain the R&D it plans to undertake, and the further R&D that may be required to implement geological disposal. The document should also help RWM develop a more focussed R&D programme during the generic phase, which will be useful once a site (or sites) is identified. The document provides a good explanation of how RWM plans to use scientific readiness levels to demonstrate how it is addressing its knowledge gaps, and a good summary of the drivers that RWM has used to establish a focussed R&D programme. We commend RWM on its national and international collaboration on R&D relevant to implementing geological disposal. Our review of the S&T plan focussed on the processes within it, and we looked particularly at how the S&T plan currently links with RWM's Technical Programme document [37]. We did not consider fully the specific research tasks, other than to comment on some selected topic areas with respect to the quality of the information in the task sheets and to assess the linkage between the task sheets and the wiring diagrams. When developing its S&T plan further, we expect RWM [68] to:

- Consider including a pictorial representation of the document hierarchy, covering all R&D across the organisation; ensure that the S&T plan clarifies the wider R&D that is ongoing within the organisation and the programmes under which these sit; and improve the linkage between the S&T plan and other R&D programmes currently ongoing within RWM.
- Clarify how often it intends to review the S&T plan and its plans for reviewing all hierarchal R&D documentation.
- Include information on the options that were available to, and assessed by, RWM (in addition to the Scientific Readiness Level (SRL) and Technical Readiness Level (TRL) approaches) to help it identify and address knowledge gaps and demonstrate progress.
- Provide, in the S&T plan, further information on the SRL approach, such as: who is responsible for assessing and assigning SRLs; who is the owner of each task; and how it will assess whether the target SRL level has been reached when the R&D task is completed.
- Consider periodic independent review of how RWM is implementing the SRL process across the topic areas. Maintain an awareness of developments in the SRL approach and newly

[x] The published version of the S&T Plan has taken account of our comment that we thought the R&D programme was biased towards radioactive contamination and somewhat lacking in its coverage of the effects of non-radioactive species.

emerging alternative approaches within the nuclear industry internationally and the wider industrial community.

- Clarify the linkage between changes in SRL and the knowledge gap highlighted, for each area within the technical programme.
- Acknowledge, in the S&T plan, that RWM has a Technical Baseline and Underpinning Research and Development Requirements document (TBuRD), and explain why R&D undertaken as part of the TBuRD is not part of the S&T plan.
- Continue to consider the need for prioritising the R&D programme.
- Improve the consistency in structure between the S&T plan and Part C of the Technical Programme, to clarify the links between R&D tasks and the technical programme.
- Present consistent levels of detail in task sheets where the R&D will be commissioned at the same time, and provide the level of detail commensurate with the stage of implementing geological disposal.
- Demonstrate how each of the tasks will be managed and monitored, to ensure delivery of the scheduled plan, and how progress will be presented (externally), and keep us informed of such progress.
- Identify explicitly those tasks, in the S&T plan, which support the assessment of packaging solutions.

In addition to these recommendations, we identified a number of areas where we consider RWM could improve the documents, and a number of matters that we would like RWM to clarify for us.

Through our ongoing dialogue we will seek to ensure that RWM's R&D is addressing issues identified on its issues register and, to help this, we expect the links between RWM's issues register and the S&T plan to be readily apparent.

RWM considers that there are no generic issues that challenge the viability of geological disposal, within the underpinning science base, and hence no impediments to site-based work. Overall, we remain confident that RWM is progressing R&D in areas it identifies as high priority. However, we note that there may be concept-limiting issues, such as, in relation to construction, which may need to be explored once a site (or sites) is identified for further investigation.

6.2. Engagement with RWM on specific aspects of its R&D

6.2.1. Criticality

We understand that RWM's aim is to gather and present evidence to support its assertion that separate, deterministically derived post-closure fissile material limits (over and above those calculated for the operational and transport phases of a GDF) are not required in order demonstrate criticality safety (through the Letter of Compliance (LoC) process). RWM's work in this area has now reached a level of maturity such that it should provide a useful platform against which to underpin pragmatic waste packaging advice. We have asked RWM to progress this matter [69] and to engage with waste producers to help inform packaging plans. We have continued to engage with RWM to discuss progress on its work on criticality [70, 71].

RWM needs to establish fissile material limits for waste packages via an approach that takes into account the, sometimes conflicting, demands throughout the waste life cycle. The aim should be to achieve an overall 'balance of risk'. Safety and environmental performance, in all phases of waste management including disposal, should not be compromised.

We acknowledge RWM's demonstration that post-closure criticality carries very low risk. We accept that post-closure criticality in the gDSSC is a low likelihood, low consequence event [72]. Our view has been informed by the work of Nirex[xi] [73] and RWM [70, 72].

We agree with RWM that long-term, post-closure criticality risks are less significant than the risks associated with surface storage of unconditioned fissile wastes. Conditioning raw waste reduces risks of criticality by, for example, segregating waste and constraining geometry within packages. Criticality safety constraints during operations and transport will ensure a level of control on package fissile contents and provide a degree of assurance that criticality will not occur whilst packages remain intact. We do not want the conditioning of fissile waste to be delayed by undue emphasis on low risk, far future scenarios, as it could effectively extend the time at risk for the storage of unconditioned fissile waste and result in burdens and undue risks now.

Post-closure criticality safety should not be as significant a driver as it has been historically for setting fissile material package limits. We therefore asked RWM to reconsider the need for further constraints on waste package fissile loadings beyond those already deterministically calculated for the operational and transport phases of a GDF, particularly since very low fissile material limits could affect upstream waste management, for example by resulting in the need for more waste packages.

RWM's ongoing work on post closure criticality safety has concluded that only six (or so) low heat generating waste streams may require specific consideration (with respect to post closure fissile material limits). RWM intends to remove deterministically derived fissile material limits (based on pessimistic post closure GDF evolution scenarios) from the LoC process, for relevant wastes that instead can be shown to conform to a generic low likelihood package envelope. This package envelope contains a fissile material 'level' parameter, but as those 'levels' have been estimated based on a less pessimistic probabilistic modelling approach, the fissile material levels estimated are generally less restrictive than those calculated deterministically. RWM will still require fissile material limits for transport and operations and the intention is that the more restrictive of these two deterministically derived limits will define the overall package safe fissile material limit. RWM intends to invoke its change control procedures to integrate the revised approach into the LoC process. We advised RWM that we are satisfied with its proposed approach and we recommend RWM implements it as soon as possible.

6.2.2. Non-aqueous phase liquids

Non-aqueous phase liquids (NAPLs) were, at one point, thought to threaten the viability of geological disposal [74], therefore we have maintained an overview of RWM's work in this area. RWM informed us that recent work [75, 76] on NAPLs has concluded that it is unlikely that significant quantities of NAPLs would be able to escape from waste packages, and even less likely that NAPLs would be sufficiently persistent in the disposal environment that they could accumulate under buoyancy at the highest point of a vault and be transported into the geosphere. An output of work in this area will be for RWM to provide guidance to waste producers on the control of NAPLs and their pre-cursors during the packaging of ILW.

6.2.3. Carbon-14

We have previously noted that carbon-14 (C-14) is an important radionuclide in the post-closure gas source term. RWM has progressed experimental and modelling studies to scope the extent of any (potential) problem. This work has suggested that, while the largest inventory of C-14 is in graphite associated with reactor wastes, the C-14 associated with irradiated reactive metals provides the main challenge from C-14 to post-closure safety. Work has also provided evidence to support the assumption that methane is converted to carbon dioxide in soil and this understanding

[xi] RWM's predecessor organisation

has been combined with understanding of uptake through the root system and processes in the plant canopy to develop a revised biosphere model.

6.2.4. Uranium

Our work with waste producers has shown the problems associated with conditioning of legacy wastes packages containing uranium metal. RWM provided an update on the work of the uranium integrated project team (IPT) which aims to develop an integrated approach across waste producers and to identify optimised solutions for the long term management of uranium, which will include consideration of disposal as a viable endpoint. RWM observed that a radiological risk assessment approach for natural or depleted uranium may be of limited value. One possibility is to consider such materials as stable chemotoxics. RWM is developing a post-closure safety methodology and we will continue to engage with RWM on this.

6.2.5. Heat Generating Wastes

RWM gave us an update on the heat generating wastes IPT which is investigating issues in relation to temperature limits for disposal (with possible significant implications with respect to plans to store spent fuel). RWM has undertaken work to study use of a multi-purpose container (MPC) with an aspiration to explore the dimensional, thermal and mass constraints for geological disposal for HLW and sent fuel. The driver for this is the inability to transport certain existing cask and MPC designs. We noted that provision of comprehensive LoC advice for heat generating wastes may not be appropriate at this time, because site specific aspects (which cannot be defined in the current context) may dictate.

6.2.6. Superplasticisers

There appears to be a growing call for use of superplasticisers where practical, and where real benefits are possible. RWM's upstream optioneering programme appears to offer a real possibility of resolving the matters relating to their use in radioactive waste applications. We are supporting RWM and industry's efforts here and encouraging early progress on this topic to inform decisions on waste conditioning approaches.

Superplasticisers are used in concrete applications to ensure well-dispersed particle suspension and improve the flow characteristics. Their addition to concrete allows less water to be used (while not affecting the workability of the mixture), thus enabling the production of self-consolidating and high performance concrete.

RWM presented its work which is looking at the functional requirements of superplasticisers as an additive in cementitious mixtures for use in radioactive waste disposal (such as waste conditioning, container manufacture, and vault construction). Waste producers discussed numerous applications where using superplasticiser could be very beneficial, or essential, and hence demonstrated a need for a way forward on this matter.

An important restraint on using superplasticisers relates to consistency of supply and hence properties. RWM's proposed programme will help to address the issue of sourcing reliable batches of reagent and simple superplasticiser formulations.

A potential issue is that superplasticisers and related degradation products may complex radionuclides and increase mobility, for example by increasing solubility or reducing sorption, with a subsequent effect on post-closure safety. This is the subject of debate and clearly depends on several factors, such as, type or chemistry of superplasticiser; chemistry of the degradation products; mobility of the superplasticiser within cement systems; and hydrodynamics in the disposal environment. Experimental work, to date, may not have adequately reflected the likely

disposal environment, and resolving the issue of post-closure effects of superplasticisers is not straightforward (in terms of experimental design, the lead times for experimental work, and remaining uncertainties). Any decisions need to take into account all benefits and drawbacks throughout the waste management lifecycle.

7. Site evaluation and characterisation

We expect RWM to have appropriate plans and procedures in place to undertake the wide range of site evaluation and characterisation activities required to implement geological disposal, including development of any ISE, PESE, and generic and site-specific safety cases. In particular, we want to ensure that RWM's plans and actions for future investigations are consistent with the Environment Agency's permit requirements for intrusive site investigations.

We have no role in the decision-making process for selecting potential sites for a GDF. However, to inform the decision-making process, we will provide regulatory advice and comment on environmental, safety, security, and transport matters, within our regulatory remits, and we will aim to make this regulatory advice available to the public.

7.1. Plans for surface based investigations and characterisation

The Environment Agency is maintaining an overview of RWM's plans and work to support site characterisation. RWM's generic programme for surface-based investigations comprises approximately 30 high level activities (commencing with getting landowner permissions and including planning, drilling and monitoring activities), with around 900 more detailed activities underlying this.

We want to ensure that RWM's programme allows sufficient time for preparatory activities such as, borehole design, rig procurement, and appropriate regulatory scrutiny. RWM's current programme did not include such activities. While recognising that these activities are not initially on the critical path for the project, we are pleased that RWM recognises that substantial lead times are required and that they could be on the critical path if not addressed in a timely manner. RWM has since included these activities in its developing programme.

RWM will apply lessons learnt from the development of this generic programme to develop the site-specific site investigation programme. We are pleased that RWM recognises that any generic programme will require significant review and revision for a site-specific programme. RWM noted that its understanding of the scope of the front-end programme for site investigations might not move forward until communities become actively involved in the siting process.

We advised RWM that, in the event it seeks planning consent for multiple boreholes but only applied for an environmental permit for a sub-set of these, we would consider an application for a permit for the subset, and, if granted, RWM would then need to apply for a permit variation for further boreholes.

RWM has a two year programme to deliver a suite of documents on its preparations for site investigation. It intends to publish the documents at the same time as the 2016 gDSSC. The main information in these documents will be brought together in a single overview report aimed at a non-technical readership.

RWM has developed a staged programme for developing sub-surface understanding. This comprises the development of a national model (GB3D), regional models, and site-specific models.

RWM estimates that it would take between 6 and 9 months to prepare a detailed area model to support engagement with a potential volunteer community. We agree that such a model would be

useful to raise awareness and provide understanding, in particular during the learning phase prior to moving to site-specific assessment.

We also noted that none of the current geological models helps to present or visualise the inherent geological uncertainty in either data quality or interpolation. We recognise that addressing this issue will be difficult, and RWM needs to consider it. A qualitative discussion of uncertainty is included in the regional geological summaries published by the British Geological Survey[xii] in June 2014.

7.2. Data and information requirements, collection, processing & management

We engaged with RWM to understand the current position with respect to the Nirex data archive (of geological data). NDA owns the Nirex site investigation data archive, which includes data from Cumbria, Dounreay, Killingholme, Bradwell, Elstow and Fulbeck. These data were transferred to BGS in 2000. They were incomplete and passively managed, so RWM contracted BGS to actively manage the data. The project has been successful; 99% of data from floppy discs and 99% of geophysics data from tapes has been recovered, approximately 460 missing reports have been recovered, and 327 uncatalogued core characterisation reports found. A fully searchable master index (covering >26000 records) has been created for all Nirex' assets held at BGS. BGS will continue to manage the archive and transfer all digital data into a long-lasting format. All of the data is publicly available through the BGS National Geological Archive. We note that there will be important lessons from experience gained in bringing this data under management control, not least for ensuring appropriate management and quality assurance of data to be collected in RWM's ongoing site investigation programme, but also to feed into its wider work on information and records management more generally.

We provided regulatory advice on RWM's data and information requirements [77, 78] that we hope will encourage RWM to improve its system and data in support of assessments, and to meet statutory and government requirements for implementing geological disposal. Our main recommendations, for RWM to consider, are:

- RWM will need to manage updates to data and information and minimise the potential for future inconsistencies where there are overlaps between topic areas.
- RWM should establish the quality and quantity of data needed to support decisions by, for example, developing performance and acceptance criteria; identifying and defining the appropriate type of data; and specifying tolerable levels of potential decision errors.
- RWM should set out clearly its quality assurance processes for collecting, processing and managing data and information.
- RWM should explain how it intends to develop and use the spreadsheet [77] further, for example, to provide links to, or store, real site data, and as implementation progresses.
- RWM, and its contractors, should register for the Environment Agency's Datashare[xiii].

7.3. Borehole sealing

Proper sealing of site investigation boreholes is important to environmental safety because an unsealed or poorly sealed borehole can provide a preferential pathway for contaminant release from a GDF. Furthermore, exploratory boreholes at candidate sites, that are found to be unsuitable

[xii] http://www.bgs.ac.uk/research/ukgeology/regionalGeology/home.html

[xiii] Datashare is our data download portal that allows members of the public to access our data, such as, historic flood map, historic landfill and consented discharges to controlled waters.

for developing a GDF, will need to be properly sealed to protect aquifers. We expect the ISE to provide a clear description, supported by reference to R&D and technology demonstrations, of how boreholes might be sealed in the future.

Because of the importance of this issue, we have maintained an overview of RWM's work on borehole sealing [for example 79, 80, 81, 82, 83] and provided regulatory advice. Some important points from our dialogue with RWM on this, to date, are:

- RWM's proposals for borehole sealing techniques [79], based on the Swedish approach [84], will need to take into account the fact that the geology, borehole design, and seals, will be more complex in the UK.
- RWM's sealing objectives include the need for borehole seals to be fit for purpose ('post-closure seals' to prevent adverse impact on the long-term environmental safety case for the disposal facility, and 'water resource seals' to protect water resources in the area). Post-closure seals are the most challenging in terms of required performance; RWM will need to understand the potential range of seal permeabilities required for different geological environments and disposal concepts.
- RWM's borehole sealing objectives should include the need to provide a seal against gas migration.
- Research into the long-term stability of swelling clays [80] concluded that using the proposed sealing types in the UK should achieve the required longevity. However, significant uncertainties remain. We recommended RWM should consider kinetics in any future work of this nature.
- A key aspect of RWM's work is to develop a QA methodology to demonstrate the quality of the sealing system. We are pleased that RWM recognises the importance of QA in sealing operations, and that it will need to supervise sealing operations closely to ensure appropriate emplacement.
- We advised RWM to consider mitigation measures if monitoring were to indicate that seals were not working as intended.
- RWM will need to rely on expert support from the supply chain and maintain a close relationship with any contractor. We recommended RWM to engage with potential contractors as early as possible, such as during test drilling.

RWM is developing an implementation plan [85] to undertake additional work on borehole sealing. This may cover issues such as: the tension between requirements for borehole sealing and the borehole casing programme; the need for site-specific consideration of the thermodynamic phase-equilibrium of clay; the positioning of different seal types in relation to known geology; and the application of sealing techniques to deeper and wider boreholes. RWM is considering how its borehole sealing work could be enhanced through international collaborative work. While recognising the value of this, we advised RWM that it should develop its own thinking on the case that it needs to present for borehole sealing in an ISE submitted in support of a permit application under EPR10. We advised RWM that, as part of developing a case for borehole sealing, it will also be important for it to identify the work areas and activities it needs to complete and the associated timescales. Through phase 2 of its ongoing programme [83], RWM aims to reach a fairly robust generic position on borehole sealing by March 2017, with Phase 3 comprising site-specific R&D.

8. Waste packaging advice and assessment

RWM provides advice to waste producers on the packaging of their HAW. RWM has developed a process of disposability assessment to minimise the risk to waste producers that waste packaged now will be unsuitable for disposal in at GDF in the future. This packaging advice is used by waste producers to inform their integrated waste strategies and safety cases and is included as part of their radioactive waste management case for a particular wastestream.

The Office of Nuclear Regulation and the environment agencies have issued joint guidance on the management of higher activity radioactive waste on nuclear licensed sites [86]. Section 5 of the guidance covers waste conditioning and disposability and states "For wastes destined for deep geological disposal, the regulators expect that a LoC will be issued by RWM stating that the conditioned waste is likely to be acceptable for future disposal."

We expect RWM to assess packaging proposals for HAW against clear and consistent published specifications to assure us that HAW is packaged in a manner suitable for handling and disposal in a future GDF with no, or minimal, re-working. We also encourage RWM and waste packagers to share best practice in waste packaging to avoid duplication of effort.

8.1. Disposability assessment and the LoC process

We inspected RWM's disposability assessment process and provision of packaging advice in June 2013. Our aim was to find out how well RWM's arrangements for disposability assessment and its provision of advice are operating, in order to gain confidence that HAW currently stored on licensed sites will be suitable for safe handling, transport, storage and ultimate disposal. Ahead of our inspection, we attended one of RWM's Nuclear Safety and Environment Committee (NSEC) meetings, which helped us understand the role that NSEC plays in RWM's disposability assessment processes, and we provided feedback for RWM [87] to help RWM improve operation of the NSEC.

We held discussions with staff from across RWM and considered a sample of RWM's packaging assessments in detail (selected to represent a cross-section of the types of packaging advice provided by RWM).

Our findings [88] indicate RWM's disposability assessment process is generally robust and;

- provides confidence in the advice RWM gives to waste producers and reduces risks associated with packaging waste before a GDF is available
- is subject to continuous improvement
- supports progress in decommissioning and clean-up

We identified some specific areas of good practice, concerning the interactions among RWM staff and in their engagement with waste producers, as follows:

- there is good interaction between members of the packaging assessment team and other parts of RWM in relation to disposability assessment
- RWM has revised its packaging specifications using early engagement with waste producers
- there is good interaction between members of RWM and waste producers, at several levels, in relation to disposability assessment and packaging advice

We also identified some areas that could be improved, including, for example:

- internal assurance activities associated with RWM's provision of disposability assessments and waste packaging advice
- the scheduling and prioritisation of disposability assessments

- establishing periodic reviews on the same basis as disposability assessment, and resolving the uncertainty in the current status of fLoCs reviewed to date
- the assessment of innovative packaging proposals
- waste package records

We followed-up our inspection of RWM's provision of disposability assessment advice and its LoC process with a series of meetings at waste producer sites, to assess how well they are interacting with RWM and what value they place on the advice provided to them [89].This gave us confidence that RWM's disposability assessment process provides waste producers with the information and advice necessary to minimise the risks that HAW stored on licensed sites will not be suitable for safe handling, transport, storage and disposal. From these meetings we identified further points of good practice and suggestions for improvement.

Areas of good practice

- RWM's process of disposability assessment is flexible and so can be focussed on specific areas, such as the management of action points or generic issues.
- RWM provides its packaging advice in high quality technical assessment reports or to support waste producers during optioneering exercises; at internal project review milestones; and in engagement with regulators.

Areas for RWM to improve:

- Consider whether disposability assessment could be applied in a more proportionate manner on occasion, which more explicitly takes into account the hazard presented by the waste under consideration and the stage of the disposability assessment.
- Consider whether it could use project launch meetings or other holdpoints to check its understanding of key data and assumptions submitted by the waste producer, and also to provide justification of any changes to the waste producer.
- Consider whether it could amend its packaging specifications to make them more user-friendly and help waste producers improve their submissions.
- Gain a better understanding of the operational constraints and existing obligations on licensed and permitted organisations, to support its provision of disposability advice.
- Consider whether establishing itself as the design authority for those containers adopted into its disposal system specification, would be useful in providing a single and enduring point of contact for waste producers (who are likely to use them over long timescales).

We will encourage and support RWM in its efforts to improve the disposability assessment process and the associated assurance activities, to manage the risk that wastes packaged will be unsuitable for disposal. RWM is progressing work to improve its LoC and disposability assessment process, and has made significant progress since our inspections. We will continue to work with RWM to help it meet our regulatory expectations, through our ongoing scrutiny programme, applying the regulatory issue resolution process, where appropriate [90, 91].

8.2. Inspection of RWM's assurance of data and calculations associated with packaging advice and safety assessment

We carried out a joint regulatory inspection after RWM made us aware that some disposability assessments were affected by the use of an erroneous thermal modelling spreadsheet. The spreadsheet was used to estimate the cooling times required for high-heating generating wastes prior to geological disposal.

RWM re-issued some affected disposability assessments and feasibility studies, and informed us that for operational wastes from the Sellafield waste vitrification plant, for example, the maximum discrepancy, due to use of the erroneous thermal modelling spreadsheet, was less than three years and that it considers the impact of this discrepancy to be "trivial" in the light of wider uncertainty inherent in the modelling. RWM has advised its customers for the other assessments affected, and has engaged with them to explain the implications of the findings, and to consider any required follow-up studies in support of the customers' plans for long-term management of high-heat generating wastes.

Our inspection built on work already carried out [92, 93, 94, 95, 96], and covered: a sample of RWM's models (in order to gain an oversight of RWM's approach to the use, management and development of codes, modelling software and calculation tools); discussions with RWM staff; and audits of specific work areas.

We advised RWM of the findings from our inspection [97], as follows:

- At the time of the inspection no single board Director was responsible for quality; it was shared across all board members. We recommended RWM considers how the Board addresses important areas of risk/performance (such as, quality assurance) and the most appropriate means of improving governance. RWM has subsequently reviewed its corporate structure and brought together the health, safety, security and environment (HSSE) function and Quality function. This should help to ensure a sufficiently directed and integrated internal assurance function that is sufficiently resourced. The Board has also developed health, safety, security, safeguards, environment and quality, and audit and risk sub-committees.
- It was not clear to us how RWM determines whether changes (in outputs) from one model affect other models that depend on it. We recommended RWM considers how best it can develop and present a high level understanding of the interdependencies between the components of RWM's business model.
- We discussed with RWM its developing model register and we viewed a working draft of it. We advised RWM to include model version numbers on its model register to assist in version control. We recommended RWM ensures its model register is complete and maintained, and that it should have plans to mitigate risks associated with software obsolescence.
- From our inspections of the files and discussions with RWM staff, it was clear to us that RWM's proposal review meetings play a crucial role in disposability assessments. However, we consider that the conduct of such meetings is not transparent, but instead relies heavily on the experience of the staff present rather than on adherence to written procedures. We recommended RWM reviews its current arrangements for the assurance of calculations performed in support of disposability assessment (particularly those associated with Nature and Quantities assessments) to ensure they are compliant with RWM procedures.
- From discussions with RWM staff, for example relating to DIQuest[xiv], we identified some potential risks associated with 'singleton' working, both in-house and in its supply chain, for RWM to manage. We recommended RWM identifies and monitors risks associated with resource availability, both within its supply chain and in-house.
- We discussed with RWM its programme of audits (specifically those audits of the supply chain associated with models), and RWM gave us a list of those carried out recently. We learnt that a recent management review identified that insufficient resources are currently available for audits. We recommended RWM reviews whether its current programme of supply chain audits is consistent with the risk associated with RWM's stated role as a 'thin client'. RWM has subsequently reviewed its structure and provided additional audit resource.

[xiv] The Derived Inventory Query and Scenarios Toolkit (DIQuest) is a database querying tool that is used to ensure that inventory information can be produced quickly and accurately in a quality assured manner. Amongst its capabilities, DIQuest has the ability to decay a radionuclide inventory to a specified date, and to generate data, such as: activity, heat output, package dose rate, at that date.

We will monitor RWM's progress towards addressing these findings through our ongoing scrutiny programme, including oversight of RWM's Data & Models compliance project.

8.3. Treatment of gaseous pathway within disposability assessments

We queried [98] that some of RWM's disposability assessment reports state that 'regulators have recommended that detailed modelling of gas migration should be delayed until after a site has been selected'. RWM should not interpret our recommendations from our review in 2005 [99] in this way. We asked RWM [98] to review its position on the consideration of the assessment of gas generation and transport to ensure that it is suitably able to inform decisions on the endorsement of waste packaging proposals. RWM agreed that the statement is misleading and has removed it from its disposability assessment report template; RWM has also clarified how it considers gas generation as part of its disposability assessment process [100].

8.4. Waste product quality

RWM's waste product quality storyboard [101] represents work in the early stages of development by RWM, never-the-less we hope that our regulatory advice [102] will help RWM develop work in this area. In summary, we recommended RWM should:

- improve its existing guidance rather than publishing additional material, wherever possible
- assess any potential effects on existing LoC endorsements or the status of packaged wastes as part of the development of new or additional guidance and put in place mechanisms, and resources to support any management or mitigation activities required by waste packagers
- engage with waste packagers during the development of the waste product quality document
- clarify and demonstrate the extent of the linkages between the gDSSC and the information required to develop guidance suitable for specific packaging proposals

8.5. Guidance to waste producers on safeguards considerations

We explored the waste stream information RWM has which could, if necessary, be used to address any challenge to the presumption of continuing exclusion from safeguards (on the basis that the quantities of nuclear material involved are small and at concentrations lower than Euratom thresholds for the termination of safeguards coverage). We continued to emphasise that exclusion from safeguards reporting requirements does not remove the on-going need for nuclear materials accountancy and control/tracking for other purposes.

RWM's guidance [103] aims to provide waste packagers with a basic guide to the safeguards requirements applicable to HAW containing "nuclear material". It explains the application of safeguards at waste processing and interim storage facilities, and during transport, and outlines the stages involved in termination of safeguards on waste, if applicable, to be consigned to a GDF. We provided regulatory advice on the developing guidance, which RWM has largely taken on board, and we advised RWM of a few remaining comments where RWM could further improve the clarity of the guidance.

We advised RWM that any waste stream potentially subject to ongoing safeguards oversight will need to be clearly flagged and carefully tracked. This will include reporting on its nuclear material content and agreement with Euratom on appropriate, proportionate verification arrangements.

9. Organisational development

We expect RWM to establish and develop its structure and management arrangements appropriate to an organisation capable of holding the necessary licences and environmental permits to develop and operate a GDF. We will seek assurance that RWM has taken appropriate actions to develop as a prospective Site Licence Company (SLC).

We have continued to engage with RWM and have provided regulatory advice on its continuing programme of organisational development.

9.1. Organisational development action plan

We provided regulatory advice on RWM's three year plan for organisational development, which focuses on readiness to meet regulatory expectations as part of wider organisational development. We were generally content with RWM's draft plan [104, 105], but had some residual comments [106] on the detailed information presented in an annex, as follows:

- We asked RWM to include the need to develop and maintain a capability for environmental assessment, at the next update, noting that this could help RWM demonstrate that it recognises the need to meet statutory requirements for environmental assessment in its implementation of a major development programme.
- We welcome that RWM recognises the need for discussion with the regulators during the process of site identification and assessment. However, we are concerned that the text for the 2017 vision, as shown in RWM's three year plan for organisational development, could suggest that the regulators have a role in site identification and in judging the suitability of a site. We asked RWM to revise, at the earliest opportunity, the text for the 2017 vision to reflect our regulatory role better[xv].
- We recommended that, in its next update of the plan, RWM considers including the organisational management arrangements between work streams that could influence future site characterisation. For example, work on developing regional geological summaries could influence development of the site characterisation R&D programme.
- The numerous typographical errors throughout the annex and, in places, the lack of clarity, do not give us confidence in RWM's quality checking procedures. We noted that we would have more significant concerns if we found evidence of similar poor quality checking in safety critical documentation. We asked RWM to review thoroughly its procedures for release of final versions of documents.
- We recommended that RWM should review and update the annex periodically, if it is to be retained, to ensure that its content is consistent with the ongoing and developing scrutiny programme.

RWM will consider these further recommendations when it next reviews the plan. RWM's Executive agreed that the plan should be reviewed at least annually, to ensure it remains up to date and reflects wider developments, and to increase the scope of the plan at next review. RWM will review it more frequently where necessary, for example, in response to the 2014 white paper [1], or changes to RWM's role.

[xv] It is RWM's responsibility to identify sites and decide on suitability. We may comment on matters within our regulatory remit but we will remain independent of such decisions. The Environment Agency's role is to decide whether to grant an environmental permit when RWM applies to start intrusive investigations at a selected site or sites. In support of such an application, RWM will need to present arguments on why it considers such sites suitable.

9.2. Subsidiary formation

RWMD (as the forerunner to RWM) continued to work on a number of important items required for subsidiary formation to inform its management of organisational change case, such as, the terms of reference of the subsidiary, and the contracts and service level agreements between NDA and RWMD. The management of organisational change case was central to the implementation of the subsidiary formation project within RWMD. The management of organisational change case reflects a category B 'significant' change and was provided to regulators for review, in line with RWMD's arrangements. We advised RWMD that it is important to base the categorisation of change proposal upon the consequences of the change being inadequately implemented rather than an already mitigated view of its significance. We also advised that the management of change case should set out arrangements to review the implementation of the change and the effectiveness of mitigation actions after the change is implemented.

Overall we did not have any significant concerns with RWMD's developing management of organisational change case [107]. However, we advised RWMD that the lack of any direct reference to the responsibility of the board to deliver a GDF constitutes an omission, since this should be the ultimate goal and focus for the board. Some further examples of regulatory advice we gave to RWMD are:

- RWMD should include a note about conflict resolution for cases where NDA might adopt a policy or procedure that does not fit with RWMD's role or reflect its particular needs[xvi].
- RWMD should not be overly dependent on the services provided by NDA. RWMD will need to have a strong intelligent customer capability to understand when and how it might need to take on full responsibility for delivery of some of the services, currently provided by NDA, to meet its specific needs in delivering geological disposal. In particular, we expect RWM to have its own, independent HSSE capability.
- RWMD should clearly differentiate its role and work from that of NDA, and help stakeholders understand the two different roles.
- RWMD should recognise that its records management approach and information assurance requirements might need to diverge from, and go beyond, those of NDA, in order to meet the needs consistent with the potential longevity of a geological disposal programme.

Radioactive Waste Management Limited (RWM) was established as a subsidiary on 1st April 2014. We want to ensure it continues to develop as a company suitable to hold the necessary licences and permits to develop and implement a GDF. As part of this work we interviewed selected RWM Board members in April 2014. Our intention was to assess, at an early stage, RWM's readiness to function as a standalone subsidiary organisation, and to set a baseline for further assessment in the future. Recognising that our interaction was at a very early stage in RWM's development, we did not, therefore, necessarily expect to see a mature operating Board but rather we were looking for signs of how the Board would develop. We were satisfied that Board members were aware of the issues that they are facing and are initiating appropriate actions in terms of governance, assurance and challenge that will better reflect the Board's role in a subsidiary company. We provided feedback to RWM [108] which was well received.

We plan to audit RWM's suitability as a company to implement geological disposal and to hold the necessary permits and licences to develop and operate a GDF, and will feed the outcome of the Board interviews into this audit. RWM's assurance procedures will be a key focus of the audit. We want to establish a benchmark at a suitable time after RWM's change in status to a subsidiary company, which will probably be during 2015/16. We will reconsider the timing after we have looked at RWM's latest management of change case, early in 2015.

[xvi] The document indicates that 'NDA shall consult with RWMD before changing policies. It is the responsibility of the nominated NDA person to update RWMD of any changes and RWMD will then be expected to update its policies and procedures in line with updates to NDA policies and procedures.'

9.3. Regulatory issues from previous inspections/audits

We continue to monitor progress towards addressing matters arising from our previous inspections and audits [109, 110] in the four main areas:

- leadership and governance
- organisational capability
- control and assurance
- organisational learning

We raised these matters in four regulatory issues (RIs) following our inspections. While the fundamental expectations underlying the four RIs are likely to be of enduring relevance we are aware that the context around them, such as RWM's organisational arrangements and legal status, has changed significantly since we raised them. Therefore we have not formally tracked resolution of the RI's, however, we will revisit them, as a framework for our next inspection of RWM's organisational management arrangements (see section 9.2).

9.4. Organisational baseline document, and safety and environmental management prospectus

We provided regulatory advice on RWM's organisational baseline document and safety and environmental management prospectus (SEMP) [111, 112, 113]. RWM is updating these documents to reflect changes in its legal status and organisational structure, and to reflect the new GDF siting process. RWM will consider our advice when it updates the documents.

In its present form, we consider that the SEMP provides an appropriate description of RWM's safety and environmental management arrangements and provides an acceptable basis for RWM's future development as a subsidiary company. However, we have provided a few suggestions that may help to improve any future version. In particular, we noted many minor typos and small inconsistencies throughout the text that suggest to us that RWM needs to improve its quality assurance procedures.

An updated organisational baseline document will be required for RWM as a subsidiary company, to provide a suitable basis for assessing future organisational development needs, including reducing RWM's dependencies on NDA. The areas for which RWM needs to be a capable organisation remain relevant. We advised RWM that it might need to consider the timing for establishing capability in some areas (such as, site assessment methodology, environmental assessments, and commercial strategy). We also noted that changes may be required to the accountabilities, to better reflect the revised siting process.

10. Conclusion

We are satisfied that RWM has adequate systems in place to monitor our regulatory concerns and recommendations, such that it can take them into account and implement any necessary changes and improvements in its ongoing programme towards implementing geological disposal, and that RWM is responsive to our regulatory advice.

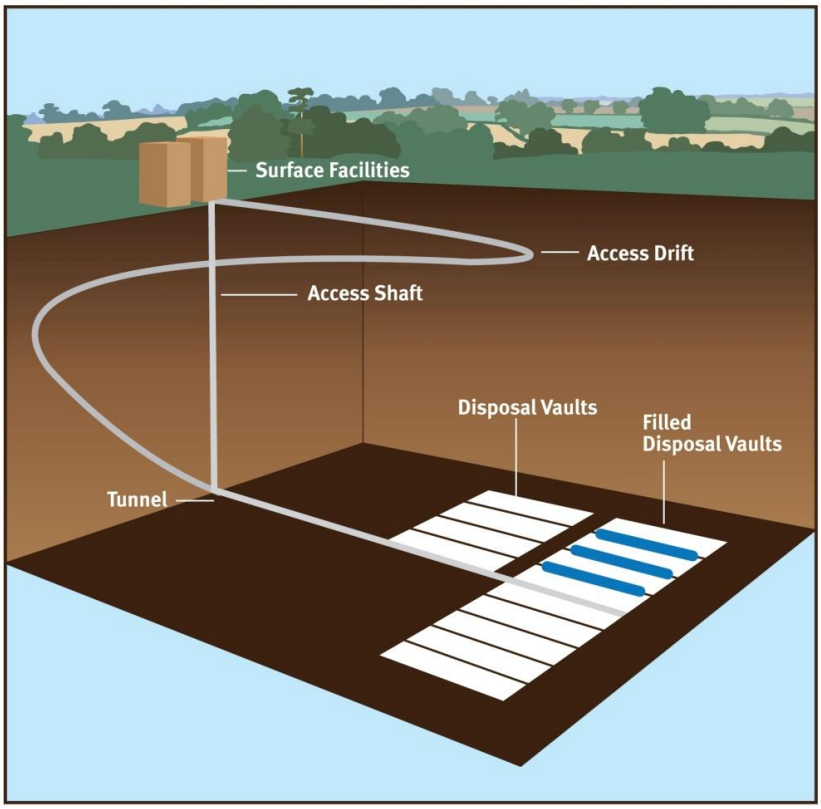

Figure 1 Illustrative layout of a geological disposal facility

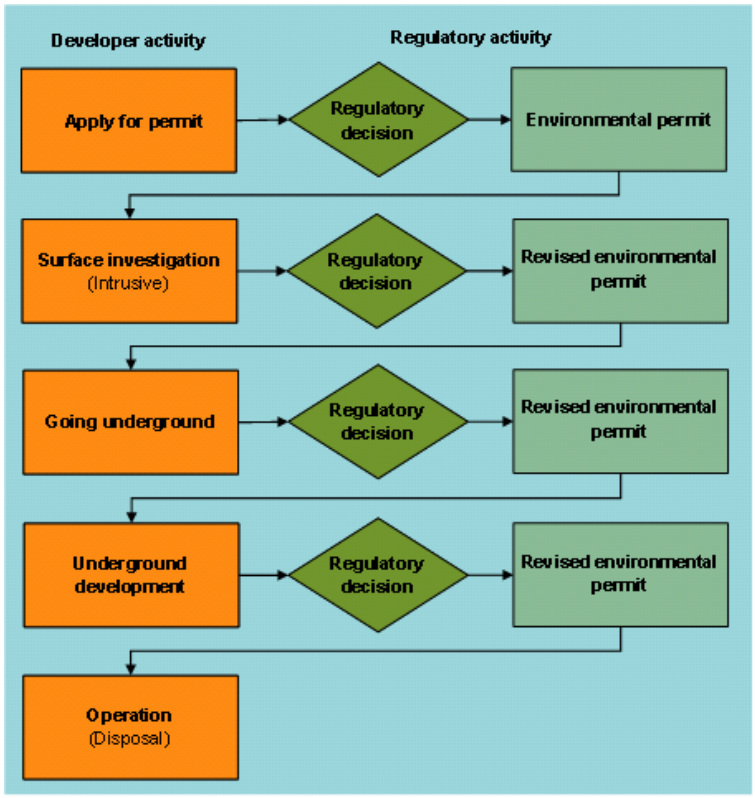

Figure 2 Environment Agency: Staged regulation – simplified process

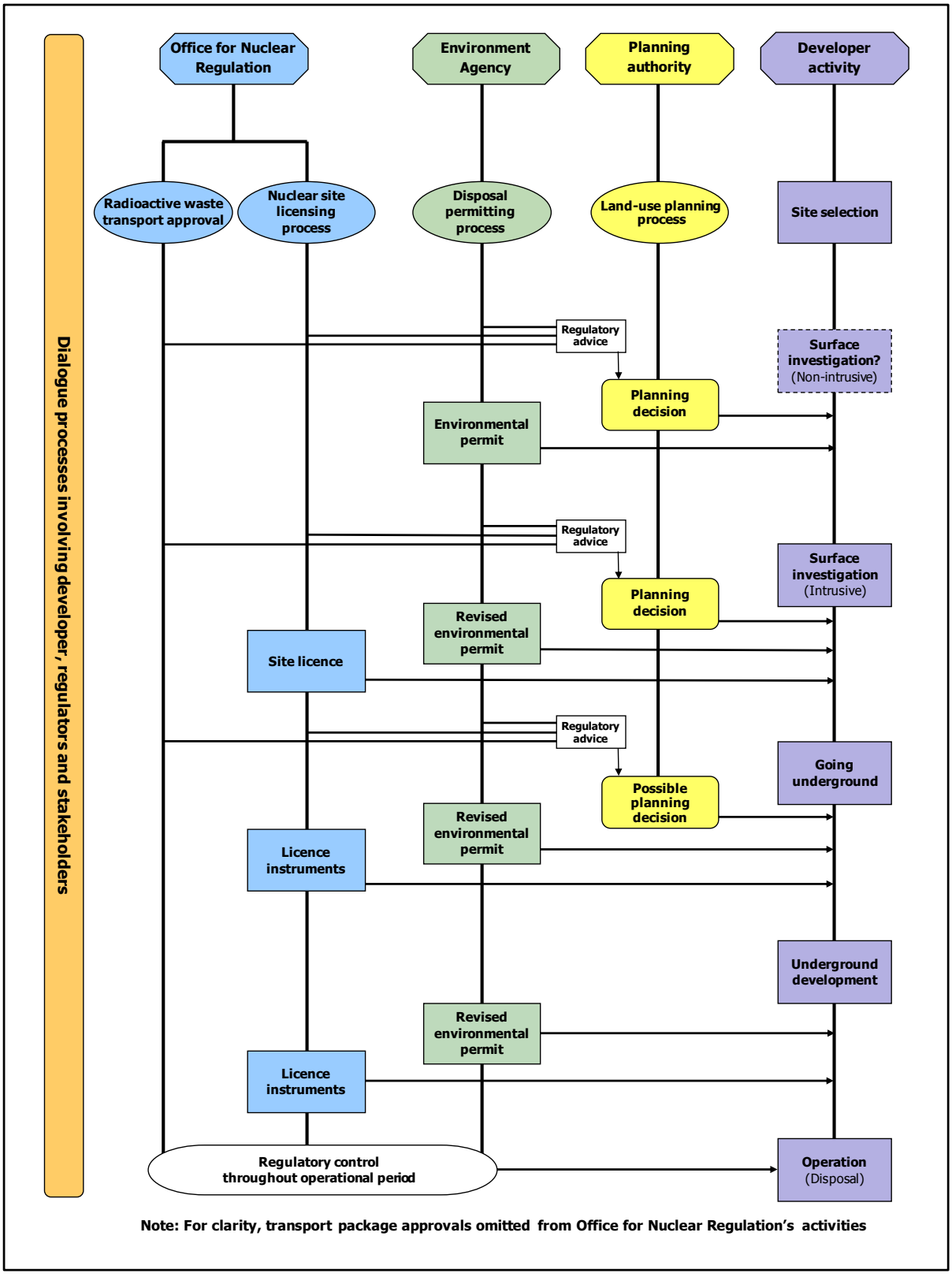

Figure 3. Illustration of the possible links between a development programme for a GDF and the regulatory processes

List of abbreviations

AoS	Assessment of Sustainability
BGS	British Geological Survey
CDM	Construction (Design and Management) Regulations
COMAH	Control of Major Accident Hazards Regulation
CoRWM	Committee on Radioactive Waste Management
DECC	Department of Energy and Climate Change
DSS	Disposal System Specification
DSSC	Disposal System Safety Case
EIA	Environmental Impact Assessment
EPR10	Environmental Permit Regulations 2010
ESC	Environmental Safety Case
ESS	Environmental Safety Case Strategy
Euratom	The European Atomic Energy Community[xvii]
FEPs	Features, Events and Processes
GDF	Geological Disposal Facility
gDSSC	generic Disposal System Safety Case
GRA	Guidance on Requirements for Authorisation
GWDD	Ground Water Daughter Directive
HAW	High Activity radioactive Waste
HLW	High Level radioactive Waste
HSE	Health and Safety Executive
HSSE	Health, safety, security and environment
IAEA	International Atomic Energy Agency
ILW	Intermediate Level radioactive Waste
IPT	Integrated Project Team
ISE	Initial Site Evaluation
LLW	Low Level Radioactive Waste
LoC	Letter of Compliance
MPC	Multi-Purpose Container
MRWS	Managing Radioactive Waste Safely
NAPLs	Non-aqueous phase liquids

[xvii] Co-ordination of European Community activities (such as research, safety standards) for the peaceful use of nuclear energy.

NDA	Nuclear Decommissioning Authority
NORMS	National Objectives, Requirements and Model Standards
NPS	National Policy Statement
NRW	Natural Resources Wales
NSEC	[RWM's] Nuclear Safety and Environment Committee
NSIP	Nationally Significant Infrastructure Project
NWAT	[Environment Agency's] Nuclear Waste Assessment Team
ONR	Office for Nuclear Regulation
OSC	Operational Safety Case
OSS	Operational Safety Strategy
PESE	Preliminary Environmental Safety Evaluation
PCSA	Post-Closure Safety Assessment
QA/QC	Quality Assurance / Quality Control
R&D	Research and Development
RIRP	Regulators' Issue Resolution Process
RI	Regulatory Issue (from the RIRP)
RMS	Requirements Management System
RO	Regulatory Observation (from the RIRP)
RQ	Regulatory Query (from the RIRP)
RWMD	Radioactive Waste Management Directorate (to 31 March 2014)
RWM	Radioactive Waste Management Limited (from 1 April 2014)
SAG	Sustainability Assessment Group
SAPs	Safety Assessment Principles (ONR)
SEA	Strategic Environmental Assessment
SEMP	Safety and Environmental Management Prospectus
SEPA	Scottish Environmental Protection Agency
SLC	Site Licence Company
SRL	Scientific readiness level
S&T	Science and Technology Plan
TBuRD	Technical Baseline and Underpinning Research and Development Requirements
TRL	Technical readiness level
TSS	Transport Safety Strategy
UKRWI	United Kingdom Radioactive Waste Inventory
WAG	Welsh Assembly Government
WIPP	Waste Isolation Pilot Plant (in New Mexico, USA)

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